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Corrosion Behavior of Biodiesel in Plant Machinery

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ABSTRACT

Environmental factors and depleting reserves of crude oil are becoming the main driving force in the quest for cleaner and alternate fuels. The main objective of the project was to carry out corrosion studies using biodiesel at different operating parameters and to study corrosion behaviour in plant machinery. Different mode of operations such as batch and continuous mode were carried out for the corrosion studies. The experiments were conducted for various operating parameters and the result shows that with increase in temperature the corrosion rate increases for both samples namely aluminium and mild steel. In addition the pit radius is determined by stimulation.

Key words: Biodiesel, Mildsteel, Aluminium

1.0 Introduction

The concept of bio fuel dates back to 1885 when Dr. Rudolf Diesel built the first diesel engine with the full intention of running it on vegetative source. In 1970, scientists discovered that the viscosity of vegetable oils could be reduced by a simple chemical process and that it could perform as diesel fuel in modern engine. Since then the technical developments have come a long way and the plant oil today has been highly established as bio fuel, equivalent to diesel. Biodiesel fuel is based on vegetable oil and is a mixture of mono alkyl esters of long fatty acids derived from renewable feedstock. The rising prices of commercial fuel and concerns from increased global energy consumption, all over the world biofuel programmes are implemented to develop alternatives to conventional fuels. Biodiesel is biodegradable and renewable by nature.

Biodiesel is produced in two ways namely esterification and trans-esterfication with the help of KOH as catalyst from alcohol to form fatty acid esters. The most common form uses methanol (converted to sodium methoxide) to produce methyl esters (commonly referred to as Fatty Acid Methyl Ester - FAME) as it is the cheapest alcohol available, though ethanol can be used to produce an ethyl ester (Fatty Acid Ethyl Ester - FAEE) biodiesel and higher alcohols such as isopropanol and butanol have also been used. Using alcohols of higher molecular weights improves the cold flow properties of the resulting ester, at the cost of a less efficient transesterification reaction. Biodiesel may contain small but problematic quantities of water. Although it is not miscible with water, it is, like ethanol, hygroscopic. Water contamination is a potential problem when using certain chemical catalysts involved in the production process, substantially reducing catalytic efficiency of base (high pH) catalysts such as potassium hydroxide. Water can cause pitting corrosion in the metals. Corrosion is the wearing a way of metals due to a chemical reaction. Many structural alloys corrode merely by the use of biodiesel.

'Yellow metals' such as copper, brass, bronze are not suitable for the production of biodiesel [1, 2]. The present study aims to investigate the corrosion behaviour of mildsteel and aluminium in crude biodiesel at the time of production in industry. Stainless steel is widely used for the production of biodiesel since it is compatible material for biodiesel [2]. The cost of stainless steel is more when compared to mildsteel and aluminium.

Aluminium has low atomic weight and high strength to density ratio and is the most abundant metal to be found in the earth crust. It is light, nontoxic and has high thermal conductivity with excellent corrosion resistance property. The corrosion behaviour of aluminium and its alloys has been widely studied in various medium. In addition, the corrosion resistance of aluminum has a strong dependency on pH. The corrosion resistance of aluminium decreases dramatically for higher pH, particularly in alkaline solutions, which dissolve the protective oxide layer [3]. Mildsteel is the most common form of steel because its price is relatively low and it is neither brittle nor ductile as well as malleable.

In literature, material compatibility and solvency of biodiesel are reported which causes elastomers to dissolve and leads to plugging [4]. Fluorine containing elastomers did not exhibit significant swelling and can be used for biodiesel service of different metals in biodiesel [5,6]. Corrosion behavior of biodiesel studies from non-edible oil such as Pongamia glabra, Salvadora oleoides, Madhuca Indica and Jatropha curcas oils using long duration static immersion test on diesel engine parts such as piston liner and piston metal [7]. Aluminum was exposed to biodiesel with different levels of contaminants and impurities, and its corrosion behavior was evaluated by conventional electrochemical techniques [8]. Till date no literatures have been found with the use of crude biodiesel at the time of production. To see the effect of use of aluminium and mildsteel as plant machinery, the corrosion studies have been carried out in our laboratory.

2.0 Method and materials

2.0.1 Raw materials

The commercially available palm oil was acquired from a local supermarket. This was used for the production of biodiesel. Anhydrous butanol and potassium hydroxide of analytical grade were used in this process. The test samples were two metals namely aluminium and mildsteel.

2.0.2 Synthesis of biodiesel

The biodiesel were produced by means of trans esterification reaction in our laboratory using palm oil with butanol at 60-70^{0}C for about 4 hrs in the presence of KOH as catalyst. Along with glycerol, the crude biodiesel was taken for the studies.

2.0.3 Pre-treatment of metal samples

The samples are taken and are cut into small pieces of size 483cm^2. After machining the metal samples were degreased using acetone. Weighed up to an accuracy of 0.1mg before exposing the metal samples in crude biodiesel.

2.0.4 Test method

Metal samples were degreased, preweighed and suspended using Teflon thread separately inside the crude biodiesel. Studies were carried out in batch and continuous mode for various temperatures and are evaluated.

a.Quantitative Estimation

During experimentation the test samples were removed repeatedly after certain hours. The samples were derusted using ethanol and weighed. The weight loss of each test metal was recorded. The corrosion rate, penetration and corrosion current were calculated using the formulae given below.

$$corrosion\ \ rate = \frac{Wt.loss * 534}{Area * Time * MetalDensity}(mpy) \qquad (1)$$

$$Penetration = \frac{Wt.loss * 372}{Area * Time}(mdd) \qquad (2)$$

$$Corrosion\,Current = \frac{n * F * W}{M * t}\ (A) \qquad (3)$$

Where wt. loss in mg,
Area in sq. inches of metal surface exposed
Time in hours exposed
Density is in g/cm^3

The metals are used with the following properties namely,
Surface area of metal sample = 10 sq. inches
Density of aluminium = $2.72 g/cm^3$
Density of mildsteel = $7.85 g/cm^3$

Modes of operation

Batch mode

In the batch process, the crude biodiesel produced was taken in a beaker. The test samples namely, aluminium and mild steel are immersed inside the solution as shown in the fig1. For various time intervals the test samples are weighed to measure the weight loss. These static immersions were carried out for a period of 720hrs at ambient temperature. During the test period the temperature variation was observed for 30 and 50^0C at which the production of biodiesel takes place.

b. Continuous mode

In the continuous process, the crude biodiesel produced was taken in a reservoir. With the help of pump, the flow is made continuous. The flow meter is attached to it to control the flow rate. The experiments were carried out for about 140 hrs and the weight loss are noted. For different flow rates namely 60 and 120 LPH and temperature variation of 30 and 50^0C the values are noted. The schematic representation of the continuous process is shown in the fig.2

Fig 1: Batch process

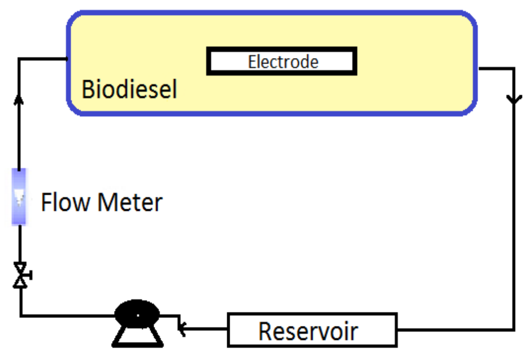

Fig 2: schematic representation of continuous process

3.0 Results and Discussion

3.1. Batch mode

In the batch process, static immersion process the weight loss has increased with increase in time and using the above formula (1), (2), (3) the corrosion rate, penetration, corrosion current are calculated. With the increase in temperature the weight loss has greatly increased compared to ambient temperature. Little amount of KOH present in the crude biodiesel are responsible for the corrosion to take place in mildsteel and aluminium. The corrosion rate has decreased with increase in time and then decreases gradually with variation in temperature as shown in fig 3, 4. The penetration increases with increase in time and temperature as shown in fig 5, 6. The corrosion current is directly proportional to weight loss. With increase in weight loss the corrosion current also increases with time as shown in fig 7. Due to increase in temperature the corrosion product formation increases. This causes change in the corrosion current as shown in fig 8.

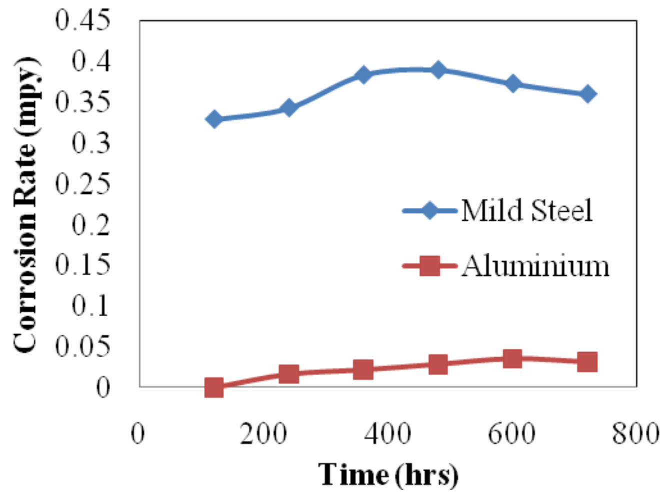

Fig 3: Corrosion rate of aluminium and mild steel at 30^0C in batch mode

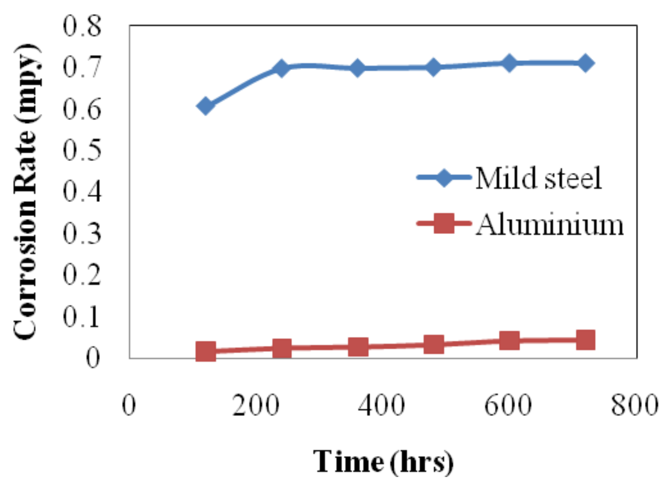

Fig 4: Corrosion rate of aluminium and mild steel at 50^0C in batch mode

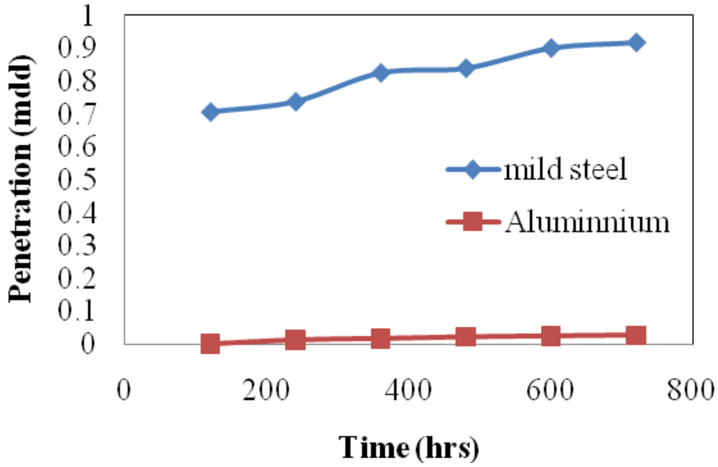

Fig 5: Penetration behaviour of aluminium and mild steel at 30^0C in batch mode

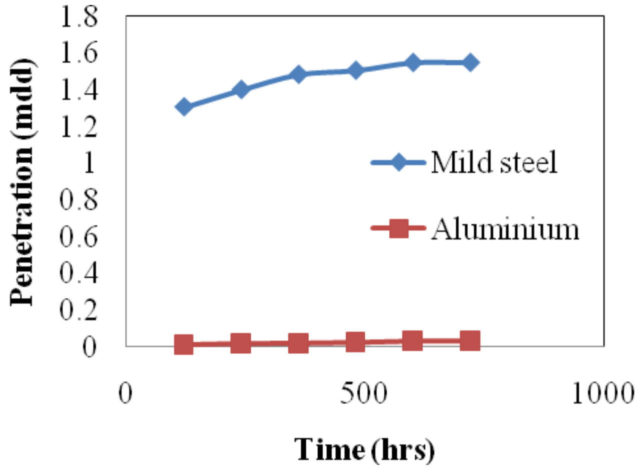

Fig 6: Penetration behaviour of aluminium and mild steel at 50^0C in batch mode

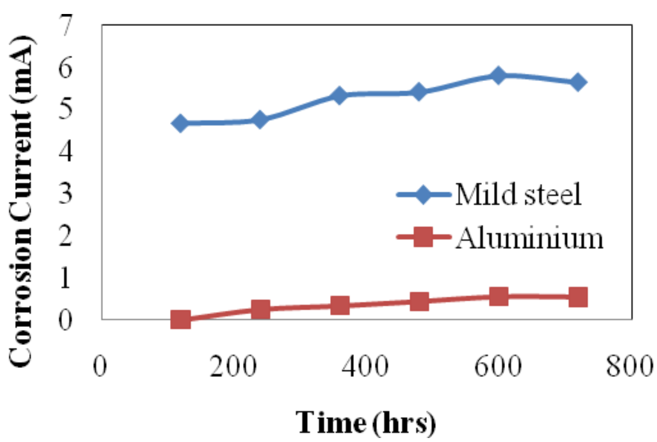

Fig 7: Corrosion current of aluminium and mild steel at 30^0C in batch mode

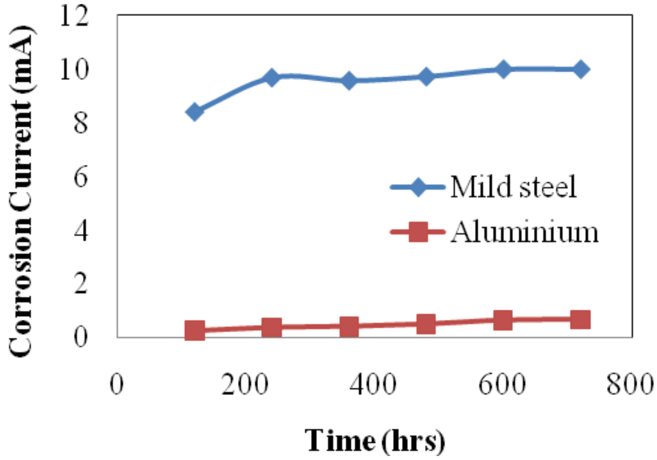

Fig 8: Corrosion current of aluminium and mild steel at 50^0C in batch mode

3.2. Continuous mode

In the continuous process, the variation of flow rate shows difference in weight loss at 60 and 120 LPH. The temperature is varied which shows that increase in corrosion the weight loss also increase. The corrosion rate, penetration and corrosion current are calculated using the equation (1), (2), (3). The fig 9, 10 shows the corrosion rate of mildsteel with respect to time and flow rate variation. The corrosion rate decreases gradually for both 60 and 120 LPH. When the temperature is increased the corrosion rate also decreases. The fig 11, 12 shows the corrosion rate of aluminium for different flow rates with increase in time. This shows initially the corrosion rate decreases slowly but with increase in time the corrosion rate decreases rapidly in aluminium. The penetration behaviour of mildsteel and aluminium for ambient room temperature is shown in fig 13 and 15 which shows the penetration increases with increase in time and flow rate. The fig 14 and 16 shows the penetration behaviour at 50^0C for mildsteel and aluminium. The penetrations gradually increase with increase in time and temperature. The corrosion current variation with time is shown in fig 17 and 18 for mildsteel. The corrosion current decreases gradually with increase in time and flow rate. The fig 19 shows the corrosion current for aluminium at room temperature. In this with increase in time the corrosion current increases and then decreases slowly. For higher temperature the corrosion current decrease with increase in time and is shown in fig 20.

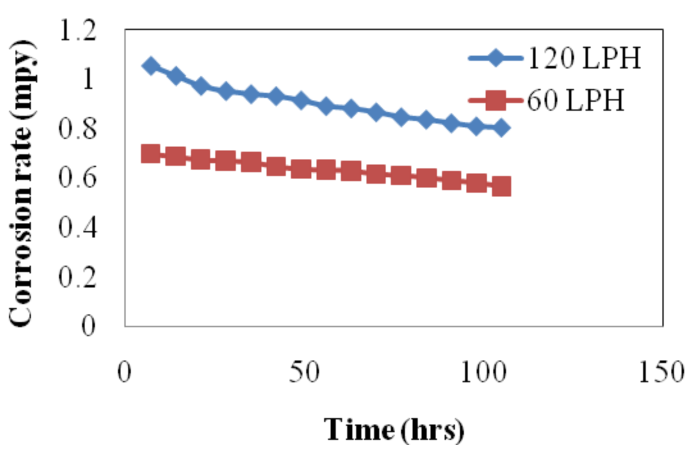

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Fig 9: Corrosion rate of mild steel for various flow rates at 30^0C in continuous mode

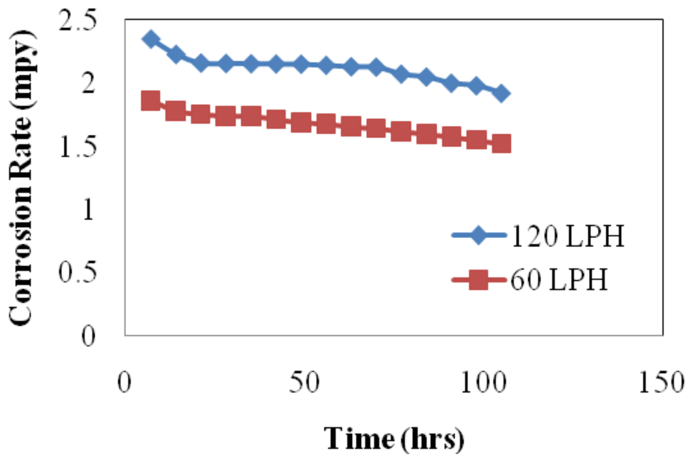

Fig 10: Corrosion rate of mild steel for various flow rates at 50^0C in continuous mode

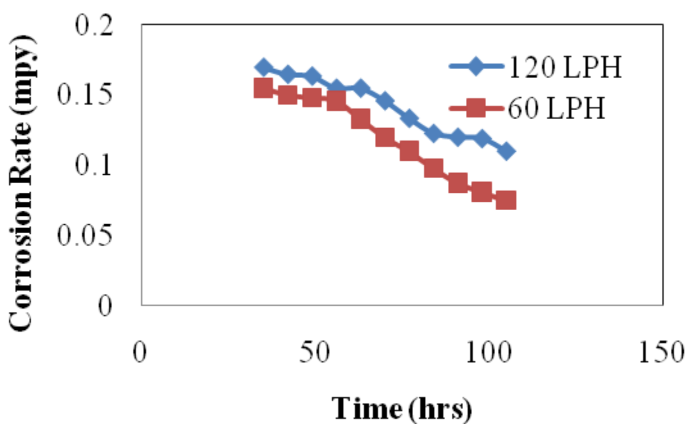

Fig 11: Corrosion rate of aluminium for various flow rates at 30^0C in continuous mode

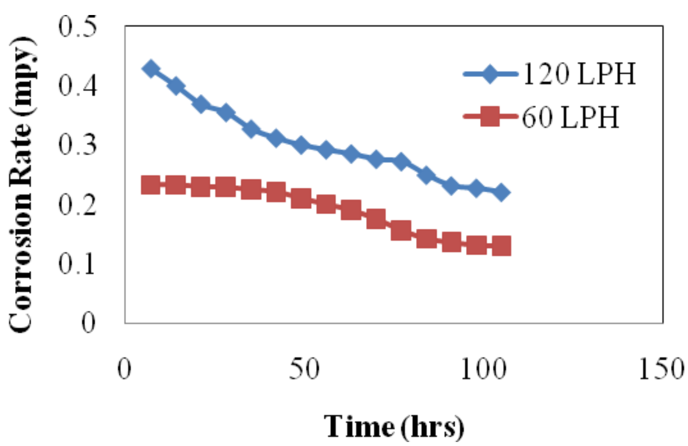

Fig 12: Corrosion rate of aluminium for various flow rates at 50^0C in continuous mode

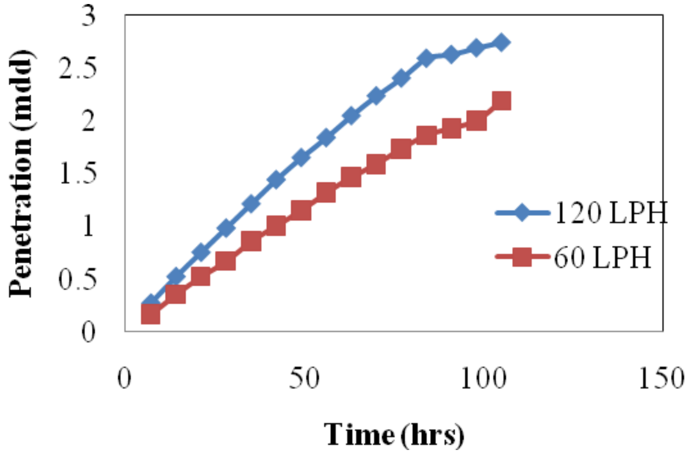

Fig 13: Penetration of mild steel for various flow rates at 30^{0}C in continuous mode

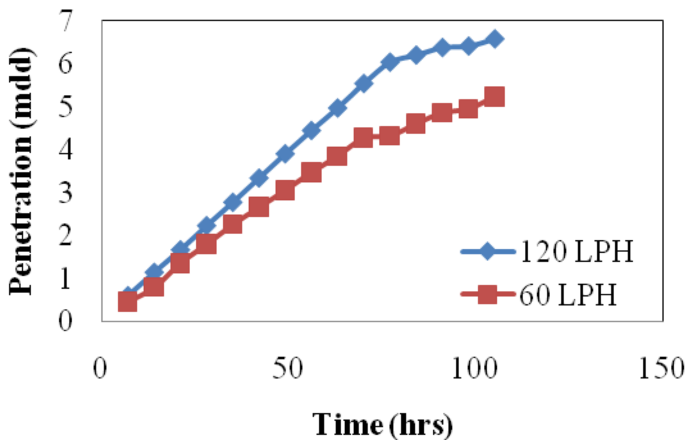

Fig 14: Penetration of mild steel for various flow rates at 50^{0}C in continuous mode

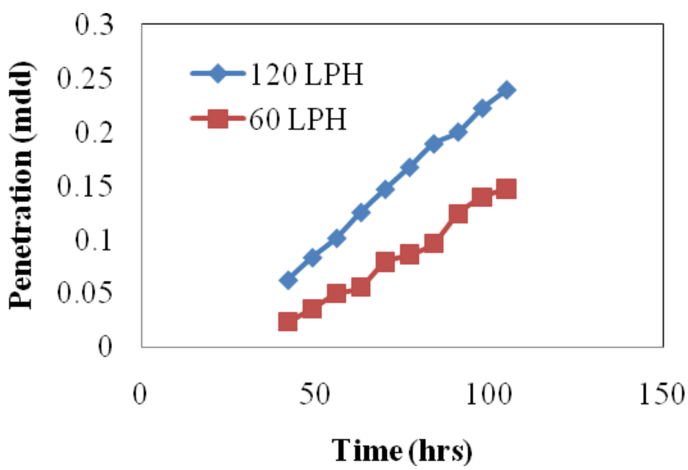

Fig 15: Penetration of aluminium for various flow rates at 30^{0}C in continuous mode

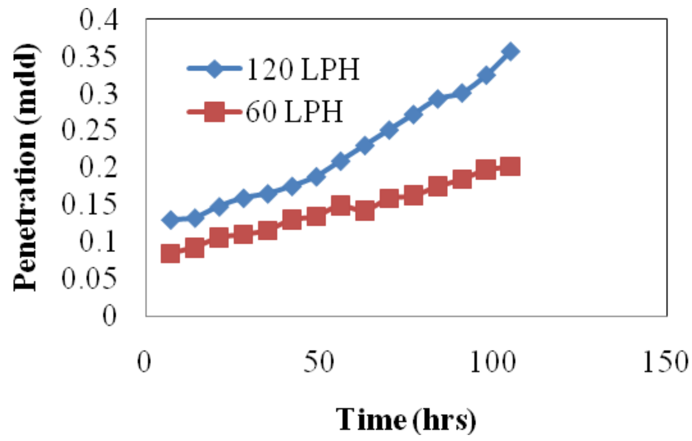

Fig 16: Penetration of aluminium for various flow rates at 50^0C in continuous mode

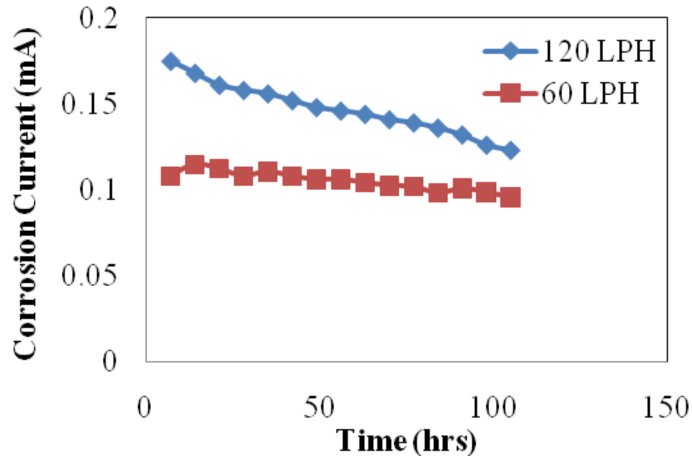

Fig 17: Corrosion current of mild steel for various flow rates at 30^0C in continuous mode

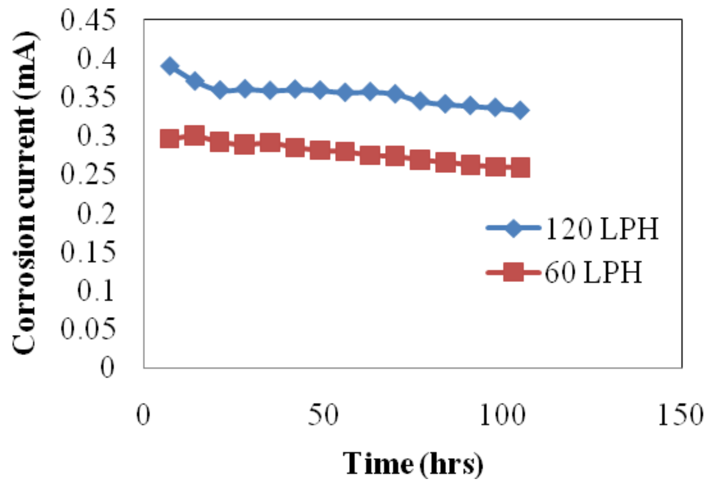

Fig 18: Corrosion current of mild steel for various flow rates at 50^0C in continuous mode

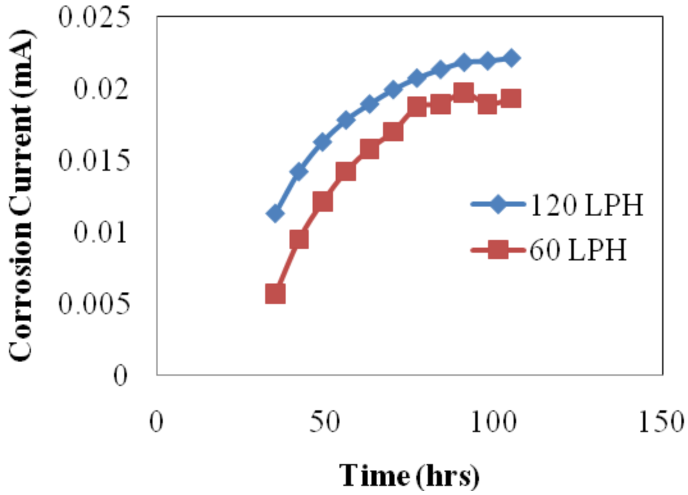

Fig 19: Corrosion current of aluminium for various flow rates at 30^0C in continuous mode

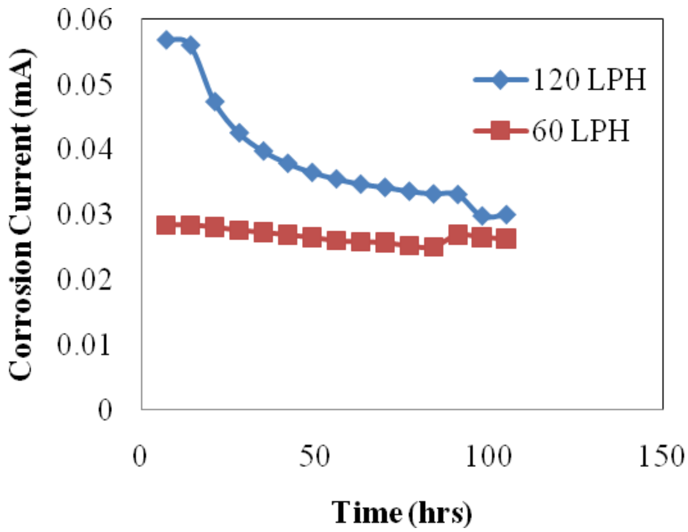

Fig 20: Corrosion current of aluminium for various flow rates at 50^0C in continuous mode

4.0 Conclusion

The corrosion studies carried out in batch mode shows weight loss gradually increases with increase in time at room temperature. At higher temperature the weight loss is more in comparison to room temperature. In continuous mode the higher flow rate shows higher weight loss than lower flow rate. The corrosion rate decreases with time and the penetration behaviour of mildsteel shows more when compared to aluminium. The corrosion current varies with weight loss and temperature. More the corrosion current more will be the weight loss in mildsteel and aluminium. The crude biodiesel taken for studies has higher KOH concentration.

References:

a) *Baldric P. Regul. Toxicol.Pharmacol.* ***2000****, 32, 210.*

b) *Ugurlu T;Turkoglu M; Gurer U S; Akarsu B G. Eur. J. Pharm. Biopharm.* ***2007,****67, 1, 202-210.Malviya R;Srivastava P;Bansal M; Sharma P K . Int. J. Pharm. Sci.****2010****, 9,119.*

c) *D. Boonrod, K. Reanma and H. Niamsup, "Extraction and Physicochemical Characteristics of Acid-Soluble Pectin from Raw Papaya (Carica papaya) Peel",Chiang Mai J. Sci., vol. 33, no. 1, pp.129-135,2006.*

d) *D.V. Sudhakar andS.B. Maini, "Isolation and Characterization of Mango Peel Pectins", Journal of Food Processing and Preservation, vol.24, no. 3, pp.209–227, 2000*

e) *Pagan J, Ibraz A, Liorco M and Coll L. 1999. Quality of industrial pectin extracted from peach pomace at different pH and temperatures. J Sci Food Agric. 79(7):l038-1042.*

f) *Rouse AH and Crandall PG 1976. Nitric acid extraction of pectin from citrus peel. Proc. Florida State Hort Soc. 89(2):166-168.*

g) *Sarfraz A. 1976. Extraction of pectin from orange peel. M.Sc. Thesis, Deptt. Chemistry Univ Agric,*

h) *Zheng Jie, Yang Ting, Wu Qiang, Li Jing, Wang Ya-Na. (2009). Microwave-assisted Extraction of Pectin from Orange Peel. Vol. 30,No. 20,p. 134-137.*

i) *P.Y. Tang, C.J. Wong and K.K. Woo. (2011). Optimization of Pectin Extraction from Peel of Dragon Fruit (Hylocereus polyrhizus). Asian Journal of Biological Sciences, ISSN 1996-3351, Knowledgia Review, Malaysia, 4 (2): 189-195.*

j) *P. G. Crandall, R. J. Braddock, and A. H. Rouse. (1978). Determining .The Yield And Quality Of Pectin From Fresh Peel And Pectin Pomace. Proc. Fla. State Hort. Soc. 91:109-111.*

k) *Takuo Sakai & Minoru Okushima. (1998). Microbial Production of Pectin from Citrus Peel.Applied and Environmental Microbiology, Vol. 39, No. 4, p. 908- 912.*

l) *Harshal Makode (2012).Project report submitted for B.Tech to Rashtrasant Tukadoji Maharaj Nagpur University,Nagpur.*