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Hydrogen-Ethanol Fuel

Parameters of Asphaltenes

Highlights

Exhaust Gas Simulation

Biohydrogen Production

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 2 VERSION 1.0

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Exhaust Gas Simulation of Hydrogen-Ethanol Dual Fuel

By Dr. Syed Yousufuddin, Dr. Sultan Ali, Naseeb Khan & Dr. Syed Nawazish Mehdi
Jubail University, Saudi Arabia

Abstract - The drawback of lean operation with ethanol is a reduced power output. Lean operation of ethanol fuelled engines has additional drawbacks. Lean mixtures are hard to ignite, despite the mixture being above the low fire (point) limit of the fuel. This result in misfire, which increases unburned hydrocarbon emissions, reduces performance and wastes fuel. Hydrogen can be used in conjunction with ethanol provided it is stored separately. Mixing hydrogen with oxygenated hydrocarbon fuel like ethanol reduces all of these drawbacks. Hydrogen's low ignition energy limit and high burning speed makes the hydrogen-ethanol mixture easier to ignite, reducing misfire and thereby improving emissions, performance and fuel economy.

This paper involves generating the simulation software that provides the mole fraction of each of the exhaust species when the hydrogen is burnt along with ethanol. The proportion of hydrogen in the hydrogen–ethanol blend affecting the mole fraction of the exhaust species is also simulated. The program code developed gave reasonably good results for the present hydrogen-ethanol dual fuel. At low and high percentages of hydrogen and during transition between ethanol and hydrogen the model predictions are not very clear. The best results were obtained for for a combination of 80% hydrogen and 20% ethanol by volume.

Keywords : *combustion, dissociation reaction, dual fuel, equivalence ratio, mole fraction.*

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Exhaust Gas Simulation of Hydrogen–Ethanol Dual Fuel

Dr. Syed Yousufuddin [α], Dr. Sultan Ali [σ], Naseeb Khan [ρ] & Dr. Syed Nawazish Mehdi [ω]

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Keywords : combustion, dissociation reaction, dual fuel, equivalence ratio, mole fraction.

I. Introduction

Among the various alternative fuels, hydrogen and alcohol are very attractive substances for many practical applications in the energy sector [1]. While conventional energy sources such as natural gas and oil are non-renewable, hydrogen and alcohol can be coupled to act as renewable energy sources [2, 3].

Combustion is a chemical reaction between a fuel and oxygen, which is accompanied by the production of a considerable amount of heat. The composition of the exhaust gas produced is a function of temperature as well as equivalence ratio (ratio of actual fuel ratio to theoretical fuel air ratio). Many components are present in the exhaust gas because of dissociation of some species. Thermodynamics is able to predict the equilibrium state that results from burning a fuel-air mixture given only the initial conditions. Combustion is a chemical reaction between a fuel and oxygen, which is accompanied by the production of a considerable amount of heat. The composition of the exhaust gas produced is a function of temperature as well as equivalence ratio (ratio of actual fuel ratio to theoretical fuel air ratio). A lean mixture has $\Phi<1$ A rich mixture has $\Phi>1$. The mixture is said to be stoichiometric if $\Phi=1$.

Many components are present in the exhaust gas because of dissociation of some species. The heat of combustion of a fuel is defined as the heat transferred out of a system per unit mass or mole of fuel when the initial and final states are at the same temperature and pressure. Based on the combustion stoichiometric theory a computer program had been developed for blend fuels to calculate the mole fractions of the exhaust gases [4]. Thermodynamic data for elements, combustion products and many pollutants are available in a compilation published by the National Bureau of Standards called the JANAF (Joint Army-Navy-Air Force) tables (1971). For single component fuels the data presented by Stull, We strum and Sinke (1969) is in the same format as that of JANAF tables. A compilation by Rossini (1953) is useful for hydrocarbon fuels at temperatures as high as 1500K.

II. Inputs to the Program

The fuel is to be specified in terms of the C, H, O, and N atoms in the fuel. For the blend of two fuels considered i.e., Ethanol and Hydrogen, the percentage with which they blend in the mixture also has to be specified. The other parameters that need to be, specified are equivalence ratio, pressure and temperature. For the calculation of equilibrium constant, the data for constants is considered from JANAF tables. The molar-air fuel ratio is calculated from the number of Carbon, Hydrogen, Nitrogen and Oxygen atoms present in the fuel.

III. Formation of Equations

The mixture is blend of fuel of composition Cp Hq Or Ns and Hydrogen. Considering that there are ten constituents the combustion reaction is written as

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$$\varepsilon\phi\,[(x * (C_p H_q O_r N_s)) + (y * H_2)] + (0.21 * O_2) + (0.79 * N_2) \rightarrow$$

$$\upsilon_1 CO_2 + \upsilon_2 H_2O + \upsilon_3 N_2 + \upsilon_4 O_2 + \upsilon_5 CO + \upsilon_6 H_2 + \upsilon_7 H + \upsilon_8 O + \upsilon_9 OH + \upsilon_{10} NO$$

The molar fuel –air ratio is given by

$$\varepsilon = (x * (0.210 / (p + (0.25 * q) - (0.5 * r)))) + (y * 0.42)$$

Convenient approximations for lean and rich combustion are

$\phi < 1 \quad \upsilon_5 = \upsilon_6 = 0$

$\phi > 1 \quad \upsilon_4 = 0$

The mole fractions are obtained for the products are obtained by

$$y_i = \nu_i / \Sigma \nu_i$$

$i = 1$ to 6

For a lean mixture the coefficients of combustion products are obtained as

$\upsilon_1 = x*(p * \phi * \varepsilon)$;

$\upsilon_2 = (x*(q*\phi*(\varepsilon/2))) + (y*(q*\phi*(\varepsilon/2)))$;

$\upsilon_3 = (x*(0.79+(s*\phi*(\varepsilon/2)))) + (y*0.79)$;

$\upsilon_4 = (x*(0.21*(1-\phi))) + (y*(0.21*(1-\phi)))$;

$\upsilon_5 = 0$;

$\upsilon_6 = y*0.42$;

For a rich mixture the coefficients of combustion products are obtained as

$\upsilon_5 = (-b+(sqrt((b*b)-(4*a*c))))/(2*a)$;–(8a)

Where

a=(x*(1-k))+(y*(1-k));

b=(x*(0.42-(ϕ*ε*(2-r)) + (k*((0.42*(ϕ-1)) + (p*ϕ*ε))))) + (y*(0.42-(2*ϕ*ε) + (k*(0.42*(ϕ-1)))));

c=-(x*(0.42*p*ϕ*ε*(ϕ-1)*k));

and

$k = \exp (0.273 - (1.761 / t) - (1.611 / t^2) + (0.283 / t^3))$;

$\upsilon_1 = (x*((p*\phi*\varepsilon)-v5)) + (y*v5)$;

$\upsilon_2 = (x*(0.42+(\phi*\varepsilon*((2*p)-r))+v5)) - (y*(0.42+v5))$;

$\upsilon_3 = (x*(0.79+(s*\phi*(\varepsilon/2)))) + (y*0.79)$;

$\upsilon_4 = 0$;

$\upsilon_6 = (x*((0.42*(\phi-1))-v5)) + (y*0.42)$;

The mole fractions for all the remaining species is obtained in terms of y_3, y_4 and y_6 i.e, the mole fractions of N_2 , O_2 and H_2 respectively as

$y_7 = C_1 * (y_6)^{0.5}$;

$y_8 = C_2 * (y_4)^{0.5}$;

$y_9 = C_3 * (y_4)^{0.5} * (y_6)^{0.5}$;

$y_{10} = C_4 * (y_4)^{0.5} * (y_3)^{0.5}$;

where

$C_1 = K_1 / P^{1/2}$;

$C_2 = K_2 / P^{1/2}$;

$C_3 = K_3$;

$C_4 = K_4$;

Where K^p value is obtained from equation

$$\log K_p = \exp [(A / T) + (B + C/T) \ln(T) + D]$$

where T is in Kelvin. The value of A, B, C and D are obtained from the JANAF tables based upon the reaction of the species with oxygen.

With the variation in the input parameters various results and plots can be obtained.

IV. Results and Discussion

As shown in Fig.1 for 80% hydrogen substitution, with higher temperature of 1800K the CO_2 value is higher than that obtained at 1200K and 1500 K. Under the stoichiometric conditions the mole fractions of CO_2 is at its peak and decreases when the mixture becomes either richer or leaner due to presence of other products. As the temperature increases, the mole fraction of CO_2 decreases as the dissociation increases with temperature. As explained earlier under heat release rate explanation the peak heat release rate (i.e. the peak combustion at low outputs is considerably low in dual fuel mode) with different hydrogen substitutions when compared to the ethanol mode. This is the reason for the reduced brake thermal efficiency and reduced rate of pressure rise as compared to ethanol at low outputs. This incomplete combustion results in higher amounts of CO_2 emissions in the beginning, but as the hydrogen substitution is increased, rigorous and strong complete combustion reduces the emissions of CO_2 as the dissociation increases with temperature.

As shown in Fig.2 for 80% hydrogen substitution with higher temperature of 1800K the mole fraction of H_2O value is higher than that obtained at 1200K and 1500 K. As the mole fraction of H_2O increases with hydrogen substitution, this brings down the combustion temperature, and hence the reason of reduction in the values of NO and N_2 at higher percentages of hydrogen substitution.

Figs. 3 show the change in mole fraction of Nitrogen (N_2) for various percentages of hydrogen substitutions for different constant equivalence ratios for temperatures of 1200 K, 1500K and 1800 K. It is

observed that mole fraction of N_2 decreases for all hydrogen fractions except for 60 and 80% hydrogen substitutions. Fig.4 shows that with the increase in equivalence ratio the mole fraction value of N_2 decreases. However, slight increase in mole fraction value corresponding to 60 and 80% hydrogen addition could be seen at equivalence ratio of 1.0 (Fig.4). For 80% Hydrogen substitution (Fig.5) it is seen that for temperatures of 1200K, 1500K and 1800K the mole fraction of N_2 first decreases at equivalence ratio of 1 and then again increases at equivalence ratio of 1.2 and further decrease is observed at 1.4 equivalence ratio.

Fig.6 shows the change in mole fraction of carbon monoxide (CO) for various percentages of hydrogen substitutions for different constant equivalence ratios for temperatures of 1200 K, 1500K and 1800 K. It can be noted that as the hydrogen percentage is increasing the mole fraction of CO increases sharply for equivalence ratio values of 1.2 and 1.4 and for other equivalence ratios, no increase is found in mole fraction of CO. From Fig.7, it is seen that maximum deviation for mole fraction of CO is for 80% hydrogen when compared to 60% hydrogen. The value of mole fraction of CO found to be higher at higher temperatures for 80% hydrogen substitution (Fig.8). Therefore, it is clear that the CO_2 and CO concentrations decrease as the percentage of hydrogen and ethanol blending are increased. This is due to the reduction in carbon atoms concentration in the blended fuel and the high molecular diffusivity of hydrogen, which improves the mixing process and, hence, provides higher combustion efficiency [5].

The variations of mole fractions of hydrogen (H_2) for various percentages of hydrogen substitutions for different constant equivalence ratios at temperatures of 1200 K, 1500K and 1800 K is depicted in Fig. 9. It is seen that with increase in hydrogen percentage substitution the mole fraction of H_2 increases. As shown in Fig.10 all fractions of hydrogen showed decreasing trend until equivalence ratio of 1.0 and then afterwards appreciable increase in mole fraction of hydrogen was observed until equivalence ratio of 1.4. Fig.11 shows that mole fraction for 80% hydrogen is higher at lower temperatures (i.e.1200K) with increase in equivalence ratio. The adiabatic flame temperature calculated on the available theory gives higher values of peak temperature. The higher adiabatic temperature is because of the higher heating values of hydrogen. It does not take into account the formation of moisture theoretically. However, exhaust simulation code takes into account the formation of complete exhaust species along with the moisture that forms during combustion. Therefore, as the percentage of hydrogen increases the formation of H_2O during combustion increases which keeps the peak temperature down and reduces the formation of NO and N_2 [6].

V. Conclusions

1. At equivalence ratio of 1.4, the molar fraction of CO_2 decreases for lean equivalence ratios due to a reduction in fuel carbon.
2. For 80% hydrogen substitution, with higher temperature of 1800K the CO_2 value is higher than that obtained at 1200K and 1500 K.
3. As the percentage hydrogen increases, the mole fraction of H_2O also increases, and has higher value for equivalence ratio of 1.0. Further, with the increase in equivalence ratio the mole fraction of H_2O falls down considerably.
4. For 80% hydrogen substitution, with higher temperature of 1800K the mole fraction of H_2O value is higher than that obtained at 1200K and 1500 K.
5. Mole fraction of N_2 decreases for all hydrogen fractions except for 60% and 80% hydrogen substitutions.
6. Maximum deviation for mole fraction of CO is for 80% hydrogen when compared to 60% hydrogen. The value of mole fraction of CO found to be higher at higher temperatures for 80% hydrogen substitution.
7. With increase in hydrogen percentage substitution the mole fraction of H_2 increases. All fractions of hydrogen showed decreasing trend until equivalence ratio of 1.0 and then afterwards appreciable increase in mole fraction of hydrogen was observed until equivalence ratio of 1.4.
8. As the percentage of hydrogen increases, the formation of H_2O during combustion increases which keeps the peak temperature down and thus reduces the formation of NO and N_2.

The code developed gave reasonably good results. However, there exist many areas which are unaddressed by the code. At low and high percentages of hydrogen and during transition between ethanol and hydrogen the model predictions are not very clear, this eventually shows the limitation of the model and opens the doors for further investigations. The best results were obtained for a combination of 80% hydrogen and 20% ethanol by volume.

Notation:

k_p	specific heat ratio of the products
k_r	specific heat ratio of the reactants
K	equilibrium constant
p	number of C atoms
P	pressure in bar
q	number of H atoms
r	number of O atoms
s	number of N atoms
T	temperature in K

v_i coefficient describing product composition of i^{th} species

x percentage of Ethanol in Ethanol- Hydrogen fuel blend

Y percentage of hydrogen in Ethanol- Hydrogen fuel blend

yi mole fraction of ith species

☐ Equivalence ratio

☐ Molar air-fuel ratio

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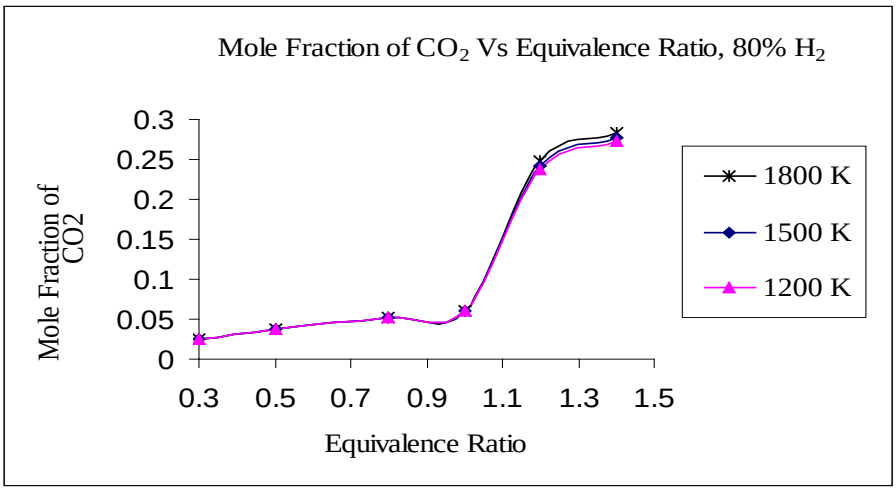

Figure 1 : Mole fraction of CO_2 against the Equivalence ratio, for 80% Hydrogen and at T=1200K, 1500K and 1800K

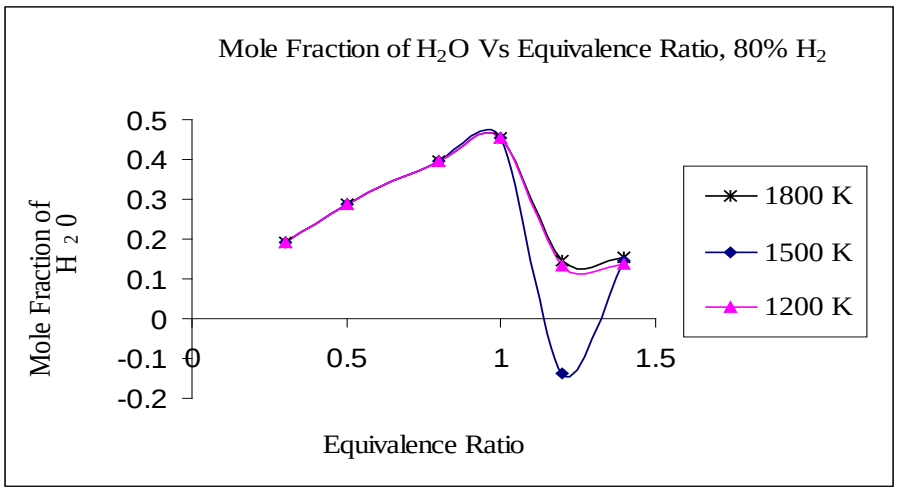

Figure 2 : Mole fraction of H_2O against the Equivalence ratio, for 80% Hydrogen and at T=1200K, 1500K and 1800K

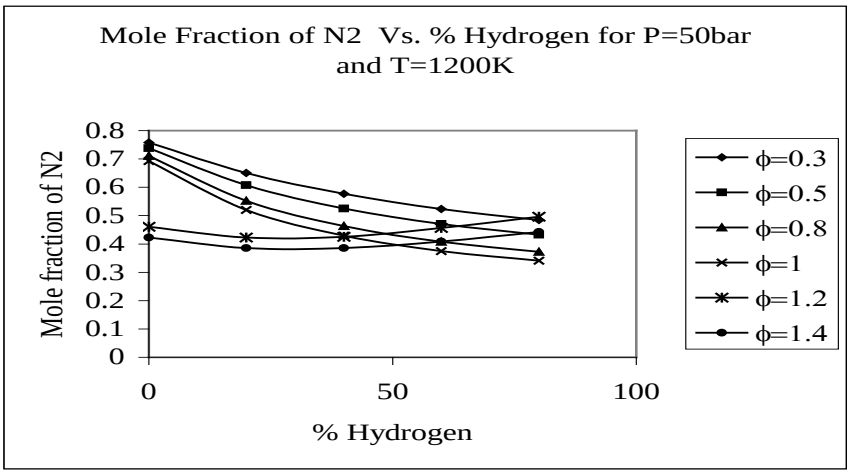

Figure 3 : Mole fraction of N_2 against the percentage substitutions of hydrogen at T=1200K

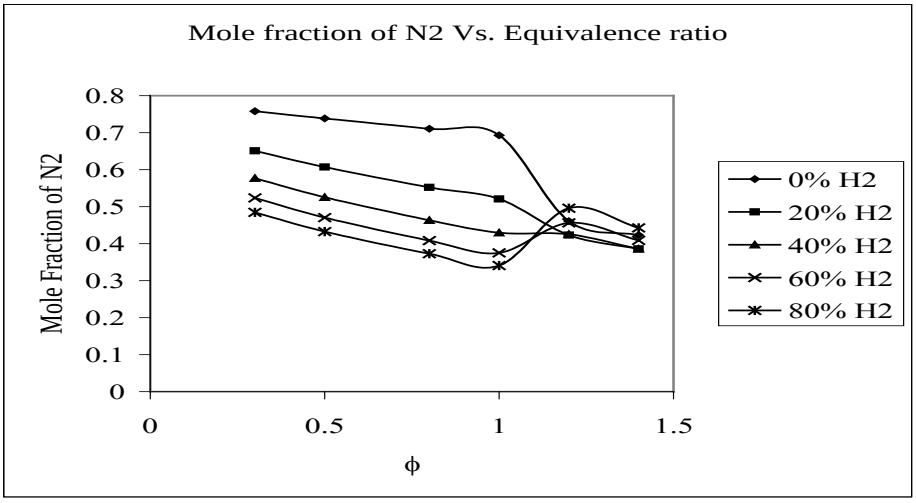

Figure 4 : Mole fraction of N_2 against equivalence ratio at T=1200K

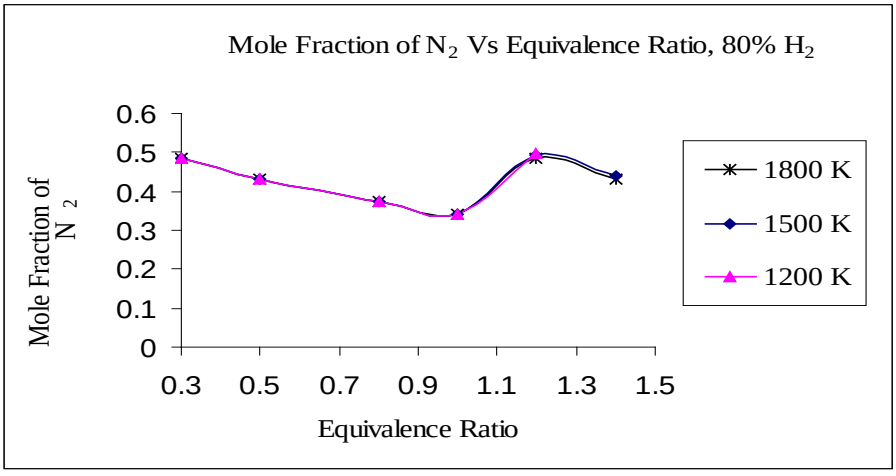

Figure 5 : Mole fraction of N_2 against the Equivalence ratio, for 80% Hydrogen and at T=1200K, 1500K and 1800K

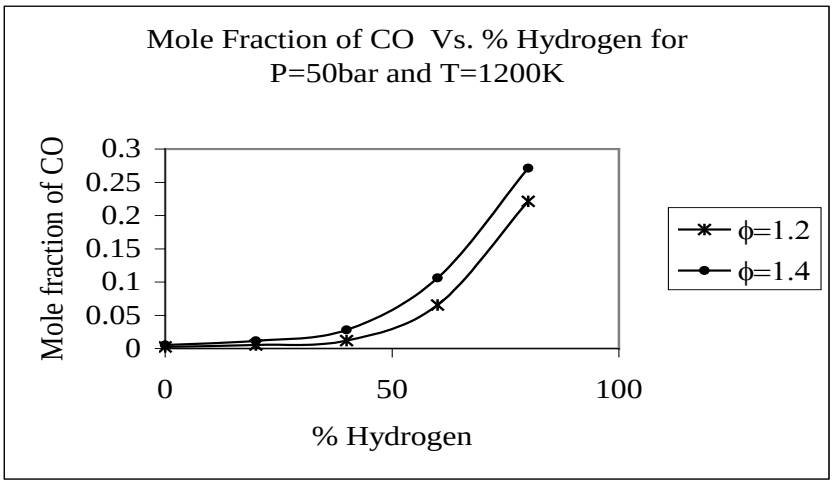

Figure 6 : Mole fraction of CO against the percentages of hydrogen at T=1200K

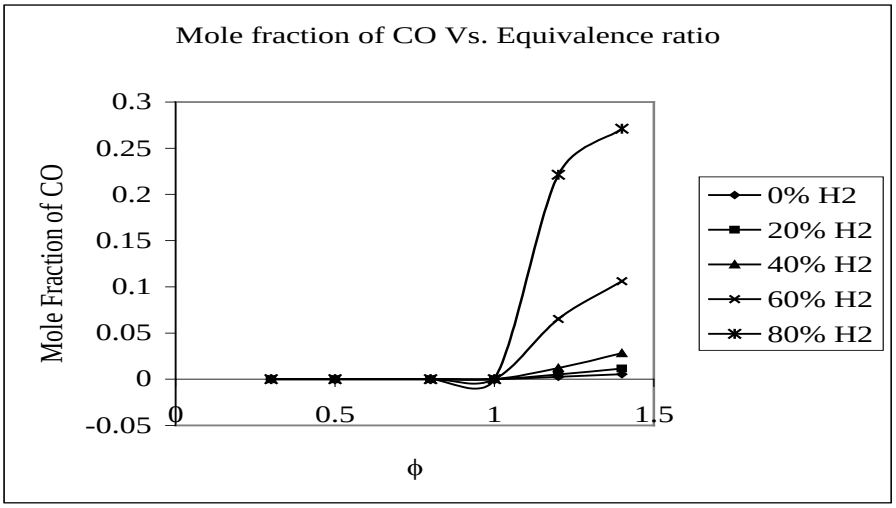

Figure 7 : Mole fraction of CO against equivalence ratio at T=1200K

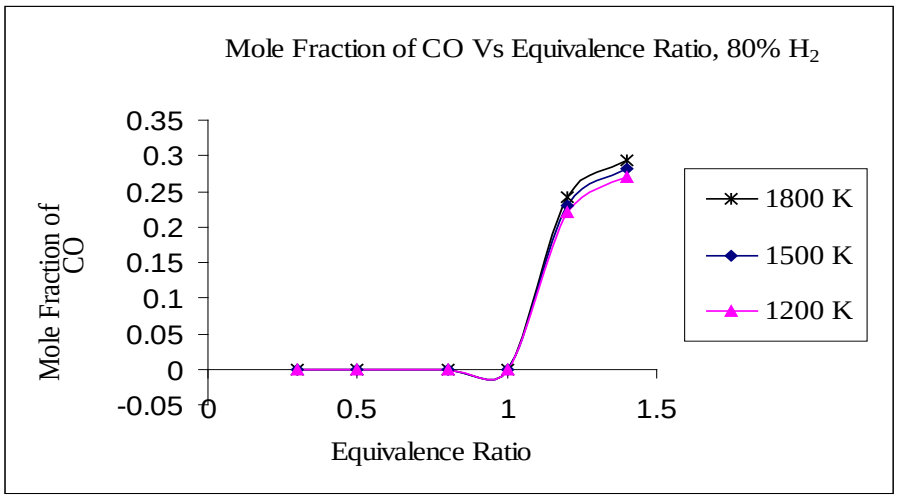

Figure 8 : Mole fraction of CO against the Equivalence ratio, for 80% Hydrogen and at T=1200K, 1500K and 1800K

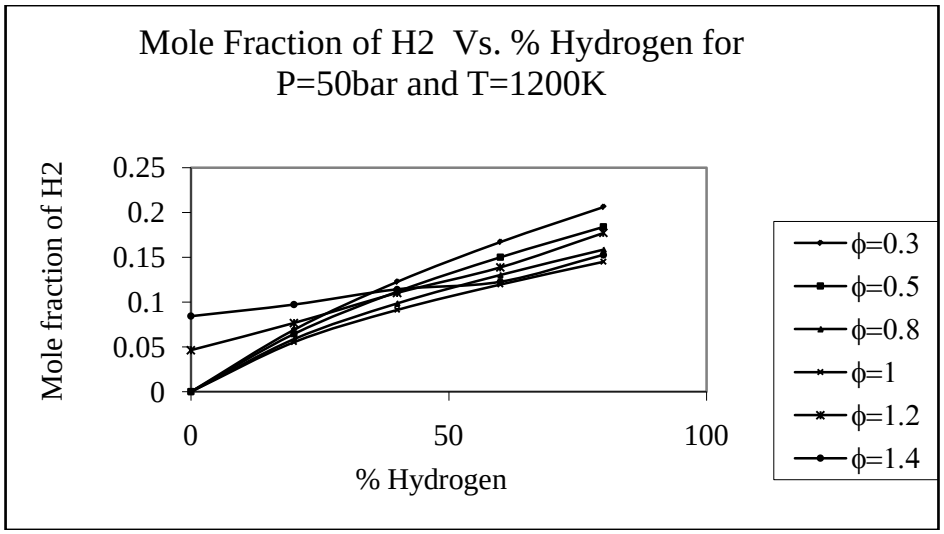

Figure 9 : Mole fraction of H_2 against the different percentages of hydrogen at T=1200K

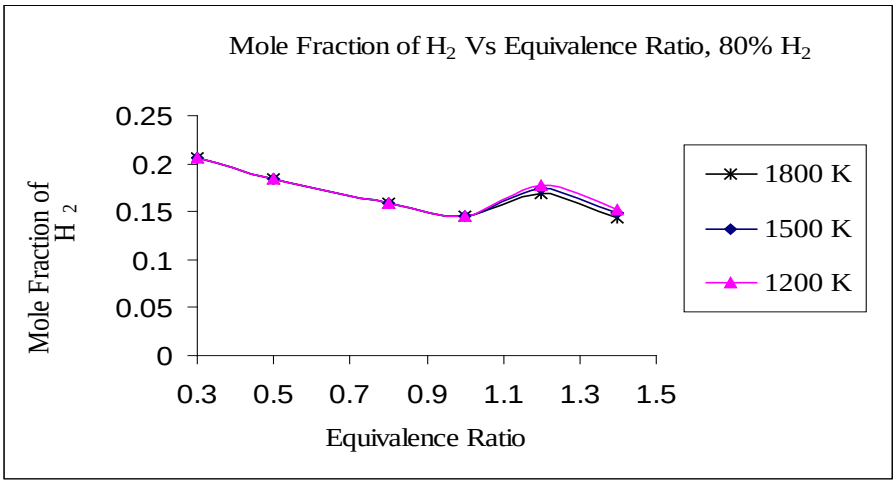

Figure 10 : Mole fraction of H_2 against the Equivalence ratio, for 80% Hydrogen and at T=1200K, 1500K and 1800K

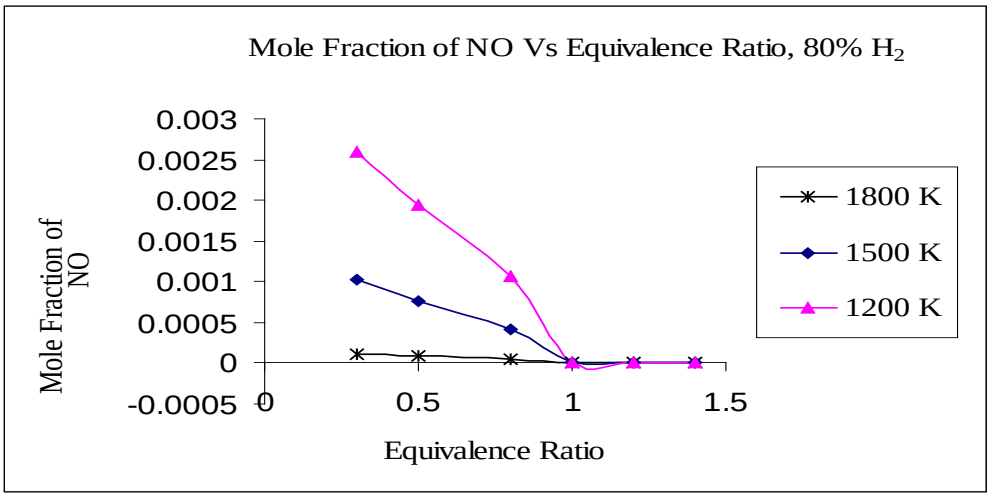

Figure 11 : Mole fraction of NO against the Equivalence ratio, for 80% Hydrogen and at T=1200K, 1500K and 1800K

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Fire Retardants for Civil Structures

By Ali I. Al-Mosawi, Ali A. Al-Zubadi, Mohammad H. Al-Maamori & Najah M. Al-Maimuri

Babylon University, Iraq

Abstract - Aluminum hydroxide as a coating layer of (4mm) thickness was used to increase the fire retardancy for advanced composite material consist of polyvinyl chloride (PVC) reinforced by carbon fibers .The resultant composite was exposed to a direct gas torch flame with flame exposure intervals 10,15,20mm, and study the range of resistance of retardant material layer to the flames and protected the substrate . The Method of measuring the surface temperature opposite to the flame was used to determined the heat transferred to composite material.

Keywords : *fire retardancy, advanced composite, inorganic retardants.*

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Fire Retardants for Civil Structures

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Abstract - Aluminum hydroxide as a coating layer of (4mm) thickness was used to increase the fire retardancy for advanced composite material consist of polyvinyl chloride (PVC) reinforced by carbon fibers .The resultant composite was exposed to a direct gas torch flame with flame exposure intervals 10,15,20mm, and study the range of resistance of retardant material layer to the flames and protected the substrate . The Method of measuring the surface temperature opposite to the flame was used to determined the heat transferred to composite material.

Keywords : fire retardancy, advanced composite, inorganic retardants.

I. Introduction

A fire retardant coating or paint is intended to delay ignition and reduce the surface burning rate of a combustible wood, cellulosic fiber or cellular plastic building material for a short period of time. It may be applied as a thick protective covering by trowel or as a fire-retardant paint by brush, spray, or roller. The reduction of burning rate usually depends on the applied thickness[1]. In the case of a fire-retardant paint exposed to fire, the paint may intumesce, forming an insulating blanket which retards surface ignition and reduces the burning rate of the combustible material on the coated side. Fire-retardant coatings will effectively reduce the burning rate of a combustible surface for a period of about10-15 minutes. Their use is particularly applicable in very low hazard occupancies not requiring sprinkler protection, where occupancy is not likely to change and the only hazard is that of exposed, interior finish materials [2]. Fire retardants commonly divided into four major groups: Inorganic FRs, Organ phosphorus FRs, Nitrogen-containing FRs and Halogenated organic FRs [3]. Inorganic flame retardants make up a large part of the market encompassing various aluminum, nitrogen, phosphorous, and boron compounds[4]. These widely used low cost materials have been around for centuries, proven to be effective flame retardants in fibers in clothing and fillers for textiles. The majority of these inorganic flame retardants work by diluting both the condensed and vapor phase of the polymer with non-flammable salts, acids and by-products such as water and alumina (Al_2O_3)[5] . Figure-1 shows the mode action for inorganic FRS.

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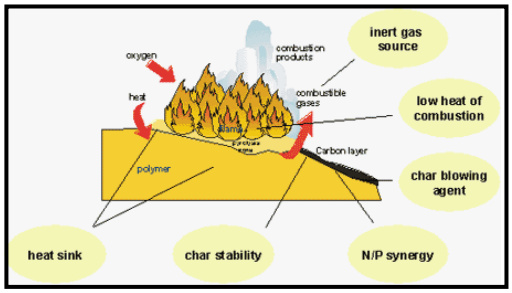

Figure 1 : Mode of action for inorganic FRs

Polymeric plastic combustion occurs in the vapor phase. When a plastic is exposed to increased temperatures, the plastic undergoes pyrolysis. Potentially combustible vapors are slowly released at first. Since many polymers are substituted, the increase in surrounding temperatures can cause variations in connectivity among the monomer units [6]. Often, these variations in connectivity result in an overall weakening of the polymer structure and can encourage the release of more vapors and liquids, both flammable and non-flammable. As the heat source persists, the temperature of the polymer increases steadily[7].

II. Materials and Method

a) Materials Used

Aluminum hydroxide with particle size (1μ). Matrix material: polyvinyl chloride (PVC), this resin was supplied by Huntsman Advanced Materials (Switzerland) GmbH. Reinforcing material: Woven roving (0 º - 45º) carbon fibers was used as a reinforcing material, the company supplied these fibers is Hyfil lt, UK .

b) Preparation of Test Specimens

Specimen of thermal erosion test have a square shape, with dimensions (100×100×10mm).These Specimens consist of two layers: Fire retardant material layer with (4mm) thickness, and composite material layer with (6mm) thickness.

c) Thermal Erosion Test

Gas torch flame with temperature (2000°C) was used in this test. The system (contains fire retardant material and composite material) was exposed to this flame under different exposure intervals (10 ,15, 20mm). Surface temperature method used here to calculate the amount of heat transmitted through fire retardant material and composite material. A transformation card (AD) which called Thermal monitoring and recording

system (Figure-2) was used to observed and saved temperatures with time (in seconds) .

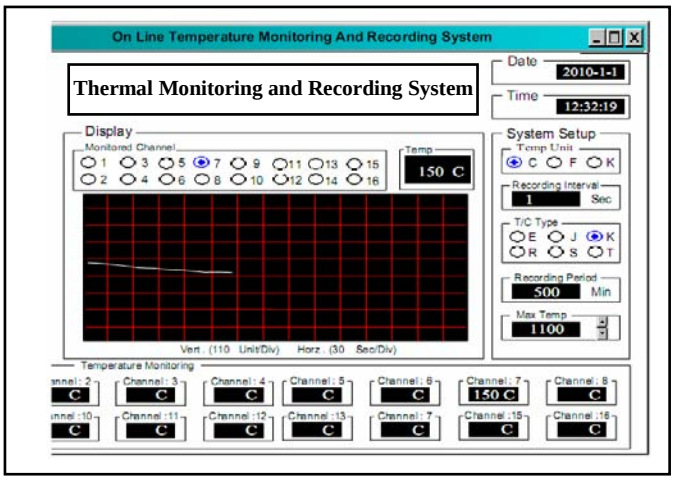

Figure 2 : Thermal monitoring and recording system

III. Results and Discussion

Figure-3 Curve.1 represents the thermal erosion test for composite material with retardant surface layer at exposed interval (10mm), the temperature of the opposite surface to the torch begins to increase with increasing the time of exposition to the flame [8]. Aluminum hydroxide will form a glassy char at high temperatures that prevents flame propagation ,It also releases water of hydration from its chemical structure . Therefore, the substrate (composite material) will protect and the fire spread will decrease [9].

The improvement in flame retardancy will increased with increased exposed interval to (15mm) as shown in Figure-3 Curve.2. As a result, when the exposed interval to flame increased to (15mm), the time necessary to break down of fire retardant layer will increase and the combustion gaseous will reduced and there will be a less plastic to burn due to water of hydration and protected glassy coating layer comes from Aluminum hydroxide [10] .

Figure-3 Curve.3 represents the thermal erosion test for composite material with retardant surface layer at exposed interval (20 mm),where this increment in exposed interval will rise the time of break down for Aluminum hydroxide layer and substrate composite material [11] . From figures , the better results obtained with large exposed interval (20 mm).

IV. Conclusions

Flame resistance of composite material will enhanced with addition retardant layer from Aluminum hydroxide. The resistance to flame spread will increased with increasing of exposed interval. The flame retardancy is increased as the flame temperature is decreased.

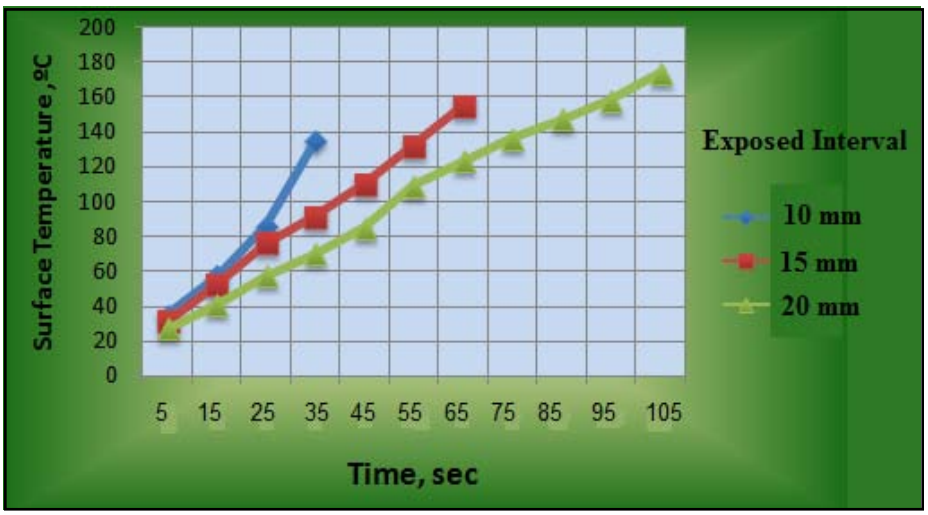

Figure 3 : Thermal Erosion Test

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Modifications in Molecular Parameters of Asphaltenes of Two Brazilian Oils for Action of Stockage Time

By Erika C. A. N. Chrisman & Viviane S. Lima
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Abstract - In the extraction of the oil, it is mixed with water thus forming emulsions. The emulsions are found in almost all the stages of production and processing of the oil and in some cases is very difficult to be “broken”. The presence of emulsifiers agents is one of the responsible factors for the stability of emulsions. Certain fractions of high point of boiling, such as the as phaltenes and resins, can be emulsifier´s agents and to stabilize emulsions W/O. In some stages of refining, the oil suffers thermal treatments like the atmospheric distillation in order to separate the interest fractions. As the chemical composition of petroleum is much complex, it is interesting to evaluate the possible molecular transformations that can happen in those fractions as phaltenics. Temperature variations, pressure and chemical composition can cause some problems like the precipitation of the asphaltenes of the crude oil. In this work, the aim of is to evaluate if the effect of conditions as, for example, ambient temperature, presence of light and humidity can influence in the quantity of water and mainly in the structures of asphaltenes of two Brazilian oils, A and B, that were submitted for a period of stockage of two years in not inert atmosphere and the atmospheric pressure. Significant modifications had been observed in two oils principally in the amount of the asphaltenic fraction that can have the structural characteristics of the species contained in this fraction that can have action differentiated on emulsions water in oil.

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Abstract - In the extraction of the oil, it is mixed with water thus forming emulsions. The emulsions are found in almost all the stages of production and processing of the oil and in some cases is very difficult to be "broken". The presence of emulsifiers agents is one of the responsible factors for the stability of emulsions. Certain fractions of high point of boiling, such as the as phaltenes and resins, can be emulsifier´s agents and to stabilize emulsions W/O. In some stages of refining, the oil suffers thermal treatments like the atmospheric distillation in order to separate the interest fractions. As the chemical composition of petroleum is much complex, it is interesting to evaluate the possible molecular transformations that can happen in those fractions as phaltenics. Temperature variations, pressure and chemical composition can cause some problems like the precipitation of the asphaltenes of the crude oil. In this work, the aim of is to evaluate if the effect of conditions as, for example, ambient temperature, presence of light and humidity can influence in the quantity of water and mainly in the structures of asphaltenes of two Brazilian oils, A and B, that were submitted for a period of stockage of two years in not inert atmosphere and the atmospheric pressure. Significant modifications had been observed in two oils principally in the amount of the asphaltenic fraction that can have the structural characteristics of the species contained in this fraction that can have action differentiated on emulsions water in oil.

I. Introduction

The oil can be defined as a complex mixture of natural occurrence, consisting predominantly of hydrocarbons and, in lesser amount, of sulphurates organic compounds, nitro genated, oxygenated and organometallics beyond inorganics impurities as salts and sediments. The main components of the oil are divided in four categories: saturated, aromatics, resins and as phaltenes. This classification is known for SARA that is a quantitative analysis of these fractions in the oil (Tissot and Welt, 1978; Speight, 2001; Wang et al, 2002). According to Gauthier et al (2008), as phaltenes consists of a heterogeneous mixture complex composed for condensed poliaromatics rings, aliphatic chains, naphthenic rings, heteroatom and metals as iron, nickel and vanadium. The as phaltenes are unque stionably the fraction most complex of the oil. In variations of pressure, temperature or composition of oil, as phaltenes tend to associate and to precipitate causing some operational problems since the transport until the refining (Duda and Lira, 2006; Trejo et al, 2007). With passes of the years, it had a significant increase in studies about as phaltenes due the great discoveries of heavy oil reserves with low degree API (<20°) in Brazil (Montserrat, 2008). These oils heavy present a bigger presence of compounds as resins and as phaltenes (Merdrignac and Espinat, 2007). Another problem related with presence of as phaltenes in oil is its participation in emulsion stability. The oil is produced together with the water and it can be found in free form or emulsified form, generating a series of operational problems as blockage of separation equipment (Saudi Sunil and, 2005). In the oil are found emulsifying agents natural as as phaltenes, resins and wax. These species are accumulated in the interface oil-water forming a rigid interfacial film that prevents the coalescence and consequently stabilization of the drops in emulsion (Montserrat, 2008; Saudi Sunil and, 2005). When an emulsion ages, the stability increases due oxidation, loss of light fractions, precipitation of some components, and, mainly, greater accumulation of the natural surfactants in the interface, propitiating formation of more rigid interfacial films. With relation of all oil fractions, the molecular structure of as phaltenes is less understood (Trejo et al, 2007). Some researchers (Oak, 2003; Salazar et al, 1995; Speight, 1999) has concentrated its efforts in improving information regarding this mixture developing its knowledge on the involved chemical structures, characterizing the existing functions and establishing its behaviors front the solvents.

II. Objective

The aim of this work is to evaluate if the effect of conditions as, for example, ambient temperature, presence of light and humidity can influence in the structures of as phaltenes of two Brazilian oils denominates A and B, that were submitted for a period of stockage of two years in not inert atmosphere and the atmospheric pressure.

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III. Methodology

The methodology of this work was divided in 5 parts. The first stage was quantification of water present in two oils for the method of Karl Fischer titration using a Metrohm Ltd. 831 KF. The second part involved the obtaining of atmospheric residues of two oils that were submitted to procedure of cut in 420 °C. The cut is an experiment recommended when if wants to quantify yield of as phaltenes in samples of oil with yields of light above 20% and with low yield of as phaltenes. The cut in laboratory scale is about a simple distillation, only with equipment lightly differentiated to guarantee the collect of the light fractions, to prevent losses and to allow the closing of balance of mass of the all process. The atmospheric residues were used, later, in determination of the yield of as phaltenes. A comment to be salient is that the cut was carried through to the atmospheric pressure and in duplicate. The third stage involved the extraction and quantification of as phaltenes from raw oils and of atmospheric residue following the norm based on ASTM 6560-00 standardized for the Institute of Petroleum of London. A fourth stage involved the characterization of as phaltenes, where the techniques of elementary analysis and NMR of ^{1}H and ^{13}C were used. Finally, all the results obtained were analyzed and their molecular parameters were correlated to observe the differences promoted by the stockage time.

IV. Results and Discussion

a) Water Content

Table 1 : Water Content

Year	Water Content (%)	
	Oil A	Oil B
2007	0,82 ± 0,05	12,65 ± 0,20
2009	0,39 ± 0,01	11,43 ±0,08

Average values of water content for crude oils A and B are shown in Table 1. Karl Fischer titrations confirm the presence of the biggest aqueous phase in oil B. For oils A and B, it is observed a decrease of water content in 2007 to 2009. For oil A, this decrease is bigger due the water to be in the free form and not emulsified as in oil B.

b) Results of Cut

With base in the results of the Table 2, it is verified that there is an increase in the value of the cut residue from 2007 to 2009 for two oils, being more accentuated in the oil A. That increase can be justified by loss of the light fraction during the time of stockage.

Table 2 : Values of Residue of cut in 420°C

Year	Residue (% m/m)	
	Oil A	Oil B
2007	59,21 ± 5,66	63,76 ± 3,15
2009	70,21 ± 2,31	70,59 ± 2,45

c) Asphaltenes Quantity

The as phaltenes was extracted using ASTM 6560-00 of the raw oils and of the coming residues of the cuts gotten in 420°C. The results of as phaltenes quantity obtained starting from the oils A and B and its respective residues of cut temperature are presented in the Tables 3 and 4. Being compared the results only when it is preceded to the cut in the temperature of 420°C it is that the as phaltenes quantity suffers a significant change in both years, principally in the residue of the cut.

Table 3 : Values of the as phaltenes obtained by ASTM 6560-00 for Oil A in 2007 and 2009

Temperature of Cut	Value of Asphaltenes (%m/m) - OIL A	
	2007	2009
0 °C (raw oil)	2,85 ± 0,01	2,52 ± 0,04
420°C (residue of cut)	4,17 ± 0,25	3,08 ±0,10

Table 4 : Values of the as phaltenes obtained by ASTM 6560-00 for Oil B in 2007 and 2009

Temperature of Cut	Value of Asphaltenes (%m/m) - OIL B	
	2007	2009
0 ºC (raw oil)	2,19 ± 0,11	2,15 ± 0,11
420ºC (residue of cut)	3,24 ± 0,01	2,42 ± 0,41

The difference between the values in 2007 to 2009 for the same type of product is not significant for the raw oils, probably by the initial homogeneity of each sample.

d) Elementary Analysis

In elementary analysis, % in m/m of C , H and N had been determined of each sample of asphaltene.The sulphur quantitity and of oxygen had been grouped and calculated as shown in the following Equantion.

$$(S+O)=100-(C+H+N)$$

The Table 5 shows results of elementary analysis of oil A and its residue of cut obtained in the years 2007 and 2009.

Table 5 : Values of elementary analysis of oil A obtainded in the years 2007 and 2009

Temperature of Cut	OIL A									
	C (%m/m)		H (%m/m)		N (%m/m)		S + O (%m/m)		Ratio of C/H	
	2007	2009	2007	2009	2007	2009	2007	2009	2007	2009
0 ºC (raw oil)	87,0	86,7	7,9	7,8	1,9	1,1	3,2	4,4	0,9	0,9
420ºC (residue of cut)	87,2	86,5	6,5	7,0	2,2	1,3	4,1	5,2	1,1	1,0

The ratio between amount of Carbon and Hydrogen (C/H) indicates that asphaltenes present characteristic values of heavy fractions, next to 1. Comparing results of years 2007 and 2009, it is observed a significant reduction in values of N and conse quently increase in amount (S + O). This fact can be decurrent of oxidation facilitated for the presence of heteroatom. The Table 6 shows results of elementary analysis of oil B and its residue of cut obtained in the years 2007 and 2009.

Table 6 : Values of elementary analysis of oil B obtainded in the years 2007 and 2009

Temperature of Cut	OIL B									
	C (%m/m)		H (%m/m)		N (%m/m)		S + O (%m/m)		Ratio of C/H	
	2007	2009	2007	2009	2007	2009	2007	2009	2007	2009
0 ºC (raw oil)	74,7	71,5	7,0	6,7	1,6	0,7	16,7	21,1	0,9	0,9
420ºC (residue of cut)	66,0	70,5	5,3	5,8	1,5	0,7	27,2	23,0	1,0	1,0

Low values for % C and H are observed. An explanation for this fact is the presence in this oil, with bigger amount of water, metals and halogen, as for example, Ni, V, Sr, Ca, K, Na, Cl, among others, that are not burnt by technique of elementary analysis, however are computed for final result given in percentage of total sample weighed. Calculating again the percentages of C and H abstaining contributions of metals and halogen, are gotten values well more coherent for as phaltenics fractions. Although these low

values, correlation C/H remains inside of indicative band for asphaltene. Also is observed a significant reduction in values of N and consequently increase in amount (S + O). This fact can be decurrent of oxidation facilitated for the presence of heteroatom.

e) NMR ^{1}H

The nuclear magnetic resonance of ^{1}H and ^{13}C was used for identification of different types of carbon and hydrogen as basic source of information to allow the agreement of differences existing between as phaltenes of two oils submitted to thermal treatments. In Table 7, the results for molecular parameters obtained by NMR of ^{1}H for as phaltenes of oil A (years 2007 and 2009) are presented.

Table 7 : Values of NMR ^{1}H of oil A obtainded in the years 2007 and 2009

Molecular Parameters (%)	Oil A			
	Year 2007		Year 2009	
	0ºC (Raw oil)	420ºC (residue of cut)	0ºC (Raw oil)	420ºC (residue of cut)
Aromatic hydrogen (Har)	7,5	14,7	8,1	9,1
Saturated hydrogen (Hsat)	92,5	85,3	91,9	90,9
Alpha hydrogen (Hα)	16,5	20,1	18,6	22,0
Beta hydrogen (Hβ)	59,4	48,5	54,6	54,2
Gamma hydrogen (Hγ)	20,1	16,3	20,0	15,5

The molecular parameters change so much and inside the statistical error when are comparated the raw oil in 2007 and in 2009. Significant changes are observed when the comparation focus are the changes of the oil to residue in each time. The increase of Har of oil for residue is much more significant in 2007 that in 2009. This increase possibly that means, the aromatical part of as phaltenic fraction becomes less substituted due to loss of lateral chains or naphtenics ring opening; and/or that this aromatic part is increasing of size due to biggest ring number being formed by a possible oxidation of naphtenics rings or cyclization of lateral chains followed by oxidations. Analyzing the Hα, observes an increase in 420ºC. This fact can be explained by possible oxidation of naphtenics rings next to aromatical rings and/or cyclization to lateral chains. For the Hβ, is observed a reduction in 2007, what it can be explained by a possible loss or reduction in the length of lateral chain, arrangement differentiated of naphtenics rings next to aromatic rings, and/or cyclization of lateral chains followed oxidation of naphtenics. For the Hγ, is observed a reduction in 2007 and 2009, involving a possible cyclization of lateral chains with formation new naphtenics ring and/or elimination of aromatic part for breaking for temperature increase. In Table 8, the results for molecular parameters obtained by NMR of ^{1}H for as phaltenes of oil B (years 2007 and 2009) are presented.

Table 8 : Values of NMR ^{1}H of oil A obtainded in the years 2007 and 2009

Molecular Parameters (%)	Oil B			
	Year 2007		Year 2009	
	0ºC (Raw oil)	420ºC (residue of cut)	0ºC (Raw oil)	420ºC (residue of cut)
Aromatic hydrogen (Har)	9,4	11,9	7,4	10,6
Saturated hydrogen (Hsat)	90,6	82,7	92,6	89,4
Alpha hydrogen (Hα)	19,4	20,9	20,6	22,2
Beta hydrogen (Hβ)	55,4	47,2	56,2	51,9
Gamma hydrogen (Hγ)	19,8	14,6	17,4	19,2

For this oil B, the changes are also observed in the raw oil and the residue. The principal parameter is the aromatic hydrogen. The others molecular parameters changes like in the oil A. A reduction of Hsat from oil to residue most significant in 2007 is observed, indicating bigger substitution of aromatic part. The increase of Har can be explained by sequence of cyclization lateral chain, resulting in new naphtenics rings and/or for an increase or break of length or ramification in lateral chains and naphtenics ring

oxidation with formation aromatic ring. For the Hβ, only observes a more significant reduction in 2007, that it can be explained by the same reasons cited in the case of oil A. For the Hγ, is observed a reduction in 2007 but in 2009, this value increase. In this case, possible occur the increase of ramifications and lateral chains.

f) RMN of ^{13}C

The molecular parameters gotten by NMR ^{13}C for oils A and the B are presented in Tables 9 and 10.

Table 9 : Values of NMR ^{13}C of oil A obtainded in the years 2007 and 2009

Molecular Parameters (%)	Oil A			
	Year 2007		Year 2009	
	0ºC (Raw oil)	420ºC (Residue of Cut)	0ºC (Raw oil)	420ºC (Residue of Cut)
Total Aromatical carbons (Car)	50,2	69,0	49,7	57,3
Saturated carbons Total (Csat)	49,8	31,0	50,3	42,7
Carbons Opening				
Aromatical carbons linked alkil chains or heteroatom (Car-R/Het)	12,4	19,8	10,7	9,2
Aromatical carbons linked hydrogen (Car-H)	11,3	19,2	12,2	12,9
Aromatical carbons in ring junction (Car-J)	26,5	30,0	26,8	34,6
Substituted Aromatical carbons (Car-H+ Car-R/Het)	23,7	39,0	22,9	22,7

The raw oil changes so much when compared 2007 and 2009. The changes occur in the raw oil to residue in each case. An increase of Car is observed and reduction of Csat throughout of increase of temperature cut more significant in 2007, these data Confirm the results of Har and Hsat gotten in the NMR ^{1}H. The value of quantity of Car-J suffers a more significant increase in 420ºC in 2009 possible by the formation of the increase of aromatic rings in the continental basic structure. This can be also confirmed by the results of Car-R/Het and Car-H+Car-R/Het that increase in 420ºC, in 2007, what it can be decurrent of the same type of characteristic above, as well as for formation new naphtenics ring decurrent of cyclization of lateral chains but in 2009 is observed a significative reduction by possibly lost of lateral chains.

Table 10 : Values of NMR ^{13}C of oil B obtainded in the years 2007 and 2009

Molecular Parameters (%)	Oil B			
	Year 2007		Year 2009	
	0ºC (Raw oil)	420ºC (Residue of Cut)	0ºC (Raw oil)	420ºC (Residue of Cut)
Total Aromatical carbons (Car)	50,5	60,7	48,7	59,6
Saturated carbons Total (Csat)	49,5	39,3	51,3	40,4
Carbons Opening				
Aromatical carbons linked alkil chains or heteroatom (Car-R/Het)	13,9	13,9	8,3	10,7
Aromatical carbons linked hydrogen (Car-H)	14,0	16,6	11,2	14,9
Aromatical carbons in ring junction (Car-J)	22,6	30,2	29,2	34,0
Substituted Aromatical carbons (Car-H+ Car-R/Het)	27,9	30,5	19,5	25,6

This result is the most important because more expresive changes are observed in the raw oils in 2007 to 2009. In all parameters the changes are significantly. An increase of Car is observed and reduction of Csat throughout of increase of temperature cut in two years, these data confirm the results of Har and Hsat gotten in the NMR ^{1}H. The value of quantity of Car-J suffers a more significant increase in 420°C in 2009. The values of Car-R/Het and Car-H+Car-R/Het decrease in 2009, what it can be possibly decurrent of oxidation and loss of lateral chains. In all cases the structures changes in the residue so significantly in comparation to the changes in the raw oil from the time.

V. Conclusion

With base in the results of cut, was verified that there is an increase in the value of the cut residue that can be justified by lost of the light fraction. The analysis of the quantity of as phaltene showed, for the first time, a surprise results, but with the analysis of molecular parameters in these fractions, we concluded that is very important this chemical focus to explain what happening. The oxidation and the changes in as phaltene structure is confirmed by the NMR and reforced the importance of the stock age type and time.

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Condensate Recovery in a Plant and its Improvement

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Institute of Chemical Technology, India

Abstract - Condensate recovery systems help us reduce three tangible costs of producing steam:

- Fuel/energy costs
- Boiler water make-up and sewage treatment
- Boiler water chemical treatment

The amount of steam generated and the condensate recovered was calculated for the plant. These values were used to find out the Condensate Recovery Factor (CRF) which can be defined as the ratio of the amount of condensate recovered to the amount of steam generated. This paper concentrates on the condensate recovery factor calculation of a Distilled Fatty Acid (DFA) Plant and its improvement by suggesting various methods.

Keywords : *condensate, DFA, steam.*

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Condensate Recovery in a Plant and its Improvement

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I. Introduction

Distilled Fatty Acid Plant consists of the following sections:

- Splitting
- Crude Glycerin Section (CGS)
- Distillation / Fractionation
- Hydrogenation
- Flaking

a) Splitting Section

In this section, the splitting of oil done, following reaction is carried out at 250°C and 50 bar.

$$\text{Oil} + \text{Water} \longrightarrow \text{Fatty Acid} + \text{Glycerin}$$

This reaction is carried out in the two Splitting Towers:

1. Lurgi Splitting Tower
2. Jutasama Splitting Tower

b) Crude Glycerine Section

i. *Pre-concentration (PRECON)*

The triple effect evaporators concentrate sweet water from 15% to 35%.

ii. *Treatment*

In this section, the sweet water is subjected to chemical treatment to remove residual fatty acid and other impurities and is filtered by plate and frame filter press.

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iii. *Post-concentration (POSTCON)*

The double effect evaporators concentrate sweet water from 35% to 85%.

iv. *Glycerine Dehydration Unit (GDU)*

The crude glycerine in concentrated from 85% to 92% by flash evaporation.

c) Fractionation / Distillation

Distillation is an operation in which different constituents of a feed material is separated. Different cuts of Fatty Acids are obtained with varying carbon chains.

The distillation/fractionation plant consists of:

- Section 3
- Section 4
- Section 5

d) Hydrogenation Section

The unsaturated fatty acids are hydrogenated batch wise in Loop Reactor to form saturated fatty acid

- Capacity : 60 MT / day
- Feed

1. DLGMFA
2. S PFAD
3. L/E PKO
4. RBDPS

Products:

1. Hyd. DLGMFA
2. Hyd. PFAD
3. Hyd. L/E PKO
4. Hyd. RBDPS
5. P 12

e) Flaking Section

Material which are solid at room temp. are flaked & packed in bags in two flakers.

- Capacity : 65 MT / day
- Grades:

1. Stearic Acid UTSR
2. Stearic Acid DTP 7
3. Stearic Acid P 12
4. Lauric Acid
5. Behenic Acid
6. HPS

The steam that is being generated or consumed can be classified on the basis of pressure into 3 types:

TYPE OF STEAM	PRESSURE
LOW PRESSURE STEAM (LPS)	<5 Kg/cm2
MEDIUM PRESSURE STEAM (MPS)	5-15 Kg/cm2
HIGHPRESSURESTEAM(HPS)	>15 Kg/cm2

Figure 1 : Types of steam based on pressure

f) Calculation of Condensate Recovery Factor

Total LP steam Generated = x

Total condensate Recovered = y

Condensate Recovery Factor (CRF) = y/x

Total CRF =

$$(y1+y2+y3\ldots+yn) \ / \ (x1+x2+x3\ldots+xn)$$

The steam that can be recovered in the form of condensate is the Low Pressure Steam (LPS).The following diagram shows how the steam is being converted on the basis of different pressures.

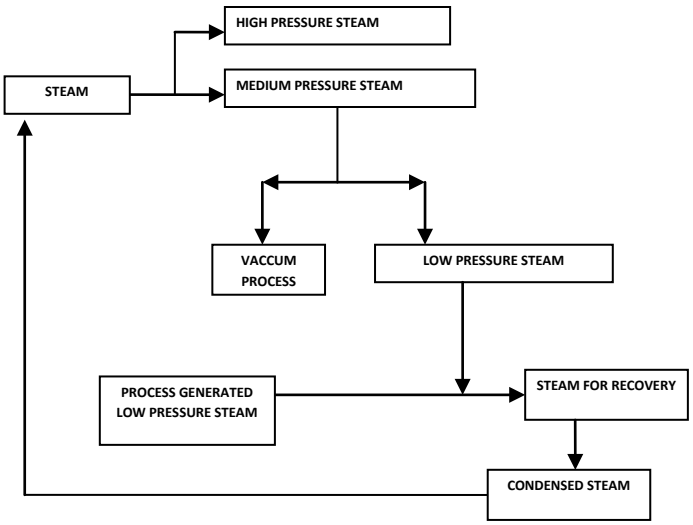

Figure 1 : Steam flow diagram

The steam that is being generated gets converted into high pressure steam (HPS) and medium pressure steam (MPS).The high pressure steam (HPS) cannot be further converted into recoverable form and gets used in various processes. The medium pressure steam can either go into the vacuum processes or else get treated and get converted into low pressure steam (LPS).Our main aim is to obtain the amount of low pressure steam (LPS) as this is the only steam that can be converted to condensate and can be recovered. Low pressure steam (LPS) is also generated from various processes. This LPS undergoes condensation which is eventually used to generate the initial steam. Thus more the condensate recovered better is the Condensate Recovery Factor (CRF), better is the efficiency and lesser the costs of generating steam.

The LP steam network in DFA Plant can be seen as follows:

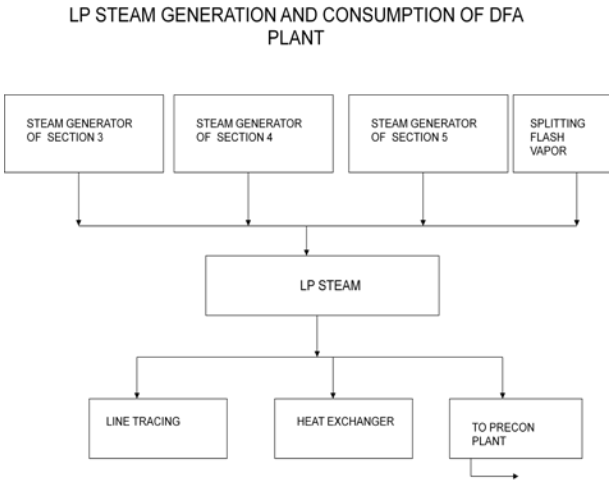

Figure 2 : LP steam generation and consumption in DFA PLANT

In order to calculate the LPS generated, heat balance at steady state has been applied across the system.

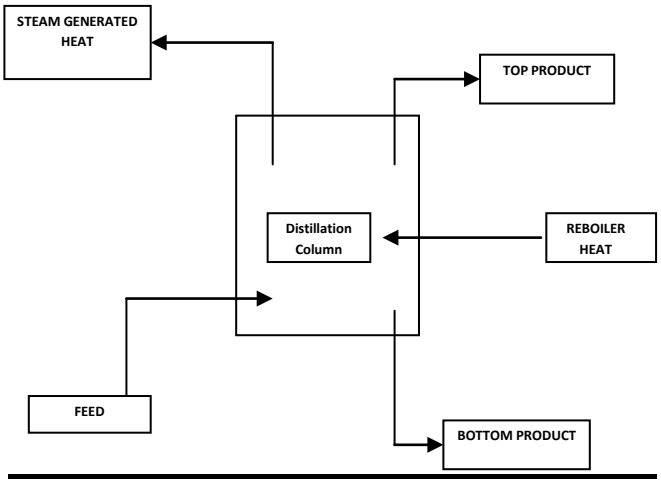

Figure 3 : Heat Balance across the System

g) Condensate Recovery Improvement

There are various reasons due to which the steam that gets converted to condensate is not able to be recovered to a large extent.

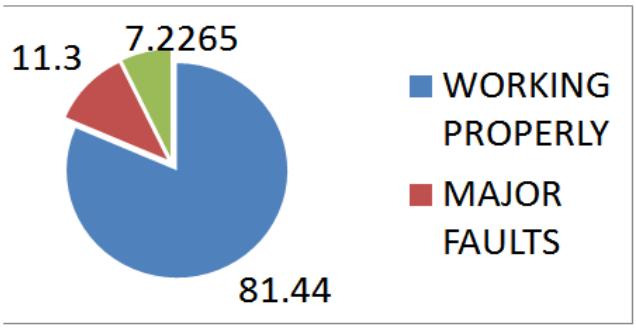

Figure 4 : Total steam and Condensate drains in Working Condition

ISSUE	TYPE OF LEAKAGE	REASON
Leakage of steam from c-402 to e-423 on 7th floor of DFA	Minor	gap between the flanges
Loss of steam as condensate via sampling point on 5th floor of DFA	Minor	bypass completely open
Vent condensate loss via 5th floor of DFA	Minor	hole in pipe
Steam loss while going to 4th floor header of DFA (P 304 A/B)	Minor	bypass completely open
Loss of steam on 2nd floor of DFA by P-352	Major	hand wheel broken and bypass is open.
Overflow of condensate in the vertical drum	Major	pumping not taking place properly
Overflow of condensate in the storage tank	Major	possible backflow and cavitation
Leakage at header leading to old boiler house	Minor	gap between flanges
Leakage at header where Sm-30 and Sm-50 produce steam to FA plant	Minor	gap between flanges
Loss of steam while coming from the Captive Power Plant (CPP)	Major	hand wheel broken and bypass is open.

Figure 5 : Leakages and losses in DFA Plant

h) Improvements

There are two ways in which improvement can be done:

1. Improving the condensate recovery in the existing system
2. Increasing the condensate in the system

In order to improve the condensate in the existing system, the steam traps play a very important role. The type of steam trap also plays an important role. If the steam traps function to their fullest ability then there will be an increase of condensate recovery by approximately 10%.

A steam trap is a device used to discharge condensate and non condensable gases with a negligible consumption or loss of live steam. The three important functions of steam traps are:

- Discharge condensate as soon as it is formed.
- Have negligible steam consumption.
- Have the capability of discharging air and other non-condensable gases.

i) Steam Trap Failure

Steam traps will typically fail in two different ways.

- The trap can stick in the closed position, which causes condensate to back up into the steam system.
- The trap can also stick in the open position, allowing live steam to discharge into the condensate system.

j) Maintenance of Steam Traps

- Visual
- Visual inspection depends on a release valve situated downstream of certain traps.

These valves can be released, and checked to see if condensate or steam is released

- Acoustic
- Involves listening to the steam trap operation, while ignoring any ambient sounds. Devices that can be used include stethoscopes, and ultrasonic leak detectors.
- Ultrasonic devices are typically the best and most accurate choice. These instruments are basically

electronic stethoscopes with acoustic filtering allowing them to be sensitive to high frequency sounds.

- Thermal

Involves observing upstream/downstream temperature variations in the steam traps. This method is most effective when used in conjunction with an ultrasonic leak detector.

- There was overflow of condensate observed in the storage tank due to which a lot of condensate was getting wasted. This was due to the ineffective working of the pump (due to cavitation) due to which the condensate was not able to be pumped to the Old Boiler House and was backflowing into the tank due to which it was getting wasted. In order to stop this the following methods can be followed:

1. Instead of a centrifugal pump, a mechanical pump should be used or a centrifugal pump with an ejector must be used such that there is no cavitation taking place. Hence there will be no loss of condensate and there will be improvement in condensate recovery by about 10%.
2. The second method is diverting the path of the condensate. Instead of making the liquid flow into the condensate tank where it overflows and gets wasted, the condensate should directly be directed to the deaerator so that the pump does not come into the picture. This not only improves the condensate recovery factor but also saves the pumping costs. The condensate recovery factor will improve by about 10 %.
3. All the leaks and losses due to poor functioning of the steam traps and broken valves and flanges should be fixed. Proper connection of steam traps and condensate line with condensate header in order to prevent any loss of steam and hence condensate. This will help improve the efficiency by about 8 to 10 %.
4. Finally all the condensate that comes out of the steam traps and gets drained in order to move the steam forward should be diverted directly to a storage tank or directly to the de-aerator to prevent condensate loss. This will increase the condensate recovery factor by about 10 %

II. Conclusion

This paper focuses on the steam condensate recovery of a DFA Plant and also proposes various suggestions and methods for the improvement of the condensate recovery factor.

III. Acknowledgement

I take this opportunity to thank Mr. Prasad Kale and Mr. Vijaykumar Patil VVF INDIA LTD. for providing me an excellent opportunity to gain exposure to the professional world by assigning me this project. I also express sincere gratitude towards Mr. Suryakanth Shabolu for his help and guidance without which this project would not have been possible.

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

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

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

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

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

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Final Points:

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

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· Present your points in sound order

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- Fundamental goal
- To the point depiction of the research
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- Significant conclusions or questions that track from the research(es)

Approach:

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- Center on shortening results - bound background information to a verdict or two, if completely necessary
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- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

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- If use of a definite type of tools.
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- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
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- Leave out information that is immaterial to a third party.

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

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

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