Design And Development Of Pilot Type Biodiesel Production Plant

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ABSTRACT
Aim: Biodiesel is biodegradable, renewable and non-toxic, safe to storable fuel has the performance comparable to petro-diesel that is gaining an importance as an alternative of future fuel due to depletion of fossil fuel resources. Cyclone type biodiesel production plant of higher capacity has been developed, which has very low cost of production per kg of biodiesel as compared with the traditional (batch type) biodiesel production set up of low production capacity.
Methodology: Planned arrangement depends on the standard of typhoon separator. In which, the fluid (combination of straight vegetable oil sodium methoxide) stream is infused at high speeds through the delta pipe, which is situated digressively to the body of the twister. The state of the cone incites the stream to turn, making a vortex. Bigger or denser particles are constrained outward to the dividers of the twister where the drag of the turning air just as the power of gravity makes them tumble down the sides of the cone into a source.
Results: Production cost per kg is very less and production capacity is do high as compare to existing (batch type) bio-diesel production plant.
Conclusion: Development of an efficient of trans-esterification (biodiesel formation) set up can affect the technique for reaction condition, molar extent of alcohol to oil, sort of alcohol, type and proportion of stimuli, reaction time and temperature and excellence of reactants.

Keywords: An efficient set up is designed to increase production capacity, minimized cost of production per kg of product.

1. INTRODUCTION

Over hundred years ago, Rudolf Diesel invented CI engine and first tested it using vegetable (peanut) oils as fuel and demonstrated it on August 10, 1893 in Germany. It was an important invention to minimize depletion of world petroleum reserves and researchers paid much attention over fuel potential of vegetable oil. In this way diesel fuel and diesel engine, start evolving together. Indian Railway Conducted a fruitful preliminary attempt of an Express Passenger train on the Delhi-Amritsar course was utilizing 5% of bio-diesel as fuel.
Several methods are available for Biodiesel production Trans esterification is the most efficient, methyl ester formation method from vegetable oils. To produce Bio-diesel a large number of lab scale trans-esterification setup has been developed but needed an efficient transesterification setup. The results of developed Cyclone type transesterification setup

shows that it is very effective in terms of yield of biodiesel, production time, production cost etc. as compared to the batch type trans esterification setup.

2. METHODS TO PRODUCE BIODIESEL

The vegetable oils were all incredibly gooey, with viscosities running 10-20 times more noteworthy than diesel fuel. Pyrolysis, Micro emulsification, Dilution, and Trans-esterification are the four methods applied to tackle the issues experienced with the high fuel kinematic thickness [4]. Transformation of the vegetable oil as a CI motor fuel should be possible by four techniques:

- Dilution
- Pyrolysis
- Micro emulsification
- Trans-esterification

Trans-esterification

Trans-esterification is the technique of bio-diesel creation from oils and fats and can be done by two different ways.

- Catalytic Trans-esterification.
- Supercritical Methanol Trans-esterification.

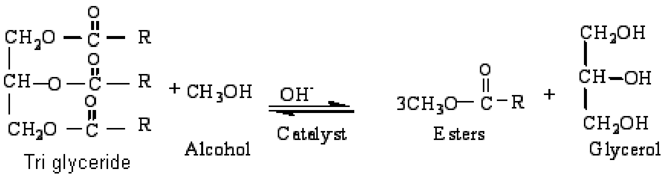
Catalytic Trans-esterification

The "Reactant Trans-esterification" measure is the reaction of greasy oil (fat/oil) with alcohol inside seeing some impulse to outline esters and glycerol. A greasy substance has a glycerin iota as its base with three long chains unsaturated fats annexed. The possibility of the unsaturated fats can subsequently influence the qualities of the bio-diesel. During the trans-esterification measure, the oily substance is responded with liquor inside observing impetus. The liquor responds with the unsaturated fats to layout the mono-alkyl ester, or bio-diesel and unforgiving glycerol. In a large portion of the creation methanol or ethanol is the liquor utilized (methanol produces methyl esters, ethanol produces ethyl esters) and is base catalyzed by one or the other potassium or sodium hydroxide. Potassium hydroxide has been discovered to be more appropriate for the ethyl ester bio-diesel creation; either base can be utilized for the methyl ester.

The segment of the ester and glycerol layer suggests a productive trans-esterification reaction after the response time. The heavier, co-thing, glycerol settles out and might be sold generally or it very well might be cleaned for use in various organizations, for instance the medication, magnificence care items, etc.

Most common type of catalytic Trans-esterification reactions are;

- Base -Catalyzed Transesterification
- Acid -Catalyzed Transesterification
- Lipase-Catalyzed Transesterification

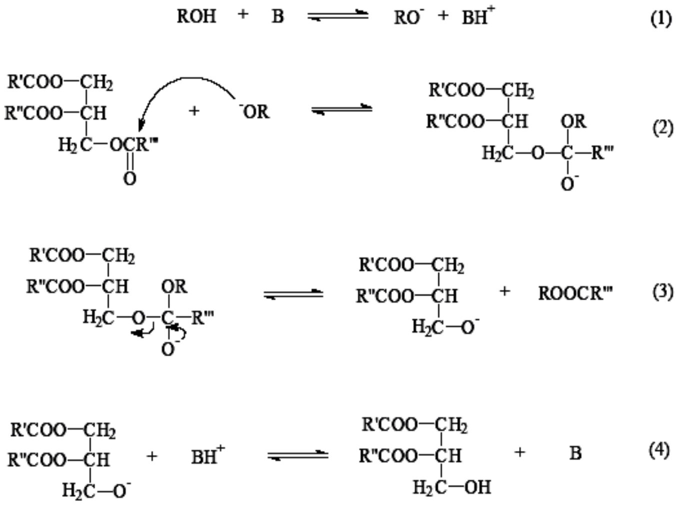


Base-Catalyzes Transesterification

The measure is the response of fatty oil (fat/oil) with liquor in base-catalysed Trans-esterification of vegetable oils continues quicker than the corrosive catalysed response. Because of this explanation, along with the way that the soluble impetuses are less destructive than acidic mixes, modern cycles as a rule favour base impetuses, for example, antacid metal alkoxides and hydroxides similarly as sodium or potassium carbonates.

The part of the base-catalysed trans-esterification of vegetable oils is showed up beforehand. The underlying advance [1] is the response of the base with the liquor, passing on an alkoxide and the protonated main thrust. The nucleophilic assault of the alkoxide at the carbonyl social event of the oily oil conveys a tetrahedral focus [2] from which the alkyl ester and the taking a gander at anion of the diglyceride are framed [3]. The last deprotonates the upgrade, in this way recovering the dynamic species [4], which is before long set up to respond with a second atom of the liquor, beginning another reactant cycle. Diglycerides and monoglycerides are changed over by similar portion to a blend of alkyl esters and glycerol. Dissolvable metal alkoxides (as CH3ONa for the methanolysis) are the most exceptional main thrusts, since they give basic returns (> 98%) in short response times (30 min) regardless of whether they are applied at low molar habitats (0.5 mol%). Before long, they require most exceptional impediment of ruinous worth (< 1) and dampness substance of oil (0.06%) for most conspicuous yield. Dissolvable metal hydroxides (KOH and NaOH) are more moderate than metal alkoxides, in any case less groundbreaking. In a little while, they are a reasonable option since they can give relative high changes of vegetable oils just by stretching out the driving force obsession to 1 or 2 mol%. Notwithstanding, whether or not a without water alcohol/oil mix is used, some water is made in the structure by the reaction of the hydroxide with the alcohol. The presence of water offers ascend to hydrolysis of a piece of the made ester, with coming about synthetic new development. This lamentable saponification response lessens the ester yields and widely problematic the recuperation of the glycerol because of the improvement of emulsions.

High measure of free corrosive outcomes in saponification of oil and in this way, fragmented response during trans -esterification measure with resulting development of emulsion and trouble in partition of glycerol. The yield of esterification measure diminishes impressively if FFA esteem is more prominent than 2%. Canakci and Van Gerpan observed that trans-esterification would not happen if FFA content in the oil is about 3%.



Principle of Cyclone separators

The Cyclone separators are gadgets that use diffusive powers and low weight brought about by turning movement to isolate materials of varying thickness, size, and shape. Gas twisters are broadly utilized in industry for the detachment of particles from gas and air streams (Coker, 1993), while water typhoons, otherwise called hydro tornadoes are utilized for the partition of liquids of varying densities (Svarovsky, 1984). Tornadoes are famous because they are basic and cheap to produce, require little upkeep, contain no moving parts, and can work at high temperatures and weights (Coker, 1993).

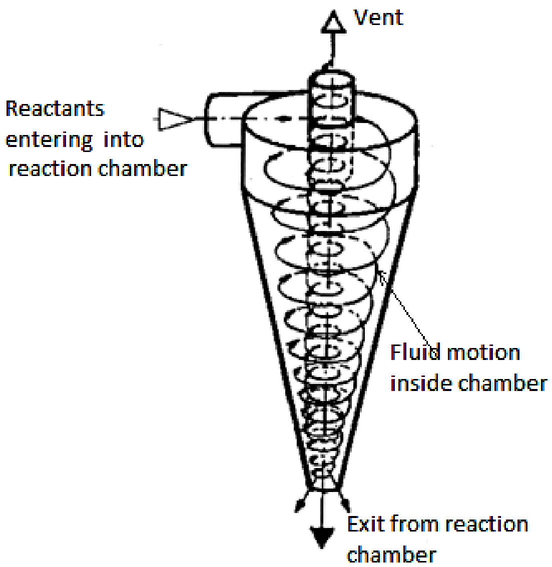


Fig1: Cyclone separator

Figure 1 delineates the fundamental working standards of a typhoon separator. The gas or liquid stream is mixed at high rates by the cove line, is arranged incidentally to the body of twister (Seinfeld, 1975). The condition of the cone prompts the stream to turn, making a vortex. Greater or thicker particles are compelled outward to the dividers of the storm where the drag of the turning air likewise as the power of gravity makes them tumble down the sides of the cone into a source (Seinfeld, 1975; Svarovsky, 1984).Then the lighter and additionally less thick particles just as the gas or fluid medium exit through the highest point of the typhoon by means of the low weight community. The effectiveness of twister separators is reliant upon the typhoon distance across and the weight drop between the bay and source of the tornado (Clift et al, 1991).

Cyclone Design Ratios

Utilizing Strairmand plan information for the high effectiveness typhoon, the different measurement proportions are recorded from which the twister measurements are shown up:

$B_c / D_c = 0.25$

$H_c / D_c = 0.5$

$Z_c / D_c = L_c / D_c = 2$

$S_c / D_c = S_c$

$J_C = D_e = \text{arbitrary} = \frac{D_C}{4} = 0.0255$ m or 25.5 mm.

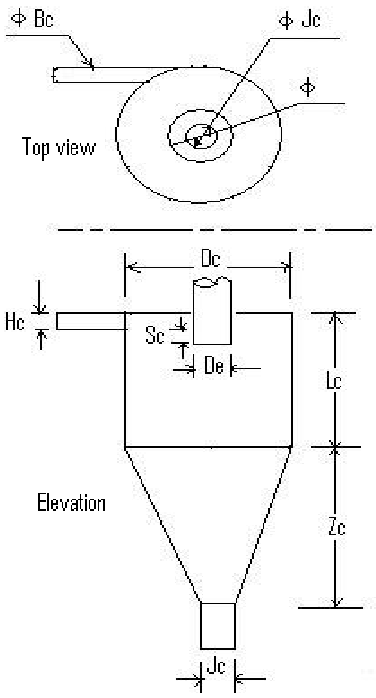


Fig 2: Design of Cyclone Separator

Experimental set up

Arranged plan relies upon the rule of twister splitter. The fluid flow is infused at high speeds by the delta pipe, which is orchestrated digressively to the body of the twister. The state of the cone prompts the flow to turn, making a vortex. More prominent or denser particles are obliged external to the dividers of the hurricane where the drag of the turning air comparably as the power of gravity makes them tumble down the sides of the cone into a source.

In this arrangement the reactants (oil, methanol +NaOH) enters in the response chamber through the fly and ceaselessly re-flowing in a cycle by the assistance of stuff siphon [8], from blending chamber [2], channel lines and fly, response chamber [5], lastly to the gathering reservoir [7] and a few mountings were mounted with arrangement as appeared in figure may be, thermocouples to quantify temperature of surfaces and within arrangement at various stage, compel measure to show pressure, warming component on the outside of response chamber with protection , air vent, source valve [10], and working table.

In this process, first, sodium meth oxide was prepared in a particular ratio of sample. After preparation of sodium meth oxide, flow the oil for 2-3 min in reaction chamber to achieve temperature 60 ^{0}C and then mixed the sodium Meth oxide gradually and kept on it continuous for an hour and kept it for 10-12 hours for proper separation, after having indication of separation during reaction. It is continuous type trans-esterification setup and can produce 150 litres of biodiesel per day and it is portable type compact.

Feature of set up

To overcome the limitations found in traditional set up, certain features have been introduced in new set up such as,

- It works on the principle of cyclone separator.
- It can work continue and it eliminates load/unloading problems.
- It reduces the energy consumption as the required reaction time is less.
- It stands for high capacity in when old set up was low capacity in batch.

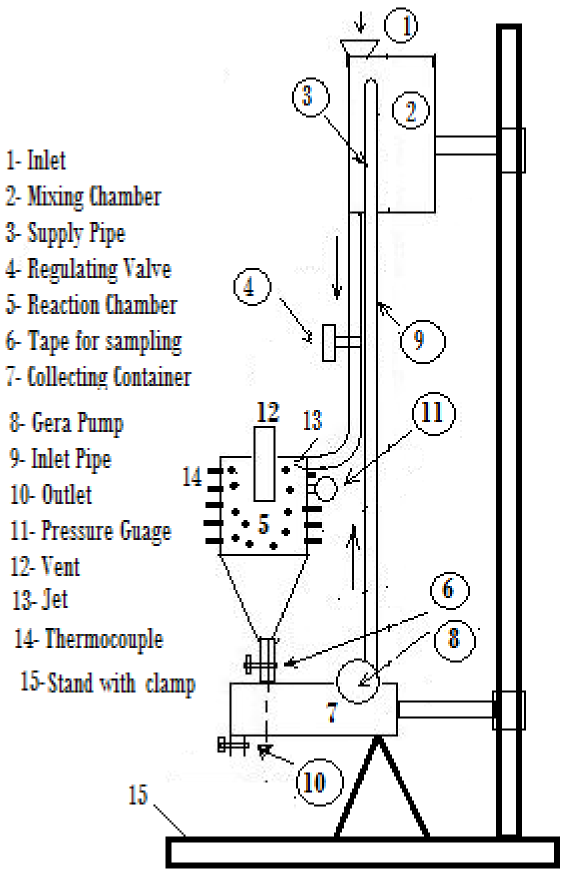


Fig. 3: Cyclone type Trans-esterification Setup

Design Equations

Design Calculation for Designed Transesterification Setup

Rate of Flow through The pipe (in downward direction)

Applying Bernoulli's theorem to the upstream tapping (1) and to the orifice (2) indicated in Fig A, we can write,

$$\frac{p_i}{w}+\frac{V_i^2}{2g}+gz_i = \frac{p_0}{w}+\frac{V_0^2}{2g}+gz_2+\frac{4fLv_0^2}{2gd} \quad \text{........ (1)}$$

$$\text{or} \quad gz_i = \frac{p_o}{w}+\frac{V_o^2}{2g}+gz_o+\frac{4fLv_o^2}{2gd}$$

Where, $\frac{p_i}{w} = 0$ and $\frac{V_i^2}{2g} = 0$

Loss due to friction, $= \frac{4fLv_o^2}{2gd}$ (According Darcy's equation)

$$\Rightarrow V_o = \sqrt{\frac{g(z_i - z_o) - p_o}{\left[\frac{1}{2\times g}+\frac{4fL}{2gd}\right]}} \text{ m/sec.}$$

Assuming that the pipe is running full and for the moment that no expansion of the fluid takes place,

Flow rate, $Q = A_i V_i = A_o V_o = AV \ m^3/sec$

Theoretical mass flow rate (m_t) of air can be expressed as:

$$m_t = \rho_a A_o V_o \quad \text{kg/s}$$

$$m = \rho[\frac{\pi}{4}\times(\frac{d_o}{100})^2] \times \frac{2g\times 10\Delta p}{\rho(1-m_1^2)}]^{1/2} \times 3600 \quad kg/hr.$$

When flow is in upward direction:

$$w\ (h_o - h_i) = \frac{32\ \mu\ v_o L}{d^2} \quad \text{.......(2)}$$

$$\Rightarrow (h_o - h_i) = \frac{32\ \mu\ v_o L}{d^2} w$$

$$h_o - h_i = \left(\frac{p_i}{w}+z_i\right) - \left(\frac{p_o}{w}+z_o\right)$$

Pressure drop in pipe,

$$p_i - p_o = \left(\frac{h_2 - h_1}{z_o - z_i} \times w\right) \text{kgf/sq m}$$

Stress on pipe during flow,

$$z = \left(- \frac{dp}{dx} \times \frac{r}{2} \right) \text{ kgf/sq m}$$

Power required keeping the flow rate,

$$P = \frac{Q(p_i - p_o)}{75}$$

3. RESULT AND DISCUSSION

To produce bio-diesel from Soya bean oil using base catalysed, Cyclone type transesterification set up was designed and developed for the capacity of 120 litters per day. To decide the ideal season of response, temperature and mass stream rate for trans-esterification of vegetable oil (soya bean oil) were conducted by varying reaction time, reaction temperature and mass flow rate of reactant. Where concentration of methanol and NaOH were kept constant on 20% and 1% respectively. All the results captured in experimental study are given in following tabulations along with graphs.

Effect of time duration on the bio-diesel production by using designed Trans-esterification setup with Soya bean oil.

(For the fixed quantity of 650 gm oil, 130 gm methanol and 6.5 gm NaOH at 60 ^{0}C temperature).

Experiments	Time (min)	Biodiesel Yield (gm)		Glycerol Yield (gm)	
		From New Set Up	From Existing Set Up	From New Set Up	From Existing Set Up
Exp1	30	571	**535**	210	248
Exp2	45	598	**560**	183	223
Exp3	60	649	**580**	132	202
Exp4	90	650	**595**	131	187

Table 1: Yield of Biodiesel in new and old set up

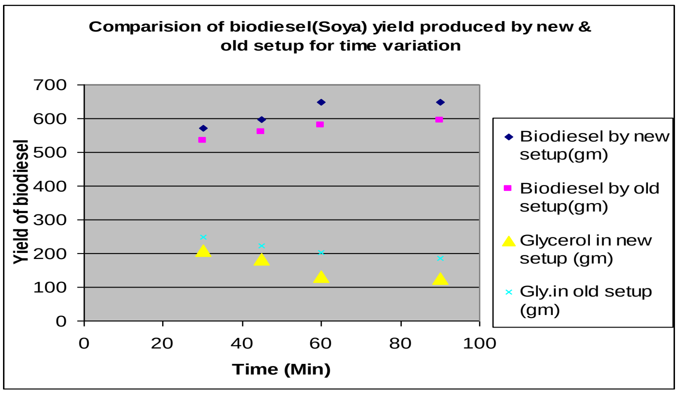


Fig 4: (Graph) Comparison of biodiesel yield produced in designed set up and in existing for varying reaction time.

It was discovered to be pretty much the equivalent at 60 and 90 min of response time.

Effect of temperature on the bio-diesel yield, using new & old transesterification setup with Soyabean oil

Sample

(For the fixed quantity of 650 gm oil, 130 gm methanol and 6.5 gm NaOH for 60 minutes of reaction time)

Exp	**Temp (0C)**	**Biodiesel Yield (gm)**		**Glycerol Yield (gm)**	
		From New Set Up	**From Existing Set Up**	**From New Set Up**	**From Existing Set Up**
Exp1	**50**	**618**	**535**	**516**	**266**
Exp2	**55**	**644**	**560**	**580**	**202**
Exp3	**60**	**650**	**580**	**612**	**170**

Table 2: Yield of Biodiesel in new and old set up for varying temperature.

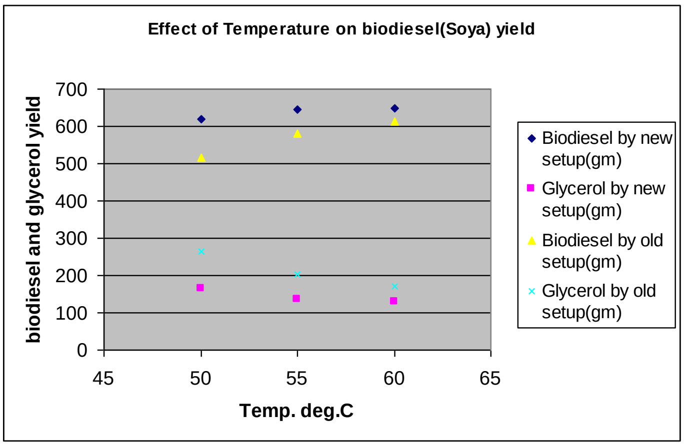


Figure 5: (Graph) Effect of temperature on yield of biodiesel produced by designed and old setup.

Effect of mass flow rate on the bio-diesel yield

The mass flow rate varieties received in this investigation were 9 kg/min, 9.5 kg/min and 10 kg/min. The consistent response season of 60 min, temperature 60 0C and the steady methanol and NaOH convergences of 20% and 1.0% individually, provides the optimal ester yield, was kept up by the stream rate varieties for the creation of bio-diesel from Soya-bean oil.

(For the fixed quantity of 650 gm oil, 130 gm methanol and 6.5 gm NaOH for 60 minutes of reaction time)

Exp	**Mass flow rate**	**Biodiesel**	**Glycerol**

	(kg/min)	(gm)	(gm)
Exp1	**9**	**630**	**152**
Exp2	**9.5**	**645**	**137**
Exp3	**10**	**649**	**132**

Table 3: Effect of mass flow rate on the bio-diesel production.

NMR Report on % of biodiesel and other element.

This report shows the percentage of different components in the sample.

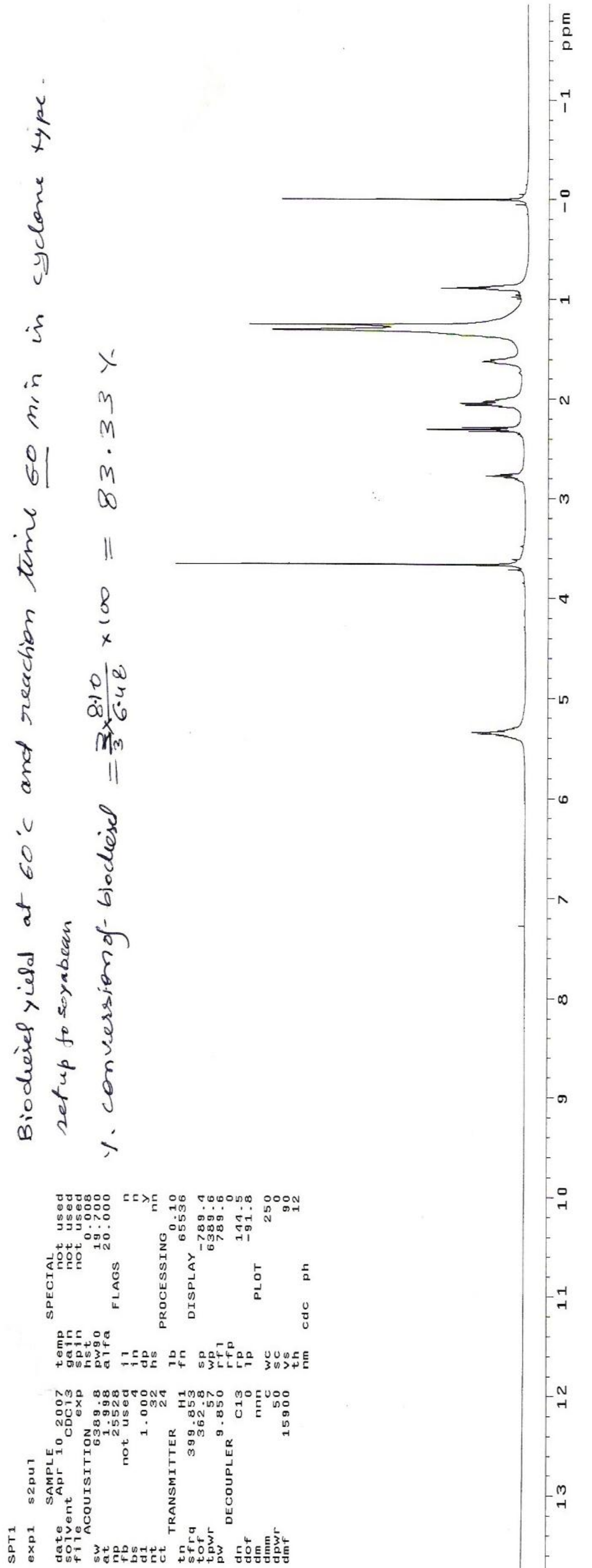


Figure 6: (Graph) NMR report showing % of biodiesel

Comparative data of Capacity and Production Cost of Biodiesel for new and existing set up.

Parameters	**New Designed Setup**	**Existing Setup**
Capacity in kg per day (for 8 hours)	**120**	**6**
Production Cost/kg	**16 Paisa**	**94 Paisa**

Table 4: Showing the difference between capacity and economy of both new set up and old set up.

Physical-Chemical, properties methyl ester produced in by designed set up and petro-diesel.

Properties	BDP	Petro-diesel
K.V (cSt.)	7.79	3
Flash Point (0C)	180	47
C.V.(kj/kg)	33726	43000
Pour Point (deg.C)	-2	-
Cloud point (deg.C)	1	-
Aniline point (deg.C)	42	47
Cetane No.	45	40-55

Table 5: Physical-Chemical, properties methyl ester produced in by designed set up and petro-diesel.

BDP => Biodiesel from Designed Plant
BOP => Biodiesel from Old Plant
K.V. => Kinematic viscosity
C.V. => Calorific value

4. CONCLUSION:

Proper processing of transesterification can ascertain the quality of Liquid Biofuels. Based on the principle of cyclone separator, a new set up has been developed and his improved setup was studied & variables effecting biodiesel production were obtained. New designed setup has been performed very well than old setup, like capacity, time, loading, energy consumption, continuity and variable amount.

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