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Highlights

Devulcanization Yield

Physicochemical Parameters

Activated Sludge Process

Disi Water Field Project

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 1 VERSION 1.0

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Improvement of Devulcanization Yield during Reclamation of Waste Tires

By Dr. Kalrenganathan Sharma
Lone Star College University Park

Abstract - Waste tire recycling has become a bigger environmental problem. Despite regulations waste tires are stockpiled and often are breeding ground for west Nile virus and mosquitoes that cause pandemic. A number of times waste tires are incinerated or pyrolysis. Reclamation of value in the rubber portion of the waste tires may be more profitable and more environmentally benign compared with incineration and fuel use methods. Devulcanization and depolymerization reactions can lead to recovery of polybutadiene and butadiene monomer. Competing parallel reactions after the devulcanization step is studied in more detail. Dynamics of the general Denbigh scheme of reactions in a CSTR is studied. The composition of the species involved is obtained as a function of time from model solutions. A general state space form is proposed for simultaneous series-parallel reactions. Types of instability that may arise depends on the eigenvalues of the system. The Eigenvalues of the sparse matrix indicate that the system is of the integrating type. Solutions can be obtained from the eigenvalues for 7 species. Information from the model solution can be used to optimize the yield of rubber during reclamation of rubber from waste tires.

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IMPROVEMENT OF DEVULCANIZATION YIELD DURING RECLAMATION OF WASTE TIRES

Strictly as per the compliance and regulations of :

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I. Introduction

Estimates of DOT, department of transportation indicate there are 254.4 million registered passenger vehicles in this country, United States as of 2007. The number of passenger vehicles has grown steadily from the year 1960. The per capita car ownership is higher in the United States. In terms of volume, the number of passenger vehicles registered in the first eight months of 2011 in China was 9.83 million [1]. The number tires used in the cars on the road in the Unites States is more than a billion. Over 2 billion waste tires are estimated to be stockpiled in the landfills of this country, United States.

Texas Commission on Environmental Quality has collected data in 2011 about waste tire recycling problem. Nearly one tire for every resident, i.e. 292 million automobile tires is discarded each year. In Texas State 32 million tires were thrown away last year. Per Houston Chronicle [2] 14 million tires in shredded form are allowed to form heaps across Texas. Many more end up south of the border. 5 million tires form a mountain in Odessa and another 809,000 are piled alongside Genoa Red Bluff Road in southeast Houston. Relegation of tires to landfills has been outlawed for the past two decades. This has not stopped the 1 in 10 tires in Texas ending up in the landfill. The Houston Chronicle has received public complaints. 1200 people were upset about illegal piles of tires. These tires collect water and leads to pandemic due to West Nile virus. Tire fires ruins the happy parties creating polluted runoffs. TCEQ has issued 420 citations for illegal tire disposal in the past 5 years. Tire shredders are paid a fee per tire. TCEQ and EPA see cement kilns, paper plants and fuel furnaces using the waste tires. Environmental challenges are faced by 12 million people in the border between Mexico and U.S. A tire mountain in Ciudad Juarez, Mexico across the Rio Grande from El Paso, TX has gone down some from 7 million tires to 2.5 million tires. Engineering students at Institute for Sustainable Energy and Environment at Texas a& M, Kingsville are experimenting with using old tires to build new roads. This study in response to the call in [2] for affordable solutions to the waste tire problem.

Two large tire stockpile fires in St-Am able, Quebec and Hagersville, Ontario in 1989 [3] increased public awareness of the waste tire recycling problem. Large sums of money were invested in the USA in the development of reducing, reusing and recycling-techniques and processes for scrap tires-shredded tires (TDF) in the case of pulp and paper mills, generating stations, and some cement kilns or whole tires for most kilns accounts for 70 to 80% of all recycled tires in North America. Seven years later, it seems this is still the most economical and environmentally acceptable solution. One serious environmental problem related to the transportation field is the stockpiling of old rubber tires [4]. Several huge fires of old tires have already occurred in Canada and the United States and have caused considerable air and possibly soil pollution.

Development of techniques to recycle this potentially valuable material is of increased significance. The focus of current research at the Centre for Surface Transportation. Technology has been to develop a high-performance rubber asphalt concrete based on the stone mastic asphalt (SMA) concept which will be flexible enough (yet strong enough) to resist differential frost heave along roadways better than standard hot-mixed asphalt.. A solution to reduce the littering of the environment is to use ground tire rubber in road construction. Currently, about 27 million tons of asphalt is used each year in road construction and maintenance of the country's 2 million miles of roads. If all of the waste tire rubber could be combined with asphalt in

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road construction, it would displace less than 6% of the total asphalt used each year, yet could save about 60 trillion Btus annually [5].

As the automobile tire technology has grown and met the need for safer and more durable tires, stronger reinforcement and more chemically resistant rubber compounds have made recycling tires more difficult. In an effort to resolve this problem, techniques and equipment were developed to grind tires into small pieces, and new markets were sought to utilize the crumb rubber product streams from ground tires. Industrial combustion processes were modified to accept scrap tires as fuel. These efforts have been beneficial, steadily increasing the percentage of scrap tires recycled to about 10% in 1985, and reaching 72% in 1995. Vulcanized rubber scrap was used as a filler in PE-based and PVC-based compositions intended for manufacturing traffic control equipment elements, viz. road guides, rigid large-sized road emergency sign supports, speed humps, guiding rails etc. The compositions examined were based entirely on recyclates. Rubber scrap was prepared from worn-out tires in particulate form, Segregated and sieved to collect fractions of a suitable particle size. The PE and PVC scraps were obtained from the cable production plant; some containing copper wire bits; reclaimed PEfilm, termed the agglomerate, was also used. Paraffin oil was used as a compatibiliser; EVA was used as an impact strength modifier, and chalk and phosphogypsum (a calcium sulfate waste product from the phosphoric acid process- very difficult to utilize) were used as fillers. Optimum composition formulations were established and verified for making road sign and traffic control equipment elements by injection, & compression molding and extrusion molding techniques [6]. Tire-added latex concrete (TALC) was developed to incorporate recycledtire rubber as part of concrete [7].

Crumb rubbers from tires were used in TALC as a substitute for fine aggregates or styrene-butadiene rubber (SBR) latex, while maintaining the same water cement ratio. Various static and dynamic strengths of TALC were measured and compared to those of conventional and latex-modified concrete. TALC showed higher flexural and impact strengths than those of portland cement and latex-modified and rubber-added concretes. Microscopic pictures taken using the scanning electron microscope (SEM) seem to support thatthere is better bonding between crumb rubbers and portland cement paste due to latex. TALC showed potential of becoming a viable construction material to enhance brittle concrete while incorporating waste tires. Vulcanized rubber scrap was used as a filler in PE-based and PVC-based compositions [8] intended for manufacturing traffic control equipment elements, viz. road guides, rigid large-sized road emergency sign supports, speed humps, guiding rails etc. The compositions examined were based entirely on recycles. Rubber scrap was prepared from worn-out tires in particulate form, segregated and sieved to collect fractions of a suitable particle size. The PE and PVC scraps were obtained from the cable production plant, some containing copper wire bits; reclaimed PE film, termed the agglomerate, was also used. Paraffin oil was used as a compatibiliser; EVA was used as an impact strength modifier, and chalk and phosphogypsum (a calcium sulfate waste product from the phosphoric acid process, very difficult to utilize) were used as fillers. Optimum composition formulations were established and verified for making road sign and traffic control equipment elements by injection, compression molding and extrusion molding techniques. The technical uses of scrap tires, and the recycling of rubber in the U.S was shown [9] that over 172 million tires, 64% of the total, were used as tire derivative fuel in 1997, representing the single largest use of scrap tires. Other utilizations of scrap time are illustrated. A special feature of this process was that flushing air from the cavity of the machine and blanketing it with nitrogen generally gives a stiffer and less tacky soluble mass. Most vulcanizing processes produce significant amounts of waste and rejects.

A process which can economically reduce this waste to zero was described [10]. Current practicein-cludes retreading, recycling as crumb rubber and combustion for thermal energy. A literature review was made to compare the discarded tire recycling practices in the United States, Japan and Korea. The durability of rubber modified mixtures [11] used in paving projects was evaluated. While the presence of moisture affects the adhesion between the binder and the aggregate producing stripping effects, the characteristics of the rubber modified binder is expected to improve the mixture durability and performance. Experience with road fills in Washington State constructed with thick layers of tire chips spontaneously burning has led to a decrease in tire chip use nationally [12]. The rheological properties of composites of recycled high density polyethylene (HDPE) with recycled tire rubber particles at shear rates from 1.167 to 116.7 s^{-1} was studied [13]. The recycling rate of used tires in Japan is much higher [14] than that in other countries. The new Solid-State Shear Extrusion (SSSE) pulverization process can [15]) convert tire rubber and/or plastics into controlled particle size powder in a once through, continuous process using a modified co-rotating twin-screw extruder. Mechanical properties were studied on composites of recycled high density polyethylene (HDPE) and recycled tire rubber particles [16]. Either portland cement or magnesium oxychloride cement was used [17] as binders for concretes that incorporated fine rubber aggregate, ranging from 0 to 25 percent by volume. An experimental study has been conducted to evaluate the effects of incorporating granulated rubber into Portland cement concrete [18]. One potential use of scrap tires within the civil engineering field, specifically, as a lightweight backfill material for retaining walls, has been investigated [19]. The percentage of rubber products going to landfill have increased dramatically [20]. The value of using crumbed old tires in pavements were recognized in the 1960s. If properly incorporated into pavement, Crumbed rubber can improve asphalt-concrete performance [21]. How tire recyclers are Struggling with ways to make profits from scrap tires was discussed in [22]. A multi-disciplinary Research effort to develop new asphalt materials with improved engineering properties using Different types of modifiers, plus new manufacturing technologies, is underway at the University of Calgary [23]. For Envirotire (Lillington, North Carolina), producing quality Crumb rubber this summer is all in a night's work [24]. The marketplace for recycled products Places substantial demands on suppliers for consistent high quality and production flexibility [25]. Previous attempts to commercialize processes for the pyrolysis of scrap tires are Reviewed [26], and results are presented of research undertaken by the Pyro Division of Svedala Industries in the processing of raw pyrolysis char into pyrolysis carbon black for use as a modifier in asphalt road surfaces. It is reported in this short item that the North American Recycled Rubber Association (NARRA) and two Canadian companies have successfully completed a research project to use recycled tire fibers in the production of rebound carpet cushion [27]). Brief details are provided. Scanning electron microscopy (SEM) was utilized to observe the microstructure and fracture surfaces of tensile, bending, and internal bonding specimens of diphenylmethane diisocyanate (MDI) bonded wood fiber/recycled tire rubber composites [28]

Annual production of polybutadiene is about 2.1 million tons in 2000 [29]. 70% of the PBd goes into tire manufacture. 25% of PBd goes into ABS and HIPS engineering thermoplastics. Vulcanization is used convert synthetic rubber into more durable materials by addition of sulfur. Cross-links are intentionally formed between polymer chains by sulfur bridges. Goodyear invented vulcanization in 1839. In his *Gum-Elastica* he records [30] how the effect of heat on the same compound that had decomposed in mail bags can be charred like leather. The rubber is cured. About 30% of automotive tires are carbon black. Other additives are also added for better balance of properties.

II. Solution to the Tired Old Problem– Reclamation More Valuable Compared to Incineration

Per a patent on depolymerization [31] the total energy required to make 1-3 butadiene monomer is 60,000 BTU per pound. The fuel energy value of tire is approximately 15,000 BTU per pound. The value of the monomer in the waste tires is lot higher than the value attained from using waste tires as fuel. Further the pollution and proliferation of West Nile virus is an added concern. Therefore it would be more profitable and more environmentally benign to reclaim the butadiene and/or the polybutadiene in the waste tires.

2013 would be the centennial of the award of the nobel prize in physics to K. Kamerlingh Onnes for his investigations on the properties of matter at low temperatures. Among other things like liquid Helium, he came up with the Virial equation of state. A careful study of polybutadiene-butadiene reversible polymerization equilibrium at low pressures has not been undertaken. What pressures and temperatures does PBd exist as vapor, gas or supercritical state? What pressures does PBd depolymerize to butadiene monomer? When one were to lower the pressure in the laboratory of a kettle containing PBd which would happen first: (i) vaporization of PBd or ; (ii) depolymerization ?

P-T, Pressure-Temperaturediagrams and zero pressure isotherms can be constructed using the information given in [32] for PBd, polybutadiene. The Tait equation of state (Eq. 2.27) is;

$$V = V_0\left(1 - C\ln\left(1 + \frac{P}{B}\right)\right) \quad (1)$$

can be used. The Tait parameter B for PBd is given in Table 2.1 in [5] as $1777e^{-3.593E-3T}$. C is taken as 0.0894 and zer pressure isotherm V_0 is given in Table 2.1 in the book as $1.0970e^{6.6E-4T}$.

A side-by side comparison of the predictions of Pressure-Temperature equilibrium for different molecular weights of PBd can be made using: (i) Tait equation; (ii) FOV, Flory Orwoll and Vrij Theory, Eq. (2.37); (iii) Prigogine Square-Well cell model, Eq. (2.40); (iv) lattice fluid theory of Sanchez and Lacombe, Eq. (2.59).

The ceiling temperature of polyalphamethyl styrene is 61 ^{0}C. This is the temperature at which the depolymerization reactions are as favorable as the polymerization reactions. Thermal terpolymeization kinetics for alpha methyl styrene acrylonitrile and styrene was reported at three different temperatures [33]. Approach to reclamation of rubber from waste tires was proposed in [34-39].

The Clapeyron equation for polymerization-depolymerization equilibria was derived [32]. The ceiling temperature of PBd is about 585 ^{0}C at atmospheric pressure. An approximate estimate of the ceiling temperature of PBd at low pressures can be made using the Clapeyron equation as follows;

$$\Delta P = \frac{\Delta H}{\Delta V}\ln\left(\frac{T_2}{T_1}\right) \quad (2)$$

The enthalpy of polymerization of PBd can be expected to be similar to that of polyethylene and is about -17.4 $kcal.mole^{-1}.K^{-1}$. The change in density of PBd upon polymerization goes from 640 $kg.m^{-3}$ for 1.3 butadiene monomer to 900-950 $kg.m^{-3}$ for PBd. More refined estimates can be made by allowing for change of volume during polymerization and change of enthalpy during polymerization to vary with change in pressure. Thus Eq. (12.8) can be reintegrated. Another method of simulating the ceiling temperature at low pressures is by use of Eq. (12.43) in [32];

$$T_c = \frac{\Delta H_p}{R\ln(M_e) + \Delta S_p} \quad (3)$$

The entropy change of polymerization is about 25-30 $cal.K^{-1}.mole^{-1}$ for most polymerization systems by free radical propagation/depropagation.

There can be two approaches to reclamation of rubber from waste tires. One method is by chemical reactions involving devulcanizing and depolymerization and the other is by solvent extraction. The outlines of the two methods are as follows;

Method I A 3 phase Gas-Liquid-Solid Fluidized bed can be used to depolymerize the PBd the PBd is one of several components in the tire. Ozone treatment or ultrasound treatment of rubber tires can be used to remove the sulfur cross-links. Devulcanization is anessential pre-treatment step. The Gas-Liquid-Solid Fluidized bed can be operated at vacuum pressures. Optimal temperature and pressure in the presence of a catalyst such as $AlCl_3$ needs to be arrived at by experimentation.

Method II A dipolar aprotic solvent such as N-Methyl-2-Pyrrolidone or γ-butyrolactone can be used to extract the carbonaceous matter in the waste tires. Similar extraction of bituminous West Virginia coals was reported earlier [40]. The solvent is recovered using water. The recovered Pbd can be re-vulcanized and retreated Techno-economic analysis can be used in order to evaluate the process by method I and the process by method II against the current pyrolysis and incineration methods. Information from mathematical state-space modeling of depolymerization using computers is useful in process design and optimization of yield of the valuable material in the tires. The dynamics of the intermediate product formation is studied in more detail below.

III. Denbeigh Scheme of Reactions

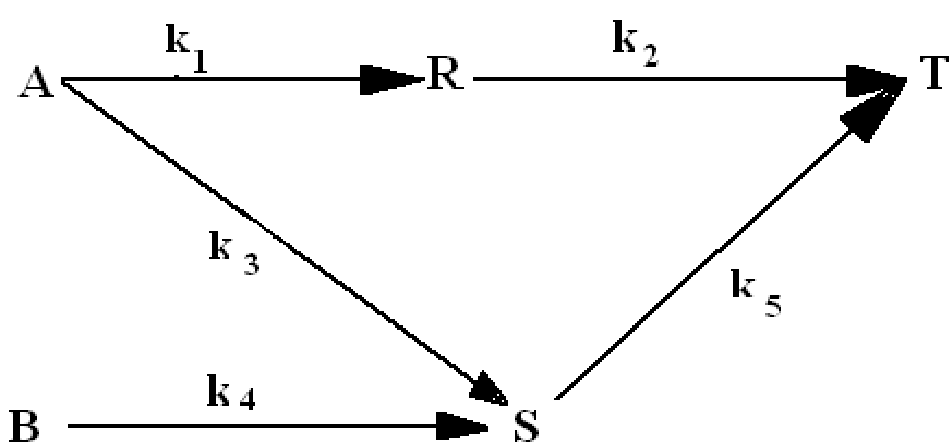

Figure 1.0 : Denbigh Scheme of Reactions

Consider the Denbigh scheme of reactions [41] performed in the CSTR shown in Figure 4.0. A scheme of reactions as shown in Figure 1.0 was discussed in [38] as a special case of Denbeigh reactions. A state space model that can be developed to describe the dynamics of the 5 species, C_A, C_R, C_T, C_B and C_S. The assumptions are that the inlet stream contains species A and B at a concentration of C_{Ai} and C_{Bi} and the initial concentrations of the other species are zero. The kinetics of the simple irreversible reactions shown in Figure 4.0 can be written as follows;

$$\frac{dC_A}{dt} = -(k_1 + k_3)C_A \quad (4)$$

$$\frac{dC_B}{dt} = -k_4 C_B \quad (5)$$

$$\frac{dC_S}{dt} = k_4 C_B + k_3 C_A - k_5 C_S \quad (6)$$

$$\frac{dC_R}{dt} = k_1 C_A - k_2 C_R \quad (7)$$

$$\frac{dC_T}{dt} = k_2 C_R + k_5 C_S \quad (8)$$

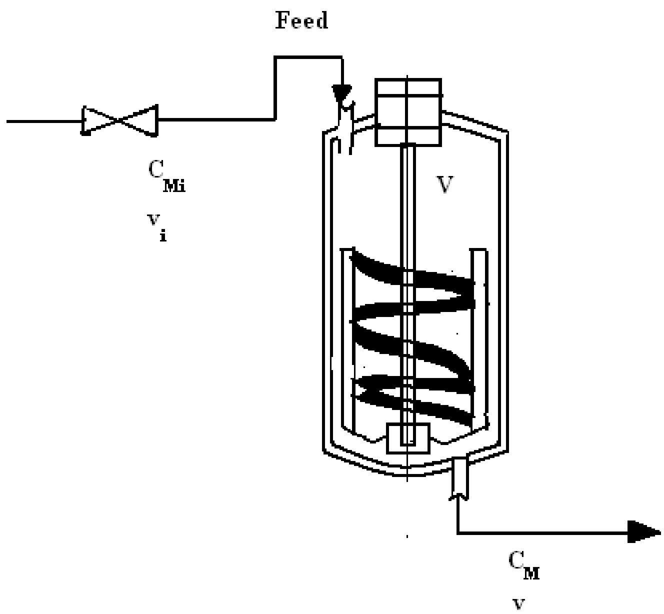

Figure 2.0 : CSTR, Continuous Stirred Tank Reactor

The reactions are considered to peformed in the CSTR similar to the one shown in Figure 2.0. Component mass balances on each of the species assuming incompressible flow and constant volume reactor can be written as follows;

Species A

$$C_{Ai} - C_A(1 + Da_1 + Da_3) = \frac{dC_A}{d\tau} \quad (9)$$

Where; $Da_1 = k_1\theta; Da_3 = k_3\theta; \tau = \frac{t}{\theta}; \theta = \frac{V}{v}$, θ with units of (hr) is the residence time of the species in the reactor, V is the volume of the reactor, (liter) and v is the volumetric flow rate (lit.hr^{-1}) in and out of the reactor.

Species B

$$C_{Bi} - C_B(1 + Da_4) = \frac{dC_B}{d\tau} \quad (10)$$

Where $Da_4 = (k_4\theta)$

Species S

$$-C_S(1 + Da_5) + Da_4 C_B + Da_3 C_A = \frac{dC_S}{d\tau} \quad (11)$$

Species R

$$-C_R(1 + Da_2) + Da_1 C_A = \frac{dC_R}{d\tau} \quad (12)$$

Species T

$$-C_T + Da_2 C_R + Da_5 C_S = \frac{dC_T}{d\tau} \quad (13)$$

The model equations that can be used to describe the dynamics of the 5 reactant/product species in a CSTR can be written in the state space form as follows;

Global Journal of Researches in Engineering (C) Volume XIII Issue I Version I Year 2013

$$\frac{d}{dt}\begin{pmatrix} C_A \\ C_B \\ C_S \\ C_R \\ C_T \end{pmatrix} = \begin{pmatrix} -(1+Da_1+Da_3) & 0 & 0 & 0 & 0 \\ 0 & -(1+Da_4) & 0 & 0 & 0 \\ Da_3 & Da_4 & -(1+Da_5) & 0 & 0 \\ Da_1 & 0 & 0 & -(1+Da_2) & 0 \\ 0 & 0 & Da_5 & Da_2 & -1 \end{pmatrix}\begin{pmatrix} C_A \\ C_B \\ C_S \\ C_R \\ C_T \end{pmatrix} + \begin{pmatrix} C_{Ai} \\ C_{Bi} \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad (14)$$

The stability of the dynamics of the 5 reactants/products in the Denbigh scheme performed a CSTR can be studied by obtaining the eigenvalues of the rate matrix. The characteristic equation for the eigenvalues are obtained by evaluation of the following determinant;

$$\det\begin{pmatrix} (\lambda+1+Da_1+Da_3) & 0 & 0 & 0 & 0 \\ 0 & (\lambda+1+Da_4) & 0 & 0 & 0 \\ Da_3 & Da_4 & (\lambda+1+Da_5) & 0 & 0 \\ Da_1 & 0 & 0 & (\lambda+1+Da_2) & 0 \\ 0 & & Da_5 & Da_2 & (\lambda+1) \end{pmatrix}$$

$$(\lambda+1+Da_1+Da_3)(\lambda+1+Da_4)(\lambda+1+Da_5)(\lambda+1+Da_2)(\lambda+1)=0 \quad (15)$$

The 5 eigenvalues are negative when Damkohler numbers are greater than zero. When eigenvalues are all negative the system is considered to be stable.

The Laplace transform of the model equations developed in order to describe the transient dynamics (Eqs. 39 – 43) for the 5 species in the Denbigh scheme in a CSTR can be written as follows;

$$C_A(s)=\frac{C_{Ai}}{(s)(s+1+Da_1+Da_3)} \quad (16)$$

$$C_B(s)=\frac{C_{Bi}}{(s)(s+1+Da_4)} \quad (17)$$

$$C_S(s)=\frac{Da_3C_{Ai}}{(s)\left(s+1+Da_1+Da_3\right)(s+1+Da_5)}+\frac{Da_4C_{Bi}}{(s)(s+1+Da_4)(s+1+Da_5)} \quad (18)$$

$$C_R(s)=\frac{Da_1C_{Ai}}{(s+1+Da_2)(s)(s+1+Da_1+Da_3)} \quad (19)$$

$$C_T(s)=\left(\frac{1}{s(s+1)}\right)\left(\frac{Da_5Da_3C_{Ai}}{(s+1+Da_1+Da_3)(s+1+Da_5)}+\frac{Da_4Da_5C_{Bi}}{(s+1+Da_4)(s+1+Da_5)}+\frac{Da_1Da_2C_{Ai}}{(s+1+Da_2)(s+1+Da_1+Da_3)}\right)$$

(20)

The inverse Laplace transform of Eq. (42) can be obtained by invocation of the convolution theorem and written as;

$$\frac{C_A(t)}{C_{Ai}}=\left(\frac{1}{1+Da_1+Da_3}\right)\left(1-e^{-\tau(1+Da_1+Da_3)}\right) \quad (21)$$

The inverse Laplace transform of Eq. (47) can be seen from the time shift property to be;

$$\frac{C_B(t)}{C_{Bi}}=\left(\frac{1}{1+Da_4}\right)\left(1-e^{-(1+Da_4)\tau}\right) \quad (22)$$

The inverse Laplace transform of Eq. (48) can be obtained by look-up of Laplace inversion Tables in Mickley, Sherwood and Reed [42]

$$\frac{C_R(t)}{C_{Ai}} = \frac{\left(e^{-\tau(1+Da_2)}\right)}{(1+Da_2)(Da_2 - Da_1 + Da_3)} - \frac{\left(-e^{-\tau(1+Da_1+Da_3)}\right)}{(1+Da_1+Da_3)(Da_2 - Da_1 - Da_3)} + \frac{1}{(1+Da_2)(1+Da_1+Da_3)} \tag{23}$$

IV. State Space Representation

State space models are those that describe more than one variable at a given instant in time. Vector form for several variables is used. A set of n differential equations is represented by one equation in matrices and vectors. The coefficient matrix and input and output vectors are used. Output vector can be solved for by matrix manipulations. This would form the output response of the system. The stability of the system can be studied by looking at the Eigen values of the coefficient of the matrix. The different instabilities that may arise and the conditions under which they would arise are given in Table 1.0 [43].

Eigen Values	Characterization of Stability	Stability Type
$\lambda_2 < \lambda_1 < 0$	Asymptotically Stable	Improper Node
$\lambda_2 > \lambda_1 > 0$	Unstable	Improper Node
$\lambda_2 = \lambda_1 = \lambda$	Asymptotically Stable if $\lambda < 0$, Unstable if $\lambda > 0$	Proper or Improper Node
$\lambda_1 < 0 < \lambda$	Unstable	Saddle Point
$\lambda = a \pm ib$	Stable if a < 0 Unstable if a > 0	Focus or Spiral
$\lambda = \pm ib$	Marginally Stable	Center

Table 1.0 : Characterization of Stability Types

V. Kinetics of Simultaneous Reactions in State Space Form

As an example a state space model is developed to describe the kinetics of the following set of reactions in series and in parallel as suggested in Levenspiel [41]:

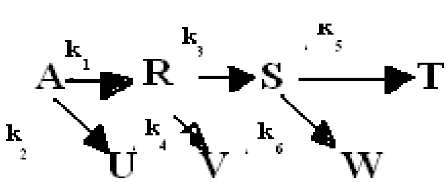

Figure 3.0 : Scheme of 7 Simultaneous Reactions

The kinetics of the 7 simultaneous reactions shown in Figure 3.0 is given below as follows;

$$\frac{dC_A}{dt} = -k_1 C_A - k_2 C_A \tag{24}$$

$$\frac{dC_R}{dt} = k_1 C_A - k_3 C_R - k_4 C_R \tag{25}$$

$$\frac{dC_S}{dt} = k_3 C_R - k_5 C_S - k_6 C_S \tag{26}$$

$$\frac{dC_T}{dt} = k_5 C_S \tag{27}$$

$$\frac{dC_U}{dt} = k_2 C_A \tag{28}$$

$$\frac{dC_V}{dt} = k_4 C_R \tag{29}$$

$$\frac{dC_W}{dt} = k_6 C_S \tag{30}$$

The above equations can be represented in the state space form in one line as follows;

$$\frac{d}{dt}\begin{pmatrix} C_A \\ C_R \\ C_S \\ C_T \\ C_U \\ C_V \\ C_W \end{pmatrix} = \begin{pmatrix} -(k_1+k_2) & 0 & 0 & 0 & 0 & 0 & 0 \\ k_1 & -(k_3+k_4) & 0 & 0 & 0 & 0 & 0 \\ 0 & k_3 & -(k_5+k_6) & 0 & 0 & 0 & 0 \\ 0 & 0 & k_5 & 0 & 0 & 0 & 0 \\ k_2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & k_4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & k_6 & 0 & 0 & 0 & 0 \end{pmatrix}\begin{pmatrix} C_A \\ C_R \\ C_S \\ C_T \\ C_U \\ C_V \\ C_W \end{pmatrix} \tag{31}$$

Or,

$$\frac{dC}{dt} = KxC \tag{32}$$

The stability of the system of reactions can be studied by obtaining the Eigen values of the K matrix. The Eigenvalues of the K matrix are obtained from the roots of the characteristic polynomial

$$\mathrm{Det}(\lambda I - K) = 0 \tag{33}$$

The K matrix is *sparse*. The polynomial form of the characteristic equation can be written as follows;

$$(\lambda + k_1 + k_2)(\lambda + k_3 + k_4)(\lambda + k_5 + k_6)\lambda^4 = 0 \tag{34}$$

The 7 Eigenvalues are 0 repeated 4 time and $-(k_1+k_2)$, $-(k_3+k_4)$ and $-(k_5+k_6)$. This system can be viewed as an *integrating system* since all but Eigen values are negative with 4 Eigen values 0.

VI. Conclusions

As the total energy required to make 1-3 butadiene monomer (60,000 BTU per pound) is greater than the fuel energy value of tire (15,000 BTU per pound), it would be more profitable to recover the butadiene from the waste tires rather than salvaging the fuel value in the waste tires. Furthermore, the stockpiles of was tires cause spread of waste nile virus and cause pandemic. Thermodynamic analysis including P-T phase behviour and the depolymerizationequilibria for polybutadiene has been completed using desktop computers. Different Equation of states such as (i) Tait equation, FOV, Flory Orwoll and Vrij Theory, Prigogine Square-Well cell model, lattice fluid theory of Sanchez and Lacombe were used in the simulations. The Clapeyron equation was derived for ceiling temperature variation with pressure for polybutadiene. Process analysis for two methods for value recovery from waste tires has been drafted. One method is by devulcanization and depolymerization conducted in a three phase fluidized bed. The other method is by swelling and solubilization. A critical step in the reaction process is the optimization of intermediate yield. The dynamics of the general scheme of Denbigh reactions is discussed in detail. State space representation of the series-parallel reactions and criteria for stability are discussed.

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Modelling of Activated Sludge Process

By Anvita Sharma & Himanshu Choksi
Pandit Deendayal Petroleum University

Abstract - In this report, I have used commercial matlab software for activated sludge process. Have included various types of activation process, and then done simulation of a simple fermenter and activated sludge processer used in activated sludge process included the future developments in activated sludge process.

GJRE-C Classification : JEL Code: 090409

MODELLING OF ACTIVATED SLUDGE PROCESS

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Anvita Sharma [α] & Himanshu Choksi [σ]

Abstract - In this report, I have used commercial matlab software for activated sludge process. Have included various types of activation process, and then done simulation of a simple fermenter and activated sludge processer used in activated sludge process included the future developments in activated sludge process.

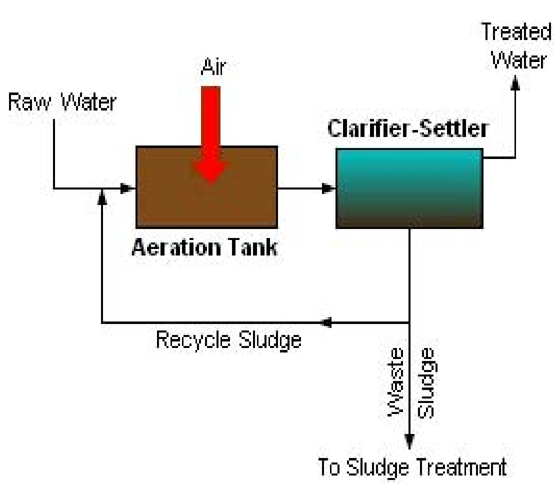
I. Introduction

a) Activated Sludge [18]

Activated sludge process is a highly efficient system for the aerobic biological treatment of industrial or municipal wastes. The process depends on the use of a high concentration of microorganisms in the form of floc, which is kept in suspension by agitation. Agitation is provided either by mechanical means or by aeration.

In this process, a portion of the separated sludge along with the native population of living microorganisms is added to the incoming effluent as inoculums. This added sludge is often referred to as activated sludge and carries out the actual oxidation. Thus, a constant microbial population is maintained in the activated sludge tank.

The activated sludge tank is simple in design. It is an oblong deep tank, provided with an inlet at the top of one end and an outlet at the bottom of the other end. Aeration is provided either by an air diffuser located at the bottom of the tank or by agitators at the surface of waters along both sides of the tank.



Author α σ : School of Technology, Pandit Deendayal Petroleum University, Gandhinagar.

b) Modeling and Simulation[19]

- Modeling
  - To realistically simulates a true plant
  - To evaluate controllers and control strategies
- IAWQ's Activated Sludge Model No. 1
  - Most widely used model
  - Developed by Henze et al. (1987)
  - Used to model each zone of bioreactor.
- The bioreactor model describes
  - Removal of organic matter
  - Nitrification
  - Denitrification.

II. Simplified System

a) Constants

- mu_m=0.48;
- k_m=1.2;
- p_m=50;
- k_i=22;
- alpha =2.2;
- bita =0.2;
- y_x_s=0.4;
- x_s= 7.3059;
- s_ss=5.1340;
- p_ss=25.0081;
- d_ss=0.20; % DILUTION RATE
- sf_ss=30; % SUBSTRATE CONCENTRATION

b) Related Equations

- d = d_ss+ 0.016*u(1) ;

% actual input dilution rate at given instance

- s = sf_ss + 2.3*u(2) ;

% Actual substrate concentration at given instance

- mu_m1=mu_m;%+u(3);

% maximum specific growth rate at given instance

- num=(1-(x(3)/p_m))*x(2);
- den=k_m+x(2)+((x(2)^2)/k_i);
- mu=mu_m1*(num)/den;

c) Differential Equations

- (dx1/dt) = -d*x (1) +mu*x (1);
- (dx2/dt) = d*(s-x(2))-mu*x(1)/y_x_s
- (dx3/dt) = -d*x(3)+(alpha*mu + bita)*x(1) ;

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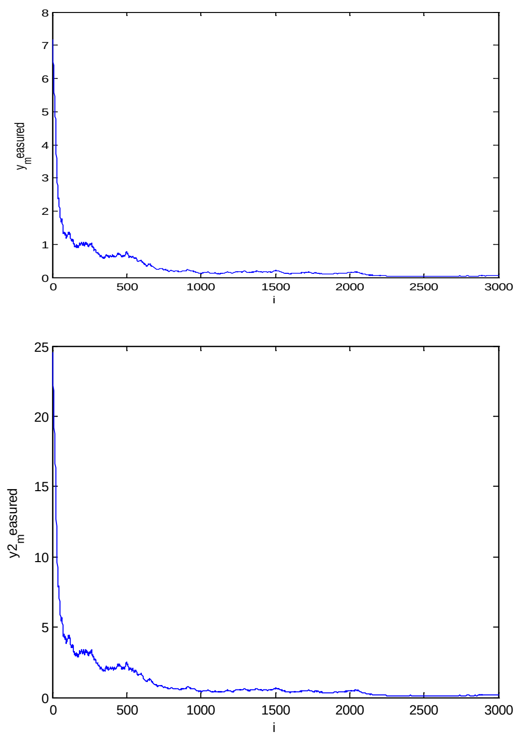
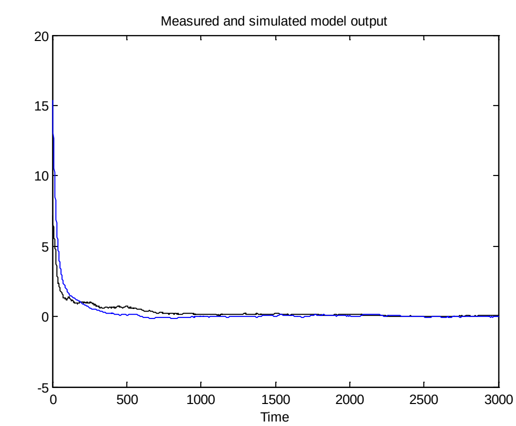
III. Results of The Fermenter System



a) After Performing Identification



b) Study Related to the Actual Activated Sludge System[19]

Exceptions

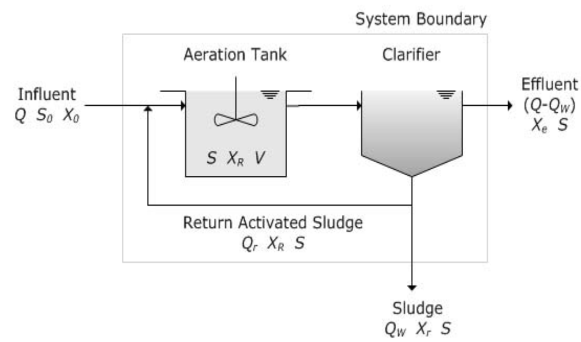
- S_I (inert soluble organic matter) and S_{ALK} (total alkalinity) are not included.
- The inert ($X_{I,IAWQ}$) and particulate ($X_{P,IAWQ}$) matter are combined into one variable

Hence $X_I = X_{I,IAWQ} + X_{P,IAWQ}$.

- (S_O) dissolved oxygen describes the oxygen transfer.
- K_La is the oxygen transfer function
- u is the airflow rate
- $S_{O,sat}$ is the saturated dissolved oxygen concentration.

Parameters [19]

- S_{NH}(t) soluble ammonium nitrogen
- S_{NO}(t) soluble nitrate nitrogen
- S_{ND}(t) soluble biodegradable organic nitrogen
- S_O(t) dissolved oxygen
- S_S(t) soluble substrate
- $X_{B,A}$(t) autotrophic biomass
- $X_{B,H}$(t) heterotrophic biomass
- X_{ND}(t) particulate biodegradable organic nitrogen
- X_S(t) slowly biodegradable substrate
- X_I (t) particulate matter & products

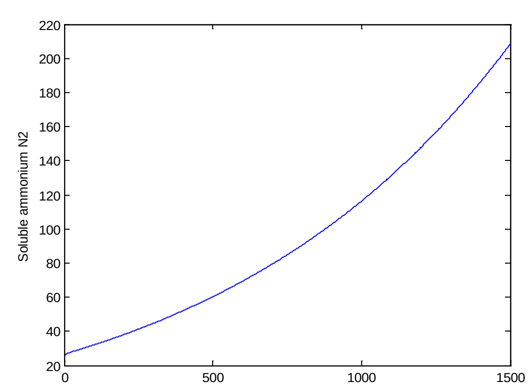


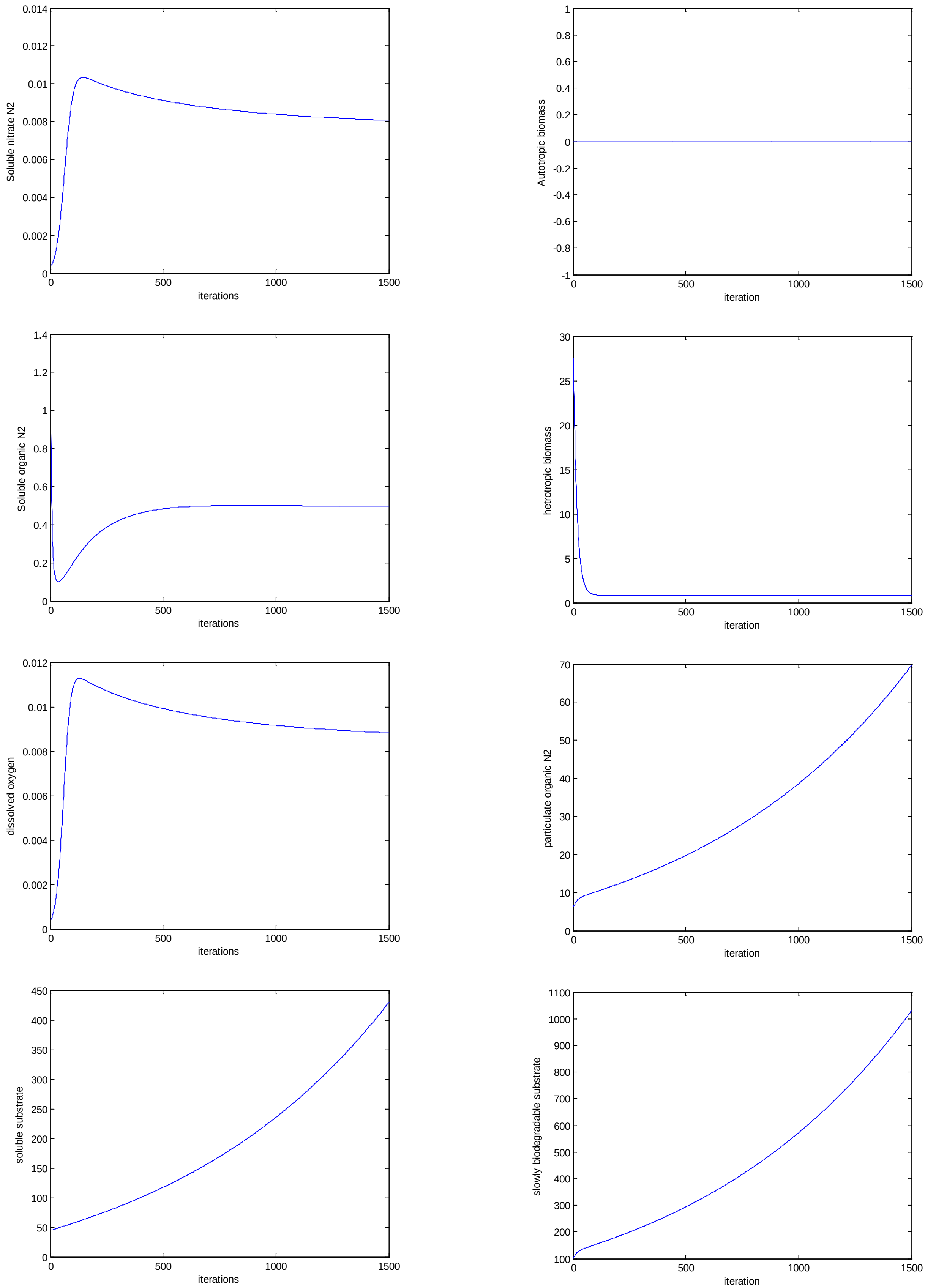
c) Default Inlet Concentration[19]

STATE	mg/l
S_S	60
X_I	50
X_S	100
$X_{B.H}$	25
$X_{B.A}$	0
S_O	0
S_{NO}	1
S_{NH}	25
S_{ND}	2
X_{ND}	6

IV. Results of Simulation

a) Without using Do-Controller

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iterations
Autotropic biomass
iteration
Soluble organic N2
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dissolved oxygen
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particulate organic N2
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soluble substrate
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slowly biodegradable substrate
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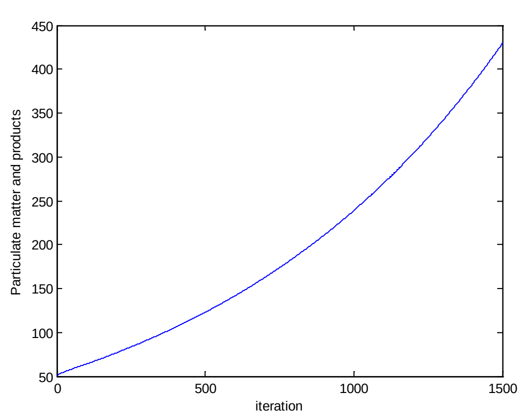
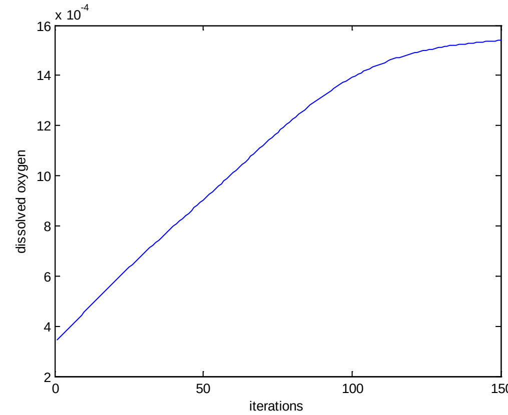
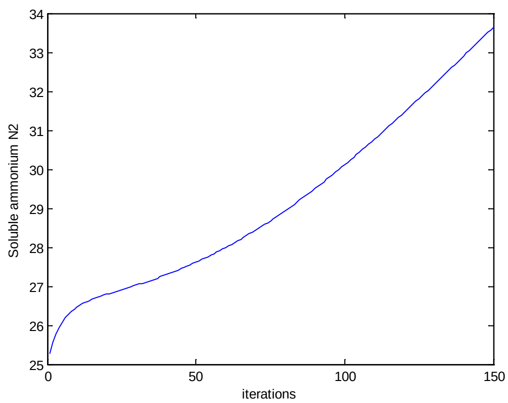
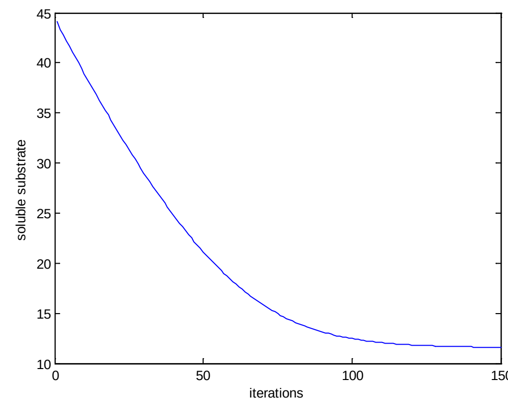
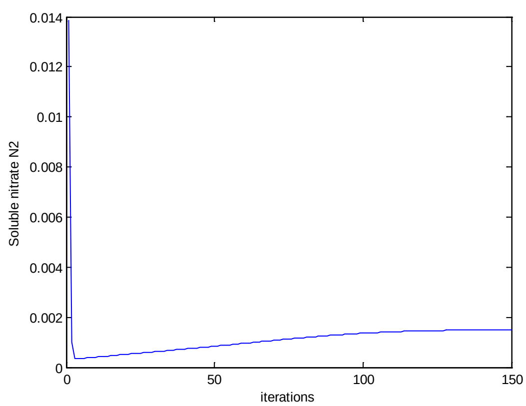


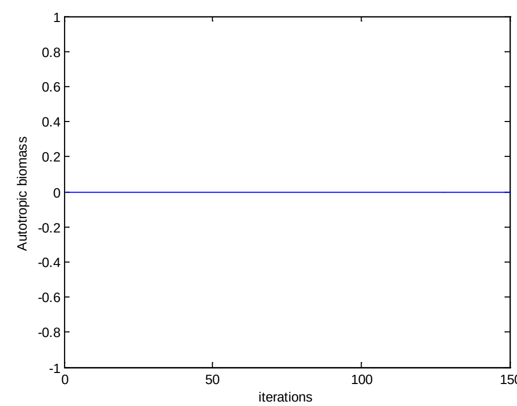


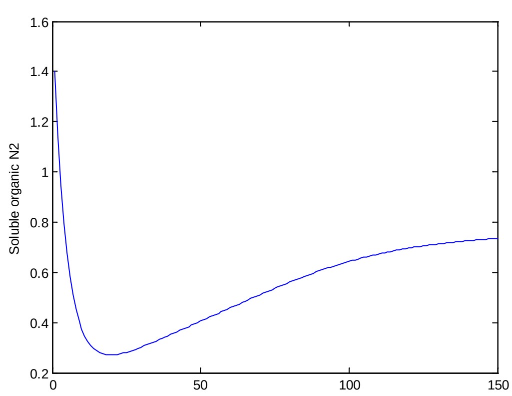
b) When using A P Controller to Do-Concentration

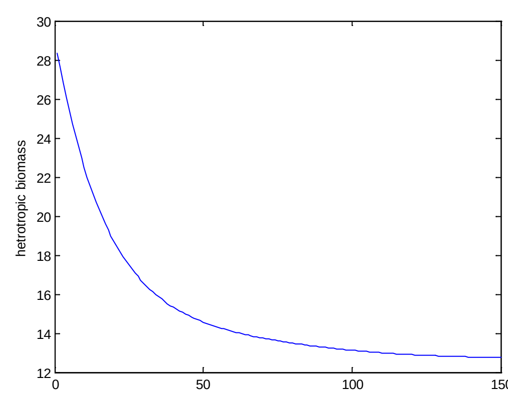


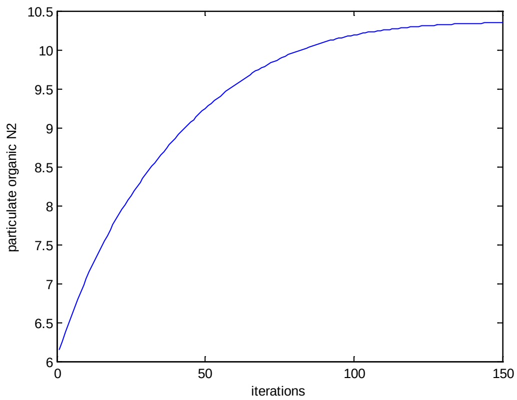


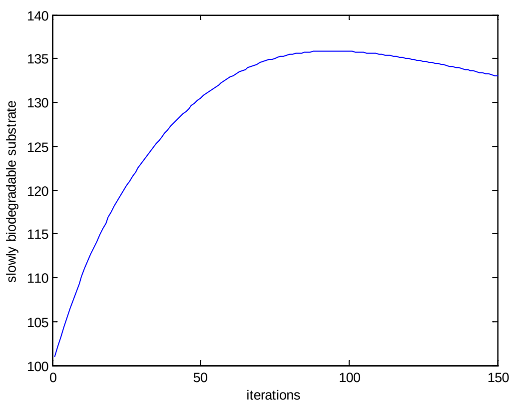


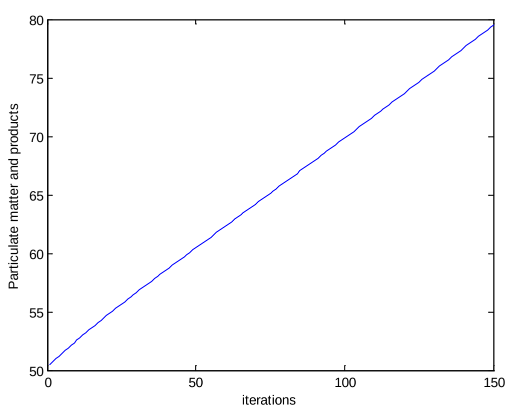












V. Conclusion

1. The pilot plant has been a very fruitful tool in studying various aspects of the activated sludge process, ranging from innovative operating modes microbiological studies to advanced control and estimation schemes.
2. New methods have been easy and inexpensive to test. It is, however, important to observe that the operation of a pilot plant with an extensive instrumentation is quite demanding in terms of maintenance.
3. The results from the pilot plant studies have given important guidelines for full scale plant design and operation.
4. The developed control strategies show that an increased automation can lead to energy savings and reduced consumption of chemicals.
5. The simulation model has been a very useful tool for evaluation of all the different controllers and control strategies.
6. Much time and work have been saved by first doing simulations prior to practical tests in the pilot plant.

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Investigation on Physicochemical Parameters of Mylavaram Reservoir in YSR Kadapa District, A.P (India)

By Dr. T.Ramachar, K.Mahammad Rafi, Lakshmi Prasanna & Dr. M.Umamahesh
College (Autonomous)

Abstract - Mylavaram reservoir is mainly constructed for irrigation purposes but water is also reserved for drinking. In the present study the physico-chemical parameters of Mylavaram dam water analyzed for a period of one year (January 2012 to December 2012) to check the pot ability of water. The parameters such as Temperature, pH, Dissolved oxygen, Total dissolved solids, Total hardness and Nitrates were used. Almost all the parameters analyzed with standard methods & compared with the WHO & BIS standard and presented statistically then concluded.

Keywords : mylavaram reservoir, physico-chemical parameters.

GJRE-C Classification : FOR Code: 090499

INVESTIGATION ON PHYSICOCHEMICAL PARAMETERS OF MYLAVARAM RESERVOIR IN YSR KADAPA DISTRICT, A.P INDIA

Strictly as per the compliance and regulations of :

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Keywords : mylavaram reservoir, physico-chemical parameters.

I. Introduction

The importance of water can't be overstated when it comes to life on Earth. Safe drinking water and basic sanitation will bring a payback worth many times the investment involved. It will also bring health, dignity and transformed lives to many millions of the world's poorest people. The humanitarian case for action is blindingly apparent1. Drinking water must be 'wholesome' and this is defined in law by standards for a wide range of substances, organisms and properties of water in regulations. The standards are set to be protective of public health and the definition of wholesome reflects the importance of ensuring that water quality is acceptable to consumers. There is good agreement amongst worldwide on the science behind the setting of health based standards for drinking water and this expert evidence is documented by the world health organization in the guidelines for drinking water quality.

The reservoir serves as a rich source of water supply for irrigation, drinking to nearest villages & fish culture. The quality of water is getting polluted due to the industrialization, Urbanization and indiscriminate use of pesticides in agriculture which runoff with water and contaminate the water bodies. This dam provides water supply for Veparala, Dommaranandyal, etc and nearby villages. It is 15 km away from Jammalamadugu town and 90 km from YSR Kadapa city. It is constructed basically for agricultural purpose. But water is supplying for drinking purposes also, hence the quality of water for pot ability is assessed on the basis of physico-chemical parameters in order to provide the information.

Fig. 1 : Mylavaram Reservoir North side

Fig. 2 : Mylavaram Reservoir Gates

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Fig. 3 : Top view of reservoir water source through hills

II. Experimental

Water samples were collected at monthly interval from the selected spots (where from the water is pumping for supply). For the collection of sample used a clean polythene bottles usually; between 8:00 am to 10: 00 am. Throughout the period of study from January- 2012 to December-2012. The water temperature and pH was measured at the spot with Mercury thermometer & Hand pH meter and rest of the parameters were analyzed on same day in laboratory by using standard methods suggested BIS,ISO & WHO .Preservatives were used while carrying the sample at laboratory.

III. Results and Discussion

The physico-chemical parameters of Mylavaram reservoir water during January 2012- December 2012 are given in table . Water temperature is one of the most important physical parameter. It is also determining factor for seasonal distribution of organisms, solubility of gases & salts in water .No other factor has so much influence as temperature. In the present study the water temperature ranges from 22.5 to 38.0oc recorded at the spot. The season wise analysis showed that the highest values recorded in summer, moderate in rainy season & lowest in winter season. Narayana *et. al* (2005) reported the water temperature varies from 24.75 to 30.25c in Aujanapra reservoir. Similar finding were observed in the present study. pH plays an important role in the aquatic situations for the growth of flora & fauna. The most of the aquatic organisms are adapted to a average pH & do not withstand abrupt changes. Dhanora reservoir ranges from 7.1 to 8.9 at the spot in the present study the alkaline trends of the pH was observed. Similar alkaline pH was reported by Khan *et.al* (2005). The high pH was observed in summer season it is due to aquatic plants use carbon dioxide in their photosynthetic activity and its removal is responsible for such a high pH.

Dissolved oxygen is very important parameter of water quality and is an index of physical & biochemical processes occurs in water. The dissolved oxygen values are ranges from 7.6 to 12.4 mg/l. The highest value of DO was observed in the early summer months and it may be due to high photosynthetic activity by plants and low values in summer which is due to high atmospheric temperature. Similar results were reported by Devidas (2006) and Lokhande (2009) . The Total Dissolved Solids (TDS) are the amounts of particles that are dissolved formed in the water. It may also include all suspended impurities (solids) that may or may not pass through the filter. In the present study the TDS values ranges from 108 to 276 mg/l. The lowest values were observed in the months of December and January in winter season while highest values in August and September in rainy season similar observation were made by Lokhande (2004) while working on Dhanegaon reservoir Naturally the Total Dissolved Solid content in this reservoir were well below the permissible limit.In the present investigation the total hardness ranges from 85 to 130 mg/L. the minimum values of hardness were observed in the summer season & maximum in the rainy season. Highest values may be due to rainwater carries the surface runoff The similar results were observed by Hosmani (1999). Pendse (2000) also reported law value of hardness in summer season.

Table 1 : Physicochemical parameters of Mylavaram reservoir During the year January to December 2012

Parameters_ Months	Temperature (°C)	pH	Dissolved Oxygen (Mg/L)	Total Dissolved solids(Mg/L)	Total Hardness (Mg/L)
January	22.6	7.5	11.9	125	119
February	25.4	7.9	10.2	118	105
March	*29.5*	*8.2*	*8.9*	*228*	*89*
April	38.6	8.4	9.2	256	82
May	35.2	7.9	11.6	274	107
June	31.2	7.6	9.8	112	121
July	29.6	7.4	12.4	258	130
August	25.7	8.2	9.3	241	128
September	26.7	8.3	9.2	195	95
October	23.6	7.4	12.1	162	123
November	22.3	8.4	8.9	136	96
December	23.8	8.6	12.3	158	89

IV. Conclusion

From the above study it can be concluded that almost all the parameters are within the prescribed limit of WHO & BIS standards. The Mylavaram reservoir water is suitable for drinking purposes. It is also useful for irrigation and Fish culture activities because the physico-chemical parameters are in suitable range for the growth of fishes zooplankton, phytoplankton. Over all the mylavaram reservoir water is suitable for

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Economic Feasibility of Briquetted Fuel

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Abstract - Commercialization of briquetting technology, it is essential to know whether the technology was economically viable or not. Therefore an attempt was made for estimation of economics of the briquettes prepared from carbonized cashew nut shell and other selected biomass. The briquettes were prepared on screw press extruder briquetting machine for different combinations of major biomass. The prepared briquettes after sun drying were subjected to various tests for assessing the quality of fuel. The suitability of briquetted fuel as domestic fuel was studied with standard water boiling test. Cashew shell briquettes burnt with good flame in cook stove and observed 15.5 per cent thermal efficiency. Better results in cashew shell briquettes related to calorific value, shattering indices test, tumbling test, degree of densification, energy density ratio, resistance to water penetration and water boiling test as compared to grass and rice husk briquettes were observed. Calorific value was found more in cashew shell briquetted fuel as 5154.58 kcal/kg. Net Present Value of cashew shell, grass and rice husk briquettes were 1935370.8, 2256434.38 and 631948.8 respectively. Pay back period for cashew shell, grass, rice husk briquettes were 8.1, 7.56 and 29.35 months respectively. Benefit Cost Ratio for cashew shell, grass, and rice husk briquettes were 2.8, 2.93 and 1.51 respectively.

Keywords : screw extruder, economics, NPW, IRR, BC ratio.

GJRE-C Classification : *FOR Code: 090405*

ECONOMIC FEASIBILITYOF BRIQUETTED FUEL

Strictly as per the compliance and regulations of :

Economic Feasibility of Briquetted Fuel

S. H. Sengar [α], S. S. Patil A.[σ] & D. Chendake [ρ]

Abstract - Commercialization of briquetting technology, it is essential to know whether the technology was economically viable or not. Therefore an attempt was made for estimation of economics of the briquettes prepared from carbonized cashew nut shell and other selected biomass. The briquettes were prepared on screw press extruder briquetting machine for different combinations of major biomass. The prepared briquettes after sun drying were subjected to various tests for assessing the quality of fuel. The suitability of briquetted fuel as domestic fuel was studied with standard water boiling test. Cashew shell briquettes burnt with good flame in cook stove and observed 15.5 per cent thermal efficiency. Better results in cashew shell briquettes related to calorific value, shattering indices test, tumbling test, degree of densification, energy density ratio, resistance to water penetration and water boiling test as compared to grass and rice husk briquettes were observed. Calorific value was found more in cashew shell briquetted fuel as 5154.58 kcal/kg. Net Present Value of cashew shell, grass and rice husk briquettes were 1935370.8, 2256434.38 and 631948.8 respectively. Pay back period for cashew shell, grass, rice husk briquettes were 8.1, 7.56 and 29.35 months respectively. Benefit Cost Ratio for cashew shell, grass, and rice husk briquettes were 2.8, 2.93 and 1.51 respectively.

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I. Introduction

India produces nearly 350 million tonnes of agricultural waste per year (Naidu, 1999). It has been estimated that 110-150 million tonnes crop residues is surplus to its present utilization as a cattle feed, constructional and industrial raw material and as industrial fuel. Due to their heterogeneous nature, biomass material possesses inherently low bulk densities and thus it is difficult to efficiently handle large quantities of most feedstock. Therefore, large expenses are incurred during material handling, transportation, storage etc. Transportation had the 2nd highest cost by considering all factors, when the biomass power plant was run at full capacity (Kumar et al.2003). It is noted that transportation cost will increase with increasing power plant size. In order to combat the negative handling aspects of bulk biomass, densification is often required. If such crop residues are converted into briquettes they can provide huge and reliable source of feedstock for thermo chemical conversion (Anonymous, 2002). Apart from the problems of transportation, storage and handling, the direct burning of loose biomass in conventional grates is associated with very low thermal efficiency and widespread air pollution (Grover and Mishra, 1996). In India total area under cashew nut cultivation 7,20,000 ha of which 76,270 ha are productive producing 4,50,000 MT of cashew. On an average shell makes 50 % of weight of nut while CNSL makes 15 to 30 per cent of shell production of cashew nut shells may be estimated to 2,25,000 MT from available statistics (Raina & Kulkarni, 2005). The CNSL removed, deoiled shells are abundantly available as a biomass waste. The waste biomass generated in cashew processing is utilized as a substitute to wood fuel or thrown as waste. This biomass requires much energy to make it in powder form for briquette. On such typical task, only the solution is to convert this biomass firstly into activated carbon form which is easier to make briquette from carbonization of cashew nut shell, grass, rice husk and hence keeping in view study is undertaken.

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II. Materials and Methods

The carbonized biomass samples were obtained by burning them in a kiln. A kiln made up of a cylindrical metal drum which incommoded about 100 kg of biomass. A kiln was closed with metal lid after loading with biomass as shown in Fig 1 (1). Little amount of biomass was used in the firing portion to ignite the kiln. Due to absence of air heat spreaded over a biomass and carbonized samples were obtained.

a) Process for briquette preparation

The carbonized cashew shell, rice husk and grass were used as major constituents for briquetting without any binding material. The various combinations of major constituents were tried in order to get briquettes of the desired quality. Different combinations as 50:25:25, 25:50:25 and 25:25:50 for cashew shell, rice husk and grass were made for observing the properties of briquettes. The known quantity of water was added in mixture using thumb rule for that the material should get bind by hand pressing after addition of water. The mixture was fed to briquetting machine and briquetting machine was operated at rated speed and power. The complete setup for briquettes preparation and testing is shown in Fig. 1.

Figure 1 : Complete setup for briquettes preparation and testing

b) Screw press extruder type briquetting machine

The screw press extruder type briquetting machine was used in the present study. It consists of driving motor, screw, die, and hopper and power transmission system. Pulley and belt were used to transmit power from motor to the screw. The raw material was fed to the hoppers, which convey it to screw by gravity. The material was pushed forward due to geometry of screw. As the material was pushed, it got compressed and binded material comes out of die in the form of briquettes. The detail technical specification of screw extruder type briquetting machine is shown in Table 1.

Table 1 : Technical specifications of the screw extruder type briquetting machine

Sr. no.	Particular	Specifications
1	Screw dimensions	No of turns = 4 Screw pitch = 6 cm Maximum diameter of screw = 9 cm Minimum diameter of screw = 6 cm
2	Die dimensions	No of exit tubes = 3 Diameter of exit tube = 2.5 cm Length of exit tube = 4 cm
3	Voltmeter	Analog with range = 0 to 300V
4	Ammeter	Analog with range = 0 to 30 A
5	Pulley and belt	Diameter of driven pulley = 26 cm Diameter of driving pulley = 9 cm Belt type V-belt
6	Motor	Single phase induction motor Power = 1Hp Speed = 1425 rpm
7	Overall dimensions	Overall length of machine = 31 cm Overall width of machine = 31 cm Overall height of machine = 62 cm

III. Economic Analysis

The cost analysis was carried out as complete briquettes processing of cashew shell, rice husk, saw dust, glyricidia and cow dung, grass residue briquettes by screw press technologies, in order to compare the three types of combinations briquettes in respect of their economics.

Following economic indicators were used for economic analysis of briquettes prepared from caebonized cashew nut shell and other selected biomass under this study.

1. Benefit cost ratio (B/C)
2. Payback period (PBP)
3. Net present worth (NPW)
4. Internal rate of return (IRR)

a) Net present worth (NPW)

The present values of the future returns calculated through the use of discounting. Discounting was essentially a technique by which future benefits and cost streams can be reduced to their present worth. The process of finding the present worth of a future value is called discounting. The discounting rate is the interest rate assumed for discounting.

An agricultural project returns the same benefit for several years and we need to know the present worth of that future income stream to know how much it was justified in investing today to receive that income stream. After deducting capital investment from gross benefit what is left over is a residual that is available to recover the investment made in the project. The residual is the net benefit stream.

The most straightforward discounted cash flow measure of project worth is the net present worth (NPW). The net present worth may be computed by subtracting the total discounted present worth of the cost stream from that of the benefit stream.

$$\text{NPW} = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

Where, C_t = Cost in each year
B_t = Benefit in each year
t = 1, 2, 3................n
i = discount rate

b) Internal rate of return (IRR)

Another way of using the incremental net benefit stream or incremental cash flow for measuring the worth of a project is to find the discount rate that makes the net present worth of the incremental net benefit stream or incremental cash flow equal to zero. This discount rate is called the internal rate of return. It is the maximum interest that a project could pay for the resources used if the project is to recover its investment and operating costs and still break even. It is the rate of return on capital outstanding per period while it is invested in the project. The internal rate of return is a very useful measure of project worth.

$$\sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} = 0$$

c) Benefit cost ratio (BCR)

This ratio was obtained when the present worth of the benefit stream was divided by the present worth of the cost stream. The formal selection criterion for the benefit-cost ratio for measure of project worth was to accept projects for a benefit-cost ratio of 1 or greater.

In practice, it was probably more common not to compute the benefit-cost ratio using gross cost and gross benefit, but rather to compare the present worth of the net benefit with the present worth of the investment cost plus the operation and maintenance cost. The ratio will be computed by taking the present worth of the gross benefit less associated cost and then comparing it with the present worth of the project cost. The associated cost is the value of goods and services over and above those included in project costs needed to make the immediate products or services of the project available for use or sale. Project economic cost is the sum of installation costs, operation and maintenance cost and replacement costs.

$$\text{Benefit-cost ratio} = \frac{\sum_{t=1}^{t=n} \frac{Bt}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{Ct}{(1+i)^t}}$$

Where,
C_t = Cost in each year
B_t = Benefit in each year
t = 1, 2, 3................n
i = discount rate

d) Payback Period (PBP)

The payback period is the length of time from the beginning of the project until the net value of the incremental production stream reaches the total amount of the capital investment. It shows the length of time between cumulative net cash outflow recovered in the form of yearly net cash inflows.

IV. Results and Discussions

Cost analysis was carried out to check economic acceptability of briquetting plant by considering following assumptions:

1. Proportion of carbonized material to raw material is 1:3.3 i.e. is 30% of raw material.
2. Cost of briquetted fuel was 7 Rs/kg.
3. Output of machine was 36 kg/hr, 41 kg/hr, and 22.5 kg/hr for cashew shell, grass and rice husk respectively.
4. Initial cost of fabrication of machine was Rs. 10000.
5. Total electricity used during operation of plant was 2 kwh/day.
6. Total days for plant operation was 300 days.
7. Cost of electricity unit was 5 Rs.

Cost of installation for different briquetted fuel is depicted in Table 2,3 and 4 as well as details of income expenditure is depicted in Table 5. On the basis of income and expenditure of briquetted fuel present worth of cashew outflow present worth of cash inflow and net present worth were calculated for cashew shell, grass and rice husk show in Table 6, 7 and 8 respectively.

Table 2 : Cost of installation of briquetting plant for cashew shell

Sr. No.	Item	Quantity	Rate	Cost (Rs.)
1	Cost of casing + cost of motor	1	10000 Rs.	10000
2	Labour	300 days	150 Rs.	45000
3	Raw material	178200 kg (36 kg/hr)	0.5 Rs./kg	89100
Total				**144100**

Table 3 : Cost of installation of briquetting plant for grass

Sr. No.	Item	Quantity	Rate	Cost (Rs.)
1	Cost of casing +cost of motor	1	10000 Rs.	10000
2	Labour	300 days	150 Rs.	45000
3	Raw material	202950 kg (41 kg/hr)	0.5 Rs./kg	101475
Total				**156475**

Table 4 : Cost of installation of briquetting plant for rice husk

Sr. No.	Item	Quantity	Rate	Cost (Rs.)
1	Cost of casing +cost of motor	1	10000 Rs.	10000
2	Labour	300 days	150 Rs.	45000
3	Raw material	111375 kg (22.5kg/hr)	1 Rs./kg	111375
Total				**166375**

Table 5 : Details of income and expenditure for different briquetted fuel

Sr. No.	Particulars	Cashew shell	Grass	Rice husk
1	Briquettes (kg)	54000	61500	33750
2	Total revenue from briquetted fuel (Rs.)	378000	430500	236250
3	Cost of briquette preparation (Binder, water, chemicals, labour etc) (Rs.)	89100+45000 = 134100	101475+45000=146475	111375+45000 =156375
4	Initial investment of (Rs.)	10000	10000	10000
5	Cost of electricity (Rs.)	3000	3000	3000
6	Total operation and maintenance cost (Rs.)	500	500	500

Table 6 : Cash flow for cashew shell briquetted fuel

Year	Cash outflow	PW of Cash outflow	Cash inflow	PW of Cash inflow	NPW
(1)	(2)	(3)	(4)	(5)	(5)-(3)
0.0	147100.0	147100.0	0.0	0.0	-147100.0
1.0	137100.0	123513.5	378000.0	340540.5	**217027.0**
2.0	137100.0	111273.4	378000.0	306793.3	195519.8
3.0	137100.0	100246.3	378000.0	276390.3	176144.0
4.0	137100.0	90312.0	378000.0	249000.3	158688.3
5.0	137100.0	81362.2	378000.0	224324.6	142962.4
6.0	137100.0	73299.3	378000.0	202094.2	128795.0
7.0	137100.0	66035.4	378000.0	182066.9	116031.5
8.0	137100.0	59491.3	378000.0	164024.2	104532.9
9.0	137100.0	53595.8	378000.0	147769.6	94173.8
10.0	137100.0	48284.5	378000.0	133125.7	84841.2
11.0	137100.0	43499.5	378000.0	119933.1	76433.6
12.0	137100.0	39188.8	378000.0	108047.8	68859.1

13.0	137100.0	35305.2	378000.0	97340.4	62035.2
14.0	137100.0	31806.5	378000.0	87694.0	55887.6
15.0	137100.0	28654.5	378000.0	79003.6	50349.1
16.0	137100.0	25814.9	378000.0	71174.5	45359.6
17.0	137100.0	23256.6	378000.0	64121.1	40864.5
18.0	137100.0	20951.9	378000.0	57766.8	36814.9
19.0	137100.0	18875.6	378000.0	52042.1	33166.5
20.0	0.0	0.0	378000.0	46884.8	46884.8
TOTAL		1074767.2		3010138.0	1935370.8

Table 7 : Cash flow for grass briquetted fue

Year	Cash outflow	PW of Cash outflow	Cash inflow	PW of Cash inflow	NPW
(1)	(2)	(3)	(4)	(5)	(5)-(3)
0.0	159475.0	159475.0	0.0	0.0	-159475.0
1.0	149475.0	134662.2	430500.0	387837.8	**253175.7**
2.0	149475.0	121317.3	430500.0	349403.5	228086.2
3.0	149475.0	109294.8	430500.0	314777.9	205483.1
4.0	149475.0	98463.8	430500.0	283583.7	185119.9
5.0	149475.0	88706.1	430500.0	255480.8	166774.7
6.0	149475.0	79915.4	430500.0	230162.9	150247.4
7.0	149475.0	71995.9	430500.0	207353.9	135358.1
8.0	149475.0	64861.2	430500.0	186805.4	121944.2
9.0	149475.0	58433.5	430500.0	168293.1	109859.6
10.0	149475.0	52642.8	430500.0	151615.4	98972.6
11.0	149475.0	47425.9	430500.0	136590.5	89164.5
12.0	149475.0	42726.1	430500.0	123054.5	80328.4
13.0	149475.0	38491.9	430500.0	110859.9	72367.9
14.0	149475.0	34677.4	430500.0	99873.8	65196.3
15.0	149475.0	31240.9	430500.0	89976.4	58735.4
16.0	149475.0	28145.0	430500.0	81059.8	52914.8
17.0	149475.0	25355.8	430500.0	73026.8	47671.0
18.0	149475.0	22843.1	430500.0	65789.9	42946.9
19.0	149475.0	20579.4	430500.0	59270.2	38690.9
20.0	0.0	0.0	430500.0	53396.6	53396.6
TOTAL		1171778.5		3428212.8	2256434.3

Table 8 : Cash flow for rice husk

Year	Cash outflow	PW of Cash outflow	Cash inflow	PW of Cash inflow	NPW
(1)	(2)	(3)	(4)	(5)	(5)-(3)
0.0	169375.0	169375.0	0.0	0.0	-169375.0
1.0	159375.0	143581.1	236250.0	212837.8	**69256.8**
2.0	159375.0	129352.3	236250.0	191745.8	62393.5
3.0	159375.0	116533.6	236250.0	172744.0	56210.3
4.0	159375.0	104985.2	236250.0	155625.2	50639.9
5.0	159375.0	94581.3	236250.0	140202.9	45621.6
6.0	159375.0	85208.4	236250.0	126308.9	41100.5
7.0	159375.0	76764.3	236250.0	113791.8	37027.5
8.0	159375.0	69157.0	236250.0	102515.1	33358.1
9.0	159375.0	62303.6	236250.0	92356.0	30052.3
10.0	159375.0	56129.4	236250.0	83203.6	27074.2

11.0	159375.0	50567.0	236250.0	74958.2	24391.2
12.0	159375.0	45555.9	236250.0	67529.9	21974.0
13.0	159375.0	41041.3	236250.0	60837.7	19796.4
14.0	159375.0	36974.2	236250.0	54808.8	17834.6
15.0	159375.0	33310.1	236250.0	49377.3	16067.2
16.0	159375.0	30009.1	236250.0	44484.0	14475.0
17.0	159375.0	27035.2	236250.0	40075.7	13040.5
18.0	159375.0	24356.0	236250.0	36104.2	11748.2
19.0	159375.0	21942.4	236250.0	32526.3	10584.0
20.0	0.0	0.0	236250.0	29303.0	29303.0
TOTAL		1249387.5		1881336.3	631948.8

Table 9 : Economic indicators for three combinations of briquetted fuel

Particulars	Cashew shell	Grass	Rice husk
Net Present Worth (Rs)	1935370.8	2256434.3	631948.8
Pay Back Period (Years)	0.68 (8.1 months)	0.63 (7.56 months)	2.5 (29.35 months)
Internal Rate of Return (%)	374.0	428.0	230.0
BCR for first year	2.8	2.93	1.51

All economic indications for different biomass briquetted fuel as Internal Rate of Returns (IRR), Pay Back Period (PBP), Benefit Cost Ratio (BCR), and Net Present worth (NPW) are summarized in Table8. It was observed from Table 9 that the cost of the plant is recovered within 8 months only i.e. the pay back period of the plant was only 0.68 and 0.63 years for cashew shell and grass briquetted fuel respectively and after that the unit will produce net profit. Whereas payback period of rice husk briquetting plant is 29.35 months i.e. 2.5 years.

V. Conclusions

It was observed that combination of grass briquetted fuel is more economical than other combinations. It has net present value of Rs. 2256434.38, pay back period of 7.56 month and benefit cost ratio was 2.93.

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Air Drilling Improves Efficiency in Wellbores in Disi Water Field Project

By Mehaysen Ahmed Mahasneh
L-Huson University Irbid

Abstract - In many of today's most challenging land drilling applications, the lower weight on bit and hydrostatic head, achieved with air drilling methods with foam are consider a key to reducing drilling time and costs which can improve efficiency . These systems improve rates of penetration, minimize problems such as differential sticking, lost circulation. Air drilling with foam, also drills a straight hole in vertical sections, and reduces deviation by comparing with conventional drilling methods.

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Abstract - In many of today's most challenging land drilling applications, the lower weight on bit and hydrostatic head, achieved with air drilling methods with foam are consider a key to reducing drilling time and costs which can improve efficiency . These systems improve rates of penetration, minimize problems such as differential sticking, lost circulation. Air drilling with foam, also drills a straight hole in vertical sections, and reduces deviation by comparing with conventional drilling methods.

Keywords : air hammer drilling, foam, improves Efficiency, water wells.

I. Introduction

It has been shown conclusively that air or gas is a better drilling fluid than liquid .The use of air or gas as a circulating medium was introduced in the early 1950 .Even though initial attempts were crude ,significant increasing penetration rate and bit life were obtained .Since these initial tempts development of air and gas drilling techniques have expended and are widely accepted [(1)] today as a method to reduce drilling times and cut cost of many wells .Along with the time and resultant money savings ,other advantages such as immediate and continuous hydrocarbon detection ,minimum damage to liquid sensitive pay zone ,better control of lost circulation and cleaner cores are obtained.

Air-hammer drilling evaluation first presented by Howard, Vincent, and Wilder [(2)] and Liljestrand The five wells described herein are located in the Permian Basin of West Texas (3,4).

Air drilling techniques [(11)] are used to drill formations prone to lost circulation, stuck pipe, slow rates of penetration, and other associated problems. The method of using airas a circulating "fluid" has been used for a long time, mainly to drill hard and dry Formations. Larger diameter wells [(12)], particularly Those with severe fluid loss zones, Can be drilled using foam as a drilling fluid.

Changes In the normal air-compressor services for air drilling have been required, other than 10 to 20 percent more volume to maintain a clean hole While drilling at higher penetration rates, because the basic design of the air hammer permits optimum performance between 200 and 300 psi air pressure [(5 ,9)].

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Drilling with "foam" combined with compressed air is used in different ways to help the drilling process. It involves using small-capacity pumps to inject a 'foam' mix at quite low flow rates into the compressed air supply line to make soap bubbles form in the borehole.

In shallow boreholes where there is little backpressure, the piston impacts the top of the bit shank at a rate of from 600 to 1700 blows, (depending on volumetric flow rate per minute of air). However, in deep boreholes where the annulus back pressure is usually high, impact rates can be as low as 100 to 300blows per minute[(6)]

- Foam. A larger amount of foaming agent is added into the flow. Bubbles and slugs of bubbles in an atmosphere of mist bring cuttings back to the surface. (Sheffied, J.S:Exxon co.USA)[(7)])
- Stable foam. An even larger amount of foaming agent is added into the flow. This is the consistency of a shaving cream .The purpose of this study is to investigate the current technology used in air drilling and to determine the advantages and limitations of air drilling .Further, air drilling in various area is to be compared to mud drilling to determine which method is the most economical . paper addressed field experience in hard rock air and foam drilling technology to used in the Disi Areas, and covers pertinent operational design topics .An important pertinent operational ,an important ingredient to any air or foam drilling operation is knowing when and where to used it. Well construction optimization requires carefully matching of the technology to the application .including dry ai, gas, mist, foam and gasified fluids [(8)].

This type of technology provide unique performance characteristics in a wide range of applications. Including formations that are extremely hard or consolidated, produce water, have lost circulation problems or are sensitive to hydrostatic pressure and Improvement Operating Efficiency.

Drilling five wells involved compressed air, water mixed with foam, as illustrated in table (2) .

II. Equipments Used in Air Drilling With Foam

Conversion of a conventional rotary rig to an air drilling operation is a simple matter. Most of the liquid and solids handling equipment, normally used for mud drilling can be removed for an air drilling operation, the liquid handling equipment should consist of one mud pump, a centrifugal transfer pump and sufficient water storage (steel mud pits can be used for water storage).

For today's air drilling operations, air compressors are available which provide adequate air volumes along with portability.

The most commonly used oil field air compressor is a positive displacement, double acting, reciprocating, two or three-stage type compressor. This type compressor offers a wide range of sizes and

Pressure ratings necessary for an efficient drilling operation. Also, this type Compressor has been designed for continuous operation. Package units consisting of two or more compressors can be put together. The number of compressors in a package will depend on the air volume required to dril1 the hole efficiently. Generally, one air compressor, available on today's market, for oil field drilling will put out from400 to 1200 cubic feet of air per minute at 300 to 320 psig maximum pressure. The positive displacement type air compressor is rated according to piston size and the output is dependent upon the altitude at which the compressor will operate. The compressor manufacturers can provide data on volume output at varying operating rates.

Some points that to be remembered for optimum compressor operation is as follows:

– Compressors should be located in the direction of prevailing winds to maximize circulation and minimize dust intake from exhaust lines. They should be located about200 ft from the rig floor to permit cooling of the air before it reaches the rig floor.
– The engine exhaust should be directed away from the compressor to provide maximum cooling. This also explains the purpose in locating compressors in a series or line arrangement. This prevents the discharge of hot exhaust gas from hitting another compressor.
– Battery and oil filters should be checked regularly because of evaporation from the batteries and collection of dust in the oil bath. An added precaution should be the use of automatic shutdown devices to prevent excessive temperatures.
– An adequate starting system is required, particularly during cold weather.
– Air pressure gauges should be located on the rig floor and be kept under constant surveillance by the driller. Any sudden change in pressure may indicate water encroachment, caving formations or changes in penetration figure (1 a, b), illustrated the equipments used in air drilling technology with foam.

Air requirements for operation may vary; however under most conditions a flow volume of 1200 cfm is required for an inlet pressure of 350 psi. Under normal operating conditions the hammer will strike about 1800 blows per minute under the inlet pressure of 350 psi [11].

Figure (1 a, b)

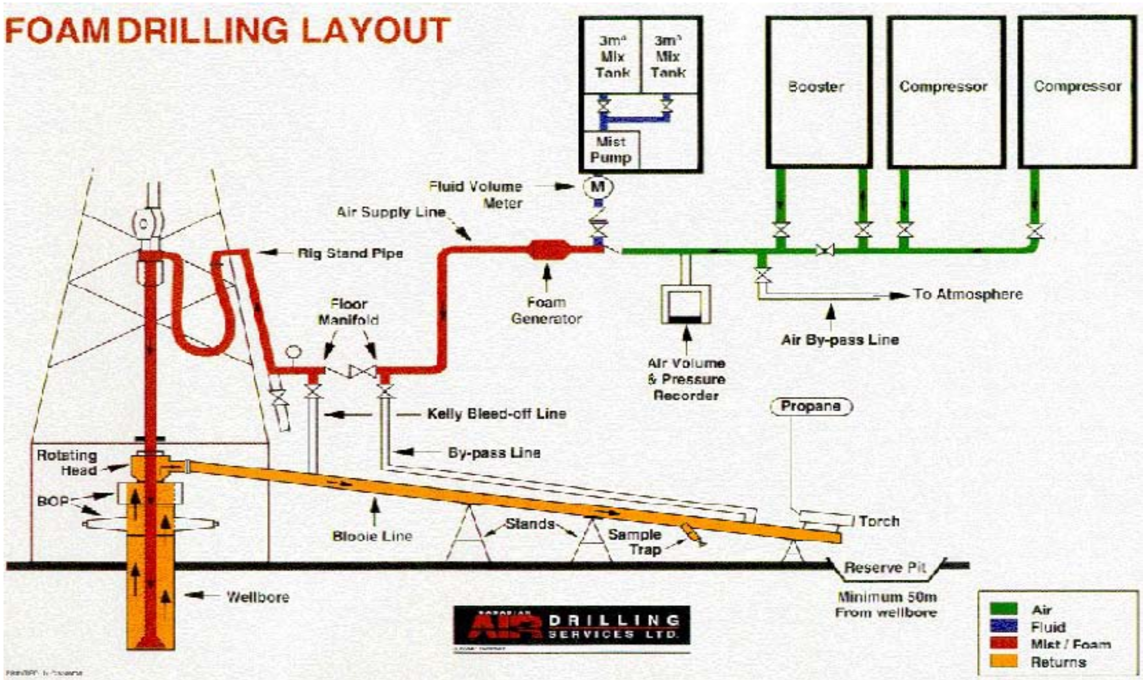


Figure 2 : Foam Drilling Layout

III. Field Results

The results of using air and foam drilling in the field actually need no Explanation, since it is common knowledge that drilling rates with this medium may be10 times those obtained using fluids. Frequently the question is asked "Why is the drilling rate increased when using air and foam . The increase in penetration rate is believed to be a result of reducing the hydrostatic pressure on the formation. This believed is justified by the many field and laboratory results that show a reduction in drilling rate as fluid weight is increased. The decrease in drilling rate as hydrostatic Pressure or mud weight is increased. These are typical results for porous and Impermeable shale sections.

Well construction optimization requires carefully matching of the technology to the application .including dry air, gas, mist, foam and gasified fluids.

This type of technology provide unique performance characteristics in a wide range of applications, Including formations that are extremely hard or consolidated, produce water, have lost circulation problems or are sensitive to hydrostatic pressure.

IV. Line A Sand Rate of Penetration

Slow penetration rates and hole deviation, when drilling by conventional methods, line A, silty shale, sandstone medium to hard, siliceous cement in Dubadydib formation Area.

A conventional well plan in the hard dry rock. To drill four wells 24 inch surface hole to total depth between 300 to 310 m. (984.3FT ,1000.70 FT), as illustrated in table (1). The parameters of drilling Regime. We drill four vertical wells using conventional drilling with mud fluids and tricone bit. The first well was drilled low penetration rates, 3 .58 ft/hr, 270m (886.85ft) in 247.3 hours. In The second well 269.95 m (868.69 ft) in 246.8 hours3.51 ft/h. The third well 287.4 m (942.95 ft) in 372.5 hours2.53 ft/hr. In the fourth well 265.5m (871.10 ft) in 259 hours3.36ft/hr. During the drilling these wells have deviation problems, it takes long time to straight the hole and waste time for reaming the hole. Figure (3) show the penetration rate according the parameters of drilling Regime.

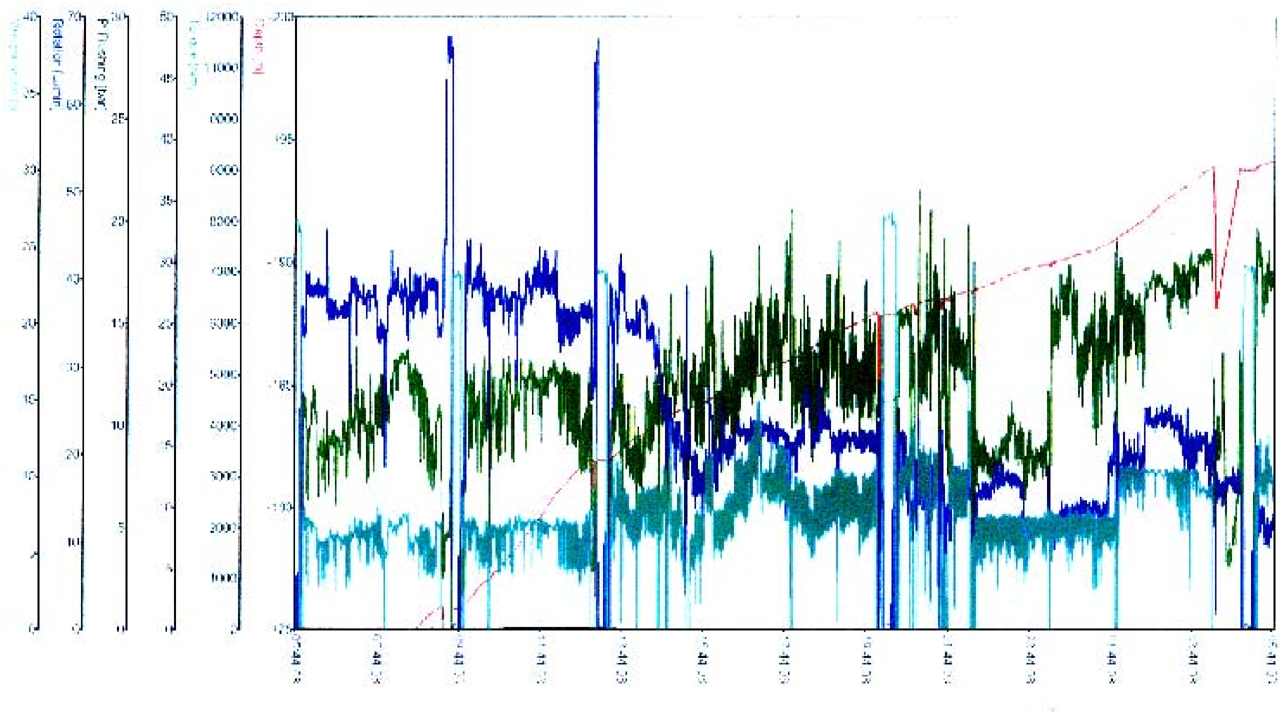


Figure 3 : The penetration rate according the parameters of drilling Regime

Slow penetration rates were (2.53 to 3.58) ft/hr, and hole deviation problems 2.5 degree, when used conventional drilling, provide to shift to air drilling hammer with foam using down the hole hammer bits (DTH).

Table 1 : The parameter of drilling regime

Well Number	RPM	W.O. B T	Q L/m	P bar	Total penet m (ft)	Total hours	ROP ft/hr	Formation
1	30-40	7.5-15	1500	2	270m (886.85ft)	247.3	3.58	Sand stone medium to hard
2	25-35	5-15	1800	1.5-2	269.95m (868.698ft)	246.8	3.51	Sand stone medium to hard Siliceous cemented
3	25-40	5-15	2100	2	287.4m (942.95ft)	372.5	2.53	Sand stone medium to hard Siliceous cemented
4	30-40	4-13	2200	2.5	265.5m (871.10ft)	259	3.36	Sand stone medium to hard Siliceous cemented

V. Line B Sand Rate of Penetration

The shift to air drilling was tracked in 5 Wells where it is use cut time from spud to total depth illustrated in table(2).

Air hammer drilling with foam in the line B, silty shale and sandstone medium hard to hard, eliminated 11.71 to 1.67 days of drilling time by minimizing and reducing well bore deviation in comparable with conventional drilling which was 2,5 degree. The significant reduction in deviation allowed to drill the hole section to be drilled with a single hammer for each well.

Total air drilling cost for the hole section U.S. $17901per well was cut more than half, compared to conventional drilling methods, the cost drilling for the same hole section U.S. $ 117212 per well .

Deviation problems reduced in the line B sand. Hammer drilling places a light weight on the bit–typically just enough to keep the face of the bit on contact with formation, with less weight, the bit drills a much straighter vertical hole.

Table 2 : Parameter air hammer drilling with foam at water project in Jordan

Well Number	RPM	W.O. B T	Q L/m	P bar	Total penet m (ft)	Total hours	ROP ft/hr	Formation
1	6-8	2- 4		14-18	266m (872.74ft)	42.20	20.68	Sand stone medium to hard
2	6-8	2- 3.5		12-20	276.16m (906.08ft)	39.45	22.96	Sand stone medium to hard Siliceous cemented
3	8	2.5- 5		10-14	296.14m (971.63ft)	40.05	24.26	Sand stone medium to hard Siliceous cemented
4	12	3- 4		14	290m (951.49ft)	39.40	24.14	Sand stone medium to hard Siliceous cemented
5	8	3- 4.5		12-15	233m (764.47ft)	53.75	14.22	Sand stone medium to hard Siliceous cemented

In table (2) illustrate the drilling parameters of air drilling hammer with foam.

Drilling the four wells involved compressed flow volume air injection rates ranging (500-600 cfm), pump pressure 200-204 psi and the liquid rates during mist –foam drilling were (13 gal /m to 15 gal/m) (49.20 l/min to 56.77 l/min) and strike of hammer was expected to be in range of (925-950) blows per minute.

The first well was drilled with one hammer bit type Bulroc and average 6.30m/hr(20.68 ft/hr)including connection time .Instantaneous ROP (Rate of Penetration) in the range of 6.30 m/hr (20.68 ft/hr) records with 266m (872.74 ft)drilled in 42.20 hours was observed the hammer bit ,Penetration rates while conventional drilling methods were significantly less than the offset records ,with 270 m (886.85 ft) drilled in 247.3 hours.

In the second well, 276.16 m (906.08 ft) were drilled in 39.45 hours using one hammer bit type Bulroc. The third well used one hammer bit to dill 269.14 m (971.63ft) in 40.05 hours.

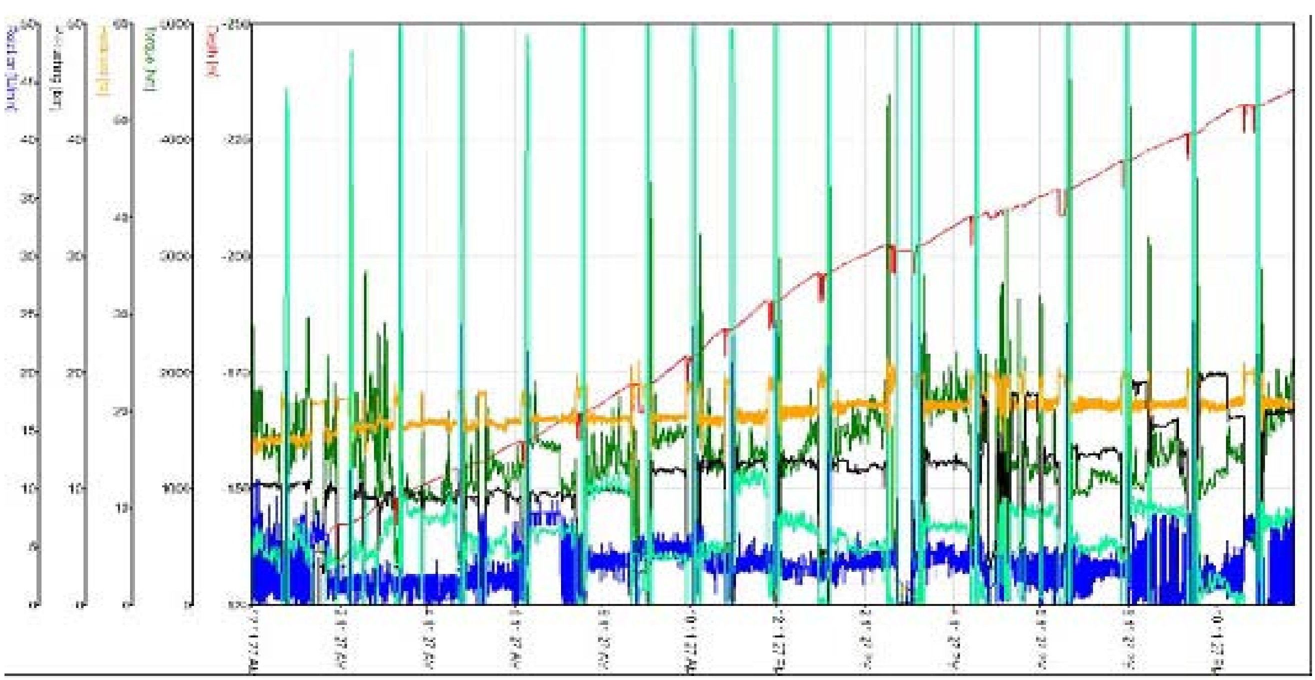
In the fourth well 290m (951.49 ft) were drilled in 39.40 hours using two hammer bits type Bulroc.

The fifth well 233 m(764.47ft)were drilled in 53.75hours using one hammer bit type Numa.

Hammer drilling with foam places a light weight on the bit and just enough to keep the face of the bit in contact with the formation, with less weight the bit drills a much straighter vertical hole.

Drilling a high –quality vertical borehole with an air hammer with foam, enhances drilling, it means the rate of penetration ranging from (14.22 ft to 24.14 ft /hr) were enhanced with down hole the hammer (DTH).

Figure 4 : Shown the penetration rate by air hammer with foam



The drilling with hammer bits also have a much longer life than conventional bits, resulting in fewer trips and lower bit expenses. Air drilling with foam removes cuttings from the face of the bit by using high air velocities to get best hole cleaning and able to deal with large water influx recyclable, and fewest compressors, minimized lost circulation compared to conventional fluid systems.

VI. Conclusions

Planned and applied correctly, air drilling hammer technology can address problems of lost circulation, deviated hole and poor penetration rates .Based on the analysis of the real cases studied during operation in the water field, the following conclusion could be cited:

1. The air drilling hammer is a very useful technique especially when you phase problems, it prevents formation deviated hole, increase rate of penetration (ROP) and reduces the total cost of the well.
2. The air drilling hammer with stable foam, can be conducted safely and successfully drilling with foam has some appeal because foam has some attractive qualities and properties with respect to very low hydrostatic densities, which can be generated with foam systems. Foam has good rheology and excellent cutting carrying capacity and maintain hole wall stability.
3. A proposed air drilling hammer with foam program to be implemented in Jordan water field Disi–Mudawarra to Amman Water Conveyance System Project to be completed partially enhanced the project.

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Approach

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

Figures and tables

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

Discussion:

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

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

Approach:

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

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

Index

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