A Review Study on Performance Modelling of Single Cylinder CI Engine Fuelled with Blend of Diesel and Pyrolysis using Taguchi Method

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Abstract— There are many alternative or blend fuels are discovered and tested successfully in existing engine with and without engine modification. Still research is continuing in this area to find best alternative fuel for the existing diesel engine. In this experimental study has been carried out for pyrolysis oil blended with diesel used in single cylinder diesel engine. Blending of pyrolysis oil with diesel in maximum possible proportion helps to reduce the consumption of diesel fuel. The main aim of this experiment is to optimize parameter which gives maximum performance for mechanical efficiency and break thermal efficiency. In this study, the effects of parameters i.e. percentage of pyrolysis oil in diesel blend, injection pressure and load are taken as variable for optimization. As the experiment required simultaneously optimization of four parameters with five levels, taguchi method of optimization is used in this experiment. From this experimental study we will get maximum performance for mechanical and break thermal efficiency for single cylinder CI engine fuelled with blend of diesel and Pyrolysis using Taguchi Method.

Key words: Cascaded multilevel inverter, developed H-bridge, multilevel inverter, voltage source inverter

I. INTRODUCTION

Diesel engines are attracting greater attention due to higher efficiency and cost effectiveness, because of that they have been widely used as a power of engineering machinery, automobile and shipping equipment. Oil provides energy for 95% of transportation. All countries including India are grappling with the problem of meeting the ever increasing demand of transport fuel within environment concerns and limited resources. So, the most attentive question arises in our country and at world level is “How long we can use this petroleum fuels? “The solution of this question is in three words `Reduce’,' Reuse' and `Recycle'.

A. *Pyrolysis Oil of Tyre:*

An automobile tyre was cut into a number of pieces and the bead, steel wires and fabrics were removed. Thick rubber at the periphery of the tyre was alone made into small chips. The tyre chips were washed, dried and fed in to a mild steel pyrolysis reactor unit. The pyrolysis reactor used was a full insulated cylindrical chamber of inner diameter 110 mm and outer diameter 115 mm and height 300 mm. Vacuum was created in the pyrolysis reactor and then externally heated by means of 1.5 kW heaters. A temperature controller controlled the temperature of the reactor. The process was carried out between 450˚ C and 650˚C in the reactor for 2 hours and 30 minutes. The products of pyrolysis in the form of vapour were sent to a water cooled condenser and the condensed liquid was collected as a fuel. The schematic diagram of the pyrolysis process of waste automobile tyres is given in Figure 1.

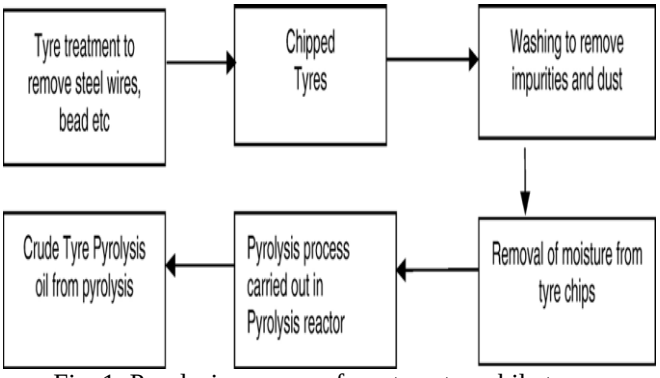

Fig. 1: Pyrolysis process of waste automobile tyres.

The non-condensable gases were let out to atmosphere. The Pyrolysis oil collected was crude in nature. The product yields from the process are: Tyre Pyrolysis Oil (50 %), gas (40 %) and char coal (10 %).

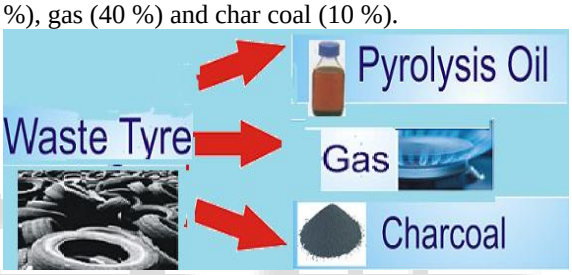

Fig. 2: Products from Waste Tyre

The composition of pyrolysis oil reconfirms and comparable with the values available in the early research works. Since the oil collected for this study was untreated, the oil contains impurities, dust, low and high volatile fractions of hydrocarbons. Pyrolysis oil was filtered by fabric filter and again filtered by micron filter. The efficiency of the filtration is 99 %.

B. *Use of Pyrolysis Oil as Fuel in Diesel Engine:*

- Density of Pyrolysis oil was higher than that of diesel.
- Kinematics viscosity of oil is nearly same as diesel.
- Flash point is less than that of diesel.
- The distillation boiling point range is nearly similar to diesel.

II. LITERATURE SURVEY

M. Pandian et al [2011] have investigated the effect of injection system parameters such as injection pressure, injection timing and nozzle tip protrusion on the performance and emission characteristics of a twin cylinder water cooled naturally aspirated CIDI engine. RSM is a collection of the mathematical and statistical technique for empirical model building to optimize a response(output variables)which is influenced by several independent variables(input variables).The main objective of this work is

to study the individual and combined effects of injection system parameters on the performance and emission characteristics of the diesel engine employing Pongamia biodiesel–diesel blend as fuel using response surface methodology based experimental design and the other objective is to determine the optimal values of injection pressure, injection timing and the nozzle tip protrusion which would be resulting in improved performance with lesser NOx emissions without much penalty on CO and HC emissions using the desirability approach of numerical optimization.

The results depicted that the BSEC, CO, HC and smoke opacity were lesser, and BTE and NOx were higher at 2.5 mm nozzle tip protrusion, 225 bar of injection pressure and at 300BTDC of injection timing.

T. Ganapathy et al [2009] proposed a methodology for thermodynamic model analysis of Jatropha biodiesel engine in combination with Taguchi's thermodynamic model based on two-zone Weibe's heat release function had been employed to simulate the Jatropha biodiesel engine performance. Among the important engine design and operating parameters 10 critical parameters were selected assuming interactions between the pair of parameters. Using linear graph theory and TAGUCHI METHOD an L16 orthogonal array has been utilized to determine the engine test trials layout. In order to maximize the performance of Jatropha biodiesel engine the signal to noise ratio (SNR) related to higher-the-better (HTB) quality characteristics has been used. The present methodology correctly predicted the compression ratio, Weibe's heat release constants and combustion zone duration as the critical parameters that affect the performance of the engine compared to other parameters.

M Nataraj et al [August 2005] has investigated that taguchi parameter design research methodology allow one to make product or processes robust to uncontrollable noise factor & Will also reduce the number of experiment to be carried out to arrive an optimized system.

This study is aimed at investigating the effect of injection system parameters such as injection pressure, injection timing and nozzle tip protrusion on the performance and emission characteristics of a twin cylinder water cooled naturally aspirated CIDI engine.

Biodiesel, derived from Pongamia seeds through transesterification process, blended with diesel was used as fuel in this work. The results depicted that the BSEC, CO, HC and smoke opacity were lesser, and BTE and NOx were higher at 2.5 mm nozzle tip protrusion, 225 bar of injection pressure and at 300 BTDC of injection timing. Optimization of injection system parameters was performed using the desirability approach of the response surface methodology for better performance and lower (NOx) emission. An injection pressure of 225 bar, injection timing of 210 BTDC and 2.5 mm nozzle tip protrusion were found to be optimal values for the Pongamia biodiesel blended diesel fuel operation in the test engine of 7.5 kW at 1500 rpm.

S.Arunprasad et al has investigated to optimize the engine parameters by using biodiesel as a fuel. Neem oil is used as a bio diesel in CI engine which is produced by transesterification process. Taguchi optimization technique was used to get optimum level of parameters such as brake thermal efficiency (BTHE), indicated thermal efficiency (ITHE) and specific fuel consumption (SFC).Experiments were conducted with neem oil biodiesel blends and diesel value were compared with these results and presented in this paper. The result clearly shows that blend B60, compression ratio 18:1 and 6 Kg load was the optimum parameters.

S.Murgan has investigated that tyre pyrolysis oil is produced from automobile waste tyre from vacuum pyrolysis method. In this study the effect of on performance and emissions of a single cylinder four stroke diesel engine running on tpo-df at 30 pecent blend (TPO 30) at different injection pressure (210,220,230 and 250) were investigated.

Result showed that The engine was able to run up to the fuel injection pressure 250.The brake thermal efficiency increased marginally for the fuel injection pressure 220.Ignition delay was longer compare to that of DF operation. Result also indicated that TPO 30 with fuel injection pressure of 220 gave better performance among all the injection pressure of TPO 30 and DF.

Jinang M.Patel has investigated that oil obtained from pyrolysis of waste tire was studied upon for its suitability to be used with diesel fuel. A study was carried out to evaluate the use of various tire pyrolysis oil (TPO) blends with diesel fuel (D5, D10, and D15). Performance and emission characteristics of TPO blends with diesel on a 4 cylinder direct injection engine are presented in his work. Result concluded that Brake thermal efficiency increased for all D10 when compared to neat diesel fuel. The maximum brake thermal efficiency was found to be 2.68% higher than neat diesel fuel. Brake specific fuel consumption was lower than neat diesel over entire range. At maximum loading condition BSFC of neat diesel was 9.55% higher than D10 blend. The exhaust gas temperatures were significantly lower than neat diesel for D10 and D15 at low loading conditions.

R. Senthil Kumar, his research describe a comparison of the use of pyrolysis oils which are the tire pyrolysis oil, plastic pyrolysis oil and diesel oil in the assessment of engine performance, and feasibility analysis. Pyrolysis oils from waste tire and waste plastic are studied to apply with one cylinder multipurpose agriculture diesel engine. Tests have been carried out to evaluate the performance analysis of a single cylinder direct injection diesel engine fuelled with 5%,15%, 25%, 50%,75%and 85% of tyre pyrolysis oil (TPO) blended with Diesel fuel (DF). Best suitable blend was found and pyrolysis oil was added in concentration of 50%, 75%, with diesel.

III. SCOPE OF THE WORK

From above investigations and experiments carried by various researchers conclude that there is vast possibility of alternative fuel which is used in diesel engine. If alternative fuel is used as blend with diesel in diesel engine, it reduces dependency on diesel and gives solution of scarcity of fossil fuel. But Diesel engine is already optimized for particular fuel i.e. diesel. So, it does not give optimum performance for selected blend i.e. pyrolysis and diesel. If parameters are optimized for selected blend, then it gives optimum performance for desirable effect i.e. mechanical efficiency and brake thermal efficiency. Also from above survey, taguchi method is more appropriate than any other method of DOE because this method is simplest method of optimizing experimental parameters in less number of trials.

The number of parameters involved in the experiment determines the number of trials required for the experiment. More number of parameters led to more number of trials and consumes more time to complete the experiment. Also, S/N ratio is excellent tool, which reduce the effect of other factors and parameters, which are not used in the experiment. Hence, a method called 'Taguchi' will be tried in the experiment to optimize the levels of the parameter involved in the experiment. Using this taguchi method for optimization of parameter will be gives solution of present problem of scarcity of fossil fuel and increased price of fuel in global market.

IV. DEFINITION OF PROBLEM

In recent time, main reasons for developments of alternative fuels are the fuel prices are increasing, lots of road vehicles, shortages of petroleum resources, continuing accumulation greenhouse gases. There are many alternative or blend fuels are discovered and tested successfully in existing engine with and without engine modification. Still research is continuing in this area to find best alternative fuel for the existing diesel engine.

It is usually to use alternative sources of fuel in diesel partially which is proven technology by various researchers were already made on diesel engine. The diesel engine is made for diesel and its all system is developed for diesel fuel and its parameters are already optimized for diesel engine. If we use blend of diesel and other extra fuel then it is not give satisfactory performance as per requirement, so it is required to optimize parameter for blended fuel.

The main aim of our experiment is to optimize parameter which gives maximum performance for mechanical efficiency and break thermal efficiency. For getting that result there is required number of experiments which gives results in the form of set of parameter. This set of parameter give different performance with reduction in different fuel consumption. From this sets of parameters, there must be choose set of parameters.

V. OBJECTIVES

To get our objective Taguchi L_{25} orthogonal array is used for statistical method. Five levels for each factor are used. For blend proportion i.e. percentage of pyrolysis oil in diesel blend 5, 10,15,20,25 % by V/V, for injection pressure 160,180,200,220,240 bar, for engine load 4,8,12,16 and 20 kg.

- To get optimum set of parameters for highest mechanical efficiency from values find by experimental sets which were suggest orthogonal array.
- To get optimum set of parameters for highest brake thermal efficiency from values find by experimental sets which were suggest orthogonal array.
- To find experimental value for suggested optimum sets of parameters by Minitab software for highest mechanical efficiency and brake thermal efficiency.
- Compare predicted value and experimental value of mechanical efficiency and brake thermal efficiency.

VI. METHODOLOGY

To achieve the objective, experimental set up is developed first of all. It contains diesel engine, rope brake dynamometer, inlet air tank and manometer. The experiment contains selected control parameter for optimization are blend proportion i.e. percentage of pyrolysis oil in diesel blend, injection pressure and engine load and measuring the response are brake thermal efficiency and mechanical efficiency. Prepare experiments for suggested set of parameter by Minitab software. After conducting experiment, find value of mechanical efficiency and brake thermal efficiency and also predict sets of parameter. Also, find value of mechanical efficiency and brake thermal efficiency for predicated sets of parameters. Conduct experiment for optimum set of parameters and compare experimental value and predicated value. The Taguchi's parameter design approach has been used to obtain the above objective.

VII. CONCLUSION

The Taguchi's approach has been carried out for optimizing the performance of diesel_engine using pyrolysis and diesel blend. Three input parameters have been optimized using SNR. The higher-the-better quality characteristic has been used for maximizing the thermal efficiency of the engine. An L25 orthogonal array with three parameters and five levels has been used for predict set of parameter which gives value of predicated mechanical efficiency and brake thermal efficiency.

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