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Natural Gas Consumption

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Interplay of Casting & CFD

Critical Analyses of Sewing

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VOLUME 18 ISSUE 1 VERSION 1.0



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING

VOLUME 18 ISSUE 1 (VER. 1.0)

OPEN ASSOCIATION OF RESEARCH SOCIETY

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GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING
Volume 18 Issue 1 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Thermo Dynamic Analysis on MHD Casson Nano-Fluid Flow in a Vertical Porous Space with Stretching Walls

By R.K. Selvi, R. Muthuraj & S. Srinivas

VIT-AP University

Abstract- This work is concerned with MHD Casson nanofluid flow in a vertical porous space with heat and mass transfer in the presence of chemical reaction. The governing non-linear partial differential equations are reduced to ordinary differential equation by employing the similarity transformations then it solved by homotopy analysis method (HAM). The results are presented with the help of graphs for different values of the involved parameters and discussed. It is found that increasing Brownian motion parameter, thermophoresis parameter and Prandtl number are lead to promote fluid temperature significantly than other parameters. Also, it is observed that increasing Lewis number lead to enhance the concentration field whereas the opposite trend can be noticed with increasing thermal parameters. Further, we have compared HAM solution with the numerical solution by using ND solver in Mathematica.

Keywords: *homotopy analysis method, MHD, chemical reaction, stretching walls.*

GJRE-J Classification: FOR Code: 020304



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Thermo Dynamic Analysis on MHD Casson Nano-Fluid Flow in a Vertical Porous Space with Stretching Walls

R.K. Selvi^α, R. Muthuraj^σ & S. Srinivas^ρ

Abstract- This work is concerned with MHD Casson nanofluid flow in a vertical porous space with heat and mass transfer in the presence of chemical reaction. The governing non-linear partial differential equations are reduced to ordinary differential equation by employing the similarity transformations then it solved by homotopy analysis method (HAM). The results are presented with the help of graphs for different values of the involved parameters and discussed. It is found that increasing Brownian motion parameter, thermophoresis parameter and Prandtl number are lead to promote fluid temperature significantly than other parameters. Also, it is observed that increasing Lewis number lead to enhance the concentration field whereas the opposite trend can be noticed with increasing thermal parameters. Further, we have compared HAM solution with the numerical solution by using ND solver in Mathematica.

Keywords: homotopy analysis method, MHD, chemical reaction, stretching walls.

I. INTRODUCTION

The problem of mixed convective flow in vertical channels with different wall temperatures has a number of important engineering applications such as microelectronic components cooling, in the design of compact heat exchangers, industrial furnaces, power engineering and so on. Also, convection flows with heat and mass transfer under the influence of a magnetic field, chemical reaction occurs in many branches of engineering applications and transport processes in industrial applications such as chemical industry, power and cooling industry for drying, chemical vapour deposition on surfaces, cooling of nuclear reactors and MHD power generators (See Refs. [1-10]). Moreover, MHD channel flows gained significant theoretical and practical importance owing to their applications in MHD generators, accelerators and blood flow measurements. In view of these applications, Srinivas et al. [7] have studied the effects of thermal-diffusion and diffusion-thermo effects in a two-dimensional viscous flow between slowly expanding or contracting walls with weak permeability.

The effect of chemical reaction and thermal radiation on MHD flow over an inclined permeable stretching surface with non-uniform heat source was examined by Srinivas et al. [8]. Later, Muthuraj et al. [9] discussed the combined effects of thermal-diffusion and diffusion-thermo with space porosity on MHD mixed convective flow of micropolar fluid in a vertical channel. Immaculate et al. [10] have investigated the influence of thermophoretic particle deposition on fully developed MHD mixed convective flow in a vertical channel with thermal-diffusion and diffusion-thermo effects. More recently, effects of thermal diffusion and diffusion thermo on MHD Couette flow of Powell-Eyring fluid in an inclined porous space in the presence of chemical reaction was investigated by Muthuraj et al. [11].

In engineering applications, the flows of non-Newtonian fluid have been attracting researchers significantly during the past few decades. In particular, it occurs in the extrusion of polymer fluids, cooling of metallic plate in the bath, exotic lubricants, artificial gels, natural gels, colloidal and suspension solutions. The most important among these fluids is the Casson fluid. It can be defined as a shear thinning liquid which is assumed to have an infinite viscosity at zero rate of shear, a yield stress below which no flow occurs and a zero viscosity at an infinite rate of shear. Human blood can also be treated as a Casson fluid due to the blood cells' chain structure and the substances contained like protein, fibrinogen, rouleaux etc [16]. Hence the Casson fluid has its own importance in scientific as well as in engineering areas. Many researchers have used the Casson fluid model for mathematical modeling of blood flow in narrow arteries at low shear rates (See Refs.[12-18]). Nadeem et al. [15] examined MHD flow of a Casson fluid over an exponentially shrinking sheet. Sarojamma et al.[16] have investigated MHD Casson fluid flow with heat and mass transfer in a vertical channel with stretching walls. Arthur et al.[17] have analyzed of Casson fluid flow over a vertical porous surface with chemical reaction in the presence of magnetic field. More recently, the unsteady MHD free flow of a Casson fluid past an oscillating vertical plate with constant wall temperature was analyzed by Khalid et al.[18].

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Nanoparticle research is currently an area of intense scientific interest due to a wide variety of potential applications in biomedical, optical and electronic fields. It is a microscopic particle with at least one dimension less than 100 nm. Many existing studies indicate that an enormous enhancement in the emission intensity, quantum yield, and lifetime of the molecular rectangles has been observed when the solvent medium is changed from organic to aqueous and it clearly exhibit enhanced thermal conductivity, which goes up with increasing volumetric fraction of nanoparticles[19-28]. The model of nanofluid was first developed by Choi [19]. Later, fully developed mixed convection flow between two paralleled vertical flat plates filled by a nanofluid with the Buongiorno mathematical model using HAM was analyzed by Xu et al. [25]. Nadeem et al. [26] presented the steady stagnation point flow of a Casson nanofluid in the presence of convective boundary conditions. Khan et al. [27] analyzed the fully-developed two-layer Eyring–Powell fluid in a vertical channel divided into two equal regions. One region is filled with the clear Eyring–Powell fluid and the other with the Eyring–Powell nanofluid. The problem of MHD laminar free convection flow of nanofluid past a vertical surface was analyzed by Freidoonimehr [28]. More recently, Immaculate et al. [29] examined the MHD unsteady flow of Williamson nanofluid in a vertical channel filled with a porous material and oscillating wall temperature using HAM. To the best of our knowledge MHD Casson nanofluid in a vertical channel with stretching walls has not been studied before. In this paper, we therefore propose to analyze the steady fully-developed mixed convection flow of MHD Casson nanofluid in a vertical porous space with stretching walls in the presence of chemical reaction. It is important to note that this type of analysis has direct applications to the study of blood flow in the cardiovascular system subject to external magnetic field. The reduced non-dimensional, highly non-linear,

coupled system of equations is solved by HAM [30-35]. The influence of significant parameters on heat and mass transfer characteristics of the flow is presented through graphs and discussed.

II. FORMULATION OF THE PROBLEM

We consider MHD Casson nanofluid flow in a vertical porous space bounded by two stretching walls and are maintained at different temperatures, concentrations. The channel walls are at the positions $y = -L$ and $y = L$, as shown in Fig.1. A constant magnetic field of strength B_0 is applied perpendicular to the channel walls. The fluids in the region of the parallel walls are incompressible, non-Newtonian and their transport properties are assumed to be constant.

The constitutive equation for the Casson fluid can be written as [16]

$$\tau_{ij} = \begin{cases} 2 \left[\mu_B + \frac{\tau_y}{\sqrt{2\pi}} \right] e_{ij}, & \pi > \pi_c \\ 2 \left[\mu_B + \frac{\tau_y}{\sqrt{2\pi_c}} \right] e_{ij}, & \pi < \pi_c \end{cases} \quad (1)$$

where μ_B is the plastic dynamic viscosity of the non-Newtonian fluid, τ_y is the yield stress of the fluid, π is the product of the component of deformation rate with itself, namely, $\pi = e_{ij}e_{ij}$, and e_{ij} is the (i, j) th component of deformation rate, and π_c is critical value of this product based on non-Newtonian model. Under the above assumptions and usual Boussinesq approximation, the fluid flow is governed by the following equations (See Refs. [16, 25, 26])

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (2)$$

$$\rho_f \left(u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} \right) = -\frac{\partial p}{\partial x} + \mu_f \left(1 + \frac{1}{\beta} \right) \nabla^2 u - \sigma B_0^2 u - \frac{\mu_f \Phi^*}{k^*} u - \rho_f C_F u^2 + \rho_f g \beta_t (1 - C_0)(T - T_0) + g \beta_c (\rho_p - \rho_f)(C - C_0) \quad (3)$$

$$\rho_f \left(u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} \right) = -\frac{\partial p}{\partial y} + \mu_f \left(1 + \frac{1}{\beta} \right) \nabla^2 v - \frac{\mu_f \Phi^*}{k^*} v \quad (4)$$

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \alpha^* \nabla^2 T + \tau^* \left[D_B \left(\frac{\partial C}{\partial x} \frac{\partial T}{\partial x} + \frac{\partial C}{\partial y} \frac{\partial T}{\partial y} \right) + \frac{D_T}{T} \left\{ \left(\frac{\partial T}{\partial x} \right)^2 + \left(\frac{\partial T}{\partial y} \right)^2 \right\} \right] \quad (5)$$

$$u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = D_B \nabla^2 C + \frac{D_T k_T}{T} \nabla^2 T - k_1 C \quad (6)$$

The boundary conditions of the problem are

$$u = bx, v = 0, T = T_1, C = C_1 \text{ at } y = -L \quad (7)$$

$$u = bx, v = 0, T = T_2, C = C_2 \text{ at } y = L \quad (8)$$

where u and v are the velocity components in x and y directions, T_1 and T_2 are the wall temperatures ($T_2 > T_1$), C_1 and C_2 are the wall concentrations, \bar{T} is the mean value of T_1 and T_2 , C_f is the inertial coefficient, C_p is the specific heat, B_0 is the transverse magnetic field, D_B is the Brownian diffusion coefficient, D_T is the thermophoresis diffusion coefficient, g is the acceleration due to gravity, p is the pressure, T is the temperature, k^* is the permeability of the medium, K is the thermal conductivity of the fluid, $\alpha^* = \frac{K}{(\rho C_p)_f}$ is the thermal

diffusivity of the fluid, $\tau^* = \frac{(\rho C_p)_p}{(\rho C_p)_f}$, $b > 0$ is the stretch

of the channel walls, respectively, $\beta = \frac{\mu_B \sqrt{2\pi_c}}{\tau_y}$ is the

Casson parameter, ρ_f, ρ_p densities of the base fluid and nanoparticle, respectively, $(\rho C_p)_f$ is the heat capacity of the fluid, $(\rho C_p)_p$ gives the effective heat capacity of the nanoparticle material, ν is the kinematic viscosity, ϕ^* is the porosity of the medium, μ_f is the dynamic viscosity of the fluid, σ is the coefficient of electric conductivity, β_t is the coefficient of thermal expansion, β_c is the coefficient of expansion with concentration and $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$.

We introduce the similarity variables

$$u = bxf'(\eta); v = -Lbf(\eta); \eta = \frac{y}{L}; \theta = \frac{T - T_1}{T_2 - T_1}; \phi = \frac{C - C_1}{C_2 - C_1} \quad (9)$$

Invoking the above similarity variables to equations (3)-(6) and eliminating pressure gradient, we get

$$\left(1 + \frac{1}{\beta}\right) f^{iv} - R_e (f'f'' - ff''') - Hf'' - Iff'' + G_r\theta' + G_c\phi' = 0 \quad (10)$$

$$\theta'' + P_r [N_b\phi'\theta' + N_t(\theta')^2 + R_e f\theta'] = 0 \quad (11)$$

$$\phi'' + \frac{N_t}{N_b}\theta'' + L_e (R_e f\phi' - \gamma\phi + k_1^*) = 0 \quad (12)$$

The corresponding boundary conditions are:

$$f' = 1, f = 0, \theta = 0, \phi = 0 \text{ at } \eta = -1 \quad (13)$$

$$f' = 1, f = 0, \theta = 1, \phi = 1 \text{ at } \eta = 1 \quad (14)$$

Where $H = M + \frac{1}{D_a}$, $k_1^* = \frac{-k_1 C_1 L^2}{\nu_f (C_2 - C_1)}$, $I = \frac{2C_f b x L^2}{\nu_f}$ is the inertia coefficient,

$R_e = \frac{L^2 b}{\nu_f}$ is the Reynolds number, $M = \sqrt{\frac{\sigma B_0^2 L^2}{\mu_f}}$ is the Hartmann number,

$D_a = \frac{k^*}{\phi^* L^2}$ is the permeability parameter,

$N_b = \frac{\tau^* D_B (C_2 - C_1)}{v_f}$ is the Brownian motion

$G_r = \frac{g\beta_t(1-C_0)(T_2-T_1)L^2}{v_f b x}$ local temperature

parameter $N_t = \frac{\tau^* D_T (T_2 - T_1)}{\bar{T} v_f}$ is the thermophoresis

Grashof number, $G_c = \frac{g\beta_c(\rho_p - \rho_f)(C_2 - C_1)L^2}{\mu_f b x}$ is

parameter, $\gamma = \frac{k_1 L^2}{v_f}$ is the chemical reaction parameter.

the local nano-particle Grashof number, $P_r = \frac{v_f}{\alpha^*}$ is

The dimensionless volume flow rate \bar{Q} is given by

the Prandtl number, $L_e = \frac{v_f}{D_B}$ is the Lewis number,

$$\bar{Q} = \int_{-1}^1 f' d\eta. \quad (15)$$

The skin friction coefficient, local heat rate transfer and the local mass diffusion rate at the walls are defined as

$$C_f = \frac{L\tau_w}{\mu_f b x}; \quad Nu = \frac{Lq_w}{K(T_2 - T_1)}; \quad Sh = \frac{Lm_w}{D_B(C_2 - C_1)}$$

$$\text{where } \tau_w = \mu_f \left(1 + \frac{1}{\beta}\right) \left(\frac{\partial u}{\partial y}\right); \quad q_w = -K \left(\frac{\partial T}{\partial y}\right); \quad m_w = -D_B \left(\frac{\partial C}{\partial y}\right) \quad (16)$$

Its non-dimensional form is given by

$$C_f = \left(1 + \frac{1}{\beta}\right) f''(\eta) \Big|_{\eta=\pm 1}; \quad Nu = -\theta'(\eta) \Big|_{\eta=\pm 1}; \quad Sh = -\phi'(\eta) \Big|_{\eta=\pm 1} \quad (17)$$

III. SOLUTION BY HOMOTOPY ANALYSIS METHOD (HAM)

For HAM solutions, we can choose the initial guesses and auxiliary linear operators in the following form:

$$f_0(\eta) = \frac{\eta^3 - \eta}{2}; \quad \theta_0(\eta) = \frac{1 + \eta}{2}; \quad \phi_0(\eta) = \frac{1 + \eta}{2} \quad (18)$$

$$L_1(f) = f^{iv} \quad L_2(\theta) = \theta'' \quad L_3(\phi) = \phi'' \quad (19)$$

$$(1 - \wp)L_1[\hat{f}(\eta, \wp) - f_0(\eta)] = \wp h N_1[\hat{f}(\eta, \wp), \hat{\theta}(\eta, \wp), \hat{\phi}(\eta, \wp)] \quad \hat{f}(-1, \wp) = 0, \hat{f}(1, \wp) = 0 \quad (20)$$

$$(1 - \wp)L_2[\hat{\theta}(\eta, \wp) - \theta_0(\eta)] = \wp h N_2[\hat{f}(\eta, \wp), \hat{\theta}(\eta, \wp), \hat{\phi}(\eta, \wp)], \quad \hat{\theta}(-1, \wp) = 0, \hat{\theta}(1, \wp) = 1 \quad (21)$$

$$(1 - \wp)L_3[\hat{\phi}(\eta, \wp) - \phi_0(\eta)] = \wp h N_3[\hat{f}(\eta, \wp), \hat{\theta}(\eta, \wp), \hat{\phi}(\eta, \wp)], \quad \hat{\phi}(-1, \wp) = 0, \hat{\phi}(1, \wp) = 1 \quad (22)$$

where,

$$N_1[\hat{f}(\eta, \wp), \hat{\theta}(\eta, \wp), \hat{\phi}(\eta, \wp)] =$$

$$\left(1 + \frac{1}{\beta}\right) f^{iv}(\eta, \wp) - R_e \left(\hat{f}'(\eta, \wp) \hat{f}''(\eta, \wp) - \hat{f}(\eta, \wp) \hat{f}'''(\eta, \wp)\right) - H \hat{f}''(\eta, \wp) - I \hat{f}'(\eta, \wp) \hat{f}''(\eta, \wp) + G_r \hat{\theta}'(\eta, \wp) + G_c \hat{\phi}'(\eta, \wp)$$

$$\begin{aligned} \mathbf{N}_2[\hat{f}(\eta, \wp), \hat{\theta}(\eta, \wp), \hat{\phi}(\eta, \wp)] \\ = \hat{\theta}''(\eta, \wp) + P_r[N_b \hat{\phi}'(\eta, \wp) \hat{\theta}'(\eta, \wp) + N_t (\hat{\theta}'(\eta, \wp))^2 + R_e \hat{f}(\eta, \wp) \hat{\theta}'(\eta, \wp)] \end{aligned}$$

$$\mathbf{N}_3[\hat{f}(\eta, \wp), \hat{\theta}(\eta, \wp), \hat{\phi}(\eta, \wp)] = \hat{\phi}''(\eta, \wp) + \frac{N_t}{N_b} \hat{\theta}''(\eta, \wp) + L_e (R_e \hat{f}(\eta, \wp) \hat{\phi}'(\eta, \wp) - \gamma \hat{\phi}(\eta, \wp) + k_1^*)$$

For $\wp = 0$ and $\wp = 1$, we have

$$\hat{f}(\eta, 0) = f_0(\eta) \quad \hat{f}(\eta, 1) = f(\eta) \quad (23)$$

$$\hat{\theta}(\eta, 0) = \theta_0(\eta) \quad \hat{\theta}(\eta, 1) = \theta(\eta) \quad (24)$$

$$\hat{\phi}(\eta, 0) = \phi_0(\eta) \quad \hat{\phi}(\eta, 1) = \phi(\eta) \quad (25)$$

when \wp increases from 0 to 1, then $\hat{f}(\eta, \wp)$, $\hat{\theta}(\eta, \wp)$, $\hat{\phi}(\eta, \wp)$ vary from initial guess $f_0(\eta)$, $\theta_0(\eta)$,

$\phi_0(\eta)$ to the approximate analytical solution $f(\eta)$, $\theta(\eta)$, $\phi(\eta)$. By Taylor's theorem the series $\hat{f}(\eta, \wp)$, $\hat{\theta}(\eta, \wp)$, $\hat{\phi}(\eta, \wp)$ can be expressed as a power series of \wp as follows,

$$\hat{f}(\eta, \wp) = f_0(\eta) + \sum_{m=1}^{\infty} f_m(\eta) \wp^m, \quad f_m(\eta) = \frac{1}{m!} \left. \frac{\partial^m \hat{f}(\eta, \wp)}{\partial \wp^m} \right|_{\wp=0} \quad (26)$$

$$\hat{\theta}(\eta, \wp) = \theta_0(\eta) + \sum_{m=1}^{\infty} \theta_m(\eta) \wp^m, \quad \theta_m(\eta) = \frac{1}{m!} \left. \frac{\partial^m \hat{\theta}(\eta, \wp)}{\partial \wp^m} \right|_{\wp=0} \quad (27)$$

$$\hat{\phi}(\eta, \wp) = \phi_0(\eta) + \sum_{m=1}^{\infty} \phi_m(\eta) \wp^m, \quad \phi_m(\eta) = \frac{1}{m!} \left. \frac{\partial^m \hat{\phi}(\eta, \wp)}{\partial \wp^m} \right|_{\wp=0} \quad (28)$$

In which 'h' is chosen in such a way that these series are convergent at $\wp = 1$, therefore we have

$$f(\eta) = f_0(\eta) + \sum_{m=1}^{\infty} f_m(\eta), \quad \theta(\eta) = \theta_0(\eta) + \sum_{m=1}^{\infty} \theta_m(\eta), \quad \phi(\eta) = \phi_0(\eta) + \sum_{m=1}^{\infty} \phi_m(\eta) \quad (29)$$

b) *The m-th order deformation equations*

Differentiating the zero-order deformation Eqns. (20) - (22) m -times with respect to \wp and then dividing them by $m!$ and finally setting $\wp = 0$, we obtain the following m -th order deformation equations:

$$L_1[f_m(\eta) - \chi_m f_{m-1}(\eta)] = hR_m^f(\eta) \quad (30)$$

$$L_2[\theta_m(\eta) - \chi_m \theta_{m-1}(\eta)] = hR_m^\theta(\eta) \quad (31)$$

where,

$$R_m^f(\eta) = \left(1 + \frac{1}{\beta}\right) f_{m-1}^{iv} - R_e \sum_{k=0}^{m-1} (f_{m-k-1}' f_k'' - f_{m-k-1} f_k''') - H f_{m-1}'' - I \sum_{k=0}^{m-1} f_{m-k-1}' f_k'' + G_r \theta_{m-1}' + G_c \phi_{m-1}'$$

$$R_m^\theta(\eta) = \theta_{m-1}'' + P_r \left(\sum_{k=0}^{m-1} [N_b \phi_{m-k-1}' \theta_k' + N_t \theta_{m-k-1}' \phi_k'] + R_e f_{m-k-1} \theta_k' \right)$$

$$L_3[\phi_m(\eta) - \chi_m \phi_{m-1}(\eta)] = hR_m^\phi(\eta) \quad (32)$$

together with condition

$$f_m(-1) = 0 \quad f_m(1) = 0 \quad (33)$$

$$\theta_m(-1) = 0 \quad \theta_m(1) = 0 \quad (34)$$

$$\phi_m(-1) = 0 \quad \phi_m(1) = 0 \quad (35)$$

$$R_m^\phi(\eta) = \phi_{m-1}'' + \frac{N_t}{N_b} \theta_{m-1}'' + L_e \left(R_e \sum_{k=0}^{m-1} f_{m-k-1} \phi_k' - \gamma \phi_{m-1} + k_1^* (1 - \chi_m) \right)$$

where,

$$\chi_m = \begin{cases} 0 & \text{for } m = 1 \\ 1 & \text{for } m \neq 1 \end{cases}$$

where E_1, E_2 and E_3 are the residual error at m -th order of HAM approximation for f, θ and ϕ respectively. The average square residual error is given by:

$$\Delta_m = \frac{1}{3} \sum_{i=1}^3 \int_{\eta=-1}^{\eta=1} E_i^2 d\eta \quad (39)$$

IV. CONVERGENCE AND THE RESIDUAL ERROR

The convergence and rate of approximation for the HAM solution depends on auxiliary parameter 'h' (See Refs. [29-34]), for this purpose, we have plotted h-curves in Fig.2 with fixing the values of involved parameters $G_r = 5, G_c = 5, R_e = 1, l = 1, N_t = 0.45, N_b = 0.45, L_e = 10, M = 2, P_r = 2.5, D_a = 0.5, K_1 = 1, \gamma = 0.5, \beta = 0.6$. As a result, we can choose proper value of 'h' and also we obtain the optimal values of the auxiliary parameter 'h' by minimizing the average square residual error for the equations (10) to (12). We define the residual error for above mentioned equations as:

$$E_1 = \left(1 + \frac{1}{\beta} \right) f^{iv} - R_e (f'f'' - ff''') - Hf'' - Iff'' + G_r \theta' + G_c \phi' \quad (36)$$

$$E_2 = \theta'' + P_r [N_b \phi' \theta' + N_t (\theta')^2 + R_e f \theta'] \quad (37)$$

$$E_3 = \phi'' + \frac{N_t}{N_b} \theta'' + L_e (R_e f \phi' - \gamma \phi + k_1^*) \quad (38)$$

Further, we have tabulated the minimum average square residual errors for 10th, 15th, 20th, 25th order of HAM approximation for different values of parameters with optimal 'h' in Table 1. It is noted that the number of HAM approximation increases the corresponding minimum square residual error decreases significantly and hence it leads to more accurate solutions. Further, it is important to note that our present HAM solution is good agreement with Numerical solution which is obtained by NDSolve scheme of Mathematica (See Fig.9).

Table 1: The average square residual error for the optimal value of 'h' for different order of approximations

Optimal h		Δ_m			
		10 th order	15 th order	20 th order	25 th order
-0.50	$M = 5$	4.48300×10^{-1}	2.17722×10^{-2}	8.560151×10^{-3}	6.293116×10^{-3}
-0.46	$\beta = 0.4$	9.61660×10^{-1}	4.76619×10^{-2}	1.085990×10^{-2}	7.63834×10^{-3}
-0.28	$\gamma = 1.5$	2.41549×10^{-1}	6.41384×10^{-2}	1.741480×10^{-2}	7.771010×10^{-3}
-0.46	$P_r = 1$	3.23985×10^{-3}	8.82479×10^{-4}	1.155850×10^{-6}	1.230240×10^{-8}
-0.51	$N_t = 0.5$	5.53236×10^{-1}	2.67400×10^{-2}	1.01741×10^{-2}	6.737690×10^{-3}
-0.49	$N_b = 0.2$	7.79008×10^{-3}	7.15877×10^{-3}	6.053300×10^{-3}	6.032410×10^{-3}
-0.58	$L_e = 5$	1.341560×10^{-1}	1.15096×10^{-2}	7.017850×10^{-3}	6.73713×10^{-3}

V. RESULTS AND DISCUSSIONS

To study the behavior of solutions, numerical calculations for different values of magnetic parameter (M), Permeability parameter (D_a), Casson fluid parameter (β), thermophoresis parameter (N_t),

Brownian motion parameter (N_b), Lewis number (L_e), Chemical reaction parameter (γ) and Prandtl number (P_r) have been carried out. Throughout the computations we employ $G_r = 5, G_c = 5, R_e = 1, l = 1, N_t = 0.45, N_b = 0.45, L_e = 10, M = 2, P_r = 2.5,$

$D_a = 0.5$, $K_1 = 1$, $\gamma = 0.5$, $\beta = 0.6$ unless otherwise stated. Fig. 3a is prepared to see the influence of the Casson fluid parameter with two different values of magnetic parameter 'M' with fixed values of all other parameters. It is observed that magnitude of velocity is a decreasing function with increasing Casson fluid parameter and also we noted that increasing 'M' is lead to decelerate the velocity. Physically it means that the application of transverse magnetic field produces a resistive type force (Lorentz force) similar to drag force which tends to resist the fluid flow and thus reducing its velocity (as noted in [18]). The effect of permeability parameter D_a on the velocity is displayed in Fig. 3b. It depicts that the effect of increasing the value of D_a is to increase the velocity, which means that the drag force is reduced by increasing the value of the permeability parameter. Fig. 3c illustrates the influence of thermophoresis parameter N_t on velocity. It shows that increasing N_t is not shown much influence on velocity distribution. The quite similar effect can be noticed by varying Brownian motion parameter N_b on the velocity (See Fig.3d).

Fig. 4a is graphed to see the effect of Lewis number on temperature distribution. It is seen that temperature field is an increasing function in the left half of the channel whereas the behavior is reversed in the other region. Fig. 4b describes that, increasing chemical reaction parameter gives opposite behavior that of Fig.4a. Fig. 4c is plotted to see the influence of Brownian motion parameter on temperature distribution. It is evident that increasing N_b is to increase the fluid temperature significantly. The similar effect can be noticed with increasing N_t and P_r , which are shown in Figs.4d and 4e. Physically speaking, increasing thermal parameters is to increase momentum diffusivity, which leads to enhance the fluid temperature. Further, it is noted that N_t , P_r shows the significant influence on temperature field than other parameters. Fig. 5a shows the variation in concentration field with different values of Lewis number L_e . It depicts that increasing L_e lead to enhance species concentration significantly. Also, it is observed that when increasing L_e from 0 to 5 there is nearly 45% increase in concentration whereas increasing L_e from 5 to 10 there is only 20% (approx) decrease in the same, which means that low values of L_e dominates on concentration field. The opposite trend can be seen if L_e is replaced by chemical reaction parameter. (See Fig. 5b). Fig. 5c is prepared to

see the effect of N_b on concentration. It is observed that concentration enhances with an increase of N_b whereas increasing thermal parameters N_t and P_r leads to suppress the concentration gradually (See Figs. 5d and 5e).

The variation of pressure gradient $\frac{dp}{dx}$ with M and G_r is plotted in Fig.6a. It is observed that increasing both the parameters lead to enhance the pressure gradient whereas in the absence of magnetic field pressure gradient is negative with increasing G_r , it means that high pressure gradient is need to promote the flow in the presence of magnetic field. The influence of inertia coefficient and material parameter on $\frac{dp}{dx}$ is graphed in Fig. 6b. It illustrates that pressure gradient is decreasing function with increasing I and β whereas very high pressure gradient exist for lower value of material parameter ($\beta < 0.5$). It indicates that more driving force is required for non-Newtonian fluid than Newtonian fluid. The variations on wall heat transfer rate (Nu) and wall mass transfer rate (Sh) with different values of N_b , N_t , L_e and γ are presented in Figs. 7 and 8 respectively. Influence of N_b and N_t on 'Nu' at both the walls is displayed in Fig 7. At the wall $\eta = -1$, 'Nu' is a decreasing function with increasing N_b , N_t whereas at the other wall there is no much influence with increasing N_b . Also, a sharp increment occurs in 'Nu' with increasing N_t . Variation on 'Sh' with different values of L_e and γ at both the walls is displayed in Fig 8. It depicts that, 'Sh' is a decreasing function with increasing L_e while increasing γ is not shown much influence at the wall $\eta = -1$. At the other wall, the opposite trend is noticed with increasing L_e .

VI. CONCLUSIONS

This article looks at flow, heat and mass transfer characteristics of a MHD Casson nanofluid in a vertical porous space with stretching walls in the presence of chemical reaction. HAM is adopted to obtain analytical solutions of the reduced set of ordinary differential equations. The results are presented through graphs for various values of the pertinent parameters and the salient features of the solutions are discussed graphically. This type of investigations is very important for mathematical modeling of blood flow in narrow arteries at low shear

rates. It is found that magnitude of velocity is a decreasing function with the Casson fluid parameter and Hartmann number whereas increasing permeability parameter D_a . Increasing N_b , N_t and P_r are tends to promote the fluid temperature significantly. Concentration field significantly enhances

with increasing L_e while increasing N_t and P_r suppresses the fluid concentration. Nusselt number distribution is a decreasing function with increasing N_b , N_t at the wall $\eta = -1$ while the parameter N_t tends to enhance at the other wall $\eta = 1$.

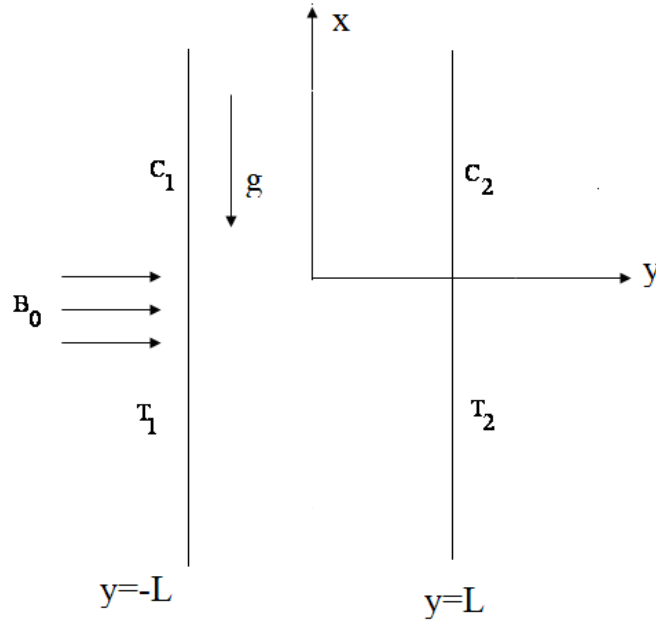


Fig. 1: Schematic diagram of the problem

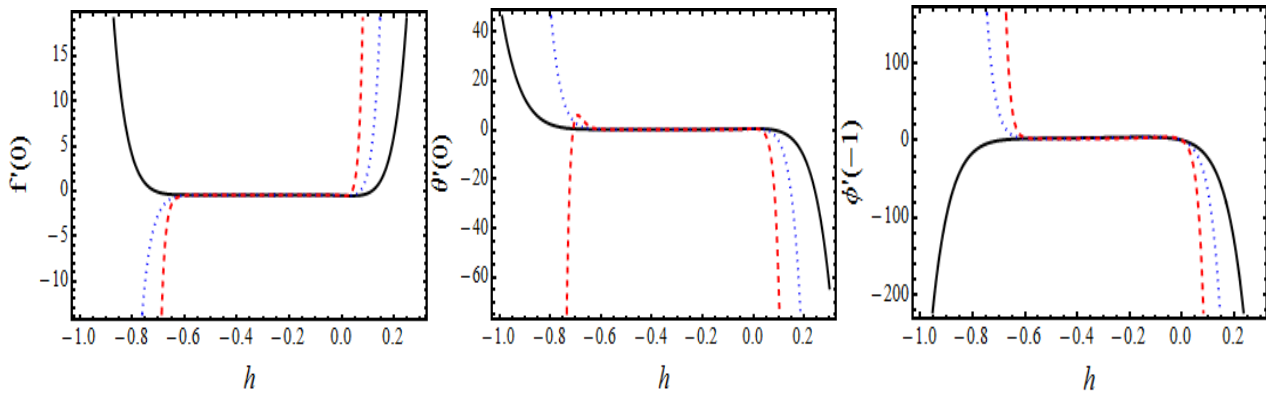


Fig. 2: h-curves for velocity, temperature and concentration distribution (— 10th, 15th, --- 25th orders of approximation)

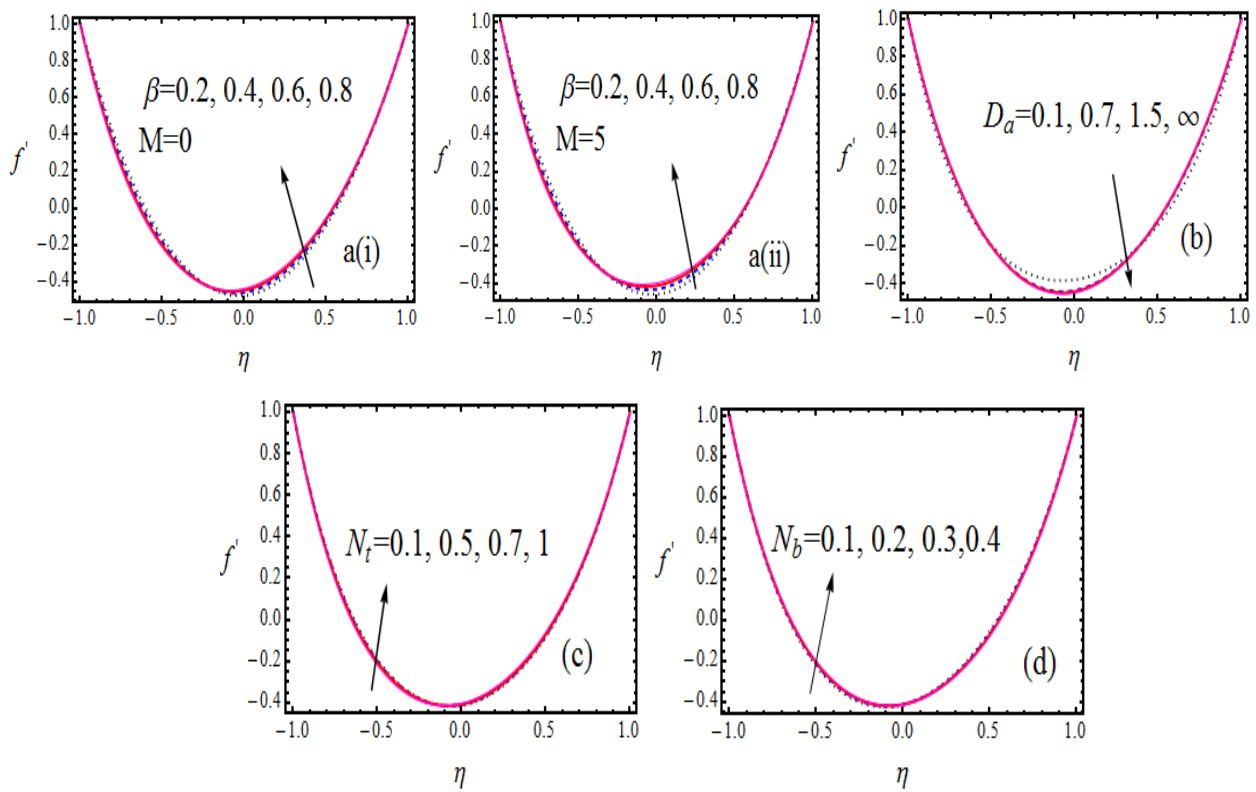


Fig. 3: Effects of M , β , D_a , N_t and N_b on Velocity distribution

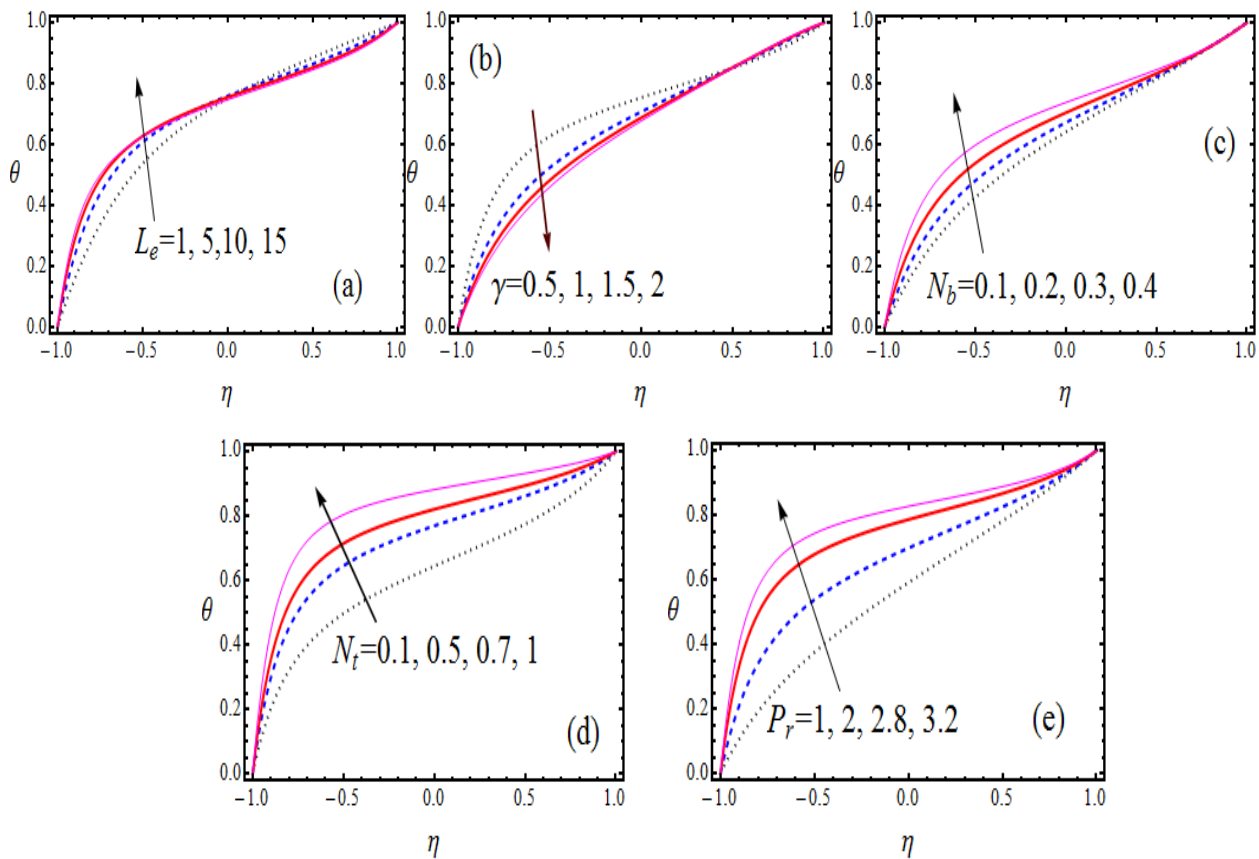


Fig. 4: Effects of L_e , γ , N_b , N_t and P_r on Temperature distribution

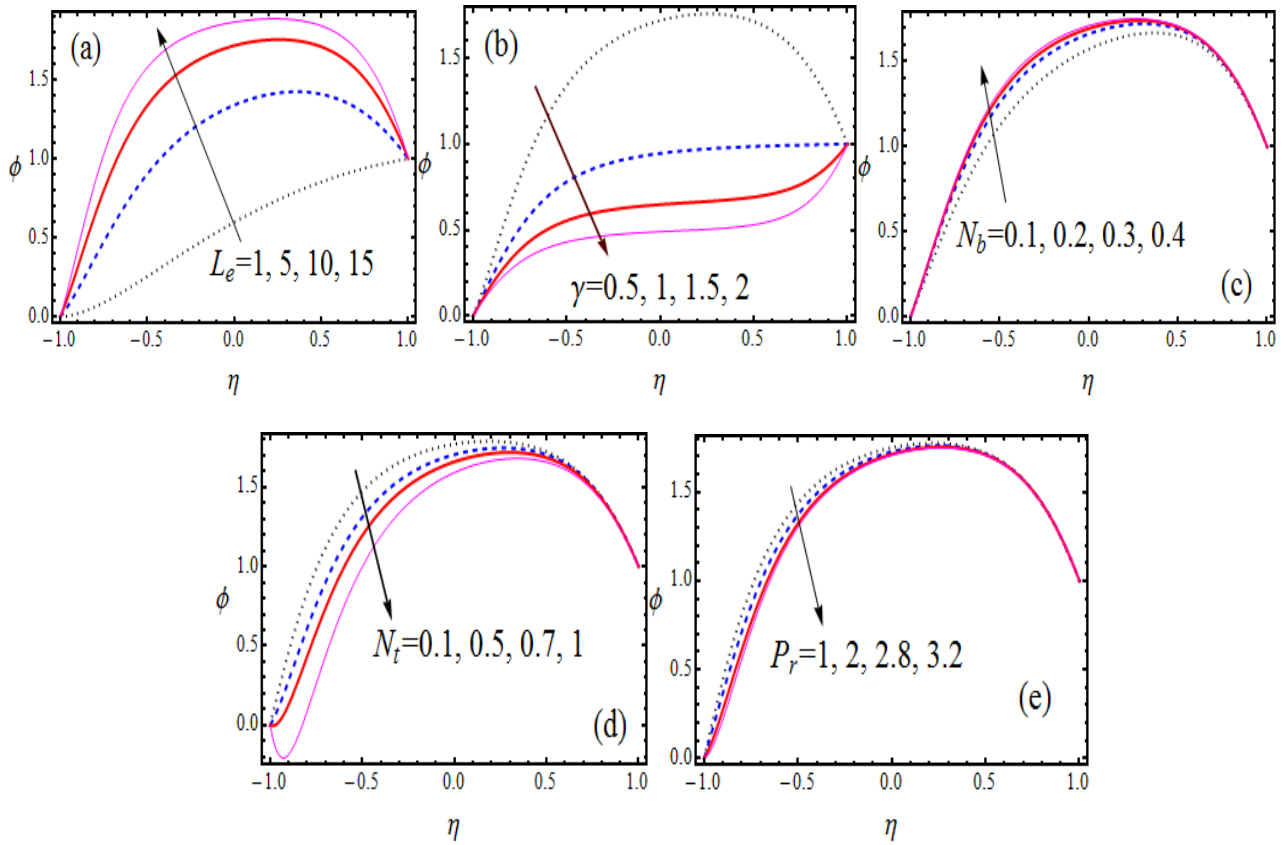


Fig. 5: Effects of L_e , γ , N_b , N_t and P_r on Concentration distribution

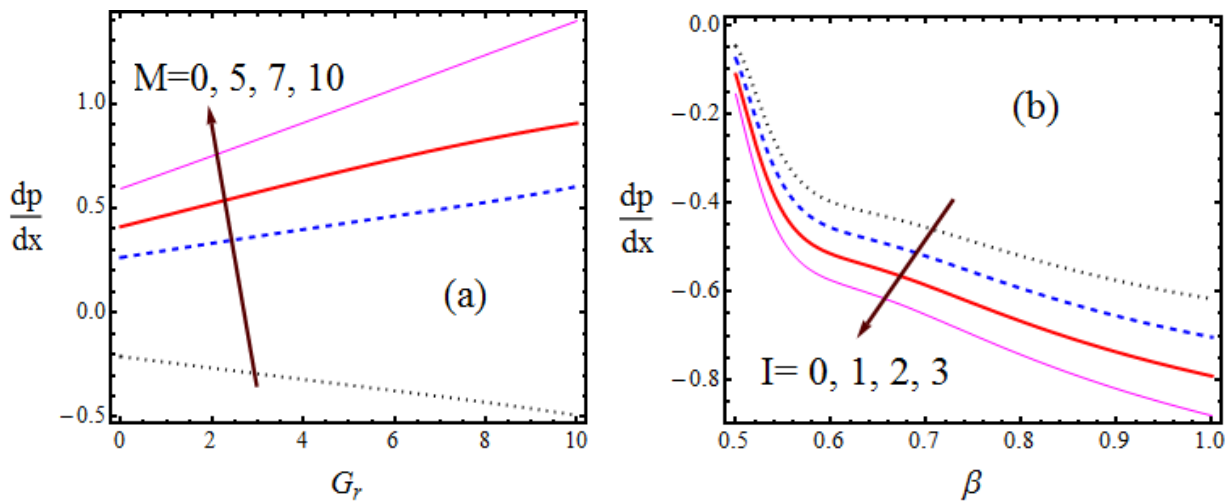


Fig. 6: Effects of M and I on Pressure gradient distribution

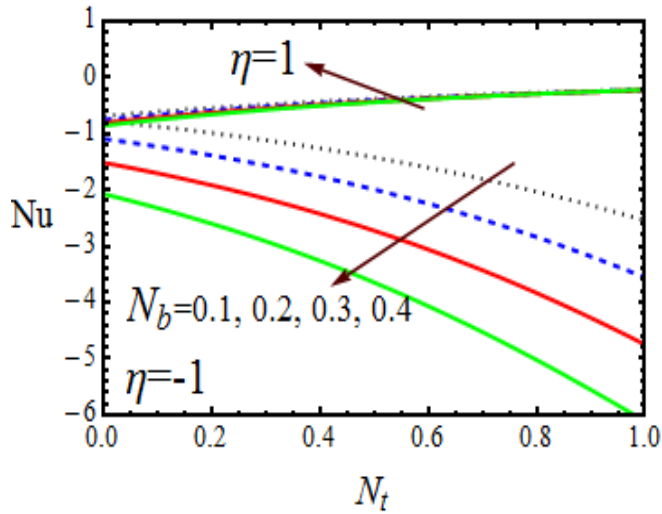


Fig. 7: Effect of N_t on Nusselt number distribution

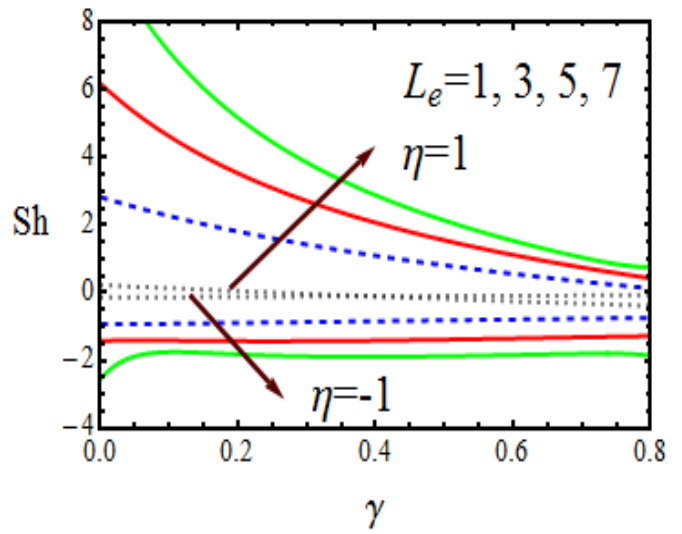


Fig. 8: Effect of γ on Sherwood number distribution

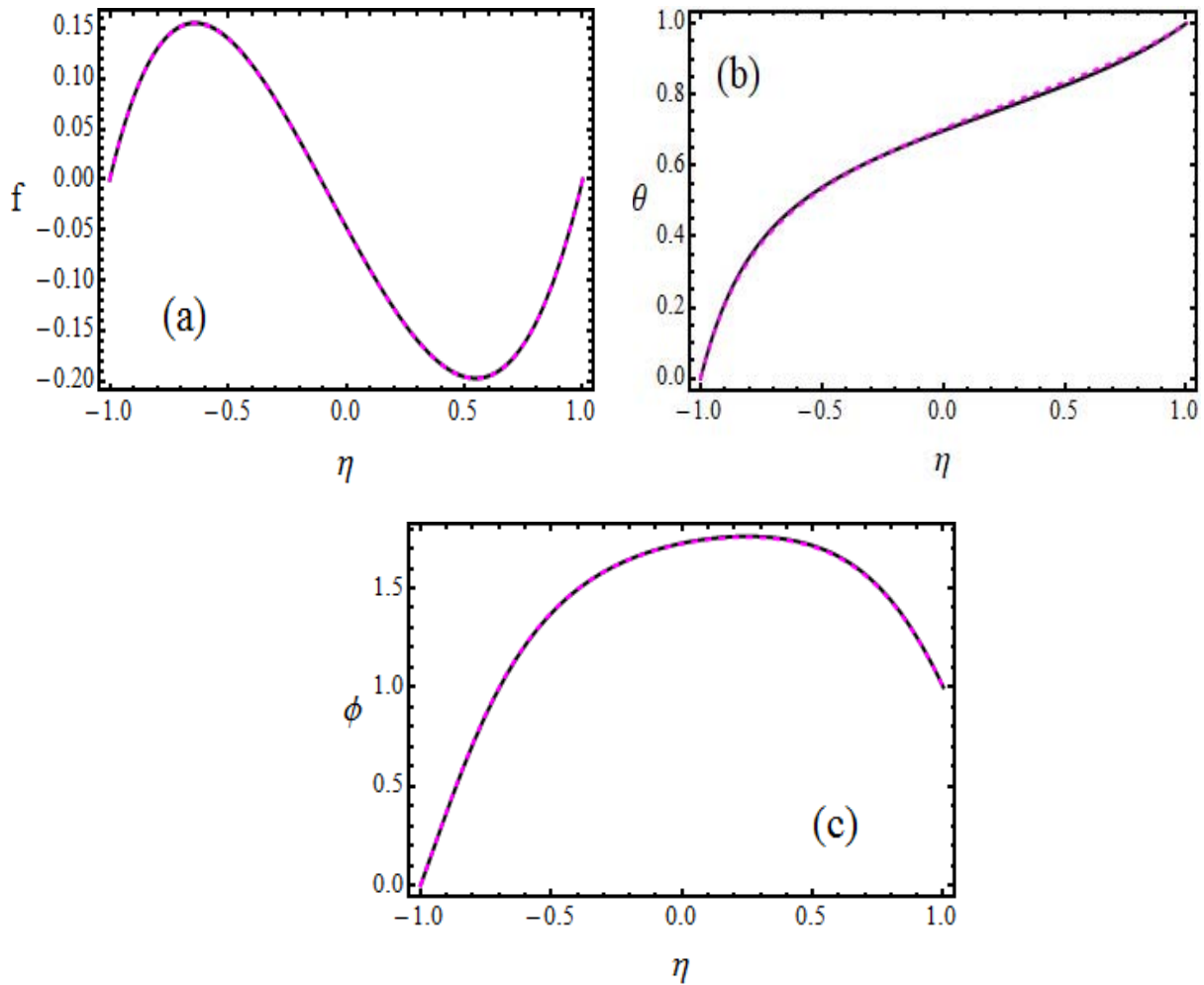


Fig. 9: Comparison between _____HAM Solution and - - - - -Numerical Solution

$$(G_r = 5, G_c = 5, R_e = 1, l = 1, N_t = 0.45, N_b = 0.45, M = 2, P_r = 2, D_a = 0.5, K_1 = 1, \gamma = 0.5, \beta = 0.6)$$



NOMENCLATURE

B_0 Transverse magnetic field
 $b > 0$ Stretch of the channel walls(m)
 C Dimensional concentration(Kg / m^3)
 C_1, C_2 Wall concentrations (Kg / m^3)
 C_0 Initial concentration (Kg / m^3)
 C_F Inertial coefficient
 C_p Specific heat
 D_a Permeability parameter
 D_B Brownian diffusion coefficient (m^2 / s)
 D_T Thermophoresis diffusion coefficient (m^2 / s)
 e_{ij} (i, j)th component of deformation rate
 f Dimensionless stream function
 f' Dimensionless velocity
 g Acceleration due to gravity(m / sec^2)
 G_r Local temperature Grashof number
 G_c Local nano-particle Grashof number
 I Inertia coefficient
 k^* Permeability of the medium(m^2)
 K Thermal conductivity of the fluid ($W / m K$)
 L_e Lewis number
 M Hartmann number
 N_b Brownian motion parameter
 N_t Thermophoresis parameter
 p Pressure(N / m^2)
 P_r Prandtl number
 Re Reynolds number
 T Dimensional temperature
 T_1, T_2 Wall temperatures (K)
 \bar{T} Mean value of T_1 and T_2 (K)
 T_0 Inlet temperature (K)
 u, v Dimensional velocity components in x and y directions (m/s)

Greek Symbols

α^* Thermal diffusivity of the fluid (m / s^2)
 β Casson parameter
 θ Dimensionless temperature
 β_t Coefficient of thermal expansion(K^{-1})

β_c Coefficient of expansion with concentration(K^{-1})
 μ_B Plastic dynamic viscosity of the non-Newtonian fluid ($N s / m^2$)
 μ_f Dynamic viscosity of the fluid ($N sec / m^2$)
 γ Chemical reaction parameter
 ν Kinematic viscosity(m^2 / sec)
 ρ_f, ρ_p Densities of the base fluid and nano-particle (Kg / m^3)
 $(\rho C_p)_f$ Heat capacity of the fluid(J/K)
 $(\rho C_p)_p$ Effective heat capacity of the nanoparticle Material (J/K)
 ϕ^* Porosity of the medium
 ϕ Dimensionless fluid concentration
 σ Coefficient of electric conductivity(S/m)
 τ_y Yield stress of the fluid (N / m^2)
 π Product of the component of deformation rate

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GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING

Volume 18 Issue 1 Version 1.0 Year 2018

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals

Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Critical Analyses of Sewing Defects and Minimization of Sewing Reworks in the Apparel Industries

By S. M Masum Alam & Dr. Mohammad Nurul Huda

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Abstract- Improving productivity is major concern of apparel industries. There are many factors to increase productivity. The efficiency of workers, tactic and sewing defects of production are interrelation of productivity. Entirely sewing faults are not possible to reduce, but it can improve to minimize the defects of productivity with the help of some technics. This paper considers the quality and productivity enhancement in a manufacturing process through practical study. An experimental investigation for the sewing defects is collect sufficient data from industries. Statistical tools Bar chart, Fishbone diagram, and Regression values help to analysis sewing faults of apparel industries. The outcome of this study is find out the reasons, effects, and remedies of garments sewing defects.

Keywords: GSM, DHU, broken stitch, skipped stich, sewing tension, sewing rework and AQL system.

GJRE-J Classification: FOR Code: 290502



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Critical Analyses of Sewing Defects and Minimization of Sewing Reworks in the Apparel Industries

S. M Masum Alam^α & Dr. Mohammad Nurul Huda^σ

Abstract- Improving productivity is major concern of apparel industries. There are many factors to increase productivity. The efficiency of workers, tactic and sewing defects of production are interrelation of productivity. Entirely sewing faults are not possible to reduce, but it can improve to minimize the defects of productivity with the help of some technics. This paper considers the quality and productivity enhancement in a manufacturing process through practical study. An experimental investigation for the sewing defects is collect sufficient data from industries. Statistical tools Bar chart, Fishbone diagram, and Regression values help to analysis sewing faults of apparel industries. The outcome of this study is find out the reasons, effects, and remedies of garments sewing defects.

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I. INTRODUCTION

The fast-changing economic conditions such as global competition, declining profit margin, customer demand for the high-quality product, product variety, and reduced lead-time, etc. had a significant impacts on manufacturing industries. The demand for higher value a lower price is increasing and surviving apparel manufacturers need to improve their operations through producing right first-time quality and waste reduction. This paper discusses the quality and productivity improvement in a manufacturing enterprise through practical study. The work investigates a framework to identify quantify and eliminate sources of variation in an operational process, to optimize the operation variables, improve and sustain process performance with well-executed control plans. The primary quality characteristics are static physical dimensions, and secondary qualitative are the reactions of the clothes to an applied dynamic force. The apparel manufacturer is primarily interested in the secondary characteristics of the fabric and focuses on the seam quality during the fabrication and production of apparel [1].

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The application of this practice improves the process performance of the critical operational process, leading to better utilization of resources, decreases variations & maintains consistent quality of the process output. The production process includes a set of workstations, each of has a specific task that carried out selected sequence, for the different styles simultaneously [2] The outcome of this observation reflected that an industry might gain higher productivity and profitability with improved quality product by minimizing reworks activities. In the present work, the impact of an increase in needle thread tension [3], [4], [5] on the fabric is analyzed in Single Needle Lock Stitch sewing machine with stitch type Class 300 and Type 301.

At present, the success of the Readymade Garments sector highly depends on several factors such as manufacturing lead time, quality of the product, production cost, etc. Broken stitch, Skipped stitch, Open seam, and others sewing problems are related to the product quality. The lower quality products are hampered productivity. These flaws can be repairable that leads to rework or non-repairable that leads to rejection. Rework in the garments industry is a regular work that hampers the smooth production rate and focuses poor quality products having an impact on overall factory economy. Minimization of reworks is a must in quality and productivity improvement. Rework is a vital issue for inferiority product and low production rate [6]. Reworks are the non-productive activities focusing on any operations that customer is not willing to pay for it. Non-productive activities describe that the customer does not consider as adding value to this product.

II. MATERIAL AND METHODOLOGY

a) Materials Descriptions

Fabric: We have studied 95 % cotton, and 5 % Lycra knit composite fabric for a T-Shirt and the fabric weight was 200 gram per square meter.

Sewing thread: Sewing thread applied 100% cotton spun yarn that counts mentioned 40 Tex and stitches per minute (SPI) 12.

b) *Methods and process sequence*

We have performed this research work on 32 garments line based in Apparel Industry in Bangladesh. Every garments line contained 26 no of the machine. As per Acceptable Quality level (AQL) inspection system, we selected lot size code "J" and sample size 80. Everyday 80 pcs garments we have inspected and similarly, total 560 pcs sample observed during seven days. Different types of sewing tension like 3, 4, 5, 6, and 7 applied in same garments line and found different kinds of several faults..

III. DATA ANALYSIS

Table 1: Total No of Inspected samples- 560 pcs and Sewing Tension used- 3

Day	F1	F2	F3	F4	F5
1st	10	15	5	2	7
2nd	11	13	4	1	8
3rd	14	11	3	2	8
4th	12	15	2	2	7
5th	13	13	3	2	8
6th	10	14	3	2	6
7th	14	15	4	2	8
TD	84	96	24	13	52
DHU%	15	17.14	4.29	2.32	9.29

Table 2: Total No of Inspected samples- 560 pcs and Sewing Tension used- 4

Day	F1	F2	F3	F4	F5
1st	12	12	4	2	6
2nd	10	12	3	3	7
3rd	12	14	5	2	8
4th	11	14	1	1	6
5th	10	13	2	1	8
6th	9	14	3	2	7
7th	15	14	2	2	8
TD	79	93	20	13	50
DHU%	14.11	16.61	3.57	2.32	8.93

F1 = Brocken Stitch, F2 = Skipped Stitch,
 F3 = Open seam, F4 = Uneven stitch,
 F5 = Others Defects, TD = Total No of Defects,
 DHU % = Defects per Hundred Unit

Table 3: Total No of Inspected sample-560 pcs And Sewing Tension used-5

Day	F1	F2	F3	F4	F5
1st	8	10	4	2	5
2nd	9	11	3	1	7
3rd	11	8	4	2	8
4th	10	10	3	3	9
5th	11	11	2	2	8
6th	10	12	1	2	5
7th	10	14	2	0	4
TD	69	76	19	12	46
DHU%	12.32	13.57	3.39	2.14	8.21

Table 4: Total No of Inspected sample-560 pcs And Sewing Tension used-6

Day	F1	F2	F3	F4	F5
1st	14	11	4	2	6
2nd	12	12	3	1	8
3rd	13	15	3	2	7
4th	11	14	4	1	6
5th	13	12	2	0	8
6th	12	14	3	4	6
7th	10	13	2	3	7
TD	85	91	21	13	48
DHU%	15.18	16.25	3.75	2.32	8.57

Table 5: Total No of Inspected sample-560 pcs And Sewing Tension used-7

Day	F1	F2	F3	F4	F5
1st	11	13	3	3	7
2nd	13	14	2	4	6
3rd	15	12	4	2	7
4th	13	14	3	2	8
5th	11	15	4	2	8
6th	14	13	2	3	7
7th	14	14	4	4	7
TD	91	95	22	20	50
DHU%	16.25	16.96	3.93	3.57	8.93

a) Cause and effect diagram of Skipped and Broken Stitch

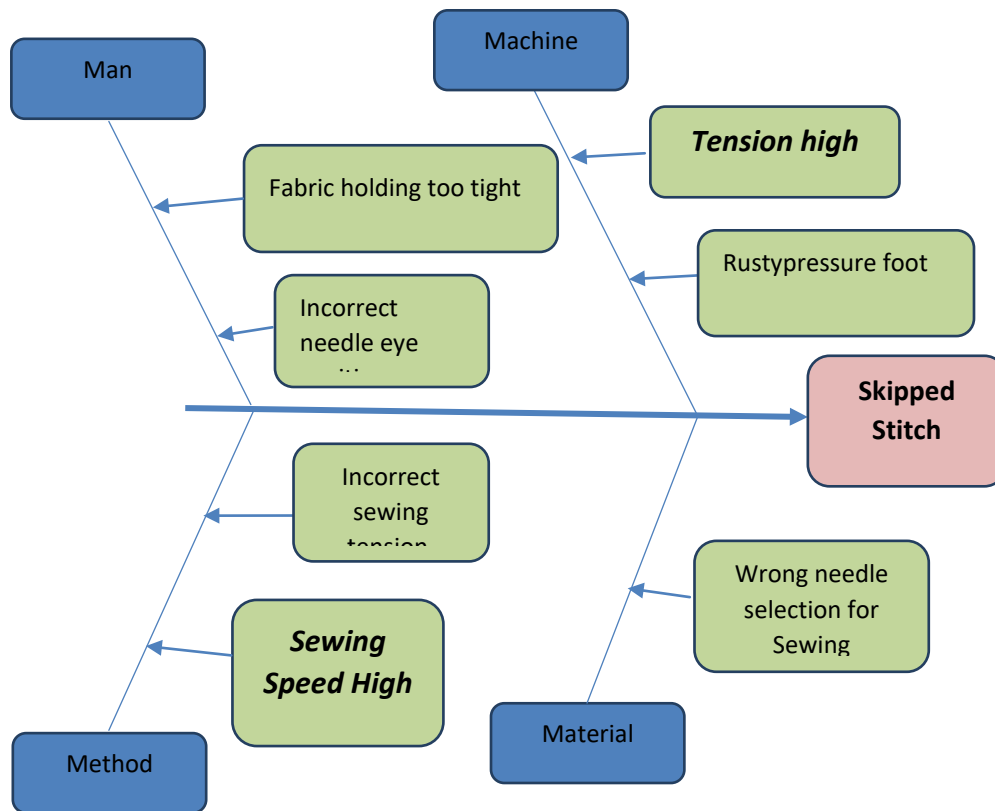


Fig. (a)

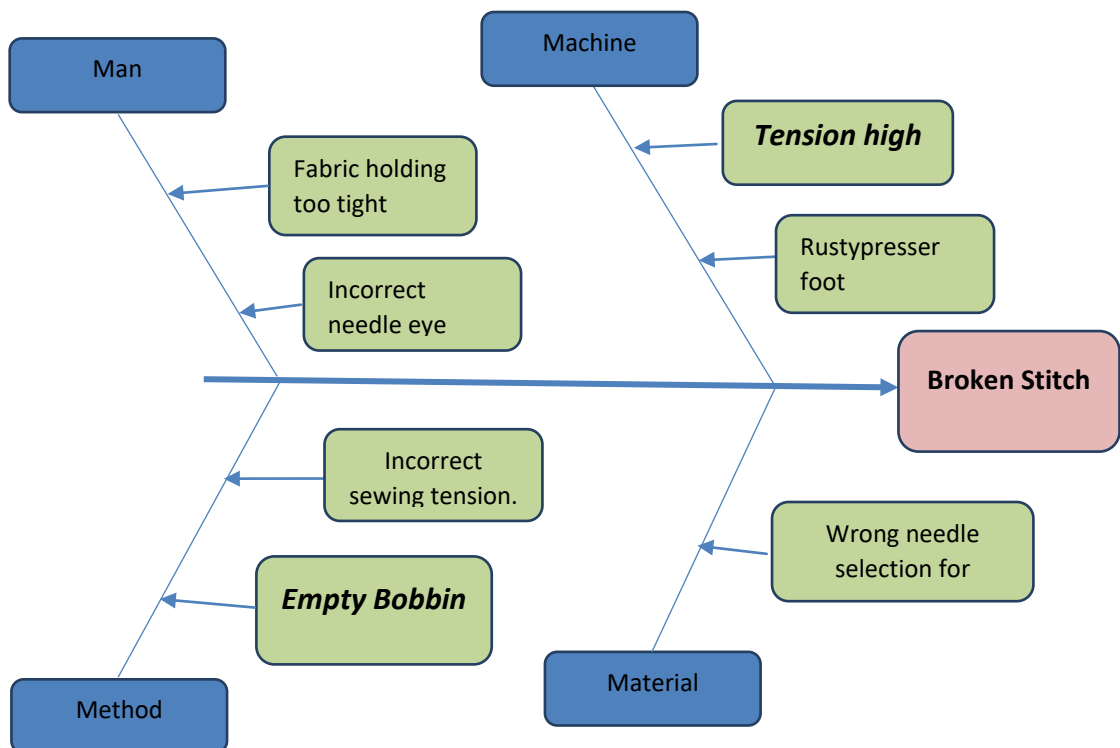


Fig. (b)

IV. RESULTS AND DISCUSSION

Table 6: Effects of different tension on sewing faults

Sewing Tensions	Broken stitch	Skipped stitch	Open seam	Uneven stitch	Others defects
3	15	17.14	4.29	2.32	9.29
4	14.11	16.61	3.57	2.32	8.93
5	12.32	13.57	3.39	2.14	8.21
6	15.18	16.25	3.75	2.32	8.57
7	16.25	16.96	3.93	3.57	8.93

By Analysis the defects% from the above research work we have identified that the top defects of sewing problems are Broken and skipped a stitch. These are about 14.6% and 15.94% respectively of total errors. There are many factors which directly influenced by occurred Skipped and Broken stitch. Among them, we have applied different tensions and found the effects. The tension scale shows 0 to 9 categories, from

there we have applied stress 3 to 7 category. “0” class tension that shows loose stitch and “9” category tension exposition too tight stitch. As per our assessment sewing tension “5” shows fewer defects compare to others sewing tensions.

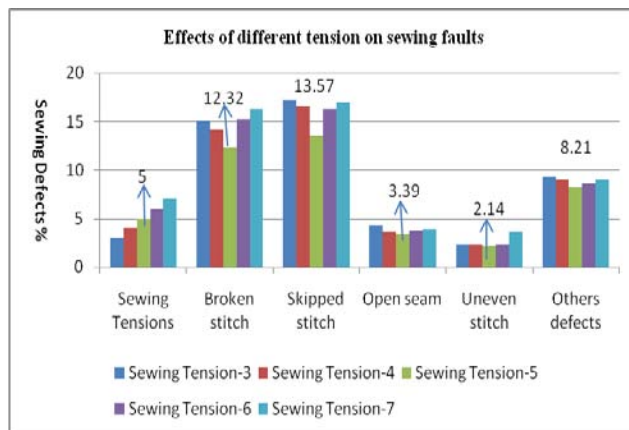


Fig. 1

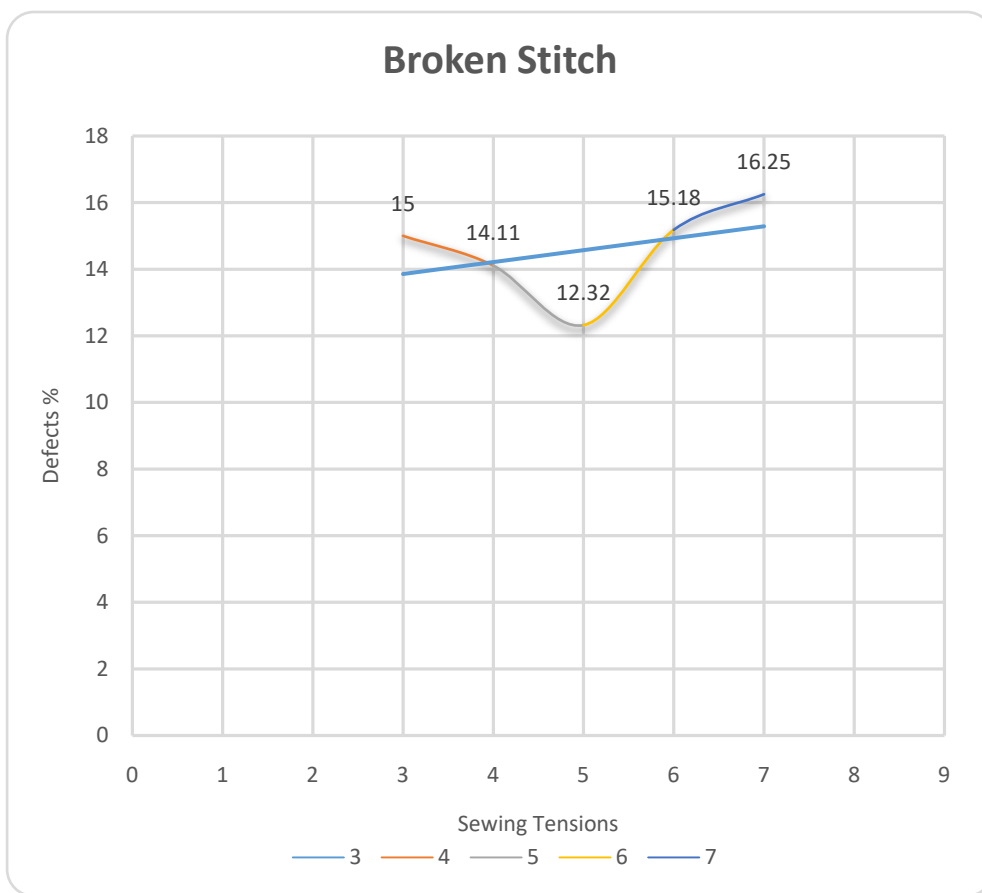


Fig. 2

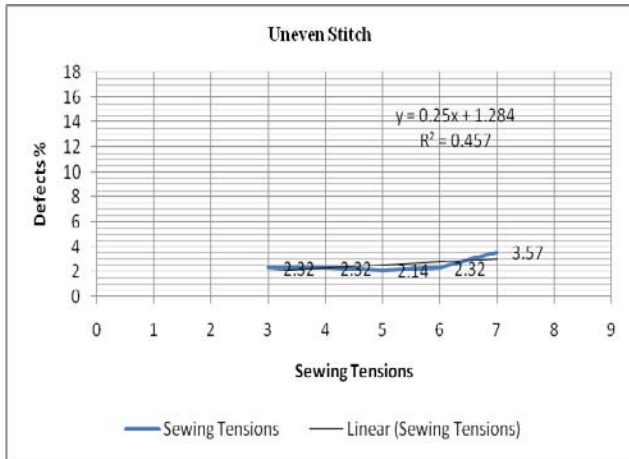


Fig. 3

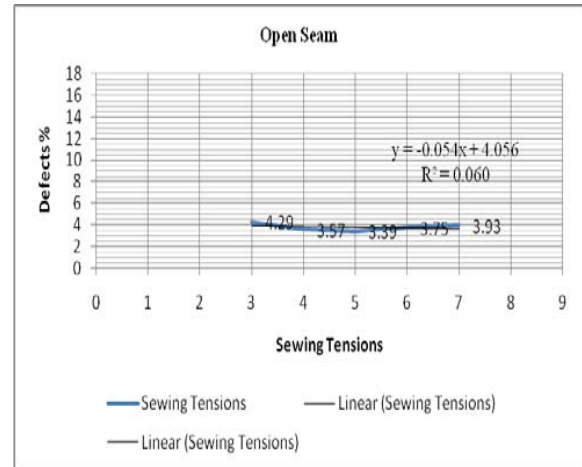


Fig. 6

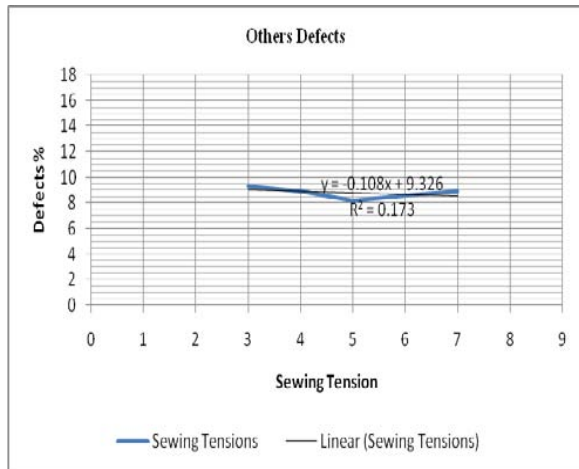


Fig. 4

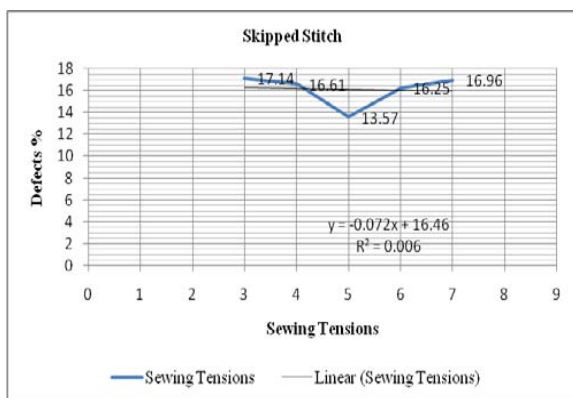


Fig. 5

V. CONCLUSION

This study indicates that by eliminating non-productive activities like reworks in the apparel industries time as well as cost are saved by ensuring quality products which has an significant impact on the overall factory.

We have implements different sewing tensions that were the leading causes for broken stitch as well as a skipped stitch. Except for this reason many other factors like high speed, empty bobbin, rusty pressure foot and materials handling by the worker also impact on same types of faults. We can have further research work on the way out to minimize those sewing defects by developing some methods to identify the bobbin condition just before empty.

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GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING

Volume 18 Issue 1 Version 1.0 Year 2018

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals

Online ISSN: 2249-4596 & Print ISSN: 0975-5861

A Meta Analysis of Natural Gas Consumption

By Prabodh Pradhan & Sunil Dhal

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Abstract- Natural Gas is considered to be one of the leading energy sources for India which provide pollution free, flexible to move to our industry. Due to limited Natural Gas resource, it is a challenge to conserve, utilize our resource in an optimal way. For this a number of authors are tried to predict the natural gas consumption in short and long term basis using mathematical and computational Techniques. The objective of the paper is to meta-analysis the papers published related to Natural Gas consumption for the year 2002-2017. This research helps to find out a better and accurate prediction techniques in short and long term basis for prediction of Natural Gas Consumption(NGC).

Keywords: NGC.

GJRE-J Classification: FOR Code: 850499



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A Meta Analysis of Natural Gas Consumption

Prabodh Pradhan^α & Sunil Dhal^σ

Abstract- Natural Gas is considered to be one of the leading energy sources for India which provide pollution free, flexible to move to our industry. Due to limited Natural Gas resource, it is a challenge to conserve, utilize our resource in an optimal way. For this a number of authors are tried to predict the natural gas consumption in short and long term basis using mathematical and computational Techniques. The objective of the paper is to meta-analysis the papers published related to Natural Gas consumption for the year 2002-2017. This research helps to find out a better and accurate prediction techniques in short and long term basis for prediction of Natural Gas Consumption(NGC).

Keywords: NGC.

I. INTRODUCTION

Natural gas(NG) is an important energy resources that is becoming more and more popular because of its environmental benefits(lower impact on environmental pollution). All most all developed countries are concerned about the natural gas consumption due to low reserve. Omer Fahrettin Dem, IREL, Selim Zaim, 2011 predicted that china's natural gas consumption will continue to grow and expected to achieve 354.1bcm by 2020. Michael Ratner(India), 2017 on his research article, he found that the natural gas portion in india's energy mix is 7% as it remains small compared to that of the US and other developed countries like Brazil, China. India's target it to double the proportion of natural gas consumption by 2022. To achieve this goal we would require major upstream, midstream and downstream investments as well as the continued political will to take necessary steps and to decrease reliance on coal and oil. Therefore, demand for this source of energy has increased considerably in recent years. The largest increase in world's primary energy consumption is attributed to N.G as per U.S Energy Information Administration 2016.

It is projected that the Natural Gas consumption as primary energy source will increase to 2040 TCF compared to the recorded consumption 120 TCF in the year 2012-2013. As per British Petroleum(BP) global 2015 NG contributes 23.8% of the primary energy consumption globally and remains as the main fuel in production of electricity and as a fuel for the industry.

A number of researchers attempted to develop models for the prediction of NGC on daily, weekly,

monthly, quarterly and yearly basis. It has reviewed that the computational models were suitable for natural gas consumption for a better input parameters. The model efficiency not only depends upon the algorithm but majorly depends upon the input parameters. Every natural gas distributor is obliged to make a nomination of natural gas by its supplier, which is the amount of gas needed for the future days. There is a certain regulated tolerance that is allowed. In case the actual consumption exceeds the nominated amount, the distributor must pay a certain penalty. On the other hand, if nominated amount exceed actual consumption, different type of penalty will be charged as well. Since the incorrect nominations lead to high costs, accurate predictions of natural gas consumption for the following day are very important due to financial reasons.

II. METHODOLOGY

For the research purposes, literature overview analysis was conducted using PRQUEST database. The keywords "natural gas consumption", "prediction of Natural Gas" OR "demand of Natural Gas", "Consumption of Natural Gas", "Prediction models in Natural Gas)", were used for searching articles. The articles were searched within three indexes: Science Citation Index Expanded (SCI-Expanded), Social Science Citation Index (SCI), and Arts and Humanities Citation Index (A&HCI) for the period of 2002 to 2017.

This search resulted with 276 papers, including article (201), proceedings paper (28) and review (47). After reviewing the title, abstracts and keywords of all found articles, articles that are not related to models for prediction of CNG for residential or commercial use were eliminated. Thereafter, 72 articles remain that met posted criteria. Those papers were analysed according to several criteria: methods used for predictions of CNG, input variables used for modelling, prediction area and prediction horizon.

Similar literature review was conducted by Soldo (2012), who analysed natural gas consumption from the year 1949 to 2010 and Dario Sebalj, Josip Mesarie, Davor Dujak, 2017, he predicted the Natural Gas consumption from the year 2002-2017 using web of science core collection (WOSCC) database.

As it can be seen in Table 1, in the last three years 34 papers considering natural gas prediction were published, which is more than 55% of all analysed papers.

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Table 1: Number of published papers per year

Year Publication	No.	%	Authors
2004	1	1.38%	Gil & Deferrari.
2005	2	2.76%	Aras; Gutierrezetal.
2006	2	2.76%	Hillard G. Huntington, Dejan Ivezić
2007	4	5.52%	Potocnik et al, Hongjie Lu, Hongjun You , Reed P. Timmer, Peter J. Lamb; <u>Syed Ali Naqi</u> , <u>Syed Jamil Hassan Kazmi</u> , <u>Jeong C. Seong</u>
2008	2	2.76%	Brabecetal., Nil Aras.
2009	3	4.14%	Tonkovic, Omer Fahrettin Demirel, Selim Zaim; Steven R. Vitullo; Ronald H. Brown; George F. Corliss, Brian M. Marx.
2010	7	9.66%	Azadeh.; Forouzanfar.; Ma&Li; Mustafa Akkurt , Omer F. Demirel, Selim Zaim; Kaynar, Oguz Yilmaz, Isik Demirkoparan, Ferhan; F. B. Gouucu; Ebrahim Kamrani
2011	7	9.66%	Kaynar; Saboe; Zia Wadud, Himadri S Dey, Md. Ashfanor Kabir, Shahidul I Khan; Omer Fahrettin Demirel, IREL, SelimZaim ; Junchen Li, Xiucheng Dong, Jianxin Shangguan, Mikael Höök; Hossein Iranmanesh, Majid Abdollahzade, Arash Miranian; Hossein Iranmanesh, Majid Abdollahzade, Arash Miranian
2012	7	9.66%	Demirel.; Olgun, Mahbubur Rahman, Mohammad Tamim & Lutfar Rahman; Fahim Faisal; Yi-Shian Lee, Lee-Ing Tong; Azari, Ahmad; Shariaty-Niassar, Mojtaba; Azari, Ahmad; Shariaty-Niassar, Mojtaba; Alborzi, Mahmoud
2013	4	5.52%	Taspinar; AhmetGoncu, Mehmet, Oguz Karahan, Tolga Umut Kuzuba; Hongjie Lu, Hongjun You; Mohsen Hajabdollahi, Mostafa Hosseinzadeh, M.M Ghanadi Arab
2014	5	6.90%	Soldo, Nguyen Hoang Viet, Jacek Mandziuk; <u>Mustafa Akpinar</u> , Nejat Yumusak; Krzysztof Nęcka, Małgorzata Trojanowska: Małgorzata Trojanowska
2015	11	15.18%	Azadeh.; Boran; Izadyar; Szoplik; Wu.; Zhueta.; Wei Zhang, Jun Yang; Halle Bakhteyar, Abbas Maleki; Jolanta Szoplik; Junwei Miao; Junghwan Jin, Jinsoo Kim
2016	10	13.8%	Akpinar & Yumusak; Bai & Li; Baldaccietal.; Zeng&Li; Sergas Sergipe Gas S. A., Aracaju; Mustafa Akpinar, M. Fatih Adak, Nejat Yumusak; Beyzanur Cayir Ervural, Omer Faruk Beyca, Selim Zaim; Gaurav Bhattacharya; Hans-Holger, Rogner; Miha Kovačič, Božidar Šarler, Uroš Župerl
2017	8	11.04%	Akpinar & Yumusak; Panapakidis & Dagoumas; Almir; Beserra dos Santos, Erika Christina Ashton Nunes Chrisman; Xiaoyu Wang, Dongkun Luo, Jianye Liu, Wenhuan Wang, and GuixinJie; Zhenwu Zhang, Xiantao Liu; Michael Ratner; Dublin Sanjay Kumar Kar; Tim Boersma, Akos Losz, Astha Ummat
Total	72	100.00%	

a) *Overview of prediction of various time horizon*

Consumption of Natural Gas can be predicted over different time horizons starting from annual basis to hourly basis. Different researchers have used different

methods for this purpose. Given below is a list of research papers giving the methods used and different time horizons.

Table 2: Overview of predictions of natural gas consumption

Sl. No.	Author	Year	Region	Remarks
1	S. Gil, J Deferrari	2004	Argentina	ANN is used to predict the maximum consumption in the intermediate range.
2	DejanIvezić	2006	Belgrade	applications are classifications problems, pattern recognition and functions approximation.
3	Hongjie Lu, Hongjun You	2007	China	It results in good economic and social benefits in China.
4	Nil ARAS	2008	Turkey	ANN used as an alternative solution approach to forecast the future demand of natural gas.
5	Omer Fahrettin DEMIREL, Selim ZAIM,	2011	Istanbul	China will be the number one natural gas consumption country in the asia pacific region by 2015.
6	Hossein Iranmanesh Majid Abdollahzade Arash Miranian	2011	Iran	The optimized model (ANN) which is employed for prediction of annual natural gas consumption in Iran and Unites States.
7	Hongjie Lu Hongjun You	2013	Canada	The practical experimental values & Natural gas consumption in China can be accurately estimated through prediction models
8	Małgorzata Trojanowska	2014	Poland	Predict the daily demand for natural gas by rural consumers.
9	Nguyen Hoang Viet Jacek Mandziuk	2014	Poland	The neural network model is most efficient techniques and the result is acceptable by the natural gas company's viewpoints.
10	Wei Zhang Jun Yang	2015	China	ANN model can be used as an effective tool to estimate natural gas consumption in different countries.
11	Halle Bakhteyyar Abbas Maleki	2015	Iran	A trial-and-error procedure used to identify the suitable parameters for prediction of natural gas
12	Jolanta Szoplik	2015	Poland	Focused to predict gas consumption on any day of the year and any hour of the day.
13	Junghwan Jin Jinsoo Kim	2015	Korea	GARCH model is more suitable model than ANN techniques to forecast the detail components.
14	Sergas Sergipe Gas S. A., Aracaju	2016	Brazil	Daily the producer adjusts its production capacity considering the availability of transportation pipelines, gas pipelines and demands from consumers.
15	Mustafa Akpınar M. Fatih Adak Nejat Yumusak	2016	Ukraine	The ANN model with two hidden layer gives better results in demand forecasting than the other model.

16	Beyzanur Cayir Ervural Omer Faruk Beyca Selim Zaim	2016	Turkey	Genetic algorithms provide an objective and effective identification way for parameter estimation of ARMA method
17	Xiaoyu Wang, Dongkun Luo, Jianye Liu, Wenhuan Wang, and Guixin Jie	2017	China	The results shows China's natural gas consumption will grow rapidly over the next five years and reach 354.1 billion cubic meters (bcm) by 2020
18	Zhenwu Zhang Xiantao Liu	2017	China	the PSO-GBP prediction model improved the mean absolute deviation and mean absolute percentage error values by 0.065 and 0.03485 and 6.67944 and 3.62817, respectively, and increased the calculation time by 0.00726 and 0.00378 s.
19	Sanjay Kumar Kar	2017	India	useful to researchers, professionals, and policy makers working in the area of natural gas and related fields.
20	Michael Ratner	2017	India	India is targeting to double the proportion of natural gas consumption by 2022.

Table 2: (Natural Gas Prediction Papers in country wise)

	Country	Number of published Papers
1	Argentina	02
2	China	11
3	Croatia	03
4	Greece	01
5	Iran	11
6	Italy	01
7	Poland	05
8	Slovakia(SLK)	01
9	Slovenia(SLO)	02
1	Spain(SP)	01
1	Turkey(TUK)	13
12	United Kingdom(UK)	01
12	India(IND)	03
13	Bangladesh	03
14	Brazil	02
15	USA	02
16	Istanbul	01
17	Serbia	01
18	Taiwan	01
19	Canada	01
20	Ukraine	01
21	Korea	01
22	Austria	02
23	Pakistan	01

III. OVERVIEW OF PREDICTION HORIZONS

There are several prediction horizons that can be used for prediction of NG consumption. Large numbers of authors were predicting NG

consumption on annual level. Out of which I found four authors predicting Natural gas consumption on yearly basis.

Gil & Deferrari (2004) presented a model to prediction of the annual consumption of NG for there gionin Argentina, Zia Wadud, Himadri S Dey, Md. Ashfanoor Kabir, Shahidul I Khan Gutierrez et al. (2011) used the Engineering-economy models model for forecasting annual NG consumption in Bangladesh, Halle Bakhteyar, Abbas Maleki(2015) used a Radial Basis Function Neural Network (RBFNN)&Particle Swarm Optimization (PSO) to predict the annual NG consumption in Iran, Mustafa Akpinar, M. Fatih Adak & Nejat Yumusak (2016) predicted Ukraine gas consumption in 2016 by using hybrid neural network, Olgun et al. (2012) presented a model in order to calculate the annual NG demand for Turkey until year 2030, Boran (2015), Wu et al. (2015) and Zeng & Li (2016) used grey prediction models to predict annual NG consumption in Turkey and China. Forouzanfar et al.(2010) modeled seasonal NG consumption as well as Baldacci et al.(2016).

There are eight papers in which monthly prediction of Natural Gas consumption was reported below. Predicting NG consumption on monthly level was reported by Aras(2005), who forecasted residential consumption using genetic algorithms, Nobuyuki Higashi (2009) who predict the monthly consumption in china, Nguyen Hoang Viet & Jacek Mandziuk(2014) who predict the monthly consumption by using BMA model in china, Jolanta Szoplik(2015) who predict monthly consumption in Poland, Azari, Ahmad, Shariaty-Niassar & Mojtaba(2012) who predict the monthly prediction in

Iran, Azadeh et al.(2015), who proposed a computer simulation based on hybrid method and ANFIS, Izadyar et al. (2015), who predicted the residential heating demand in Iran, and Akpınar & Yumusak(2016),who forecasted NG consumption using time series methods.

There are four papers in which weekly prediction of NG consumption was reported. Those are papers written by Potocnik et al. (2007), who proposed a forecasting model in order to forecast risk estimation, and Kaynar et al. (2011), who used neural network and neuro fuzzy system for prediction of NG consumption on weekly basis. Dejan Ivezić (2006) predicts natural gas consumption on weekly basis by using ANN model in Belgrade, Serbia. Małgorzata Trojanowska (2014) also predicts on weekly basis by using Regression model in Poland.

There are many number of authors predicted NG consumption on daily level.

Gil & Deferrari (2004) proposed a daily prediction model in Argentina, Steven R. Vitullo, Ronald H. Brown; George F. Corliss, Brian M. Marx.(2009) proposed a daily prediction model using mathematical model in USA, Ahmet Goncu Mehmet, Oguz Karahan Tolga &Umut Kuzuba(2013) proposed a daily prediction model using Temperature modeling approach in Istanbul, Azari, Ahmad, Shariaty-Niassar & Mojtaba (2012) proposed a daily prediction model using Neural Network in Iran, and Potocnik authors (2007) presented a forecasting risk based on risk model to estimating the daily forecasting risk. In order to do that, they had to create a model for daily prediction of NG consumption. Brabec et al. (2008) forecasted a commercial NG consumption in Slovakia, Azadeh et al. (2010) predicted short-term NG demand, Demirel et al. (2012), Taspınar et al. (2013) and Akpınar & Yumusak (2017)predicted daily NG consumption in Turkey, Soldo et al. (2014) used solar radiation as an input variable in order to predict daily NG consumption, Zhu et al. (2015)tried to predict NG demand in United Kingdom, Bai & Li (2016)proposed a structure-calibrated support vector regression(SCSVR)methods to forecast the daily NG consumption, Panapakidis & Dagoumas (2017) predicted daily natural gas demand.

Tonkovic et al.), who created a prediction model of NG consumption by using neural networks on a regional level on hourly scale for predicting NG consumption, Sabo et al. (2011), who proposed mathematical models of natural gas consumption, and Szoplík (2015), who forecasted NG consumption in Poland using neural network models. Krzysztof Nęcka, Małgorzata & Trojanowska who created a prediction model by using Regression model on a particular area on hourly basis to predict Natural Gas consumption.

IV. OVERVIEW OF PREDICTION METHODS

Natural gas consumption is predicted by using various predicting techniques and methods or even a combination of several methods. Soldo (2012) discovered that among the first tools for prediction of CNG was the Hubbert curve model used in 1950s. Since 1960s, when statistical models were developed, various statistical models have been used for predictions of NG consumption. From the late 1970s and 1980s, the artificial neural networks became very popular forecasting tool. Lately, there are new methods used in predictions of NG consumption such as Grey models or genetic algorithms.

There are only seven papers that predicted natural gas consumption on regional level. Gil & Deferrari (2004) presented their results for the case of Greater Buenos Aires region in Argentina. Dejan Ivezić. (2006) investigated the prediction of NG consumption in the region of Belgrade, Serbia to predict the Natural Gas consumption using Parameters of ANN are obtained from the historical data using a Levenberg-Marquardt training algorithm.

Nil Aras (2008), Beyzanur Cayir Ervural Omer Faruk Beyca Selim Zaim(2016) used genetic algorithm to predict NGC of Turkey city Eskisehir. Istanbul, Omer Fahrettin DEMIREL, Selim ZAIM, proposed neural networks and multivariate time series models to predict Natural Gas consumption for the city of Istanbul. Ahmet Goncu Mehmet, Oguz Karahan & Tolga Umut Kuzuba, (2013) propose a methodology which combines natural gas demand estimation with a stochastic temperature model. The model demand and temperature processes separately and derive the distribution of natural gas consumption with a conditional temperature. Hossein Iranmanesh, Majid Abdollahzade & Arash Miranian (2011) predict natural gas consumption using PSO Optimized least squares in Iran. Hongjie Lu & Hongjun You (2013) predicts NG consumption using the methods Back propagation & Gray model in Canada. Małgorzata Trojanowska (2014) predict natural gas consumption using the methods Regression model in Poland. Nguyen Hoang Viet & Jacek Mandziuk (2014) predict the NG consumption using methods Neural & Fuzzy Neural network in Poland. Wei Zhang & Jun Yang (2015) predict the consumption by using the techniques Bayesian model, Averaging model & linear regression in China. Halle akhteyar & Abbas Maleki (2015) using PSO model to predict the NG consumption in Iran. Jolanta Szoplík (2015) & Junghwan Jin Jinsoo Kim(2015) predict the NG consumption using ANN in Poland & Korea. Sergas Sergipe Gas S. A., Aracaju (2016) predict the natural gas consumption using Arima model in Brazil. Mustafa Akpınar, M. Fatih Adak & Nejat

Yumusak (2016) predict NG consumption using technique hybrid neural networks in Ukraine. Beyzanur Cayir Ervural, Omer Faruk Beyca & Selim Zaim (2016) predict natural gas consumption using methods Genetic algorithm in Turkey. Xiaoyu Wang, DongkunLuo, Jianye Liu, Wenhuan Wang, and Guixin Jie (2017) predict the NG consumption using methods hybrid MVO-NNGBM model in China. Zhenwu Zhang & Xiantao Liu (2017) predict the natural gas consumption using the method PSO & Gray neural network in China. Sanjay Kumar Kar & Michael Ratner (2017) predict the natural gas consumption using techniques ANN in India.

Techniques used for prediction of NG in this paper are Neural Network and Adaptive neural network (NNANN) based, Fuzzy Inference System (ANFIS). Programs of Neural Network use iterative process taking given past data to find the connection between given input and output variables and use the model to capture output value for the given input variables. (Zekic Susac et al. 2009). The fuzzy inference system implemented in the framework of adaptive networks (azadeh et al) by using Adaptive network-based fuzzy inference system (ANFIS). This technique possesses both learning capability and structured knowledge representation employed in fuzzy inference systems of neural networks. Therefore it is appropriate for time series non linear models.

Authors who used neural networks were Tonvokovic et al. (2009), Kaynar et al. (2011), Demirel et al. (2012), Olgunet al. (2012), Taspinari et al. (2013), Soldo et al. (2014) Izadyar et al. (2015) and Szoplik (2015) Tonkovic et al. (2009), Taspinar et al. (2013) and Kaynar et al. (2011) trained and tested two neural network algorithms the multilayer perceptron and the radial basis function network with different activation functions. The first mentioned algorithm produced the smallest mean absolute percentage error in all analysed paper. Taspinari et al. (2013) also compared neural networks algorithms and time series model. In their research, Demirel and co-authors (2012) used multilayer perceptron algorithm for neural network and compared this model with 2 time series models. Olgunet al. (2012) compared neural networks with support vector machines. Taspinar et al. (2013) and Szoplik (2015) also used a multilayer perceptron algorithm in order to predict NG consumption. Soldo et al. (2014) investigated the emphasis of solar radiation on residential NG consumption. Among several different methods, they used neural networks on two different datasets. The data sets are model house and local distribution from company. Extreme learning machine (ELM), a learning algorithm for feed forward neural network, was used by Izadyar et al. (2015).

An interesting model which is a combination of different techniques such as Wavelet transform,

generate algorithm, ANFIS and feed forward neural network was proposed by Panapakidis & Dagoumas (2017). This model hybrid computational intelligence model was tested for its robustness by prediction of day ahead natural gas demands.

Another hybrid model consisting of ANFIS and computer simulation was proposed by Azadeh et al. (2015) have presented ANFIS based techniques. The ANFIS is was also used by Kaynar et al. (2011) to predict weekly NG consumption in turkey.

Ma & Li (2010) predicted NG consumption based on the Grey system model. The same approach was using Boran (2015) grey prediction with rolling mechanism (GPRM), Wu et al. (2015), and Zeng & Li (2016). According to Kayacan et al. (2010) "Grey models predict the future values of a time series based only on a set of the most recent at a depending on the window size of the predictor.

Other commonly used techniques for NG consumption prediction are support vector regression (SVR) and support vector machine (SVM). Olgunet al. (2012) compared neural networks with support vector machines and they concluded that support vector machines had less statistical error for demand estimation of natural gas consumption. Soldo et al. (2014) used several linear and nonlinear models for predictions. The testing errors obtained by nonlinear neural networks and SVR models are slightly higher compared to linear models. Zhu et al. (2015) presented the method that integrated the SVR algorithm with the reconstruction properties of a time series and optimizes the original local predictor by removing false neighbors. A structure-calibrated SVR approach was used by Bai & Li (2016).

Using genetic algorithms Aras (2008) tried to forecast short-term demand of NG in residences by Genetic programming technique was used by Forouzanfar et al. (2010) and Izadyar et al. (2015) as well. Some authors used mathematical models in order to predict NG consumption. Gil & Deferrari (2004) developed a model which is able to predict the NG consumption 1 to 5 days in advance with 10% of uncertainty. Gutierrez et al. (2005) presented a stochastic Gompertz innovation diffusion model while Potocnik (2007) forecasted NG consumption by using their model used in several gas distribution systems. Brabec et al. (2008) developed nonlinear mixed effects model (NLME), a parametric statistical model which is later compared with two classical time series approaches. Several advanced linear and nonlinear mathematical models, such as exponential, Gompertz and logistic model, were used by Sabo et al. (2011). Forouzanfar et al. (2010) used a method based on the concept of the non linear programming with earlier mentioned genetic programming technique. Soldo et al.

(2014) compared several linear models such as auto-regressive model with exogenous inputs and stepwise regression. Akpınar & Yumusak (2017) used multiple linear regression (MLR) for prediction of NG consumption.

There are several time series methods used for predicting NG consumption. Kaynar (2011) and Demirel (2012) used auto regressive integrated moving average (ARIMA). Taspınar (2013) also used type of ARIMA model, called SARIMAX, which is seasonal autoregressive integrated moving average model with exogenous inputs. Akpınar & Yumusak (2016)

presented time series decomposition, Holt-Winters exponential smoothing and ARIMA.

Among other methods used for NG consumption predictions can be highlighted Baldacci et al. (2016), who defined two predicting techniques, one based on a nearest neighbor approach and one employing local regression analysis.

Table 3 shows a systematic overview of prediction methods used in predicting natural gas consumption by prediction area and prediction horizon.

Table 3: (Prediction area and horizon)

Prediction method	Prediction area				Prediction horizon*					
	Country	Region	City	House	Y	S	M	W	D	H
Neural network	3	3	4	1	2		2	2	3	1
ANFIS	1								1	
Grey model	2				2				1	
SVM/SVR	2		2	1						
Genetic Algorithms	2		2		2		2			
Mathematical and statistical models	2	1	2	1	1	1		1		1
Time series	1	2	1					1		
Hybrid models	2						1	1	1	
Other			1							

*Y yearly, S seasonal, M monthly, W weekly, D daily, H hourly

V. CONCLUSION

The study was conducted with seventy two number of research articles of Natural Gas prediction for various Countries in different mathematical and scientific methods. It was found that China and other developed countries are focusing this type of study for weekly, monthly and yearly basis. ANN is the most appropriate techniques for the prediction of Natural Gas consumption. The different researchers applied genetic algorithm, feed forward, Back propagation & PSO methods for this prediction. All most all researchers are agreed upon the other popular methods are neuro-fuzzy inference system, genetic algorithms, time series methods, support vector machines/ regression, Grey system models, mathematical and statistical models or hybrid models based on several methods. Some researches use two or more methods in the same paper. But analysis has shown that for modeling, authors often use past NG consumption data and weather data (mostly temp.) as input variables. Other variables include month, days of the week, wind speed, temperature, humidity & price number of natural gas

subscribers, GDP, inflation rate etc. Speaking of prediction areas, it can be seen that most of the papers deal with the predictions on country level. Predictions can be made as well as on regional, city, or even house level.

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GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING

Volume 18 Issue 1 Version 1.0 Year 2018

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals

Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Investigation of Surface Roughness by using the Vibration Assisted Milling Process of Glass Fiber Reinforced Polymer

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Abstract- This project has presented an approach to reducing surface roughness of milled work pieces of glass fiber reinforced polymer via excitation of the first axial mode of the vibration milling device. A combined application of numerical and experimental analysis has confirmed the validity of the proposed approach. Milling experiments demonstrated that excitation of the axial mode in the vibration milling tool leads to an appreciable reduction in the surface roughness of mild steel and glass fiber work pieces. We proposed a new technique to measure the surface roughness of material with vibration assisted milling process. For this process the main material used was glass fiber reinforced polymer but also the additional material were used like mild steel. Controlling vibration phenomena in production is one of the approaches for improving their efficiency.

Keywords: glass polymer, vibration device, end mill cutter, milling machine, surface roughness.

GJRE-J Classification: FOR Code: 091599



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Investigation of Surface Roughness by using the Vibration Assisted Milling Process of Glass Fiber Reinforced Polymer

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Abstract- This project has presented an approach to reducing surface roughness of milled work pieces of glass fiber reinforced polymer via excitation of the first axial mode of the vibration milling device. A combined application of numerical and experimental analysis has confirmed the validity of the proposed approach. Milling experiments demonstrated that excitation of the axial mode in the vibration milling tool leads to an appreciable reduction in the surface roughness of mild steel and glass fiber work pieces. We proposed a new technique to measure the surface roughness of material with vibration assisted milling process. For this process the main material used was glass fiber reinforced polymer but also the additional material were used like mild steel. Controlling vibration phenomena in production is one of the approaches for improving their efficiency. This also applies to cutting tool vibrations generated during machining, when the magnitude of the vibrations directly influences work piece surface quality. Conventional milling process gives rough surface which was the problem to the machining industries therefore recent developments to solve this problem are described in which one of the process is vibration assisted milling process. It is also a kind of natural idea which nobody has been done before on milling process. In this research the surface roughness of glass fiber reinforced polymer is tested under two main process, Vibration assisted milling process and conventional milling process and then the results obtained were compared.

Keywords: glass polymer, vibration device, end mill cutter, milling machine, surface roughness.

I. INTRODUCTION

Glass fiber is a material consisting of numerous extremely fine fibers of glass or Fiber glass is a type of fiber-reinforced plastic where the reinforcement fiber is specifically glass fiber. The glass fiber may be randomly arranged, flattened into a sheet (called a chopped strand mat), or woven into a fabric [1]. Milling machines were first invented and developed by Eli Whitney to mass produce interchangeable musket parts. Although crude, these machines assisted man in maintaining accuracy and uniformity while duplicating parts that could not be manufactured with

the use of a file. Development and improvements of the milling machine and components continued, which resulted in the manufacturing of heavier arbors and high speed steel and carbide cutters. These components allowed the operator to remove metal faster, and with more accuracy, than previous machines [2]. The main aim of this study is to improve the surface roughness of materials, finally a study of using vibration device with milling machining is described and it is demonstrated that using a vibration device with milling machining can give a better surface roughness rather than that of conventional or normal milling process. This paper summarize a few experimental studies we have been engaged in to improve surface roughness of glass fiber reinforced polymers. The milling process remove material by performing many separate, small cuts. This is accomplished by using a cutter with many teeth, spinning the cutter at high speed, or advancing the material with a cutter slowly. The speed at which the piece advances through the cutter is called feed rate (feed) $F = f. u. N.$ [3]

II. EXPERIMENTAL DESCRIPTION

In this research two processes are used to measure the surface roughness of glass fiber reinforced polymer and mild steel, these two processes are;

- 1) Vibration assisted milling process (with vibration mechanism)
 - 2) Conventional milling process (without vibration mechanism)
- a) *Vibration assisted milling process of glass fiber*

During this process we placed the vibration device to the bottom of the work piece and tightly attached with work piece in milling machine (Fig 1) and turned on the vibration device which is connected to motors and battery (Fig 2) applying the voltage of 2 volts to the vibration device (Fig 3). When the vibration mechanism is on it slightly vibrate the work piece and thus the cutting tools move with high speed and small amplitude and start the surface roughness test using different RPM (revolution per minute) and constant feed rate and depth cut in cutting process[4]. Firstly the glass fiber was machined with three different Cutting speed (cs) of 15, 20 and 25 with 12 mm cutter tool Using 48

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mm/min feed rate and 2 mm depth of cut for the rpm of 403, 538 and 792, the rpm and feed was obtained by using equation 1 and 2 respectively, the surface roughness response was $3.36 \mu\text{m}$, $3.51 \mu\text{m}$ and $3.96 \mu\text{m}$ respectively using surface roughness tester (Fig 4,5), Thus shows that with low rpm the surface roughness of glass fiber with vibration assisted milling process is better than that of using high rpm using the feed rate of 48 mm/min (Table 1). Bar chart 1, also shows the rpm vs roughness analysis results.

$$\text{Rpm} = \text{cs} * 1000 / 3.14 * D \quad (1)$$

Where cs is the cutting speed [5] and D is the diameter of cutting tool. So the nearest rpm Obtained for 12 mm cutting tool is 403, 538 and 792 respectively.

$$\text{FR} = \text{Rpm} * T * \text{CL} \quad (2)$$

Where FR is the calculated feed rate in mm/min, T is the number of teeth on the cutter and CL is the chip load or feed per tooth.

Secondly the glass fiber was machined using the same technique with 197 rpm and different feed rates of 26 mm/min and 35 mm/min, the cutter diameter of 20 mm and the depth of cut of 2 mm, the surface roughness response was $2.78 \mu\text{m}$ for 26 mm/min feed rate and $2.38 \mu\text{m}$ for 35 mm/min feed rate, showing that with low feed rate and higher cutter diameter the surface roughness obtained will be better (Table 2). Bar chart 2 Shows the analysis graph wise.

The same method was repeated for the mild steel but this time we obtained $2.81 \mu\text{m}$, $4.09 \mu\text{m}$ and $3.54 \mu\text{m}$ surface roughness for 403, 538 and 792 rpm respectively, which shows a little different results than that of glass fiber. It is due to the use of different material, Table 3 shows the experimental results of mild steel after machining process [6]. Bar chart 3 shows the analysis in graph wise.

This is because of the phenomenon that controlling vibration in production machines is one of the approaches for improving their efficiency. This also applies to cutting tool vibrations generated during machining, when the magnitude of the vibrations directly influences work piece surface Quality. Continuous efforts to enhance cutting performance have revealed that machining quality may be improved if a tool is assisted with high-frequency vibrations. During the resulting vibration cutting process, the tool periodically loses contact with the chip leading to a reduction in machining forces, friction, and temperature in the cutting zone and the formation of thinner chips, as well as simultaneously preventing generation of micro-cracks on the cutting edge and work piece surface. As a consequence, this improves cutting stability, surface

finish, and tool life when compared to conventional machining [7].

b) Conventional milling process

The same experiment is repeated without vibration device for glass fiber and for mild steel which was an alternative material and studied surface roughness test under different RPM (Revolution per minute). Firstly the glass fiber was machined and then tested with surface roughness tester for measuring the surface roughness with three different Cutting speed (cs) of 15, 20 and 25 with 12 mm cutter tool Using 48 mm/min feed rate and 2 mm depth of cut for the rpm of 403, 538 and 792, Using the same machine and cutting tool (End milling cutter) but the only difference is the vibration device is not used and milling is conventional [8] so there is no transfer of vibrations (Fig 6) and the surface roughness of glass fiber using surface roughness tester obtained was $4.13 \mu\text{m}$, $5.73 \mu\text{m}$ and 5.83 for 403, 538 and 792 rpm respectively (Table 1) (Bar chart 1), which shows different and not good results as that of vibration assisted milling process. Secondly the glass fiber was machined without vibration device and then tested with surface roughness tester using the same method and the same equations (1 & 2) for rpm and feed rate considering the cutting speed, diameter of the cutter, number of teeth on the cutter and feed per tooth as previous with cutting tool of 20 mm, rpm of 197, feed rates of 26 mm/min and 35 mm/min, the surface roughness for 26 mm/min feed rate was $2.95 \mu\text{m}$ and for 35 mm/min feed rate was $2.53 \mu\text{m}$ which also give different surface roughness results compare to vibration assisted milling process (Table 2), (Bar chart 2). Thus the same procedure is done for the Mild steel for rpm of 403, 538 and 792 and the surface roughness measured after machining with conventional milling process was $4.04 \mu\text{m}$, $4.22 \mu\text{m}$ and $4.48 \mu\text{m}$ respectively, showing different and not good results as compared to vibration assisted milling process [9].

It is because of the Chip width starts from zero and increases which causes more heat to diffuse into the work piece and produces work hardening. Tool rubs more at the beginning of the cut causing faster tool wear and decreases tool life. Chips are carried upward by the tooth and fall in front of cutter creating a marred finish and re-cutting of chips. Upwards forces created in horizontal milling tend to lift the work piece, more intricate and expansive work holdings are needed to lessen the lift created [10].

III. RESULTS AND DISCUSSIONS

The results are detailed in tables and chart.

IV. CONCLUSIONS

In this research two different material are used, one is Glass fiber and the other one is Mild steel.

First of all glass fiber is machined using conventional milling having cutter diameter 12mm, Feed rate 48 mm/min, depth of cut 2mm and the machining operation is done under different rpm which gives different surface roughness. Then the same material is machined using vibration assisted milling process, In this process the vibration device is attached to the bottom of the work piece and having cutter diameter 12 mm and the machining operation is done under different rpm, which also gives surface roughness. Next compare the surface roughness that is obtained through conventional milling and vibration assisted milling process.

Then the same material is used having cutter diameter 20mm, feed rate 26mm/min for one case and 35mm/min for another case under same Rpm (197) using the same machining processes as above.

Then Mild steel is machined using conventional milling having cutter diameter 12mm, Feed rate 48 mm/min, depth of cut 2mm and the machining operation is done under different rpm which gives different surface roughness. Then the same material is machined using vibration assisted milling process, In this process the vibration device is attached to the bottom of the work piece and having cutter diameter 12 mm and the machining operation is done under different rpm, which also gives surface roughness. Next compare the surface roughness that is obtained through conventional milling and vibration assisted milling process.

ACKNOWLEDGEMENTS

We express our heartiest gratefulness to God for His divine blessings, which made us able to complete this Project successfully.

The project was carried out by the authors under the close supervision of PROF.DR. ANAYET ULLAH PATWARI Department of Mechanical and Chemical Engineering, Islamic University of Technology (IUT). The supervisor had dedicated his valuable time, even at odd hours, which had ensured the completion of this project. We express profound gratitude to the supervisor for his support, cooperation and guidance in accomplishing the project.

I wish to take this opportunity to express my sincerest gratitude and heartiest thanks to my dear parents and family members for being such delightful people and the inspiration for our effort. Without their prayers, continued encouragement, moral and financial

support, it would not have been easy for us to accomplish this work.

I also thank to all my friends, colleagues and whoever helped us in the course of our work and or write-up.

We seek excuse for any errors that might occur in this report despite of our best effort.

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FIGURES

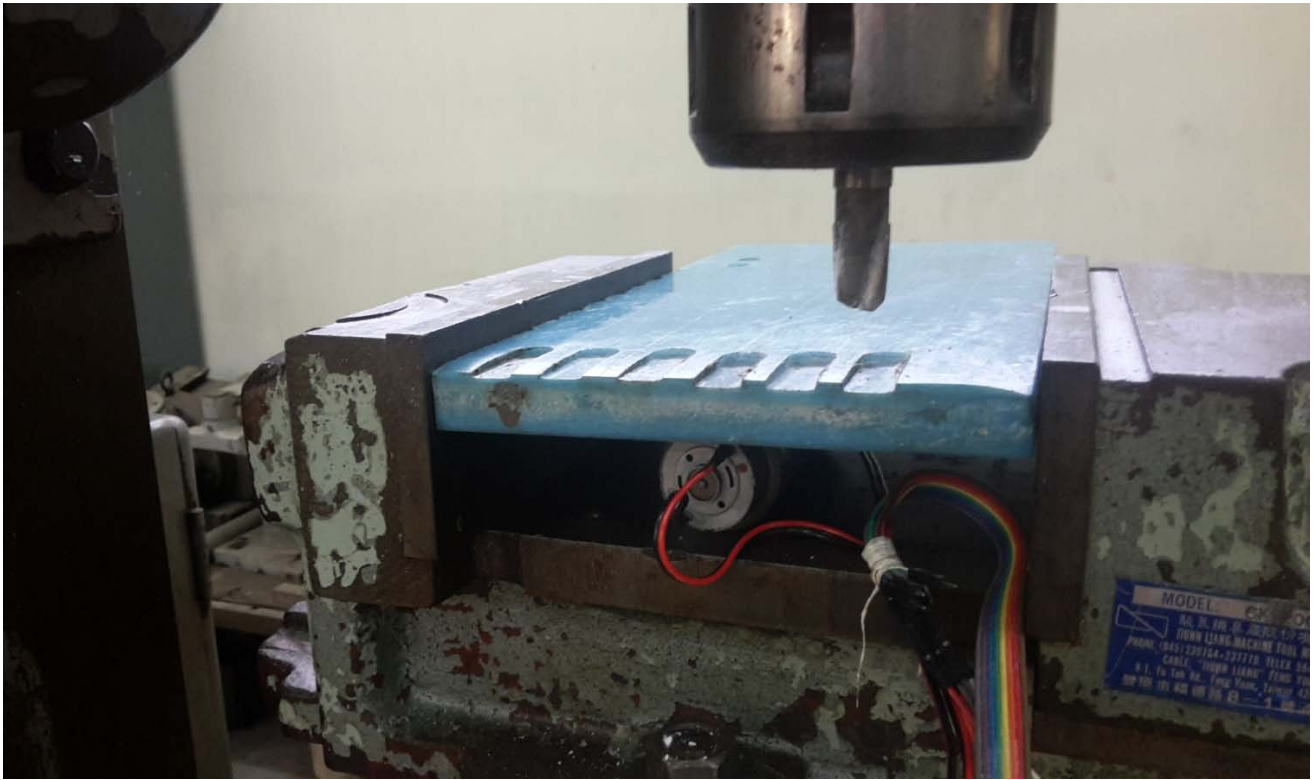


Fig. 1: Vibration device attached to the work piece

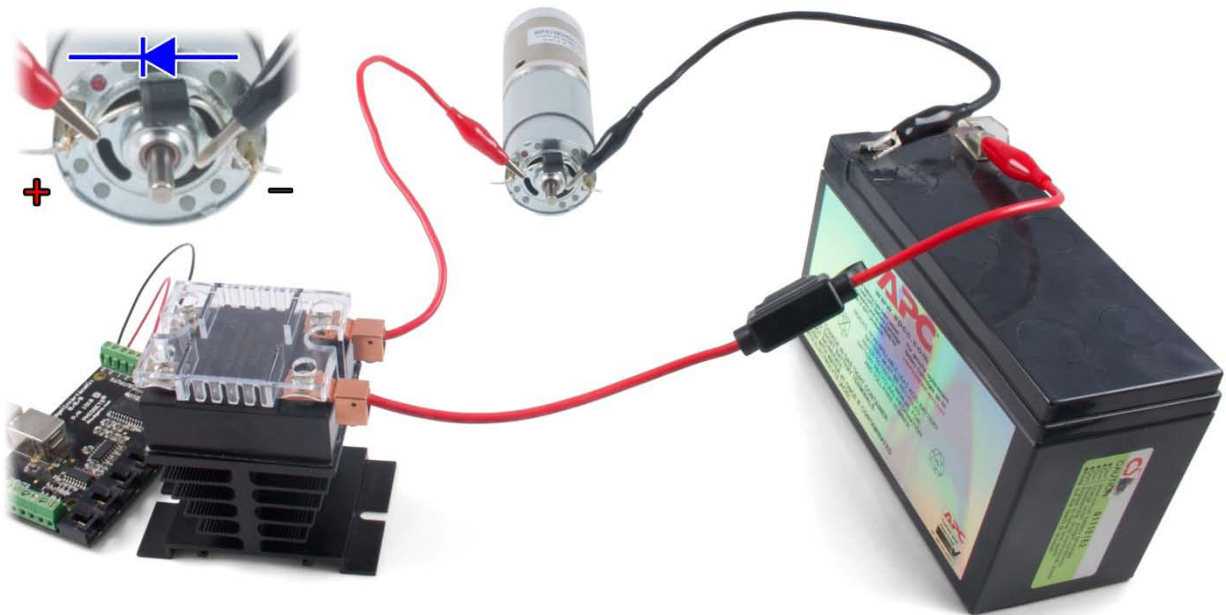


Fig. 2: Vibration device connected to the battery

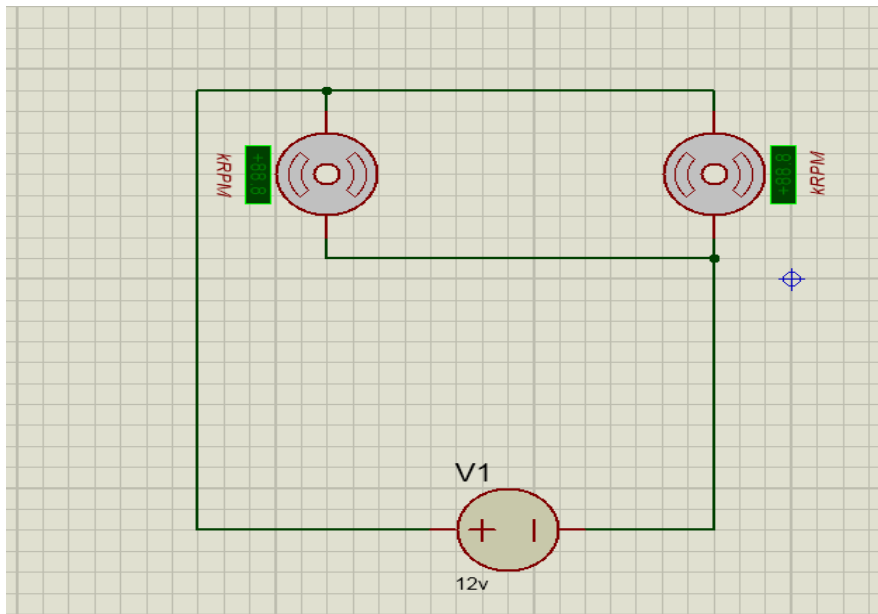


Fig. 3: Circuit Diagram, Applying voltage



Fig. 4: Surface roughness tester instrument



Fig. 5: Experimental setup of measuring surface roughness



Fig. 6: Conventional Milling Process

Data tables:

The results obtained during this research are as follows;

Data Table 1

Observation	RPM	Feed rate (mm/min)	Depth of cut (mm)	Surface roughness with vibration (μm)	Surface roughness without vibration (μm)
1	403	48	2	3.361	4.139
2	538	48	2	3.514	5.735
3	792	48	2	3.960	5.887

Cutter diameter = 12 mm, Material used = Glass fiber

Data Table 2

Observations	Rpm	Feed rate (mm/min)	Depth of cut (mm)	Surface roughness with vibration (μm)	Surface roughness without vibration (μm)
1	197	26	2	2.781	2.959
2	197	35	2	2.389	2.538

Cutter diameter = 20 mm, Material used = Glass fiber

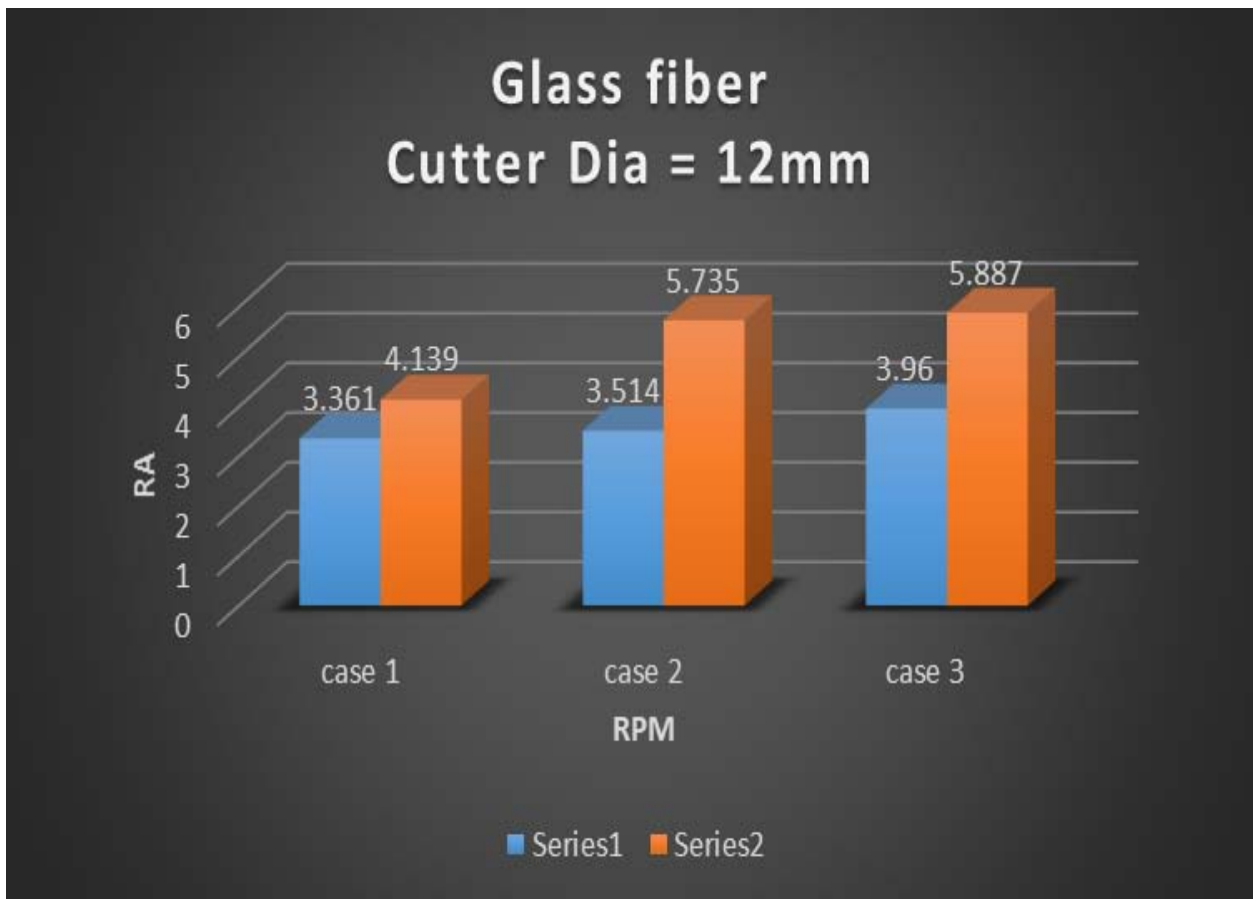
Data Table 3

Observations	RPM	Feed Rate (mm/min)	Depth of cut (mm)	Surface roughness with vibration (μm)	Surface roughness without vibration (μm)
1	403	48	2	2.871	4.041
2	538	48	2	4.091	4.221
3	792	48	2	3.546	4.481

Cutter diameter = 12mm, Material = Mild steel

BAR CHARTS

Bar chart 1:



Glass fiber, cutter diameter 12mm

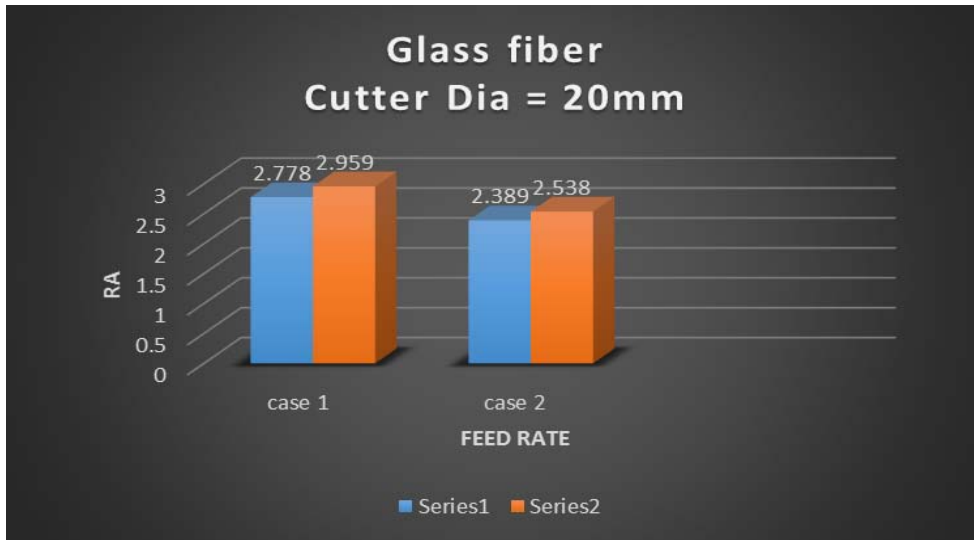
Case1 =403 rpm

Case2=538 rpm

Case3=792 rpm

Blue bar represent the surface roughness of glass fiber that obtained through vibration assisted milling process and the orange bar represent the surface roughness of glass fiber that obtained through conventional milling process.

Bar chart 2:



Cutter diameter = 20mm, Material = Glass fiber

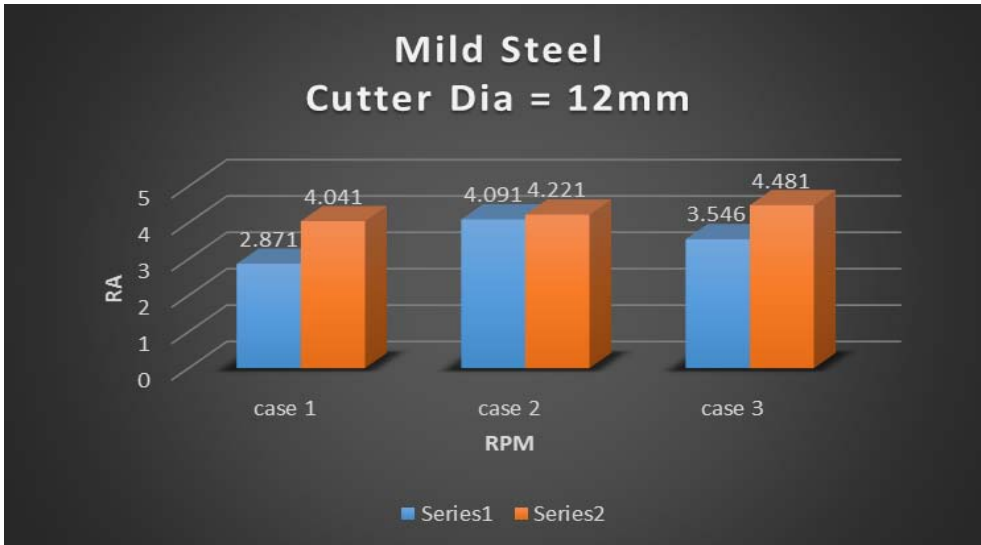
Case1 = 26mm/min

Case2 = 35mm/min

Blue bar represent the surface roughness of glass fiber that obtained through vibration assisted milling process and the orange bar represent the

surface roughness of glass fiber that obtained through conventional milling process.

Bar Chart 3:



Cutter diameter = 12mm, Material = Mild steel

Case1 = 403 rpm

Case2 = 538 rpm

Case3 = 792 rpm

Blue bar represent the surface roughness of glass fiber that obtained through vibration assisted milling process and the orange bar represent the surface roughness of glass fiber that obtained through conventional milling process.



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING
Volume 18 Issue 1 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Interplay of Casting and CFD Software for Improved Accuracy of the Simulation

By Manuela Neri, Michele Brognoli, Davide Luscietti & Mariagrazia Pilotelli

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Abstract- The advantages of using two simulation codes in casting simulations have been investigated: a finite element code designed to simulate casting processes, and a finite volume CFD code designed to simulate thermal and fluid-dynamic boundary conditions. The temperature-time curve at an important injection point of a mould system has been measured: in this point, the agreement between numerical and experimental results is very sensitive to the specific boundary conditions that are assumed in the casting simulation. It has been demonstrated that the agreement is good if instead the choice of boundary condition parameters are chosen and tuned to experimental data with the help of a CFD code.

Keywords: *numerical simulations, experimental results, casting.*

GJRE- J Classification: FOR Code: 091599



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Interplay of Casting and CFD Software for Improved Accuracy of the Simulation

Manuela Neri^α, Michele Brognoli^σ, Davide Luscietti^ρ & Mariagrazia Pilotelli^ω

Abstract- The advantages of using two simulation codes in casting simulations have been investigated: a finite element code designed to simulate casting processes, and a finite volume CFD code designed to simulate thermal and fluid-dynamic boundary conditions. The temperature-time curve at an important injection point of a mould system has been measured: in this point, the agreement between numerical and experimental results is very sensitive to the specific boundary conditions that are assumed in the casting simulation. It has been demonstrated that the agreement is good if instead the choice of boundary condition parameters are chosen and tuned to experimental data with the help of a CFD code.

Keywords: numerical simulations, experimental results, casting.

I. INTRODUCTION

Casting processes can be divided into filling of the mold, solidification, and cooling, and they can be monitored by means of numerical simulations. There are several steps involved in the development of a casting simulation [1], of which the main important are: comprehension of the system/process, choice of a program (or writing of a code) to simulate the process, shape of the mold and definition of the materials properties, definition of the mesh element, application of the boundary conditions and interface conditions, run of the program, analysis of the results. In the majority of cases, to simulate a process, it is not possible to reproduce the system completely; rather, it is necessary to make simplifications of the system/process under investigation so as to include the relevant elements only [2, 3, 4]. The aim of this simplification is the reduction of the numerical model size and to perform less time-consuming numerical simulations. To be sure that the process has been simulated properly, numerical results should be verified by means of experimental tests.

A review of experimental techniques for validating numerical solutions of flow configuration is presented in [5]: it has been stated that the validation of numerical model should be attended by the quantification of the uncertainty of the results obtained experimentally.

There are several available numerical techniques to perform numerical simulations [6-11],

among which the finite element method (FEM), the finite element difference (FDM) and the finite volume method (FVM). The difference among these techniques is related to the position where the variable value is stored: in the FEM and FDM methods it is stored at the element nodes, while in the FVM it is stored in the center of the volume. In the finite element method the domain is divided into hexahedral cells; in the FVM the domain is divided into more volumes, and for each volume the governing equations are solved. In the finite FEM, discretization is based upon a piece wise representation of the solution regarding specified basis functions; the computational domain is divided up into finite elements, and the computed value in each element is constructed from the basis functions.

Theoretically, by performing numerical simulations with different codes on the same model should lead to consistent results, but some codes are designed for a specific purpose and they may include different resolving models for simulating a phenomenon. For example, some codes are designed for casting simulations specifically, while others are dedicated to thermal-fluid-dynamic simulations; also the discretization of the domain and the way of solving the governing equation may affect the output of numerical simulations. To simulate casting process, FEM and FDM are usually used. Another parameter that influences simulation results is the grid: a regular and small grid allows to solve thermal-fluid-dynamic equations correctly, especially in the boundary layer.

The comparison of codes was performed in several fields. For example, codes accuracy was compared for jewelry casting [12]: the fluid flow inside a cavity was monitored in simulations performed with Magma, PROCAST, and FLOW-3D. Marshall [13] made a benchmarking of codes for simulating casting processes and it was stated that PROCAST is the best code among the ones analyzed. Experimental data was compared with results obtained by means of the CFD code Fluent [14].

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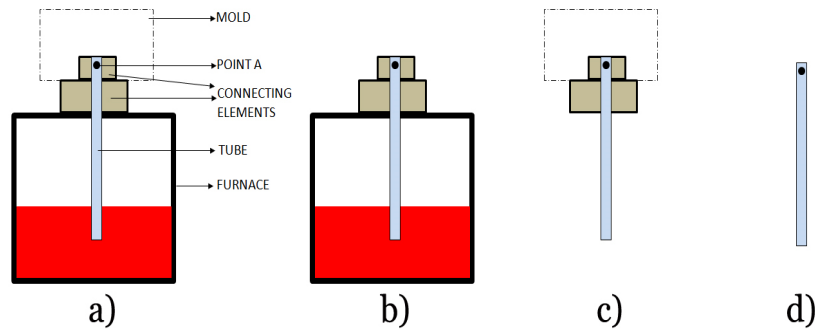


Figure 1: System under investigation: a) real case, b) system considered in the preliminary simulations, c) system considered in the final simulations, d) standard configuration. The temperature at point A is analyzed.

In this paper, the accuracy of two codes to predict the temperature in an alloy is investigated: one of them is a finite element code designed for casting simulations specifically, and the other is a CFD code. The study has requested the identification of parameters necessary for a true and fair view of a casting process simulation. The search for the most appropriate boundary conditions has led to the comparison of the two codes, and this has highlighted how it is possible to take advantage of two or more codes designed for different purposes to improve casting simulations.

II. CASE OF STUDY: ANALYSIS OF A CASTING PROCESS

In this paper, a particular casting process is analyzed; the final product on which our experimental data is taken is not specified for reasons of trade secrecy, but this does not undermine the purpose of the study. The study has been prompted by a factory that produces objects using low pressure casting processes.

The process takes place in the system shown in Figure 1 a), that consists of an oven connected to a mold by means of a pipe; the pipe passes through the upper wall of the oven and other elements (called connecting elements in the following) whose function is to insulate and to hold it. The time duration of the process is non-dimensional. The process consists in the pressurization of the oven to 0.25 times the total time duration of the process, resulting in the consequent owing of the alloy in the mold. Then, the pressurization ceases and the cooling phase continues for 0.86 times the total duration of the process. It can be considered that after 0.04 times the total duration of the process the mold is filled of the alloy.

The process has been also simulated by considering the elements shown in Figure 1 c), that in

the following is denoted as standard configuration. A certain discrepancy has been detected between the process simulated with the casting code using standard boundary conditions and measured temperature, as shown in Figure 2. Standard boundary condition consisted in an adiabatic condition on the external surface of the pipe, and a convective heat transfer and a related temperature on the connecting elements. The temperature at the entrance of the pipe was set equal to the temperature measured experimentally at point A; in this way, the passage of the alloy from the oven to the mold was not taken into consideration. The output of the numerical simulations was sufficiently consistent with the reality except for the temperature of the alloy during the process at point A of Figure 1 a), with consequence from a metallurgical point of view: in the simulations, the final product presented a greater pasty zone near point A than the real product. In Figure 2, the temperature estimated by the numerical model is compared with temperatures measured experimentally: it is shown that at point A, despite at the beginning of the process the temperature of the alloy is lower than that measured in the oven, the final temperature is higher than that measured.

III. METHOD AND RESULTS

The study has investigated the causes of the difference in temperature between estimated and measured temperatures in a casting process: it has consisted in numerical simulations executed with a finite element casting code (FE) and a CFD finite volume (FV) code, and experimental tests have been performed to validate the numerical results.

As the causes of the difference between measured and simulated temperature were not known, the analysis has been quite articulated as sketched in

Figure 3. Given that it was not sure that the standard boundary conditions were correct, the first step of the study consisted in the investigation of their correctness.

As it has not been possible to measure physical quantities in the oven, it has been necessary to simulate the entire system to determine the boundary conditions indirectly. To do this, a CFD code specifically designed for thermal fluid-dynamic computing has been used to perform numerical simulations on the configuration

shown in Figure 1 b). Boundary conditions so obtained have been set in the model shown in Figure 1 c): the model represents the pipe and the connecting elements, and numerical simulations have been performed with both the casting and the CFD codes. As only the temperature estimated with the CFD code has matched with measured data, the influence of the grid and the interface conditions has been investigated.

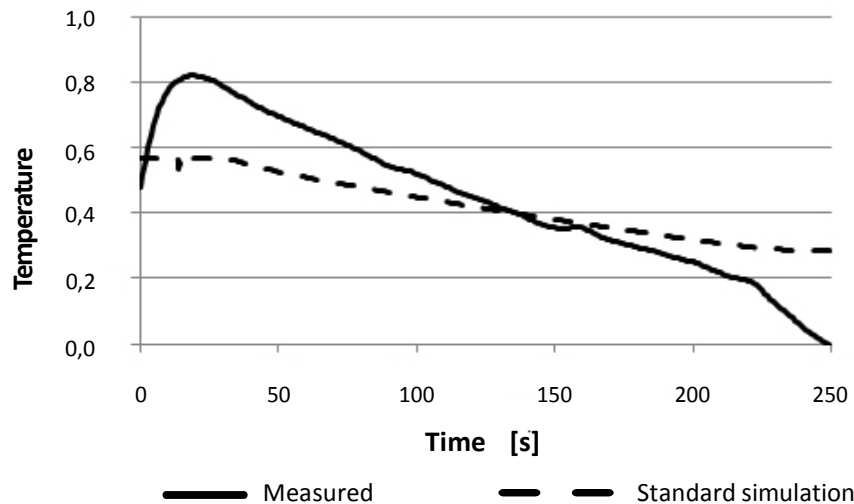


Figure 2: Temperature estimated with the casting code using standard boundary conditions and experimental measurements at point A of Figure 1 a).

To make measured and estimated temperatures matching, specific boundary conditions to be set in the casting code have been researched: they have been checked by performing a simulation with the numerical model shown in Figure 1 d) that includes the mold.

In the following, each step is deepened. Given that the temperature of the alloy in the process is a secret trade, unless otherwise noted, the temperatures are nondimensional concerning the temperature of the aluminum in the oven. To give an idea of the temperatures involved, the range of temperature in the graphs (from 0 to 1) is in the order of 100°C.

a) Measurement of the alloy temperature in the pipe

In Figure 2 the temperatures are nondimensional with respect to the temperature of the alloy in the oven: as the temperatures are lower than 1, the temperature at point A is lower than the temperature of the alloy in the oven. On an initial analysis, it has been inferred that the alloy undergoes a cooling process when it flows in the pipe; another hypothesis has considered that the thermocouple performs a distorted measurement.

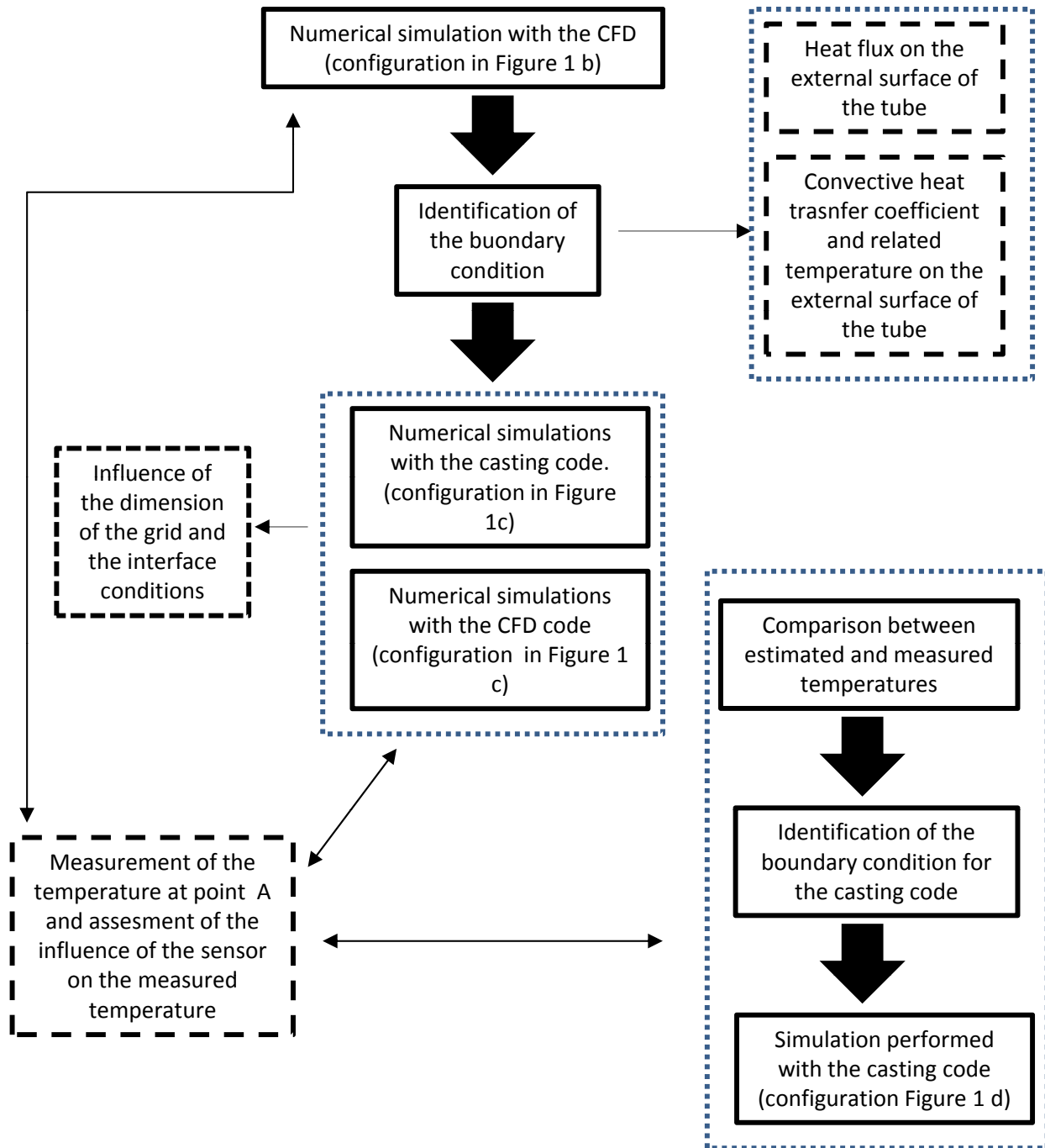


Figure 3: Scheme of the study with the finite element casting code is identified, with the finite volume CFD code is identified.

Firstly, it was investigated whether the difference between the maximum temperature measured at point A and the temperature of the alloy is due to the time response of the sensor.

The response of a thermocouple sensor depends on its properties and the environment in which it is immersed; however, no sensor responds instantly to a change in its environment. The temperature at point A

of Figure 1 a) has been measured using a thermocouple of type K, immersed in the duct so as its tip has reached the center of the ceramic pipe. To protect the thermocouple from the high temperature, it has been

encased in a covering made of INCONEL 600 [16] of 9 mm in diameter that could have caused a retard in the measurement.

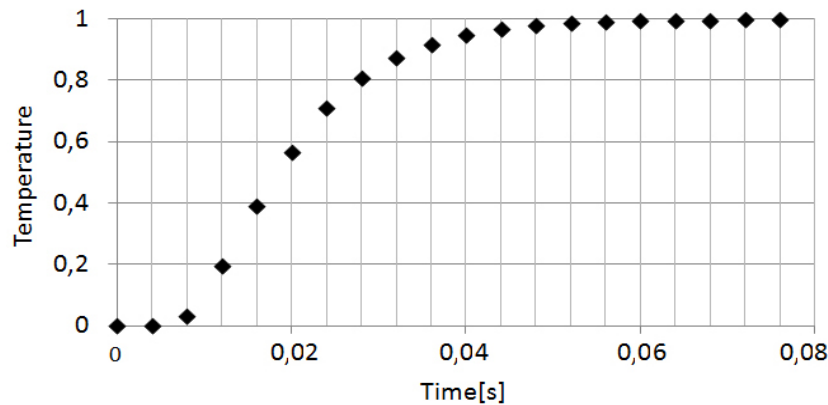


Figure 4: Temperature trend measured by a thermocouple immersed in the alloy for estimating the time response τ of the sensor. The time axis is non dimensional with respect to the total time duration of the process.

To quantify the thermocouple time response τ , a test has been performed: a thermocouple similar to that used to measure the temperature at point A has been immersed in the alloy at temperature T_f and the variation in temperature detected by the thermocouple has been monitored. Figure 4 shows the temperature detected by the thermocouple which has been used to compute the time constant τ of the thermocouple following the approach proposed by [15]. The temperature T of the alloy at a given time instant t can be calculated as

$$T_e - T = (T_e - T_1) \cdot e^{-\frac{t}{\tau}} \quad (1)$$

where T_e is the temperature of the alloy in the oven, and T_1 is the temperature at the initial instant that is $t=0$. For the considered sensor, the time constant is 0.016 times the total duration of the process and this is the time necessary to reach the 63.2% of the difference in temperature between the initial temperature T_1 and the environment temperature T_e . To reach the 99% of recovery a time equal to $4,6 \cdot \tau$ is required [15], then, for the thermocouple used in this study, a time lapse of about 0.0736 times the total duration of the process is necessary to almost detect the actual temperature of the alloy.

b) Comparison of the temperatures estimated with the casting and CFD codes

In order to assess whether these codes are able to detect the temperature trend in a point of the alloy, numerical simulations performed with the casting and

the CFD codes have been compared with the temperature measured at point A.

i. Determination of the boundary conditions

It was supposed that the difference between measured and simulated temperatures in Figure 2 was due to the incorrectness of the standard boundary conditions set in the model; to investigate their correctness a CFD code specifically designed for thermal-fluid-dynamic computing has been used.

As physical quantities in the oven near the pipe are not easy to be measured, it has been decided to determine the boundary conditions on the external surface of the pipe indirectly. To do this, a CFD code has been used to perform numerical simulations on the system shown in Figure 1 b) that represents the oven, the pipe and the connecting elements. This model counts a great number of cells, then, to limit their quantity, the mold has not been represented; however, its presence is taken into account by setting an adiabatic condition in the upper part of the pipe. Heat transfer coefficients on the external walls of the oven have been estimated from measured temperatures and correlations reported in [17] by considering both convection and radiation. The properties of the alloy and of the materials of which the oven is made have been obtained from databases. For the air in the oven, the Boussinesq model has been set. The simulation has been performed in a steady-state condition in which the pipe is full of motionless aluminum. This numerical simulation has allowed determining the conditions on the external surface of the pipe.

c) *Boundary conditions on the external surface of the pipe*

Numerical simulations described in this section are performed on the configuration shown in Figure 1 c), that represents the pipe and the connecting elements only. This configuration can be considered an intermediate model that has allowed to investigate the correctness of the boundary conditions using a model made of a limited number of cells. Also in this case, the presence of the mold has been taken into account by

setting an adiabatic condition on the upper surface of the pipe: this condition seems quite appropriate since the alloy in the mold is hotter than the surrounding, then greater heat flux occurs from the alloy in the pipe towards the oven and the connecting elements. Given the distinct nature of the codes, some numerical simulations described in the following have been performed to assess the influence of some parameters, such as the dimension of the grid and the interface conditions.

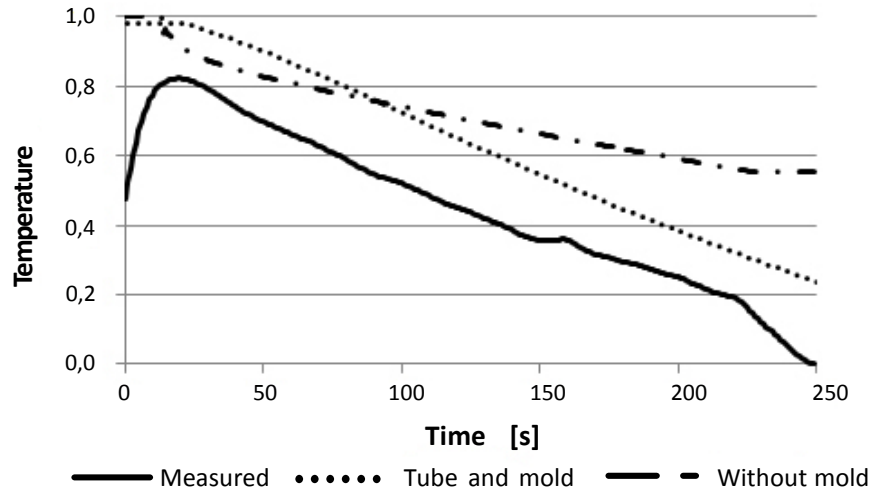


Figure 5: Temperature at point A: measured and estimated with the casting and the CFD codes. In the numerical simulations the configuration shown in Figure 1 c) has been considered. A convective heat transfer coefficients has been set on the external surface of the pipe.

i. *Convective heat transfer coefficients*

The convective heat transfer coefficient and the related temperature determined in the preliminary simulation have been set on the external surface of the pipe in the model shown in Figure 1 c), and numerical simulations have been performed with both the casting and the CFD codes. Temperatures so estimated are shown in Figure 5.

The numerical simulation performed with the CFD code consists of a steady-state condition followed by an unsteady condition: in the first phase schematized in Figure 6 a) the alloy flows in the pipe, then, in the second phase schematized in Figure 6 b) the alloy is motionless. The second phase lasts 0.96 times the total duration of the process.

In the simulation performed with the casting code, the alloy has flowed in the pipe for 0.1 times the total duration of the process, then it has been stopped and the temperature trend at point A has been monitored for 0.96 times the total duration of the

process. The initial condition for the simulations has been determined from the numerical simulation performed with the CFD code in Figure 6 a).

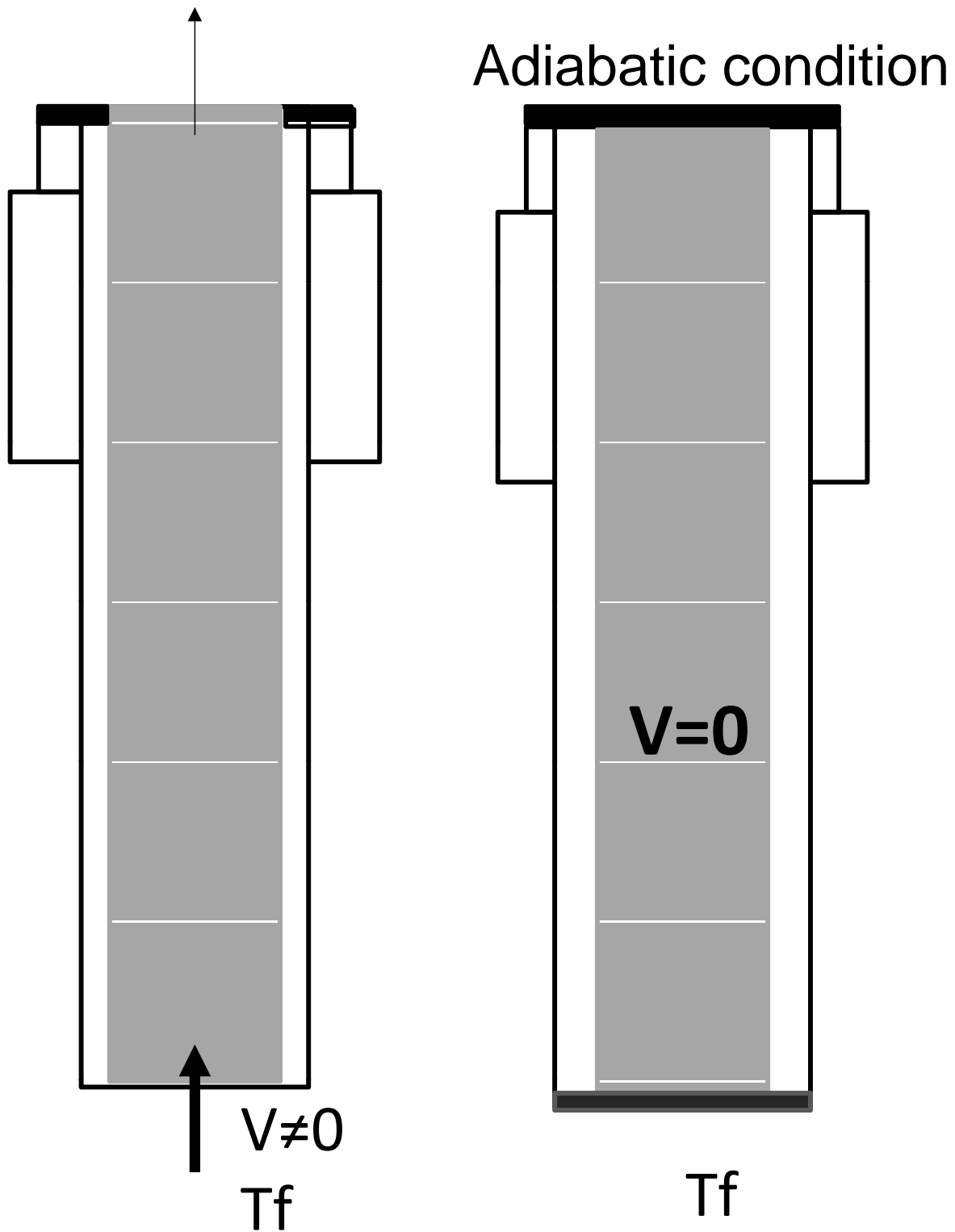


Figure 6: Conditions simulated with the CFD code: a) first step with a stationary condition, b) final step with an unsteady condition.

d) *Influence of the grid and of the interface conditions*

The influence of the grid and the interface conditions has been investigated by means of numerical simulations performed with the casting code on the configuration shown in Figure 1 c).

To investigate the influence of the dimension of the grid, two models have been defined: the dimension of the cells in the pipe has been set equal to 5 mm (GB), and 2 mm (SG) respectively. In both cases, the standard interface conditions have been set.

The casting code requires both boundary and interface conditions, while the CFD code requires

boundary conditions only: it has been investigated the influence of the interface conditions on the temperature estimated at point A. One simulation, denoted with No Interfaces, has been performed with the SG model and the interface conditions have been set equal to a value higher than that set in the previous simulation: such a value is representative of a condition without contact thermal resistance, and it approaches the condition simulated with the CFD code.

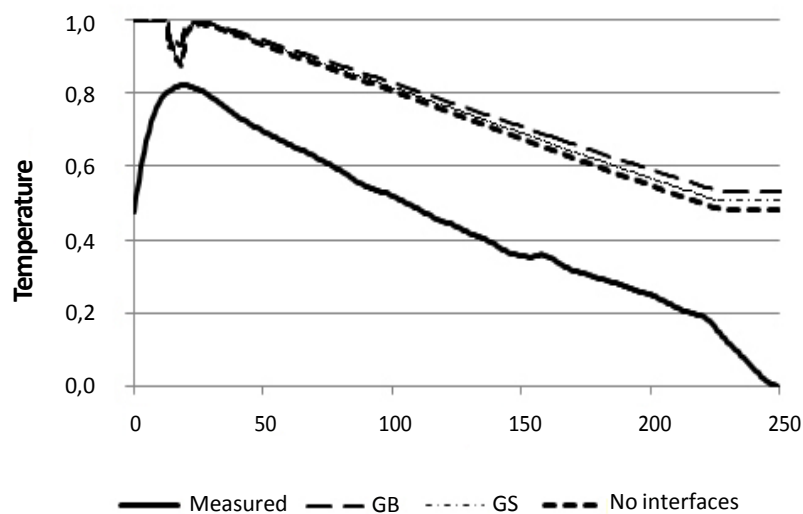


Figure 7: Temperatures at point A. Numerical simulations have been performed for different dimension of the grid and interface values.

Temperatures so estimated are shown in Figure 7.

i. *Heat flux*

A campaign of numerical simulations has been performed with the casting code by setting on the external surface of the pipe a heat flux, instead of a convective heat transfer coefficient. The heat flux has been obtained from the preliminary numerical simulation performed with the CFD code and the model shown in Figure 1 c). In this numerical simulation, the standard interface conditions have been set and the grid has cells of 5 mm.

The same condition, that is, a heat flux on the external surface of the pipe, has been set in a numerical simulation performed on the configuration shown in Figure 1 d) which includes the mold: this is the standard configuration.

Temperatures so estimated are shown in Figure 8.

IV. DISCUSSION

The system shown in Figure 1 a) has been analyzed; in particular, the temperature at point A has been monitored. The study has investigated the causes of the difference in temperature between measured and estimated temperatures shown in Figure 2.

Three hypothesis were made:

- A delay of the thermocouple has distorted the temperature measurement;
- The aluminum undergoes a cooling process while owing in the pipe, then the adiabatic condition on the external surface of the pipe is in-correct;
- The standard boundary conditions are incorrect.

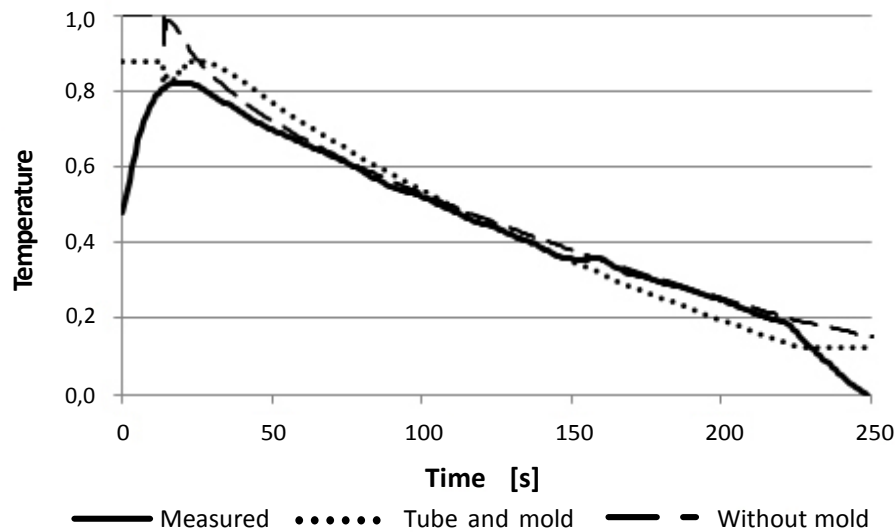


Figure 8: Comparison between measured temperatures and temperatures estimated with the casting code by setting heat flux on the external surface of the pipe. The configurations in Figure 1 c) and d) have been considered.

A test has been performed to check whether the thermocouple has distorted the temperature measurement; more precisely, to assess the time response of the thermocouple used to monitor the temperature at point A. In Figure 4, it can be seen that the actual temperature of the alloy has been approached after 0.048 times the total duration of the process from the immersion of the thermocouple, but the time necessary to detect the 99% of the temperature has been calculated and it is about 0.072 times the total duration of the process. For this, the time necessary to detect the maximum temperature of the alloy is longer than the time interval required for filling the mold and for the cooling process beginning, that lasts about 0.04 time the total duration of the process. For this, the actual maximum temperature of the alloy can not be detected by the thermocouple installed at point A.

Even if a cooling of the alloy in the passage through the tube can not be excluded completely, it can be stated that the difference between measured and estimated temperatures at point A is mainly due to a retard in the measurement. For this, it is correct that the codes estimate a higher temperature of the alloy at the beginning of the process. Setting a lower temperature of the alloy at the entrance of the pipe is incorrect because the temperature of the alloy is diverse and this could result in an incorrect simulation output especially from a metallurgical point of view.

A numerical simulations campaign has been performed to determine the correctness of the standard boundary conditions. Figure 5 shows temperatures at point A: temperatures have been estimated by setting

the same boundary conditions in models representing the configuration in Figure 1 c).

It can be seen that only the temperature estimated with the CFD code match with the measured temperature, and estimated temperatures are higher: higher temperatures estimated with the CFD code were expected because the simulation has been performed from a stationary condition in which the alloy flows in the pipe continuously (Figure 6 a)) and its passage heats the system, while, in the real case the alloy flows for only 0.04 times the total duration of the process. However, it can be assumed that the CFD code estimates the temperature at point A with enough accuracy. On the contrary, there is discrepancy between measured values and those estimated with the casting code.

Given that a greater discrepancy has occurred for the temperature estimated with the casting code, the influence of the grid and the interfaces conditions has been investigated. Results are shown in Figure 7, where it can be noted that the dimension of the grid does not affect the temperature significantly, indeed very similar time-temperature trends have been estimated for models with cells of 2 mm and 5 mm. Also, the interface conditions seem not to affect the temperature at point A: even if the thermal resistance between the elements has been neglected the time-temperature trend has not changed. Then, the difference in temperature in Figure 2 is not due neither to the dimension of the grid nor to the interface conditions.

At this point, a more severe condition has been set on the external surface of the pipe in the model shown in Figure 1 c) set for the casting code: instead of

a convective heat transfer and the related temperature, a heat flux has been set on the external surfaces of the pipe and the connecting elements.

This condition is more severe inasmuch the computing of the heat flux by the software is not required because the value has been set. In Figure 8, it can be seen that the temperatures (Measured and Without mold) now match even if at the beginning of the process the estimated temperature is higher: this is probably due to the fact that on the upper part of the pipe an adiabatic condition has been set, while in the real case a heat flux occurs towards the mold.

By comparing the time-temperature trends estimated by the casting code shown in Figures 5 and 8, it emerges the difference between imposing a heat convective heat transfer and a heat flux: in this latter case, the initial and final temperature match better and also the trend is detected better. By imposing the heat flux value, releases on the ability of the software to make thermal-fluid-dynamic computing: the heat flux is not computed correctly by the casting code and this is probably due to the shape of the grid elements. The grid defined for the casting code is made of hexahedral elements, while the one built for the CFD code is made of square elements: square is the most suitable shape to the thermal-fluid-dynamic computing in the boundary layer. Then, to estimate heat transfer boundary conditions in casting simulations, it is advisable to make use of CFD codes that are designed for this purpose specifically.

Finally, a final numerical simulation has been performed on the standard configuration shown in Figure 1 d) to check whether the new boundary conditions are appropriate also in the model with the pipe, the connecting elements and the mold. In this way, it has also been possible to assess whether the presence of the mold in the model affects the temperature trends so as to change the results significantly. The time-temperature trend so estimated is shown in Figure 8 and it can be seen that measured and estimated temperatures match also for the configuration in Figure 1 d). The little difference at the end of the process, that is, at 1 time the total duration of the process, is probably due to the cooling system in the mold set in the standard simulation: the cooling system works far from the pipe and the connecting elements, however, it removes heat from the alloy in the mold; then, in this configuration a greater heat flux flows from the pipe towards the mold. As the difference in temperature is only about 10°C, it can be stated that the temperatures match satisfactorily.

V. CONCLUSIONS

The study has investigated a casting process. The temperature-time curve at an important injection

point of a mould system has been measured and compared with the values estimated by means of numerical simulations. For the simulations, a casting code and a CFD code have been used. It has been shown that, for the considered system, the casting code is not able to estimate heat transfer correctly if a convective heat transfer coefficient and the related temperature are set, while the estimated temperatures match with measured temperatures if a heat flux is imposed. Given that the estimated temperature is not significantly affected by the interface conditions and the dimension of the grid, the difference in temperature is attributed to the diverse types of grid: in the CFD code, the grid made of squared elements seems to be more appropriate for the thermal-fluid-dynamic computing than a grid made of hexahedral elements.

Then, it is shown the possibility to take advantages of codes in the definition of numerical models for casting simulations.

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GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: J
GENERAL ENGINEERING
Volume 18 Issue 1 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

A Survey on the Factors Affecting Employee Turnover in the Readymade Garments of Bangladesh

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Northern University

Abstract- As an emerging and potential sector, RMG plays significant role in the development and sustainability of the economic sector of Bangladesh, which has been led by millions of manpower. This huge number of manpower is the driving force of this sectors in terms of productivity and hence in the achievement of the organizational goal. But now-a-days, it has been a significant challenge for any organization to retain their employee at work. Employee retention in the organization has become a baffling complication for all types of organization. Inadequate wage, violence in the workplace, safety issues of the workplace, unwilling overtime and not getting sufficient paid for overtime, lack of motivation, long working hours and night shift, not getting appreciation for their contribution, irregular increments and promotion, job insecurity and less scope for self-skill development are some leading reasons for the employee dissatisfaction which results in employee turnover.

Keywords: *readymade garment, employee, employee satisfaction, employee turnover, employee retention.*

GJRE-J Classification: *FOR Code: 291899p*



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A Survey on the Factors Affecting Employee Turnover in the Readymade Garments of Bangladesh

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Abstract- As an emerging and potential sector, RMG plays significant role in the development and sustainability of the economic sector of Bangladesh, which has been led by millions of manpower. This huge number of manpower is the driving force of this sectors in terms of productivity and hence in the achievement of the organizational goal. But now-a-days, it has been a significant challenge for any organization to retain their employee at work. Employee retention in the organization has become a baffling complication for all types of organization. Inadequate wage, violence in the workplace, safety issues of the workplace, unwilling overtime and not getting sufficient paid for overtime, lack of motivation, long working hours and night shift, not getting appreciation for their contribution, irregular increments and promotion, job insecurity and less scope for self-skill development are some leading reasons for the employee dissatisfaction which results in employee turnover. The survey we used selected questionnaires in order to find out the reasons for employee turnover. The results showed great impact of those facts on the job satisfaction, motivation and performance of the employee in the workplace. When the authorities concern and reflect on their needs, keep the employee more motivated and inspired, acknowledged their contribution in the workplace, then the employees are found to have positive attitude toward the organization and are more likely to stay in the organization.

Keywords: readymade garment, employee, employee satisfaction, employee turnover, employee retention.

I. INTRODUCTION

Bangladesh is a developing country with great potential in the textile sectors. The textile and clothing industries is the most significant source in the vastly growing economy of Bangladesh. Exporting of textiles and ready-made garments (RMGs) is the

principal source of foreign currency. According to the World Trade Organization (WTO), by 2002 exports of textiles, clothing, and ready-made garments (RMGs) accounted for 77% of Bangladesh's total merchandise exports^[1].

In 1972, the World Bank approximated the gross domestic product (GDP) of Bangladesh at USD 6.29 billion, in 2014, the GDP stood at USD 173.82 billion. In the last four decades the exporting grown by almost 27 times. Bangladesh's exports industry alone comprised USD 31.2 billion in FY 2014-15. Ready-made garments (RMGs) contribute 81.69% of it. After China, Bangladesh now holds the 2nd place in producing garments. It is expected that by the next five years, Bangladesh will become the largest ready-made garments manufacturer^[2]. The value of global garment industry is over \$1 trillion. Every year Bangladesh's garment industry fetches in revenue that worth \$22 billion dollars approximately. Ready-made garments (RMGs) already been come out as the biggest earner of foreign exchange. RMGs are the finished textile product from clothing factories and the *Bangladeshi RMG sector* is one of the fastest growing sectors in the Bangladeshi economy, with a growth rate of 55% from 2002 to 2012^[3]. This sector contributed significantly to the *GDP of Bangladesh*. Along with this significant contribution to the economy it also provides employment to around 4.2 million of workers, mainly women from low income families. In 2012 Bangladesh's garment exports – mainly to the US and Europe – made up nearly 80% of the country's export income^[4] among which the RMG industry represented 81.13% of Bangladesh's total export in 2014^[5]. With a population of about 170 million people the Bangladeshi garment sector employs approximately 3.5 million workers. Bangladesh is the second largest apparel manufacturer behind only China. There are over 5,000 garment factories in Bangladesh, employing approximately 4 million workers a year.

Productivity, profitability, employee satisfaction and various internal and external operating environment factors must be considered to withstand the potential

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and competitive global market. Along with this rising potential business of RMG sector, management of employees is one of the challenging practice for the human resource department of the respective organizations. Productivity and profitability, discipline of the sectors is highly related with employee satisfaction. This highly potential RMGs sectors of Bangladesh always been rattled with disputes and violent protest by the workers in recent time. Low wages, unsafe working environment, workers health, ergonomic hazards, chemical hazards, frequent accidents in the various factories and various other crisis are prone to employee turnover in the RMGs sectors of Bangladesh. Employee turnover reflects directly on the efficiency, productivity, profitability working environment of a factories.

The high probability of workers leaving is a key driver of low efficiency and leads to widespread refusals by factories to invest in the training of workers or creating a more safest environment. As the RMGs sector plays significant role in the growing economy of Bangladesh, retention of employees is of vital importance to maintain the harmony of this sectors. Many psychological and management strategy regarding the types of job content which is intrinsically satisfying to employees and which, in turn, should minimize external voluntary turnover. Business is about people. Therefore, it is vital to find out what motivates them, what inspires them, what incentivizes them, what satisfy them. There is a rapid growth of industrialization in Bangladesh. Most of the manufacturing companies in Bangladesh are labor-intensive, particularly the ready-made garment (RMG) industry^[9]. Therefore, the practice of human resource management (HRM) is of vital factor in labor intensive industry like RMG. Employees and technology are the backbone of any organization. Human resource management (HRM) plays important role by dealing with peoples working in an organization. HRM deals it by designing and coordinating various employee management activities^[10].

a) *Research Objectives*

This study involves the assessment of the impact of the various factors affecting on employee turnover, performance of employees and employee retention. The general objectives of this study are:

1. Finding out the possible reasons for employee turnover.
2. Assessment of the impact of those factors on the employee performance.
3. Assessment of the impact of those factors on employee retention.
4. Finding out the possible problems regarding employee turnover and minimizing the problems associated with employee turnover and retention.

In this survey we aimed to find out the plausible reason for employee turnover in the RMG sectors and impact of those factors on employee turnover and retention in the RMG sectors.

II. LITERATURE REVIEW

As a developing and emerging country, reduction of employee turnover and retention of employees are of the most significant practice for the highly potential RMGs sector of Bangladesh. Employee turnover is a significant drawback for this potential sector. Over the decade comparatively no significant researches have been performed to justify the worker's work satisfaction in the RMG sector in developing countries like Bangladesh. Worker performance and productivity is significantly dependent of their satisfaction. Adoption and implementation of properly organized supervision could be a significant factor between workers and its satisfactions. The significant reasons are insufficient wage, unprivileged benefits, pitiful communication, harsh work environment, insufficient motivation of the worker, lack of sufficient acknowledgement of their efforts, lack of fair attitude towards them, deficiency of job security, limited opportunities, better scope elsewhere, lack of interesting in work, lack of appreciation of their efforts, lack of appropriate practice of HRM, unable to adjust with organizational decorum, external factors, discrimination at work. All these reasons lead to the dissatisfaction of the employee towards the job and institutions.

Hossan, et.al defined worker satisfaction as workers overall effective state of mind resulting from an approval of all aspects of his work^[6]. When their expectations are being monitored and fulfilled their performance enhance statistically significantly. The attitude, responsibilities and roles of the workers towards work is a reflection of job satisfaction. Higher the satisfaction of the workers always exhibits positive attitude and responsibilities towards work and are less prone to turnover and vice versa^[7]. In order to anticipate strongly organized and strong management team for long term results proper incentives should be given according to the goals of business^[8]. The retention of employees could be more effective with the implementation of the career development plan for the employees by the organizations. These career development opportunities play significant role in preventing employees from leaving the organization and results in increasing the loyalty of the workers towards the organizations^[9]. An extensive study was conducted by Walton in which he has found and stated the reasons to be considered in order to understand about employee demands from the institutions are adequate and fair compensation, safe and healthy working

conditions, development of human competencies, growth and security, social integration for understanding quality of work life [10]. Ahmed and Hossain studied and stated that there is no significant safety observation has been conducted in the organizations, no significant investigation or veritable policy adopted by the RMGs owners. There is also lack of proper supervision regarding safety issues by the authorities responsible for safety work environment [11]. Many buildings have been converted and used as factories due to the significant expansion of the Readymade Garments (RMG) industry which were actually built for various other purposes rather than industry/factories. Random installation of factories and conversions of other buildings into garment factories most often performed as shortlys as possible in the inexpensive way. This resulting in oblation of safety issues like electrical circuits, unstable buildings, inadequate escape routes and unsafe equipment [12]. Sufficient compensation, regular promotion and performance acknowledgement and evaluation impart positive impact on employee performance which deals with overall organizational performance [13]. Financial solvency and social status are being found to influence directly on the employee performance in labor intensive manufacturing industry. Proper HR practices in the respective organization significantly regulate employee's behavior and bring out positive attitudes towards organization which in turn helps in attaining organizational goals with reference to the Bangladesh with lower per capita income [14].

Organizational success is dependent on the proper HRM practice. The ability of individual can be significantly influenced by managers by motivating them. Retention of employees is very much important for the organizational goals. As a labor-intensive sector, the success of this sector is very much dependent on the satisfaction of the employee.

III. RESEARCH METHODOLOGY

This study is based on surveying the employees using different questionnaires to the workers working in different RMG factories.

a) Research Scheme

The scheme of this study is to collect data and explain the phenomena include. In this study both primary and secondary sources have been exploited to gather data. Various questionnaires which have exploited on the workers is the primary data source. Various text books, journals, published research and online references and report were the secondary data sources for this survey.

b) Target Population and Sample Size

The target population were the permanent workers in the various RMG industries. The study is a

representation of the entire RMG sectors in Bangladesh. About 120 were selected randomly from various industries for this survey which includes workers of different age, experience and levels among which there were 80 males and 40 female workers.

c) Data Collection Tools and Analysis Technique

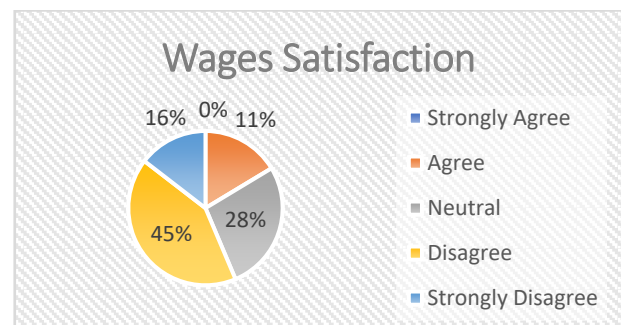
Questionnaires were the main instrument for data collection for this survey study. Questionnaire was used for collecting responses from the sample selected for the study. Basic simple analytical tools were used in the analysis the collected data. The collected data has been processed by using word processing software (MS Word). The collected data are represented in different analytical pie charts using percentage method.

IV. RESULTS AND DISCUSSION

We have taken ten parameters for our analysis and representation of the survey results. The scale of response on the questionnaire was from strongly agree, agree, neutral, disagree to strongly disagree which have been represented using pie chart.

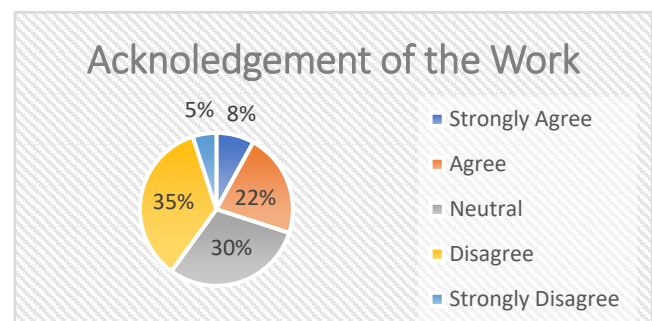
a) Wages

Salary provide by the organization is sufficient and compensate with my work. Strongly agree-0%, Agree-11%, Neutral-28%, Disagree-45%, Strongly disagree-16%.



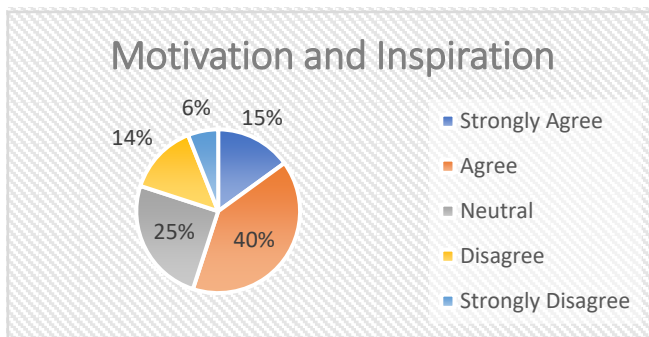
b) Acknowledgement of their work/Rewards of their effort

I am rewarded (monetarily and non-monetarily) for my good performance. Strongly agree-8%, Agree-22%, Neutral-30%, Disagree-35%, Strongly disagree-5%.



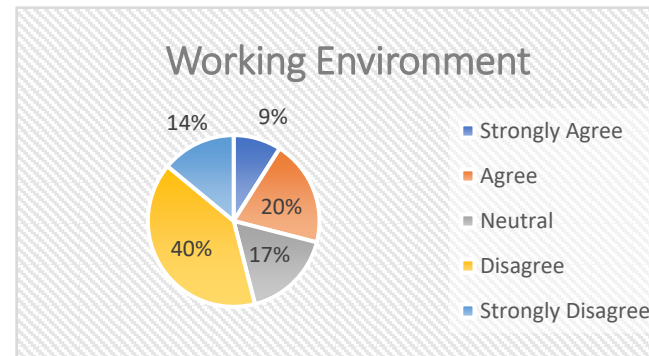
c) *Motivation*

I am motivated and inspired well by the management. Strongly agree-15%, Agree-40%, Neutral-25%, Disagree-14%, Strongly disagree-6%.



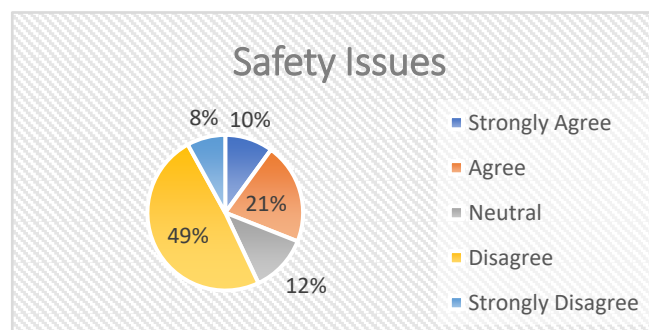
d) *Working Environment*

My working environment is friendly and supportive. Strongly agree-9%, Agree-20%, Neutral-17%, Disagree-40%, Strongly disagree-14%.



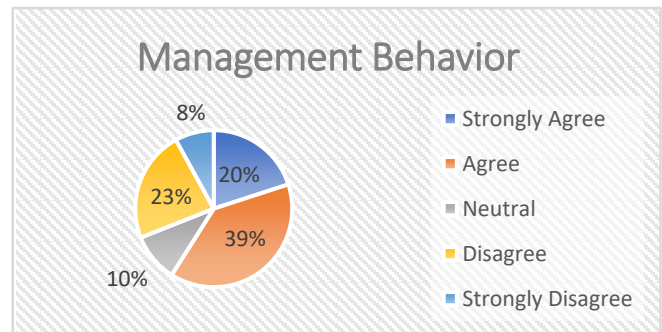
e) *Safety Issues*

My work place is safe and the safety issue is monitored and regulated by the authority regularly following safety rules and regulations. Strongly agree-10%, Agree-21%, Neutral-12%, Disagree-49%, Strongly disagree-8%.



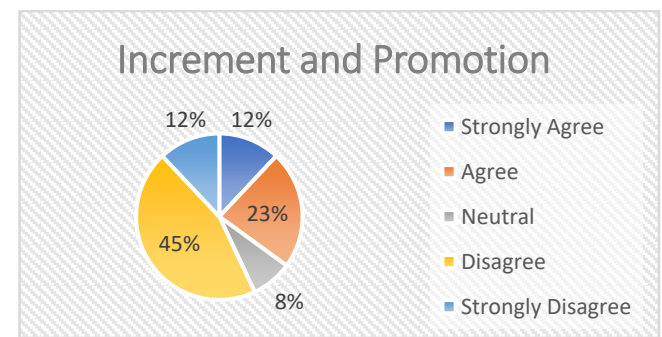
f) *Management Behavior*

I am satisfied with the management's behavior of my organization. Strongly agree-20%, Agree-39%, Neutral-10%, Disagree-23%, Strongly disagree-8%.



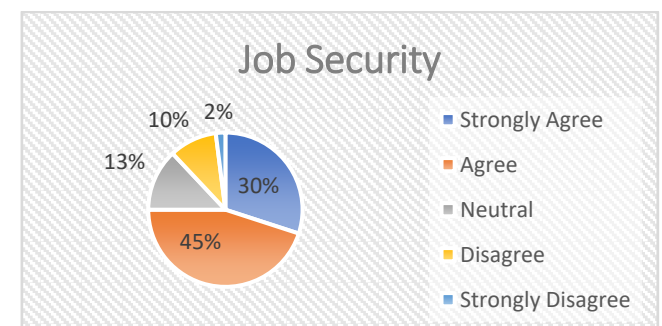
g) *Increment and Promotion*

I am rewarded by regular increment and promoted accordingly. Strongly agree-12%, Agree-23%, Neutral-8%, Disagree-45%, Strongly disagree-12%.



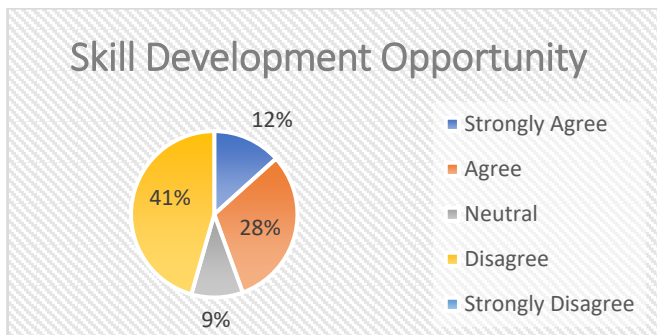
h) *Job Security*

I am concern about the security of my job and until get a secure job I am likely to find other jobs. Strongly agree-30%, Agree-45%, Neutral-13%, Disagree-10%, Strongly disagree-2%.



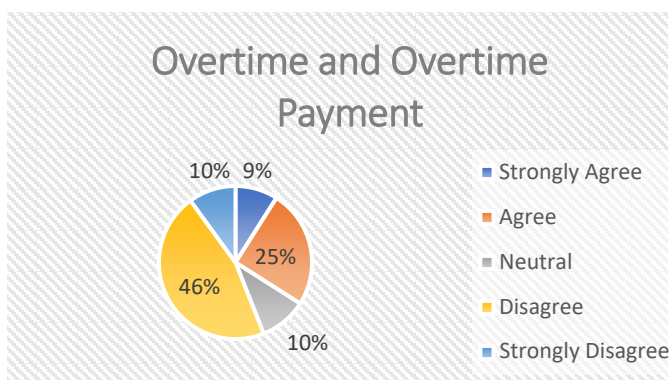
i) *Opportunities for Skill Development and Recreational Program*

I have adequate opportunity to develop my working skill and experience. Strongly agree-12%, Agree-28%, Neutral-9%, Disagree-41%, Strongly disagree-10%.



j) Overtime and Payment for Overtime

I have paid accordingly with the overtime. Strongly agree-9%, Agree-25%, Neutral-10%, Disagree-46%, Strongly disagree-10%.



V. CONCLUSION

In order to accomplish the organizational goals, it is very much significant for the organization to retain the employees. Employees are the backbone of the production industries. Therefore, their retention is significantly influence the organizational goals. As an emerging sector of our country all the authorities should pay close attention to readymade garments to understand the factors which are influencing the workers. They should pay more attention on the workers satisfaction, find out their problems and try to minimize them, they should consider about rewarding them for their contribution and they should also let the workers participate in sharing their view regarding the organization. Try to solve wages dilemma, keep eye on the sanitary working environment, work place safety issues etc. Overlooking these will led to the less working efficiency of the workers. Regular wages and occasional bonus and also profit sharing to the employees, fair and regular increment policy, appropriate promotional policy could be significant source of competitive benefits for any organization from our view point. This could help them in retaining their best talent with them for their long run success.

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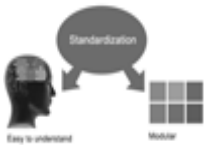
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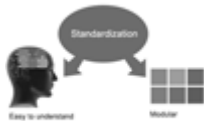


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We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from <https://globaljournals.org/Template.zip>

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

BEFORE AND DURING SUBMISSION

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct*, along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s) names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

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Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures



- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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PREPARING YOUR MANUSCRIPT

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.



Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

FORMAT STRUCTURE

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

PREPARATION OF ELECTRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

TIPS FOR WRITING A GOOD QUALITY ENGINEERING RESEARCH PAPER

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.



6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

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

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon 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 through which your research is going to be in print for 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 of 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 criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to 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 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 avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

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

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite 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 approaches 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. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a 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 limit the initial two items to no more than one line each.

Reason for writing the article—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 for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity 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 of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets 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 for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory 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 soundly written procedures segment allows a capable scientist to replicate 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 to give the least amount of information that would permit another capable scientist to replicate 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 section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show 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:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the 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—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and 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 as 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. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give 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 manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit 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 section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an 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 implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully 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 the prospect, and let it drop at that. Make a decision as to whether each premise is supported or 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 an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of 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 other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

THE ADMINISTRATION RULES

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.



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Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	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
<i>Introduction</i>	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
<i>Methods and Procedures</i>	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
<i>Result</i>	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
<i>Discussion</i>	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
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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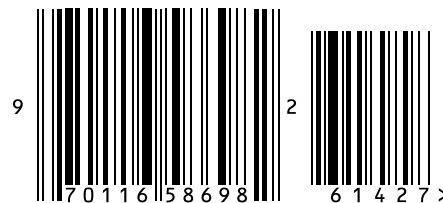


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ISSN 9755861

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