Online ISSN : 2249-4596
Print ISSN : 0975-5861
DOI : 10.17406/GJRE

Global Journal of Researches in Engineering: J

General Engineering

Effect of Step Depth
Water Infiltration Models
Highlights
Organic Amended Soils
Integration for Improving Performance

Discovering Thoughts, Inventing Future

VOLUME 16 ISSUE 4 VERSION 1.0

Global Journal of Researches in Engineering: J
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Volume 16 Issue 4 (Ver. 1.0)

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Framingham Massachusetts Pin: 01701,
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USA Toll Free: +001-888-839-7392
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200 USD (B/W) & 250 USD (Color)

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN:0975-5861

Effect of Step Depth and Angle in Kline-Fogleman (Kfm-2) Airfoil

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Abstract- Recent years have witnessed extensive research efforts that aim at improving the aerodynamic performance of aircraft. while most of the efforts are drawn towards high-lift systems, simple and innovative designs like Gurney flaps, trapped vortex cavities and backward-facing steps can have a significant effect on enhancing the aerodynamic properties of airfoils. One of those simple ideas is the Kline-Fogleman modified airfoil (KFm-2), which is basically an airfoil with a backward-facing step on the upper surface located at midway the chord length. it is claimed that the step creates a low pressure recirculation region on the suction side of the airfoil that may enhance the lifting force. This study will numerically examine the ability of the KFm-2 design to enhance the lift and drag properties of a NACA 2412 at a high Reynolds number of 5.9×10^6. The effect of the step depth and the step angle will be thoroughly examined.

Keywords: aerodynamics, stepped airfoil, backward-facing step, KFm-2 airfoil, CFD.

GJRE-J Classification: FOR Code: 090199

EFFECTOFSTEPDEPTHANDANGLEINKLINEFOGLEMANKFM2AIRFOIL

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Effect of Step Depth and Angle in Kline-Fogleman (Kfm-2) Airfoil

Fadi Mishriky [α] & Paul Walsh [σ]

Abstract- Recent years have witnessed extensive research efforts that aim at improving the aerodynamic performance of aircraft. while most of the efforts are drawn towards high-lift systems, simple and innovative designs like Gurney flaps, trapped vortex cavities and backward-facing steps can have a significant effect on enhancing the aerodynamic properties of airfoils. One of those simple ideas is the Kline-Fogleman modified airfoil (KFm-2), which is basically an airfoil with a backward-facing step on the upper surface located at midway the chord length. it is claimed that the step creates a low pressure recirculation region on the suction side of the airfoil that may enhance the lifting force. This study will numerically examine the ability of the KFm-2 design to enhance the lift and drag properties of a NACA 2412 at a high Reynolds number of $\mathbf{5.9 \times 10^6}$. The effect of the step depth and the step angle will be thoroughly examined.

Keywords: aerodynamics, stepped airfoil, backward-facing step, KFm-2 airfoil, CFD.

I. Introduction

The majority of aircraft today use high-lift systems to augment the wing's lifting capabilities at different flight regimes. The importance of these systems is emphasized during take-off and landing, when the wings are required to generate high lifting forces at minimal speeds. These hinged surfaces are employed in most commercial subsonic aircraft and controlled using heavy mechanical devices as pistons, screws, racks and pinions, etc. All these components add to the cost, mass and complexity of the aircraft. Wlezien et al. [1] stated that half the cost and complexity of an aircraft wing are due to the complexity of the high-lift system. In addition, the gaps between the surface and the wing significantly increase the drag forces and the noise. For these reasons, any less complex and innovative design should be examined.

One of the simplest potential solutions is a series of stepped airfoils designed by Kline and Fogle man (KFm-series). In the early 1960s, Richard Kline, who had the hobby of making paper airplanes, created a paper airplane design that could fly for long distances despite wind or turbulences.

He presented the paper airplane to his colleague Floyd Fogleman who saw that this model can fly and resist stalling. The two men then filled a U.S. patent for a wedged-like airfoil that is hollow from below [2], and with further developments, they filled another patent in 1977 [3] for an airfoil with a backward-facing step on the pressure side, with one or more membranes pivotally hinged near the step. A new family of airfoils (KFm1 – KFm8) diverged from their patented designs, where backward-facing steps were installed on either side of the airfoil. The KFm airfoils gained popularity among the radio controlled airplane community from that time to date, with most users claiming better stability and enhanced aerodynamic performance. The step is supposed to intentionally separate the flow from the airfoil, and trap a recirculating vortex over its vicinity. This recirculating zone creates low pressure regimes on specific locations of the airfoil, and this may enhance the aircraft performance.

Inspired by the Kline-Fogleman airfoil designs, Fertis et al. [4] designed an airfoil with a backward-facing step on the upper surface of the airfoil, and they filled a U.S. patent for their design titled "Airfoil". Six years later, Fertis [5] published the experimental results of the design shown in his patent. The experimental tests were performed on NACA 23012 airfoil at a range of Reynolds numbers from 1e+5 to 5.5e+5, and a wide range of angle of attacks; from 2° to 38°. The results showed improved stall characteristics at all tested airspeeds, increased lift coefficients and increased functional lift-to-drag ratios over a range of angle of attacks. Fathi et al. [6] performed a number of experimental and numerical experiments at a Reynolds Number of 5e+5 on 15 different configurations of a symmetric NACA 0012 airfoil with a backward-facing step on either sides. The results showed that a step on the lower side of the airfoil whose depth is half the thickness of the airfoil and extends to the trailing edge will increase the lift and the lift to drag ratio. For all other cases, especially when the step is on the upper surface, the drag coefficient significantly increases and leads to a drop in the lift to drag ratio. Cox et al. [7] compared the Rolf Girsberger (RG) -15 airfoil section with a KFm-2 step with the clean RG-15 airfoil at four low Reynolds Numbers between 2.8e+3 and 1e+5. Results revealed that at these Reynolds number, the addition of the KFm-2 step was found to have no useful aerodynamic benefits.

With most of the studies were performed at low Reynolds numbers, this paper will investigate the

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capabilities of the KFm-2 approach to enhance the aerodynamic performance of a NACA 2412 airfoil at a high Reynolds number of 5.9e+6. The KFm-2 airfoil employs a backward-facing step at the mid-chord location on the suction side of the airfoil as shown Figure 1. This design is commonly encountered in cases of sliding morphing skins. In such designs, two rigid surfaces remain in contact and slide against each other during morphing. This interface introduces backward-facing steps on the wings' surface.

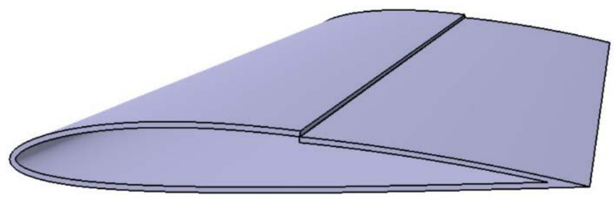


Figure 1: Kline-Fogleman (KFm-2) Airfoil with a backward-facing step mid-chord the upper surface of the wing.

The study will offer an in-depth numerical investigation on the effect of the step depth and the step angle on the aerodynamic properties of the airfoil. First, the numerical methodology and amesh independence study will be presented. The numerical testing will focus on variation of the lift coefficient c_l and the drag coefficient c_d with different step configurations. Finally, conclusion about the aerodynamics of the KFm-2 airfoil will be presented with general recommendations about the step depth and angle.

II. Numerical Modeling and Boundary Conditions

The commercial CFD code FLUENT is used in this study to simulate the flow using the finite volume method. An implicit density-based solver is used to solve the Navier-Stokes and the turbulence transport equations, where the convective and diffusive fluxes were calculated using a second-order Upwind scheme, and the gradients of scalar quantities were reconstructed using the Least-Squares cell-based method. The turbulence of the flow is modeled using the four equations Langtry-Menter transitional SST turbulence model [8, 9]. This model has been shown to accurately model the transition of the viscous boundary layer from laminar to turbulent which was observed to have an effect on the value of the lift and drag coefficients.

The airfoil used in the study is a standard NACA 2412 airfoil with a sharp trailing edge, a unity chord length and a computational domain that extends 32 chordsin a C-grid topology. The air is treated as an ideal gas whose viscosity is calculated using the three equations Sutherland's formula.

The baseline parameters of the airfoil are from the NACA 2412 with a vertical step at the mid-chord with depth of 0.015 chord lengths. The NACA profile continues after the step, but scaled along the Y direction to intersect the step at its lower edge.

The mesh that discretizes the computational domain must compromise between computational accuracy and run time. To fulfill this challenging demand, a mesh independent study is performed using a family of three consecutively refined meshes with a constant refinement factor of $r = 2$. This means that for 2D meshes, the number of cells is quadrupled from each mesh to next refined one. The coarse, medium and fine meshesconsist of 12,000, 48,000 and 192,000 cells, respectively. The Richardson's extrapolation method [10] is used to calculate the continuum value $\mathcal{F}_{h=0}$, where $\mathcal{F}$ is an aerodynamic property that is evaluated on the coarse, medium and fine meshes to obtain $\mathcal{F}_c$, $\mathcal{F}_m$ and $\mathcal{F}_f$ respectively.In our case the lift coefficientc_l was used for this analysis.

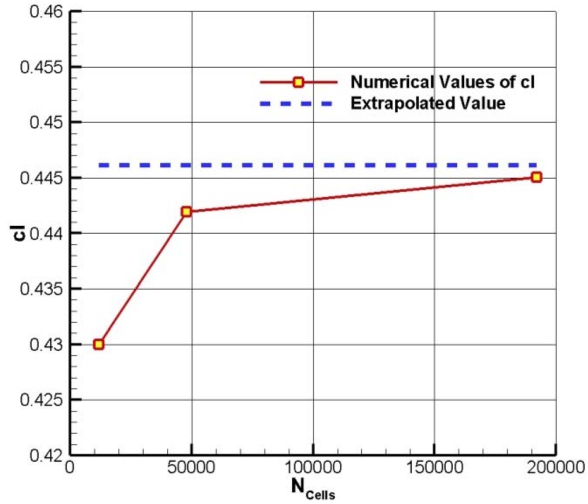


Figure 2: Convergence of the numerical value of c_l towards the extrapolated asymptotic value.

The continuum value $\mathcal{F}_{h=0}$ is calculated as follows:

$$\mathcal{F}_{h=0} \cong \mathcal{F}_f + \frac{\mathcal{F}_f - \mathcal{F}_m}{r^p - 1} \quad (1)$$

where r is the refinement ratio, and in our case it is constant at 2. While p is the observed order of accuracy of the solution and is calculated as:

$$p = \frac{ln\left(\frac{\mathcal{F}_c - \mathcal{F}_m}{\mathcal{F}_m - \mathcal{F}_f}\right)}{ln\,(r)} \quad (2)$$

This order of accuracy could be also calculated from the logarithmic slope of the errors of the three meshes ε_c, ε_m and ε_f. In this case, the error of $\mathcal{F}$ in each mesh is calculated as:

$$\varepsilon_c = |\mathcal{F}_{h=0} - \mathcal{F}_c|,\ \varepsilon_m = |\mathcal{F}_{h=0} - \mathcal{F}_m| \text{ and } \varepsilon_f = |\mathcal{F}_{h=0} - \mathcal{F}_f| \quad (3)$$

Equations (1-3) were used to calculate the continuum value $\mathcal{F}_{h=0}$ of the lift coefficient. Figure 2 shows the values obtained from three meshes as well as the extrapolated continuum value. The value obtained from the fine mesh was 0.244% away from the asymptotic value $\mathcal{F}_{h=0}$.

This shows the adequacy of the fine mesh to capture the important physical features of the flow, and further refinements will only increase the computational time without notable improvement in the numerical accuracy. Thus, the fine mesh will be used in the next section to examine the effect of the step depth and angle on the aerodynamic performance of KFm-2 airfoil with a NACA 2412 profile.

III. Results and Discussion

a) Effect of the step depth D_U

In this subsection, the effect of the step depth on the lift and drag coefficients of the airfoil will be tested. The flow is directed with an angle of attack of $2.5°$ over the NACA 2412 airfoil that has a vertical step. The location of the step is fixed at the mid chord length $(X/C = 0.5)$, and the only variable will be the step depth. The testing starts with a step of depth $D_U/C = 0.0075$ and increase to $D_U/C = 0.025$ with an increment of $0.0025\ C$ from one configuration to the other. Figure 3 shows the two extreme positions of the step depths representing $D_U/C = 0.0075$ and $D_U/C = 0.025$, where D_U is the step depth and C is the chord length.

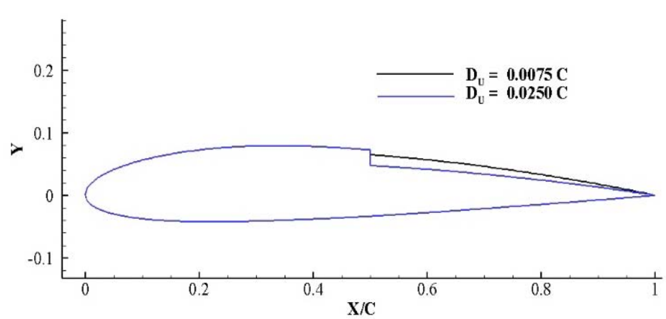


Figure 3: The two extreme depths of the step.

Eight configurations of different step depths were numerically simulated until convergence. The convergence criterion was judged by the complete stability of the lift, drag and moment coefficients.

As the depth gradually increased from $D_U/C = 0.0075$ to $D_U/C = 0.025$, the lift coefficient decreased by about 20%, and the highest value of lift coefficient obtained (0.4812), is lower than the value obtained by the unchanged (clean) NACA 2412 which is equal to 0.5172. Figure 4 shows the inverse relation between the lift coefficient c_l and the step depth D_U.

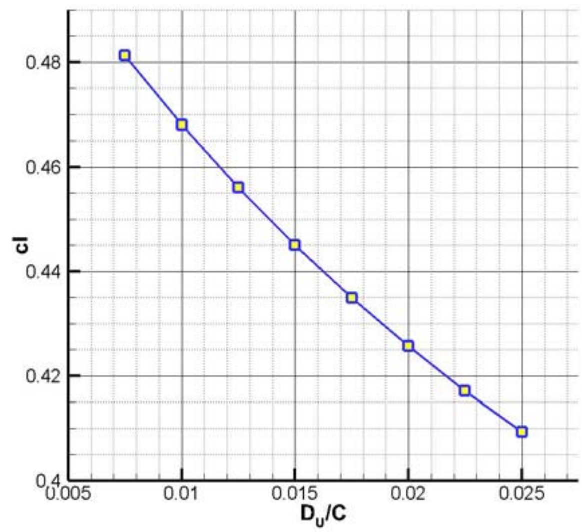


Figure 4: Effect of the step depth on the lift coefficient of the stepped NACA 2412 airfoil.

The steep slope of the curve in Figure 4 reflects the strong correlation between the step depth and lifting forces on the airfoil. To study the relation between the lifting forces and the step depth, the pressure distribution over the eight configurations of step depths is shown in Figure 5.

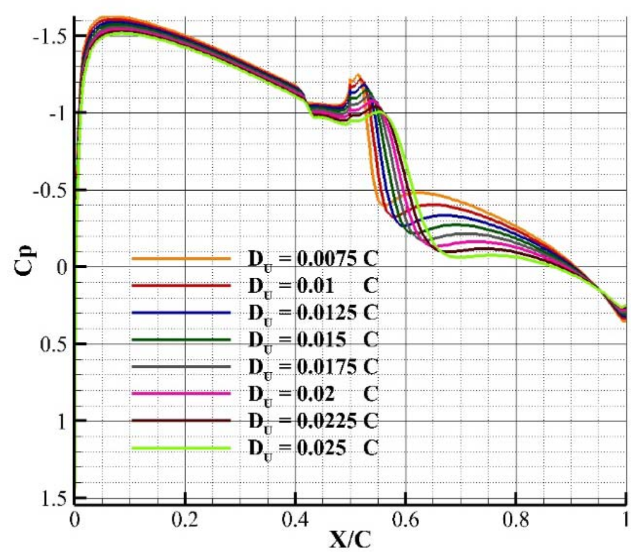


Figure 5: Pressure distribution over NACA 2412 airfoils with different step depths.

The step caused the airfoil thickness to locally decrease, which resulted in a deceleration of the flow as it traveled past the step, consequently increasing the value of the pressure after the step. As the step depth increased, the pressure increased on the suction side leading to an overall drop in the lift coefficient values.

It was also observed that the step depth affected the pressure distribution upstream the step location, which increased as the step depth increased Thus, from this analysis, it could be concluded that an increase in the step depth will cause the lifting forces to decrease.

Next, a similar analysis was performed to establish the relation between the drag coefficient and depth of the installed step. Results of this analysis are shown in Figure 6.

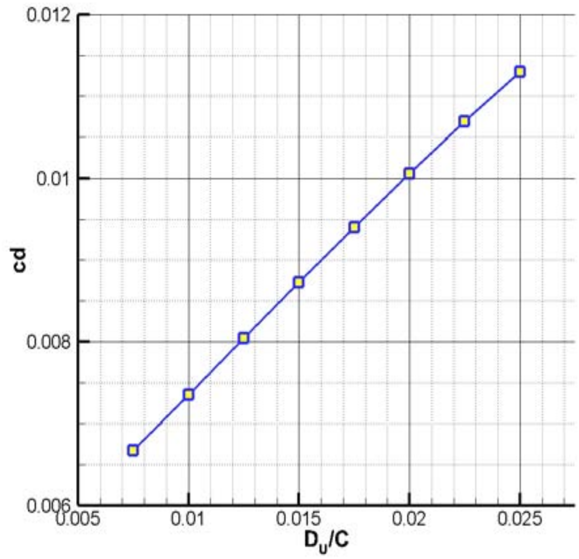


Figure 6: Effect of the step depth on the drag coefficient of the stepped NACA 2412 airfoil.

A linear-like relation is observed between the step depth D_U and the value of the drag coefficient of the airfoil. The lowest value of drag coefficient is still higher than the value obtained from the clean NACA 2412 at the same conditions. The drag coefficient value of a clean NACA 2412 is 0.00515, while the lowest drag coefficient in Figure 6 is observed at a step depth of 0.0075 C, and is equal to 0.00668.

A nearly constant increment of $7e-4$ in the drag coefficient value is observed with each $0.0025\,C$ increment in the step depth. This relation holds over the full testing range. To study this direct relation, the drag coefficient is decomposed to its two main components; the pressure drag coefficient and the viscous drag coefficient. Equation 4 provides the expression used to calculate each component.

$$c_d = c_p + c_f = \frac{1}{\rho\, v^2 A}\int_S (p - p_0)(\hat{n}\,.\,\hat{\imath})\, dA + \frac{1}{\rho\, v^2 A}\int \tau_w(\hat{t}\,.\,\hat{\imath})\, dA \qquad (4)$$

Where c_p is the pressure drag coefficient, c_f is the friction drag coefficient or viscous drag coefficient, ρ is the fluid density, v is the reference velocity, A is the reference area, p is the pressure at the surface dA, p_0 is the reference pressure, $\hat{n}$ is a unit vector normal to the surface dA, τ_w is the wall shear stresses at the surface dA and $\hat{t}$ is a unit vector tangent to the surface dA.

The pressure drag coefficient is calculated as the surface integration of the pressure coefficient value acting normal to the airfoil surface, while the viscous drag component is the surface integration of the skin friction coefficient along the tangential direction of the airfoil surface. The results of this decomposition is shown in Figure 7.

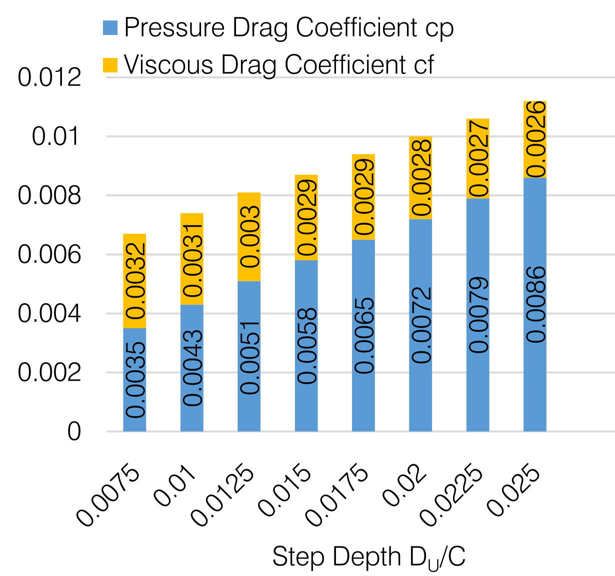


Figure 7: Decomposition of the Drag coefficient to pressure drag and viscous drag coefficients at different step depths.

The viscous drag coefficient experienced a small increase from one step depth to the other. On the other hand, the pressure drag coefficient is the dominant factor, and its contribution increased with the increase of the step depth. This is mainly due to the nature of the drag coefficient of stepped airfoils which is driven by the interaction of the low pressure region at the recirculation zone with the vertical wall of the step. With the increase of the step depth, the pressure experiences a slight increase, but the exposed area of the airfoil noticeably increases. This results in a constant increase in the pressure drag force acting on the step from one depth to the other. For that reason, the drag coefficient continuously increased as the step depth increased.

b) Effect of the step angle β

The previous subsection showed a strong correlation between the step depth and the values of the lift and drag coefficients. This subsection focuses on the effect of the KFm-2 step angle on the aerodynamic properties studied in the previous section.

Figure 8 shows five different configurations of the airfoil with the step angle rotated at different angles. In all cases the step is fixed at X=0.5 C, with a step depth of $D_{U=}$0.015 C, while the step angle **β** changes from 45° to -45°, with the zero at the vertical position and positive angles are in the counter-wise direction.

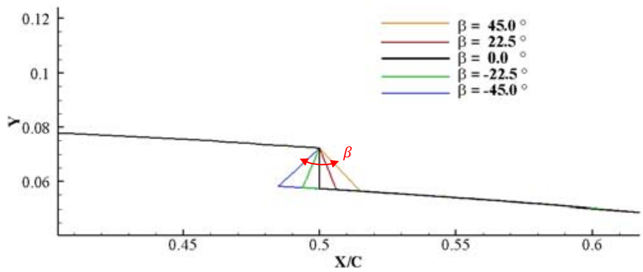


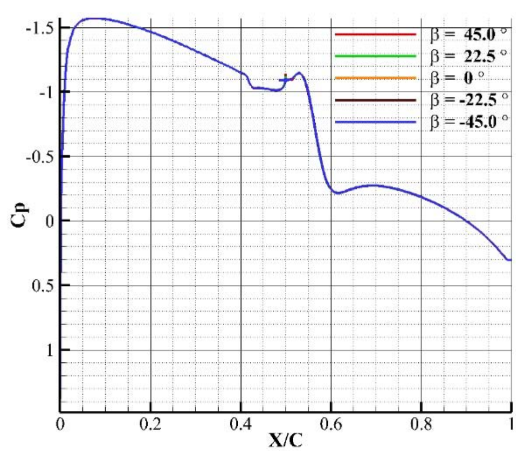
Figure 8: Different configurations of the NACA 2412 with different step angles.

The flow was set to an angle of attack of 2.5° in the simulations and the complete stability of the lift and drag coefficients marked the convergence of the solution. Table 1 shows the lift and drag coefficients calculated at different step configurations.

Table 1: Values of the cl, cd and cl/cd at different step angles β.

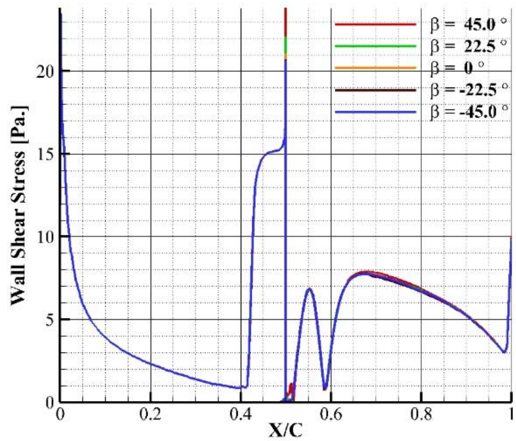
Step Angle	c_l	c_d	c_l/c_d
45.0 °	0.44439	0.00878	50.6115
22.5 °	0.44494	0.00873	50.9527
0 °	0.44504	0.00873	50.9919
-22.5 °	0.44503	0.00873	50.9779
-45.0 °	0.44495	0.00873	50.9495

The five cases obtained nearly the same values for the lift and drag coefficients. This is confirmed by the identical values of the pressure distribution and the shear wall stresses shown in Figure 9a and 9b respectively.



(a)

Global Journal of Researches in Engineering (J) Volume XVI Issue IV Version I Year 2016



(b)

Figure 9: (a) Pressure distribution and (b) wall shear stresses of five different configurations with different step angles.

The identical curves justifies the equal results of the five configurations. A small difference is observed in the lift to drag ratio c_l/c_d in case of the angle β=45°. This is due to the small displacement of the recirculation zone to the lower corner of the inclined step. In cases of step angles from β=-45° to 22.5° the recirculation zone started at X/C = 0.513, while in case of β=45°, the bottom corner of the step started at X/C = 0.517, which is the location that marks the beginning of the recirculation zone. For that reason, the case with a step angle of β=45° obtained a slightly higher drag coefficient and lower lift coefficient when compared to the other cases. For cases with negative step angles, the additional space located at the cavity of the inclined step is filled with a cascade of minute low energy vortices that have negligible effect on the aerodynamics of the flow. Therefore, the effect of the step angle β ranging between 45 to-45° could be neglected in the aerodynamic analysis of backward-facing steps installed on the upper surfaces of airfoils.

IV. Conclusion

This study examined the aerodynamic performance of the KFm-2 airfoil with a NACA 2412 profile. Different variations of this design were achieved by changing the step depth and the step angle employed at the upper surface of the airfoil. The flow was simulated numerically at a Reynolds number of 5.9e+6, a Mach number of 0.16 and angle of attack of 2.5°. The study showed that employing a step on the upper surface of a NACA 2412 airfoil has degraded the aerodynamic performance in terms of the values of the lift and drag coefficients. The lift coefficient decreased as the step depth increased, while the drag coefficient followed a linear-like behavior that increased constantly as the step depth increased. Decomposition of the drag coefficient to its two main components revealed that for stepped airfoils, the pressure drag coefficient dominates the calculation of the drag forces due to the interaction of the low pressure recirculation zone with the 'vertical' wall of the step. Changing the angle of the step from 45° to -45° did not have any effect on the drag and lift coefficients. Thus, employing a backward-facing step on the upper surface of a NACA 2412 at a high Reynolds number of 5.9e6 has degraded the aerodynamic performance when compared to the unchanged airfoil. However, decreasing the step depth diminishes these adverse effects.

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN:0975-5861

Performance of Selected Water Infiltration Models in Sandy Clay Loam Soil in Samaru Zaria

By Igbadun H. E., Othman M. K. & Ajayi A. S.
Ahmadu Bello University

Abstract- The performance of selected water infiltration models were evaluated and reported herein. Ten (10) water infiltration models consisting of five (5) empirical (Philip (PH), Kostiakov (KT), Modified Kostiakov (MK), Kostiakov-Lewis (KL) and Natural resources conservation service(NRCS)), three (3) physically based (Green-Ampt (GA), Smith-Parlange (SP), Talsma-Parlange (TP)) and two (2) semi – empirical (Swartzendruber (SW) and Horton (HT)), were evaluated for sandy clay loam soil. The aim was to study the ability of the models in accurately predicted measured cumulative infiltration. The study was carried out at the Agricultural Engineering experimental plot at Samaru, Zaria. The soil was predominantly Sandy clay loam. The results showed that the coefficient of determination (r^2) between the models simulated and field measured cumulative infiltration ranged from 0.905 to 0.998.

Keywords: *water infiltration, empirical models, sandy clay loam, samaru zaria.*

GJRE-J Classification: *FOR Code: 291899*

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Performance of Selected Water Infiltration Models in Sandy Clay Loam Soil in Samaru Zaria

IgbadunH. E. [α], Othman M. K. [σ] & Ajayi A. S. [ρ]

Abstract- The performance of selected water infiltration models were evaluated and reported herein. Ten (10) water infiltration models consisting of five (5) empirical (Philip (PH), Kostiakov (KT), Modified Kostiakov (MK), Kostiakov-Lewis (KL) and Natural resources conservation service(NRCS)), three (3) physically based (Green-Ampt (GA), Smith-Parlange (SP), Talsma - Parlange (TP)) and two (2) semi – empirical (Swartzendruber (SW) and Horton (HT)), were evaluated for sandy clay loam soil. The aim was to study the ability of the models in accurately predicted measured cumulative infiltration. The study was carried out at the Agricultural Engineering experimental plot at Samaru, Zaria. The soil was predominantly Sandy clay loam. The results showed that the coefficient of determination (r^2) between the models simulated and field measured cumulative infiltration ranged from 0.905 to 0.998. The value of the modeling efficiency (E) ranged from 0.623 to -7.145 while the. The Modified Kostiakov's model had the overall best performance, Green-Ampts model had the best performance amongst the physically based models and the modified Kostiakov's and Swartzendruber's model had the best performances in the empirical and semi-empirical group respectively.

Keywords: *water infiltration, empirical models, sandy clay loam, samaru zaria .*

I. Introduction

Infiltration is the process of water movement from the ground surface into the soil and is an important component in the hydrological cycle (Haghaibi *et. al.,* 2011).

Adequate water resource management is essential for stable and efficient agriculture. Hence, efforts are being directed towards water management and conservation activities such as irrigation and control of flood and erosion. Realistic planning of these water management activities requires sufficient information on the rate at which different soils take up water under different conditions. Data on rates of infiltration of water into soils can be used to supplement other soil information which could assist soil scientists, engineers, hydrologists and others to deal more effectively with a wide spectrum of water resource management and conservation problems (Ajayi, 2015; Mishra *et al*., 2003).

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Infiltration characteristics of soils can be quantified by direct measurement on the field and/or when field infiltration data are fitted mathematically to infiltration models (Oku and Aiyelari, 2011). Lili*et al.,* (2008) reviewed the commonly used direct methods for measuring soil infiltration which include: single ring and double ring infiltrometers, mariotte-double ring infiltrometer, disc permeameter, rainfall simulator, runoff-on-ponding, runoff-on-out and linear source methods, the results obtained from field infiltration test and soil analysis are used for infiltration modeling.

Infiltration modeling approaches are often separated into three categories: physically based, approximate/semi-empirical (analytical), and empirical models. The physically based approaches use parameters that can be obtained from soil water properties and do not require measured infiltration data. The evaluation of semi-empirical/analytical models are purely mathematical or graphical, it is called semi-empirical because their evaluation process involves the use of the asymptomatic or steady state infiltration capacity unlike the physically based models that depends strictly on soil water characteristics. Empirical models tend to be less restricted by assumptions of soil surface and soil profile conditions, but more restricted by the conditions for which they were evaluated, since their parameters are determined based on actual field-measured infiltration data (Hillel, 1998; Skaggs and Khaleel, 1982).

Researchers have condensed soil infiltration characteristics into a number of simple mathematical models (Ajayi, 2015), confidence in the model predictions needs to be demonstrated through adequate field verification, with agreement between measured values and those predicted by the simulation model (Ogbe*et al.,* 2008).

The aim of this paper is to assess the performance of ten(10) widely adaptable infiltration models for Sandy Clay loam soil. The selected models are: Philip (1957), Kostiakov (1937), Horton (1940), Modified Kostiakov (1978), Kostiakov-Lewis (1982), Green-Ampt (1911), Swartzendruber (1972), Smith-Parlange (1978), Talsma-Parlange (1972) and Natural resources conservation service (NRCS 1989) models. The specific objectives are to estimate the models parameters and to compare the cumulative infiltration

Global Journal of Researches in Engineering (J) Volume XVI Issue IV Version I Year 2016

Global Journal of Researches in Engineering (J) Volume XVI Issue IV Version I Year 2016

depths estimated by the models with those measured in the field.

II. Materials and Methods

The study was carried out at the Department of Agricultural Engineering experimental field, Samaru, Zaria, Nigeria. Zaria is located on latitude 11° 11'N and longitude 07° 38'E, at an altitude of about 668 m above sea level. The portion of the field used was 200m long by 50m wide. Six points was chosen and soil samples were collected at 0-15 cm and 15-30 cm depths for soil analysis. Infiltration measurement was carried out using a double ring infiltrometer. The infiltrometer was driven into the soil to a depth of 15cm and a measuring tape was fixed inside the inner cylinder from where readings were taken. Readings were then taken at intervals to determine the amount of water infiltrated during the time interval with an average infiltration head of 5cm maintained. The infiltration rate and the cumulative infiltration were then calculated. The soil texture of the site was determined by mechanical analysis method. The United States Department of Agriculture (USDA) Textural Classification Triangle was used to classify the soil based on the results obtained from the analysis.

Table 1: Average soil physical characteristics of the strips

Strip	B.D(g/cm^3)	M.C(g/g)	K_s(cm/hr)	%Clay	%Silt	%Sand
CM	1.53	0.06	7.37	23.2	17.8	59.0
PM	1.21	0.12	5.92	24.0	20.0	56.0
CT	1.81	0.05	4.58	26.0	14.0	60.0

**BD = Bulk density; MC =Moisture content; K_s= Saturated Hydraulic Conductivity; C = % Clay ;Si = % Silt; Sa = % Sand;*

a) *Infiltration Models Studied*

The following infiltration models were assessed for finding best fitting model to observed field infiltration rate data, Table show the models and their respective parameters.

Table 2: Summary of Equations and fitting parameters of the Ten(10) models tested

S/N	Model Name	Cumulative Infiltration equation	Fitting parameters
1	Kostiakov(1932)	$I = kt^a$	*k and a*
2	Green-Ampt(1911)	$I = Kt + \psi\Delta\theta \ell n I\left[1 + \frac{I}{\psi\Delta\theta}\right]$	*ψ, I and i*
3	Modified Kostiakov (1978)	$I = kt^a + b$	*k_1, a_1 and b*
4	Philip(1957)	$I = S\sqrt{t} + At$	*S and A*
5	Horton (1940)	$I = f_c t + \frac{f_0 - f_c}{k}[1 - e^{-kt}]$	*k, f_0 and f_c*
6	Kostiakov-Lewis (1982)	$I = kt^a + f_c t$	*A_2, k_2 and f_c*
7	NRCS Model (1989)	$I = at^b + 0.6985$	*a_3 and b*
8	Talsma & Parlange (1972)	$I = St^{1/2} + \frac{K_s t}{3} + \frac{K_s^2 t^{3/2}}{9S}$	*S and k_s*
9	Swartzendruber (1972)	$I = f_c t + \frac{c}{d}[1 - exp(-dt^{0.5})]$	*c and d*
10	Smith & Parlange (1978)	$I = k_s t\left[\frac{C_o}{k_s I} + 1\right]$	*C_o and k_s*

Where: I = cumulative infiltration (cm), i = infiltration rate, t= time from the start of infiltration (hr), and *a, a_1, a_2, a_3*,and *k, k_1*, $k_2$are empirical parameters that need to be estimated. ψ = soil suction head at the sharp wetting front (cm);ΔΘ = the change in water content (θ_s - θ_i) (g/g);θ_s = final moisture content or saturation moisture content(g/g);θ_i = initial moisture content before water infiltration (g/g);k_s = saturated Hydraulic conductivity (cm/hr); b = rectifying factor, S (cm/hr$^{1/2}$) = Sorptivity, A (cm/hr) =Transmitivity, f_0 = initial infiltration rate; f_c = steady state infiltration rate; k= Horton's decay constant specific to the soil, c = 0.6985 according to NRCS, *c* and *d* are Swartzendruber' sempirical constants, C_o = Soil's Transmitivity (cm^2/hr).

b) *Estimation of model parameters and model validation*

The averages of the cumulative infiltration depth 'I' and the cumulative infiltration time't' were used in the estimation of the models' parameters. Each model was first transformed into its linear equivalent in which 'I' and 't' are the dependent and independent variables, respectively, and the coefficients of the linear functions are the model parameters to be estimated, the physically based models and analytical models were also evaluated following standard procedures.

The values of the parameters estimated were then incorporated into the respective models and the capability of each model to simulate cumulative infiltration depth for each strip was evaluated by comparing the models simulated data with field-measured data. The field-measured data used for the comparison were those that were not previously used in determining the models parameters. The validation to check the closeness between the field-measured and model simulated cumulative infiltration depths were analyzed using the Root mean square error (RMSE) (Mahdian and Gallichand 1995), coefficient of determination (R^2) (Steel and Torrie 1960) and the Nash-Suctlife's (Nash and Sutcliffe 1970) statistical indices.

Table 3: The Average values cumulative infiltration for the entire strip

Time (min)	Strip A	Strip B	Strip C	Strip D	Strip E	Strip F
3	1.80	1.60	1.80	1.40	1.30	2.00
5	3.30	2.60	2.50	2.30	1.90	3.00
10	3.80	3.60	3.00	4.00	3.40	4.50
20	4.80	6.10	4.20	5.60	5.40	7.00
30	6.30	7.60	5.90	6.90	6.40	8.50
45	7.90	9.10	7.20	8.70	8.10	10.50
60	8.90	12.10	8.20	9.70	9.90	12.60
90	10.40	14.60	10.40	12.20	12.00	14.60
120	12.40	16.10	11.80	14.30	13.10	16.10
150	13.90	17.70	14.40	15.80	14.60	18.10
180	15.30	19.50	15.50	17.10	16.50	19.10
210	16.30	20.50	16.40	18.10	17.90	20.30
240	16.80	20.90	17.20	18.40	18.90	20.80

III. Results and Discussion

Tables4 and 5 below shows the models' simulated cumulative infiltration depth. The coefficients of determination (r^2) between the field-measured and model simulated data were very high (> 0.90) which implies that the ten models were able to simulate water infiltration in the study area adequately. The values of E (Nash-Sutcliffe's modeling efficiency) ranged from 7.145 to 0.978 for the entire study area, Kostiakov's model with the value of 0.978 gave the closest agreement between observed and predicted values while Horton and Swartzendruber's model showed the poorest agreement with values of -7.145and 0.623 respectively. The physically based models also showed good performance, and this shows their reliability in field application. To further check the discrepancies between the predicted and the measured values, Root Mean Square Error (RMSE) was used.

The result of the RMSE shows that Kostiakov and Modified Kostiakov's model had the least error in comparing the predicted values with field measured values followed by Philip's model The semi-empirical models which are Swartzendruber and Horton's model were poor in their prediction this may be due to the fact that their parameters lack a consistent physical interpretation and also the process involved in the evaluation of the parameters might be very sensitive to approximation errors and errors due to parallax while determining the initial and steady state infiltration rates from the graph as inputs for the prediction of cumulative infiltration. Philips model performed better than Kostiakov, this is contrary to the work by Igbadun and Idris (2007), who observed that classical Kostiakov (1932) model, fitted experimental data better than Philip (1957) model for a hydromorphic soil at Samaru, Nigeria.

The result of this study agrees with the findings of Al-Azawi (1985), who evaluated six infiltration models on a relatively homogenous, coarse-textured soil. He found that Philip's model gave a very good representation of the infiltration while Kostiakov, modified Kostiakov, Green-Ampt, and Holtan-Overton performed in that order respectively. Berndtsson (1987) studied the application of Infiltration Equation to a Catchment with Large Spatial Variability in Infiltration" compared two commonly used infiltration equations on a heavy calcareous clay soil. The result showed that the Horton equation displayed a slightly better fit to observed infiltration as compared with Philip's equation. Hsu *et al.,* (2002) evaluated three models (Horton, Philip and Green-Ampt) for three soil types to assess the models based on Richard's equation. Result demonstrated that all three equations provided similar fits to the numerical results, but the Horton model differed most as compared to the other two models in terms of infiltration rate.

For the purpose of this study empirical, semi-empirical and physically based models where used, Modified Kostiakov, Swartzendruber and Green-Ampt's model had best performance in their respective groups using the RMSE indices. Mbagwu (1993) recommended the modified Kostiakov equation for routine modeling of the infiltration process on soils with rapid water intake rates. The Kostiakov and modified Kostiakov equations tend to be the preferred models used for irrigation infiltration, probably because it is less restrictive as to the mode of water application than some other models.

Table 4: Estimated values for the model parameters

Model	Estimated Parameter
Kostiakov (1932)	k=9.303 a=0.530
Modified Kostiakov (1978)	k=9.992 a=0.627b= -0.54
Kostiakov-Lewis (1982)	k=3.435 a=0.119 fc= 4.58
Philip (1957)	S=8.731 A= 0.492
Natural resources conservation service (1989)	k=8.336a=0.6168 c=0.6985
Horton (1940)	k= -1.184 f_o = 35.0f_c= 4.5
Green-Ampt (1911)	k_s= 4.58 $\Delta\theta$ = 0.314 ψ= 101.57
Talsma-Parlange (1972)	K_s= 4.58 *S= 10.68*
Swartzendruber (1972)	*c= 0.758 d= 0.018* f_c *= 4.5*
Smith-Parlange (1978)	C_o*= 57.73*k_s*= 4.58*

Table 5: Observed and Model predicted cumulative infiltration

Time(hr)	Obs	KT	MK	KL	HT	PH	NRCS	GA	TP	SW	SP
0.05	1.57	1.90	2.02	1.91	1.92	1.98	2.01	2.18	2.42	0.39	1.75
0.08	2.40	2.49	2.50	1.87	3.15	2.56	2.50	2.86	3.13	0.59	2.27
0.17	3.97	3.60	3.44	2.02	6.04	3.65	3.46	4.14	4.46	1.06	3.26
0.33	6.00	5.20	4.90	2.58	11.14	5.21	4.93	6.00	6.37	1.94	4.70
0.50	7.27	6.44	6.10	3.25	15.46	6.42	6.14	7.50	7.87	2.78	5.85
0.75	9.10	7.99	7.64	4.30	20.77	7.93	7.68	9.36	9.72	4.03	7.29
1.00	10.73	9.30	9.00	5.39	25.02	9.22	9.04	10.96	11.32	5.25	8.56
1.50	12.93	11.53	11.39	7.60	31.31	11.43	11.40	13.80	14.05	7.67	10.76
2.00	14.50	13.43	13.49	9.84	35.80	13.33	13.48	16.27	16.41	10.06	12.71
2.50	16.17	15.12	15.40	12.09	39.28	15.03	15.37	18.54	18.53	12.43	14.49
3.00	17.57	16.65	17.17	14.36	42.22	16.60	17.11	20.64	20.49	14.79	16.15
3.50	18.77	18.07	18.84	16.62	44.85	18.05	18.75	22.64	22.32	17.14	17.73
4.00	19.37	19.39	20.42	18.89	47.31	19.43	20.29	24.55	24.05	19.49	19.24
	R^2	0.993	0.983	0.905	0.917	0.991	0.984	0.986	0.990	0.931	0.985
	RMSE	0.894	1.017	3.568	17.172	0.946	0.995	2.177	2.079	3.693	1.416
	E	0.978	0.971	0.648	-7.145	0.975	0.973	0.869	0.881	0.623	0.945

IV. Conclusions

The parameters and prediction accuracy of ten infiltration models was carefully studied, among the ten infiltration models studied, Modified Kostiakov model and Philip's model performed better in their ability to predict cumulative infiltration, although the other models provided good overall agreement with the field measured cumulative infiltration depths and are therefore capable of simulating infiltration under the field conditions in this study, Horton's model performed well initially at 20 minutes after the test began, however it over-predicted cumulative infiltration after this time. Consequently, the application of these equations under verified field conditions leads to the determination of the appropriate infiltration characteristics for the equations that would optimize infiltration simulation, irrigation performance and minimize water wastage.

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN:0975-5861

"Diverse Washing Consequence on Denim Fabric and its Physical & Mechanical Characteristics Analysis"

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Abstract- This is a study on different type of washing on denim fabric and its physical & mechanical characteristics. A series of experiments and investigations help us to determine the properties of Denim fabric, effects of different washing parameters on denim fabric. The textile technologist needs to know the prediction of the aspect of a finished denim look, physical & mechanical properties after different wash with the reality.

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GJRE-J Classification: FOR Code: 091599

DIVERSEWASHINGCONSEQUENCEONDENIMFABRICANDITSPHYSICALANDMECHANICALCHARACTERISTICSANALYSIS

Strictly as per the compliance and regulations of :

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I. Introduction

Denim is very strong, stiff and hard wearing woven fabric. Denim is cotton and twill weave fabric that uses colored warp and grey weft yarn. Denim is normally dyed with indigo, vat and sulphur dyes. Since denim constitutes the largest portion of the garments that are washed, the term 'wash' has come to mean the finishing of denim garments.

The most commonly denim washing methods are enzyme wash, bleach wash, acid wash, normal wash, stone wash, etc. Among the washing methods, bleach method is widely used method in industry especially for denim washing to achieve required color shade by hypochlorite bleaching. Denim Bleach is a process that can be used to decolorize indigo from denim. In this process a strong oxidative bleaching agent such as sodium hypochlorite or $KMnO_4$ is added during the washing with or without stone addition. Discoloration produced is usually more apparent depending on strength of the bleach liquor quantity, temperature and treatment time. It is preferable to have strong bleach with short treatment time. Care should be taken for the bleached goods so that after washed with peroxide to minimize yellowing. [1]

Bleaching agents essentially destroy chromophores (thereby removing the color), via the oxidation or reduction of these absorbing groups. Thus, bleaches can be classified as either oxidizing agents or reducing agents. [4]Bleaching process is difficult to control i.e. difficult to reach the same level of bleaching in repeated runs. When desired level of bleaching reached the time span available to stop the bleaching is very narrow. Due to harshness of chemical, it may cause damage to cellulose resulting in severe strength losses and/or breaks or pinholes at the seam, pocket, etc. [2]

Enzyme washing is a laundering process that uses enzymes to clean clothing or to finish fabric, especially in the case of denim and other garments with a worn-in look. Various enzymatic cleaners are available from stores that specialize in laundry supplies, and they can also be special ordered. For regular cleaning, enzymes carry many economic and environmental benefits. On an industrial scale, it has replaced laborious laundering techniques such as stonewashing, saving money and environmental impact for companies. The enzymes used in this technique are proteins produced by living organisms. [3]

'GSM' means 'Gram per square meter' that is the weight of fabric in gram per one square meter. By this we can compare the fabrics in unit area which is heavier and which is lighter. [4]

Stiffness is a special property of fabric. It is the tendency of fabric to keep standing without any support. It is a key factor in the study of handle and drape of fabric. Stiffness is the rigidity of an object — the extent to which it resists deformation in response to an applied force. [5] The fabric bending property is apparently a function of the bending property of its constituent yarns. In other words, it reflects the difficulty with which a fabric can be deformed by bending. The higher the bending rigidity, the higher the fabric ability to resist when it is bent by an external force. In addition, the effect of density and fabric thickness are also very profound for this property. [6]

Color fastness refers to the resistance of color to fade or bleed of a dyed or printed textile materials to various types of influences e.g. water, light, rubbing, washing, perspiration etc.[7]The chemical nature of the fiber, for example, cellulosic fibers dyed with reactive or vat dyes will show good fastness properties. That is to say compatibility of dye with the fiber is very important. If the dye molecule is larger in size, it will be tightly

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entrapped inside the inter-polymer chain space of a fiber. Thus the fastness will be better. The manner in which the dye is bonded to the fiber or the physical form present. The amount of dye present in the fiber i.e. depth of shade. A deep shade will be less fast than a pale or light shade. [7]Rubbing Fastness depends on:

i. Nature of the Color
ii. Depth of the Shade
iii. Construction of the Fabric.[8]

In simpler terms tear resistance or tear strength is a measure of how well a material can withstand the effects of tearing. Tear strength is the tensile force required to rupture a pre-slit woven fabric sample under controlled conditions. Materials with low tear resistance tend to have poor resistance to abrasion and when damaged will quickly fail. [9]

II. Material and Methodology

100% cotton indigo dyed 380 GSM denim fabrics were washed through desizing using detergent and desizing agent. Then desized denim fabrics were processed using non chlorine & chlorine (KCl) bleach in bleach process & enzyme were used in enzymatic process. The physical and mechanical properties of treated denim were examined using testing equipment.

Table 1: Desizing recipe for all the operation

1.	M:L	1:10	2.	Water	100 L
3.	Detergent (ID eco)	60 gm	4.	Soda Ash (HTS)	100 gm
5.	Temperature	60˚ C	6.	Time	15 min
7.	Rinse	2 times			

Table 2: Washing recipe and finishing parameter

Recipe	Operation 1 (Light Enzyme)	Operation 2 (Heavy enzyme)	Operation 3 (Light bleach)	Operation 4 (Heavy bleach)	Operation 5 (Chlorine light bleach)	Operation6 (Chlorine heavy bleach)
M:L	1:10	1:10	1:10	1:10	1:10	1:10
Water	50 L	50 L	50 L	50 L	50 L	50 L
Cellulose enzyme Liquid Enzyme (Lacase)	50 gm	100 gm	-	-	-	-
Bleach (KCl/ Japan powder)	-	-	25 gm	150 gm	KCL 25 gm	KCL 150 gm
Sequestering agent (LP30)	100 gm	100 gm	-	-	-	-
Washing Time	50 min	50 min	25 min	25 min	25 min	25 min
Wash Temperature	30° c	30° c	50°c	50°c	50°c	50°c
Rinse	2 times	2 times	2 times	2 times	2 times	2 times
Neutralizing (H_2O_2)(Hypo)(china)	-	-	50°c , 15 min	50°c , 15 min	50°c , 15 min	50°c , 15 min
Hydro-extracting	1.5~2 min	1.5~2 min	1.5~2 min	1.5~2 min	1.5~2 min	1.5~2 min
Drying type	Gas dryer	Gas dryer	Gas dryer	Gas dryer	Gas dryer	Gas dryer
Drying time	30~40 min	30~40 min	30~40 min	30~40 min	30~40 min	30~40 min
Drying temperature	80°c	80°c	80°c	80°c	80°c	80°c

a) *Testing and Analysis*

Washed denim fabrics were conditioned in 65% RH and 20°C for 24 h before testing.

- GSM was calculated from raw and different washed fabric by using GSM cutter.
- Stiffness was measured from the bending rigidity in fabric by Shirley stiffness tester.
- Change in the original color shade of the fabric was rated using gray scale for color change.
- Tearing strength was determined by GESTER GT-C10 tear tester.
- Dimensional changes (shrinkage %) was calculated from the difference in fabric length and width before and after washed.

III. Result and Discussion

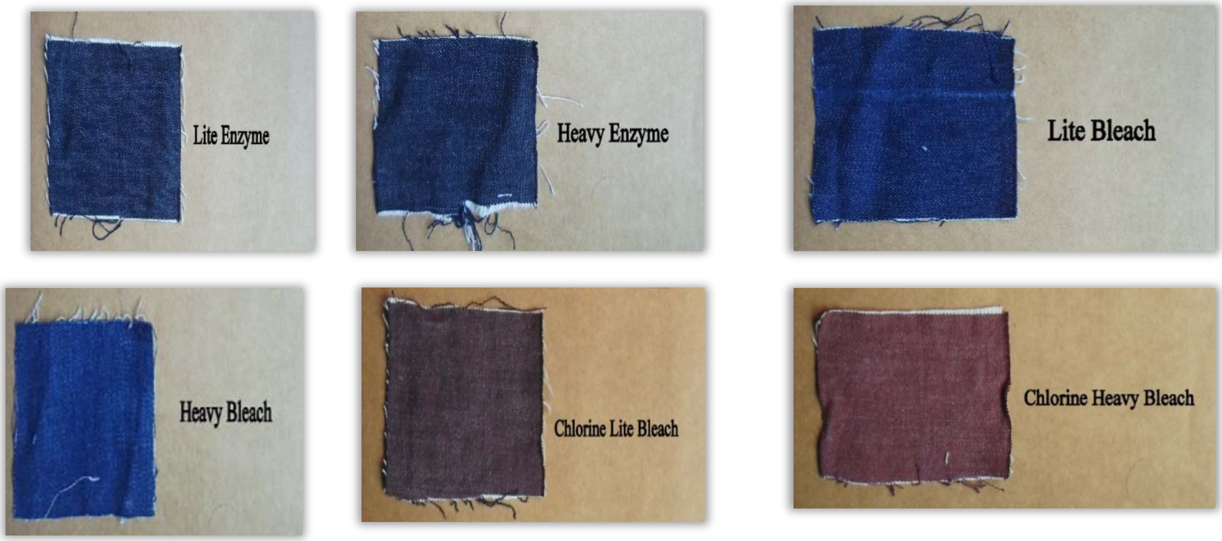


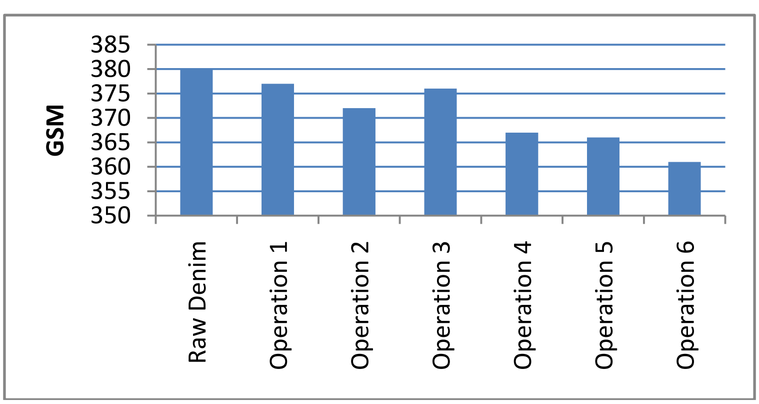
Figure 1: Specimen image of different washed fabric

The physical and mechanical properties of denim fabrics treated at different cellulose concentrations were measured and the results are summarized in Table 3.

Table 3: Experimental data of special properties of denim fabric at different wash

Operations	GSM	Stiffness	Color fastness		Tearing Strength		Dimensional Change %	
			Dry	Wet	Warp wise Strength	Weft wise Strength	Length	Width
Raw Denim	380	3.7	5	4	62.5	62.0	0	0
Operation 1: Light Enzyme	377	3.3	4	3	62.0	58.0	-6.0	0
Operation 2: Heavy Enzyme	372	3.2	4	2/3	60.0	58.0	-6.2	+1.0
Operation 3: Light Bleach	376	2.8	4	3/4	61.5	52.5	-5.25	0
Operation 4: Heavy Bleach	367	3.4	4	3	60.0	52.0	-6.44	+0.5
Operation 5: Chlorine Light Bleach	366	3.0	5	4	62.0	57.5	-6.0	+0.75
Operation 6: Chlorine Heavy Bleach	361	2.6	4	4	61.5	56.0	-6.3	+1.0

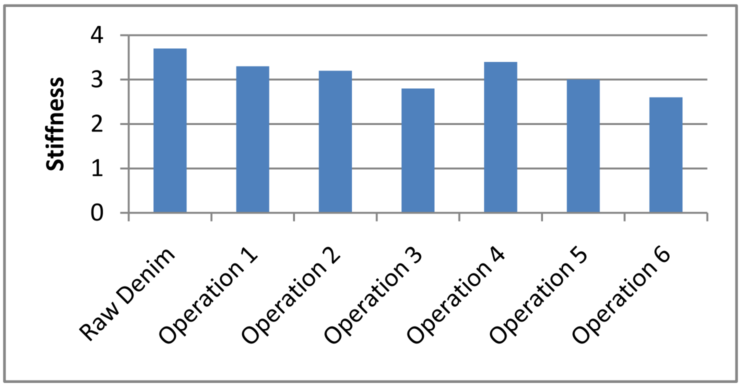
a. *Effect of different wash on Fabric GSM*



Graph 1: Effect of different wash on fabric GSM

From the Table:3 the value indicate, the light wash of enzyme, non-chlorine & chlorine bleaches decrease the weight slightly and the heavy wash of that enzyme, non-chlorine & chlorine bleaches decrease the weight so high. Higher the concentration with time, higher loss of weight. The weight of the fabric loss gradually from enzyme washes to non-chlorine bleaches then chlorine bleaches.

b. *Effect of different wash on fabric stiffness*



Graph 2: Effect of different wash on fabric stiffness

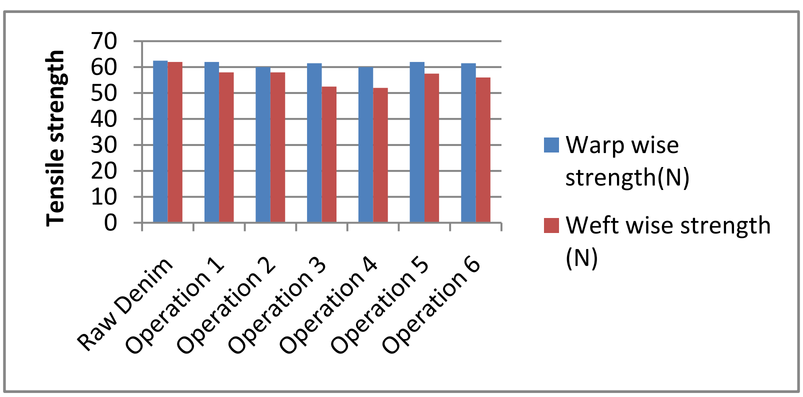
From the Table:3 the value indicate that the light wash of enzyme, non-chlorine & chlorine bleaches decrease the stiffness low and the heavy wash of that enzyme, non-chlorine & chlorine bleaches decrease stiffness high. The stiffness of the fabric reduces gradually from enzyme wash to non-chlorine bleaches then chlorine bleaches.

c. *Effect of different wash on fabric colorfastness*

We also observe that, the non-chlorine bleach is reacting with cotton denim fabric not with the Indigo dye. But in chlorine bleach, it reacts with cotton & indigo both and fully discolors the indigo. Create a new reddish shade on fabric as showed in figure: 1.

Denim fabric colors fading are monitored. In colorfastness, the denim act different fastness in various processes. The fastness is normally depending on indigo dyes. But we can get the different result from our test that shows in the Table: 3.

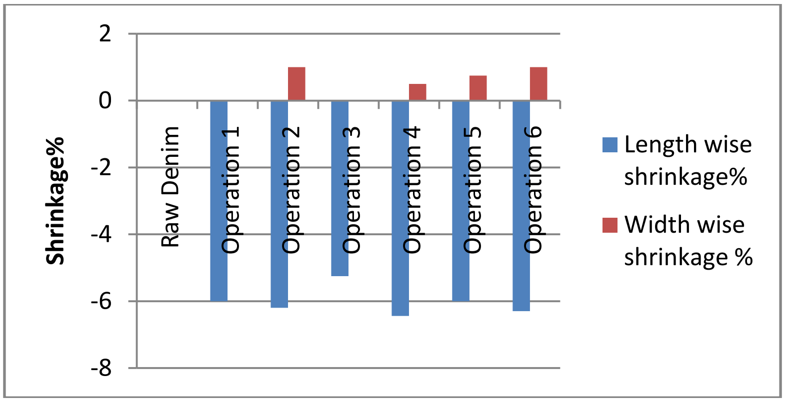
d. *Effect of different wash on fabric tearing strength*



Graph 3: Effect of different wash on fabric tearing strength

According of Table:3 it can be said that the fabric tearing strength fall after enzymatic wash. Enzyme eat the cotton wall gradually and higher the concentration higher the strength loss. Bleach wash also do the same. But bleach are more effective than enzyme as it cause of chemical reaction that break the polymer bond rapidly. The bleach effect on fabric depend on bleaching concentration with time. By increase of hardness and time, the fabric loses its physical stability. So it loose strength and become soft.

e. *Effect of different wash on fabric dimensional change (shrinkage %)*



Graph 4: Effect of different wash on fabric dimensional change

It is observed from table that fabric is dimensionally decreased much more at length wise (warp direction) for all the operation and in some cases slightly increase at width wise (weft direction). During weaving cotton denim fabrics were subjected to considerable tensions, particularly in the warp direction. In subsequent finishing processes such as calendaring this stretch was increased and temporarily set in the fabric. The fabric is then in a state of dimensional instability. Subsequently when the denim garment was thoroughly wetted in enzymatic or bleach washing, it tended to revert its more stable dimensions which results in the contraction of the yarns. This effect is usually greater in the warp direction than in the weft direction. This is known as relaxation shrinkage. Due to relaxation shrinkage, PPI (picks per inch) was increased than untreated denim fabrics, as a result fabric weight loss is slightly minimized. Although decomposition occurred in hypochlorite bleach washing, at the same time relaxation shrinkage happened, and the GSM fabric weight loss of denim garments were minimized slightly.

IV. Conclusion

In this project work we study about the different washing effect on physical & mechanical properties on the denim fabric. It can be seen that, treatment of denim fabric significantly decrease in GSM, tensile strength and this decrease was higher at higher in bleach process from enzymatic washing process. During washing, cellulose hydrolyzed cotton. First, it attacked on projecting fibers (micro-fibrils) on surface, then attacked on yarn portion, hydrolyzed them slowly and upon time penetrated inside the fabric. The result of this reaction is that the primary wall (outer layer) of the cotton fiber is loosened and broken down quicker with the frictional action (mechanical forces) of rotating cylinder of the washing machine. This effect also depends on the washing conditions. Hydrolysis of cellulose would certainly affect fabric properties, namely GSM of fabric, tensile strength, stiffness, colorfastness, dimensional change (Shrinkage%) etc. characteristics.

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN:0975-5861

Supply Chain Integration for Improving Performance on Manufacturing Industries

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Abstract- Rising global competition and the increasing costs of natural resources today as well as customers demands for higher manufactured goods quality, better product selection, and improved customer service have created new challenges for manufacturing industries. Even though research has suggested that supply chain management and supply chain integration are distinct potential, little is known about their performance effects and about the contextual conditions under which they are effective. Based on a literature survey and expert analysis of manufacturing firms, we empirically investigate the effects of supply chain integration on quality performance using Analytical hierarchical Open Decision maker analysis. We argue our study in the dynamic capabilities view and contingency theory. We investigate that supply chain integration positively affect quality performance. our result indicates that knowledge, technology, production &design and resource integration directly related and impact on quality performance for manufacturing companies.

Keywords: quality performance; supply chain integration; supply chain variables, manufacturing industry; ethiopia.

GJRE-J Classification: FOR Code: 091599

SUPPLYCHAININTEGRATIONFORIMPROVINGPERFORMANCEONMANUFACTURINGINDUSTRIES

Strictly as per the compliance and regulations of :

Supply Chain Integration for Improving Performance on Manufacturing Industries

Alie Wube Dametew [α], Frank Ebinger [σ] & Birhanu Beshah Abebe [ρ]

Abstract- Rising global competition and the increasing costs of natural resources today as well as customers demands for higher manufactured goods quality, better product selection, and improved customer service have created new challenges for manufacturing industries. Even though research has suggested that supply chain management and supply chain integration are distinct potential, little is known about their performance effects and about the contextual conditions under which they are effective. Based on a literature survey and expert analysis of manufacturing firms, we empirically investigate the effects of supply chain integration on quality performance using Analytical hierarchical Open Decision maker analysis. We argue our study in the dynamic capabilities view and contingency theory. We investigate that supply chain integration positively affect quality performance. our result indicates that knowledge, technology, production &design and resource integration directly related and impact on quality performance for manufacturing companies. Supply chain integration has also positively linkage on Production ,knowledge, Technology and Resource integration so as to improve quality performance in a supply chain. Although previous research usually investigated a positive relationship linking supply chain integration and supply chain performance, our findings also confirmed a vital role of supply chain integration in enhancing supply chain performance on firms. Even though our findings have important implications for researchers and managers, we recognize that the present study has certain limitations. we study the effects of knowledge, technology, production &design and resource integration as the independent variables to impact quality performance, but other variables such as integrated topology, information system might help to explain causal variation in supply chain quality performance.

Keywords: quality performance; supply chain integration; supply chain variables, manufacturing industry; ethiopia.

I. Introduction

Rising global competition and the increasing costs of natural resources today as well as customers demands for higher product quality, greater product selection, and better customer service have created new challenges for manufacturing industries. Companies today are increasingly dealing with supplier and customer local and from all corners of the globe. In the recent competitive market, producing value-added, high quality and innovative products have come out as the fundamental tactic for manufacturing companies to stay alive. Manufacturing industries in different nations have take on numerous performance improvement programs and developed new operating viewpoint to enhance the way they operate to stay competitive Agus (2015). However, among those improvement programs, supply chain integration has become an integral part of corporate strategy and its adoption in manufacturing companies has steadily accelerated since the 1980s.Although, effective supply chain management and supply chain (SC) integration are becoming increasingly critical factors for business success Wang & Cassivi (2006), Georgise *et al* (2014). Moreover, Supply chain integration can be defined as the degree to which a firm can strategically work together with its supply chain partners and cooperatively manage intra- and inter-organizational processes to achieve effective and efficient flows of products, services, information, money, and decisions to provide the maximum value to the final customer with low costs and high speed Huo(2012). Science, supply chain integration provided evidence of their potential joint positive impact on competitiveness and firm performance DeWitt (2006). Supply chain Scholars shows the importance of Supply Chain practice to firms' their competitive strategies and advantage as well as can improve organization performance Lambert and Cooper (2000), Birhanu (2014), Pathak (2015) Rao (2015). According to Bekele (2008), Gebreeyesus & Sonob (2011), Sarmiento & Nagi (2012), Georgise *et al* (2014) states that, the performance of an organization is influenced to a greater or lesser degree by the actions of the organizations that integrate the inputs and the supply chain at large extents. Even though, the impact of supply chain integration practices vary, depending on the type of firm trick and there are no commonly accepted concepts the impact of supply chain integration on performance. In addition, there is very little empirical evidence as how different supply chain integration influence various types of company performance. For example, Koufteros *et al* (2007), studies elaborate the sole roles of supplier integration or customer integration in improving performance. Some recent studies also consider both internal and external

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integration impact to performance, Swink *et al* (2007), Flynn *et al* (2010). Moreover, Huo (2012) supply chain research supply chain integration can be viewed as internal and external integrative capabilities that lead directly or indirectly to company performance. Even though, most of the previous studies that address the relationship between supply chain integration and performance but no researches are conducted which components of supply chain integration highly impact on performance. There is a pay little attention to scholarly work focusing on explicitly the impact of various dimensions of supply chain relationships (such as knowledge, production & design, technology and resource) on performance, rather the general supply chain integrations(internal and external integrations) impacts. A key question is whether the implementation of supply chain integration (such as knowledge, production & design, technology and resource) can make an impact on company quality performance? This paper intends to filling this gap by using data collects from literature review on significant value in supply chin integration and practices is apply.

In addition, the previous research work on supply chain shows that, the significance role of manufacturing industries to improve their efficiency and Competitive advantage Fabbe-Costes *et al* (2008), Wang (2010), Alfalla-Luque *et al* (2013), Otchere *et al* (2013).The strategic supply chain integrating with suppliers to customer implies to improved operations and overall performances of the firms Kim (2009), Flynn *et al* (2009). Despite these efforts, in the East Africa basic metal industries has not yet made their share of markets and their contribution still low. Meanwhile, the basic metal industries of developing countries doesn't get enough attention and are not studied well and seems to be isolated from global literature Georgise *et al* (2014), Msimangira & Tesha (2014). Few studies describe and show that the Ethiopian manufacturing industries including basic metal industries have various challenges and obstacles hamper their productivity, performance and competitiveness Dagne Birhanu (2009), Tolossa *et al* (2013), Georgise et al (2014). But up to now there is no effort to investigate the effect of supply chain integration on basic metal industry to impact quality performance of basic metal industries in the country. Consequently, this study addresses impact of quality performance improvements through supply chain integration in manufacturing industries. This factors that influence quality performance include knowledge, technology, resource utilization, production and design integration are considered. However, the study analyzes those significant achievement factors of quality performance related to supply chain integration (SCI). In the next section, we will review related literature and develop hypotheses by proposing a conceptual model, ahead of describing the methodology and presenting the results of analysis. We provide a discussion of the findings and managerial implications. Finally, we present the conclusions, limitations, and suggestions for future research.

II. Research Material and Methods

To test these hypotheses empirically we apply AHN (Open Decision maker). The Open Decision Makes enables you to find the best alternative for a defined goal with the AHP (Analytic Hierarchy Process) method. following the methodology successfully used in previous papers Alfalla-Luque *et al*(2012), Maleki *et al* (2013), we adopt a literature survey as the strategy for collecting data, and to identify valid measures, and then adapted existing scales to measure supply chain integration and company performance is analyze. In order to achieve the objective, we use online databases and library services such as Taylor & Francis (www.tandfonline.com), Emerald (www.emeraldinsight.com), ELSEVIER (www.elsevier.co), www. sciencedirect.com and other related sources, journal articles, reports, policies, standards and manuals were obtained from these selected databases. A search of articles published between 2000 and 2016 identify with the key words including Supply chain, integration, Quality, Performance, Global Supply chain, Basic metal, performance measurement and logistics are used for searching and screening. Depending on the significance of the material, through abstract and keyword screening operation are make and the collected data are further reduce. The screening and reducing materials also again brought down to the most important data considering recent publications, reading methodology and result of the papers. From total of 125 articles 13 articles are selected and use for the analysis. Finally, it has been filter out to for this literature purpose write up. It is difficult to include all documents that made contribution to the field. At last, 13 articles were collected as the samples area. The objective is to focus on how supply chain integration impact on performance of manufacturing industries, to see current state of the art of the researches peak and to identify the gaps from previously conducted researches. The gaps that exist can be filled by the overall research works considering further research areas.

III. Literature Review

a) *Supply chain integration*

A enormous deal of research has been done on the importance of integrating suppliers, manufacturers, distributors, retailers, and customers Huo (2012), Rehme, (2012), Hatani *et al*(2013), Rakhman *et al* (2016). Even though, the supply chain integration is relatively new as an area of research, although there is an extensive body of research on uni-dimensional supply chain relationships, examining collaborative relationships between a manufacturer and either its customers or suppliers Flynn *et al*(2009). supply chain integration continues to be a key theme amongst those seeking to understand how to harness the potential of the supply chain to create sustainable value. Kannan & Tan(2010) supply chain integration is the strategic integration of both intra- and inter-organizational processes and gauges the extent to which supply chain partners work collaboratively together to gain reciprocally beneficial outcomes. Supply chain integration means the co-operation between various functions in the supply chain. The degree to which an organization strategically collaborates with its partners and manages intra and inter-organizational processes in order to achieve efficient and effective flows of products, services, information, money and decisions Halme (2010). An effective and efficient supply chain integration achieves the well defined flows of products and services, information, money and decisions, to provide maximum value to the customer at low cost and high speed Flynn *et al* (2009). Integration can be characterized by cooperation, collaboration, information sharing, trust, partnerships, shared technology, and a fundamental shift away from managing individual functional processes, to managing integrated chains of processes Power (2005, Krishnapriya (2014). Supply chain member organizations integrate in to three dimensions customer, supplier and internal integration. This dimensions are considered as independent variables of supply chain integrations on manufacturing industries Flynn.*et.al* (2009), Otchere.*et.al* (2013). Furthermore, Study describes as, Successful coordination and integration of supply chains for all the activities associated with moving goods from the raw materials stage through to the end user for sustainable competitive advantage Lambert and Cooper (2000). World-class organizations now realize that non-integrated manufacturing processes, non-integrated distribution processes and poor relationships with suppliers and customers are inadequate for their success. the success coordination, integration management of key business across the member of supply chain will determine the ultimate success of the single industry Vorst (2000). Different supply chain integration level and various dimension of supply chain integrations are essential to ensure enhanced significance in supply chains. In most modern systems, the wisdom is it's better to do what you do best and own a very limited asset. Nearly everything is outsourced but the brand and distribution process integration with supply chain partners Ray (2013). However, in the developing Country manufacturing industry, supply integration still infant. According to Getahun (2012) investigates that, lack of supply integration and customer integration within the garment industry, have the potential to affect the quality and competitive advantage of the sector. Negussie (2014) supply chain evaluation study shows that developing nation leather industries are suffering from the shortage of raw material (hides and skins) as well as its quality problem. Companies in developing countries need to integrate their operations, especially the sourcing processes into the global supply chain Georgise (2014), Msimangira (2014) and some sectors are fragmental and infant integration including basic metal industries Xiong & Helo (2008). Hence it is an important issue, to study and implement supply chain strategy for developing nation manufacturing industries. However, we intended to study and implement integrated supply chains systems for basic metal industries, order to bring the improvement of basic metal industry performance. the study investigate the relation between supply chain integration and quality performance with associated resource, knowledge, technology , production &design is address.

b) Quality

Although there are several definitions of quality, simply put, quality can be defined as meeting or exceeding customer expectations Evans & Lindsay (2002). When we buy something we know almost without thinking about it whether it has a high quality or not. Producing items of the highest possible quality has become more and more important over recent years due to ever increasing competition between the companies who manufacture the items and the ever increasing demands of the consumer for better quality items that perform better and last longer. Therefore the pursuit of quality has developed into a science among manufacturing companies and much time and effort is spent in this area. Quality can be a confusing concept as it has different meanings to different people depending on whether they are the producers of a product or the users of it. Various definitions are available by quality gurus such as Deming, Crosby, Juran, Feigenbaum and Ishikawa. dictionary definitions of quality have their core terms like "degree of excellence", "relative nature", or "kind or character", and usually go on to equate quality with high rank or greater standing Patel (1994). Currently, an increasing number of product recalls are occurring. Such product recall incidents have resulted in serious customer dissatisfaction and significant company losses in both image and business. Because of this, quality is a critical requirement for customers, especially in the case of expensive and complex products. According to Lee (2013) states that, to ensure product quality collaboratively becomes a vital task for the companies along the supply chain. However, in its most general connotation, therefore, quality is seen as being value oriented. Quality is not absolute, it is always expressed as a relative term, take as example A is of better quality than B. Quality means different things to different people but a broad definition in relation to local government social services reads: Quality is the totality of features or characteristics of a service that bear on its ability to satisfy a given need.

This clearly indicates that quality is also judged on the customer's perception of how a service met their needs. However, there are a number of definitions that are generally accepted and used. Hence quality can be variously thought of as:

1) *Product Conformance specification* - Conformance quality is the degree to which a product's design and operating characteristics meet established standards. It reflects whether the various produced units are identically made and meet the specifications. Philip Crosby consider that, Conformance to requirements or specification and reliability as a test of quality, once a specification is established, quality can be said to be a matter of ensuring conformance to specification. It sets a level which is considered to be good enough and it results in an emphasis on inspection Birhanu Beshah&Dr.-Ing. Daniel Kitaw (2011), Board and Meyer-Ter-Vehn (2013).it is the capacity and process ability of the objects produces within the given specifications to full fill given the expectations.
2) *Product Performance*- Performance quality is the primary product characteristics. Performance quality refers to the levels at which the products primary characteristics operate. Buyers will pay more for better performance as long as the higher price does not exceed the higher perceived value. David A. Garvain categorized as Product Performance involves the various operating characteristics of the product. For a television set, for example, these characteristics will be the quality of the picture, sound and longevity of the picture tube and for an automobile, performance would include traits like acceleration handling, cruising speed, and comfort. In service businesses say, fast food and airlines performance often means prompt service Harvard Business Review (1987), No. 87603, Levine & Toffel (2010). Hence we argue that, quality performance is, the measurement of product on its capability operate within the intended requirements to meet the primary expectations and purposes.
3) *Product Reliability (RELIAB)*- Reliability is a measure of the probability that a product will not malfunction or will operate properly within a specified time period or the consistency of performance over time during which it is subjected to a given set of environment and or mechanical reliability. According to Joseph Juran has two definitions for quality, freedom from deficiencies and fitness for use, which is a utility value concept, which varies from one customer to another. His concept of fitness for use reflects meeting customer needs and is based on the following quality characteristics like, Technological (strength),Psychological (beauty),Time-oriented (reliability), Contractual (guarantee Ethical (sales staff courtesy).He emphasized that the improvement of product or services and processes applies to all customers, internal and external. U.S.A. Department of Defense also define quality as, it is doing the right thing right the first time, always striving for improvement, and always satisfying the customers. In several case, the meaning of quality in fact, remains a term that is easily misunderstood. Some used the term to refer luxury and merit and some others to mean excellence and value. The term is also being used to qualify a quality product as superior in all aspects to others in its class. Hence, quality is based up on customer actual experience with the product or service, measured against his requirements. Quality is meeting customer requirements and this has been expressed in many ways by the quality experts in the field, Deming says that, quality should be aimed at the needs of customer, present and future". A comprehensive definition of quality is that product or service which fulfils an aggregate requirement of customers, in all aspects, at present and in the future and which customers can buy it. consequently the closer this conformation indicates the higher the degree of quality.

c) The effect of Supply chain integration on Quality Performance

Alfalla-Luqu *et.al* (2013), Annan *et al* (2013) literature review analyses shows that, how supply chain integration affects the overall supply chain performance in terms of efficiency and responsiveness. Even though Boyer (1999), Huo *et al* (2012) investigates, financial performance used as a key output measure of firm performance. In addition, other scholars use different performance measurements such as, Aishah et al(2013) used Long run competitiveness and Huo *et al* (2013) financial performance and operational performances us as output measures. on the other hand for example Huo *et al* (2013) to study the effect by using internal integration, process integration as indirect variables and in their study they use. when we say internal integration there are numerous components of internal integration, which one is likely related to financial performance? we should exactly tackle and show the exact effect integration components but their study is general. it needs for further investigations by using different indirect variables of Supply chain integration like knowledge, production and design, technology, so as to decide where finance or operational performances us as key performance measures?.on the other hand the previous studies have locate the limitations in relying using on financial performance measures in supply chain studies Johnson and Kaplan (1987). For example, numerical performance measures used as simple qualitative evaluations may not sufficiently illustrate firm performance. As a result, in this study, we take on quality performance to measure the benefits of supply chain integration. Supply chain integration can help companies to understand the requirements of customers, to work with customers in joint product design, manufacturing process, information exchange, and strategic accomplishment. For example, Tan (2001), Flynn *et al* (2010) found that internal integration could create a close link between manufacturing and distribution processes to deliver products and services in a timely and effective manner.

Global Journal of Researches in Engineering (J) Volume XVI Issue IV Version I Year 2016

Competent external integration allows manufacturers to speed up product delivery processes, improve production planning and reduce inventory obsolescence using accurate information shearing about customer demands and preferences Swink *et al*, (2007), Flynn *et al* (2010). additionally, process integration facilitate manufacturers reduce error and enhance product quality through information sharing and joint planning, which are directly related to the manufacturers' operational performance ,Petersen *et al* (2005), Huo *et al* (2013),Chi *et al* (2013). Research and development integration has a positive impact both on business performance and social performance, and that business performance serves as a mediator in the relationship between the integration of R&D-marketing and social performance Xu *et al* (2014).Hence without the cooperation of various functions, it is difficult for companies to collaborate with and meet the requirements of customers in a dynamic business environment. Thus, we propose our first set of hypotheses:

H1a: The level of Supply chain integration is positively impact with quality performance.

Few previous studies have investigated the impact of supply chain integration on the dimension of supply chains. We argue that the integration and cooperation between production process, knowledge, technology between internal& external firm, can facilitate the overall performance of the organizations. as a result, we propose:

H1b: Supply chain integration has an positively related on Production ,knowledge, Technology and Resource integration in the supply chain on quality performance.

Supply chain integration plays an important role in the enhancement of quality performance. However, Supply chain integration enhances suppliers' understanding of the needs of the company, especially regarding the quality standards of raw materials, production and components. In addition, supply chain integration can improve information shearing, partnerships, joint planning, and product design with suppliers. Even though, According to Aishah *et al* (2013) supply chain integration directly impacted by different factors towards the performance of supply chain integration on the long term competitiveness and sustainable economic growth. However, very limited studies had been conducted on the effects of supply chain integration components in order to achieve long-term and sustainable economic growth. we propose the following hypothesis

H1c: Supply chain integration, through knowledge, Production, Technology and Resource integration, has an impact on quality performance of manufacturing industry.

Production integration with other functional areas and suppliers is a key aspect for achieving sustainable competitive advantage. Paiva *et al* (2011) analyze and found that the impact of manufacturing integration on performance. They found that production integration aspects are positively related to sales growth, but only manufacturing-R & D integration is positively related to profitability. Lin *et al* (2012) characterize the effect of vertical integration on profitability, product price, and quality in a competitive setting. Thus is no clear findings that shows the significant association between manufacturing integration and quality performance improvement. The diverse findings in the above studies the need for further investigation of the relationship between production integration with impact of on quality performance. as a result we propose

H2a. Production & Design integration is positively related quality performance on a supply chain.

In knowledge-based environments, necessity to develop a systematic approach to integrating knowledge resources throughout the industry in order to improve quality. The firm which is enhance the quality performance is comprises of accomplishing quality objectives in a convenient way and fortifying connections both inside and outside the boundaries of the firm Gardner *et al*(2011). integrating the firm into the knowledge features will abbreviate the correspondence chains between different departments.

The implementation of knowledge integration is an important factor for the firms in order to compete in the quality performance. Overall improvement in knowledge integration across the supply chain directly impact performance of supply chain. for establishing system-wide Knowles integration among supply chains will improve resource utilization, productivity growth, quality, delivery and flexibility of the supply chain. However, the tasks of knowledge integration is might differ from firm to firm and industry to industry. our hypotheses capture these relationships by proposing that knowledge integration in a supply chain is a function of the extent of knowledge integration with impacts on quality performance within a firm. thus we propose

H2b: The knowledge integration positively impact and will improve quality performance.

We believe that a higher level of technological exchange and sharing is increase communication between manufacturer, suppliers and Customers, improve production capability and improves performance of supply chain. A higher level of untreated linkage between internal and external supply chain firms through an recognized technology improves the company, trust and relationship, thus improving the overall performance of supply chain. though we propose, this hypothesis

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H2c: Technology integration positively impact quality performance.

Resources is viewed as the major organization driver in the global competitiveness. the quality and availability of resource an organization determines the success potential. integration and linkages facilitates product development, manufacturing, utilization and delivery efforts, which in turn has implications for quality, increased responsiveness to market changes, and the reduction of defects from the supply chain. This in turn will have implications for broader measures of quality and overall performance. we explore to hypotheses:

H2d: Resource integration directly related to quality performance

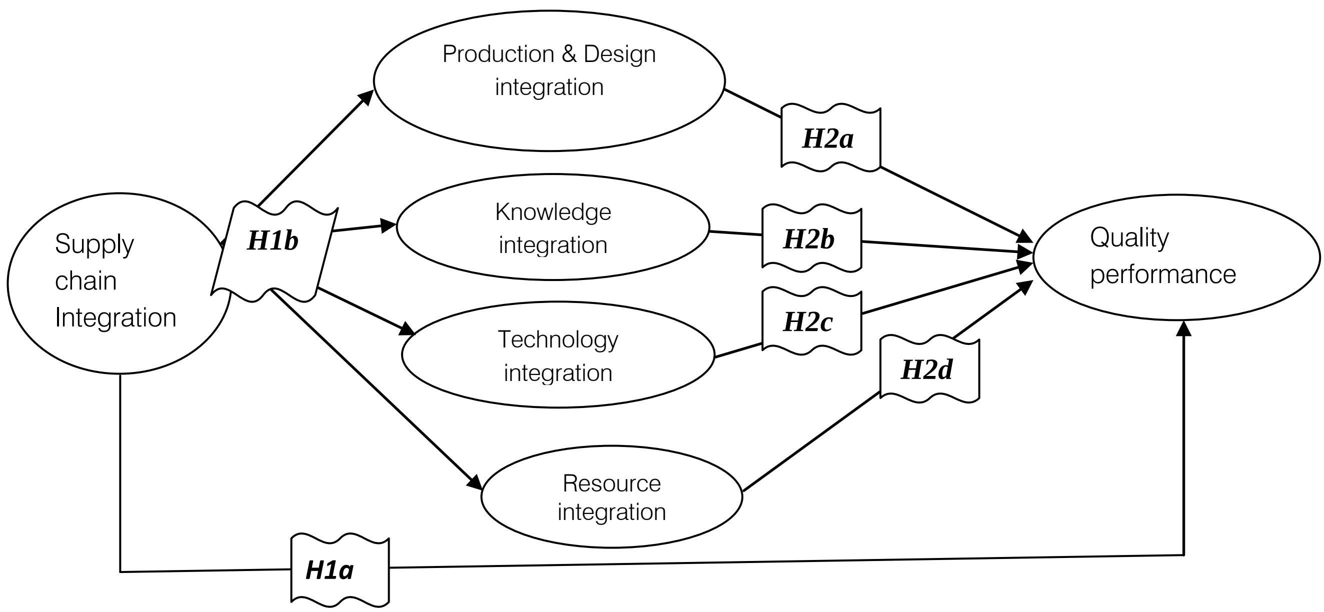

Figure 1: Conceptual Framework Research

Table 1

Authors& years (Ref.no)	Integration types	Performance measures	Methodology	Major findings
Beheshti *et al* (2014)	Internal integration and external (Supplier, Customer)integration	Financial performance	survey instrument and Data analysis by SPSS software.	The findings show that supply chain integration at any level is beneficial to the financial performance, Companies with total supply chain integration reported the highest level of financial performance.
Huo (2012)	Internal integration, supplier integration Customer integration	operational and financial performance	Using data collected from 617 companies in China and the structural equation modeling method	internal integration improves external integration and that internal and external integration directly and indirectly enhance company performance.
Huo *et al* (2014)	Internal integration ,process integration, product integration,	Financial performance	Survey methodology was used to collect data and Hierarchical linear regression used to analyze the moderating effects.	internal integration significantly affected the financial perform- ance of cost leaders, while process integration contributed more to the financial performance of differentiators.
Seo *et al* (2014)	innovativeness Integration	supply chain integration (SCI) and supply chain performance	A questionnaire survey and structural equation modeling were used	Innovativeness in the supply chain had a positive impact on both supply chain integration and supply chain performance. internal and supplier integration fully mediated innovative-ness–supply chain performance relationships, whereas customer integration had no mediating role on those relationships.
Flynn *et al* (2009)	customer, supplier and internal integration	operational and business performance.	the contingency approach, hierarchical regression was used to determine the impact and In the configuration approach, cluster analysis was used to develop patterns.	the results indicated that internal and customer integration were more strongly related to improving performance than supplier integration.

Yu *et al* (2014)	Green supply chain management with Customers, Internal GSCMI, GSCM with Suppliers integration	Operational performance in terms of flexibility, delivery, quality and cost	use survey data collection and analyzed using structural equation modeling.	This study generates important findings of the significant and positive relationships between IGSCM (internal, with customers and with suppliers) and operational performance in terms of flexibility, delivery, quality and cost.
Gimenez *et al*(2012)	Supply chain integration	Cost performance	survey-based research design is developed	shows that supply chain integration increases performance if supply complexity is high, while a very limited or no influence of supply chain integration can be detected in case of low supply complexity. Also show that in high supply complexity environment integration has a negative effect on cost performance.
Yim& Leem (2013)	social capital i.e (structural, relational, and cognitive) integra-tion	Firm performance	survey instrument is developed, authors validated their model and tested the hypotheses using the partial least squares (PLS) structural equation model (SEM).	Empirical results reveal that the three dimensions of supply chain social capital – structural, relational, and cognitive – had significant effects, directly or indirectly, on supply chain integration and performance, and supply chain integration played a mediating role in the relationships between structural capital and firm performance, between relational capital and firm performance, and between cognitive capital and firm performance.
Danese & Romano (2011)	customer and supplier integration	Efficiency performance	Survey method and hierarchical regression analysis apply.	Supplier integration positively moderates the relationship between customer integration and efficiency, whereas the analyses do not support the hypothesis that in general customer integration positively impacts on efficiency. Also supplier integration is at a low level, customer integration can even produce a reduction in efficiency.
Lee *et al* (2007)	Internal, supplier and customer integration	cost-control and reliability performance	Multivariate regression models and survey instrument are used	Internal integration is the most important contributor to cost-containment while integration with the supplier is the best strategy to achieve supply chain reliable performance.
Eckstein *et al* (2015)	supply chain agility and supply chain adaptability	cost performance and operational performance	Survey empirically invest and apply hierarchical regression analysis	find that supply chain agility and supply chain adaptability positively affect both cost performance and operational performance. Also shows Product complexity positively moderates the links between supply chain adaptability and cost performance, and supply chain adaptability and operational performance.
Yu (2015)	internal, customer and supplier integration	operational and financial performance	Survey method and structural equation modeling (SEM) was used .	Results indicate positive direct relationships between IT implementa-tion and internal, customer and supplier integration. The results also suggest that IT-enabled internal integration is significantly and positively related to both operational and financial performance.
Jayaram *et al* (2010)	supplier and customer integration	quality performance flexibility performance	Using empirical data collected, drawing on contingency theory and regression analysis approach is employed	The interaction between supplier coordination and size was directly and positively related to quality performance (large size effect). However, the interaction between customer coordination and size was directly and negatively related to flexibility performance (small size effect).Also shows interaction between supplier coordination and clock speed was directly and positively related to only flexibility performance

IV. Result and Discussion

This study investigates the impact of supply chain integration on quality performance, by openly focusing on the effect of knowledge, technology, production &design and resource integration in the supply chain context. We found that most of our hypotheses are supported or partially supported, broadly indicating that supply chain integration is related to quality performance. The independent variables are selected and then tested to know their effect on quality performances. From figure1observe that supply chain integration, knowledge, production & design, technology and resource are entered as independent variables. Whereas quality performance is selected as the dependent variable. The analysis and testing is particularly we apply Hierarchical open decision analysis is used to test our hypotheses(H1a– H2c) to (H2a-H2d). We investigated that production& design, knowledge, technology and resource integration is directly related to quality performance. Although supply chain integration affect quality performance through the interaction and integration of knowledge, production & design, technology and resource utilization.

Tables 2a-2c Result Summary of AHP - Analysis results.

Table 2 a: Alternatives Ranking

	Name	Value
1	knowledge integration	38.85%
2	Supply chain Integration	17.75%
3	Technology	15.27%
4	production & Design integration	14.83%
5	Resource integration	13.30%

Table 2b: Main Criterion-Matrix:

	Resource integration	Supply chain Integration	Technology	knowledge integration	Production & Design integration
Resource integration	17.65%	9.54%	9.26%	13.43%	13.47%
Supply chain Integration	21.06%	24.22%	12.22%	19.43%	9.49%
Technology	16.03%	18.31%	21.73%	11.58%	16.71%
knowledge integration	34.77%	34.09%	39.27%	46.03%	28.44%
Production & Design integration	10.50%	13.84%	17.52%	9.53%	31.90%

Consistency ratio: 0.07, (Critical consistency ratio: 0.1) from AHP result

Table 2c : Main Criteria Weighting

1	knowledge integration	41.12%
2	Resource integration	19.14%
3	production & Design integration	16.32%
4	Technology	12.43%
5	Supply chain Integration	10.99%

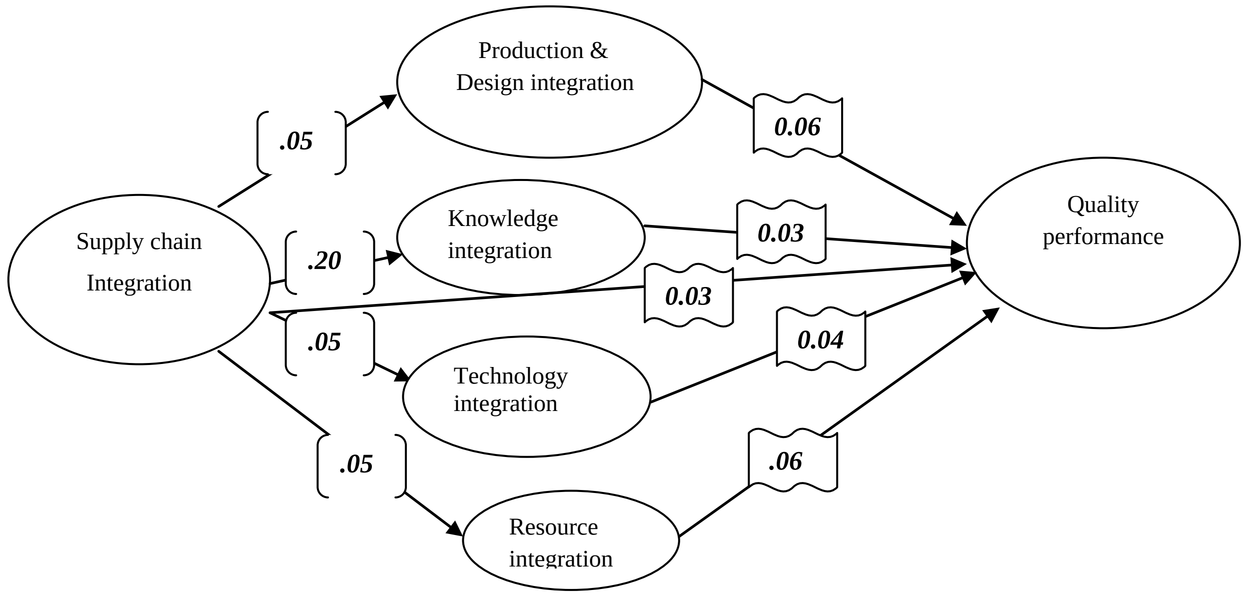

Figure 2 : performance improvement supply chain integration paths

Tables 2a-2c Result Summary of AHP-Analysis results and figure 2 performance improvement supply chain integration paths indicates that supply chain integration is positively and significantly associated with the four independent variables, that impact on the of quality performance on firms. We found that most of our hypotheses are supported that supply chain integration is related to quality performance. this implies that, the results indicated that internal integration is highly impact positively associated with quality performance, supporting *H2b*.The relationship between supply chain integration and knowledge, Production& design, Technology and Resource integration, has an impact on quality performance of manufacturing industries, supporting *H1c*. Production & design, technology and resource integration are positively related to quality performance supporting *H2a, H2c and H2d*. However, the level and interaction of supply chain variables have different effects on quality performance and supply chain practices. though, within constant Critical consistency ratio: (0.1), the Consistency ratio of each independent variables is different.

The this difference are highly related to interaction terms between supply chain practices and competitive strategies have different effects on quality performance. Knowledge and supply chain integration higher and positive effect on the improvement and success of quality performance in supply chain. we compare our results with those from previous research on supply chain integration, our finding that supply chain integration is extensively associated to supply chain performance. From table1.several studies (Gimenez *et al* (2012), Danese & Romano (2011), Yim & Leem (2013), Seo *et al* (2014), Yu (2015) investigated the effect of supply chain integration on performance. Accordingly, our research emphasize the importance of knowledge, technology, production & design and resource integration improve quality performance on supply chains. Even though some studies Flynn *et al* (2009), Huo *et al* (2014),Yu *et al* (2014) have examined the important role of internal integration in improving operational, business performance and financial performance and recognized a positive link, there are still studies Jayaram *et al* (2010) that found the significant association between supplier and customer integration impact effects on quality performance. Huo *et al*(2014) also shows that, the relation of Internal integration, process integration, product integration, with financial performance. This is an vital finding, since to a large extent of the existing literature on supply chain integration does not include multi-dimensional variables integration as a dimension of supply chain integrations. This is not exactly show the effect of this variables on supply chain performances. consequently multi dimension supply chain integrations should considered and the relationship between supply chain integration and multiple quality performance dimensions needs further investigation. Thus our study clearly shows that supply chain internal (such as knowledge, technology, production & design and resource) highly related and impact for supply chain integration improvement, and positively associated with quality performance on a supply chain. The pervious findings, as illustrated in Table 1, offer to support for our hypotheses and results. The results also indicate that the strongest relationship subsist between supply chain integration, knowledge, technology, production & design and resource integration with quality performance. However, the findings provide guidelines for managers adopting supply chain integration perform under different competitive strategies. primary, knowledge, technology, production& design and resource integration directly improve firms' quality performance. Subsequently Supply chain integration through knowledge, technology, production& design and resource are extensively enhance for quality performance. While former research typically investigated a positive relationship between supply chain integration and supply chain performance, our findings as well confirms a significance function of supply chain integration in enhancing supply chain performance. This result implies that executive should look for to tactically facilitate multi-dimensional integration by collaboratively working together with a strong emphasis on supply chain practices to improve supply chain quality performance.

V. Conclusion and Limitations

To meet the increasing demand of high-quality and technological goods from sophisticated local and overseas markets, manufacturing companies must continuously improve their efforts in technology and quality operations of SCM. Supply chain integration provides to focuses competitive advantage and improve quality performance. The effect of supply chain variables and quality performance is asses and investigated using literature review and AHP analysis. The results of this study shows in the understandings of how supply chain variables (knowledge, technology, production & design and resource) influence supply chain integration and quality performance. The result indicates that knowledge, technology, production &design and resource integration directly related and impact on quality performance for manufacturing companies. Supply chain integration has also positively linkage on Production, knowledge, Technology and Resource integration so as to improve quality performance in a supply chain. Although previous research usually investigated a positive relationship between supply chain integration and supply chain performance, our findings also confirmed a vital role of supply chain integration in enhancing supply chain performance on firms. Even though our findings have important implications for researchers and managers, we recognize that the present study has certain limitations. We study the effects of knowledge, technology, production & design and resource integration as the independent variables to impact quality performance, but other variables such as integrated topology, information system might help to explain causal variation in supply chain quality performance. Future research should investigate in addition to the effects of above the variables on, supply chain integration and firm performance, but also include the relation between information system, topology with on quality and financial performance.

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN:0975-5861

Infiltration Characteristics of Organic Amended Soils

By IgbadunH. E., Othman M. K. & Ajayi A. S.
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Abstract- The infiltration characteristics of organic amended soil were studied for soils amended with cow dung (CM) and poultry litter (PM). The aim was to determine the effect of these amendments on the infiltration characteristics of the soil. A field size of 200 m^2 was divided into three strips, 50 kg each of Cow dung and poultry litter was applied into the first and third strip and the middle strip served as control. Soil samples were taken from each strip for soil's physical property determination, one week after manure application infiltration runs were made using the double ring infiltrometer from six points on each strip, and the tests were repeated three weeks and six weeks after manure application. Bulk density of CM and PM reduced by 15.5% and 33.2% respectively, the CM strip increased infiltration rate by 60 % relative to the Control while the PM strip increased infiltration rate by 29 %. T-test showed a high significant difference between the control and the amended strips, CM and PM strip increased cumulative infiltration depth by 61.4 % and 48.1%.

Keywords: poultry litters, cow dung.

GJRE-J Classification: FOR Code: 961499

INFILTRATIONCHARACTERISTICSOFORGANICAMENDEDSOILS

Strictly as per the compliance and regulations of :

Infiltration Characteristics of Organic Amended Soils

IgbadunH. E. [α], Othman M. K. [σ] & Ajayi A. S. [ρ]

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I. Introduction

The use of organic manure in place of inorganic fertilizers in crop production by local farmers in Nigeria is increasing due to the high cost and scarcity of mineral fertilizers. Soils in which organic materials are incorporated are termed organic amended soils (Katsumi and Khan, 2012; Armin *et al.,* 2013; Ayeni and Adetunji, 2010). When soils are amended, water infiltration rate is affected amongst other physical properties. Water infiltration is the process of water movement from the ground surface into the soil and it is an important component in the hydrological cycle (Ajayi, 2015; Gana, 2011; Haghiabi*et al*., 2011).

When rainfall or irrigation soaks into the soil, a certain amount of the unfiltered water is temporally retained in the soil pores by capillary action and, if not quickly taken up by roots, gradually percolates downward from the root zone base to the water table at a rate which is equal to the constant infiltration rate or the hydraulic conductivity of the root zone layer. The amount of water retained in the topsoil is affected by the amount of organic matter content, the size, shape and arrangement of mineral particles (Gupta and Gupta, 2008).

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Infiltration has received attention from soil and water scientists/engineers because of the fundamental role of infiltration characteristics in land-surface and subsurface hydrology, irrigation and agriculture. Infiltration characteristics of soils can be quantified by direct measurement on the field and/or when field infiltration data are fitted mathematically to infiltration models (Oku and Aiyelari, 2011). Lili*et al.* (2008) reviewed the commonly used direct methods for measuring soil infiltration which include: single ring and double ring infiltrometers, mariotte-double ring infiltrometer, disc permeameter, rainfall simulator, runoff-on-ponding, runoff-on-out and linear source methods. The results obtained from field infiltration test and soil analysis are used for infiltration modelling. There is a dearth of standard infiltration characteristics of organic amended soils so that they can easily be applied in irrigation and drainage systems design and management (Gana, 2011; Stanley 2010).

The aim of this paper is to determine the effect of cow manure (CM) and poultry manure (PM) on the infiltration characteristics of the experimental site and also to use four common water infiltration modelsto predict and compare field measured values with those simulated.

II. Materials and Methods

a) Site Location and Treatments

The study was carried out at the Department of Agricultural Engineering experimental field, Samaru, Zaria, Nigeria. Zaria is located on latitude 11° 11'N and longitude 07° 38'E, at an altitude of about 667m above sea level.

An area of 200 m^2 (20 × 10m) was divided into three strips labeled CM, CT and PM, to carry out infiltration tests. Each strip was 40m^2 (20 × 2m) and50 kg each of cow dung and poultry litter was added to the CM and PM strip, respectively. The middle strip was left bare (without any amendment) as the control strip (CT).

The manure was applied in the existing furrows in the respective strip and was then plowed using animal drawn mold board plow and harrowed using a spike tooth harrow to mix the amended portion with the manure thoroughly to a depth of 20cm.Three soil samples were collected from each strip at depths of 0-15 cm and 15-30 cm using Core Samplers of 5 cm diameter and 6 cm height to collect soil samples.

b) Infiltration measurement and characteristics

The double ring infiltrometer method was used for the infiltration measurement. The infiltrometer consisted of two rings, outer ring of 40 cm diameter and 40 cm height, and the inner ring 30 cm diameter and 40 cm height. Both rings were hammered 15 cm into the soil with a plank to protect the surface of the ring from damage during hammering.

The test started by pouring water into the inner ring to an appropriate depth and at the same time, adding water to the space between the two rings to the same depth as quickly as possible. The time when the test began was recorded and the water level on the measuring rod was noted. After 3 minutes, the drop in water level in the inner ring was recorded on the measuring rod and water added to bring the level back to approximately the original level at the start of the test. The water level outside the ring was maintained similar to the one inside.

The test was repeated one, three and six weeks after the incorporation of the manure and six infiltration measurements were carried out per test. Each infiltration test lasted 4 hours with cumulative time intervals: 3, 5, 10, 20, 30, 45, 60, 90, 120, 150, 180, 210 and 240 minutes. The cumulative infiltration depth at the elapsed time was recorded. Using the data generated from a total of 36 infiltration runs (12 runs per treatment), cumulative infiltration and infiltration rates were computed for the soil of the experimental site under the tested land management systems. Curve fitting was carried out using four models:Kostiakov (1932), modified Kostiakov (Michael, 1978), Kostiakov-Lewis (1982) and Philip (1957) infiltration models by regression (Table 1).

Table 1: Equations and fitting parameters of the four models tested

	Model Name	Infiltration equation	Fitting parameters
1	Kostiakov (1932)	$I = kt^a$	*k* and a
2	Modified Kostiakov (1978)	$I = k_1 t^{a_1} + b$	k_1, a_1 and *b*
3	Philip (1957)	$I = S\sqrt{t} + At$	S and A
4	Kostiakov-Lewis (1982)	$I = k_2 t^{a_2} + i_c t$	a_2, k_2 and i_c

Where: I is cumulative infiltration (cm), *k* and *a* are Kostiakov's time coefficient terms, t is elapsed time (hour), k_1 and a_1 and *b* are Modified Kostiakov's time exponent terms (dimensionless), b is rectifying factor, S is Philip's soil water sorptivity (cm h^{-1}), A is Philip's soil water transmissivity (cm h^{-1}), k_2 and $a_2$and i_c are Kostiakov-Lewis time exponent term.

Coefficient of determination (R^2) and Root mean square error (RMSE) were used to test the goodness of fit of the four models with measured data, T-test was performed to check the effect of these amendments of the infiltration characteristics of the soil.

III. Results and Discussion

The averages of the result of analysis of soil physical properties of the study area are presented in Table 1. The results showed that the texture of the field surface (0-15cm) and the sub-surface (15-30cm) depths for the three sampled strips were predominantly sandy clay loam according to the United States Department of Agriculture (USDA) classification, having sand fraction ranging from 43-66%, silt ranging from 11-20% and clay 15-29%.

Table 2: Average soil physical characteristics of the strips

Strip	B.D(g/cm^3)	M.C(g/g)	K_s(cm/h)	%Clay	%Silt	%Sand
CM	1.53	0.06	7.37	23.2	17.8	59.0
PM	1.21	0.12	5.92	24.0	20.0	56.0
CT	1.81	0.05	4.58	26.0	14.0	60.0

*BD = Bulk density; MC =Moisture content; K_s= Saturated Hydraulic Conductivity; C = % Clay ;Si= % Silt; Sa = % Sand;

A comparison of the bulk density of the control with the other treatments shows that the application of CM and PM to the field reduced the soils bulk density by 15.5% and 33.2%, respectively. The values of saturated hydraulic conductivity ranged from 4.58-7.37 cm/h. Generally, improved soil indices were obtained in the study through the use of both amendments; however, the extent of this depends on the source of the organic manure. It was observed that poultry manure had more effect on the soils physical properties like bulk density and organic matter content although the cow dung amended strip was found to have higher saturated hydraulic conductivity values. This agrees with the result obtained by Onuh*et al.* (2008) who studied the effects of poultry Manure and cow dung on the Physical and Chemical Properties of Crude Oil Polluted Soil in Owerri, Nigeria. His findings was evidenced by the improvement in the soil physical properties.

The average results of the measured cumulative infiltration are shown in Table 3. The final infiltration rates (basic infiltration) were 7.37 cm/h for Cow dung amended strip and 5.92 cm/h for poultry litter amended strip and 4.58 cm/h for the control and these were attained after 4hours respectively.

Table 3: Average cumulative infiltration measured on the field

	Cow dung		*Poultry litter*		*Control*	
Time(hr)	*I* (cm)	*i (cm/hr)*	*I* (cm)	*i (cm/hr)*	*I*(cm)	*i (cm/hr)*
0.05	2.42	50.44	2.18	47.33	1.73	34.67
0.08	3.91	47.87	3.81	44.80	2.80	33.60
0.17	6.21	39.20	5.73	32.73	3.47	20.80
0.33	8.39	24.90	8.23	21.80	5.03	15.10
0.50	10.74	21.27	10.76	18.64	6.60	13.20
0.75	13.23	18.40	13.12	15.30	8.07	10.76
1.00	15.84	16.72	15.71	13.64	9.73	9.73
1.50	18.46	13.03	17.70	10.47	11.80	7.87
2.00	21.57	11.34	20.09	8.84	13.43	6.72
2.50	23.97	10.01	22.26	7.75	15.33	6.13
3.00	26.41	8.93	24.39	7.07	16.77	5.59
3.50	28.33	8.10	25.92	6.47	17.73	5.07
4.00	29.54	7.37	27.11	5.92	18.30	4.58

Table 3 show that the increase in the cumulative infiltration depth after 4 hours are 61.4% and 48.1% respectively. The calculated values of the t-test for CM and PM strip at a confidence level of 0.05 are 6.184 and 6.791 respectively while the critical value is 2.179. This implies that there is a significant difference and also that the incorporation of the manure affected the infiltration characteristics. Variation in the infiltration rate between the amended strip and control means that water infiltrated better into the amended soil at an average rate of 7.98 and 5.15 cm/h for CM and PM strip, Table 4 shows a variation in the estimated parameters for each strip.

Table 4 : Model's parameters and modeled equations

	Kostiakov (1932)		Modified Kostiakov			Kostiakov-Lewis			Philip (1957)	
Strip	*k*	*a*	k_1	a_1	*b*	k_2	a_2	i_c	*S*	*A*
CM	14.826	0.546	18.361	0.6301	-1.99	5. 278	0.116	7.370	13.613	1.029
PM	14.048	0.542	17.339	0.589	-3.54	5.171	0.120	5.920	13.315	0.623
CT	9.303	0.530	9.992	0.627	-0.54	3.435	0.119	4.580	8.731	0.492

The values of fitting parameters for the infiltration models under the different land management systems obtained by regression are shown in Table 4. And Tables 5a,b and c shows the values of the predicted cumulative infiltration by the different models. The table also displays R^2 values for the regression equations, RMSE values for field-measured versus model-predicted infiltration data and equilibrium infiltration rate values for the land management systems.

Table 5a: Observed and Model predicted cumulative infiltration for CM strip

Time(hr)	Obs	KT	MK	KL	PH
0.05	2.52	2.89	3.90	4.10	3.10
0.08	3.99	3.81	5.16	4.57	4.02
0.17	6.53	5.57	7.31	5.52	5.73
0.33	8.30	8.14	10.11	7.11	8.20
0.50	10.63	10.15	12.12	8.57	10.14
0.75	13.80	12.67	14.47	10.65	12.56
1.00	16.72	14.83	16.37	12.67	14.64
1.50	19.54	18.50	19.43	16.62	18.22
2.00	22.69	21.65	21.90	20.50	21.31
2.50	25.02	24.46	24.01	24.34	24.10
3.00	26.79	27.02	25.88	28.16	26.67
3.50	28.34	29.39	27.56	31.97	29.07
4.00	29.48	31.62	29.10	35.76	31.34
	R^2	0.990	0.997	0.938	0.988
	RMSE	1.054	1.006	2.831	1.097

Table 5b: Observed and Model predicted cumulative infiltration for PM strip

Time(hr)	Obs	KT	MK	KL	PH
0.05	2.37	2.77	1.06	3.95	3.01
0.08	3.73	3.65	2.23	4.40	3.90
0.17	5.46	5.32	4.30	5.30	5.54
0.33	7.27	7.74	7.12	6.79	7.90
0.50	9.32	9.65	9.21	8.15	9.73
0.75	11.48	12.02	11.72	10.08	12.00
1.00	13.64	14.05	13.80	11.95	13.94
1.50	15.71	17.50	17.21	15.60	17.24
2.00	17.69	20.46	20.03	19.18	20.08
2.50	19.37	23.09	22.48	22.72	22.61
3.00	21.20	25.49	24.67	26.24	24.93
3.50	22.64	27.72	26.66	29.74	27.09
4.00	23.67	29.80	28.50	33.23	29.12
	R^2	0.991	0.997	0.940	0.991
	RMSE	2.875	2.393	3.823	2.533

Table 5c: Observed and Model predicted cumulative infiltration for Control

Time(hr)	Obs	KT	MK	KL	PH
0.05	1.57	1.90	2.02	1.91	1.98
0.08	2.40	2.49	2.50	1.87	2.56
0.17	3.97	3.60	3.44	2.02	3.65
0.33	6.00	5.20	4.90	2.58	5.21
0.50	7.27	6.44	6.10	3.25	6.42
0.75	9.10	7.99	7.64	4.30	7.93
1.00	10.73	9.30	9.00	5.39	9.22
1.50	12.93	11.53	11.39	7.60	11.43
2.00	14.50	13.43	13.49	9.84	13.33
2.50	16.17	15.12	15.40	12.09	15.03
3.00	17.57	16.65	17.17	14.36	16.60
3.50	18.77	18.07	18.84	16.62	18.05
4.00	19.37	19.39	20.42	18.89	19.43
	R^2	0.993	0.983	0.905	0.991
	RMSE	0.894	1.017	3.568	0.946

The R^2 ranged from 0.905 to 0.997 which are all close to unity and an indication of close agreement between the measured and predicted data for each of the infiltration models. Considering the individual performance of the models in the respective strips, the modified Kostiakov model performed better in the CM and PM strip with R^2 values of 0.997 while the Kostiakov's R^2 value was the best for control strip.

The result of RMSE shows that Modified Kostiakov's model had the least error in comparing the predicted values with field measured values followed by Philip's model for the Control, Cow dung and Poultry litter amended strip.

Gana (2011) studied the effect of cow dung on soil with higher sand percentage in Bida, Niger state, the effect of cow dung was not significant and also showed that cow dung with inorganic fertilizer cannot easily influence the soil texture. However, according to Gupta *et al.* (2004) application of cow dung helps in improving soil structure, soil aeration and therefore improves the activities of soil micro-organisms.

Odofin (2012) showed that Kostiakov, modified Kostiakov and Philip infiltration models were all found to be suitable for simulating water infiltration into an Alfisol subjected to untilled mulched, tilled-mulched and tilled-unmulched management systems at Minna, Nigeria. However, modified Kostiakov model simulated water infiltration more accurately than Philip model while classical Kostiakov model was the least accurate. Infiltration data from highly permeable soils under five different land use histories on Nsukka plains of south-eastern Nigeria showed that either the modified Kostiakov model or modified Philip model could be used for routine characterization of the infiltration process (Mbagwu, 1995). The Kostiakov and modified Kostiakov equations tend to be the preferred models used for irrigation infiltration, probably because it is less restrictive as to the mode of water application than some other models.

IV. Conclusions

The application of 50 kg of organic manure to 0.004 ha (40 m^2) increased the steady state infiltration by an average rate of 7.98 and 5.15 cm/h for CM and PM strip respectively and also the cumulative infiltration depth increased by 61.4% and 48.1% for CM and PM strip, also the soil properties where improved accordingly. The models provided good overall agreement with the field measured cumulative infiltration depths and are therefore capable of simulating infiltration under the field conditions in this study. T-test showed a significant difference between the amended strip and the control, the water holding capacity also increased by 11.8% and 13.9% for CM and PM strips respectively. Similar work can be carried out to study the effect of different application rate of organic manure on the infiltration capacity and soil physical properties of the amended soils.

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 Print ISSN:0975-5861

Biosensors

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Abstract- In this paper aims to review how biosensors are made, where they can be used, their advanced and their detection methods. The biosensors are studied and fabricated to detect samples and measure demand values by using online websites that based on grounded theory. The paper reviewing some factors that help us to understand biosensor importance in our daily lives in most fields. Studies and researches are limited to real studies which has been collected from the result of experiment in various laboratories the suggested model is particularly useful for medical detecting to better illustrating and understanding the illness samples by display output of high resolution. In addition, they can be used in water treatment and food testing the paper shows design of biosensors, their application and types. Also; it highlights resolutions and sensitive the value that is detected by biosensors. Moreover, it presents simplicity of using biosensors So, it encourages the researches and inventors to focus on this challenge.

Keywords: *biosensors; biomedical; hospital's devices; biotechnology; biomedical engineering.*

GJRE-J Classification : FOR Code: 090399

Biosensors

Ahmed kh. Sabr

Abstract- In this paper aims to review how biosensors are made, where they can be used, their advanced and their detection methods. The biosensors are studied and fabricated to detect samples and measure demand values by using online websites that based on grounded theory. The paper reviewing some factors that help us to understand biosensor importance in our daily lives in most fields. Studies and researches are limited to real studies which has been collected from the result of experiment in various laboratories the suggested model is particularly useful for medical detecting to better illustrating and understanding the illness samples by display output of high resolution. In addition, they can be used in water treatment and food testing the paper shows design of biosensors, their application and types. Also; it highlights resolutions and sensitive the value that is detected by biosensors. Moreover, it presents simplicity of using biosensors So, it encourages the researches and inventors to focus on this challenge.

Keywords: biosensors; biomedical; hospital's devices; biotechnology; biomedical engineering.

I. Introduction

The history of biosensors started in 1962 with the development of enzyme electrodes by scientist Leland C. Clark. Since then, research communities from various fields such as very large scale integration (VLSI), physics, chemistry, and material science have come together to develop more sophisticated, reliable, and mature bio sensing devices (Kougianos). The first experiment to mark the origin of biosensors was carried out by Leland C. Clark. He used platinum (Pt) electrodes to detect oxygen (S. Robertson, 2016). Biosensors are analytical devices that convert a biological response into an electrical signal (Mehrotra, 2016) . Biosensors analytical device which incorporates a biologically active element with an appropriate physical transducer to generate a measurable signal proportional to the concentration of chemical species in any type of sample (Touhmi, 2015). Biosensors are integrated receptor-transducer devices capable of providing selective quantitative or semi quantitative analytical information using a biological recognition element (Pacheco, Barroso, Nouws, Morais, & Delerue-Matos, 2017). The classification of biosensors based on bioreceptors such as enzymes, antibodies (immunosensors), DNA (genosensors), and Microbial and aptasensors is discussed (Karunakaran, Rajkumar, & Bhargava, 2015). Biosensors have been applied in many fields namely food industry, medical field, marine sector etc., and they provide better stability and sensitivity as compared with the traditional methods (Mehrotra, 2016). The requirement for analytical information applies to all sectors of activity, including health care and veterinary medicine, the food, pharmaceutical, bio processing and petrochemical industries, environmental monitoring and control, defenses and agriculture (Higgins & Lowe, 1987). Rapid growth in biomaterials, especially the availability and application of a vast range of polymers and copolymers associated with new sensing techniques have led to remarkable innovation in the design and construction of biosensors, significant improvements in sensor function and the emergence of new types of biosensor (Zhang, Wright, & Yang, 2000). Biosensors were developed in two broad categories: (i) Microarray type, which usually comprised cantilever or field-effect devices with adsorption of target analytes to sensing elements as the main transduction mechanism, and (ii) Microfluidic and Nano fluidic sensors that usually involved manipulations of small fluidic volumes (Microliters to Nanowires) leading to an optical method for detection (Touhami, 2013). These recent advances in Micro and Nanotechnologies have enabled the design and implementation of innovative bio-interfaces for a variety of biomedical applications, such as point-of-care diagnostics, high resolution disease diagnostics instruments, and automated biological laboratories and/or for life science research purposes (Ghafar, 2016).

II. Research Method

My goal in my study is to prove my studies of the factors helping to understand biosensors. The research method in my paper is case study which explains the extent of the contribution of the factors in biosensor illustrating that can enhance our knowing about importance of biosensors, their design, uses, advanced and their detection ways. The case study theory in the study shows benefits of biosensors. The benefits of biosensors are many. They rapid and continuous measurement, high specificity, very less usage of reagents required for calibration, fast response time, and ability to measure non-polar molecules that cannot be estimated by other conventional devices (Azosensor, 2013). These benefits act as challenges and encourage the researchers and science to interest in this field. The future of biosensors -lab on a chip to miniaturize biochemical analysis systems to de-skill biochemical analysis (Birch, 1996) . p27. The advances of biosensors for infectious disease diagnostics and discuss the critical challenges that need to be overcome

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in order to implement integrated diagnostic biosensors in real world settings (Mandy LY Sin, 2014).

III. Biosensors

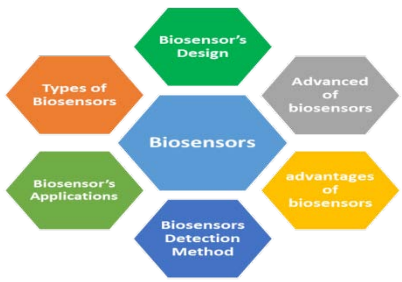

Figure 1: Factors that assist to understand importance of biosensors.

a) Biosensor's design

Biosensor consists of a bio element and a sensor element. The bio element may be an enzyme, antibody, living cells, or tissue. The sensing element may be electric current, electric potential, and so on. A detailed list of different possible bio elements and sensor-elements is shown below. Different combinations of bio elements and sensor-elements constitute several types of biosensors to suit a vast pool of applications (Elias, 2015). Biosensors would work dependent upon those standards of sign transduction. These parts incorporate a bio-recognition element, a bio transducer furthermore an electronic framework created of a display, processor What's more enhancer. Those bio-recognition element, basically a bio receptor, may be permitted to connect with a examine. Those transducer measures this collaboration what's more outputs a sign. Those power of the sign yield is proportional of the focus of the dissect. The indicator will be that point amplified and transformed by those electronic framework (Azosensor, 2013). Will outline those sensor, we use formerly accounted cationic multinomial Peptides (MDPs) which could make modularly intended to structure Different protein auxiliary structures also exhibit tunable, structure-dependent antimicrobial exercises (Liu, Marrakchi, Xu, Dong, & Andreescu, 2016). Plan for electrochemical biosensors for the identification about glutamate the table faster, all the more easy to understand also less expensive system for investigation over traditional strategies for example, such that high-octane fluid chromatography (HPLC) and gas chromatography–mass spectrometry (GC–MS) (Hughes, Pemberton, Fielden, & Hart, 2016). Electro concoction biosensors need demonstrated on a chance to be specific, particular What's more simple to utilize in the determination of metabolites for clinical, environmental also sustenance examination (Petropoulos, Piermarini, Bernardini, Palleschi, & Moscone, 2016). We bring configuration biosensors that screen structural rearrangements which occur inside alternately around channel subunits by means of progressions over bioluminescence vitality exchange (BRET). This is an cell-based protein imaging techno babble that not best faculties unpretentious conformational progressions in any case gives those groundwork for consequent utilization of this sort for biosensors On An high-throughput test organization (D. N. Robertson et al., 2016). Done principle, any bio molecules what's more sub-atomic assemblies that have the ability from claiming distinguishing a focus analyte cam wood be utilized Similarly as a bio receptor. Those Initially bio distinguish component utilized within biosensor outline might have been from existing framework. Relying upon the nature for bio receptor, reactant alternately natural inclination biosensors were produced in the writing. Proteins were those to begin with distinguish component coordinated to biosensor outlines for totally spread sensing requisitions. However, other bio receptors atoms for example, such that antibodies what's more protein natural inclination frameworks were acquainted exact quickly in the build from claiming biosensors (Bazin, Tria, Hayat, & Marty, 2017). The form claiming biosensors have been engaging for a expansive range about provisions over clinical diagnosis, biomedical research, nourishment caliber control and natural screening due to their simplicity, fast response, what's more similarity with scaling down. Previously, particular, electrochemical resistant sensors, relying on the particular antigen–antibody interaction, would those the vast majority generally utilized much appreciated on some of their particular features (Xia et al., 2017).

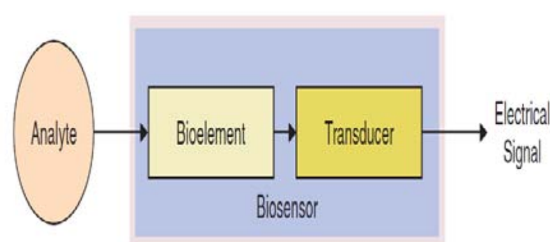

Figure 2: A schematic representation of biosensors (Elias, 2015).

b) Types of biosensors

The biosensors are of 5 types: calorimetric biosensors, potentiometric biosensors, acoustic wave biosensors, amperometric biosensors, and optical biosensors (Ksha). There are several types of biosensors based on the sensor devices and the type of biological materials used. Electrochemical, amperometric, blood-glucose, potentiometric, conduct metric, thermometric, optical, fiber optic lactate, optical for blood glucose, luminescent biosensors to detect urinary infections, piezoelectric, whole cell, and immune biosensors (Kashor, 2011). Another and guaranteeing strategy done Microbial nature, furthermore natural science may be the utilization for whole-cell bacterial biosensors. This scaled down survey depicts the utilization of such biosensors for

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identification, furthermore quantification for different exacerbates what's more different states influencing bacterial outflow for diverse genes. Three sorts of biosensors (nonspecific, stress-induced, also particular biosensors) would portrayed including their use in distinctive situations (Hansen, xf, & rensen, 2001). Electrochemical sandwich-type biosensors for α-1 antitrypsin with carbon Nanotubes, furthermore basic phosphatase marked antibody-silver Nanoparticles. An novel sandwich-type biosensor might have been formed to those electrochemical identification about α-1 antitrypsin (AAT, a perceived biomarker to Alzheimer's disease) (G. Zhu & Lee). Three diverse sorts for aerometric catalyst cathode need aid portrayed. The primary kind utilization a leading organic-salt cathode to oxidize NADH. In the second sort from claiming sensor, flavoenzymes are straightforwardly oxidized on the surface of the leading organic-salt cathode. The third sort about sensor will be outlined with measure low levels of poisonous gasses for example, H2S What's more HCN. This will be done by observing the restraint by those harmful gas of the action of the respiratory catalyst cytochrome oxidase (Albery et al., 1987). Large portions sorts about biosensor gadgets have been created in the previous 30 years, including catalyst electrodes, optical safe sensors, ligand-receptor am- perimeters, what's more evanescent-wave probes. Whole living phones likewise could be utilized concerning illustration biosensors. Whole-cell biosensors bring two imperative points of interest. In a significant number divergent compound species might bring out a reaction from a single cell. Second, the distinguishment occasion to a part might a chance to be. Amplified by signal-transduction pathways something like that that measurable reactions aftereffect from moment amounts for materia (Shear et al., 1995). There needs aid a few sorts from claiming semiconductor device (Biosensors) which might be utilized likewise with a suitableness biochemical response. The ion-sensitive field impact Covington (this symposium) could a chance to be used, to example, to measure PH in result. There are, however, likewise other possibilities for bio sensing, gas-sensitive semiconductor (Lundstrom, Spetz, Winquist, Albery, & Thomas, 1987). There need aid two sorts about biosensors. An extensive mixed bag about biosensors need aid in view of Micro/Nano fluidics. Micro/Nano fluidic gadgets offer the capacity will worth of effort with more modest reagent volumes also shorter response times, moreover, perform analyses of different sorts without a moment's delay. The second kind about biosensors incorporates Micro/Nano arrays that perform you quit offering on that one sort from claiming dissection many times (Bhushan, 2008).

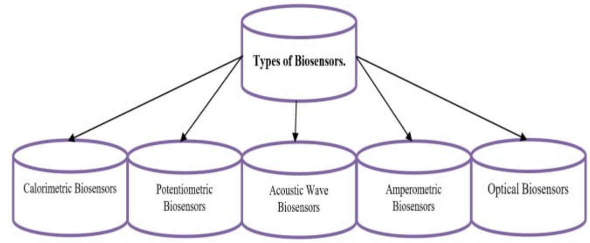

Figure 3: shows main types of biosensors.

i. *Calorimetric Biosensors*

Many enzyme catalyzed reactions are exothermic. Calorimetric biosensors measure the temperature change of the solution containing the analyte following enzyme action and interpret it in terms of the analyte concentration in the solution. The analyte solution is passed through a small packed bed column containing immobilized enzyme; the temperature of the solution is determined just before entry of the solution into the column and just as it is leaving the column using separate thermistors. This will be those practically by and large pertinent kind of biosensor. utilizing two or more proteins of the pathway in the biosensor on join a few responses with expand those heat yield. Alternatively, multifunctional proteins might a chance to be utilized. A sample is the utilization of glucose oxidase for determination about glucose (Jensen & Dietrich, 1994).

ii. *Potentiometric Biosensors*

These biosensors use ion-selective electrodes to convert the biological reaction into electronic signal. The electrodes employed are most commonly pH meter glass electrodes (for cations), glass pH electrodes coated with a gas selective membrane (for CO2, NH, or H2S) or solid state electrodes. Many reactions generate or use H+ which is detected and measured by the biosensor; in such cases, very weak buffered solutions are used. Gas sensing electrodes detect and measure the amount of gas produced. An example of such an electrodes is based on urease which catalysis the following reactions:

$$CO\,(NH2)2 + 2H2O + H+ \rightarrow 2NH4+ + HCO{-}3$$

This reaction can be measured by a pH sensitive, ammonium ion sensitive, NH3sensitive or CO2 sensitive electrode. Biosensors can now be prepared by placing enzyme coated membranes on the ion-selective gates of ion-selective filed effect transistors; these biosensors are extremely small.

iii. *Acoustic Wave Biosensors*

Acoustic waves excited in a piezoelectric medium provide an attractive technology for realizing a family of biosensors that are sensitive, portable, cheap and small. In this paper a wide range of bulk and surface-generated acoustic waves are described and prototype sensing-element geometries are presented.

Results obtained using several candidate acoustic wave biosensors are also discussed (Andle & Vetelino, 1994).

iv. *Amperometric Biosensors*

These electrodes function by the production of a current when potential is applied between two electrodes, the magnitude of current being proportional to the substrate concentration. The simplest amperometric biosensors use the Clark oxygen electrode which determines the reduction of O2 present in the sample (analyte) solution. These are the first-generation biosensors. These biosensors are used to measure redox reactions, a typical example being the determination of glucose using glucose oxidase.

A major problem of such biosensors is their dependence on the dissolved O2concentration in the analyte solution. This may be overcome by using mediators; these molecules transfer the electrons generated by the reaction directly to the electrode rather than reducing the O2 dissolved in analyte solution. These are also called second generation biosensors. The present-day electrodes, however, remove the electrons directly from the reduced enzymes without the help of mediators, and are coated with electrically conducting organic salts.

v. *Optical Biosensors*

These biosensors measure both reactant What's more natural inclination responses. They measure A progress for fluorescence alternately on absorbance brought on Toward the results produced Toward reactant responses. Alternatively, they measure those progressions prompted in the innate optical properties of the biosensor surface because of stacking on it for dielectric particles such as protein (in situation from claiming natural inclination reactions). A large portion guaranteeing biosensor directing, including radiance utilization firefly catalyst luciferase for identification of microscopic organisms clinched alongside nourishment alternately clinical tests. The microscopic organisms need aid particularly lysed should discharge ATP, which is utilized Toward luciferase in the vicinity about 02 to prepare light which is measured Eventually Tom's perusing the biosensor (Badley et al., 1987).

c) *Biosensor's applications*

Biosensors are gadgets including a living component and a physiochemical identifier that are used to recognize analyzes. These instruments have an extensive variety of requisitions going starting with clinical through should ecological, furthermore agricola. The gadgets would likewise have utilized in the nourishment industry. A percentage cases of the fields that utilize biosensor engineering include: all social insurance monitoring, screening to disease, clinical Investigation, furthermore analysis about disease, veterinary what's more agricola applications, mechanical preparing, monitoring, also ecological contamination control (Ananya Mandal, 2016). Biosensors it need an extensive variety of provisions in distinctive fields. Medicinal biosensors have been utilized within different symptomatic methods with figure out different tests. Industrial, environmental, it serves on measuring those poisonous qualities about water bodies, military, it serves to recognize explosives, medications and so forth throughout this way, observing and stock arrangement of all instrumentation may be enha, aiding to resistance of the kin. Medication regardless development, a biosensor called Nano sensors need been produced which detects and examine those tying from claiming proteins to its focuses which need demonstrated exceptionally of service Previously, drug planning (Gouvea, 2011). Glucose oxidase, altered by the covalent connection about ferrocenyl groups, need been indicated to experience immediate oxidation in clean metal electrodes. Since changed proteins of this kind don't oblige a uninhibitedly diffusing arbiter and camwood make oxidized at humble In potentials they need aid magnetic for provision over biosensors and clinched alongside bioelectric (Bartlett & Bradford, 1990). Observing, furthermore control for temperature and weight may be great made. However, late developments to checking such parameters during numerous focuses eventually Tom's perusing utilizing single, fibrotic, dispersed sensing systems (D. Payne, communication) show up a great part more suiting should control necessities. In spite of stream sensors are also great developed, requisition ,also measurement-range issues keep on going will forestall establishment about dependable liquid also gas control regimes, especially the individuals that might a chance to be needed with build physiological what's more biochemical control methods dependent upon possibility biosensor and concoction sensor (Clarke & Bergman, 1987). At those focusses to natural biotechnology (CEB) at the school for Tennessee, Knoxville, researchers headed eventually Tom's perusing focus executive gray Saylor bring engineered Microscopic organisms to utilize likewise biosensors for remediation observing furthermore other provisions. Saylor characterizes An biosensor Concerning illustration "an existing living being that might distinguish also react with chemical, physical, or Indeed living operators in the surroundings also generate an indicator that might make utilized for identification of that analyte [the substance continuously analyzed] alternately living being (Ben-Ari, 2002). Biosensors would units regularly used to recognize target bio molecules for example, such that proteins or nucleic acids; however, they camwood have other provisions for example, such that those identification of concoction contaminants to water. Bio molecules alternately concoction contaminants might make sensed alternately distinguished through an assortment from claiming components anyway by identification includes a cooperation between those focus atom furthermore a transducer to prepare a measurable sign demonstrating those vicinity and fixation for that target atom (Prakash, Pinti, & Bhushan, 2012). Despite significant exertions done biomedical Nanotechnology bring concentrated on medication regardless conveyance what's more biosensor applications, living characterization about unmodified Nanoparticles at present remains under investigated (Arvizo et al., 2013). Each sensor framework what's more entryway it enhanced the sensing execution. Basically, properties about try bring been used to a large number different sorts from claiming biosensors, which could a chance to be representatively arranged under biosensors in light of (1) fluorescence thunder vitality transfer, (2) laser desorption/ ionization impostor spectrometry (LDI-MS), (3) surface-upgraded Raman spectroscopy (SERS), also (4) electrochemistry. 1st for all, the phenomenal effectiveness for energy/charge exchange starting with color to try enabled the advancement of a quite a few FRET-based biosensors. Regular system On these provisions depends on the halter skater energy/electron exchange ability and the amphiphilicity about try (Lee, Kim, Kim, & Min, 2016).

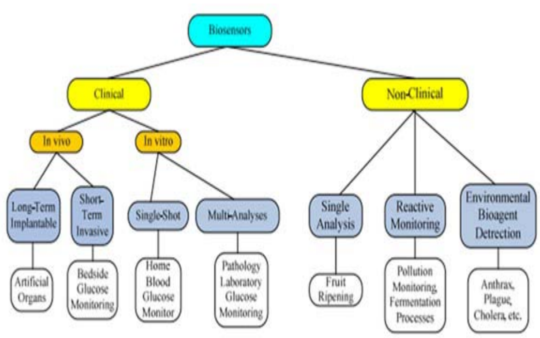

Figure 4: types and applications of biosensors (Lee et al., 2016).

d) Biosensor's detection methods

An important part in a biosensor is to attach the biological elements (small molecules/protein/cells) to the surface of the sensor (be it metal, polymer or glass). The simplest way is to functionalize the surface to coat it with the biological elements. This can be done by polyline, aminosilane, epoxysilane or nitrocellulose in the case of silicon chips/silica glass. Subsequently, the bound biological agent may be for example fixed by Layer by layer deposition of alternatively charged polymer coatings (Pickup, 2008). On the other hand, three-dimensional lattices (hydrogel/xerogel) camwood make used to synthetically alternately physically ensnare these (where by artificially entrapped it is implied that those living component may be kept set up by an solid bond, same time physically they would kept set up constantly unabated should pass recipient those pores of the gel matrix). The practically regularly utilized hydrogel is sol-gel, a glassy silica produced eventually Tom's perusing polymerization from claiming silicate monomers (added Concerning illustration tetra alkyl orthosilicates, for example, TMOS alternately TEOS) in the vicinity of the living components (along with other settling polymers, for example, such that PEG) on account for physical entanglement (Gupta, 2007). Another group of hydrogels, which set under conditions suitable for cells or protein, are acrylate hydrogel, which polymerize upon radical initiation. One type of radical initiator is a peroxide radical, typically generated by combining a persulfate with TEMED (Polyacrylamide gel are also commonly used for protein electrophoresis) (Clark, 1998). Alternatively light can be used in combination with a photo initiator, such as DMPA (2,2-dimethoxy-2-phenylacetophenone) .Smart materials that mimic the biological components of a sensor can also be classified as biosensors using only the active or catalytic site or analogous configurations of a biomolecule (Liao, 2008). A novel technique to dengue infection identification furthermore immunizer screening utilizing an graphene-polymer built electrochemical biosensor. Those dengue infection biosensor may be made Eventually Tom's perusing blending graphene oxide (GO) What's more polymers same time including dengue infection (DENV) in front of permitting a self-assembly methodology on make those sensor Exceptionally particular will DENV (Navakul et al.). Delicate identification of maltose and glucose technique In light of double enzyme-displayed Microscopic organisms electrochemical biosensor two recombinant strains shown gas What's more GDH based maltose biosensor produced. The reaction might have been extraordinarily improved compared with nothing enzyme-based biosensor. Glucose What's more maltose camwood a chance to be distinguished utilizing GDH-bacteria/MWNTs/GCE What's more GA-bacteria/GDH-bacteria/MWNTs/GCE (Xia et al., 2017). Handheld analyzer technique for on-chip molecularly-imprinted biosensors to electrical identification about propofol for plasma tests. Molecularly imprinted polymer biosensors are and incorporated with Microfluidic biochips. Compared for the opposite methods, the recommended strategy may be label-free, low-cost, Also easy-to-use. Propofol identification with plastic biochip is exhibited around An handheld electronic analyzer (Hong et al., 2016). Improvement of a novel capacitance electrochemical biosensor In light of silicon nitride for ochratoxin An identification the estimations were Exceedingly stable and proliferation for identification and interferences. Those suggested strategy may be really guaranteeing to ochratoxin a identification for a few agrofood business requisitions (Bougrini et al., 2016). Sensor-based identification routines have propelled the ticket that concoction or physical signs Might be changed over will nucleic corrosive signs on be quantitatively distinguished scorch consolidation from claiming proper identification. Instruments. Should accomplish ultrasensitive furthermore supreme quantitative identification from claiming mercury ion (Hg2þ), we need. Joined amispairingbiosensorforHg2þ

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furthermore emulsion PCR. The parameters that could impact those. Biosensor step, for example, the span of isothermal intensification and the centralization of the sensor. Oligonucleotide, need been firstly optimized done our investigation will attain those The majority productive biosensor identification (P. Zhu et al., 2016). The biosensor might have been created Toward carbon pasta sauce cathode changed with hemoglobin and multi walled carbon Nanotube. Dependent upon the phenomenal electrochemical properties of the altered electrode, a touchy voltammetry system might have been utilized for identification for methyl paraben inside a straight reach from 0. 1 will 13 μmol L−1 furthermore identification farthest point from claiming 25 nmol L−1. The produced biosensor possessed exact furthermore fast light of methyl paraben furthermore indicated beneficial sensitivity, stability, What's more repeatability. Finally, the relevance of the suggested biosensor might have been checked Toward methyl paraben assessment done Different genuine specimens (Hajian, Ghodsi, Afraz, Yurchenko, & Urban, 2016). The biological part of biosensor performs two critical works.

(a) it particularly distinguishes those dissect What's more. (b) it interacts with it clinched alongside such A way which produces a few physical changes perceivable by the transducer. These properties of the biological part of biosensor confer on the biosensor its specifically, affectability and the capability will identify and measure the examiner. biological part of biosensor will be bag immobilized with respect to of the transducer. Generally, those right immobilizations from claiming proteins enhances their soundness. Similarly, as a result, a lot of people enzyme-immobilized frameworks might be utilized more than 10,000 times through a period from claiming a few months. Those biological parts of biosensor interact particularly of the dissect which produces A physical change near those transducer surface. This physical change might be:

1. High temperature discharged alternately Consumed Toward those response (calorimetric biosensors).
2. Generation about an electrical possibility because of changed conveyance about electrons (potentiometric biosensors).
3. Development about electrons because of redox response (aerometric biosensors).
4. Light prepared alternately Consumed Throughout those response (optical biosensors).
5. Transform for impostor of the living part as an aftereffect of the response (acoustic wave biosensors).

Those transducers detect and measures this progress What's more changes over it under an electrical indicator. This indicator being little may be amplified by an enhancer When it may be nourished under the chip. Those indicators may be at that point transformed Also interpreted, also is shown clinched alongside suitableness units. Thus, biosensors change over A compound data stream under an electrical majority of the data flow, which includes the accompanying steps:

a) Those analytes diffuse from the result of the surface of the biosensor.
b) The analyte reacts particularly and proficiently for those living component" of the biosensor.
c) This response transforms those physio-chemical properties of the transducer surface.
d) This prompts A progress in the optical or electronic properties of the transducer surface.
e) Those transform for optical/electronic properties will be measured, changed over under electrical sign which may be amplified, transformed and displayed specimens (Hajian et al., 2016).

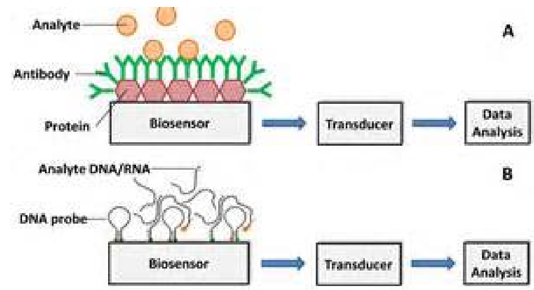

Figure 5: shows biosensor detection process (Bougrini et al., 2016).

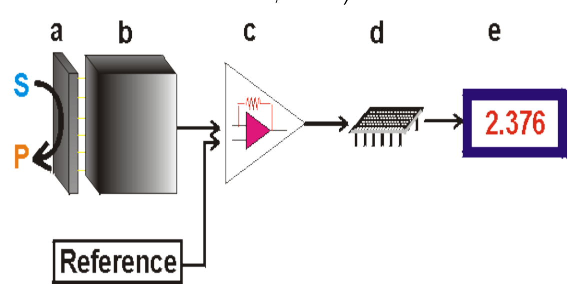

Figure 6: Schematic diagram showing the main components of a biosensor. The biocatalyst (a) converts the substrate to product. This reaction is determined by the transducer (b) which converts it to an electrical signal. The output from the transducer is amplified (c), processed (d) and displayed (e) (Chaplin, 2004).

e) Advantages of biosensor

The biosensors have a set of very specific characteristics and commons. Some of these features are a barrier to overcome in improving these devices. In the eyes of a health professional a biosensor must possess: No reaction with the measured variable, it should allow the analysis of samples with minimal pre-treatment, the answer must be exact, accurate, reproducible and linear over the whole range of analysis, If invasive, the sensor should be small and biocompatible, with no significant toxicity or effects antigens, and In case of use of biocatalysts, they must be highly specific for the purpose of analysis (Gaspar). Previously, an overview of the devices must be: Compact, in The majority applications want

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to be limited in size, reaching scales of the request of millimeters, Easy will handle, Portable or not (depending for usage) (Bartlett & Bradford, 1990). Most are portable which allows a more direct and easy. Implantable or not, responding in genuine time, yet some biosensors due on its characteristics and mechanisms need some time, hours from claiming Holding up. They are expensive, the little size, and manufacturing transducers are specific aspects that expand the cost of these gadgets (Chaplin, 2004). A great biosensor must have in any event a few of the accompanying advantageous features: The biocatalyst must make profoundly particular for the reason for those analyses, be stable under typical stockpiling states and, but on account of colorimetric catalyst strips Also dipsticks (see later), indicate handy solidness through an expansive number about assays (i. E. Significantly more terrific over 100). Those responses if make Similarly as free for such physical parameters Similarly as stirring, ph What's more temperature as will be reasonability (Petropoulos et al., 2016). This might permit those Investigation from claiming specimens for negligible pre-treatment. Though the response includes cofactors or coenzymes these should, preferably, additionally make co-immobilized with the catalyst. Those reactions ought further bolstering be accurate, precise, proliferation What's more straight over the suitable explanatory range, without weakening or fixation. It ought to Additionally make allowed from electrical commotion. If the biosensor is on be utilized for obtrusive checking in clinical situations, those probes must be small Also biocompatible, Hosting no poisonous or antigenic impacts. On it may be to make utilized within fermenters it ought further to bolster make serializable (Hajian et al., 2016). This is preferably performed Eventually Tom's perusing autoclaving However no biosensor proteins might presently withstand such intense wet-heat medicine. Done Possibly case, the biosensor if not be inclined should fouling or proteolysis. Those complete biosensors ought a chance to be cheap, small, transportable Also fit about constantly utilized Eventually Tom's perusing semi-skilled operators. There ought to a chance to be a showcase for the biosensor. There is unmistakably minimal motivation Creating a biosensor in different variables (e. G. Administration subsidies, the proceeded job for talented analysts, alternately poor client perception) urge the utilization for universal techniques Furthermore dishearten those decentralizations from claiming research center testing (Krishnamurthy V, 2010). In short we can say that a successfully biosensor must have at least some of the following features:

a) It should be highly specific for the analyte.
b) The reaction used should be independent of manageable factors like pH, temperature, stirring, etc.
c) The response should be linear over a useful range of analyte concentrations.
d) The device should be tiny and bio-compatible, in case it is to be used for analyses within the body.
e) The device should be cheap, small, easy to use and capable of repeated use.

f) Advanced of biosensors

In biosensor development studies, suitable bioreceptor molecule, suitable immobilization method and transducer should be selected firstly. Biology, biochemistry, chemistry, electrochemistry, physics, kinetics and mass transfer knowledge is required for this study. Thus, we can say that developing a biosensor is related with an interdisciplinary study. Proportional to the technological development and increase of interdisciplinary studies biosensors are being more useful and having more usage areas day by day. Recent development topics which include: electrochemical biosensor, Fiber-optic biosensor, Carbon Nanotube, Protein Engineering for biosensors and Wireless Biosensors Networks (Ahmet Koyun, 2012). In later quite some time incredible Advance need been constructed done applying nanomaterials should configuration novel biosensors. Utilization of nanomaterials offers should bio sensing platforms remarkable optical, electronic Furthermore attractive properties. Nanomaterials could expansion the surface of the transducing range of the sensors that thus achieve an expansion over reactant practices. They bring substantial surface-to-volume ratio, controlled morphological tenet What's more structure that likewise good miniaturization, an intriguing point At those example volume is An discriminating issue (Kurbanoglu, 2011). Micro biosensor Ltd is addressing this need for improved infection monitoring head-on, by offering the market unique, robust and inexpensive diagnostic solutions. Our devices provide continuous safety monitoring, enhancing patient care by allowing earlier intervention than is currently possible. This will improve treatment outcomes and ultimately help in the fight against multi-drug resistance, by improving the management of the remaining arsenal of effective antibiotic drugs (Barker, 2016). Nanomaterials improve the performance of electrochemical biosensors. Carbon nanomaterials can act as electro catalysts or label supports in biosensors. Metal nanomaterials can act as nanostructured supports or labels in biosensors. Magnetic beads are exploited as immobilization supports and/or label carriers (Barker, 2016). Nowadays, those executions about novel innovative platforms to biosensor-based developments may be essential guided of the scaling down for explanatory frameworks Further more bringing down those cutoff points of identification. Fast experimental What's more innovative unrest Advance empowers the provision from claiming biosensors for those web identification from claiming minute focuses about different concoction exacerbates for a totally determination of matrixes and checking greatly low levels for biomarkers Actually On living organic entities Furthermore distinctive phones (Rinken, 2015). Now, there are many studies and experiments in labs of universities and researches center upon biosensors to improve them and to invent supernatural biosensors that may used in environment and medical field. An example for that inventions are many as that study "new biosensor reveals transporter proteins – points towards new antibiotics" which is at technical university of Denmark. Another example for that studies, "new device detects disease before you even have it" Researchers at the University of California, San Diego have unveiled a biosensor chip that detects disease at its earliest stage, right at the genetic mutation. This could be used to screen the blood for early disease detection, to monitor illnesses, and even detect the presence of dangerous microbes or viruses, all in real time. Once implanted, the chip would be able to send information straight to a computer or smart phone, in HD (Perry, 2016). Also, that A new biosensor developed at the Georgia Tech Research Institute (GTRI) can detect avian influenza in just minutes. In addition to being a rapid test, the biosensor is economical, field-deployable, sensitive to different viral strains and requires no labels or reagents. new biosensor could detect Parkinson's, Alzheimer's, and cancer (Ahmet Koyun, 2012), biosensor could detect multiple disease biomarkers in small blood sample (An, Niu, & Zeng, 1998), glow fish: a new biosensor to detect how environmental estrogens affect tissues (Holtcamp, 2012), a new biosensor for rapid oxygen demand measurement, new biosensors for waterborne viruses: progress towards real-time detection of infectious viral particles using surface Plasmon resonance, and new biosensors enable real-time monitoring of chemical production all these naval ideas about advanced of biosensors and they still under studies and collection results.

Figure 7: Printed Sensor Platforms- Advanced of biosensors (Gustafson, 2016).

IV. Result, Discussion, and Rules of Biosensors In Next Generation

Biosensors furnish majority of the data in regards to concoction or physiological forms. Historically, information outputs produced from these units might have been Possibly simple to way alternately total apples and oranges On a design that might have been not helpful to discriminating optional or tertiary Investigation (Hughes et al., 2016). to 2010 the social insurance worldwide advertise for biosensors might have been $15. 4 billion * Also is anticipated will develop because of A climb will be interest for point-of-care diagnostics and monitoring, maturing of the number for its accompanying build in the predominance from claiming incessant disease, expanding social insurance costochondritis What's more unmet social insurance necessities. Us request alone may be needed will develop Toward 7. 7% * yearly for biosensors constantly utilized for orthopedics, neurology, urology, cardiovascular disease, ophthalmologic What's more sound rationale surgery, and the utilization of pills to implantable oncologic seeds Also insulin response (Jain, Nair, & Alam, 2012). Biosensors are found to a totally show of sorts including weight sensors, microphones, accelerometers, gyroscopes, optical What's more picture sensors, microfluidics, stream meters, Also temperature sensors. To addition, gadgets like RFID, strain sensors, vitality collecting units and bio/chemical sensors are quickly rising. * they might be Possibly advanced or analog, including the individuals that could measure temperature, flow, motion, speed, light, barometric pressure, physiologic pressure, humidity, sounds, attractive fields chemicals, Also gasses (Lundstrom et al., 1987). Clinched alongside healthcare, biosensors provide analyses for compound alternately physiological procedures and transmit that physiologic information on an eyewitness alternately to a following gadget. Historically, information outputs produced starting with these units might have been Possibly Simple Previously, nature alternately total apples and oranges to a style that might have been not favorable to incredulous optional alternately tertiary dissection biosensors (Bazin et al., 2017). Biosensors provide certain sway Previously, diagnosing, checking Furthermore looking after wellbeing. Besides those automated, latent alternately animated accumulation from claiming information Furthermore Initially level robotized dissection from claiming that information through could help oversaw economy about Ceaseless and wordy states for example, such that Diabetes, congestive heart Failure, cardiovascular Dysrhythmias. Biosensors likewise assume a paramount part done crashing sound practices for example, such that preventive health, "wellness", or sports projects the place following What's more inclining for physiologic capacities is from claiming fundamental criticalness. Biosensors likewise give the framework for real-time, customize mind oversaw economy projects. cases incorporate pharmacologic clinical trials alternately in-vivo administration about ailment Toward care-givers format (D. N. Robertson et al., 2016). By interfacing majority of the data from biosensors under social insurance it frameworks for example, such that electronic wellbeing records we hope will see upgrades in the ongoing coherence about care, especially around tolerant agreeability and engagement. alert must a chance to be utilized at mixing information created Eventually Tom's perusing the tolerant on the go alternately at home for that gathered On intense or outpatient clinical settings. Issues incorporate gathering sufficient exact Also substantial data clinched alongside an auspicious manner, furthermore security What's more security about data, regardless of who, or where, it hails from, what's more entryway the information will be translated under majority of the data that is clinically profitable for every one stakeholders (Ben-Ari, 2002).

V. Conclusion

A biosensor may be a gadget to those identifications about a systematic that combines a living part with a physicochemical identifier part. A significant number optical biosensors dependent upon the wonder for surface Plasmon thunder are transient wave systems. Those mossy cup oaks broad case of a business biosensor is the blood glucose biosensor, which utilization the catalyst glucose oxidase to break blood glucose down. Bio sensors need aid the blending from claiming bio receptor Furthermore transducer. Those bio receptor is a biomolecule that identifies those focus while transducer changes over the distinguished focus under the measurable sign (Burm et al., 2005). Biosensors need aid utilized within the showcase on Numerous different ranges. They are likewise utilized in the clinical test Previously, a standout amongst the greatest symptomatic advertise for 4000 million to US$ (Bartlett & Bradford, 1990) p. 166. They need aid exceptionally of service should measure those things for incredible correctness. Its speed could a chance to be specifically measured. They would exceptionally basic. Receptors What's more transducer need aid incorporated under solitary sensors without utilizing reagents (Jain et al., 2012). Over the most recent twenty a considerable length of time there need been colossal development in the innovative work from claiming sensors what's more sensor indicator transforming systems. Progresses clinched alongside materials and creation strategies bring prompted a flight from universal sensor sorts and the advancement about novel sensing strategies What's more devices, a significant number for which would presently discovering good over business (Schwartz & Collins, 2007). Novel Sensors Also sensing gives a presentation will current sensor sorts and sensor indicator transforming methods, for accentuation put on the underlying material science and the non-specific operating standards included. It incorporates a survey of the basics from claiming estimation Also defiant What's more blankets those guideline sorts about cutting edge sensor-resonator, semiconductor based, Furthermore optical fiber (counting a review of optical proliferation also transmission (Bhushan, 2008).

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN:0975-5861

Reservoir Simulation Models – Impact on Production Forecasts and Performance of Shale Volatile Oil Reservoirs

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Abstract- Reservoir simulation is an important tool that can be used to simulate as well as predict production from shale reservoirs. The type of reservoir simulation model used, is significant in this process. Black-oil and compositional simulators can be used for reservoir simulation. Black-oil simulations are easier and less time-consuming than compositional simulations. However, how accurate are black-oil simulation results compared to compositional simulation results? Can we afford to jeopardize the accuracy of production forecasts by using easier and less time-consuming reservoir simulation methods? Can the results be trusted to some extent? Single-phase and two-phase black-oil simulation results as well as compositional simulation results were analyzed and compared in this article.

Keywords: reservoir simulation, black-oil, compositional, production forecasting, volatile oil,unconventional resources – shale reservoirs.

GJRE-J Classification: FOR Code: 291899p

RESERVOIRSIMULATIONMODELSIMPACTONPRODUCTIONFORECASTSANDPERFORMANCEOFSHALEVOLATILEOILRESERVOIRS

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Reservoir Simulation Models – Impact on Production Forecasts and Performance of Shale Volatile Oil Reservoirs

Ibukun Makinde [α] & W. John Lee [σ]

Abstract- Reservoir simulation is an important tool that can be used to simulate as well as predict production from shale reservoirs. The type of reservoir simulation model used, is significant in this process. Black-oil and compositional simulators can be used for reservoir simulation. Black-oil simulations are easier and less time-consuming than compositional simulations. However, how accurate are black-oil simulation results compared to compositional simulation results? Can we afford to jeopardize the accuracy of production forecasts by using easier and less time-consuming reservoir simulation methods? Can the results be trusted to some extent? Single-phase and two-phase black-oil simulation results as well as compositional simulation results were analyzed and compared in this article.

Results show that the two-phase black-oil simulations are different and more accurate than single-phase black-oil simulations. As we have no field data to support our assumption, our opinion is based solely on the impact of the gas phase (for two-phase flow) on production performance. Sensitivity studies were carried out with the aid of isothermal single-phase and two-phase black-oil simulations to determine how certain parameters affect production performance of shale volatile oil reservoirs. Also, the effects of fluid compositions on cumulative oil production and oil rates were analyzed using compositional and two-phase black-oil simulations. Results from compositional simulations were different and presumably more accurate than two-phase black-oil simulations. This hypothesis is based on the fact that compositional simulation includes more of the physics that we assume are important in modeling reservoir fluids. Therefore, for thorough analysis of fluid composition effects and improved production forecasts (especially for reservoir fluids like volatile oils in shale formations), compositional simulations are necessary in most cases.

Keywords: reservoir simulation, black-oil, compositional, production forecasting, volatile oil, unconventional resources – shale reservoirs.

I. Introduction

Shale reservoirs, such as the Eagle Ford and Bakken, have emerged as extremely viable sources of hydrocarbon reserves. They do not produce economic volumes of oil and gas without some form of stimulation. There has been a steady increase in productivity of oil and gas from shale plays across the US, due to the emergence of multi-stage hydraulic fracturing and horizontal well drilling technologies. Despite this positive production trend, shale plays have been plagued by relatively low recovery factors in comparison to conventional plays.

This article discusses performance analyses of shale volatile oil reservoirs using different simulation models with the aim of improving production forecasts and overall reservoir management. Why the focus on volatile oils? It is because volatile oils have complex fluid properties that are yet to be fully understood, and the behavior becomes even more complex in shales with nanoscale pores. A better understanding of the fluid properties of volatile oils as well as an appropriate use of reservoir simulation models can help eliminate many errors in reservoir engineering calculations and forecasting. Apart from examining the influence of reservoir simulation models on production performance, Makinde and Lee (2016) also investigated the effect of fluid sampling errors on production forecasts.

As a result of the ever-rising global demand for energy, the importance of shale oil and gas research cannot be overemphasized. A better understanding of volatile oil fluid properties will be a major hurdle crossed in the race to further improve recovery in shale reservoirs. This, without doubt, will positively impact the oil and gas industry. Research and studies like this can lead to improved reservoir management and economics as well as provide insight into potential alternative methods to enhance recovery from unconventional shale formations.

II. Reservoir Simulation Models

In black-oil simulation models, oil and gas are represented by two components – one "component" called oil and the other "component", gas. Here, there is an assumption that produced gas, solution gas, injected and free gas in contact with oil all have the same physical properties. In this model, PVT properties of fluid phases are calculated as functions of pressure only. Therefore, the only inputs necessary for black-oil simulators are tables of PVT properties such as oil

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formation volume factor (FVF), gas FVF, solution gas-oil ratio, viscosity, etc. as a function of pressure.

However, in compositional models, oil and gas phases are represented as multi-component mixtures. Both phases are made up of different amounts of the same components. For example, ethane can be 45% in the gas phase and 7% in the oil phase. Here, the physical properties of the gases are different and the composition of produced gas varies with time. An equation of state is used in this case instead of simple PVT tables.

III. Reservoir Model Description

A reservoir base case model consisting of 8 horizontal wells, with 20 hydraulic fractures spaced 250 ft apart was constructed. The distance between each well is 660 ft, i.e., 330 ft from one well to half adjacent distance of the other. The horizontal well lengths are 5,000 ft. Overall dimensions of the reservoir model are 7,000 ft long, 7,000 ft wide and 250 ft thick. The simulation model is a single porosity system. The fractures are all infinitely conductive. For computational purposes, a fracture width of 2 ft was used. Actual fracture width is about 0.2 inches, but wider fractures make simulation go more smoothly. Fracture permeability is correspondingly reduced to keep the product of width and permeability (of fractures) at an appropriate level. This approach is appropriate because reservoir models with the same fracture conductivity but different fracture widths yield similar results (Alkouh et al., 2012). The initial reservoir pressure is 5,000 psia and the wells produce for 30 years at a minimum bottom hole pressure constraint of 1,000 psia. Figure 1 is a pictorial representation of the base case model after gridding. Tables 1 and 2 show the reservoir data and the model parameters used. Correlations used to generate PVT properties of oil and gas phases, as a function of pressure are shown in Table 3.

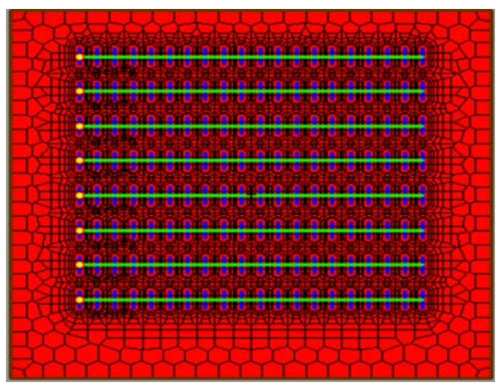

Fig.1: Reservoir Basecase Model (after gridding)

Table 1: Reservoir Data for the Reservoir Basecase Model

Permeability	0.001 md
Porosity	0.06
Reservoir Temperature	250°F
Initial Reservoir Pressure	5,000 psia
Depth to top of formation	10,000 ft
Reservoir Thickness	250 ft
Corey Relative Permeability Exponent	2.5
Critical gas saturation, S_{gc}	0.05
Residual saturation of oil (gas/oil displacement), S_{org}	0.2

Global Journal of Researches in Engineering (J) Volume XVI Issue IV Version I Year 2016

Table 2: Parameters for the Reservoir Basecase Model

Number of wells	8
Distance between wells	660 ft
Horizontal well length	5,000 ft
Fracture spacing	250 ft
Fracture half-length	150 ft
Fracture width	2 ft
Oil API gravity	42°API
Initial solution GOR	1,500 scf/STB
Gas specific gravity (Air = 1)	0.75

Table 3: Basecase Correlations Used for Black-Oil PVT Tables

Oil		Gas	
Property	Correlation	Property	Correlation
Bubble point pressure, p_b	Standing	Z-factor	Dranchuk
Oil viscosity, μ_o	Beggs - Robinson	Gas viscosity, μ_g	Lee et al.
Solution GOR, R_s	Standing	Gas formation volume factor, B_g	Internal[1]
Oil formation volume factor, B_o	Standing	-	-
Oil compressibility, c_o	Vazquez - Beggs	-	-

IV. Single-Phase vs. Two-Phase Black-Oil Simulations

30 years of production was simulated using single-phase (oil) and two-phase (oil and gas) black-oil simulators. The simulations were isothermal and simulation results are for the 8 horizontal wells combined. Figures 2 to 4 show the simulation results comparing single-phase flow with two-phase flow for cumulative oil production, oil recovery factor and average reservoir pressure. There is larger cumulative oil production and oil rate for the two-phase flow than the single-phase flow case. This is likely due to the solution gas drive mechanism in two-phase flow, caused by the presence of the second phase (gas) which is absent in single-phase flow. A higher cumulative oil production correspondingly leads to a higher oil recovery factor for the two-phase flow case. Also, there is lesser pressure drop for two-phase flow compared to the single-phase flow case due to multiphase flow effects.

[1] Internal correlations within the software

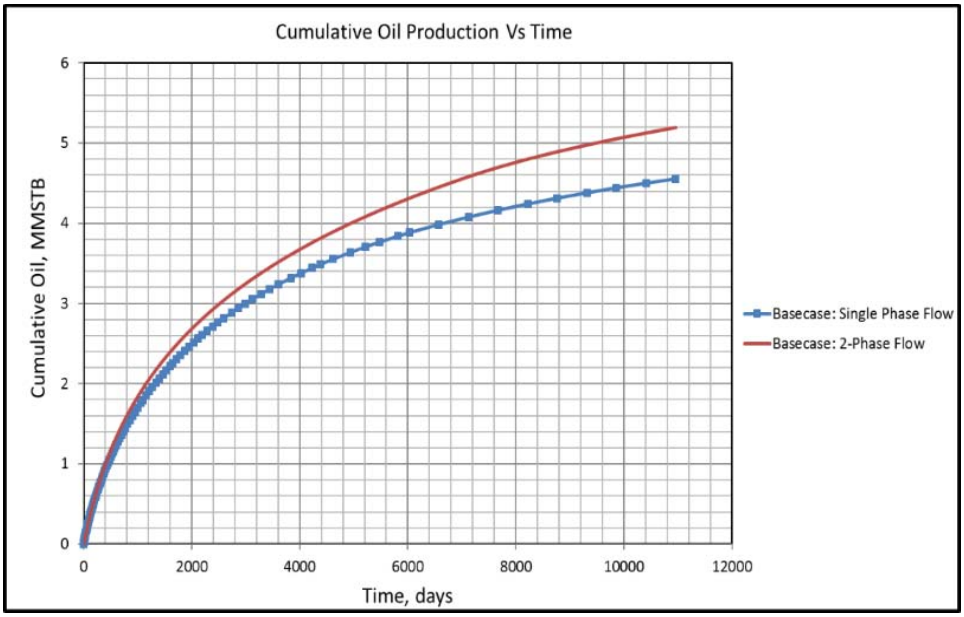

Fig. 2: Single-Phase Flow vs. Two-Phase Flow – Cumulative Oil Production

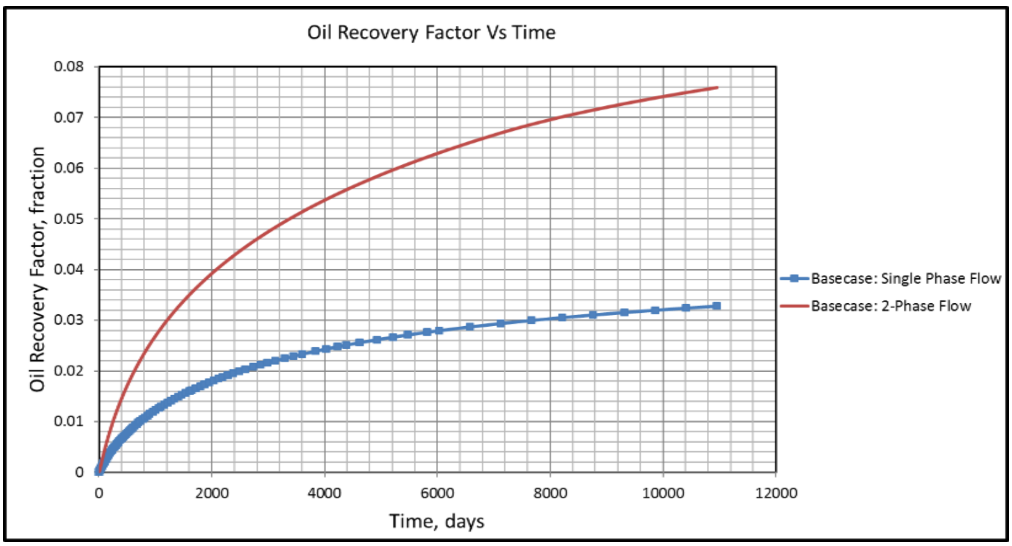

Fig. 3: Single-Phase Flow vs. Two-Phase Flow – Oil Recovery Factor

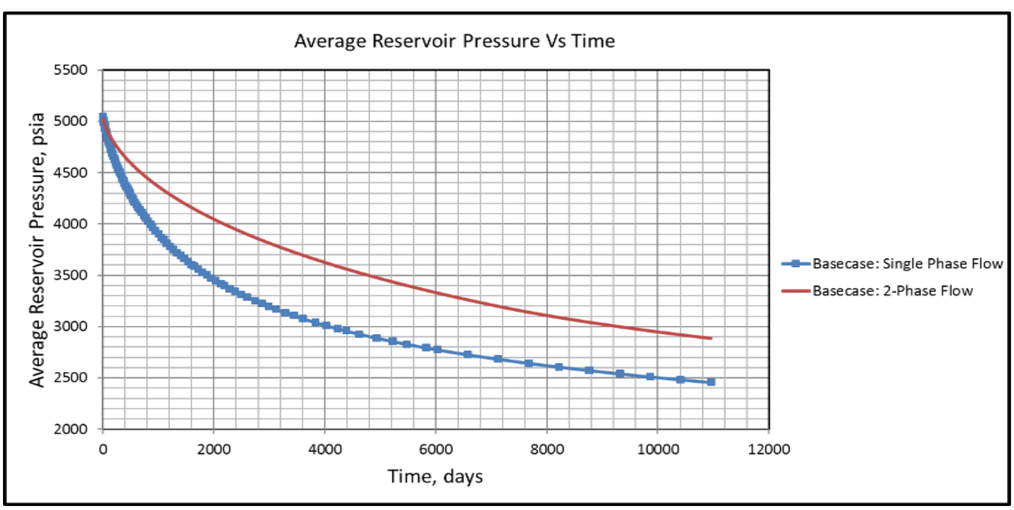

Fig. 4: Single-Phase Flow vs. Two-Phase Flow – Average Reservoir Pressure

V. Sensitivity Analyses – Single-Phase Flow vs. Two-Phase Flow Comparisons

How do certain parameters affect the production performance of shale volatile oil reservoirs when single-phase and two-phase black-oil simulators are used to simulate production? Are the results comparable or do they differ? Sensitivity studies were carried out with the aid of isothermal single-phase and two-phase black-oil simulations. The parameters studied include fracture spacing, fracture half-length, oil API gravity and critical gas saturation. These parameters were varied with other variables in the base case model kept constant.

a) *Fracture Spacing – Single-Phase Flow vs. Two-Phase Flow Comparisons*

Fracture spacing is an important well completion parameter. The fracture spacing used for the base case model is 250 ft (20 hydraulic fractures). Two other cases were considered – 100 ft (50 hydraulic fractures) and 500 ft (10 hydraulic fractures). Figures 5 to 8 show the effect of fracture spacing on cumulative oil production, oil rates, oil recovery factors and average reservoir pressure for single-phase and two-phase flow cases. Simulation results show that closer fracture spacing leads to higher cumulative oil production, higher initial oil rates and higher oil recovery factor for both single-phase and two-phase flow cases. For the oil rate cases, we can observe higher oil rates toward the end of the production period as fracture spacing widens. This is because there is faster drainage of the reservoir with closer fracture spacing, thereby leading to lower oil rates toward the end of the production period in comparison to cases with wider fracture spacing. There is a quicker pressure drop at the beginning of the production period for single-phase flow than for two-phase flow cases. Oil recovery factors, cumulative oil production and oil rates are generally higher for two-phase flow than for single-phase flow cases.

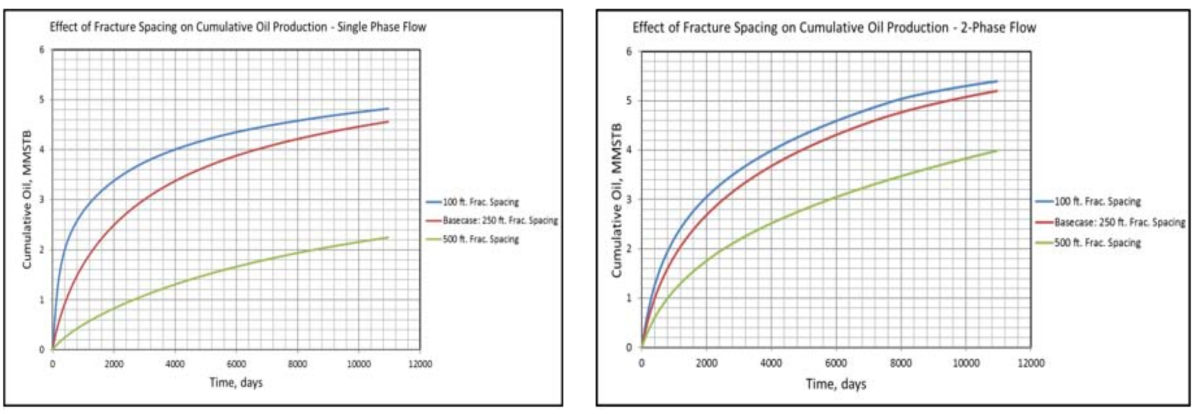

Fig. 5: Effect of Fracture Spacing on Cumulative Oil Production – Single-Phase and Two-Phase Flow Cases.

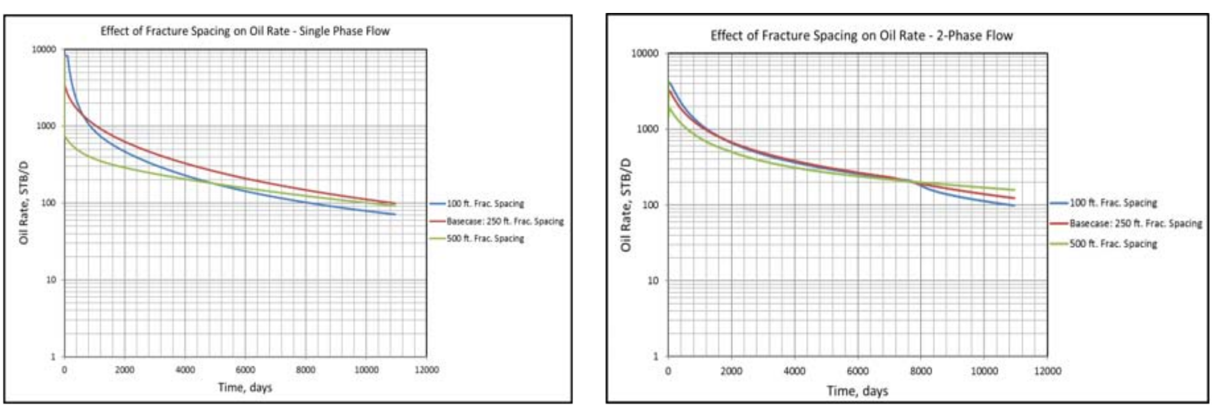

Fig. 6: Effect of Fracture Spacing on Oil Rates – Single-Phase and Two-Phase Flow Cases.

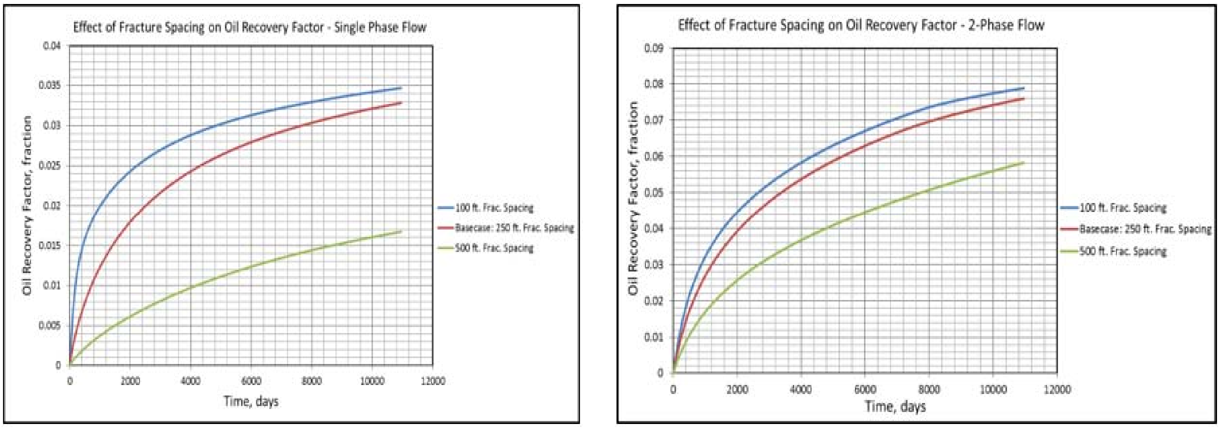

Fig. 7: Effect of Fracture Spacing on Oil Recovery Factor – Single-Phase and Two-Phase Flow Cases.

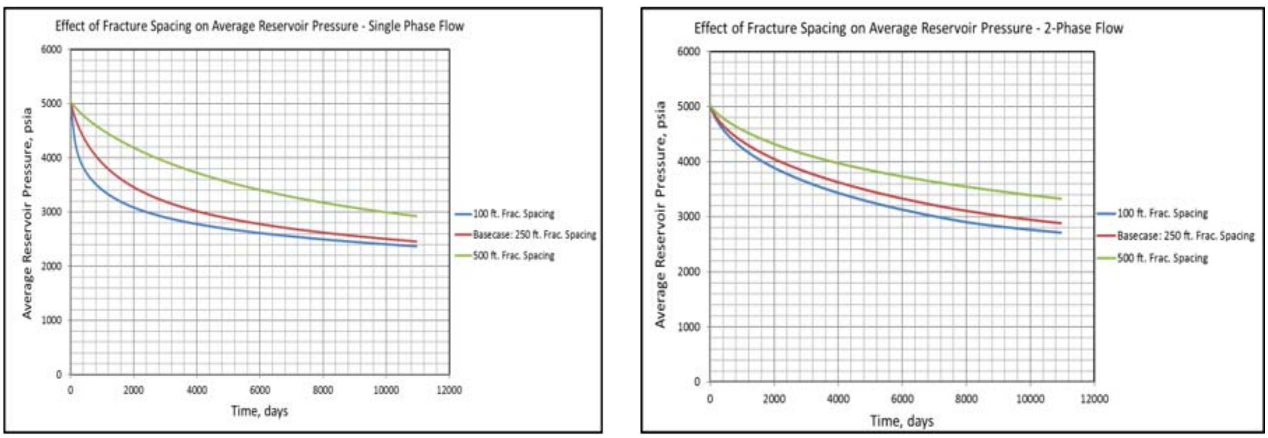

Fig. 8: Effect of Fracture Spacing on Average Reservoir Pressure – Single-Phase and Two-Phase Flow Cases

b) *Fracture Half-Length – Single-Phase Flow vs. Two-Phase Flow Comparisons*

Fracture half-length is the distance from the wellbore to the outer tip of a fracture. Three scenarios were considered here – fracture half-lengths of 100 ft, 200 ft and 300 ft. In the base case model, the fracture half-length is 150 ft. Figures 9 to 12 show the effect of fracture half-length on cumulative oil production, oil rate, oil recovery factors and average reservoir pressure for single-phase and two-phase flow cases. Results show that the larger the fracture half-length, the higher cumulative oil production, oil rate and oil recovery factor for both single-phase and two-phase flow simulations. There is a more rapid pressure drop (that later flattens out) early in the production period for single-phase flow than for the two-phase flow cases. Oil recovery factors, oil rates and cumulative oil production are mostly higher in two-phase flow than the single-phase flow cases.

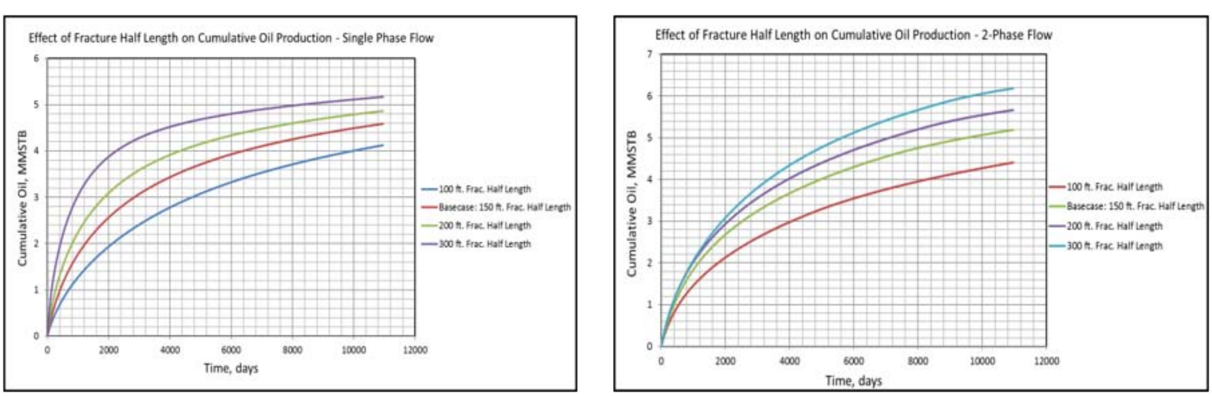

Fig. 9: Effect of Fracture Half-Length on Cumulative Oil Production – Single-Phase and Two-Phase Flow Cases

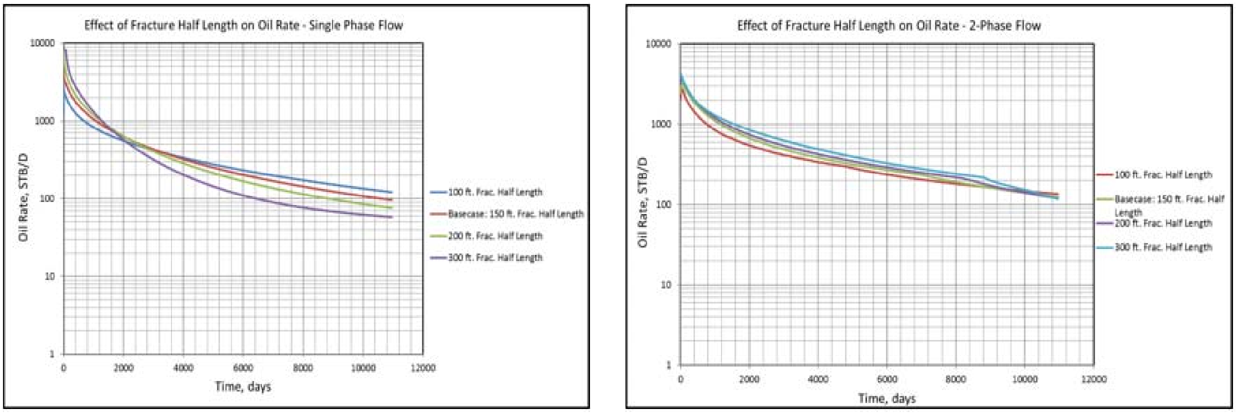

Fig. 10: Effect of Fracture Half-Length on Oil Rates – Single-Phase and Two-Phase Flow Cases

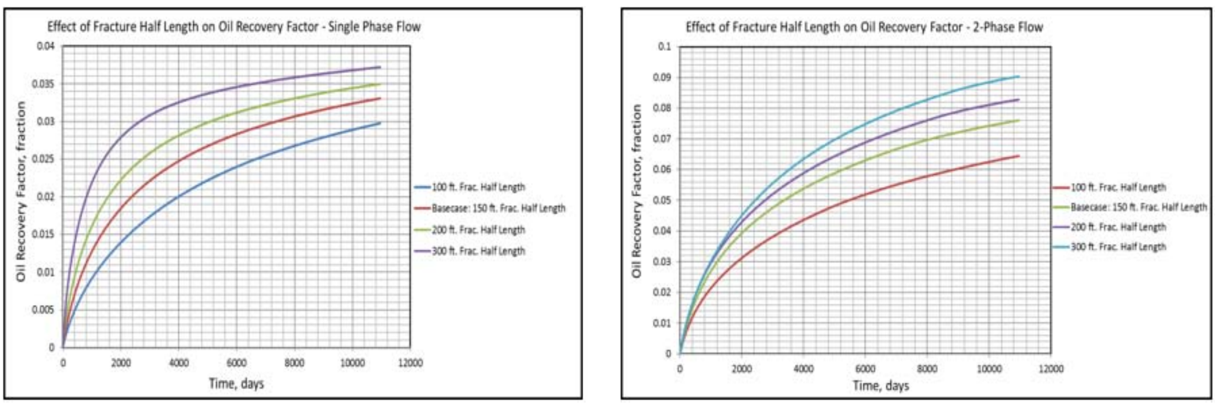

Fig. 11: Effect of Fracture Half-Length on Oil Recovery Factor – Single-Phase and Two-Phase Flow Cases

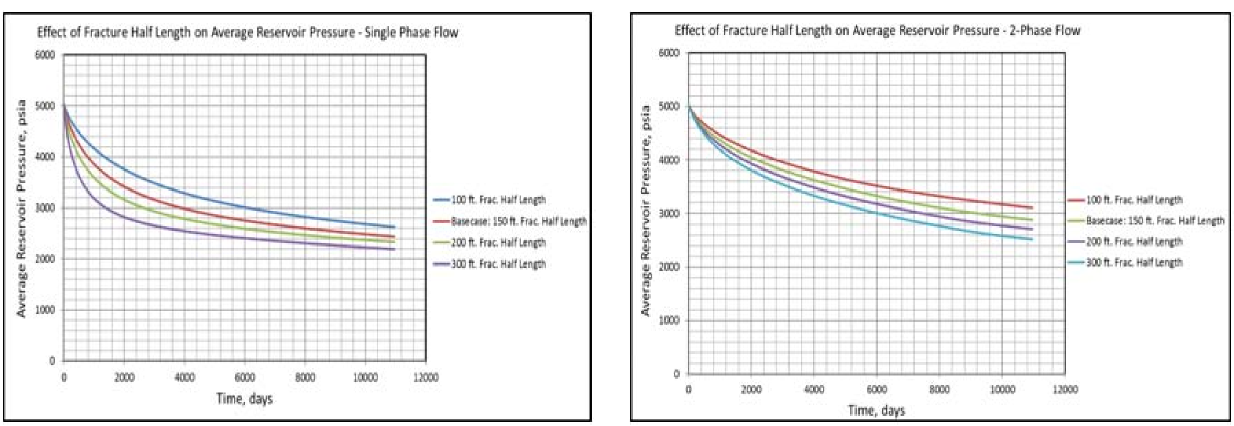

Fig. 12: Effect of Fracture Half-Length on Average Reservoir Pressure – Single-Phase and Two-Phase Flow Cases

c) Oil API Gravity – Single-Phase Flow vs. Two-Phase Flow Comparisons

Oil API gravity is a very important fluid property. It measures the heaviness or lightness of a petroleum liquid in comparison to water. Oil API gravity is inversely correlated to the specific gravity of oil; therefore, heavier oils have low API gravities and lighter oils, higher API gravities. Oil viscosity increases with lower API gravity and it decreases with higher API gravity. Oil API gravity of 42° was used for the base case model. The following oil API gravities were considered for the single-phase flow cases - 38°, 40°, 44°, 46° and 50°API. For the two-phase flow simulations - 38°, 40°, 44°, 46°, 50°, 60° and 65° oil API gravities were used. Two additional cases were added for the two-phase flow simulations in order to further demonstrate the impact of this fluid property on the behavior of shale volatile oil reservoirs. Figures 13 to 16 show the effect of oil API gravity on cumulative oil production, oil rate, oil recovery factor and average reservoir pressure for both single-phase and two-phase flow cases.

For the single-phase flow cases, the higher the oil API gravity, the higher the cumulative oil production and the initial oil production rates. This is because the higher the oil API gravity, the lighter the oil and the lower the viscosity – indicating higher oil mobility. Likewise, the analyses show that the higher the oil API gravity, the higher the oil recovery factor. Also, the lower the oil API gravity, the slower the rate of decline of the average reservoir pressure and vice versa.

Results of the two-phase flow cases provide a good demonstration of shale volatile oil reservoir behavior. As production occurs and reservoir pressure falls below the bubble point, gases start to build up around the wellbore. With time, the increasing gas saturation starts to hinder oil flow to the wellbore – eventually leading to a decline in cumulative oil production. This study illustrates that the higher the oil API gravity, the lower the cumulative oil production. This is shown in Figure 13. The higher the oil API gravity of fluids, the more the lighter components they contain. These lighter components of the fluid contribute to gas saturation around the wellbore, thus decreasing cumulative oil production with time. Table 4 shows actual production forecast data from two-phase black-oil simulations after 30 years of production. This table clearly shows the numerical value of cumulative oil production decline with increasing oil API gravity. Cumulative gas production on the other hand, increases with increasing oil API gravity. Furthermore, Figure 17 shows how average gas saturation increases with increasing oil API gravity. This also corroborates the explanations above on how increasing oil API gravity decreases cumulative oil production. In addition, results from two-phase flow cases show that oil production rates drop with increasing oil API gravity. However, there was an increase in oil recovery factor with increase in oil API gravity, even though above 60°API there was a slight drop in oil recovery factor for the 65°API case. This is shown in Figure 15, indicating that with further increase in oil API gravity above 60°API, oil recovery factor will most likely begin to decline. It is also observed from this study that the average reservoir pressure declines at a faster rate with increase in oil API gravity and vice versa. This is illustrated in Figure 16.

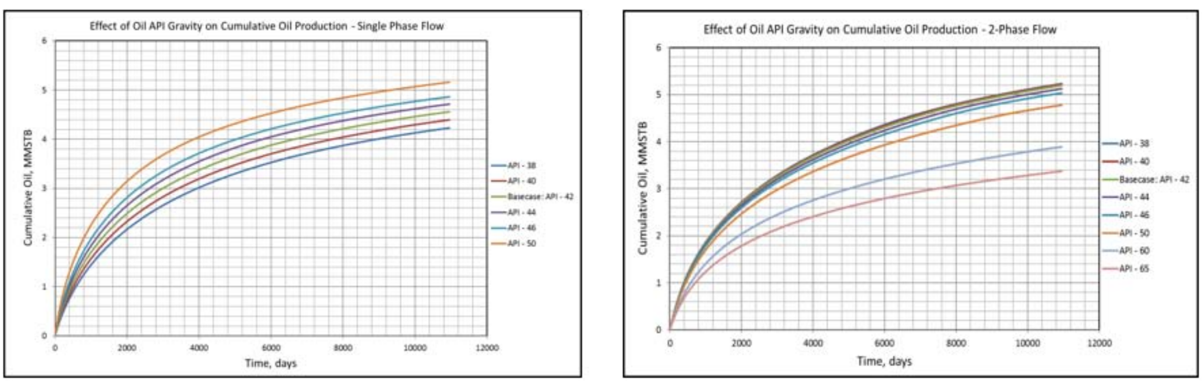

Fig. 13: Effect of Oil API Gravity on Cumulative Oil Production – Single-Phase and Two-Phase Flow Cases

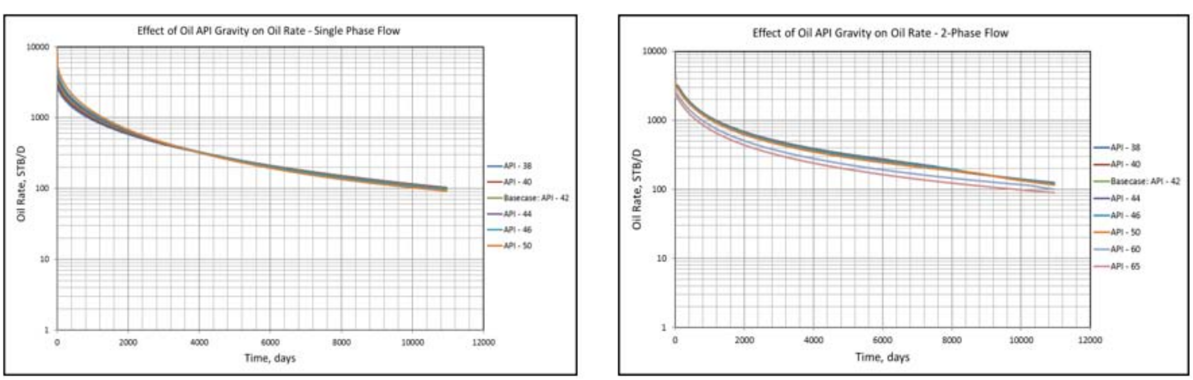

Fig. 14: Effect of Oil API Gravity on Oil Rates – Single-Phase and Two-Phase Flow Cases

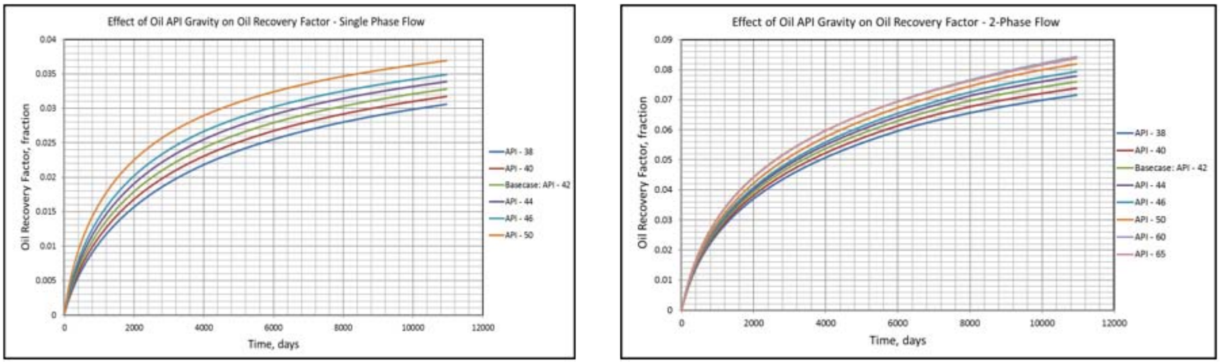

Fig. 15: Effect of Oil API Gravity on Oil Recovery Factor – Single-Phase and Two-Phase Flow Cases

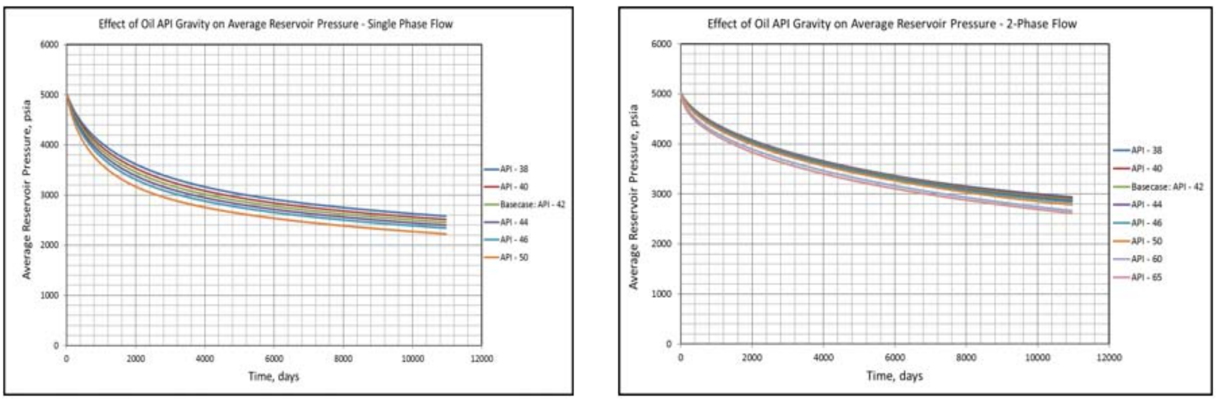

Fig. 16: Effect of Oil API Gravity on Average Reservoir Pressure – Single-Phase and Two-Phase Flow Cases

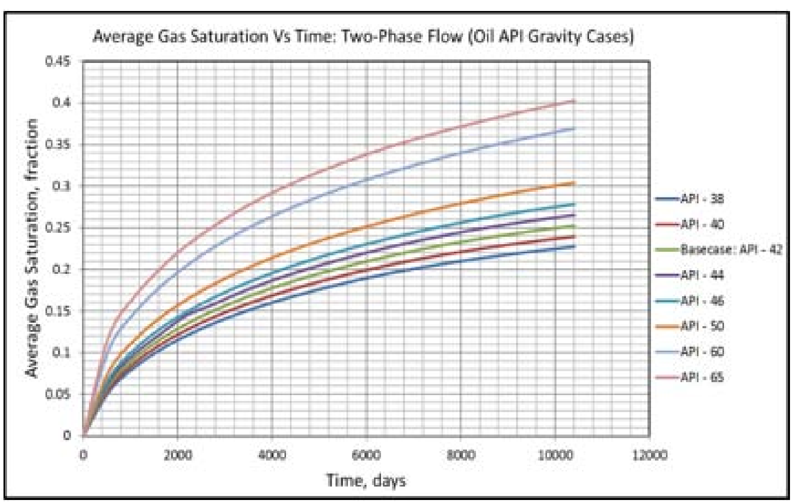

Fig. 17: Average Gas Saturation – Two-Phase Flow Cases

Table 4: Forecast after 30yrs. of Production for Two-Phase Flow (Oil API Gravity Cases)

Oil API Gravity	Cumulative Oil Production, MMSTB	Cumulative Gas Production, bscf
38°API	5.2336	27.4234
40°API	5.2257	28.7767
Base case: 42°API	5.1926	30.1184
44°API	5.1287	31.4301
46°API	5.0368	32.7155
50°API	4.7822	35.1055
60°API	3.8913	39.9792
65°API	3.3757	41.6698

d) Critical Gas Saturation – Two-Phase Black-Oil Simulation Cases

In an oil reservoir, gas evolves out of solution when the reservoir pressure drops below the bubble point. The gas is immobile until it reaches a threshold called the critical gas saturation. At and above the critical gas saturation, the gas phase becomes mobile and begins to flow towards the wellbore. Two-phase black-oil simulations were run with critical gas saturations of 2%, 10%, 15% and 20%. A critical gas saturation of 5% was used for the base case model. Figures 18 to 21 show the effect of critical gas saturation on cumulative oil production, oil rate, oil recovery factor as well as average reservoir pressure.

Results indicate that cumulative oil production increases with increase in critical gas saturation. This can be seen in Figure 18. The higher the critical gas saturation, the longer the gas stays in the pore spaces, thus pushing out more oil before it becomes mobile and starts to flow. Oil recovery factor also increases with increase in critical gas saturation. For the case with 20% critical gas saturation, the oil recovery factor is almost 12%, while it is approximately 7% for the case with 2% critical gas saturation. Figure 20 shows this.

In Figure 19, results show that at early times, a constant production rate was observed for the 20% critical gas saturation case, before decline starts to occur. From the graph, it is also observed that oil production rates decline earlier as critical gas saturation decreases. This is because at lower critical gas saturations, evolved gas becomes mobile earlier, leading to earlier decline in oil rate. This phenomenon is vice versa as critical gas saturation gets higher. It also explains why there is a slightly faster decline in average reservoir pressure as critical gas saturation gets lower. This is observed in Figure 21.

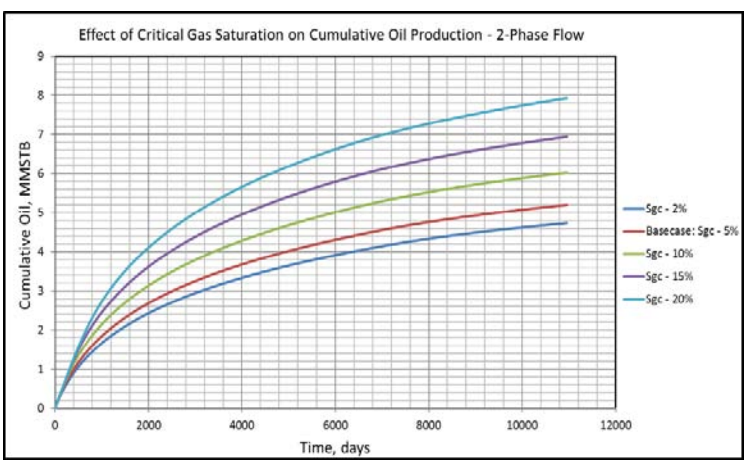

Fig. 18: Effect of Critical Gas Saturation on Cumulative Oil Production – Two-Phase Flow Cases

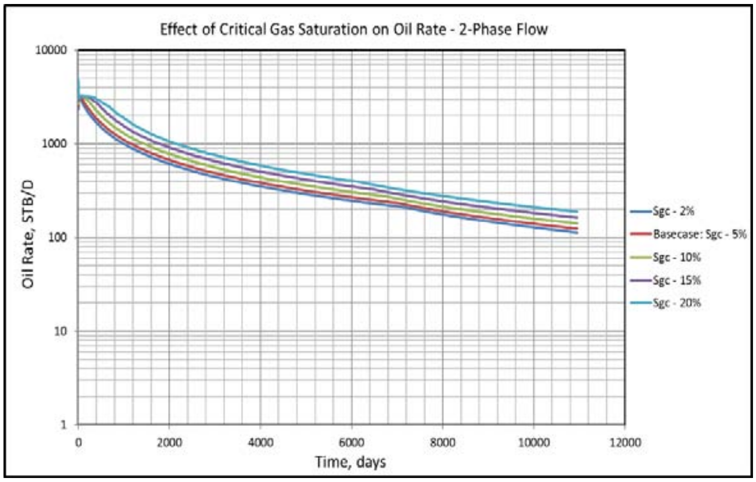

Fig. 19: Effect of Critical Gas Saturation on Oil Rates – Two-Phase Flow Cases

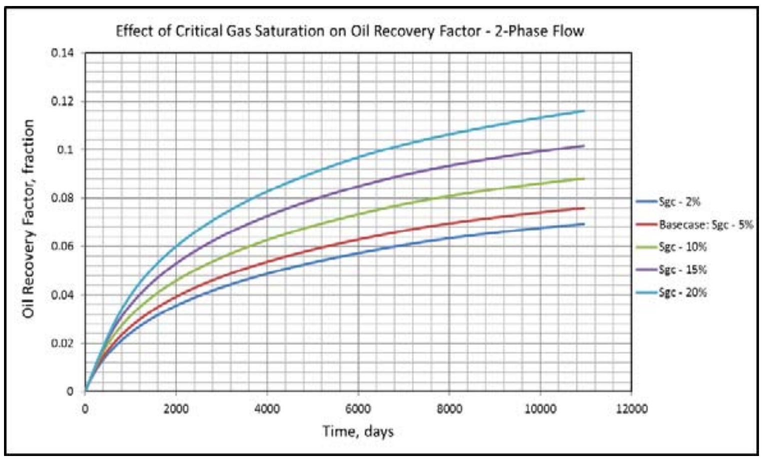

Fig. 20: Effect of Critical Gas Saturation on Oil Recovery Factor – Two-Phase Flow Cases

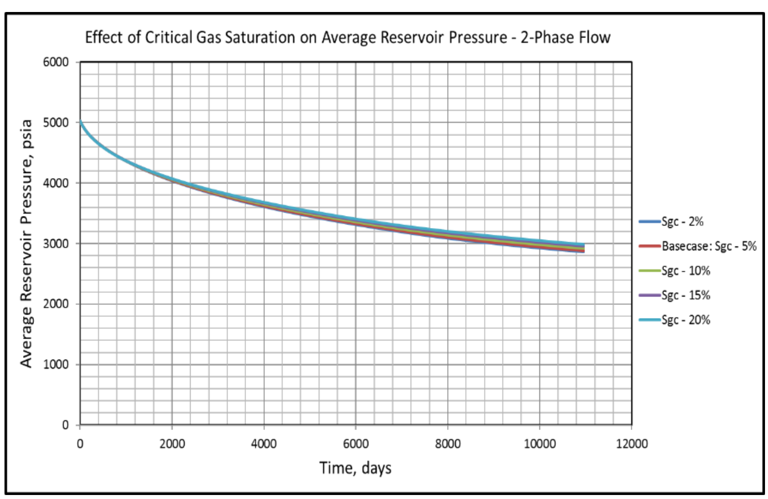

Fig. 21: Effect of Critical Gas Saturation on Average Reservoir Pressure – Two-Phase Flow Cases

VI. Compositional Simulations

Compositional simulations using different 5 different reservoir fluid samples were run for a period of 30 years. All reservoir parameters remain the same, except that in this case, the Peng Robinson equation of state was used for the PVT instead of correlations. The fluid compositions are shown in Table 5. The fluid samples are volatile oils (Fluids 3 and 4 are near-critical fluids). Figures 22 and 23 show the corresponding P-T diagrams for each of the different fluid compositions. The curves represent the two-phase boundaries; the straight lines going through the curves are the isothermal pressure decrease paths during production and the points on the curves are the critical points. The P-T diagrams were generated using the CMG Winprop software. The positions of the isothermal lines usually help us to determine the reservoir fluid type. In many instances, the isothermal line shows the pressure path in the reservoir. In this case, however, the lines just indicate the positions of the reservoir temperature compared to the critical points. Simulation results were compared to determine the effects of fluid composition on production performance of shale volatile oil reservoirs.

Table 5: Fluid Compositions

	Fluid 1	Fluid 2	Fluid 3	Fluid 4	Fluid 5
Components	Composition (%)	Composition (%)	Composition (%)	Composition (%)	Composition (%)
CH_4	58.77	58.07	61.82	53.47	49.43
C_2H_6	7.57	7.43	7.91	11.46	7.28
C_3H_8	4.09	4.16	4.42	8.79	8.02
$I\text{-}C_4H_{10}$	0.91	0.96	1.02	-	2.31
$N\text{-}C_4H_{10}$	2.09	1.63	1.74	4.56	3.61
$I\text{-}C_5H_{12}$	0.77	0.75	0.80	-	1.80
$N\text{-}C_5H_{12}$	1.15	0.80	0.86	2.09	1.79
C_6H_{14}	1.75	1.14	1.21	1.51	2.32
C_{7+}	21.76	22.59	17.59	16.92	22.41
CO_2	0.93	2.32	2.47	0.90	0.16
N_2	0.21	0.15	0.16	0.30	0.87

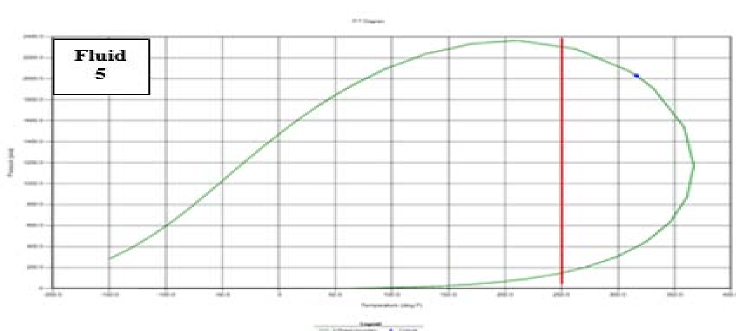

Fig. 22: P-T Diagram – Fluid 5

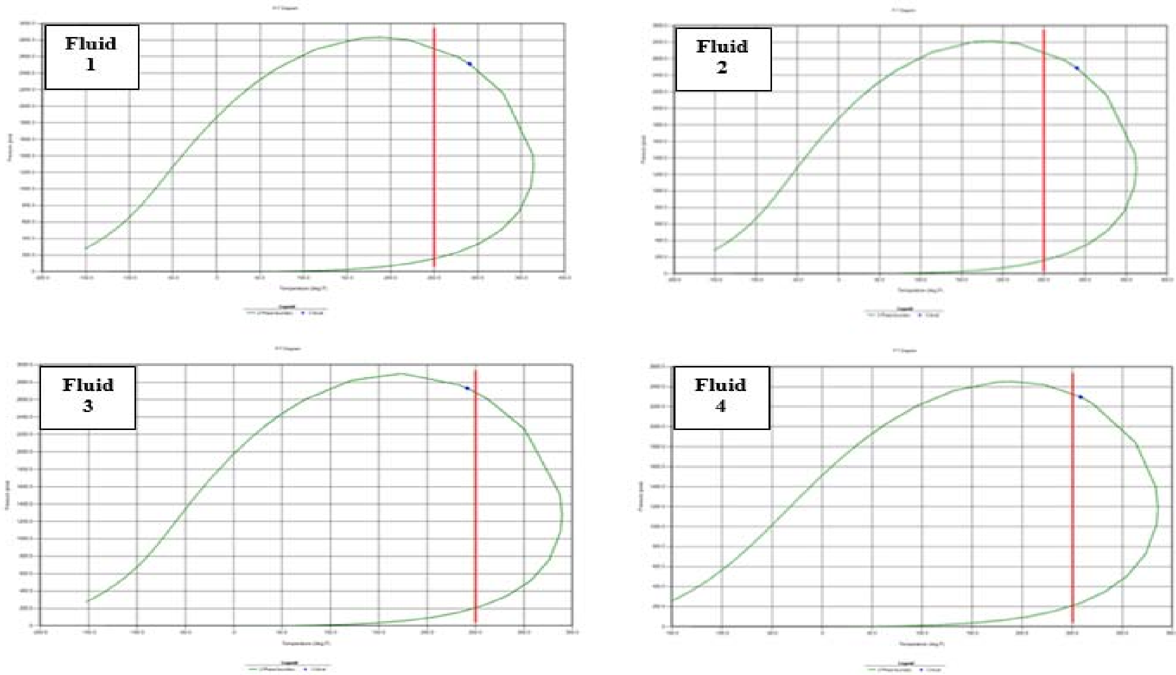

Fig. 23: P-T Diagram – Fluids 1-4

McCain (1994) suggested that the heavy components in petroleum mixtures have the greatest effect on fluid characteristics. Results of this study, however, show the importance of not only the heavy components, but also of the light components, especially methane. Figure 24 illustrates the effect of fluid composition on cumulative oil production and oil rates. Fluid 5, with the smallest methane composition and relatively high (22.41%) C_{7+} composition has the largest cumulative oil production and oil rate whereas Fluid 3, with the largest methane composition and relatively low C_{7+} composition (though not lowest – Fluid 4 has the least C_{7+} composition), has the smallest cumulative oil production and oil rate. Note that, despite the fact that Fluid 4 has a smaller C_{7+} composition than Fluid 3, cumulative oil production and oil rate for Fluid 4 is higher than for Fluid 3. This indicates that the methane composition plays a major role in reservoir performance. Fluids 1 and 2 are similar in composition (methane compositions are almost the same and the C_{7+} compositions are slightly different) – they therefore have almost the same cumulative oil production and oil rates. Fluid 2, with a slightly smaller methane composition and slightly larger C_{7+} composition, has a slightly higher cumulative oil production and oil rate than Fluid 1. Also, Fluids 5 and 2 have almost the same C_{7+} composition (Fluid 5 – 22.41% and Fluid 2 – 22.59%); however, there is a considerable difference in their methane composition [less – (49.43%) in Fluid 5 than in Fluid 2 – (58.07%)] and results indicate much higher cumulative oil production and oil rate for Fluid 5 than for Fluid 2. The trend generally indicates that the smaller the methane composition, the larger the cumulative oil production and oil rate. This clearly demonstrates the importance of the effect of the methane composition on production performance.

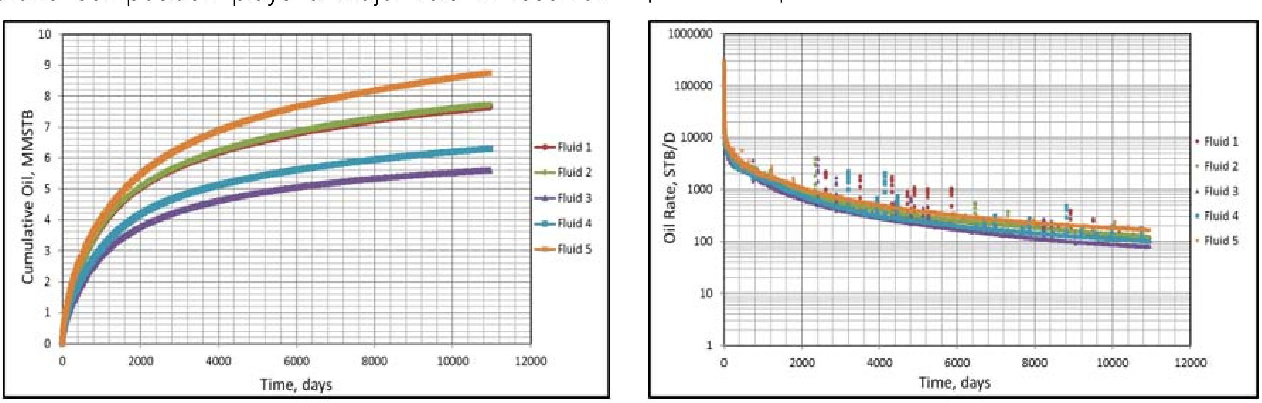

Fig. 24: Compositional Simulations – Cumulative Oil Production and Oil Rate Comparisons

The heavy components affect cumulative oil production and oil rates because the larger the heavy component composition in the reservoir fluid, the more it contributes to the oil phase production and consequently increases the cumulative oil production and oil rate. However, results of this study indicated that apart from the heavy components, the methane component has a large role to play as well. Note that the spikes in the oil rate curves are probably artifacts due to the numerical solver (in the software) used for the simulation. However, disregarding the spikes, the trends can be clearly observed.

VII. Two-Phase Black-Oil Simulations – Standing Correlation

Separator tests were done on the fluids and the results of the flash calculations were used as inputs for two-phase black-oil simulations. Two stages of separation were used, with the stock tank as one of the separators. Separator pressure and temperature were 400 psia and 100°F, while the stock tank conditions were 14.7 psia and 60°F respectively. The results of the flash calculations are shown in Table 6. This was done to provide a reasonable basis for comparison of the compositional simulation and the black-oil simulation results.

Table 6: Flash Calculation Results

	Fluid 1	Fluid 2	Fluid 3	Fluid 4	Fluid 5
Gas-Oil Ratio, SCF/STB	3,024	3,043	4,081	3,967	2,561
API @STC	63.50	63.04	63.52	64.94	65.22
Average Gravity of Total Surface Gas (Air = 1)	0.743	0.753	0.756	0.841	0.851
Oil FVF, RB/STB	3.558	3.551	-	4.806	3.529
Condensate-Gas Ratio, STB/MMSCF	-	-	245.0	-	-
Dry Gas FVF, (ft^3/SCF)	-	-	6.5E-3	-	-
Wet Gas FVF, (ft^3/SCF)	-	-	5.1E-3	-	-
Well Stream Gas Gravity (Air = 1)	-	-	1.246	-	-

First, a case where Standing's correlation was used for bubble point pressure estimates was considered. The simulation results were different from those obtained in the compositional simulations and show no notably observable trends. Figure 25 shows the results for cumulative oil production and oil rates. Fluid 1, in this case, has the largest cumulative oil production and oil rate, while Fluid 5 has the smallest. Incorrect bubble point pressures estimated with the correlations might have led to discrepancies in the results.

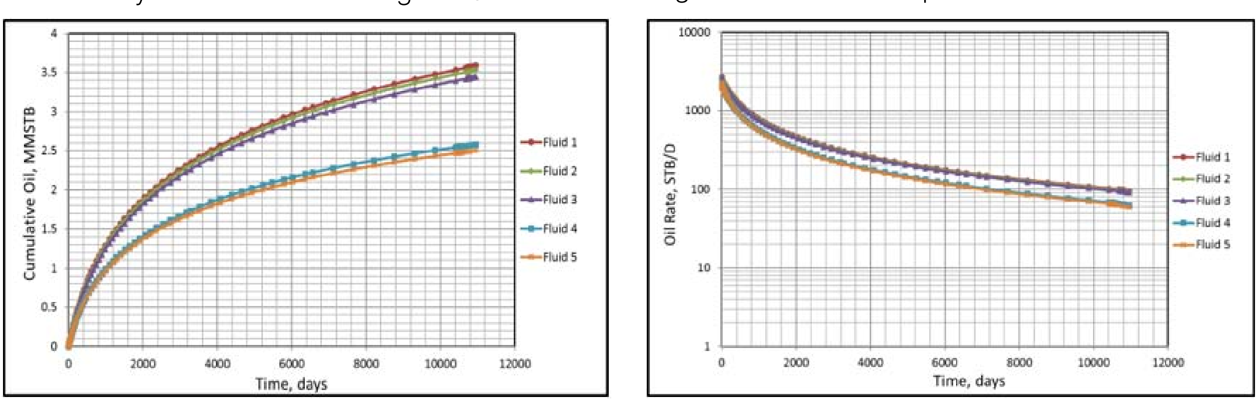

Fig. 25: Two-Phase Black-Oil Simulations – Standing: Cumulative Oil Production and Oil Rate Comparisons

VIII. Two-Phase Black-Oil Simulations – Vazquez-Beggs Correlation

Black-oil simulations were repeated using the Vazquez-Beggs correlation to estimate bubble point pressure. The Vazquez-Beggs correlation is generally applicable and the data used in the development of the correlation covers a wide range of temperatures, pressures and oil properties. Simulation results show similar trends (Fluid 1 – largest cumulative oil production and oil rate and Fluid 5 – smallest cumulative oil production and oil rate) as in cases where Standing's correlation was used to calculate the bubble-point pressure. However, the values of the cumulative oil production and oil rates were relatively larger in this case. The results for cumulative oil production and oil rates are shown in Figure 26.

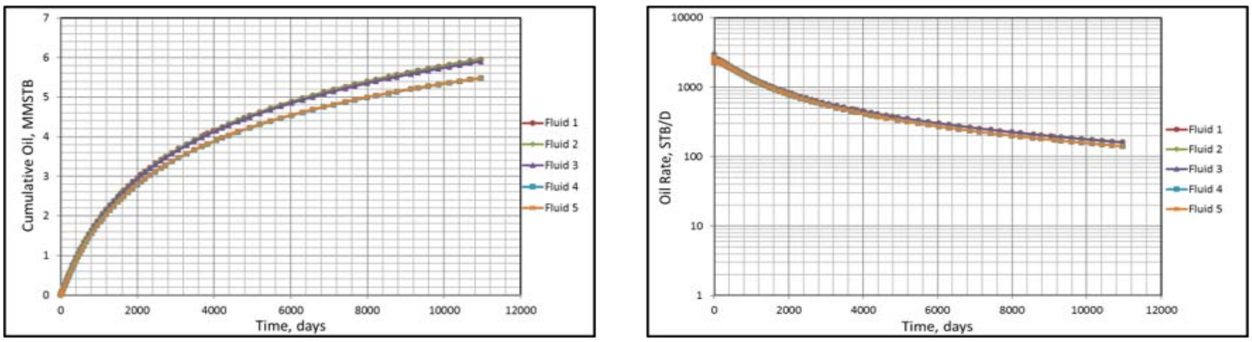

Fig. 26: Two-Phase Black-Oil Simulations – Vazquez-Beggs: Cumulative Oil Production and Oil Rate Comparisons

The inconsistencies in the results for the black-oil simulations are most likely due to inaccurate bubble point estimates using empirical correlations. In Table 7, the approximate bubble point estimates calculated with the Standing and Vazquez-Beggs correlations are shown. Note that the initial reservoir pressure is 5,000 psia. Therefore, the bubble point pressure estimates calculated are higher and lower than the initial reservoir pressure depending on the fluid type considered. Predicted values of bubble point pressure (using correlations) could be in error by 25 percent or more depending on the circumstance (McCain *et al*., 1998). This definitely affects the accuracy of production forecasts.

Table 7: Approximate Bubble-Point Estimates

	Standing	Vazquez – Beggs
Fluid 1	4,870 psia	4,650 psia
Fluid 2	4,870 psia	4,650 psia
Fluid 3	6,150 psia	5,850 psia
Fluid 4	5,270 psia	5,020 psia
Fluid 5	3,570 psia	3,450 psia

IX. Compositional vs. Two-Phase Black-Oil Simulations

Simulation results from the compositional and black-oil simulations were compared for each of the fluid samples under consideration. Results generally show greater cumulative oil production and greater oil rates from compositional simulation than from black-oil simulations. Black-oil simulations using Vazquez-Beggs correlation for calculation of most of the oil PVT properties produced results that are closer to the compositional simulation results than black-oil simulations in which Standing's correlations were used. Therefore, we conclude that proper use of correlations or the development of better correlations for black-oil simulations can lead to results that are close to or almost the same as compositional simulation results. Results of cumulative oil production and oil rate comparisons for Fluid 1 are shown in Figures 27. Results for other fluid samples (except for Fluid 3) are similar to that of Fluid 1.

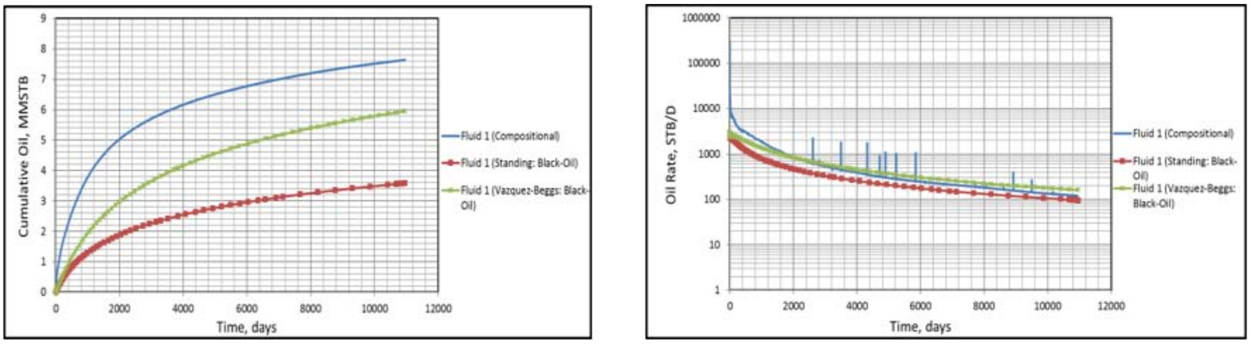

Fig. 27: Compositional vs. Two-Phase Black-Oil Simulations – Fluid 1 Cumulative Oil Production and Oil Rate Comparisons

a) *Near-Critical Fluid: Fluid 3 Case*

Fluid 3 is a near-critical fluid; therefore, an additional simulation was run by modeling it as a gas condensate using modified black-oil (MBO) simulation. MBO simulation of gas condensates takes into consideration the condensate-gas ratio, R_v, which is the amount of vaporized oil in gas.

When Fluid 3 was modeled as a gas condensate (using MBO), the result was similar to the original black-oil simulation case (when modeled as a bubble point fluid using Standing's correlation). When modeled as a bubble point fluid using the Vazquez-Beggs correlation, the cumulative oil production is a little closer to the compositional simulation case except toward the end of the production period. This highlights the difficulties inherent in modeling near-critical fluids, especially when using black-oil simulators with illustrates the results for the cumulative oil production and oil rates.

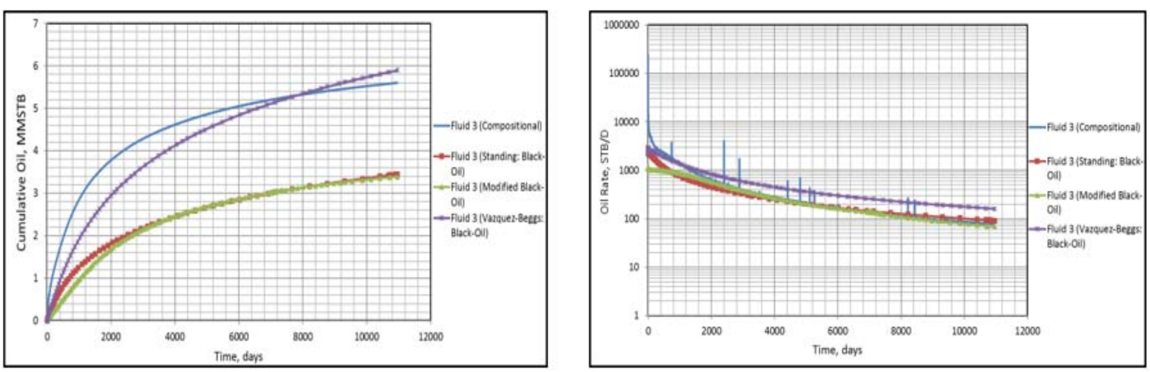

Fig. 28: Compositional vs. Two-Phase Black-Oil Simulations – Fluid 3 Cumulative Oil Production and Oil Rate Comparisons

X. Conclusions

1. Sensitivity studies done with the aid of single-phase and two-phase black-oil simulators, showed that fracture spacing, fracture half-length, oil API gravity and critical gas saturation are important parameters that affect oil production and oil rates in shale volatile oil reservoirs;
2. From the analyses of the oil API gravity cases, it is obvious that imperfect fluid samples (errors in calculation of fluid properties) can have significant impact on oil recovery estimates;
3. The gas phase in two-phase flow has a considerable effect on oil production in shale volatile oil reservoirs;
4. Results from black-oil simulations are markedly different from compositional simulations. Compositional simulations are more accurate than two-phase black-oil simulations, while two-phase black-oil simulations are more accurate than single-phase black-oil simulations;
5. Volatile oil production cannot be properly modeled using black-oil simulations (especially when PVT properties are estimated with empirical correlations);
6. Inaccurate bubble point pressures and PVT properties estimated using correlations can have huge impacts oil production forecasts, whereas identification and use of more appropriate correlations for PVT property estimates can lead to production estimates that can be almost the same as those obtained from compositional simulations;
7. Reservoir engineering calculations for volatile oils should treat the reservoir fluid as a multi-component

mixture, i.e., compositional simulation is necessary for thorough analysis of volatile oil production, especially in shale volatile oil reservoirs;

8. Light components, particularly methane composition in reservoir fluids, can have a substantial effect on shale volatile oil reservoir production performance;
9. Proper identification and classification of fluid samples prior to modeling and simulation is important (especially for black-oil simulations);
10. Near-critical fluids are very difficult to model.

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Global Journal of Researches in Engineering: J
General Engineering
Volume 16 Issue 4 Version 1.0 Year 2016
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN:0975-5861

Effect of Impeller Blade Slot on Centrifugal Pump Performance

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Abstract- The effect of impeller backward blades with slot on the centrifugal pump performance has been investigated numerically. Impeller blades have been modified with different geometrical parameters of slot such as: slot radial position (Rs), slot height (h_s) and slot inclination angle (θ_s). 3-D numerical simulation has been carried out using commercial software, ANSYS® CFX, to study the effect on the pump performance at different flow rates. The numerical simulation has been compared with previously published experimental results to verify the numerical solution. In addition, the results have been compared with the impeller without slots for the same operating conditions. It has been shown that the slot parameters have a significant effect on the centrifugal impeller performance.

Keywords: computational fluid dynamics (CFD), blade slot, centrifugal pump performance.

GJRE-J Classification: *FOR Code: 099999*

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I. Introduction

Centrifugal pumps are probably among the most often used machinery in industrial facilities as well as in common practice. After being invented, they passed long evolutionary way until they became accessible for various applications. A few centuries ago, Euler described their physical principle through a well-known equation named after him "Euler's equation for turbomachinery".

Since then, many studies have been conducted to improve the centrifugal pump performance. These studies used a lot of methods and ideas seeking a better centrifugal pump performance through attempts to increase the pump total efficiency and slip factor.

One of these methods that took a lot of interest was to improve the pump performance by impeller trimming [1-4]. These studies found that as the diameter is reduced, the head and power curves decrease continuously. The efficiency, however, will increase at first and then drop for a certain value of diameter. The main reason for this might be attributed to the growth of the gap between the impeller and stator as the impeller diameter is reduced.

Another attempt to improve the centrifugal pump performance lies in adding splitter blades between the main blades [5-7]. Unfortunately, such solution was found to render negative and positive effects on the pump behavior. It increases the head as compared to the original impeller. This was explained by the fact that increasing the impeller slip factor in effect of the splitter would help better conduct energy to the flow. However, a drop in total efficiency has been noticed in some cases due to the increase of the hydraulic friction between the pumping fluid and the splitter blades.

The pump geometrical parameters remain the greatest interest of all researchers looking for improving the centrifugal pump performance. Some authors made optimization on the blade exit angle and they found that with increasing the blade exit angle the head increases but the efficiency decreases [8-12]. Some other authors conducted optimization on the number of blades [13-15]. They concluded that when increasing the number of blades, both head and efficiency increase until a certain number of blades at which the efficiency decreases. Other authors considered the blade outlet width in their optimization research [16, 17]. It was found that at the design flow rate, the head increases gradually with the progressive increments of blade outlet width. In addition, the high efficiency area in the large flow rate region gets bigger and the area in low flow rate region changes a little with the increase of blade outlet width.

Some authors tried to improve the pump performance by making a slot in the impeller blade. The first one who start adopting this technique was E.A. Ahmed [18, 19]. Then, M. Saffaa and his group [20-22] developed this work using their own 2-D numerical code to solve a laminar flow inside the pump impeller. In an attempt to examine the effect on the pump performance, Hongxun [23] used a similar technique and made a comparison between the draughting technique and the splitter blades.

In the present work, a parametric study is attempted, based on the blade slot technique to investigate the effect of three slot geometrical parameters, namely slot radial position (Rs), slot height (h_s) and slot inclination angle (θ_s) on the impeller performance. The study implements a 3-D numerical simulation of turbulent flow inside the centrifugal impeller.

II. Computational Model

a) Geometrical Models

The centrifugal pump impeller used by [20, 24], shown in Figure (1), is chosen as a geometrical model to apply numerical computation. The main metrics of pump design and performance are listed in Table (1).

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Table 1: Pump dimensions and operating conditions

Operating Flow Rate (Q)	3.25 liter/s	Blades Number (Z)	6
Head (H)	6.5 m	Blade discharge angle (β_2)	20°
Rotational Speed (n)	1500 rpm	Blade inlet angle (β_1)	35°
Impeller Inlet Diameter (D_1)	50 mm	Blade Outlet Width (b_2)	12 mm
Impeller Outlet Diameter (D_2)	130 mm	Blade inlet Width (b_1)	15 mm

The flow patterns and the hydraulic performance of the isolated impeller (without volute) must differ from that of the impeller with volute [25]. This difference is due to impeller-volute interactions. In this work, only an isolated impeller has been considered. This is justified by the need to simplify the present study that is considered as a preliminary investigation.

Figure 1: Centrifugal impeller with backward blades

Two geometrical models have been generated as shown in Figure (2). Model MI represent the impeller without slot. Model M2 represent the impeller with slot. The slot has three parameters have been varied: the slot radial position (R_s), the slot height (h_s) and the slot inclination angle (θ_s). Slot inclination angle is measured between slot axis and the local tangent to a circle with radius equal to the slot radial position.

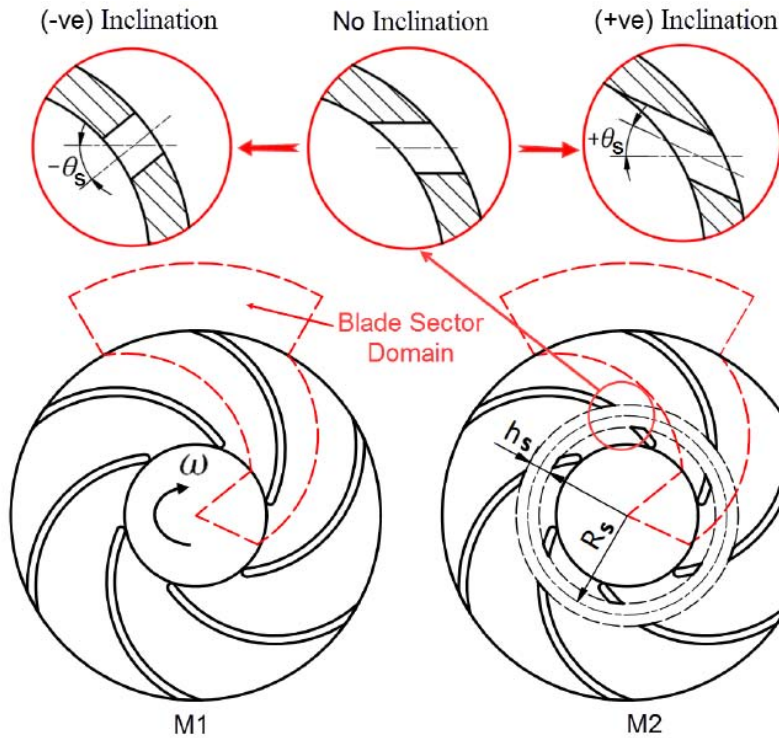

Figure 2: Two geometrical models: M1 impeller blade sector without slot, M2 impeller blade sector with slot.

b) Governing Equations

Numerical simulation is carried out using ANSYS® CFX to solve the governing equations. Since the pumped fluid is incompressible and the flow is in a steady state, the continuity equation has the following form[26]:

$$\frac{\partial u_i}{\partial x_j} = 0 \quad (1)$$

In addition, the equation of conservation of momentum together with the definition of the source term, and the shear stress is expressed as Eq. (2)

$$\frac{\partial}{\partial x_j}(\rho \bar{u}_i \bar{u}_j) = \frac{-\partial \bar{P}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\bar{\tau}_{ij} - \rho \overline{\acute{u_i} \acute{u_j}}\right) + S_{u_i} \quad (2)$$

where the source term (including the centrifugal and Coriolis force terms) is written as Eq. (3) and the average shear stress is obtained from Eq. (4):

$$S_{u_i} = -\rho[2\,\vec{\omega} \times \vec{u} + \vec{\omega} \times (\vec{\omega} \times \vec{r})] \quad (3)$$

$$\bar{\tau}_{ij} = -\mu\left(\frac{\partial \bar{u}_i}{\partial x_j} + \frac{\partial \bar{u}_j}{\partial x_i}\right) \quad (4)$$

c) Computational Domain

The computational domain consists of three zones: inlet, impeller and outlet as shown in Figure (3). They are defined by means of the multi-reference frame technique. The impeller is situated in the rotating reference frame, the inlet and outlet zones are in the fixed reference frame, and they are related to each other through the ‘‘frozen rotor’’ interface. The frozen rotor method [26] employs a quasi-steady algorithm, where the rotor and stator are modeled at a fixed (frozen) position relative to each other. Rotational terms are included in the moving frames, while the transient effects are neglected. This provides an efficient method for the calculation of interactions between impellers and outlet zone, and is a practical option for compact machines with small distances between rotor and stator. In this way, the solution provides a snapshot of the flow regime. When the Navier–Stokes equations of motion are solved in a rotating reference frame, the fluid accelerations due to rotation appear as an additional terms in the momentum equations, Eq. (3).

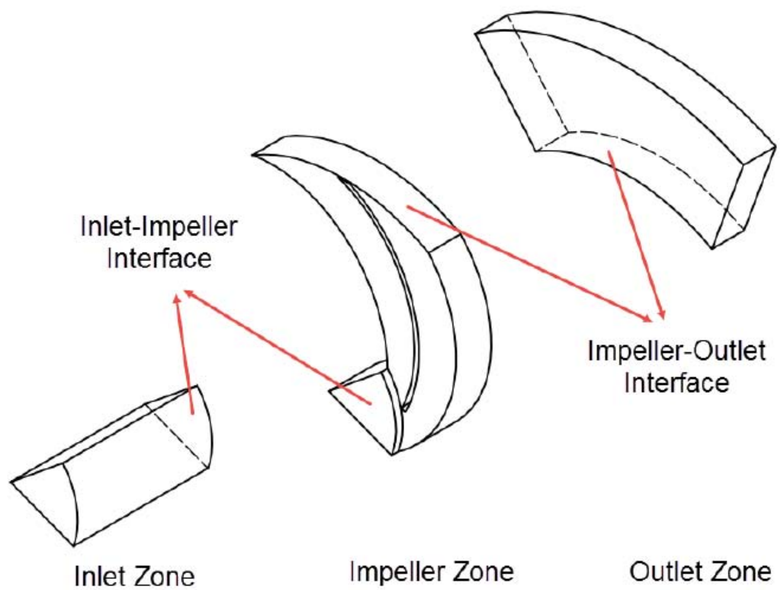

Figure 3: Computational Domain (inlet-impeller-outlet) zones

d) Domain Discretization

The meshes of three computational domains - the inlet section, the impeller, and the outlet section – are generated separately after performing mesh sensitivity analysis as shown in Figure (4). In this analysis, localized refinements of mesh are employed at regions close to the blade slot, the impeller blade and the blade leading and trailing edges in order to accurately capture the dominant flow field structure.

The motive of this localized mesh refinement is to encounter considerable variations of flow field properties such as pressure and velocity at those regions.

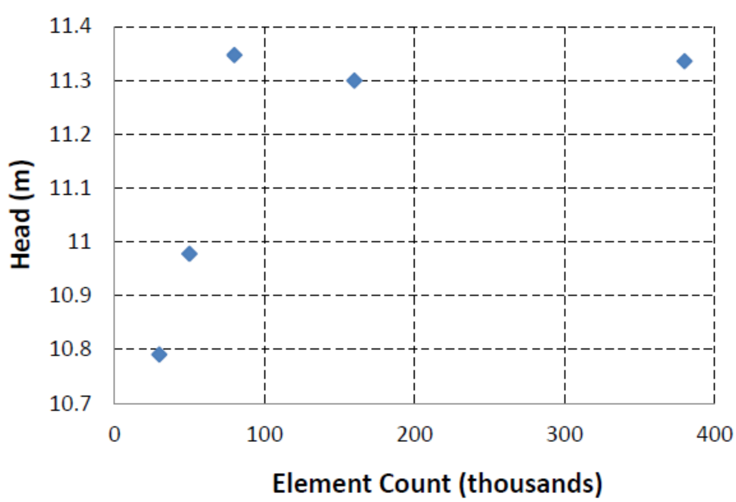

Figure 4: Result of mesh Sensitivity Analysis (Q = 3 liter/s)

The inlet and outlet section domains include 2550 and 9150 hexahedrons elements, respectively, while impeller and slot domain include 96603 and 11312 tetrahedrons elements, respectively, Figure (5). To cope with the complicated domain topology a combination of structured and unstructured grids is used.

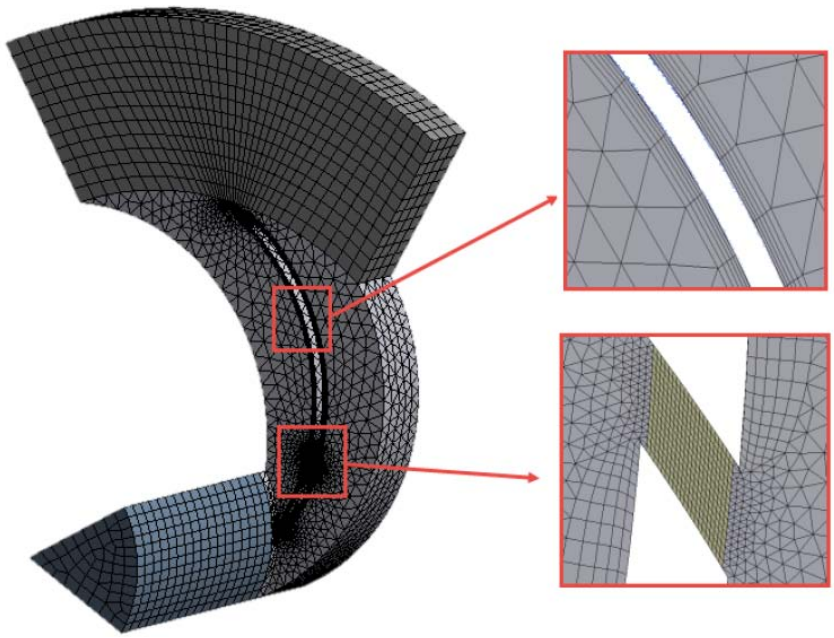

Figure 5: Inlet, impeller and outlet domain mesh

e) Boundary Conditions and Zones Interface

The boundary conditions are set as mass flow at inlet and the static pressure at outlet. A rotational periodicity is adopted at the other outer boundaries of the domain. A no-slip condition is imposed at the wall boundary defined at the blade. The impeller zone is modeled in the rotating frame, and the outlet and the inlet zones are modeled in the fixed reference frame. Figure (6) illustrate the definition of the boundary conditions.

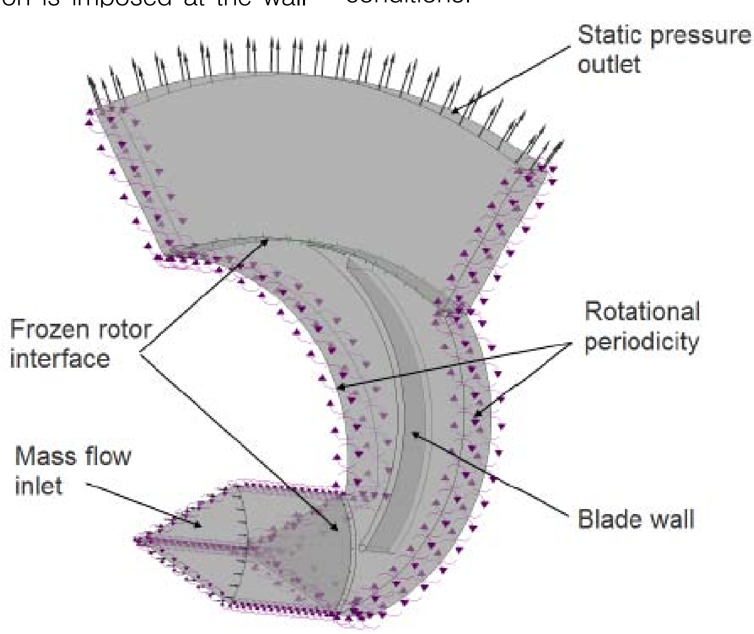

Figure 6: Boundary conditions and zones interface

f) Turbulence Model

With the help of the mixing function value, the shear stress transport (SST) model automatically uses the $k-\omega$ model in the near-wall regions and the $k-\varepsilon$ model in the regions away from the wall. This model modifies the energy production term in the kinetic energy transfer equation [27]. Considering the studies conducted on the two models of $k-\varepsilon$ and RNG $k-\varepsilon$, it is concluded that the near-wall flow can be evaluated with high precision using the $k-\varepsilon$ model and the SST function. The obtained results show better accuracy than those of the $k-\varepsilon$ model alone. Therefore, the SST turbulence model is used for the numerical investigation of flow inside the centrifugal pump.

g) Convergence Criteria of the Numerical Simulations

The numerical solution has convergence precision of residuals up to 10–6. Figure (7) shows the history of convergence.

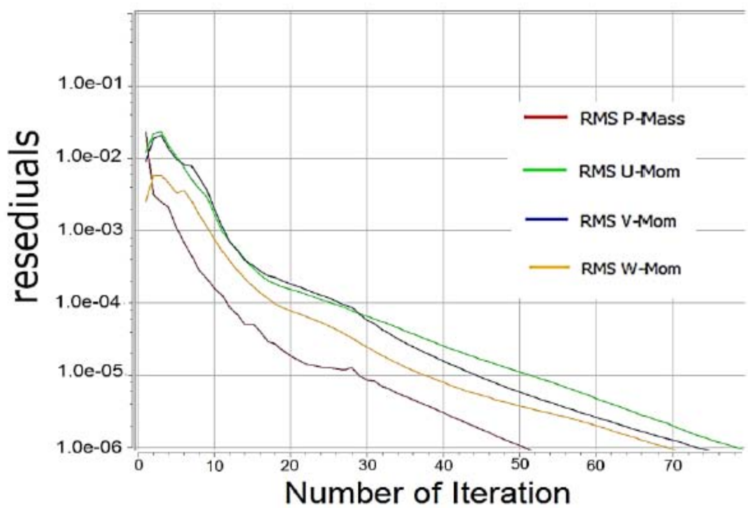

Figure 7: Residual history versus number of iterations

III. Validation of the Numerical Simulation

The comparison between the experimentally measured impeller performance with and without blade slot in reference [20] is used to validate the present study. The pump with slot has the following parameters: slot radial position Rs = 35 mm, slot height h_s = 8 mm and the inclination angle θ_s = 0° at rotational speed n = 2000 rpm.

Here, the pump head and hydraulic efficiency are calculated according to reference [28] by using Eq. (5) and Eq.(6), respectively

$$H = \frac{P_{t_{out}} - P_{t_{in}}}{\rho g} \qquad (5)$$

$$\eta_{h_{imp}} = \frac{\frac{\dot{m}}{\rho}(P_{t_{out}} - P_{t_{in}})}{T \cdot \omega} \qquad (6)$$

Figure (8) and Figure (9) show the variation of the impeller head and hydraulic efficiency with flow rate, respectively, for both impellers with and without slot. Experimental measurement show that the slot with the parameters of reference [20] reduces the impeller head. The slot shows a minor impact on the efficiency however, adding the slot increases the efficiency below the operating point and reduces the efficiency beyond the operating point. These effects of adding slot could be explained by the considerable reduction in the effective blade length and augmentation of flow rate through the slot, which in this case represents about 17% of the design flow rate.

Despite the apparent discrepancy between experimental and numerical results, the numerical simulations predict the same trend of head and efficiency. They also predict the same effect of slot on pump head at all flow rates and efficiency at high flow rate only. This discrepancy could be attributed to the omission of the volute and leakage effects in the numerical simulation.

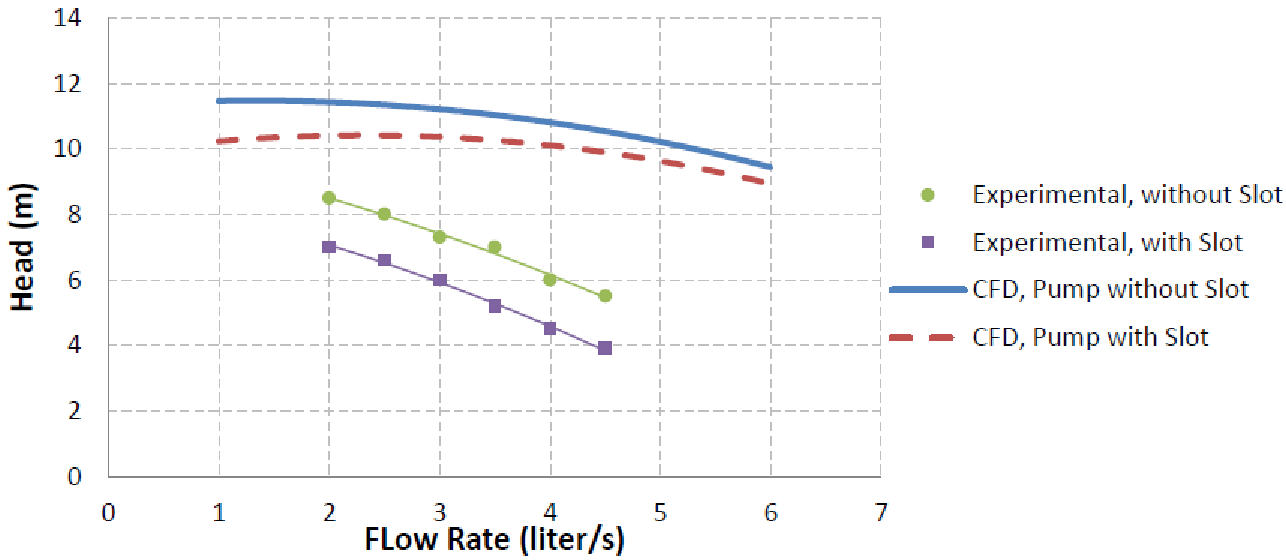

Figure 8: Pump characteristics with and without slot

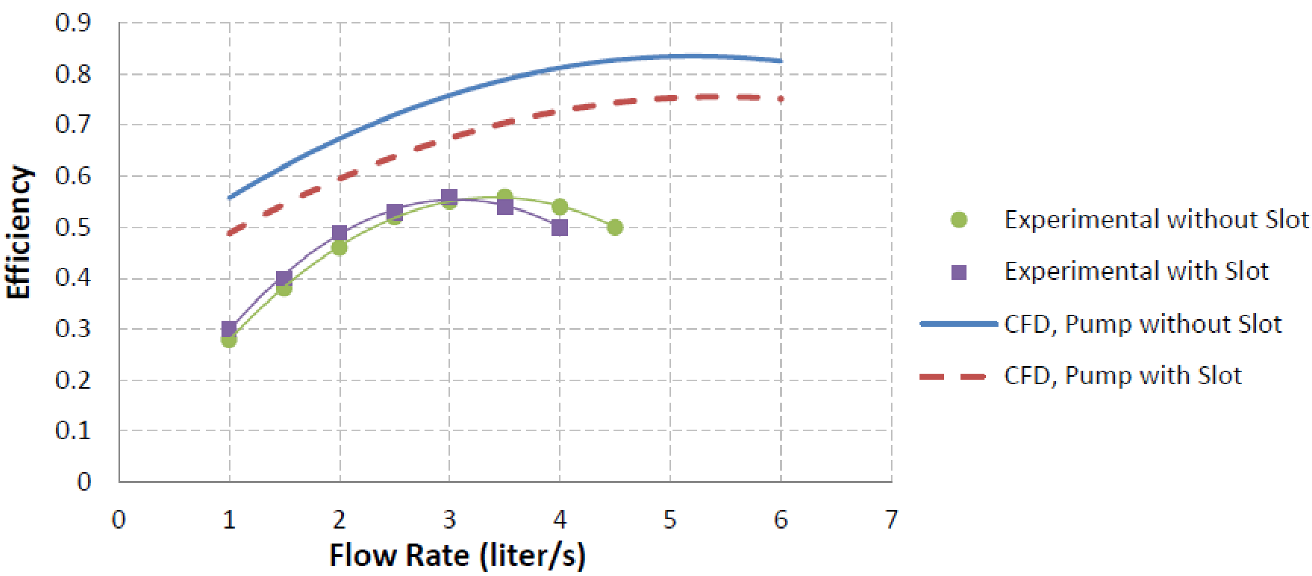

Figure 9: Pump efficiency with and without slot

The velocity vectors at two different flow rates are investigated; Q = 1 liter/s, at part-load condition and Q = 3.5 L/s at the best efficiency point. In Figure (10), the velocity vectors for part load condition indicate two circulations: the first one is created on the pressure side near the impeller outlet with a small size and high velocity. The second one is created on the suction side with large size and small velocity. The flow enters the impeller at an angle of attack causing the suction side circulation. In the presence of the slot, the fluid flowing throughout the slot reduces the size of the suction side circulation. Figure (11) indicates the absence of the two circulations. When increasing velocity the pressure side circulation dies out, and when the angle of attack approaching zero the suction side circulation is disappears.

The static pressure contours are also investigated at the flow rate Q = 3.5 liter/s. Figure (12) Shows the contours of the static pressure of the impeller with and without blade slot.

In conclusion, the head decreases at large values of the slot height h_s. Therefore, in the present study, attention will be directed to a smaller slot height h_s, together with a new parameter, namely the slot inclination angle θ_s.

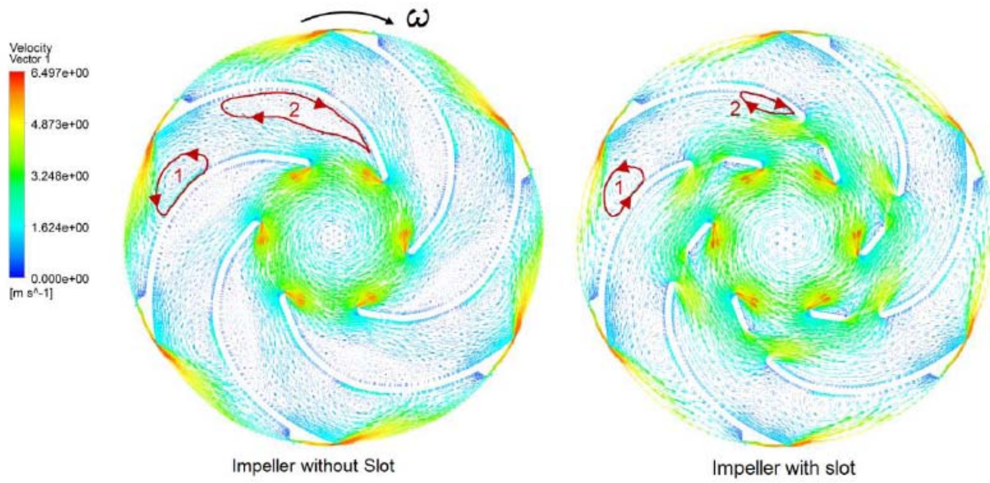

Figure 10: Impeller relative velocity vector at flow rate Q=1 L/s on mid span

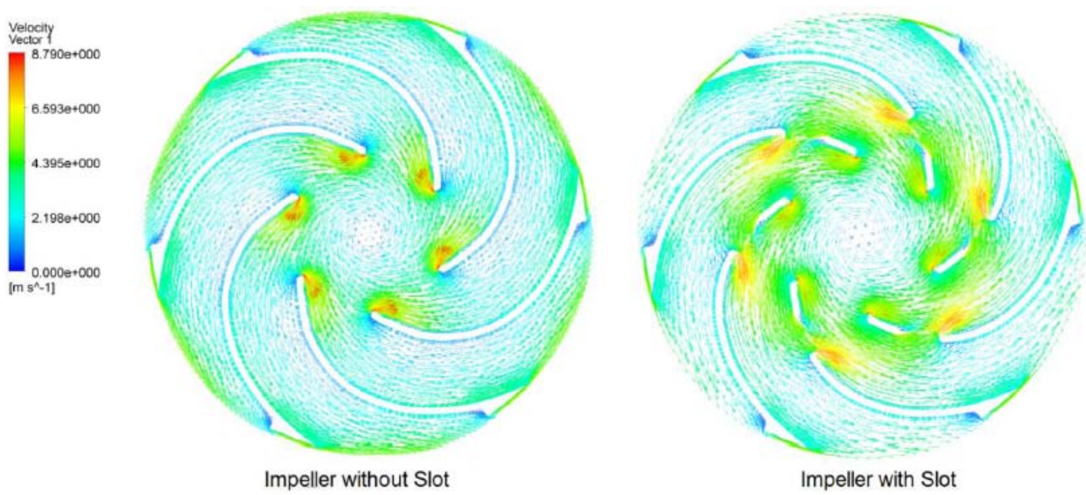

Figure 11: Impeller relative velocity vector at flow rate Q=3.5 L/s on mid span

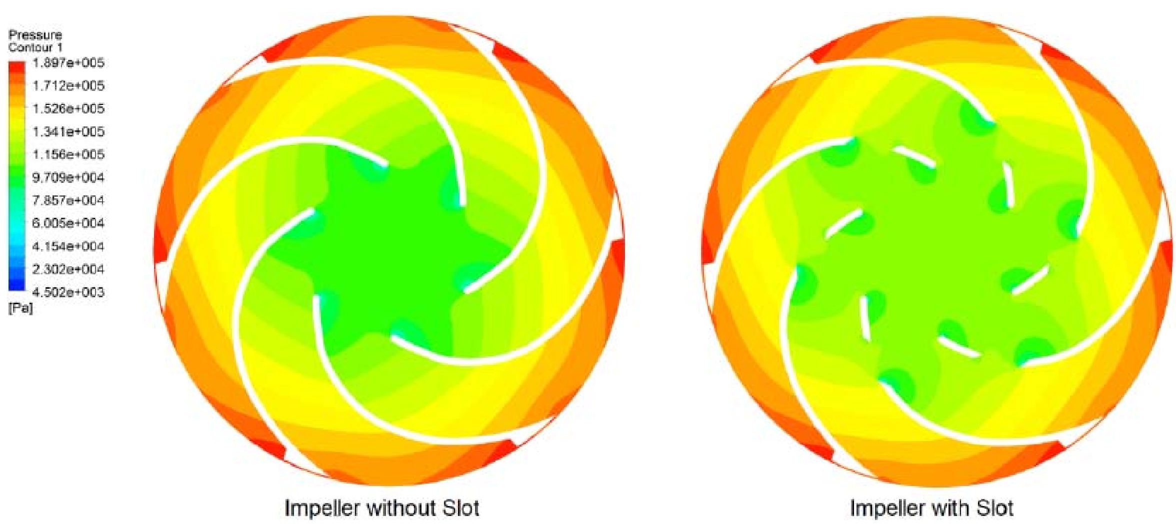

Figure 12: Impeller static pressure contour at flow rate Q=3.5 L/s at mid span

IV. Results and Discussions

A single arc blade design is assumed, and the pump speed is chosen n = 1500 rpm with impeller outer diameter D2 = 130 mm and impeller inner diameter D1 = 50 mm. The other dimensions are chosen according to Table (1). Fifteen cases have been studied to cover the slot parameters that affect the impeller performance, Table (2). When making a slot in the impeller blade the fluid goes through this slot from the pressure side to the suction side with certain flow rate. The convergence of this mass flow rate is shown in Figure (13).

Table 2: Different cases of slot parameters

Case	Parameter	Slot Position R_s (mm)	Slot inclination angle θ_s (degree)	Slot Height h_s (mm)
1	Slot radial Position R_s	35	Zero	1
2		40		
3		45		
4		50		
5		55		
6	Slot inclination angle (θ_s)	45	20	1
7			-45	
8			-90	
9			-110	
10			-130	
11	Slot height h_s	45	-90	0.5
12				1
13				1.5
14				2
15				2.5

a) *Effect of Slot Radial Position*

The effect of the variation of the slot radial position Rs on the impeller performance is studied by changing its value and keeping the values of the other parameters constant; Cases (1-5) in Table (2). Figure (14) shows the head versus the slot radial position. It is found that the head decreases with increasing Rs in other word; a slot located closer to the blade root is preferred for all value of flow rate inspected. No improvement in the impeller performance has been detected. In addition, Figure (15) shows that Rs has a small impact on the impeller hydraulic efficiency.

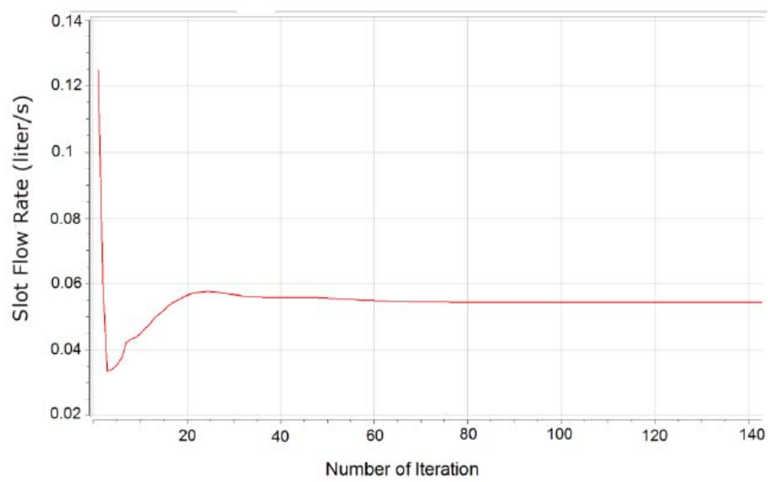

Figure 13: Convergence history of flow rate through the slot (Case 3) at pump flow rate Q = 4 liter/s

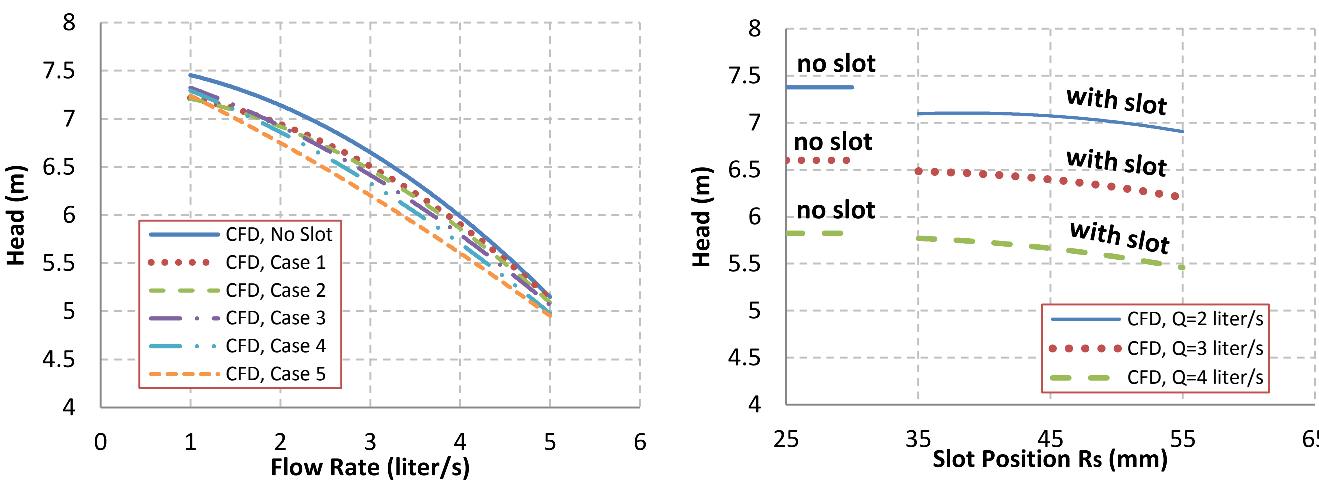

Figure 14: Effect of slot radial position Rs on the impeller head, h_s = 1mm & θ_s = 0°

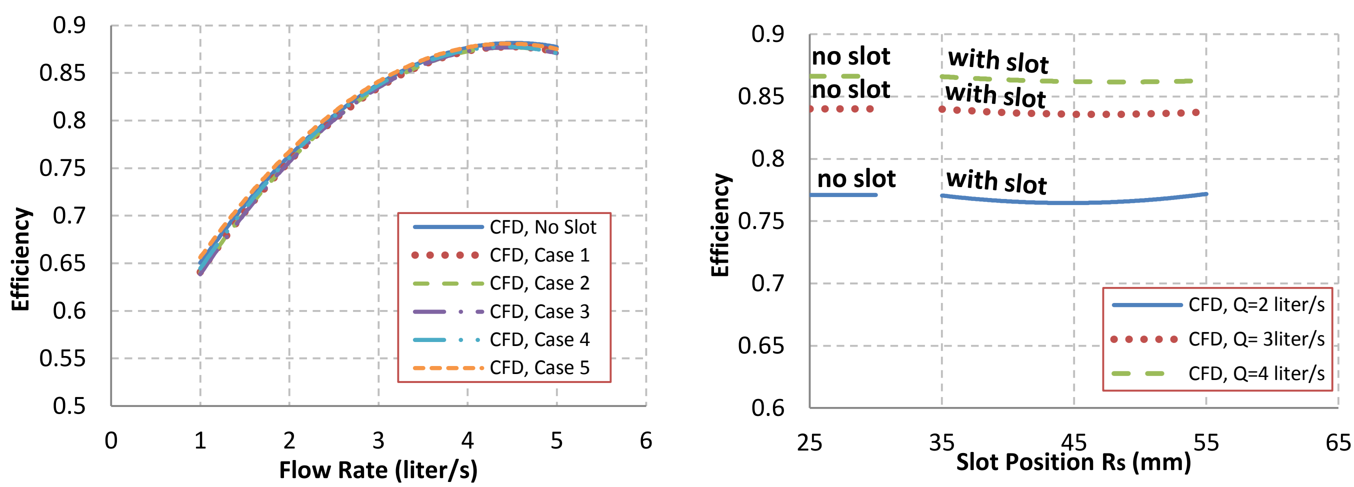

Figure 15: Effect of slot radial position Rs on the impeller hydraulic Efficiency h_s = 1mm & θ_s = 0°

b) Effect of Slot Inclination Angle

The effect of the slot inclination angle on the impeller head is addressed in the cases (6-10). From the blade geometry there is a constrain on the slot inclination angle and it should be chosen according to Eq.(7)

$$-180 + \beta < \theta_s < \beta \qquad (7)$$

where β = blade angle at slot radial position Rs, results show that the high negative inclination angle causes higher heads as shown in Figure (16). This increase in head was due to the rise in slip factor. The effect of the slot inclination angle on the hydraulic efficiency of the impeller is shown in Figure (17). Sharp reduction in efficiency is noted at slot inclination $\theta_s < -110°$ this drop in efficiency is attributed to the high change in the relative velocity direction. A similar drop in efficiency can be noted in at slot inclination angle $\theta_s > 0°$.

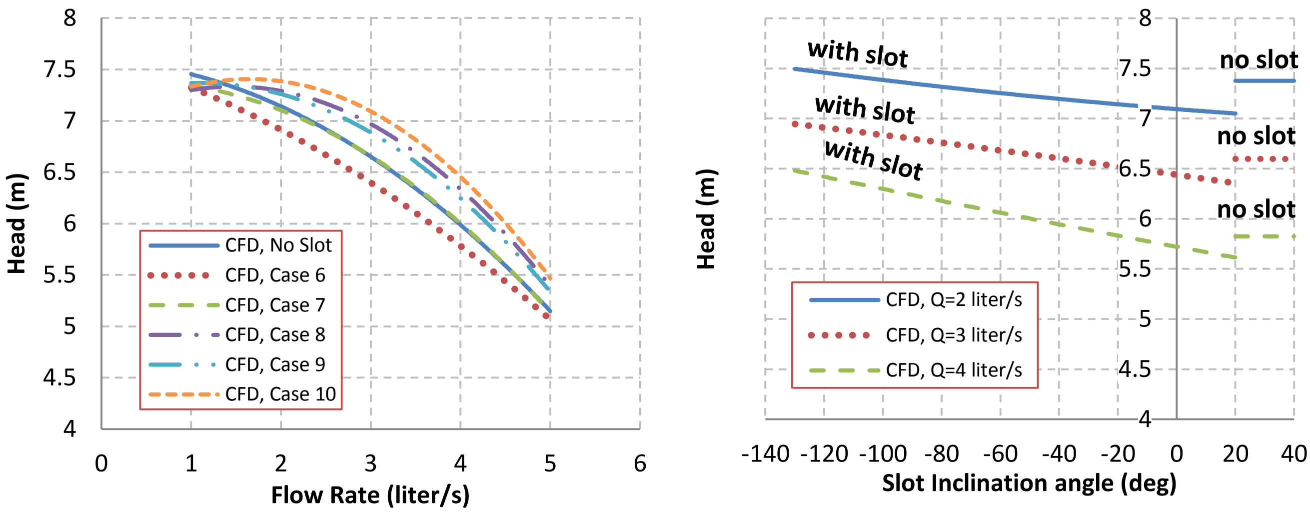

Figure 16: Effect of slot inclination angle θ_s on the impeller head, Rs = 45 mm & h_s = 1 mm

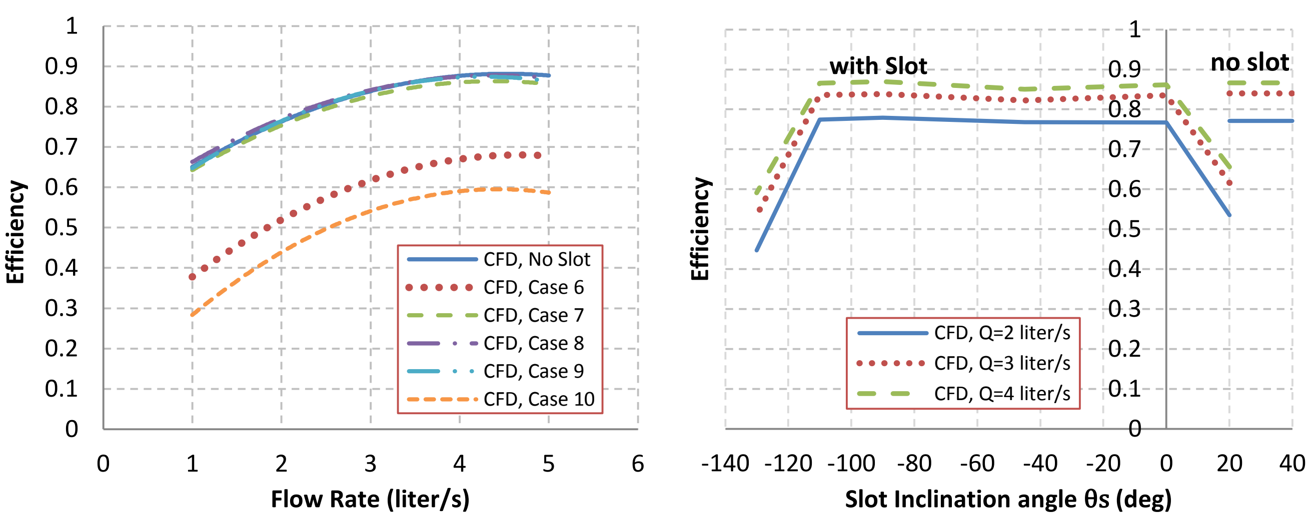

Figure 17: Effect of slot inclination angle θ_s on the Impeller hydraulic efficiency, Rs = 45 mm & h_s = 1 mm

c) Effect of the Slot Height

Finally, the effect of the slot height on the impeller head is examined, cases (11-15). Figure (18) shows that with increasing slot height the head increases up to certain value then it decreases. Figure (19) shows the impeller hydraulic efficiency. It decreases with the increase of slot height.

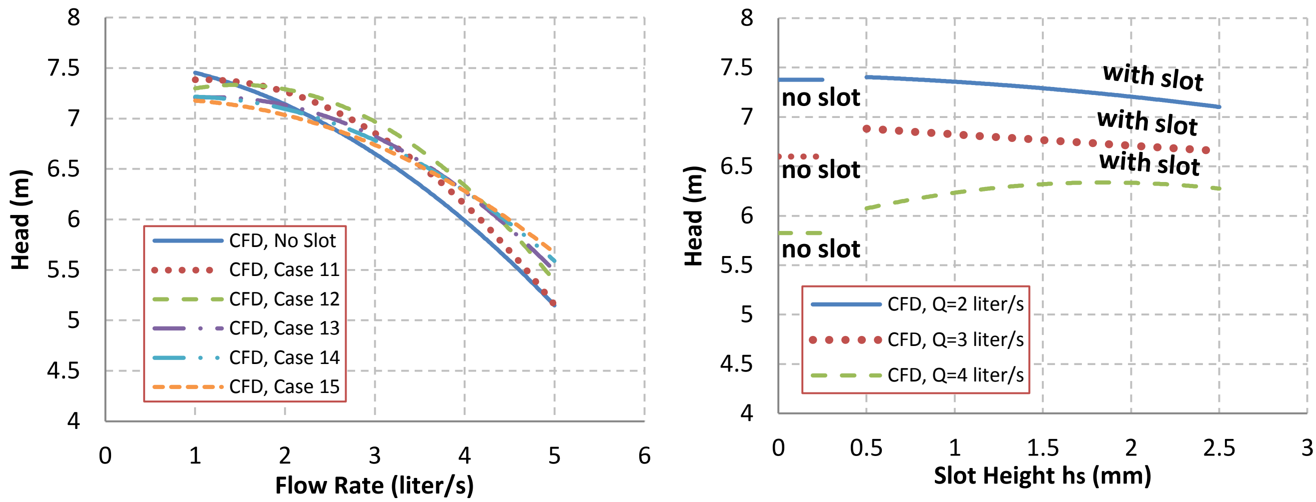

Figure 18: Effect of slot height h_s on the impeller head, Rs = 45 mm & $\theta_s = -90°$

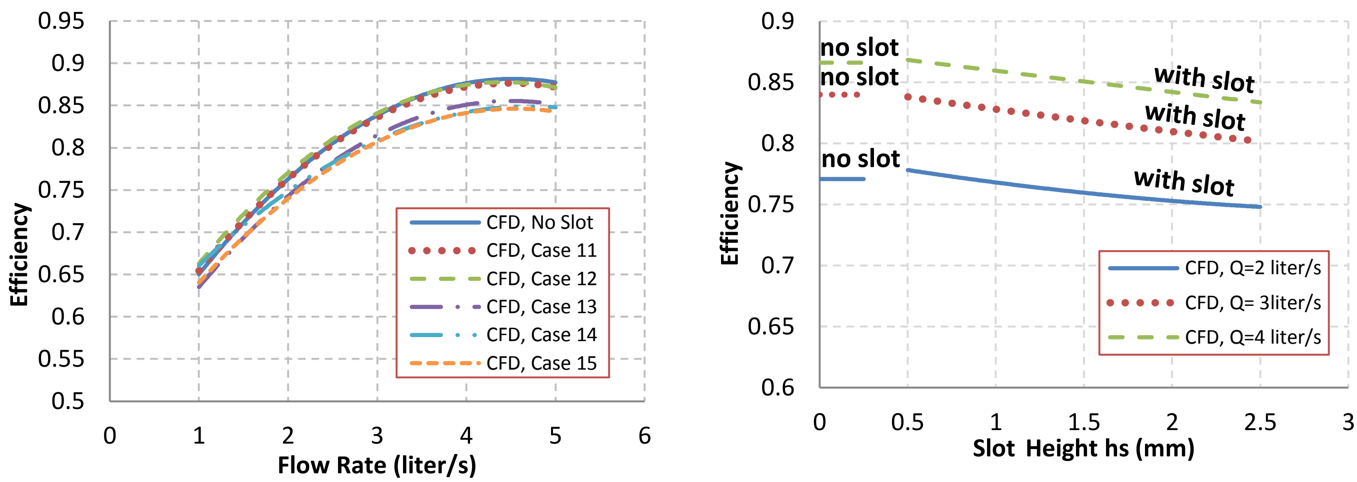

Figure 19: Effect of slot height h_s on the impeller hydraulic efficiency, Rs = 45 mm & $\theta_s = -90°$

d) Impact of Slot on Flow Field Features

Figure (20) shows the relative velocity vectors on the mid span at flow rate Q = 4L/s (case 11) for impeller with and without slots. Formation of a vortex on the suction side with the same angular direction of the impeller rotation increases the slip factor and hence increases the head.

Figure (21) shows the difference in pressure along the blade pressure and suction sides. Clearly, the pressure difference above the slot is higher than the pressure difference in case of blade without slot.

To illustrate the effect of the blade slot on the performance of the impeller, the pressure contours and the velocity vector inside the slot are shown in Figure (22) and Figure (23). The pressure contours inside the slot show that the pressure force in the slot with inclination angle (case 3) has positive direction with y-axis. In addition, for (case 9) the pressure force has a negative direction with the y-axis.

The velocity vector in the blade slot shows that the velocity has a large value at the slot upper half. In case of high inclination angle the velocity has a reverse flow in the lower slot region. The velocity in the slot has maximum value (about 5.8 m/s). The flow rate inside the slot is proportional to the slot height, in case of hs = 1 mm the slot flow rate is about 0.055 liter/s with the total flow rate equal to 4 liter/s as shown in Figure (13), which represents ≈ 1.4%.

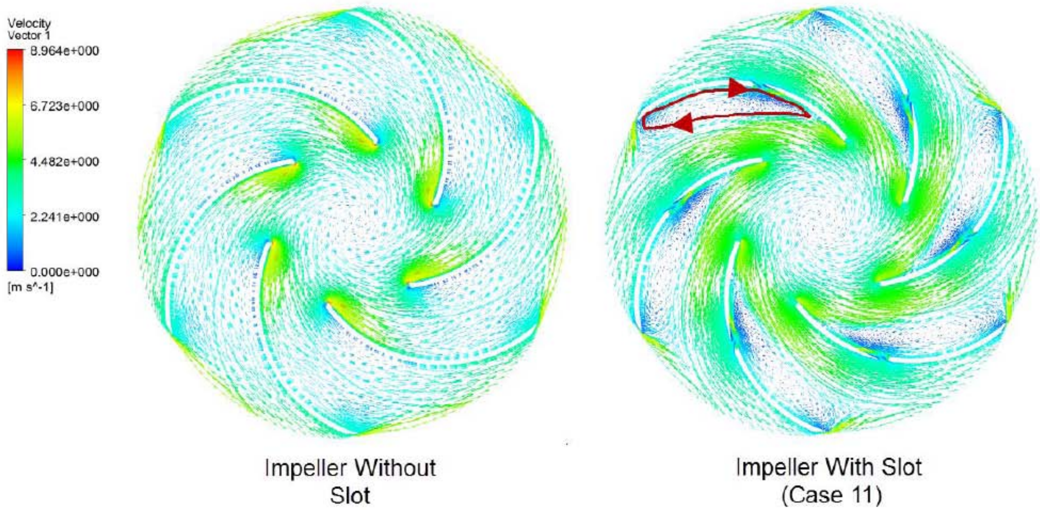

Figure 20: Relative velocity vectors on mid span at flow rate Q =4 L/s

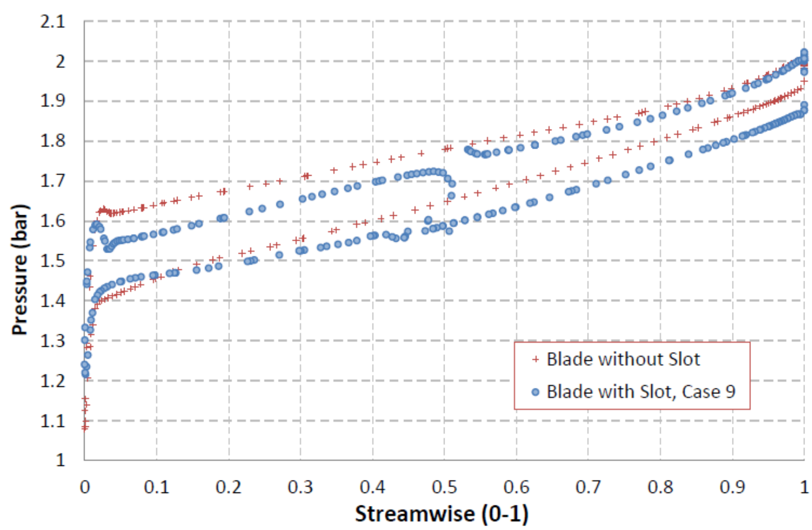

Figure 21: Streamwise Blade loading on mid-span at flow rate Q = 4 L/s

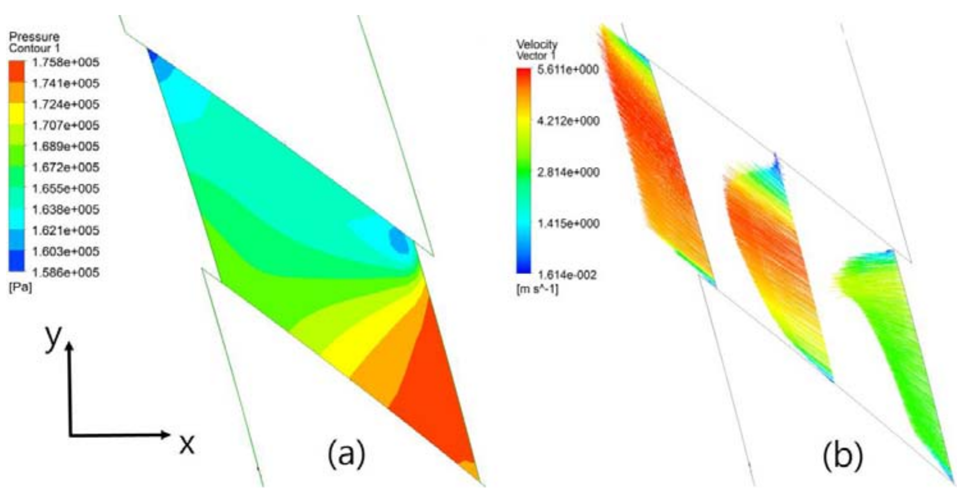

Figure 22: (a) pressure contours, and (b) relative velocity vector a cross the slot (case 3) at flow rate Q = 4L/s

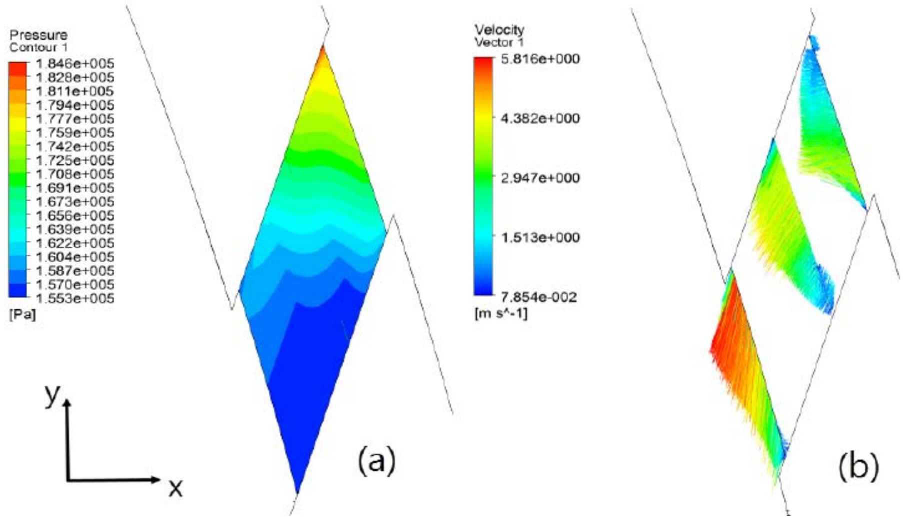

Figure 23: (a) pressure contours, and (b) relative velocity vector a cross the slot (case 9) at flow rate Q = 4L/s

V. Conclusions

In the present work, a parametric study is done based on the blade slot technique to investigate the effect of some slot geometrical parameters, namely slot radial position (Rs), slot height (h_s) and slot inclination angle (θ_s) on the impeller performance using a 3-D numerical simulation of a turbulent flow inside the centrifugal impeller, the following are concluded:

- With increasing the slot radial position Rs the impeller head is decreased. The slot radial position has an effect less than 2.5% on the impeller hydraulic efficiency when the slot height is 1.5 % of the blade length.
- The slot inclination angle has a significant effect on the impeller head and efficiency. The slot with inclination angle $-130° < \theta_s < -90°$ has a high impeller head with 5 – 10% above the impeller head without slot. The optimum efficiency can be reached within the range of slot inclination angle $-110° < \theta_s < 0°$.
- At the part load operating zone, the impeller head decreases with increasing the slot height, then at the over load zone the impeller head increase with increasing the slot height up to certain slot height value then the impeller head deacrease. The efficiency is decreased with the increase of slot height.

Attempts have been made to explain the physics of impeller with slot design. The present work is currently extended by incorporating the complete pump geometry to account for the discrepancies between CFD and experimental finding.

The study can be further extended to optimize the slot design parameters at different flow rates for maximum pump performance.

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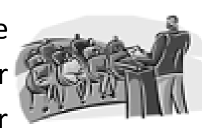

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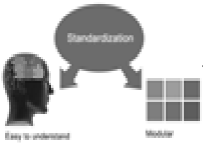

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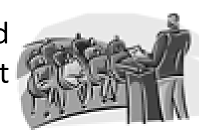

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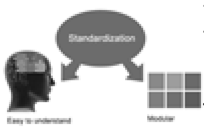

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"

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4. Manuscript’s Category,

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24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

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- Do not give permission to anyone else to "PROOFREAD" your manuscript.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9755861