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Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 4 VERSION 1.0

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Contents of the Volume

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Characterisation of Textile Wastewater Discharges in Nigeria and its Pollution Implications

By I. E. Uwidia & C. Ejeomo
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Abstract- Wastewater discharges from two textile industries in Lagos (Nigeria) were analysed for their pollution characteristics such as temperature, pH suspended solids (SS), total solids (TS), permanganate value (PV), biochemical oxygen demand (BOD) and chemical oxygen demand (COD). For the first textile industry the range of values for the above named characteristics were: 29.10 - 33.500C, 9.25 - 11.18, 506.50 - 663.20mg/l, 5157.50 - 6930.30mg/l, 528.70 – 728.60mg/l, 646.10 – 880.00mg/l, and 2190.00 – 2984.00mg/l. Also the second industry had values ranging from 31.40 – 41.800C, 9.22 - 11.60, 455.60 – 684.90mg/l,5099.20 – 7624.10mg/l, 469.60 – 746.40mg/l, 584.30 – 885.00mg/l and 2012.13 – 2960.00mg/l. The study revealed that the textile wastewaters were untreated and contained high amounts of pollutants. These pollutants are discharged daily into nearby receiving surface waters. There is need to prioritize action to minimize rapid depletion of dissolved oxygen in the receiving water so as to prevent "oxygen sag" in the water there also need to protect the quality and portability of the receiving surface water so as to reduce its adverse health implications on consumers in the surrounding environment.

Keywords: textile wastewater, textile industries, characterisation, pollution, treatment, disposal.

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CHARACTERISATIONOFTEXTILEWASTEWATERDISCHARGESINNIGERIAANDITSPOLLUTIONIMPLICATIONS

Strictly as per the compliance and regulations of :

Characterisation of Textile Wastewater Discharges in Nigeria and its Pollution Implications

I. E. Uwidia [α] & C. Ejeomo [σ]

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I. Introduction

Textile industries produce large volumes of wastewater daily. The wastewater contains organic and inorganic substances which can cause pollution of the environment if discharged indiscriminately (Ademoroti,1996a). In a developing country like Nigeria, indiscriminate dumping of untreated wastes is still the current practice. Both domestic and industrial wastewaters are discharged into rivers, streams, drainage systems etc. As a result of this practice, pollutants enter the groundwater, rivers and other water bodies causing adverse effects an ecological systems (Uwidia and Ademoroti,2012; Uwidia,2011). Ultimately, such water which ends up in our households could affect the aesthetic quality of portable water and pose threats to public health on the side of consumers (Miroslav and Vladimir, 1999).

The wastewater generated in the textile industry depends on the raw materials used and the volume of water required.

Textile generally go through three or four stages of production processes from raw cotton, raw wool and synthetic materials to the final product. This includes yarn fabrication, fabric formulation, wet processing, and textile fabrication. An example of fibres obtained from natural source is wool while fibres from chemical substances i.e. synthetic fibres are nylon and polyester. They are made from petroleum. Some of the steps in processing fibres into textile goods include pre-treatment, dyeing, printing and finishing operations. These production processes not only consume large quantities of water but also produce large volumes of wastewater, large amount of energy and substantial waste products (Babu et al, 2007; Wynne et al, 2001).

Most of the wastewater generated is during the wet processing stage which include slashing/sizing, bleaching, mercerizing, and dyeing and finishing. Little or no wastewater is generated during fiber preparation, weaving, knitting, and textile fabrication processes.

Wastewater from printing and dyeing units is often rich in colour, containing residues of reactive dyes and chemicals and requires proper treatment before being released into the environment (Azymezyk et al, 2007; Pala and Tokat 2002). Textile wastewater exhibit very high toxicity. The toxic effects of dyestuffs and other organic compounds, as well as acidic and alkaline contaminants, from industrial establishments on the general public are widely accepted. Due to increased awareness of worldwide environmental issues, there has been a great interest in ecologically friendly, wet-processing textile techniques in recent years (Padama, et al 2006).

Although wastewater disposal has become a significant cost factor, it is an important aspect to be considered in running textile industries. Characterization of such wastewaters is pre-requisite for the investigation of pollution potential and necessary treatment options.

II. Objectives of Study

The aim of this study was to determine some pollution characteristics of textile wastewater obtained from textile industries in Nigeria assess the pollution level and possibly make useful recommendations on the treatment and disposal.

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III. Materials and Methods

a) Source of Textile Wastewater

The study was carried out on two textile industries manufacturing mostly cotton fabrics. Each textile factory consists of various departments, each of which carries out different operations and produces one type of wastewater or another.

Both industries have three major departments that are directly involved in the manufacture of the products.

First is the spinning department, where the fibres are spurn into yarns.

Second is the weaving department, where the yarns are converted to grey fabrics for further processing. The third is the wet processing department. This sector enhances the aesthetic as well as technological properties of the textile materials. It consists of de-sizing, bleaching, mercerizing, dyeing, and finishing and prints work. The wet processing departments accounts for the bulk of textile wastewater generated in these industries. One industry was larger than the other. The first and larger industry had an average annual production of about 140-160thousand metric tons and the average wastewater generated per-day was 4.2×10^6 litres. For the second industry the average annual production was 130-150 thousand metric tons while the average wastewater generated per day was 3.9×10^5litres.

Wastewater from both factories contains acids used in de-sizing, dyeing bases like caustic soda used in scouring and mercerization. It also contains oxidants e.g hydrogen peroxide and peracetic acid for bleaching and other oxidative applications.

Also present in the wastewater are organic compounds like dyestuff, optical bleachers, furnishing chemicals, synthetic polymers for sizing and thickening surface-active chemicals used as wetting and dispersing agents; and enzymes for de-sizing and degumming.

All these wastes are contained in the wastewater from each factory passed into an effluent tank and then channeled through a drainage system for disposal.

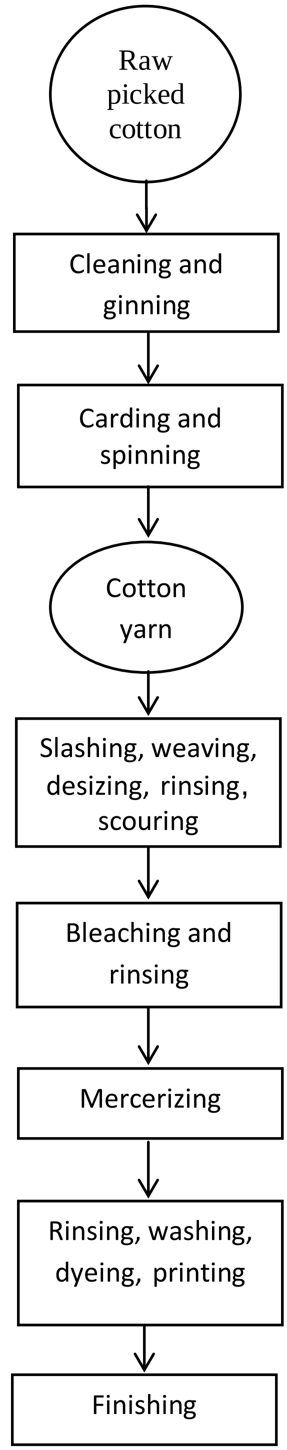

Figure 1 : A flow diagram for various steps involved in processing cotton textiles

b) Sampling Technique

The textile wastewater samples were collected from the pipe conveying all the wastewater out of the factory works into a stream.

Samples were obtained on hourly basis for 11 hours beginning at 7am and ending at 6pm. The day for sample collection in the new week was different from that of the preceding week.

This was done so that the total exercise might account for the cyclic and intermittent variations occurring at the work site.

Each sample was collected in clean well labelled plastic bottles and kept in the refrigerator maintained at 4^0C. For each sampling the rate of flow was measured. At the end of each sampling period, the samples were mixed together in volumes proportional to the rates of flow. This mixture was the composite sample that was analyzed for the pollution characteristics.

All together twenty four (24) composite samples (twelve from each textile industry) were obtained and used for analysis at an interval of once a week.

The two industries were chosen due to the similar fabrics they produce so as to obtain detailed account of the pollution characteristics studied.

c) Methods of Analysis

The sample were analyzed as described in the Standard Methods for the Examination of Water and Wastewater (APHA, 2005); Standard Method for Water and Effluents Analysis (Ademoroti, 1996) and Bureau of Indian Standards (BIS, 2005).

Where analysis was not immediately possible, they were preserved by refrigeration at 4^0C.

IV. Results and Discussion

Results of the analysis carried out in both industries are as shown in Tables I and II. The result show mean values obtained for the pollution characteristics in both factories.

Table 1 : Pollution Characteristics of raw textile wastewater (Final Discharge) obtained from factory II

Sampling Code	Temp	pH	SS (mg/l) mean ± SD	TS (mg/l) mean ± SD	PV (mg/l) mean ± SD	BOD_5 (mg/l) mean ± SD	COD (mg/l) mean ± SD
1	30.10	9.57	506.50 ± 0.21	5157.50 ± 0.24	609.70 ± 0.46	646.10 ± 0.33	2190.00 ± 0.80
2	33.40	10.44	514.80 ± 0.14	5302.50 ± 0.64	528.70 ± 0.35	654.80 ± 0.29	2236.66 ± 0.12
3	31.80	10.48	561.30 ± 0.15	6080.40 ± 0.27	627.10 ± 0.12	715.30 ± 0.08	2404.80 ± 0.18
4	29.80	9.67	583.90 ± 0.75	5601.20 ± 0.22	622.40 ± 0.13	730.50 ± 0.08	2468.31 ± 0.59
5	30.70	9.36	563.40 ± 0.85	5857.90 ± 0.55	658.50 ± 0.34	726.90 ± 1.73	2546.00 ± 0.70
6	30.60	9.58	569.30 ± 0.14	6188.70 ± 0.31	626.40 ± 1.13	729.00 ± 1.16	2456.80 ± 0.30
7	29.90	11.18	596.70 ± 0.39	6109.70 ± 0.23	723.80 ± 3.49	804.00 ± 0.13	2725.63 ± 0.66
8	32.60	10.21	606.30 ± 0.45	6148.30 ± 0.39	623.40 ± 0.25	779.30 ± 0.35	2650.00 ± 1.19
9	30.90	10.48	616.10 ± 0.12	6205.10 ± 0.12	714.30 ± 0.20	829.40 ± 0.08	2858.00 ± 1.01
10	31.00	9.48	629.40 ± 0.65	6643.40 ± 0.32	669.50 ±17.19	790.00 ± 0.73	2660.23 ± 0.52
11	29.10	10.33	623.90 ± 0.49	5997.90 ± 0.83	680.40 ± 0.17	802.80 ± 0.25	2706.14 ± 1.00
12	33.50	9.25	663.20 ± 0.66	6930.30 ± 0.66	728.60 ± 0.17	880.00 ± 0.95	2984.0 0.81

Table 2 : Pollution Characteristics of raw textile wastewater (Final Discharge) obtained from factory

Sampling Code	Temp	pH	SS (mg/l) mean ± SD	TS (mg/l) mean ± SD	PV (mg/l) mean ± SD	BOD_5 (mg/l) mean ± SD	COD(mg/l) mean ± SD
1	36.10	10.20	455.60 ± 0.14	5144.30 ± 0.24	535.30 ± 0.16	628.50 ± 0.10	2123.55 ± 0.05
2	36.90	10.80	457.20 ± 0.07	5099.20 ± 0.53	506.30 ± 0.11	602.30 ± 0.35	2025.36 ± 0.18
3	37.30	9.80	456.80 ± 1.08	5056.30 ± 0.06	469.60 ± 0.28	584.30 ± 0.21	2012.13 ± 0.63
4	35.60	10.65	574.20 ± 0.77	6349.20 ± 0.65	621.40 ± 0.09	740.00 ± 1.06	2512.00 ± 0.79
5	33.00	11.60	499.50 ±29.52	5831.80 ± 0.59	613.80 ± 0.76	725.00 ± 2.90	2650.00 ± 1.29
6	41.80	9.22	525.40 ± 0.27	5450.40 ± 0.27	584.70 ± 0.23	665.20 ± 0.10	2265.00 ± 0.33
7	38.40	10.12	573.45 ± 0.33	5726.50 ± 0.16	604.90 ± 0.23	751.00 ± 0.72	2620.00 ± 0.58
8	40.70	11.15	624.30 ± 0.25	6884.40 ± 0.32	657.30 ± 0.11	789.10 ± 0.09	2645.00 ± 1.12
9	37.30	10.12	587.30 ± 4.72	6236.40 ± 0.22	652.40 ± 0.06	835.30 ± 0.23	2950.12 ± 0.19
10	31.40	9.82	658.10 ± 16.4	7624.10 ± 1.04	734.50 ± 0.15	860.00 ± 1.22	2892.00 ± 0.67
11	39.40	9.79	665.30 ± 0.39	6530.30 ± 0.51	729.80 ± 0.41	843.40 ±12.79	2865.09 ± 0.38
12	36.30	10.40	684.90 ± 0.96	6970.50 ± 0.22	746.40 ± 0.36	885.00 ± 1.07	2960.00 ± 0.84

Most of the pollution characteristics measured from both industries had high values, indicating high pollution level. Wastewater temperatures from both factories ranged between 29.00 – 33.50^0C and 31.40 - 41.80^0C.

High values recorded for the various pollution characteristics may be linked to the various chemicals employed during processing and the nature of the raw materials for example, different enzymes, detergent dyes, acid sodas and salts used during processing.

The pH values (9.25 - 11.18; 9.22 – 11.60) show that the wastewaters were typically alkaline. Alkalinity increases with wastewater strength. High alkalinity is quite objectionable .It is an indication that the wastewaters have the capacity to neutralize acids.

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Values of suspended solids (506.50-663.20mg/l; 455.60 – 684.90mg/l) and total solids (5157.50-6930.30; 5099.20-7624.10mg/l) were quite high. This is significant. It is a reflection of the amount of oxygen required to synthesize both organic and inorganic solids present in the textile wastewaters. Suspended solids provide information on the amount of BOD present in the wastewater. The total solids include both organic and inorganic solid constituents dissolved or suspended in the wastewater.

The PV values (528.70 – 728.60mg/l ; 469.60 – 746.40mg/l) shows the magnitude of organic and inorganic substances readily available for oxidation in the textile wastewaters(Uwidia and Ademoroti,2012). The high BOD values obtained (646.10 - 880.00mg/l ; 584.30 – 885.00mg/l) show that the wastewaters have high pollution strength. COD values (2190.00-2984.00mg/l ; 2012.13 - 2960.00mg/l) were about three times higher than BOD. The remarkable increase in COD levels compared with BOD also indicates that significant levels of toxicants e.g. heavy metals may be possibly present in the wastewater. (Chavan,2001).

All these must have contributed towards toxicity in the wastewater which makes it necessary for its characterization in order to access the pollution level.

Industrial processes generate wastewater containing heavy metal contaminants. Most of these heavy metals are non-degradable into non toxic end products which could be harmful to the environment (Sekhar et al,2003). It therefore becomes necessary to reduce their concentration to acceptable levels using the necessary wastewater treatment process before discharging them into the environment. This will help reduce the detrimental effect of polluted water and general pollution of the environment caused by such discharges.

V. Conclusion

Results obtained from the analysis show that the textile wastewaters studied contained substantial pollution load. Such polluted wastewater poses threat to the environment.

Treatment in a wastewater treatment plant with optimization of the basic operating conditions is currently in practice. Combined treatment processes would be necessary to reduce the pollution load and avoid adverse pollution effect of the textile wastewaters on both the affected surface waters and the surrounding environment.

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Computational Study of Flow Around a NACA 0012 Wing Flapped at Different Flap Angles with Varying Mach Numbers

By Tousif Ahmed, Md. Tanjin Amin, S.M. Rafiul Islam & Shabbir Ahmed
University of Engineering and Technology, Bangladesh

Abstract- The analysis of two dimensional (2D) flow over NACA 0012 airfoil is validated with NASA Langley Research Center validation cases. The k-**ω** shear stress transport (SST) model is utilized to predict the flow accurately along with turbulence intensities 1% and 5% at velocity inlet and pressure outlet respectively. The computational domain is composed of 120000 structured cells. In order to enclose the boundary layer method the enhancement of the grid near the airfoil is taken care off. This validated simulation technique is further used to analyse aerodynamic characteristics of plain flapped NACA 0012 airfoil subjected to different flap angles and Mach number. The calculation of lift coefficients (CL), drag coefficients (CD) and CL/CD ratio at different operating conditions show that with increasing Mach number (M) CL increases but CD remains somewhat constant. Moreover, a rapid drastic decrease is observed for CL and an abrupt upsurge is observed for Cd with velocity approaching to the sonic velocity. In all cases range and endurance are decreased, as both values of CL/CD and √CL/CD are declined.

Keywords: NACA 0012 airfoil; lift coefficient (CL); drag coefficient (CD); lift curve; drag polar; flap angle (δ); range (R); endurance (E); mach number (M); k-ω shear stress transport (SST) model.

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COMPUTATIONALSTUDYOFFLOWAROUNDANACA0012WINGFLAPPEDATDIFFERENTFLAPANGLESWITHVARYING MACHNUMBERS

Computational Study of Flow Around a NACA 0012 Wing Flapped at Different Flap Angles with Varying Mach Numbers

Tousif Ahmed [α], Md. Tanjin Amin [σ], S.M. Rafiul Islam [ρ] & Shabbir Ahmed [ω]

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Keywords: NACA 0012 airfoil; lift coefficient (C_L); drag coefficient (C_D); lift curve; drag polar; flap angle (δ); range (R); endurance (E); mach number (M); k-ω shear stress transport (SST) model.

- Nomenclature

C_L	Lift coefficient	W_1	Final weight of plane
C_D	Drag coefficient	W_0	Initial weight of plane
δ	Flap angle	C_t	Thrust-specific fuel consumption
L	Lift	α	Angle of Attack (AoA)
D	Drag	M	Mach Number
W	Plane weight	E	Endurance
S	Frontal area	R	Range
ρ_∞	Density	V_∞	Free-stream velocity

I. Introduction

CFD study of airfoils to predict its lift and drag characteristics, visualisation and surveillance of flow field pattern around the body, before the endeavour of the experimental study is almost patent. In the present study aerodynamic characteristics of a well-documented airfoil, NACA 0012, equipped with plain flap is investigated. Wing with flap is usually known as high lift device. This ancillary device is fundamentally a movable element that supports the pilot to change the geometry and aerodynamic characteristics of the wing sections to control the motion of the airplane or to improve the performance in some anticipated way. CFD facilitates to envisage the behavior of geometry subjected to any sort of fluid flow field. This fast progression of computational fluid dynamics (CFD) has been driven by the necessity for more rapid and more exact methods for the calculations of flow fields around very complicated structural configurations of practical attention. CFD has been demonstrated as an economically viable method of preference in the field of numerous aerospace, automotive and industrial components and processes in which a major role is played by fluid or gas flows. In the fluid dynamics, For modelling flow in or around objects many commercial and open source CFD packages are available. The computer simulations can model features and details that are tough, expensive or impossible to measure or visualize experimentally.

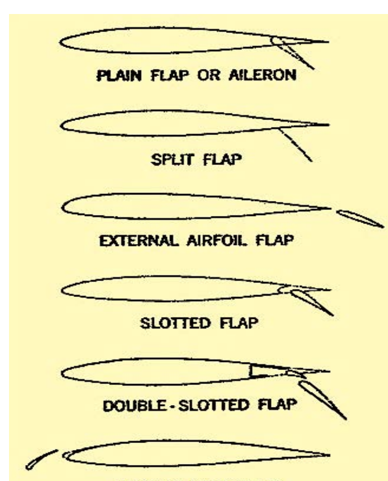

Figure 1 : Typical high lift devices

Some high lift devices are illustrated in fig. 1. These devices are primarily used to improve the maximum lift coefficients of wings with changing the

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characteristics for the cruising and high-speed flight conditions. As a result, it is very important to understand the characteristics of the wing having different flap angles (δ) at different Mach number (M). Operating the aircraft at optimum flap angle at optimum velocity may result significant amount of fuel saving. The B-17 Flying Fortress, Cessna 152 and the helicopter Sikorsky S-61 SH-3 Sea King as well as horizontal and vertical axis wind turbines use NACA 0012 airfoil which place this specific airfoil under extensive research and study.

This study does not provide any experimental data for the flow over the flapped airfoil. Therefore, to reduce the scepticism associated the results obtained, the simulation process for the study is validated instead. In the validation course the results for flow over no flapped NACA 0012 is compared with published standard data by NASA [1], as nearly same computational method is used to study flapped NACA 0012 airfoil. Many researchers have studied aerodynamic characteristics of NACA 0012 using different methods and operating conditions. The Abbott and von Doenhoff data [7] were not tripped. The Gregory and O'Reilly data [10] were tripped, but were at a lower R_e of 3 million. Lift data are not affected too significantly between 3 million and 6 million, but drag data are [11].

Selecting a proper turbulence model, the structure and use of a model to forecast the effects of turbulence, is a crucial undertaking to study any sorts of fluid flow. It should model the whole flow condition very accurately to get satisfactory results. Selection of wrong turbulence model often results worthless outcomes, as wrong model may not represent the actual physics of the flow. Turbulent flow dictates most flows of pragmatic engineering interest. Turbulence acts a key part in the determination of many relevant engineering parameters, for instance frictional drag, heat transfer, flow separation, transition from laminar to turbulent flow, thickness of boundary layers and wakes. Turbulence usually dominates all other flow phenomena and results in increasing energy dissipation, mixing, heat transfer, and drag. In present study flow is fully developed turbulent and Reynolds number (R_e) is set to 6×10^6. Spallart-Allmaras, *k-ε* realizable, *k-ω* standard and *k-ω* Shear Stress Transport (SST) are primarily used to model viscous turbulent model. However, these specific models are suitable for specific flow cases. Douvi C. Eleni [2] studied variation of lift and drag coefficients for different viscous turbulent model. His study shows that for flow around NACA 0012 airfoil *k-ω* Shear Stress Transport (SST) model is the most accurate.

II. Theoretical Background

Lowest flight velocities are encountered by an airplane at takeoff or landing, two phases that are most perilous for aircraft safety. The stalling speed V_{stall} is defined asthe slowest speed at which an airplane can fly in straight and level flight. Therefore, the calculation of V_{stall}, as well as aerodynamic methods of making V_{stall} as small as possible, is of vital importance.

The stalling velocity is readily obtained in terms of the maximum lift coefficient, as follows. From the definition of C_L,

$$L = q_\infty S C_L = \frac{1}{2}\rho V_\infty^2 S C_L$$

Thus, $V_\infty = \sqrt{\frac{2W}{\rho_\infty S C_L}}$ (1) [In case of steady level flight, L=W]

Examining Eq. (1), we find that the only alternative to minimize V_∞ is by maximizing C_L for an airplane of given weight and size at a given altitude. Therefore, stalling speed resembles to the angle of attack that yields $C_{L,max}$:

$$V_{stall} = \sqrt{\frac{2W}{\rho_\infty S C_{L,max}}} \quad (2)$$

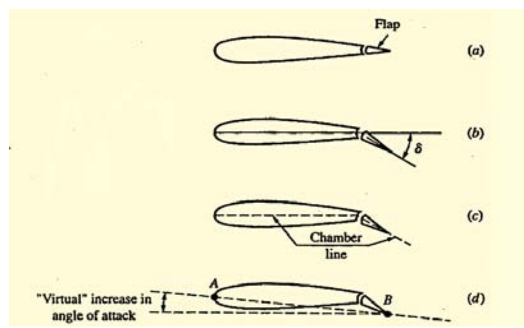


Figure 2 : When a plain flap is deflected, the increase in lift is due to an effective increase in camber and a virtual increase in angle of attack

In order to decrease V_{stall}, $C_{L,max}$ must be increased. However, for a wing with a given airfoil shape, $C_{L,max}$ is fixed by nature, that is, the lift properties of an airfoil, including maximum lift, depend on the physics of the flow over the airfoil. To assist nature, the lifting properties of a given airfoil can be greatly enhanced by the use of "artificial" high-lift devices. The most common of these devices is the flap at the trailing edge of the wing, as sketched in Fig. 2. When the lap is deflected downward through the angle δ, as sketched in Fig. 2b, the lift coefficient is increased for the following reasons:

- The camber of the airfoil section is effectively increased, as sketched in Fig. 2c. The more camber an airfoil shape has at a given angle of attack, the higher the lift coefficient.
- When the flap is deflected, we can visualize a line connecting the leading edge of the airfoil and the

trailing edge of the lap, points A and B, respectively, in Fig. 2d. Line AB constitutes a virtual chord line, rotated clockwise relative to the actual chord line of the airfoil, making the airfoil section with the deflected lap see a "virtual" increase in angle of attack. Hence, the lift coefficient is increased.

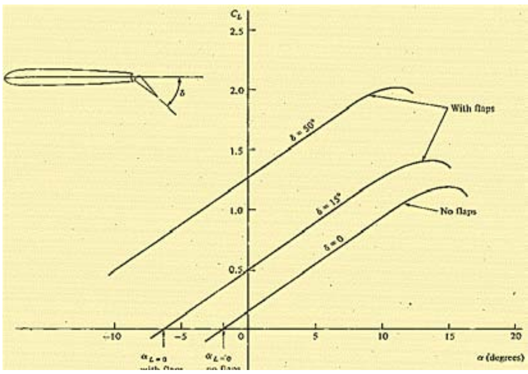


Figure 3 : Illustration of the effect of flaps on the lift curve. The numbers shown are typical of a modern medium-range jet transport

For these reasons, when the flap is deflected downward through the flap deflection angle δ, the value of $C_{L,max}$ is increased and the zero-lift angle of attack is shifted to a more negative value, as shown in Fig. 3. In Fig. 3, the lift curves for a wing with and without laps are compared. Note that when the flaps are deflected, the lift curve shifts to the left, the value of $C_{L,max}$ increases, and the stalling angle of attack at which $C_{L,max}$is achieved is decreased. However, the lift slope remains unchanged; trailing-edge laps do not change the value of$\frac{\partial C_L}{\partial \alpha}$.

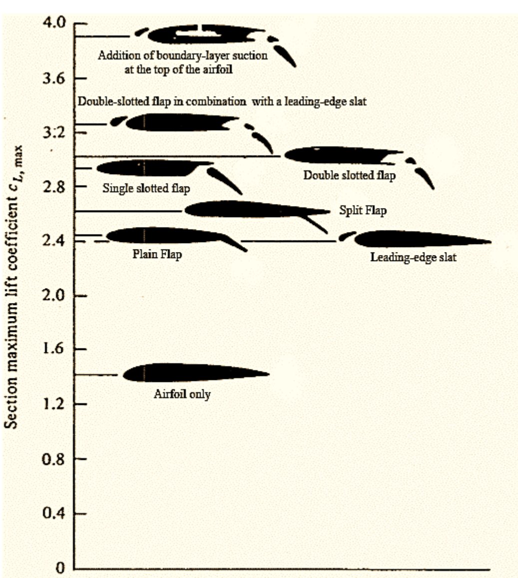


Figure 4 : Typical values of airfoil maximum lift coefficient for various types of high-lift devices

a) Range (R) and Endurance (E)

Range (R) is characterized by the maximum distance that an aircraft can travel with a full tank of fuel. Range is technically defined as the total distance (measured with respect to the ground) traversed by the airplane on a tank of fuel.All the way through20th-century aviation, range has been avital design factor, especially for transcontinental and transoceanic conveyors and for tactical bombers for the army. The range formula for jet airplane which gives a quick, practical estimate for range and which is generally accurate to within 10 to 20 percent is given by

$$R = 2\sqrt{\frac{2}{\rho_\infty S}}\frac{1}{C_t}\frac{C_L^{1/2}}{C_D}\left(W_0^{1/2} - W_1^{1/2}\right) \qquad (3)$$

From Eq. (3) that to obtain maximum range for a jet airplane, we want the following:

- Minimum thrust-specific fuel consumption c_t.
- Maximum fuel weight W_f.
- Flight at maximum $C_L^{1/2}/C_D$.
- Flight at high altitudes, that is, low ρ_∞.

Endurance (E) is defined as the entire time that an airplane stays in the air on a tank of fuel. In different applications, it may be desirable to maximize one or the other of these characteristics. The parameters that maximize range are different from those that maximize endurance. The formula for endurance is given by

$$E = \frac{1}{C_t}\frac{C_L}{C_D}\ln\frac{W_0}{W_1} \qquad (4)$$

From Eq. (4) that for maximum endurance for a jet airplane, we want:

- Minimum thrust-specific fuel consumption c_t.
- Maximum fuel weight W_f.
- Flight at maximum C_L/C_D.

b) Mathematical Formulation of Turbulance Model

Equations for mass and momentum are solver by the solver for all flows. In case of turbulent flow transport equations are also solved additionally. The equation representing the conservation of mass or continuity equation, can be written as follows:

$$\frac{\partial \rho}{\partial t} + \nabla\cdot\left(\rho\,\bar{u}\right) = S_m \qquad (5)$$

Eq. 5 is valid for incompressible as well as compressible flows which is the general form of the mass conservation equation. S_m is the source of the mass added to the continuous phase from the dispersed second phase (for instance, due to vaporization of liquid droplets) and any user-defined sources. Momentum conservation in an inertial reference frame can be described by Eq. 6

$$\frac{\partial}{\partial t}(\rho \bar{u}) + \nabla \cdot (\rho \bar{u}\,\bar{u}) = -\nabla p + \nabla \cdot (\bar{\bar{\tau}}) + \rho \bar{g} + \bar{F} \qquad (6)$$

where p is the static pressure, $\bar{\bar{\tau}}$ is the stress tensor (expressed below) and $\rho \bar{g}$ and $\bar{F}$ are the gravitational body force and external body forces , respectively. $\bar{F}$ contains additional model-dependent source terms like porous-media and user-defined sources as well. The stress tensor $\bar{\bar{\tau}}$ is given by:

$$\bar{\bar{\tau}} = \mu\left[\left(\nabla \bar{u} + \nabla \bar{u}^{\tau}\right) - \frac{2}{3}\right]\nabla \cdot \bar{u}\, I \qquad (7)$$

Where, μ is the molecular viscosity, I is the unit tensor, and the second term on the right hand side is the consequence of volume dilation.

The continuity equation for 2-D, steady and incompressible flow is given by:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial x} = 0 \qquad (8)$$

Fluent facilitates with various turbulent model having various characteristics suitable for various specific field of study. As stated earlier, no single turbulence model is generally recognized as being superior for all courses of problems. Choice of turbulence model depends on contemplations such as the physics incorporated in the flow, the conventional practice for a definite sort of problem, the level of exactness required, the obtainable computational resources, and the amount of time offered for the simulation. To make the most apposite choice of model for required work, one requires to comprehend the competencies and limitations of the various options. However, Douvi C. Eleni [2] shows in his study that the most accurate among Spalart-Allmaras Model, *k- ε* realizable Model and *k-ω* Shear Stress Transport (SST) Model, is *k-ω SST* Model for 2D NACA 0012 airfoil simulation process. Therefore, for this study *k-ω SST* Model is employed.

c) The k-ω shear stress transport (SST) model

The k -ω shear-stress transport (SST) model was proposed and developed by Menter [9] to effectively blend the vigorous and precise formulation of the k -ω standard model in the near-wall region with the free-stream liberation of the k -ω standard model in the far field. This is achieved by the conversion of the k -ω model into a k -ω formulation. The k -ω SST model is comparable to the standard k -ω model, but following enhancements are included:

- A blending function was multiplied to both of the standard k -ω model and the transformed k -ω model and then added together. In the near-wall region the blending function is one activating the standard k-ω model. Away from the surface it is zero, which activates the transformed k -ω model.
- A damped cross-diffusion derivative term is incorporated in the ω equation of SST model.
- The modified definition of the turbulent viscosity is used to account for the transport of the turbulent shear stress.
- The constants of modeling are made different.

These features make the SST k -ω model more accurate and reliable for a wider class of flows (e.g., adverse pressure gradient flows, airfoils, transonic shock waves) than the standard k -ω model. The SST k -ω model has a similar form to the standard k -ω model:

$$\frac{\delta(\rho k)}{\delta t} + \frac{\delta(\rho u_j k)}{\delta(x_j)} = P - \beta^{*}\rho\omega k + \frac{\delta}{\delta x_j}[(\mu + \sigma_k \mu_t)\frac{\delta k}{\delta x_j}] \qquad (9)$$

$$\frac{\delta(\rho\omega)}{\delta t} + \frac{\delta(\rho u_j \omega)}{\delta(x_j)} = \frac{\gamma}{\nu_t}P - \beta\rho\omega^2 + \frac{\delta}{\delta x_j}[(\mu + \sigma_\omega \mu_t)\frac{\delta\omega}{\delta x_j}] + 2(1-F_1)\frac{\rho\sigma_{\omega 2}}{\omega}\frac{\delta k}{\delta x_j}\frac{\delta\omega}{\delta x_j} \qquad (10)$$

Where,

$$P = \tau_{ij}\frac{\partial u_i}{\partial x_j}$$

$$\tau_{ij} = \mu t\left(2S_{ij} - \frac{2}{3}\frac{\partial u_k}{\partial x_k}\delta_{ij}\right) - \frac{2}{3}\rho k \delta_{ij}$$

$$S_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)$$

Turbulent eddy viscosity can be expressed as:

$$\mu_t = \frac{\rho a_{1k}}{\max(a_1\omega, \Omega F_2)}$$

Blending of inner (1) and outer (2) constant for each of the constants are done by:

$$\phi = F_1\phi_1 + (1 - F_1)\phi_2$$

Other functions are given by:

$$F_1 = \tanh(arg_1^4)$$

$$arg_1 = min\left[max\left(\frac{\sqrt{k}}{\beta^{*}\omega d}, \frac{500\nu}{d^2\omega}\right), \frac{4\rho\omega 2k}{CD_{kw} d^2}\right]$$

$$CD_{k\omega} = max\left(2\rho\sigma_{\omega 2}\frac{1}{\omega}\frac{\partial k}{\partial x_j}\frac{\partial\omega}{\partial x_j}, 10^{-20}\right)$$

$$F_2 = \tanh(arg_2^2)$$

$$arg_2 = max\left(2\frac{\sqrt{k}}{\beta^{*}\omega d}, \frac{500\nu}{d^2\omega}\right)$$

The model constants are:

$$\gamma_1 = \frac{\beta_1}{\beta^{*}} - \frac{\sigma_{\omega 1}\kappa^2}{\sqrt{\beta^{*}}} \qquad \gamma_2 = \frac{\beta_2}{\beta^{*}} - \frac{\sigma_{\omega 2}\kappa^2}{\sqrt{\beta^{*}}}$$

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

$\sigma_{k1}= 0.85$	$\sigma_{\omega 1}= 0.5$	$\beta_1= 0.075$
$\sigma_{k2}= 1.0$	$\sigma_{\omega 2}= 0.856$	$\beta_2= 0.828$
$\beta^{*}= 0.09$	$\kappa = 0.41$	$\alpha_1= 0.31$

III. Computational Method

The well documented airfoil, NACA 0012, is utilized in this study. As NACA 0012 airfoil is symmetrical, theoretical lift at zero angle of attack, AoA (α) is zero. In order to validate the present simulation process, the operating conditions are mimicked to match the operating conditions of NASA Langley Research Center validation cases [1]. Reynolds number for the simulations is $R_e=6x10^6$, the free stream temperature is 300 K, which is the same as the ambient temperature. The density of the air at the given temperature is $\rho = 1.225 kg/m^3$ and the viscosity is $\mu=1.7894\times10^{-5}$ kg/ms. Flow for this Reynolds number can be labelled as incompressible. This is a supposition close to reality and there is no necessity to resolve the energy equation. A segregated, implicit solver, ANSYS Fluent 12, is utilized to simulate the problem. The airfoil profile is engendered in the Design Modeler and boundary conditions, meshes are created in the pre-processor ICEM-CFD. Pre-processor is a computer program that can be employed to generate 2D and 3D models, structured or unstructured meshes consisting of quadrilateral, triangular or tetrahedral elements. The resolution and density of the mesh is greater in regions where superior computational accuracy is needed, such as the near wall region of the airfoil.

As the first step of accomplishing a CFD simulation the influence of the mesh size on the solution results should be investigated. Mostly, more accurate numerical solution is obtained as more nodes are used, then again using added nodes also escalates the requisite computer memory and computational time. The determination of the proper number of nodes can be done by increasing the number of nodes until the mesh is satisfactorily fine so that further refinement does not change the results. Fig. 5 depicts the variation of coefficient of lift with number of grid cells at stall angle of attack (16°).

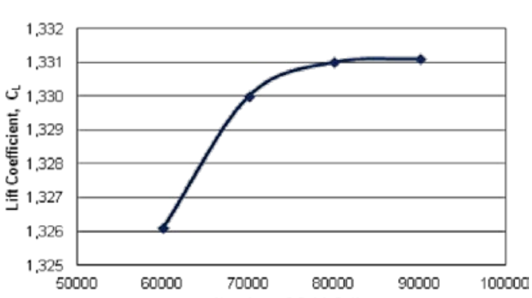


Figure 5 : Variation of lift coefficient with number of grid cells [2]

120000 quadrilateral cells with C-type grid topology is applied to establish a grid independent solution (Fig 6). From fig. 4 it is evident that 120000 cells are quite sufficient to get a stable and accurate result. Moreover, Douvi C. Eleni [2] was able to generate accurate results using only 80000 cells. The domain height and length is set to approximately 25 chord lengths. This computational model is very small compared to that of NASA's validation cases (fig. 7). Tominimize problems concomitant with the effect of far-field boundary (which can particularly influence drag and lift levels at high lift conditions), the far-field boundary in the grids provided have been located almost 500 chords away from the airfoil. But then again, simulation of NASA's specification of the large computational domain requires very high computer memory. Furthermore, far-field boundary contributes very little on the result.

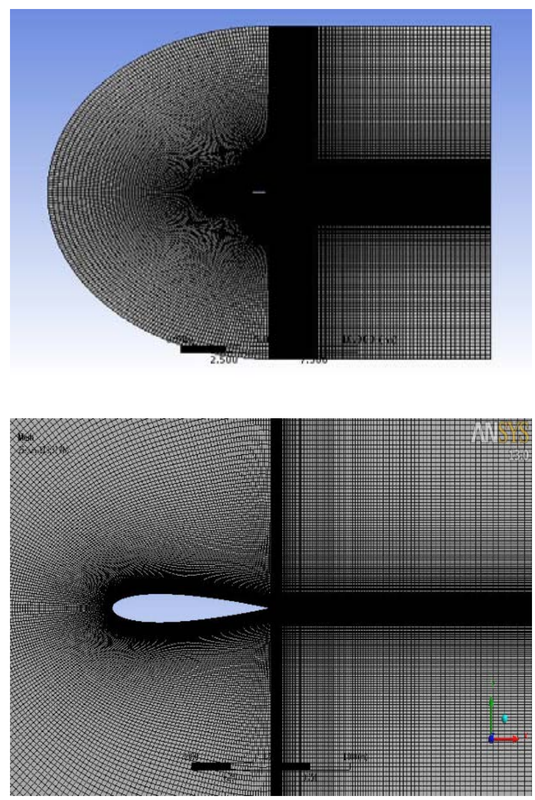


Figure 6 : Mesh of the computational domain around NACA 0012 airfoil (top) and closed detail to the airfoil (bottom)

Ansys recommends turbulence intensities ranging from 1% to 5% as inlet boundary conditions. In this study it is assumed that inlet velocity is less turbulent that pressure outlet.

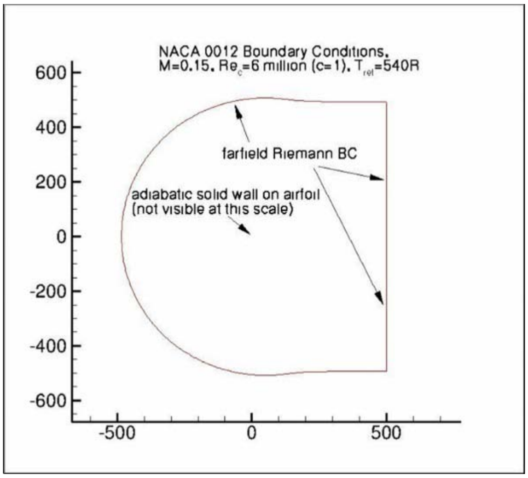
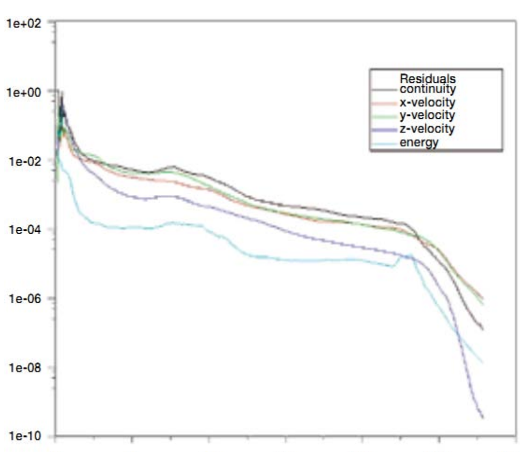
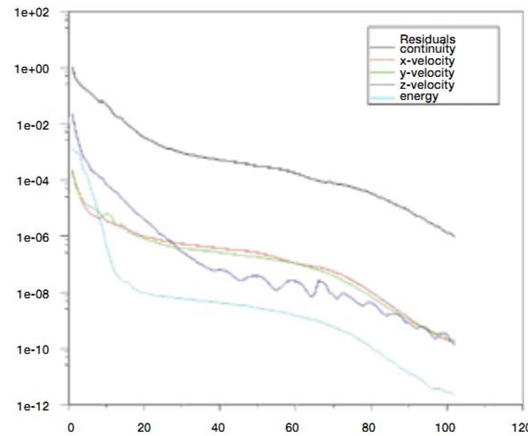


Figure 7 : Actual computational domain under NASA's experiment [1]

Hence, for velocity inlet boundary condition turbulence intensity is considered 1% and for pressure outlet boundary5%. In addition, Ansys also recommends turbulent viscosity ratio of 10 for better approximation of the problem. For accelerating CFD solutions two methods were employed on the solver. The pressure-based coupled solver (PBCS) introduced in 2006, reduces the time to overall convergence, by as much as five times, by solving momentum and pressure-based continuity equations in a coupled manner. In addition, hybrid solution initialization (fig. 8 (a) and 8 (b)), a collection of recipes and boundary interpolation methods to efficiently initialize the solution based purely on simulation setup, is employed — so the user does not need to provide additional inputs for initialization. The method can be applied to flows ranging from subsonic to supersonic. It is the recommended method when using PBCS and DBNS (density-based coupled solver) for steady-state cases in ANSYS Fluent 13.0. This initialization may improve the convergence robustness for many cases [6].



(a)



(b)

Figure 8 : (a) Standard Initialization, 279 Iterations (b) Hybrid Initialization, 102 Iterations [6]

IV. Validation of the Simulation Process

To validate the computational method stated earlier, results obtained by the 2D simulation of NACA 0012 for zero flap angle (δ) is compared with NASA's result. The lift curve, drag polar, pressure coefficient (C_P) curve (AoA 0, 10 and 15 degree) for present study is obtained and overlapped on the standard curves provided in NASA's website [1] to observe the fit of current study data. As NASA recommended the definition of the NACA 0012 airfoil is slightly altered so that the airfoil closes at chord = 1 with a sharp trailing edge. To do this, the exact NACA 0012 formula is used, then the airfoil is scaled down by 1.008930411365. The scaled formula can be written:

$$y = 0.594689181[0.298222773\sqrt{x} - 0.127125232x - 0.357907906x^2 + 0.291984971x^3 - 0.105174696x^4] \quad (1)$$

Moreover, fully developed turbulent flow is simulated in Fluent to match NASA's criteria. Variation of lift coefficient (C_L) with angle of attack (α) for the simulation can be observed from fig. 9.

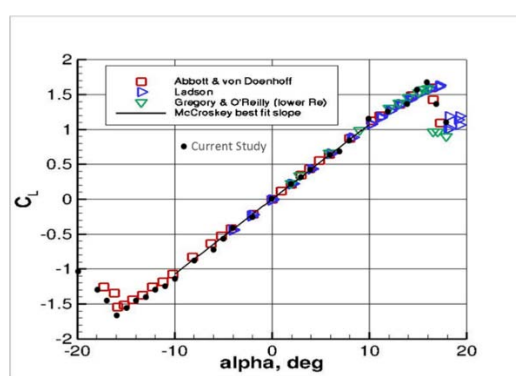


Figure 9 : Lift curve of NACA 0012 airfoil

From -16 degree AoA to 16 degree AoA the lift curve is almost linear. Throughout this regime no separation occurs and flow remains attached to the airfoil. At stall AoA lift coefficient is reduced drastically due to intense flow separation generation. Slight deviation from Abbott and Von Doenhoff's [7] unstripped experimental results occurs (almost 3%), as the computational domain of the current study is nearly 1/20th of the original computational domain under experiment of NASA.

Fig. 10 depicts the conformation of drag polar of current validation study with NASA's validation cases. Present study results tie reasonably well with Abbott and Von Doenhoff's [7] unstripped experimental results.

At zero angle of attack (AoA) surface pressure coefficients matches with all experimental data particularly well having slender deviations at the trailing edge of the airfoil (fig. 11). However, surface pressure coefficients for flow having AoA 10 degree and 15 degree appear to (fig. 12 and fig. 13) conform to data of experiment conducted by Ladson et al [8]. Leading edge upper surface pressure peak do not appear to resolve well in both cases. Additionally, present study depicts higher pressure than Ladson study [8] on the lower surface on the leading edge of the airfoil primarily due to assuming zero surface roughness of the wall.

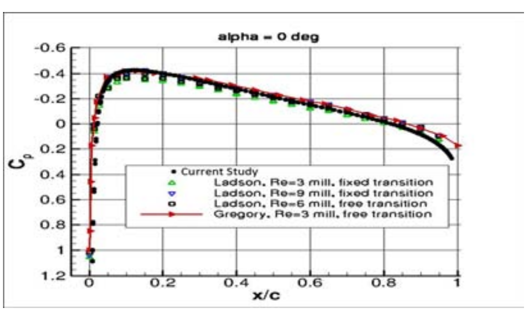


Figure 11 : Variation of pressure coefficient (C_P) for 0 degree AoA

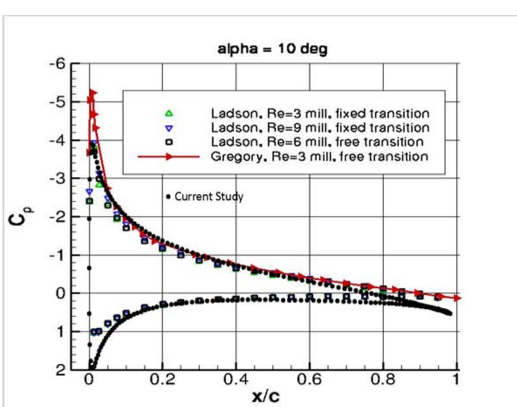


Figure 12 : Variation of pressure coefficient (C_P) for 10 degree AoA

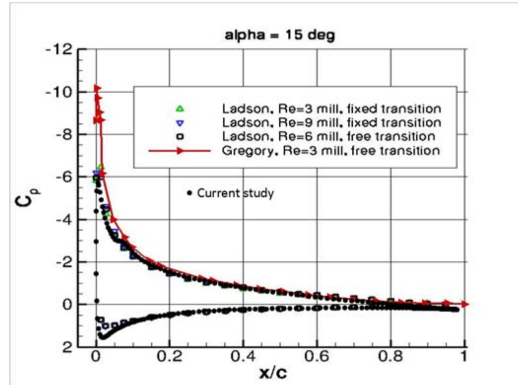


Figure 13 : Variation of pressure coefficient (C_P) for 15 degree AoA

Pressure and velocity contours along with streamlines for different AoA (α) are presented in a tabular form in fig. 15 (see appendix). As NACA 0012 is a symmetric airfoil, for zero AoA it can be observed that velocity profile, pressure profile and streamlines are also same on both upper surface and lower surface of the airfoil. As a consequence, lift generation is also zero for this case (fig. 9). However, with changing AoA the position of stagnation point also changes (fig. 14).

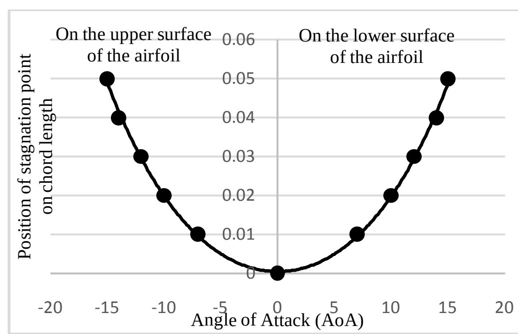


Figure 14 : Variation of stagnation point position with AoA

At stagnation point pressure is maximum and velocity is zero which is characterized by distinct red point on the velocity contour plots. It is also apparent that with positive AoA stagnation point moves toward trailing edge on the lower surface of the airfoil. This pressure deviation on the upper and lower surface of the airfoil principally creates significant amount of positive lift. Moreover, separation of flow is also evident at high angle of attack (α) from fig. 15 (see appendix). In turn this flow separation phenomenon creates another source of aerodynamic drag, called pressure drag due to separation. That is why high lift usually associates with high drag. Two major significances of separated low over the airfoil can be noted. The first is the loss of lift. The aerodynamic lift is derived from the net component of a pressure distribution in the vertical direction. When the flow is separated higher pressure is created on the top surface pushing the airfoil downward, thus creating less lift.

V. Results and Discussion

NACA 0012 airfoil having different flap angles (δ) was subjected to flow of varying Mach number (M). Flow having Mach number greater than 0.3 is considered compressible. Density based solver utilizing *k-ω* Shear Stress Transport (SST) modelin Fluent facilitates mimicking compressible flow over the body under experimentation very accurately. The resultant forces are typically resolved into two forces and moments. The component of the net force acting normal of the airfoil is lift force (F_L) and acting horizontal to the airfoil is drag force (F_D). The curves showing variation of lift coefficient (C_L) and drag coefficient (C_D) with different flap angles (δ) and Mach number (M) are analysed to realize the aerodynamic behaviour of plain flapped NACA 0012 airfoil. Curves of C_L/C_D and $\sqrt{C_L}/C_D$ are analysed further, as these are crucial factors affecting range (R) and endurance (E) of aircrafts. However, flow at high flap angles (δ) (i.e. 30, 40 and 50 degrees) are very unstable and it remains unconverged even after 5000 iteration in Ansys Fluent flow solver. Hence, flow for flap angle (δ) 30, 40 and 50 degrees are slightly erratic.

At fig. 16 variation of lift coefficient (C_L) with Mach number (M) can be observed. Higher lift coefficient (C_L) is obtained for higher flap angles (δ) at any Mach number (M). However, atypical behavior of the curves are evident at increasing Mach number (M). Lift coefficient (C_L) escalates with increasing Mach number (M) but a dramatic downslope is obtained at free-stream velocity (V_∞) approaching to sonic velocity. When Mach number (M) is in between 0.8 to 1.2, the flow is said to be transonic which is characterized by some very complex effects. This problem of drastic increasing in drag coefficient (C_D) (fig. 17 and 18) and decreasing in lift coefficient (C_L) can be dealt by using thin airfoil or supercritical airfoil. A rise in critical Mach number (M_{cr}) usually means an upsurge in the drag-divergence Mach number. Hence, before encountering drag divergence a transonic airplane having a thinner airfoil can fly at a higher Mach number if everything else being equal.

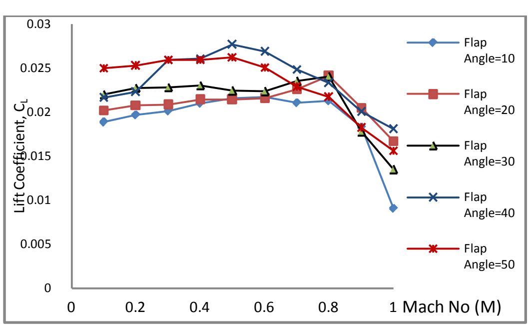


Figure 16 : Variation of lift coefficient (C_L) with Mach number (M) for different flap angle (δ)

The drag coefficient (C_D) remains somewhat constant at low Mach number (M). But, very sudden and dramatic escalation is observed when Mach number (M) approaches to unity (fig. 17). This phenomenon can be also observed in fig. 18 which depicts variation of drag coefficient (C_D) with Mach number (M). However, fig. 18 is attained for zero angle of attack (AoA). As in this study flap angle (δ) is varied, the virtual AoA is also changed (fig. 2). As a result, fig 17 gives dissimilar outcomes form fig. 18 to some extent.

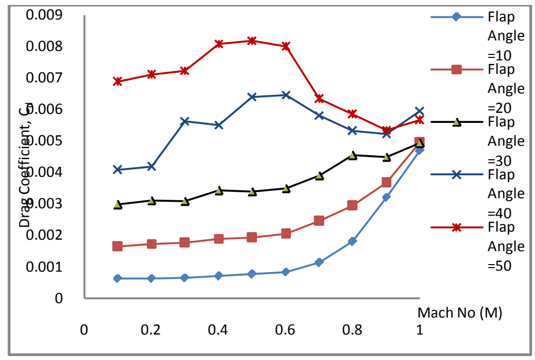


Figure 17 : Variation of drag coefficient (C_D) with Mach number (M) for different flap angle (δ)

The airfoil subjected to the flow passes through three distinct phases with Mach number (M) represented by point a, b and c in the fig. 18. At point a, free stream Mach no is characterised by $M_\infty < M_{cr}$. The physical mechanism in this flow condition can be observed from fig. 19a. Maximum velocity occurs on the upper surface of the airfoil which is well less than the sonic velocity. Usually in these cases, for zero AoA, drag coefficient remains constant, but flap angle of 10 degrees causes slight separation at the trailing edge of the NACA 0012 airfoil. This results rise in drag coefficient with Mach number (M) even at low Mach number (M) flow condition.

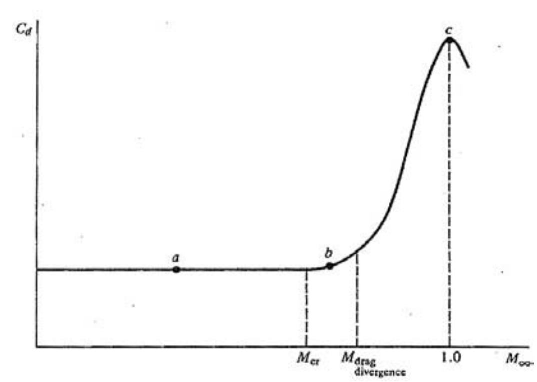
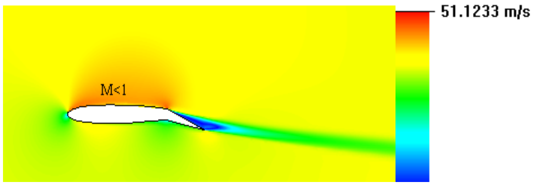
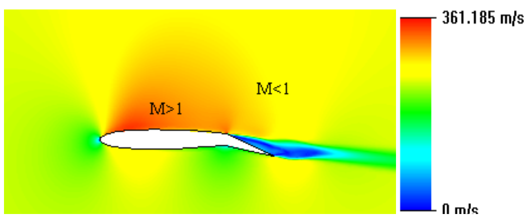


Figure 18 : Variation of drag coefficient (C_D) with Mach number (M)

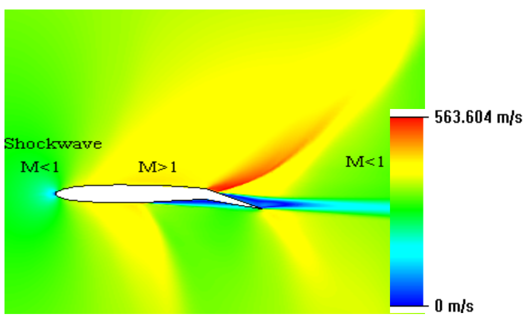
In fig. 18, b is the point where M is increased slightly above M_{cr} and drag coefficient starts to escalate very rapidly. A supersonic bubble forms on the upper surface of the airfoil having Mach number (M) greater that unity (fig. 19b) and surrounding by minimum pressure point. However, even at this point drag coefficient remains reasonably low.



(a)



(b)



(c)

Figure 19 : Physical mechanism of drag divergence in Fig. 17 for 20 degrees of flap angle (δ) (a) Flow field at point, a (b) Flow field at point, b (c) Flow field at point, c

Fig. 17 suggests for flow around airfoil having flap angle (δ) 10, 20 and 30 degrees maximum drag coefficient happens at sonic velocity (i.e. M=1.0). Fig. 18 also depicts the same trend at point c. The physical mechanism can be well perceived from fig. 19c where presence of shockwave is depicted. Shock waves themselves are dissipative occurrences, which results in an escalation in drag on the airfoil. Moreover, sharply increase of pressure across the shock waves creates an adverse pressure gradient, causing the flow to separate from the surface. This flow separation also contributes to the drag substantially. However, with high flap angles (δ) (i.e. 40 and 50) this trend occurs somewhere at Mach 0.5 (fig. 17). This is mainly due to increasing flap angle (δ) associates with increasing frontal area of the airfoil.

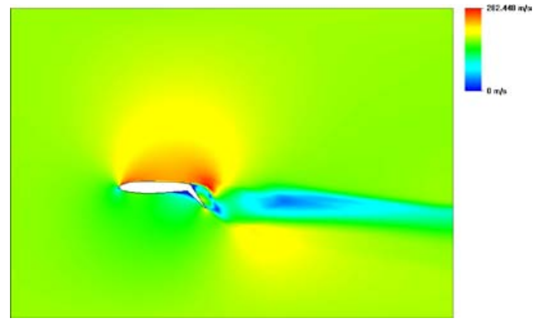


Figure 20 : Velocity contour for 50 degrees of flap angle (δ) at 0.5 Mach number (M)

Due to this reason very intense amount of flow separation occurs even at low Mach number (M) (fig. 20). Moreover, the increase in flap angle also increases the effective thickness of the airfoil. Hence, airfoil having higher flap angle experiences drag divergence even at lower Mach number (M) (fig. 21).

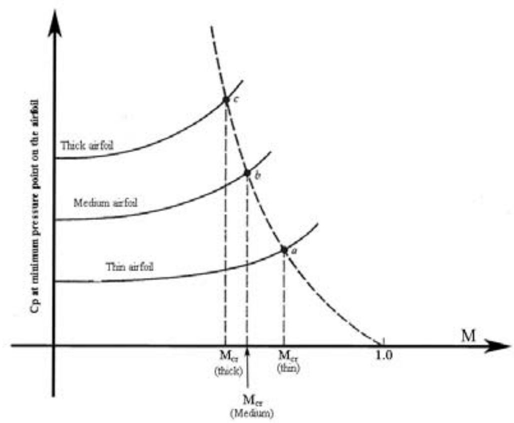


Figure 21 : Critical Mach number (M_{cr}) for airfoils of different thickness

Fig. 21 depicts variation of Critical Mach number (M_{cr}) with thickness of airfoil. Thick airfoil encounters critical Mach number (M_{cr}) which is well less than M_{cr} for thin airfoil. Hence, the point where rapid increase of drag coefficient (C_D) occurs is well before the Mach number 1.0 for thick airfoils.

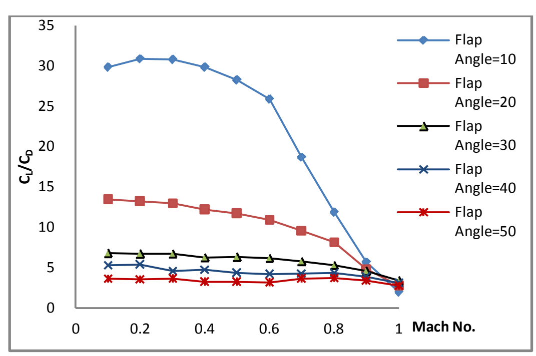


Figure 22 : Variation of C_L/C_D with Mach number (M) for different flap angle (δ)

The alteration of C_L/C_D with Mach number (M) can be observed from fig. 22. As, variation of $\sqrt{C_L}/C_D$ with Mach number (M) is patently same as fig. 22, it has not shown here. For a definite flap angle (δ) higher range (R) and endurance (E) are attainable at low Mach number (M), as C_L/C_D is decreasing with increasing Mach number (Eq. 3 and Eq. 4). However, for higher flap angle range (R) and endurance (E) remains somewhat constant or fluctuates in a negligible manner. At a certain Mach number (M) higher range (R) and endurance (E) is available at lower flap angle. At lower flap angles (δ) separation of flow is relatively low compared to higher flap angles (δ) which results a greater lift coefficient (C_L) corresponding to a lower drag coefficient (C_D).

VI. Conclusions

Present study divulges behavior of NACA 0012 airfoil at different flap angles (δ) and Mach numbers (M). The *k-ω* Shear Stress Transport (SST) model is used to simulate NACA 0012 non-flapped and plain flapped airfoil, as it was mostly recommended by Douvi C. Eloeni [2] for airfoil study.Using the methodology of current study with 120000 cells, a very negligible deviation of 2% - 3% from NASA validation cases are obtained. High flap angles (δ) results higher lift but it also increases drag very significantly. Study shows increased flap angle increases effective thickness. Hence, drag divergence ensues at considerably lower Mach number (M) for wing having high flap angles which further results a speed limitation for aircrafts during lift-off. Moreover, it is also evident that range (R) and endurance (E) increases with decreasing flap angles (δ). Moreover, for each flap angle (δ) range (R) and endurance (E) decrease with increasing Mach number (M).However, for higher flap angles somewhat constant range and endurance is obtained for increasing Mach number. This comprehensive study willfacilitate efficient design of wing sections of aircrafts and an optimized flight.

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Appendix

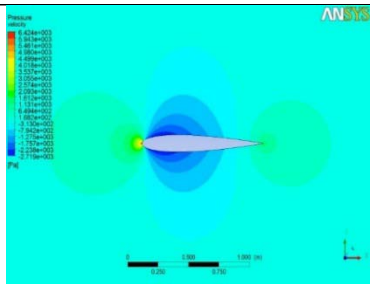
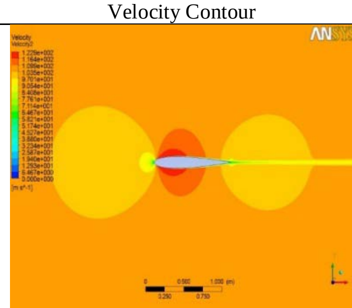
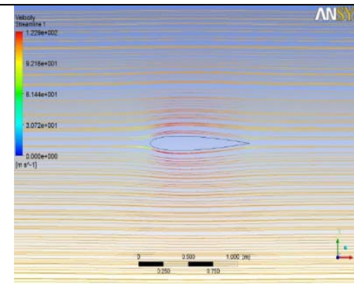
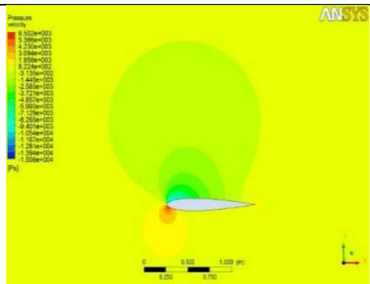
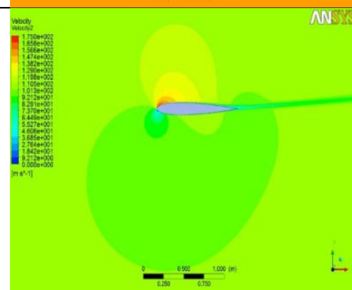
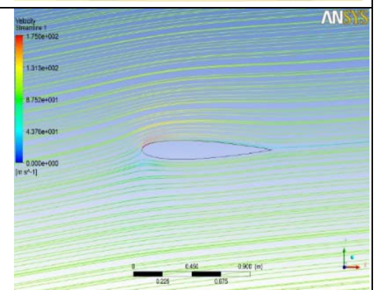
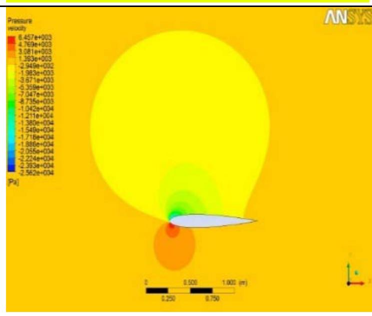
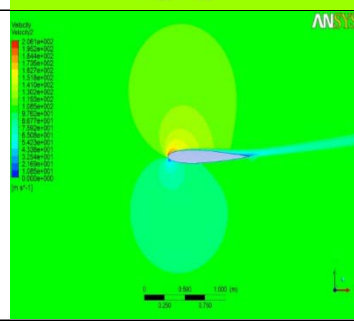
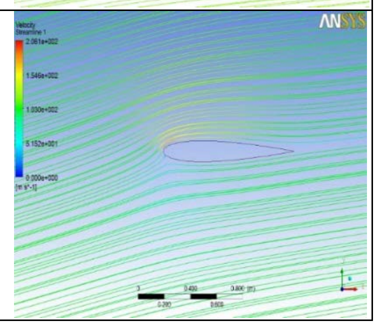
AoA (α)	Pressure contour	Velocity Contour	Streamlines
0 (zero) deg.			
10 deg.			
15 deg.			

Figure 15 : Velocity, pressure contours and streamlines formed around NACA 0012 airfoil for different AoA

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Identification and Characterization of Hazardous Road Locations on Dhaka-Chittagong National Highway

By Monisha Alam & Hasib Mohammed Ahsan
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Abstract- Road safety problem draws significant attention in a developing country like Bangladesh where road accidents are extremely high. It is estimated by AAA that among eight national highways, over 14% fatal accidents occur on only Dhaka – Chittagong highway, a major transportation artery in Bangladesh. The study was intended to identify the accident-prone locations commonly termed as Hazardous Road Locations on Dhaka – Chittagong highway. The accident data were collected from the database of Accident Research Institute, Bangladesh University of Engineering & Technology, using the Microcomputer Accident Analysis Package Five (MAAP5) software. The Geographic Information System was used as a tool to identify the HRL on Dhaka – Chittagong highway. A total of 35 segments were identified as HRL on Dhaka – Chittagong Highway. This research work comprises the detail accident analysis of one segment on Dhaka – Chittagong Highway which is identified as the most hazardous among the 35 HRL.

Keywords: hazardous road locations, dhaka-chittagong highway, geographic information system, accident, road safety.

GJRE-J Classification : FOR Code: 0

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I. Introduction

Every year more than 1.17 million peoples die in road crashes around the globe [1, 5]. The "Study Global Burden of Disease" undertaken by the World Health Organization (WHO), showed that traffic accidents were the world's ninth biggest cause of deaths during 1990. The study forecasts that by the year 2020, road accidents would move up to third place in the table of major causes of death and disability [1]. Bangladesh has been found as a country in high risk in terms of number of accidents among the South Asian countries. Bangladesh has one of the highest fatality rate in road accidents higher than 73 deaths per 10,000 registered motor vehicles every year [2]. The national loss due to road accident is estimated to be about 15 billion taka i.e., US$ 300 million [3, 4]. A recent road traffic accident report shows that nearly 50% [2] of all accidents occur on National Highways of which 75.5% are fatal. The Dhaka-Chittagong Highway (N1) is a main transportation artery in Bangladesh, linking the country's two largest cities, Dhaka, the capital of Bangladesh and Chittagong, our business capital. Although it is an important link in national economy, traffic accident rates are very high on this corridor. In 2007, among all national highway accident records, 14% fatal accidents occurred on N1 (6). Very limited study has been done considering the issue of quantitative assessment of the factors involved in traffic accident for Dhaka-Chittagong highway. On this road network, accidents have been shown not to be completely randomly distributed but to be clustered at certain locations. These are the hazardous road locations (HRL). Hazardous road locations are identified as the locations which experiences abnormal frequencies, rates and severities of accident. The period used to identify hazardous road locations varied between 1 and 5 years. In identifying the Hazardous Road Locations (HRL) on Dhaka – Chittagong Highway, the accident database of the Accident Research Institute (ARI) BUET is a rich one. The Microcomputer Accident Analysis Package Five (MAAP5) software helps to obtain the data from the accident database. But these accident databases are usually in the form of linear record file system, which lacked visibility, which is essential for better understanding and good decision making. Geographic information system (GIS) has been identified as an excellent system of linking a large number of separate databases. GIS is also a potential tool for producing maps which provide a clear and immediate impression of the accident distribution on the road network, identifying those locations that have accident concentrations. Several techniques of identification of Hazardous Road Locations have been established but GIS has been applied to display such locations and to analyze problematic cases.

II. Analysis

The study was conducted on Dhaka – Chittagong National Highway. Dhaka – Chittagong Highway has a large volume of traffic. N1 has a bypass and there are three major bridges on this highway which are the Meghna Bridge, the Gomoti Bridge and the Third Karnaphuli Bridge, which is an extra dosed Cable Straight Bridge.

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a) Reason behind the Selection of Dhaka – Chittagong Highway as Study Area

This study has been taken on Dhaka – Chittagong highway. This route has been taken critically on two important issues for those it bears a serious effect on not only country economy but also on human lives. The reasons behind the selection of this study area are as follows:

- ➢ High volume of traffic on Dhaka – Chittagong Highway
- ➢ High rate of accidents on Dhaka – Chittagong Highway

Dhaka – Chittagong Highway is one of the busiest national highways in Bangladesh. High volume of traffic travels through this highway. On the other hand it is a main transportation artery in Bangladesh which connects the capital city Dhaka with the business capital of our country, Chittagong. It is the most profitable linkage road which has become a death trap due to its narrowness and the rise in vehicles over the years. Chittagong port is the only natural port in the world having a very fine navigation and has a tremendous strategic geographic advantage which can contribute immensely to the country to become an ideal global trade and business pivot. Recently works have been started to convert the Dhaka-Chittagong Highway into a four lane highway which will cause a significant increase in traffic volume on this highway. Selection of Dhaka-Chittagong Highway as the study area also has been done due to its high frequency rate of accidents among all national highways in Bangladesh. In near future, the accident rate is supposed to be increase further due to rise in traffic volume as the highway will be a four lane highway and also because of the improvement works of Chittagong port.

b) Accident Data Analysis Using MAAP5 and GIS

The accident analysis was done on Dhaka – Chittagong National Highway by analyzing six years accident data from the year 2004 to 2009. The accident data was collected from the MAAP5 database of Accident Research Institute (ARI) of Bangladesh University of Engineering and Technology (BUET). The Hazardous Road Locations (HRL) were identified by analyzing total and fatal accident data on the highway. Accident data was analyzed at every 100 meter interval on the road. The locations which have three or more fatal accidents and/or five or more total accidents during the six year time period have been identified as HRL.

The procedure followed in identification of HRL on Dhaka-Chittagong highway is divided into several steps. The steps are the following:

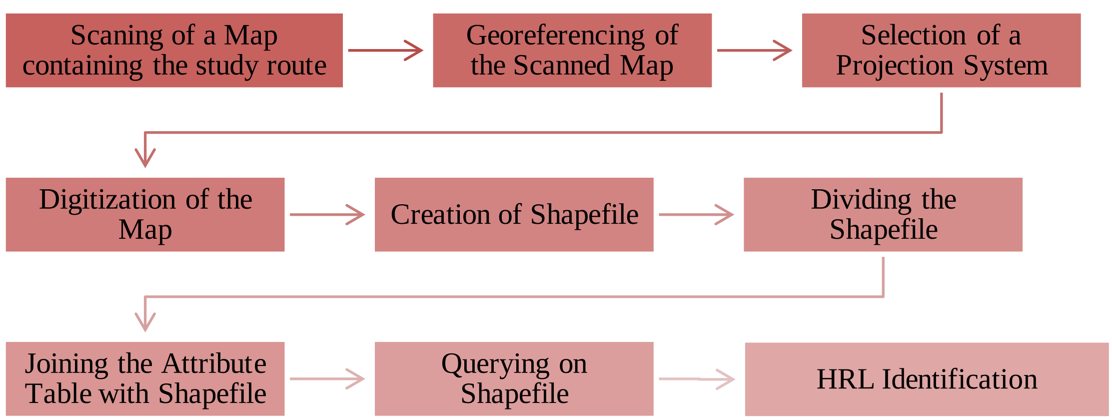

Figure 1 : Steps followed in GIS for HRL identification

The GIS maps of the total and fatal accidents are shown below:

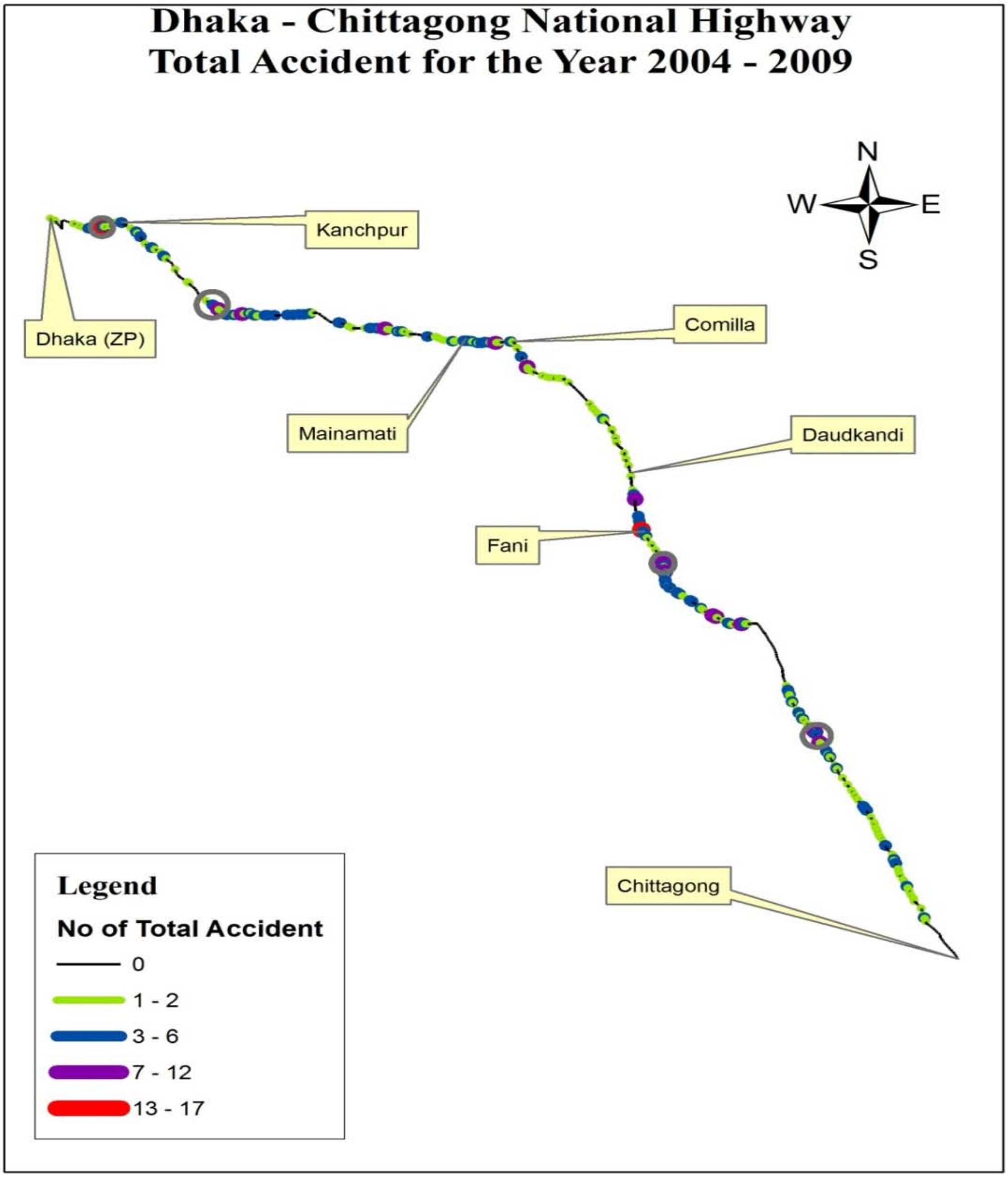

Figure 2 : Total Accidents for the year 2004 to 2009 on Dhaka – Chittagong National Highway

Figure 2 shows the total accidents occurred on Dhaka-Chittagong National Highway during the six years time period. The Hazardous Road Locations on the highway are easily identified from this map.

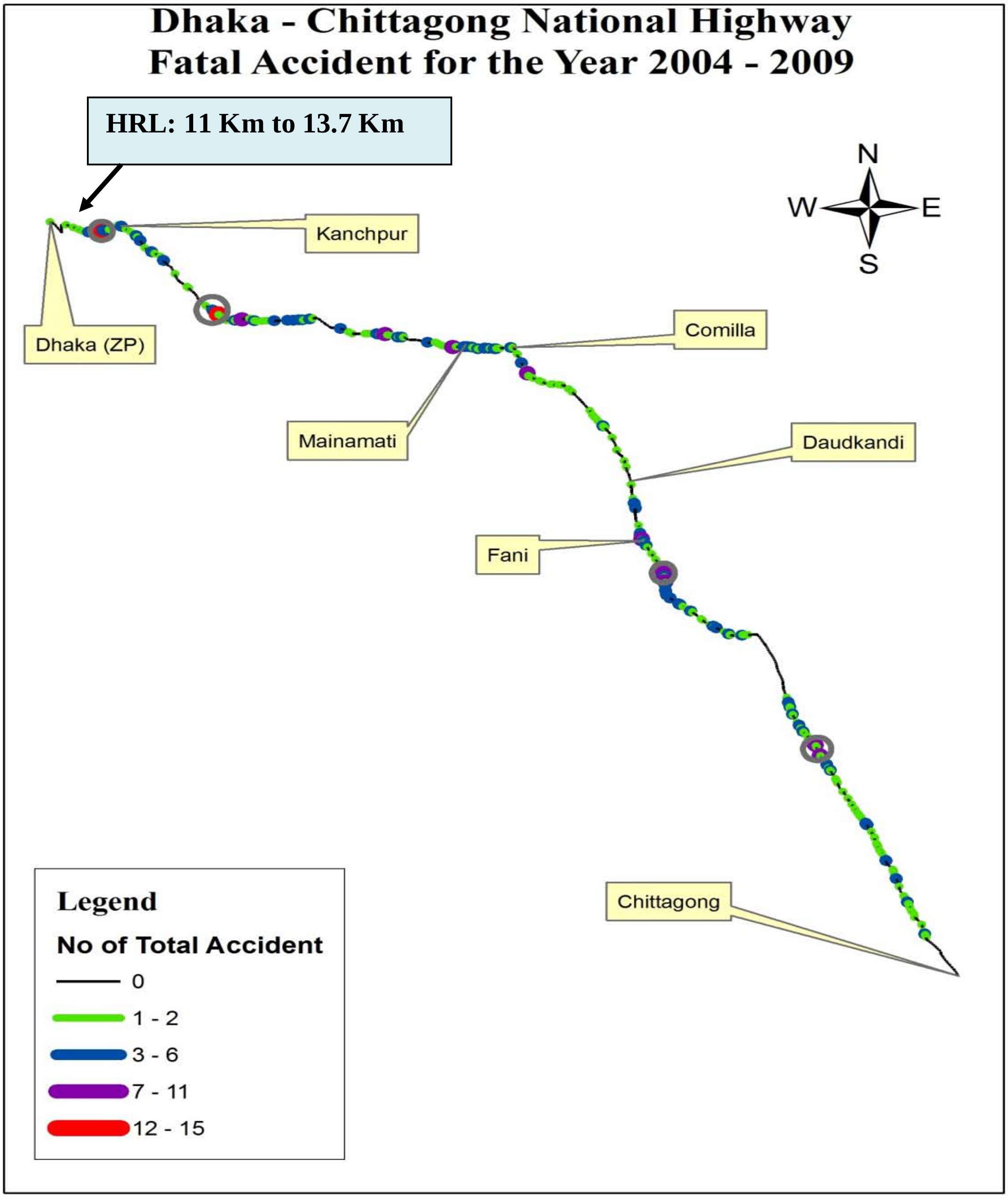

Figure 3 : Fatal Accidents for the year 2004 - 2009 on Dhaka – Chittagong National Highway

The above two figures clearly show that the maximum number of accidents on Dhaka–Chittagong National Highway during 2004 to 2009 are occurring repeatedly in the following areas:

- Kanchpur
- Daudkandi
- Mainamati
- Fani

From the GIS maps, 35 locations on Dhaka-Chittagong highway which have been identified as HRL are listed below in Table 1:

Table 1 : Hazardous Road Locations on Dhaka-Chittagong Highway (2004-2009)

Segment (Km)	Total Accidents	Fatal Accidents
9 – 10.9	9	7
11 – 13.7	46	41
20 – 21.9	11	9
26 – 27.9	8	7
40 – 43	35	32
46 – 48	19	14
50 – 53	21	14
58 – 60	17	15
66 – 69	9	7
72 – 73.9	21	17
74 – 77	24	18
86 – 87.9	17	11
88 – 91	24	19
94 – 95.9	22	8
104 – 105.9	13	10
122 – 123.9	22	19
146 – 148.1	19	13
148.2 – 149.9	23	15
150 – 151.9	9	8
156 – 158	43	30
158.1 - 160	24	16
160.2 – 161.9	12	7
162 – 163.9	10	6
164 – 166.2	18	9
164 – 166.2	18	9
172.3 – 173.9	21	15
178 – 179.9	21	16
198 – 200	13	12
202 – 205.1	15	13
207.2 - 210	29	24
212 – 213.9	14	12
224 – 227	20	15
232.8 – 235.4	12	10
237.9 - 240	17	15
244.4 – 247.4	11	9
252.4 – 258.9	8	6
Total	840	675

Among these 35 segments, the four most vulnerable segment have been selected on the basis of the highest number of accidents occurred during the analysis period. This most hazardous location have been highlighted in the table. This accident prone zone is located in the Kachpur area on Dhaka-Chittagong highway. The details accident analysis on this HRL is done.

c) Accident Characteristics on the Selected Segment

From the data analyzed, the most hazardous location identified is a 2.7 km long segment which is from 11.0 km to 13.7 km from Dhaka zero point. At the starting of this portion of the road there is a petrol pump and at the end of the segment a spinning mill is located. The figure 4(a) shows the total number of accidents and the number of fatal accidents on this area is shown in figure 4(b).

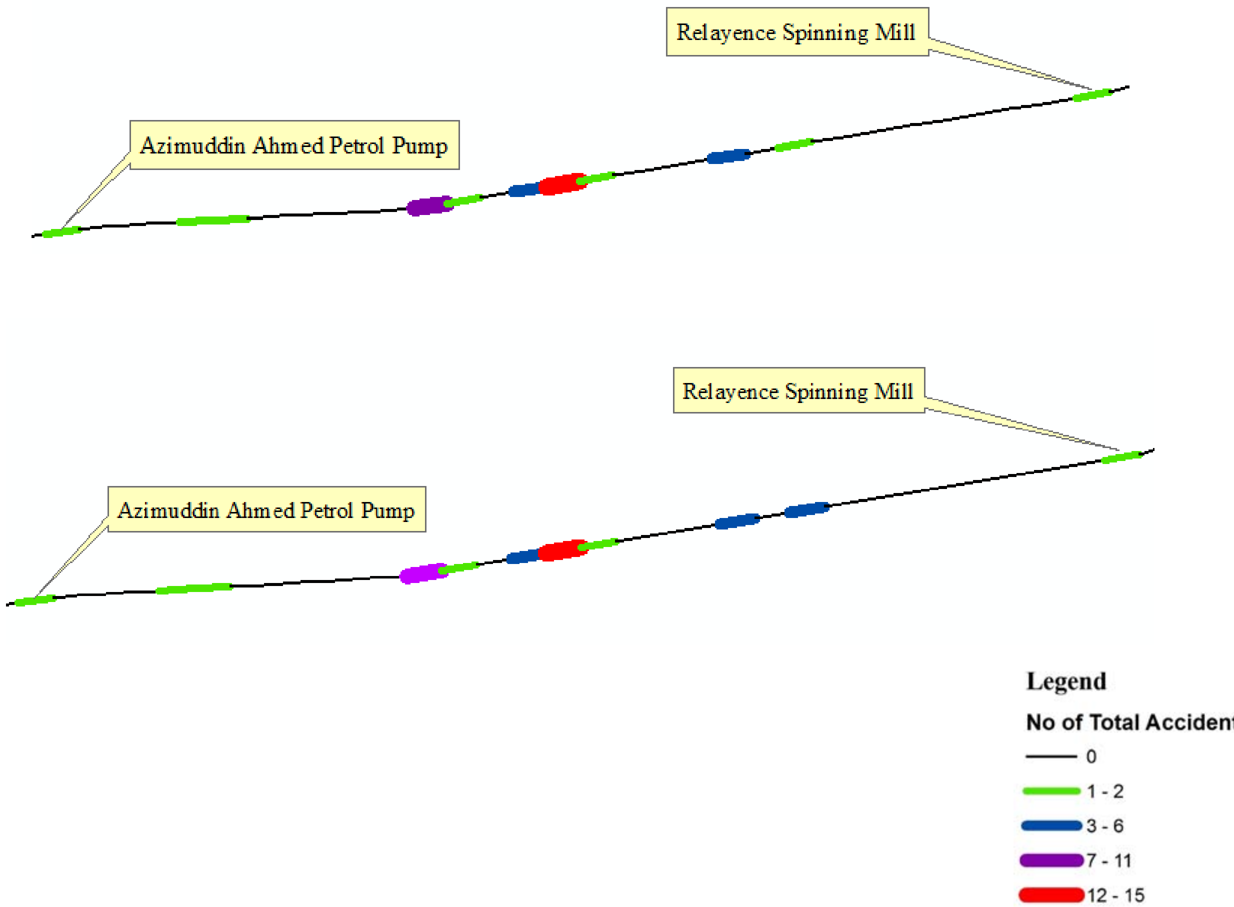

Figure 4 : (a) Total and (b) Fatal Accidents on the selected HRL during the year 2004 – 2009

The accident characteristics of the HRL are discussed below.

i. *Number of Accidents*

Figure 5 shows the number of total and fatal accidents on various kilometer posts on the segment from 11.0 km to 13.7 km.

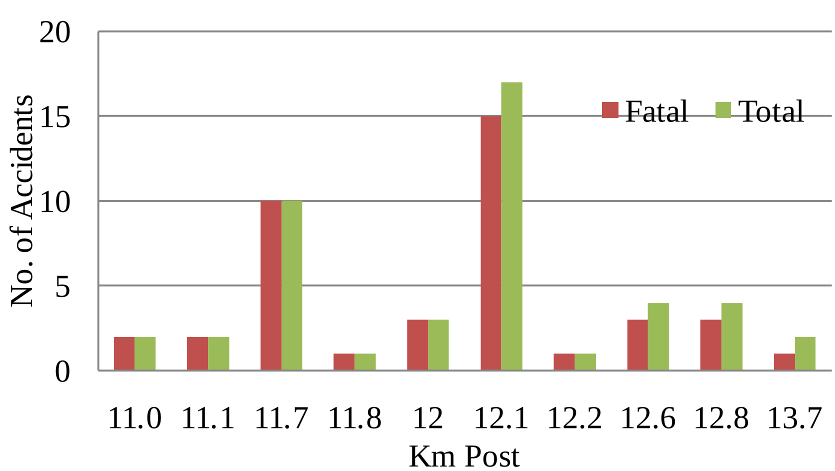

Figure 5 : Total Accidents vs. Fatal Accidents on various km posts on the selected HRL

This road segment lies between a petrol pump and a spinning mill. So, a large number of vehicles as well as pedestrians use this segment every day. So, the number of accidents is very high in this location. In Figure 6, it is clearly identified that accidents are concentrated on the 12.1 km post. About 37% of the total accidents occurred on this point only. It is also found that shows that the majority of the accidents are fatal. So, in consideration of the number of the total and fatal accidents, this segment is a vulnerable one.

The Driver, passenger and pedestrian casualties are analyzed. From figure 6, it is found that pedestrians are the most vulnerable group in road accidents on this segment. Passengers are next to the pedestrians facing severe casualties.

ii. *Casualty*

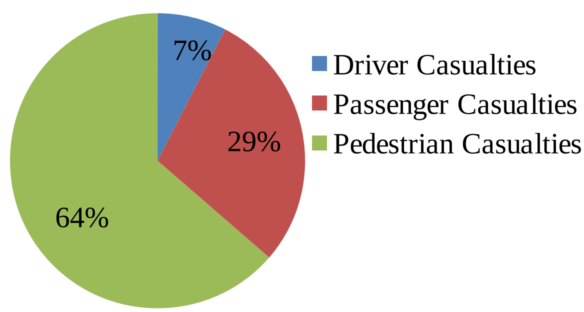

Figure 6 : Casualties occurred on the selected HRL

iii. *Type of Collision*

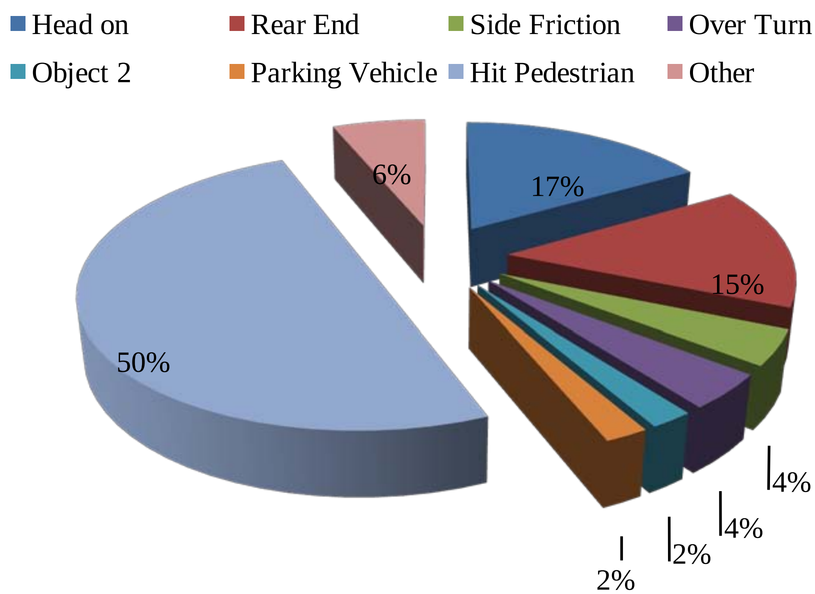

Figure 7 : Collisions occurred on the selected HRL

The figure 7 shows that the maximum collisions occurred on this segment are Hit Pedestrian. So, the pedestrians face the maximum casualty.

iv. *Light Condition*

Since the local traffic as well as the trough traffic are high during the day time, accidents occur frequently at this time. Table 4 represents that phenomenon.

Table 4 : Number of accidents at various Light Conditions on selected HRL

Km Post	Day	Dawn Day	Night Lighted	Night Unlighted
11.0	1	1	0	0
11.1	1	1	0	0
11.7	5	1	1	0
11.8	0	1	0	0
12	0	1	0	0
12.1	12	3	4	2
12.2	1	0	0	0
12.6	1	1	1	0
12.8	2	1	0	1
13.7	1	0	0	0
Total	24	10	6	3

v. *Types of Vehicles Involved*

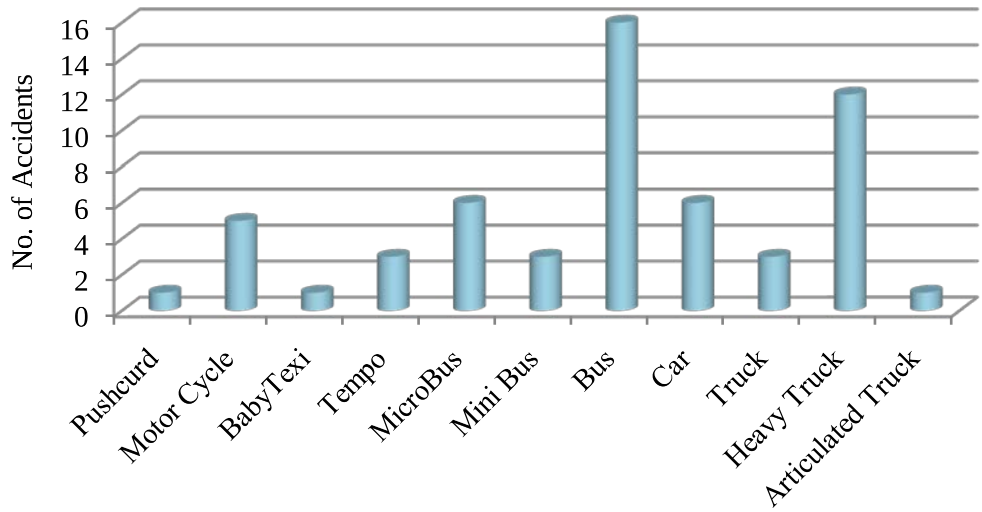

Figure 8 : Involvement of Vehicles in Accidents on the selected HRL

We can see from figure 8 that, a number of vehicles are involved in accidents on this segment. Among those, buses, trucks, cars, micro buses are predominant type of vehicles.

vi. *Contributory Factors*

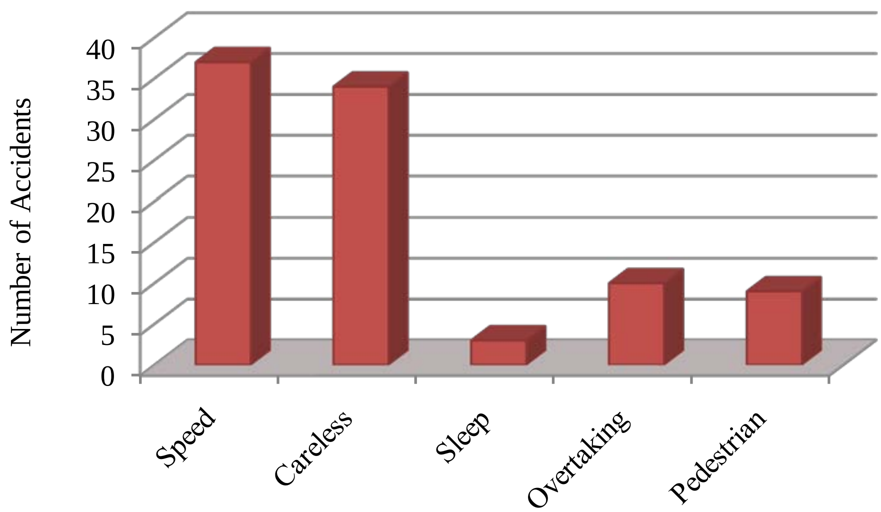

Figure 9 : Involvement of Vehicles in Accidents on the selected HRL

Figure 9 shows the factors contributing mostly in accidents on the selected HRL. It is found that over speed and carelessness of driver are the major causes of accidents.

vii. *Accident Trend*

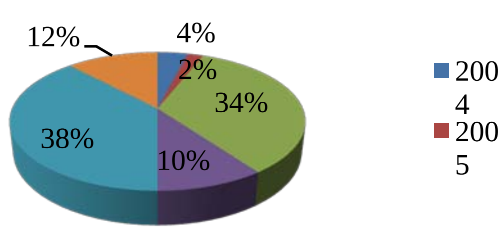

Figure 10 : Yearly Distribution of Accidents on the selected HRL

The rate of accidents at each year during the six years interval from 2004 to 2009 is shown in figure 10. It is seen from this figure that the accidents do not follow any fixed trend. Highest number of accidents occurred on segment during the year 2008 and the minimum number of accidents occurred in 2004. So, it is clear that accident rate is increasing in recent times.

III. Results and Discussion

After conducting the detail study, it has been found that a total of 840 accidents have occurred on Dhaka – Chittagong Highway during the six year duration from 2004 – 2009 and 675 accidents among the total accidents are fatal. So, it is clearly visible that about 80% of the accidents are fatal accidents which have caused severe casualty and loss to life as well as the economy of our country.

The GIS maps prepared from analyzing the six years accident data from 2004 to 2009 have shown that 35 locations on Dhaka – Chittagong National Highway are hazardous. One of the most important features is that although the hazardous locations have been found in the entire portion of the highway, the highest accident rates have been found in the first 77 km length of Dhaka-Chittagong highway. About 31% of the total accidents occurred in this portion of Dhaka-Chittagong highway. So it has been clearly identified that accidents are concentrated on this portion of the Dhaka – Chittagong Highway and this portion requires proper treatment and remedial measures to decrease the higher accident rates and improve the road traffic condition.

One segments on Dhaka-Chittagong Highway have been selected from all the 35 hazardous locations on the basis of the highest number fatal accidents. Details accident analysis on this segment on various parameters has given the following accident scenario.

- About 70% to 90% of the total accidents are fatal
- Pedestrian casualties occur in 50% to 60% accidents whereas passenger casualties occur in 35% to 41% accidents and driver casualties occur in only 10% to 15% accidents
- Hit pedestrian (40% – 50% fatalities) is the most dominating collision type
- About 80% - 85% of the total accidents occur during day time, where only 16% - 20% accidents occur in night and dawn.
- Buses (30%-37% casualties) and trucks (25%-30% casualties) are mostly responsible for accidents. Cars are responsible for about 20% accidents whereas involvement of cycle and baby taxi is negligible
- Speed (75% to 80% fatalities) and carelessness (80% to 90% fatalities) contribute mostly in accidents on the four segments.

IV. Conclusion

The recommendations based on the findings of the study are discussed here. Some more general recommendations have been also provided. Further site study is required to design appropriate remedial measures.

- The rate of fatality is very high on the HRL on Dhaka-Chittagong National Highway. So immediate site investigation should be done on all the hazardous road locations identified in our study.
- Over speed and careless attitude of the drivers are the two most contributory factors of accidents on the highway found in the study. So adequate enforcement should be provided to ensure that the drivers follow the traffic rules strictly.
- Pedestrians are the most vulnerable group facing the highest rate of casualty on the studied segment. So, reduction of the pedestrian casualty is a must. To do that some facilities for the pedestrians such as overpass, underpass, zebra crossing, pedestrian signal etc should be provided where required.
- The identified most hazardous location on the studied route is near a bridge. So, proper attention should be given on the nearby locations of the bridge to reduce the accident frequency.
- Head on collision is one of the dominating collision types on the selected HRL of the highway. Undivided highway, reckless overtaking are the main causes of head on collision. Speed variation is the main cause of rear end collision. So exclusive lane for non motorized vehicles may reduce rare end collision.
- Buses and trucks are the vehicles responsible for the highest number of casualties. So dangerous and inappropriate operation of heavy vehicles should be prohibited strictly to reduce accidents on the hazardous locations of Dhaka-Chittagong highway.
- As our study results show that most of the accidents occur during day time, so drivers should have safe attention while driving during day time and also at night.
- As during our study, some errors have been found in the accident data, so the accident database should be improved. Upgrading MAAP5 software from DOS to windows version can be an effective measure.

Recently the Dhaka-Chittagong highway is being converted to a four-lane highway, which will turn its operation more complicated and hazardous. So the necessary remedial measures should be provided immediately to ensure the safe and efficient operation of Dhaka-Chittagong Highway.

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The Oil Transition Time, and the use of Biofuels and Solar Energy as Optimal Clean Energy on Right Time

By Dr. Luis Barrera Aguilar, Master Narciso Xicohtencatl Rojas, Master Horacio Lima Gutierrez, Dr. Saul Tlecuitl Beristain & Dr. José Pablo Nuño de la Parra

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Abstract- In the time when the energy from oil is in transition, and exist the shale gas as energy option for the next years, but the shale gas is not consider clean energy, and the need to reduce environmental pollution, we lead to use the biofuels and solar energy as the options to combat the environmental problem by reducing pollution and search the sustainability systems for that solution, because the both systems are from nature process , and on the other side we want clean energy , savings and better quality of life, but is important consider factors for the successfully implementation, in reality is not easy implement all ideal measures, without consider the optimal conditions for follow the sun, such as solar Tracking system or the optimal mix of hybrid systems on the use of biofuels and solar energy as clean energy solution.

But is important consider that in not all countries, the biofuels is the best solution, such as the case of developing countries, where the governments are finding solutions for solve the problem of environmental pollution and on the other side need places to grow food, for this reason is very important consider how is the best option for energy production, for that cases solar energy can be the best solution, and for another countries where the soil is rich and the conditions are differents is possible use biofuels like best solutions, those cases benefit for example in rural areas where is very expensive make electricity nets, and is necessary use nature energy resources for reach better life quality and combat the poverty.

Keywords: solar energy, oil trnasition, biofuels, sustainable development.

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Strictly as per the compliance and regulations of :

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I. Introduction

WHY BIOFUELS AND SOLAR ENERGY ARE IMPORTANT ALTERNATIVE FONT FOR CLEAN ENERGY FOR THE PRESENT AND FUTURE?

The earth make natural process and give for us raw material for biofuels and are consider renewable clean fuel, and solar energy is available all days in almost all parts of earth planet.

The use of actually energy systems that use biofuels and solar energy have a high impact and social benefit, for example, can reduce the atmospheric emissions and pollution.

We can have benefits of large scale, but exist some social and economic problems, such as:

- The actually use of fossil fuels for transportation, and that represent cost for replacement with solar energy and biofuels systems, that is one important economic factor.
- The biofuels and solar energy that can be produce clean energy and respectfully with the environment but , how can make poverty reduction and helping poor people for survive?, that is an economic and social factor.
- In some countries the soil is consider for corps for food, but the sun is free for all people , and biofuels are second place, in that cases is important consider the sun energy as first option that is due the social and economic factor.

Those examples are only some aspects, that will be aboard in this article.

Many strategic business opportunities that can arise from technological opportunities through the use of renewable energies, can be exploited with the blue ocean strategy (W.Chan Quin,-Renee Maubogrne et al. 2005).

Although long ignored seems that the potential of power, new markets and new manufacturing capabilities are helping to make biofuels and solar energy in a global industry. Beyond political and financial interests, provides a sustainable use of technological interest.

This research will consider a solution for harnessing use of biofuels to be used in cars in the world, and propose new business alternatives based on Blue Ocean Strategy

All of this to determine and propose the use of these systems based on technical and economic feasibility.

II. State of the Art

a) Actually situations with the use of oil, and how can the biofuels and solar energy reduce the environmental problem and contribute for Sustainable Development

One of the big social problem is that people must pay much money for the healt, and the governments must make investments of millions of dollar for that cause, but this problem is ironically one problem due for greenhouse gases.

b) Greenhouse Gases

Are gases which are present in the Earth's atmosphere and give rise to the phenomenon called greenhouse effect.Its atmospheric concentration is low, but are crucial in increasing the air temperature near the ground.

The major greenhouse gases are water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chlorofluorocarbons (CFCs) and ozone (O3) (Dargay, J., D. Gately, 2007)

Another big social problem is that many poor people from rural areas in winter die due use burning wood into their houses.

But not forget that the transport in rural areas is another social problem, because is difficult carry the oil to the remote rural areas, but that problem can be solve if the people of those areas will produce biofuels in their corps, and use solar energy.

Undoubtedly, oil is the main protagonist of thisera ofcombustion, not only for theiressentialenergy functionbut also itsinfluence onthe global economy, and despite the effortsof the leadersin researchand development on theexploration and exploitation ofnew deposits, there is recognizedHubbertspeak theory(Laine J. et al. 2009)predicts that we arecurrently inthe decade of thetop of theworld's proven reservesof conventional oil (see figure). If current global consumption of 30Gbbl/year remains, havea term of 50 years for thedepletion ofthose reserveswhich now numberabout 1,500Gbbl.(GbblGigabillionbarrels)

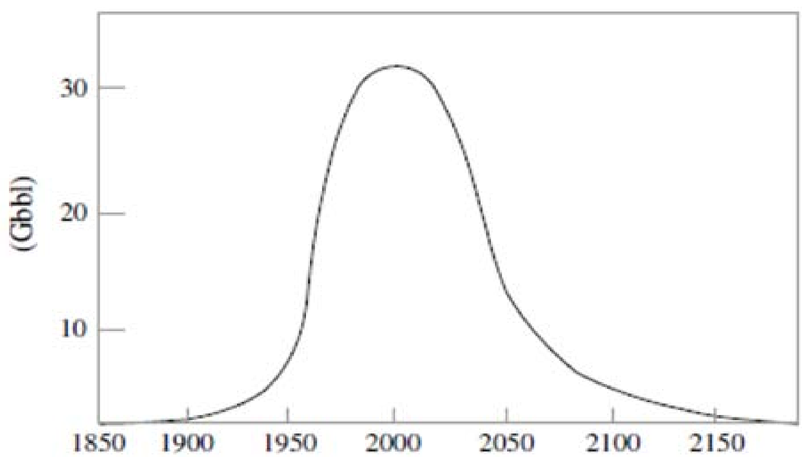

Figure 1 : Hubberts Peak (yearly oil production in Gigabillionbarrels)

Shale Gas: The source of energy of the following 100 years

Shale Gas is natural gas that is trapped within shale formation, Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas

According to a report published by Bloomberg Businessweek (June 9, 2013), the USA exported daily 4.4 billion cube feet of natural gas to Mexico and Canada. The capacity to export gas to other countries in North America is changing trade relations in the NAFTA. The article sourced above assumes the following, if US energy consumption is constant during the next 100 years, the USA will have enough reserves of shale gas to feed domestic and industrial energy consumption.

In addition, the European Union (EU) looks interested in how USA is modifying techniques to provide gas to neighbor countries. Some of the advantages in using shale gas have to do with low costs of transportation and the infrastructure to transport it. As an example.

Shale gas is extracted from deep areas. New technologies flow water and land with high pressure drainage on the underground. This process allows to recover organic material from deep areas and to delay gas and petroleum.

Even though this technology is 10 years old, the USA is optimizing techniques to make shale gas a competitive industry. The expansion of shale gas, no doubt, will decrease oil prices and revolutionize gas distributions; with both, domestic or industrial goals.

Shale Gas is a option for solve partial oil problem, but shale gas is not clean energy.

Those problems can be solve with the use of biofuels and solar energy for use in electricity ,transport and so will make better conditions of life of rural sectors. Otherimportant socialproblem that can be solve with the use of biofuels and solar energy isproverty reduction.

c) Biofuels and solar energy for sustainable developmentandpoverty reduction

i. *SustainableDevelopment*

It is calledsustainable development is development that can meet current needs without compromising the resources and possibilities of future generations.

Also sustainable development is a balancebetween society, economy andenvironment (Mohanty A. et al. 2013)

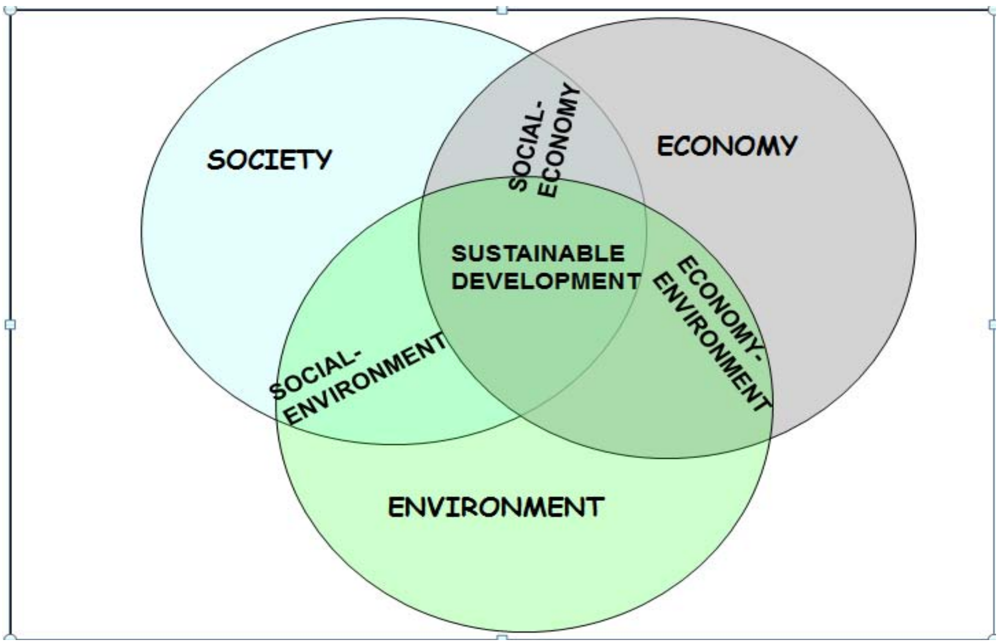

Figure 2 : Sustainable development (Mohanty A. et al.2013)

Accordingto the definitions ofpoverty, which are based on various factors including income and consumption (Poverty is defined by the relationship between income and a minimum acceptable level of consumption, ie poverty is defined as a limiton household goods and services necessary to satisfy basic needs.This limitis identified with the basic needs.

III. Industries Competitiveness

Some years ago, people thought that the competitiveness of companies was based on how factories were equipped by technological items. Recently, this belief has changed and employers are convinced that human capital is the main component of organizations.

Michael Porter has been a prominent researcher in the area of competitiveness. And he explains that competitiveness refers to the strategies and ways to produce from a unique way. The unique way to produce is saved in knowledge of members of organizations. Later, a figure shows what elements surrounding industries complete the forces to make the competitive.

However geographical position plays an important role in organizations, in terms of transportation costs, or how the organization is engaged in a cluster. According to Porter, clusters have the advantage of training people in a way that collaborates in the supply chain. Other authors, as Jones (2011) say that large companies tend to attract components from small or middle factories. And those large companies make providers more sophisticated as they demand sophisticated products.

IV. Some Considerations about Energy in Latin America

Latin America countries have great opportunities to develop technological strategies and human capital to find new ways to profit shale gas and petroleum. Brazil has made interesting efforts to produce ethanol. However this energy has not shown yet that the fuel can add to a value chain. From a sustainable point of view, ethanol is facing real challenge to face the entrance of rivalry like solar o wind power.

There are some other factors to take into considerations such as the way governments vision to train human capital and to adopt technology to assure energy supply for the next decades. One way could be the reforms that governments are promoting with the support of political forces. Or, another, by opening opportunities to create flexible companies to be part of international knowledge networks.

Universities, at the respect described above, play an important role in training human capital. Although, some publications show that, in comparison with some Asian countries as China or India, universities of Latin America do not send enough students to US universities and to compete with Asian human capital. (Openheimer, 2010). It is important to add that shale gas, if prospections of USA production come true, will make oil cheaper. The scenario motivated by shale gas and petroleum does not present a good future to the economies of Latin America whose incomes are based on fossil supplies.

a) Technology and Global Chains

Biofuels face real rivalry from different sides. Companies from different parts of the world are searching how to become more competitive by using low and sustainable cost energies, biofuels have not been able to join to the value chain or even made sophisticated markets. Even though biofuels seem to be friendly with the environment, the cost of productions is high and sometimes uses fossil sources to complete the process of producing them.

V. Sustainability and the Study of Humans' Frame of Refernce

a) Sustainability

The concept of sustainability is represented by an economic approach which handles that any kind of productive activity must be supported by an idea of row materials are not endless. Sustainability envisions a long-term development. Scientists of this approach argue that next generations must have the same conditions to generate goods as the present generations.

So, sustainability must be involved in any industrial process and fossil energies do not guarantee the same level of energy for next generations. Some specialists forecast the end of current oil or gas in the next 50 years. Shale gas, as seen earlier, changes the perspective and that is why the reserves in the USA and Mexico, used in an efficient manner, will completely modify productive interactions.

In contrast, shale gas, as current combustion processes, makes CO2 emissions and probably collaborates to the global warning. This reality shows good perspectives to nations with high reserves of shale gas. Just a few have calculated the price that next generations will have to pay to repair possible damage in the environment that emissions may cause.

In the case of solar energy

The sun is the source of renewable energy that covers a large part of the planet, so it is a source of great potential today.

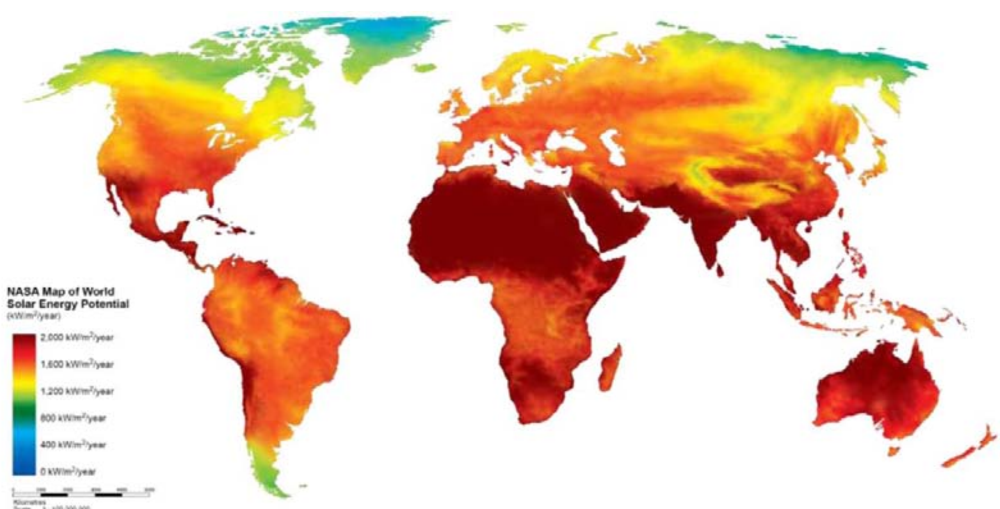

Figure 3 : Average solar radiation calculated on the basis of 24 hours per day, and considering the clouds

(NASA Data 2012)

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VI. Conclusions

Is very important remark that exist several energy solutions in the world for combat the energy lack in the future, such as the oil down production, but not all solutions are clean and friendly with the environment, such as the case of energy from radiation, that energy is dangerous and in the history have had made several injuries, such as the case of Chernobyl disaster.

Also consider that the energy form Shale Gas is a solution, but the Shale gas is not consider clean energy, the wind energy is consider one very important source of energy, but the high costs of maintenance and mechanical systems are not easy method , for that reason, the solar energy, and biofuels represent actually good options for clean energy.

VII. Propossals and Recommendations for Successfully Implementation

a) *Proposal for use solar energy with tracking systems (sun follower system)*

Solar trackers are used to increase the power output of solar panels and solar. The solar tracker is a "Device" responsible for monitoring the movement of the sun while it performs its daily routine across the sky from east to west. These devices are used to follow the sun, and make the best efficient system.

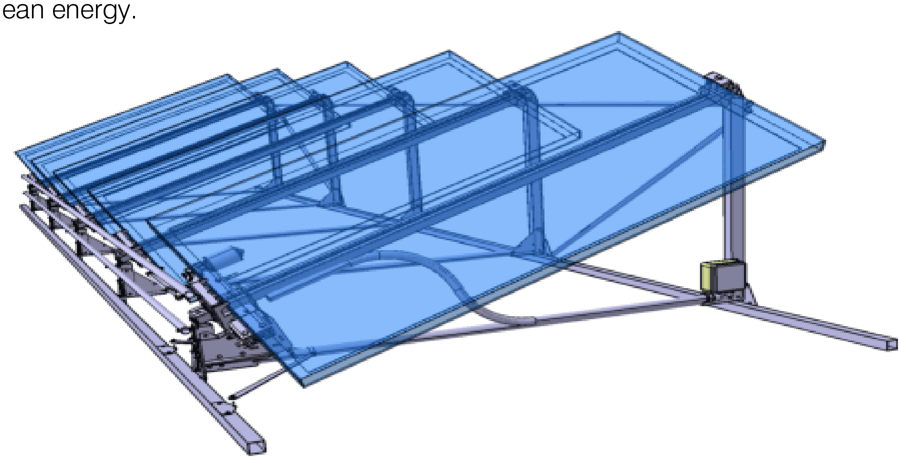

Figure 4 : Solar Tracker System

b) *Proposal for use biofuels with another energy systems (Hybrid systems)*

The biofuels alone are not the global solution for future energy, also in combination with another fonts of energy for example combine with solar energy, wind energy and nature gas, is a good solution, because every day are new trends in energy sector, and combine clean energies are the succesfully way for use biofuels.

c) *Proposal to combat poverty through the use of biofuels and solar energy. (Barrera, Lima, Tlecuilt, 2013)*

i. *Based on a strategy to combat poverty is sustainable development*

The proposal is scalable opportunity to address social aspects, is very important to note that biofuel technology and solar energy as a tool that contributes directly supports the strategy to combat poverty, poverty is based imbalance and lack of resources, so with the use of biofuels and solar energy can be combated some aspects that are listed below. For the social and environmental aspects:

Democracy- The soil is for all, and the earth provide natural resources for all, and biofuels can obtained from the soil, and the sun is for all people. Decrease of climate changes.- With the use of biofuels and solar energy systems avoids burning fossil fuels, and thereby reduce climate change factors. Also contributing to the decline of climate change disasters.

Economic and Environmental aspects – No land use unbalance and most use the ground both as food and for biofuels.

Social and economic aspects - Cost per shortages and facilities in rural areas where there is no easy have electricity from net lines,and it is very expensive to extend power grids, can grow biofuels and solar energy as hybrid systems,, and provide energy for electricity and transportation.

VIII. Recommendations

For the use of solar energy and biofuels actually be an advantage in the economic, social and environmental care, should take care of the following :

Policy: The success of biofuels depends on their use mandatory, tax facilities, subsidies provided by the State, pricing to consumers, the recognition of the rights of workers and the thousand and one ways develop from the rural communities and effective use of their land.

Grants: The production of energy from solar energy and biofuels in the world is profitable because of subsidies and incentives for renewable energy, but must ensure that these subsidies are allocated to the most vulnerable.

Research & Development: Both developed and developing nations must pay attention to the benefits associated with research and development, adopt new technologies, resulting in improved environmental heritage and obtaining economic benefits in the development of clean energy.

Environmental Benefitsvs Profits: The ambition for the profits do not should exceed the benefits of environmental preservation. In relation to environmental preservation any effective path leading to a reduced consumption of nonrenewable energy collides with the same difficulty: the decrease of the gain or extraordinary profits.

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Adsorption Mechanism for Corrosion Inhibition of Carbon Steel on Hcl Solution by Ampicillin Sodium Salt

By Hameed Hussein Alwan
Babylon University, Iraq

Abstract- In this study, the inhibitor effect of ampicillin sodium salt on carbon steel corrosion in 1M of HCl solution was investigated. The experiment was carried in HCl solution different temperature (303,313, and 323) K and by used different inhibitor concentration, the weight loss and polarization curve investigation were done. The activation energy, heat od adsorption and thermodynamic parameters of inhibition effect of Ampicillin sodium salt under investigation on the corrosion process have been calculated at different temperature.

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Keywords: corrosion, corrosion inhibitor, adsorption isotherm.

GJRE-J Classification : FOR Code: 0

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Abstract- In this study, the inhibitor effect of ampicillin sodium salt on carbon steel corrosion in 1M of HCl solution was investigated. The experiment was carried in HCl solution different temperature (303,313, and 323) K and by used different inhibitor concentration, the weight loss and polarization curve investigation were done. The activation energy, heat od adsorption and thermodynamic parameters of inhibition effect of Ampicillin sodium salt under investigation on the corrosion process have been calculated at different temperature.

It was found the effect of inhibitor was decrease with increasing temperature and Ampicillin sodium salt as a mixed inhibitor for the corrosion of carbon steel. The inhibition efficiency of Ampicillin sodium salt increases-almost-with temperature and the activation energy decreases in presence of the inhibitor. The inhibitor efficiency increased by increasing inhibitor concentration.

Keywords: corrosion, corrosion inhibitor, adsorption isotherm.

I. Introduction

Carbon steel, the most widely used engineering material, accounts for approximately acids are widely used by different industries in various technological processes. In the same time, there is a big problem come from corrosion phenomena especially when we are deal with acid solutions, they are extensively used in a variety of industrial process such as oil acidification, acid pickling and acid cleaning. [1-3]

The protection of metals against the corroding action is accomplished by adding chemical substances of small concentration to environment; these chemicals are called "Inhibitors". So inhibitors are chemical compounds that deposit on exposed metal surfaces from the corrosive environment. The inhibitor may form a uniform film, which like a coating, acts as a physical barrier. Organic compounds which containing sulfur, phosphorus; oxygen nitrogen and aromatic rings are most effective and efficient inhibitors for the metals in acidic medium due to their molecular structure. [4-7]

Several reports have documented the use of many pharmaceuticalscompounds, such as thiophene derivatives [8], methocarbamol [9], penicillin G [10], sulfacetamide(an antibacterial drug) [11], nizoral[12], Cefixime.[13]

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In the present work it was examined the corrosion inhibition and adsorption mechanism for carbon steel in 1M HCl solution by use ampicillin sodium salt and study the interaction of inhibitor concentration (100,200,300,400 and 500 ppm) with temperature effect (303,313,and323 K).

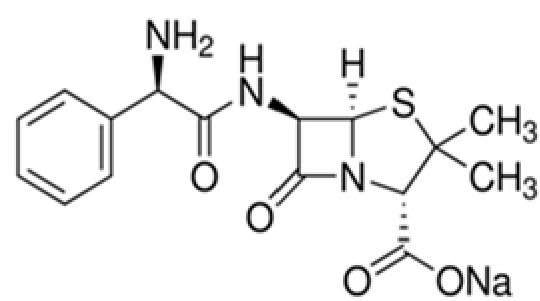
II. Experimental Work

a) Materials

Test were performed on a freshly prepared sheet of carbon steel, Specimens were mechanically cut into (3.0 cm× 3.0 cm × 0.2 cm) dimensions for mass loss tests and 5-mm diameter electrode embedded in polyester for polarization curves tests, then abraded with ambry paper abrasive 400 grit, washed in absolute ethanol and acetone, dried in room temperature and stored in a moisture free desiccator before their use in corrosion studies .

b) Inhibitor

Ampicillin Sodium Salt was used with different concentration (0,100,200,300,400) ppm, as inhibitor, figure -1, show the chemical formula and structure.



Ampicillin Sodium salt
Chemical formula ($C_{16}H_{18}N_3O_4SNa$)
Molecular weight 371.4

Figure 1 : chemical formula and chemical structure for Ampicillin sodium salt

c) Solution

The aggressive solutions, 1 M HCl were prepared by dilution of analytical grade 98% HCl with distilled water.

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d) Equipment

Glass equipment (Beaker, Flask, pipet) with different size , water bath (Thermolab Industries – Model H103 – 10 liter capacity – Temp. range 30-90 ^{o} C) , digital balance (Sartorius –Model TE214S with accuracy d=0.1 mg) , desiccator , multi-meter (UNi-T UT804), power supply (ZHAOXIN RXN3010D) , resistance (DECADE RESISTANCE BOX) , Calomel reference electrode , graphite electrode.

e) Gravimetric Measurements

The gravimetric method (weight loss) is probably the most widely used method of inhibition assessment. Weight loss measurements were conducted under total immersion using 250 mL capacity beakers containing 200 mL test solution at (303 ,313 and 323) K maintained in a thermo stated water bath. The carbon steel coupons were weighed and suspended in the beaker with the help of rod and hook. The coupons were retrieved at 1hr. interval, washed thoroughly in 20% NaOH brush, rinsed severally in deionized water, cleaned, dried in, and re-weighed. The weight loss, in grammars, was taken as the difference in the weight of the carbon steel coupons before and after immersion in different test solutions. Then the tests were repeated at different temperatures. The corrosion rate calculated in (mpy).

f) Polarization Measurements

Electrochemical polarization tests were carried out by using three-electrode cell. The specimen was exposed to the solution after it was prepared by polished on a fine grade of ambry paper up to 400 grit and followed by washing with distilled water and finally dried. The electrochemical cell consists to carbon steel as working electrode (WE), a saturated calomel electrode (RE) and graphite as auxiliary electrode (AE), the specimen (WE) was immersed in test solution 500 ml. The circuit was manually composed and the values of current as well as potential were recorded depending on the variable resistance value employed. Figure 2, show the circuit apparatus.

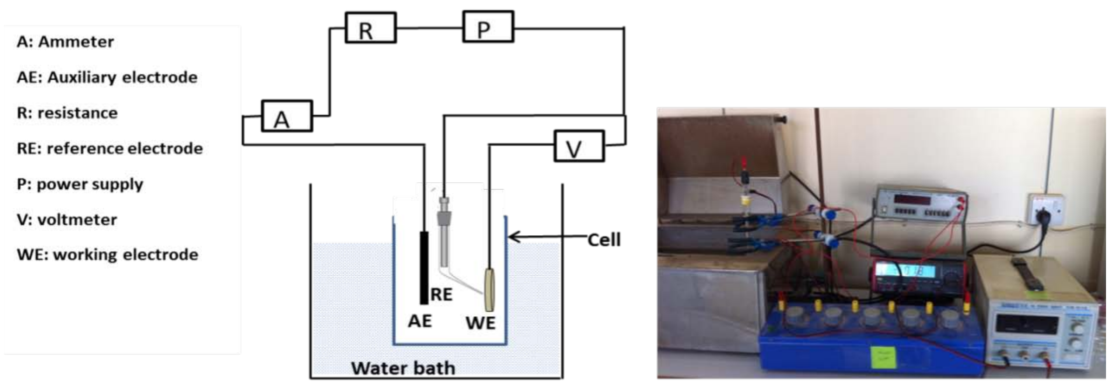

Figure 2 : (left) apparatus of the three electrode cell used in this work (right) show the arrangement for the devices are used in investigation (Corrosion Engineering Lab. Electrochemical Eng. Dept.)

III. Results & Discusion

a) Weight Loss Measurement

Weight loss of carbon steel in 1 M HCl solution was determined in absence and presence (with different concentration) of Ampicillin sodium salt as inhibitor the immersion time was 1 hour with different temperature (303, 313 and 323) K, Table 1 show the results of weight loss investigations, these results were plotted in figure 3.

Table 1 : Variationof corrosion rate in mpy with temperature and inhibitor concentration

Temperature K	Inhibitor concentration M (ppm)	Corrosion rate (mpy) $\times 10^{-3}$
303	0 (0)	6.15
	0.000275 (100 ppm)	5.45
	0.000551 (200 ppm)	4.70
	0.000827 (300 ppm)	4.18
	0.001077 (400 ppm)	4.13
313	0 (0)	8.52
	0.000275 (100 ppm)	5.02
	0.000551 (200 ppm)	4.23
	0.000827 (300 ppm)	4.55
	0.001077 (400 ppm)	3.85
323	0 (0)	9.87
	0.000275 (100 ppm)	8.12
	0.000551 (200 ppm)	8.02
	0.000827 (300 ppm)	7.82
	0.001077 (400 ppm)	7.45

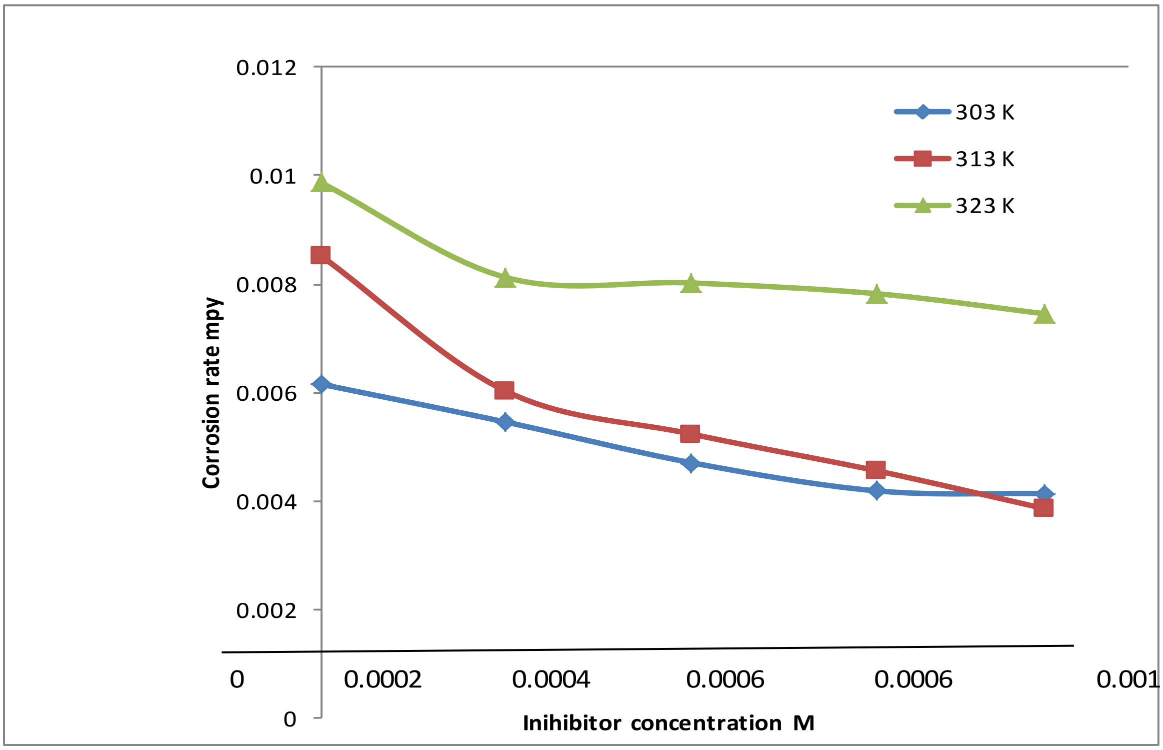

Figure 3 : corrosion rate of carbon steel in 1 M HCl solution with absence and presence of Ampicillin sodium salt by weight loss with immersion time 1 hour at different temperature

b) Electrochemical Measurement

Table 2 shows the galvanostatic polarization curves (potential versus logarithmic current density) at different temperature (303, 313, and 323) K with different inhibitor concentrations (0,100, 200, 300, and 400) ppm the study was carried out on carbon steel electrode in 1 M HCl , the inhibitor efficiencies which were listed in table 2, which calculated according to below equation:

$$\eta\% = \frac{W_u - W_i}{W_u} x100 = \left[1 - \frac{W_i}{W_u}\right] x100. \qquad (1)$$

Where i_{un}, and i_{in} are the corrosion current densities for uninhibited and inhibited condition respectively. The last column in table 2, for surface coverage,

$$\theta = \frac{W_u - W_i}{W_u} = \left[1 - \frac{W_i}{W_u}\right] \qquad (2)$$

Polarization curves were plotted in figures 4, 5 and 6 at 303, 313and 323 K respectively

Table 2 : Corrosion parameters at different condition

Temperature K	Inhibitor concentration M (ppm)	i corr µA/cm2	βc (mV / dec)	βa (mV / dec)	- E_{corr} mV	η%	θ
303	0	318.1	483.5	917.4	430	0	0.00
	0.000275 (100 ppm)	254.5	495.1	674.7	435	20	0.20
	0.000551 (200 ppm)	207.3	665.9	535.6	438	35	0.35
	0.000827 (300 ppm)	169.8	752.4	716.1	450	47	0.47
	0.001077 (400 ppm)	124.6	899.3	985.0	451	61	0.61
313	0	463.2	280.6	181.3	445	0	0.00
	0.000275 (100 ppm)	384.5	283.2	145.1	457	17	0.17
	0.000551 (200 ppm)	319.6	309.2	328.9	466	31	0.31

	0.000827 (300 ppm)	268.7	309.5	370	471	42	0.42
	0.001077 (400 ppm)	194.5	353.4	302.1	479	58	0.58
323	0	642.3	190.8	305.1	448	0	0.00
	0.000275 (100 ppm)	526.7	221.4	197.6	456	18	0.18
	0.000551 (200 ppm)	456.0	204.8	247.8	459	29	0.29
	0.000827 (300 ppm)	385.4	235.0	343.3	465	40	0.40
	0.001077 (400 ppm)	301.9	267.8	203.7	469	53	0.53

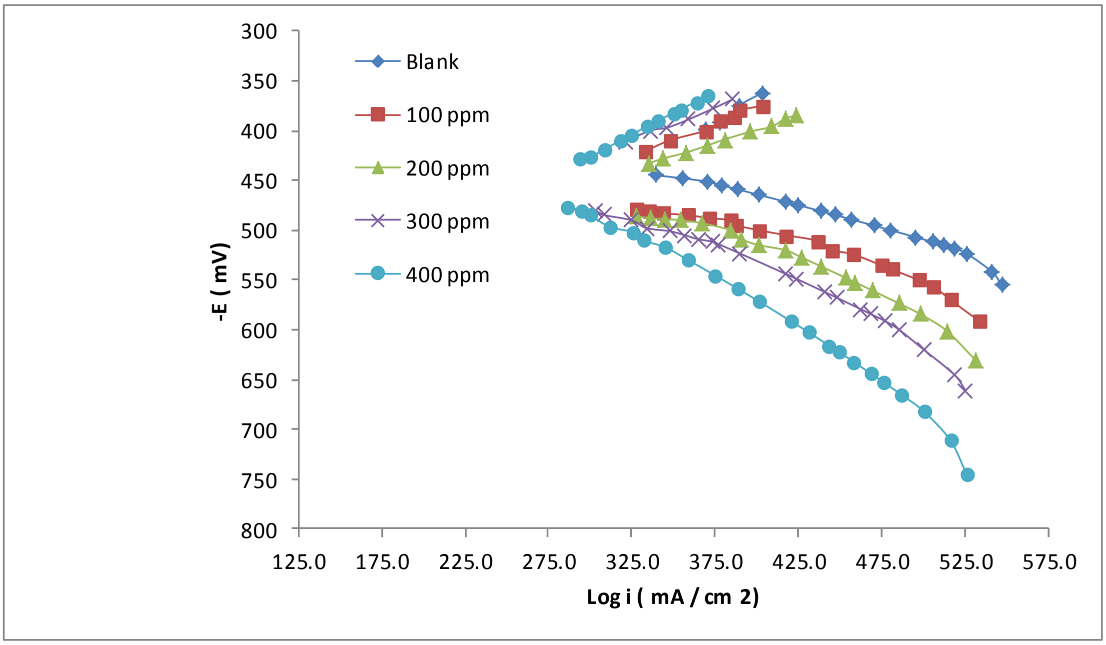

Figure 4 : Polarization curves of carbon steel in 1 M HCl solution which containing different inhibitor concentration at 303 K

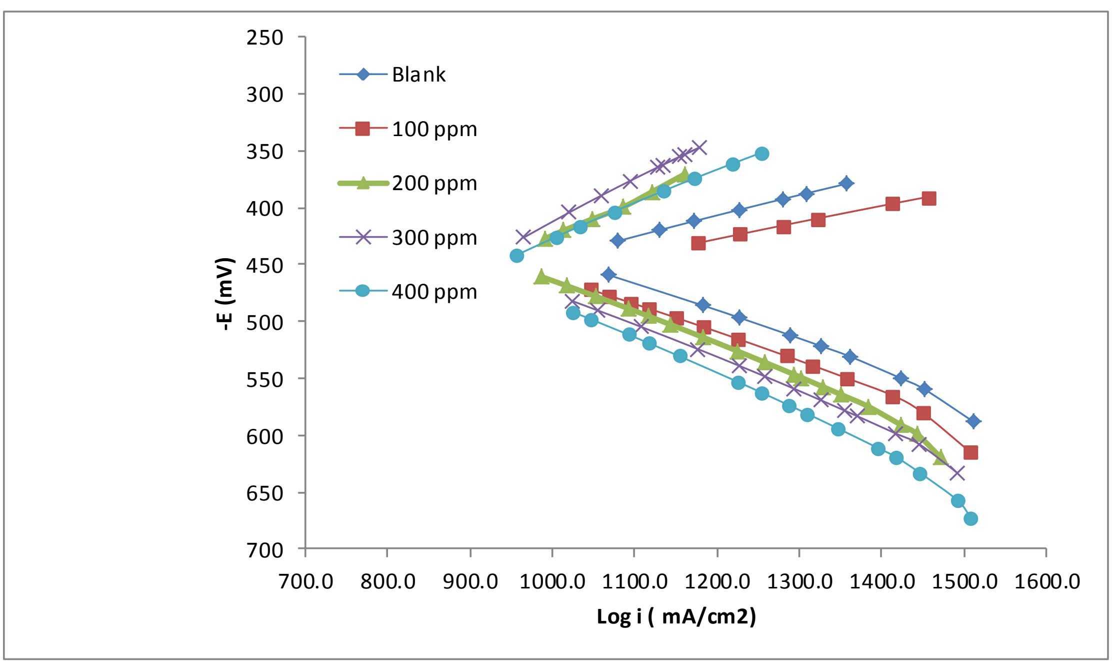

Figure 5 : Polarization curves of carbon steel in 1 M HCl solution which containing different inhibitor concentration at 313 K

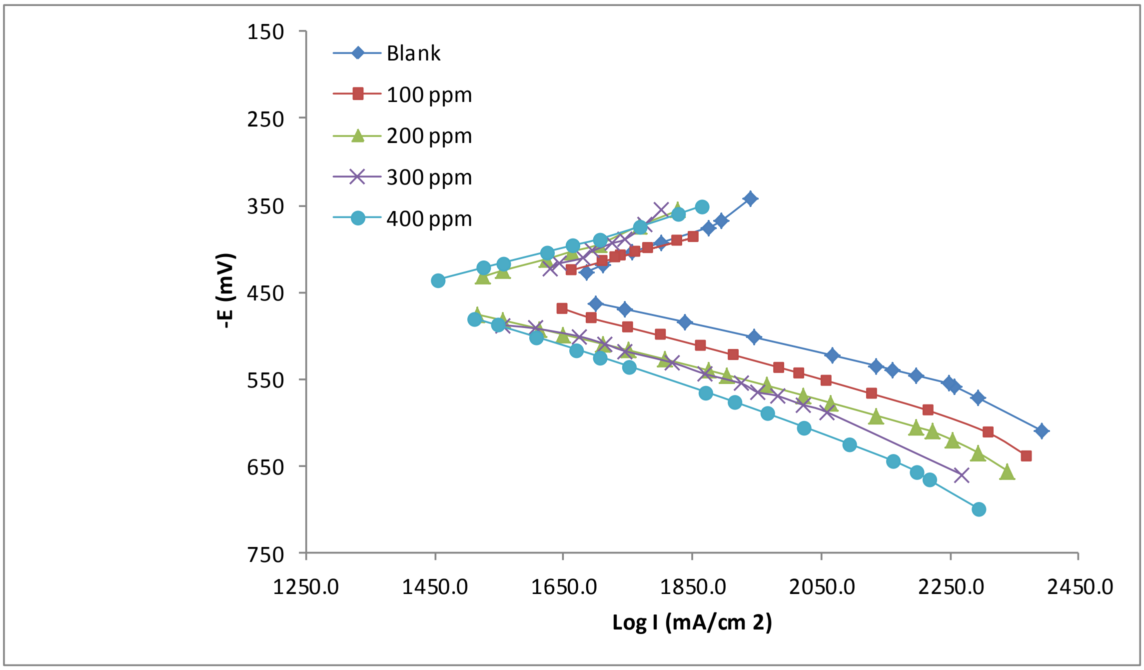

Figure 6 : Polarization curves of carbon steel in 1 M HCl solution which containing different inhibitor concentration at 323 K

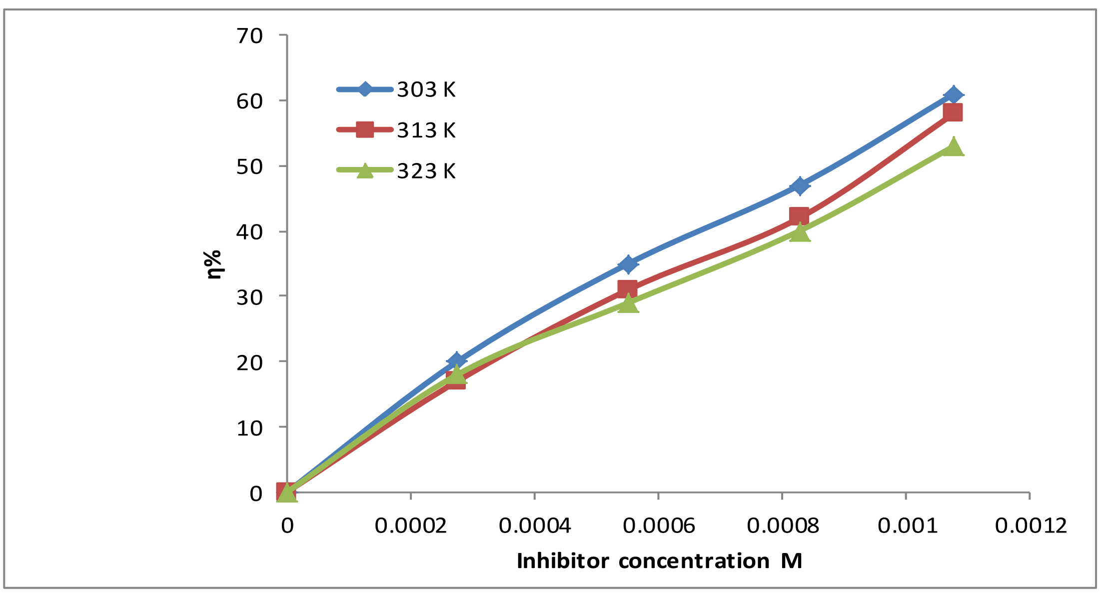

Figure 7 : variation of inhibition efficiency with inhibitor concentration at different temperature (303,313, and 323) K

c) Absorption Isotherms

The adsorption of organic compounds can be described by two mains types of interaction; physical adsorption and chemisorption .they are influenced by the nature of the change of the metal, the chemical structure of inhibitor, pH, the type of electrolyte and temperature. [14]

So adsorption isotherms are very important in determining the mechanism organic electrochemical reaction [15], the most frequently used isotherms are Langmuir, FrumKin, Temkin, Flory-Huggin, and etc. all these isotherms are of general form

$$f(\theta, x)\exp(-2a\theta) = KC$$

Freundlich adsorption isotherm was found to be suitable for the experimental findings; the isotherm is described by equation

$$\theta = K_{ads} c^{n}$$
$$\log\theta = \log K_{ads} + n\log C \quad (3)$$

Where C is inhibitor concentration, K_{ads} is adsorption equilibrium constant and θ is the surface coverage and *n* is constant, and the adsorption free energy was estimated from the following equation, adsorption equilibrium constant was calculated from plot at figure 8 , the value of them (adsorption equilibrium constant and free energy) were listed in table 3.

$$K_{ads} = \frac{1}{55.5}\exp\left(\frac{-\Delta G_{ads}}{RT}\right) \quad (4)$$
$$\Delta G^{\circ}_{ads} = -RT\ln(55.5\ K_{ads})$$

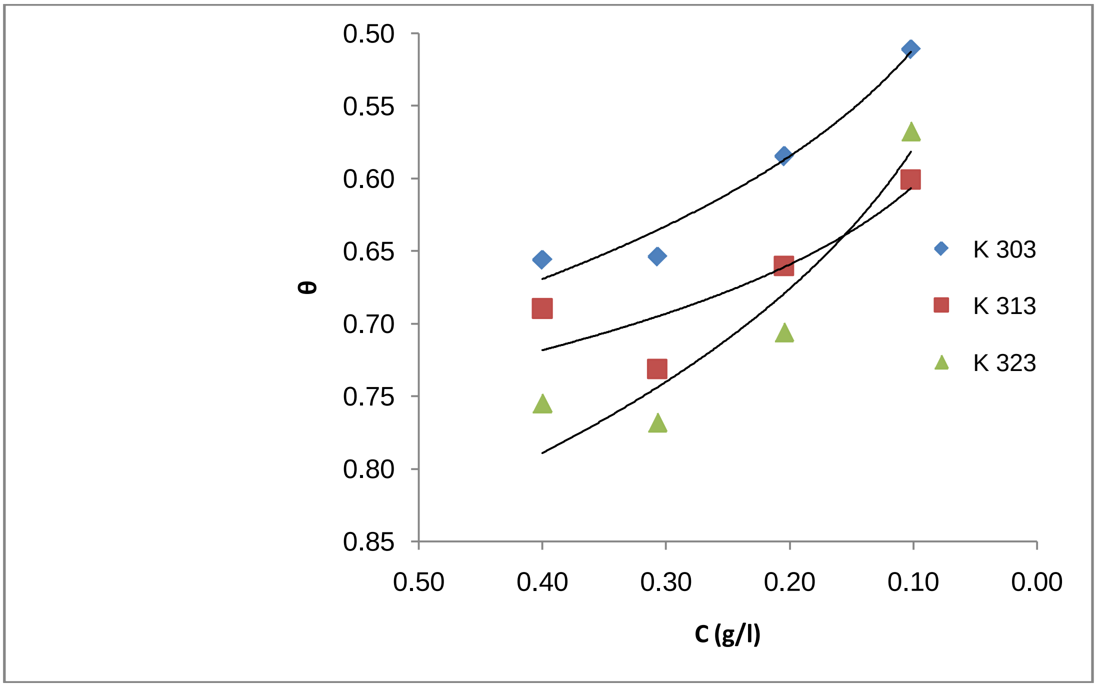

Figure 8 : Freundlich adsorption isotherms for carbon steel in 1 M HCl solution in absence and presence of Ampicillin sodium salt at 303, 313 and 323 K

Table 3 : Inhibitor adsorption constant and free energy of founded by use Freundlich adsorption isotherm for carbon steel in 1 M HCl solution in absence and presnce of Ampicillin sodium salt at 303, 313 and 323 K

Temperature K	K_{ads} adsorption equilibrium	Free energy ΔG_{ads} kJ/mol
303	6.32	-14.76
313	6.37	-15.27
323	9.31	-16.77

d) Effect of Temperature

The influence of temperature on the corrosion behavior of carbon steel in HCl solution with added various inhibitor concentrations can be obtained by estimation of activation energies.

Activation energies were calculated from the Arrhenius plots, when plot logarithmic corrosion current density (log i_{corr}) versus reciprocal absolute temperature, relationship between them can be expressed according to the following equation. This behavior was shown in figure 9

$$\log i_{corr} = \log A - \frac{E}{2.303RT} \quad (5)$$

Other parameters such as enthalpy (ΔH°) and entropy (ΔS°) of activation of corrosion process may be evaluated from effect of temperature .an alternative formulation of Arrhenius equation called transition state plot is helpful.

$$i_{corr} = \left(\frac{RT}{Nh}\right)\exp\left(\frac{\Delta S^{\circ}}{R}\right)\exp\left(\frac{-\Delta H^{\circ}}{RT}\right) \quad (6)$$

Where h is Planck's constant, N Avogadro number and, R is universal gas constant.

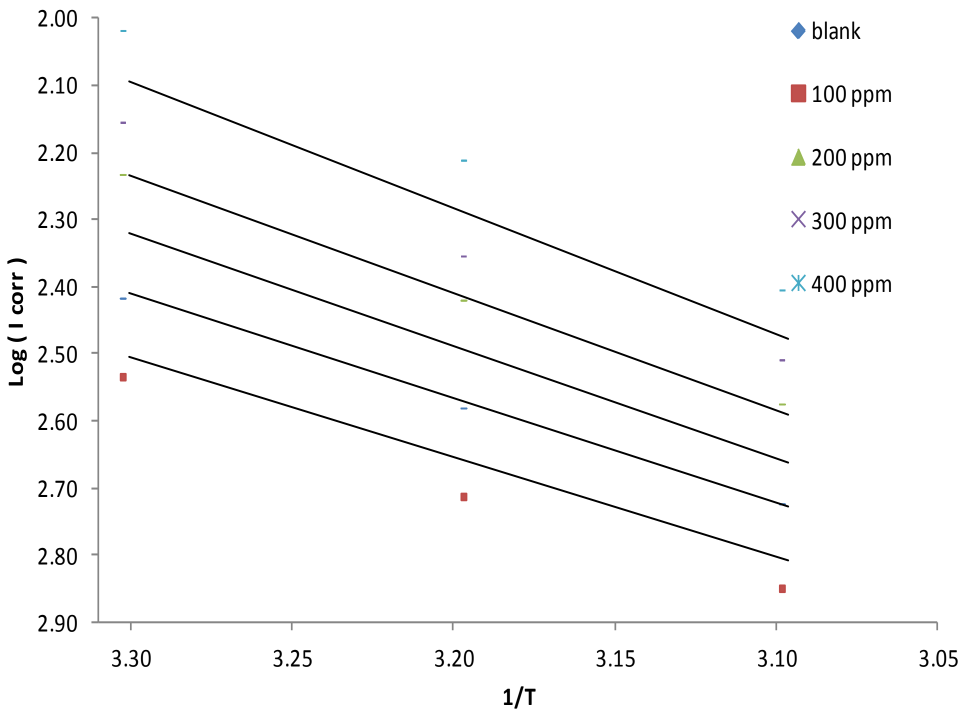

Figure 9 : Arrhenius plot for carbon steel in 1 M HCl solution in absence and presence of Ampicillin sodium salt

Table 4 : Activation and thermodynamics parameters for carbon steel corrosion in 1 M HCl solution in absence and presence of Ampicillin sodium salt

Inhibitor conc. (M) ppm	$E_{act.}$ (kJ/mol)	Enthalpy ΔH° (kJ/mol)	Entropy ΔS° (kJ/mol.K)
0	28.61	11.29	123.25
0.000275 (100 ppm)	29.63	11.74	123.94
0.000551 (200 ppm)	32.10	12.81	126.73
0.000827 (300 ppm)	33.38	12.81	127.86
0.001077 (400 ppm)	36.00	14.81	130.44

It can be seen from the above that; 1- the current density is decreased by the addition of the specified inhibitor concentration and the decrease is proportional to the inhibitor quantity.2- the current density is increased with increasing of temperature.3- the corrosion potential does not altered significantly with both the temperature and the inhibitor quantity.4- all the curves are lying within the activation control region.

The value of thermodynamic parameters for the adsorption of inhibitors can provide information about the mechanism of corrosion inhibition. The endothermic adsorption process (Q >0) is attributed unequivocally to chemisorption), while generally, an exothermic adsorption process (Q< 0) may involve either physisorption or chemisorption or a mixture of both. In general the value of adsorption heat is exothermic (table 3), i.e. as the temperature is increased the inhibition efficiency is expected to be in decreasing order. This can be explained that the effective part of the extract is not available in such density to be in contact with the metal surface and here the physical adsorption is prevailing. As the inhibitor concentration increased the availability of acting parts (the composer of tea) is increased and the reaction is becoming easier and faster. According to this statement, there are two actions of this inhibitor viz. by physorption and chemisorption one.

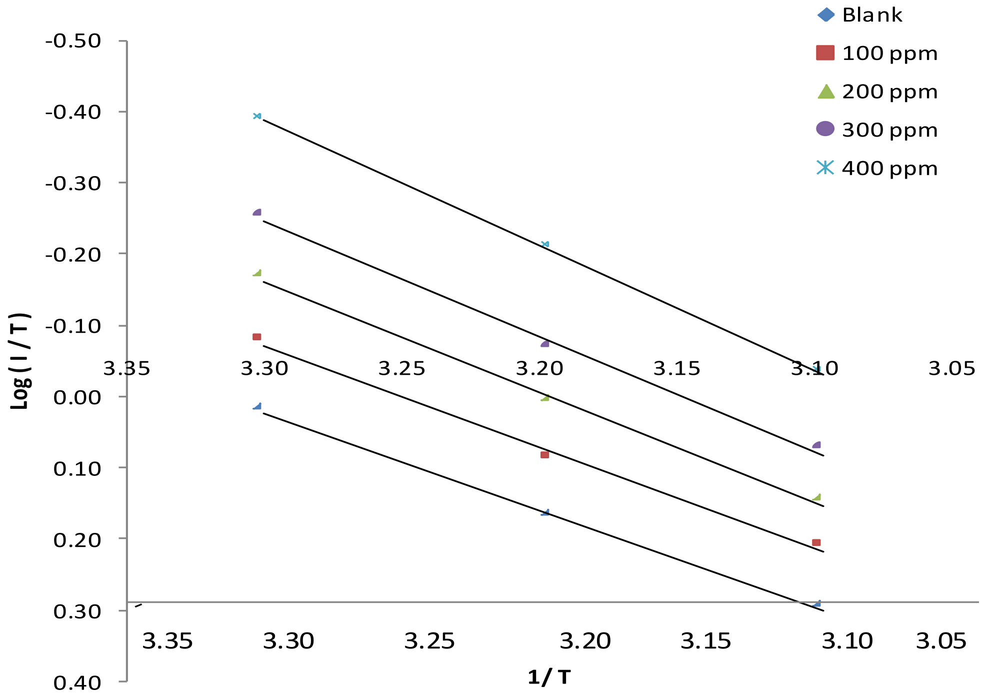

Figure 10 : Transition state plot for carbon steel corrosion in 1M HCl solution in absence and presence of Ampicillin sodium salt

The values of ΔS can be obtained from the plot of log icorr/T as shown in figure 10 and enlisted in table 4 above. These values of entropy suggest that as the quantity of inhibitor increases the order of the reactants to go to the activated complex or as the inhibitor quantity increased the formed film becomes well ordered

IV. Conclusions

- Ampicillin sodium salt as a mixed inhibitor for the corrosion of carbon steel in 1 M HCl solution without affecting the mechanism of hydrogen evolution reaction.
- The inhibition efficiency of Ampicillin sodium salt increases-almost-with temperature and the activation energy decreases in presence of the inhibitor.
- The inhibitor efficiency increased by increasing inhibitor concentration.

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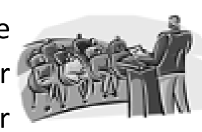

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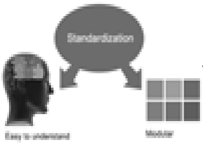

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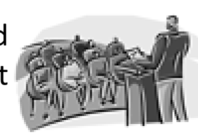

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The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

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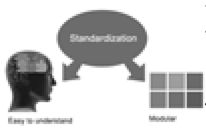

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Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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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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Key points to remember:

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

Final Points:

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

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

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

General style:

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

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

In every sections of your document

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

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

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

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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

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

Title Page:

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

Abstract:

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

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

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

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

Approach:

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

Introduction:

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

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

Approach:

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

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

Procedures (Methods and Materials):

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

Materials:

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

Methods:

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

Approach:

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

What to keep away from

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

Results:

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

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

Content

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

What to stay away from

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

Approach

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

Figures and tables

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

Discussion:

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

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

Approach:

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

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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

Index

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9 770116 58698 2 61427>

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