SELECTION OF BEST BLEND OF FUEL USING DIESEL-ETHANOL-BUTANOL IN A CI ENGINE BY AHP-PROMETHEE

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Abstract - Due to increasing the demand of fossil fuel and adverse impact on environment, selection of best blend paly a great rule in alternate energy production. In this paper, application of multicriteria decision making (MCDM) technique is applied for selecting the best blend of diesel for the CI engine. The proposed method, Analytical Hierarchy Process is integrated with PROMETHEE II (Preference Ranking Organization Method for Enrichment Evaluation) to evaluate the optimum blend. Selection of suitable blend is depends on expository analysis of the performance and emission parameters of single cylinder, constant speed direct injection diesel engine at constant (full) load condition. Here AHP is used for determining the weights. PROMETHEE II are used for final ranking of alternative. From the ranking D94 E05 B01 blend is selected best for performance parameters by AHP-PROMETHEE II. As well as D72 E25 B03 blend is selected best for emission parameters by AHP-PROMETHEE II.

Keywords - Four stroke CI engine, Performance and emission characteristics, MCDM techniques, Optimization.

I. INTRODUCTION

Worldwide engine manufacturers developed diesel engine with higher thermal efficiency and specific power output, keeping in mind that imposed emission should have in limit according to emission regulation act. For developing a cleaner diesel engine, a significant achievement has been made such as common rail system, fuel injection control strategies, exhaust gas recirculation, exhaust gas after treatment etc. Furthermore, for reduction of pollutants emission, researchers trying to change fuel related techniques, for example the use of alternative gaseous fuels of renewable nature, which are friendly the environment and able to reduce particulate emission [1-6]. Since alcohol have higher oxygen contain and less carbon and sulphur contain, it shows better tendency to decrease internal combustion engine emissions. Though, alcohol fuels have a higher octane number than conventional fossil fuels and can be used as an octane promoter for gasoline fuels. But, they have a lower cetane number, which limits the usage of neat alcohols in diesel engines as an alternative fuel. To use cetane enhancers can advance possible usage of alcohol fuel blends as a promising fuel for diesel engines. Alcohol fuels such as methanol (CH3OH), ethanol (C2H5OH), propanol (C3H7OH), butanol (C4H9OH) can be used with fossil-based fuels in various percentages for diesel engines as a clean alternative fuel source. A few researches used the butanol with ethanol as a cetane improver to study the performance and emission parameter. Lapuerta et al. [7] prepared anhydrous bioethanol blended with conventional diesel, with 10% ethanol in volume and no additives. Rakopoulos et al. [8] investigated the effects of using blends of n-butanol (normal butanol) with conventional diesel fuel, with 8% and 16% (by vol.) n-butanol. Dogan et al. [9] investigated on the influence of n-butanol/diesel fuel blends (as an oxygenation additive for the diesel fuel. He prepared five blends B5 (contains 5% n-butanol and 95% diesel fuel in volume basis), B10, B15, B20 and neat diesel fuel. In this paper, an effort has been made to use ethanol and butanol with pure diesel to study the performance and emissions parameters. The engine was operated with the ethanol-butanol-diesel blends at constant load (full) conditions. The performance and emission characteristic of the engine varies with respect to constant load conditions for different blends. It is rather difficult to choose the optimum blend to run the Internal Combustion (IC) engine. In the present work, most of the investigators have deliberated their operating fuel with reference of NOx, smoke and BTE performance and based on the decrease of NOx and smoke and increase of BTE, the operating fuel is suggested as the best blend without considering other swaying parameters such as HC, CO and EGT [13-15].

II. EXPERIMENTAL SET UP

The experiment was conducted on an existing single cylinder four stroke direct injection CI engine having the specification listed in Table 3.1 & has shown in Figure 3.1. The diesel engine is coupled with eddy current dynamometer. The dynamometer has the specification listed in Table 3.1. A standard air tank is fitted with a digital manometer having a range of 0-100 mm for measuring the Actual volume of air drawn into the cylinder. The specific fuel consumption was recorded from burette having a range of 0-50cc. A non-contact PNP sensor was used to measure the engine RPM.

Figure 1 Stroke diesel engine test rig.
III. EXPERIMENTAL RESULTS

We consider the alternatives A1, A2, A3, A4, A5, A6, A7 are BASE DIESEL, D98 E02 B00, D94 E05 B01, D89 E10 B01, D83 E15 B02, D78 E20 B02, D72 E25 B03 respectively. The performance characteristics like Brake Thermal Efficiency (BTE), Brake-specific fuel consumption (BSFC), Brake power (BP) and Brake specific energy consumption (BSEC) and emission characteristics like Nitrogen oxides (NOx), Hydro Carbon (HC), soot are experimentally found for different blends. The result are given in following tables.

IV. COMPUTATION

4.1 AHP Computation

Pair wise comparison matrix for criteria to criteria of performance parameter.

\[ CR = \frac{C_{ij}}{R_{ij}} = 0.0542 \approx 5\% < 10\% \]

Pair wise comparison matrix for criteria to criteria of emission parameter.

\[ CR = \frac{C_{ij}}{R_{ij}} = 0.0630 \approx 6\% < 10\% \]

4.2 Promethee computation

On the basis of the evaluation criteria, blends as alternatives are evaluated and the evaluation matrix is formed. There are some criteria are beneficial and some are non-beneficial. According to some criteria (BTE, BP) are beneficial and some criteria (BSFC, BSEC, NOx, H\(_2\)C\(_2\) and SHOOT) are non-beneficial. The usage of both beneficial and non-beneficial scales ensures that all criteria are properly processed on the best way. After finding the beneficial and non-beneficial criteria and weightage (by AHP method), we need to find out the normalize matrix.

4.2.1 Computation of performance parameters.

Normalize decision matrix (NDM):

\[ P_i(A_j, A_k) = 0, \text{ if } r_{ij} \leq r_{ij} \]

\[ P_i(A_j, A_k) = \frac{r_{ij}}{r_{ij}} \text{ if } r_{ij} > r_{ij} \]

\[ \varphi = 1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7 \]

Where, 1...7= Alternatives

Weighted pair wise matrix

\[ \varphi^+ = \frac{1}{7} \times \sum (Column) =0.1447288. \]

In the same manner find out \( \varphi^- \) values

\[ \varphi(A_j) = \varphi^+(A_j) - \varphi^-(A_j) \]

Now rank the alternative according to their \( \varphi \) values

From the ranking A3 is the best alternative blend.

4.2.2 Computation of emission parameters.

Now rank the alternative according to their \( \varphi \) values

From the ranking A7 is the best alternative blend.

V. DISCUSSION

The results obtained through the proposed methodology AHP-PROMETHEE at 100% load are considered to illustrate the result of PROMETHEE analysis. The ranking order are positioned in descending order based on PROMETHEE index for performance are D94> D98> DIESEL> D72> D89> D83> D78> D94 is obtained as the best blend whereas D78 stands last ranking due to the fuel characteristics. As for the same, the ranking order are positioned in descending order based on PROMETHEE index for emission are D72> D98> D78> D89> D83> DIESEL> D94. D72 is obtained as the best blend. The effect of BTE, BSFC, BP, BSEC, HC, NOx, smoke, in the engine with respect to the full load varies with respect to the fuel characteristics. Researchers cannot be able to propose the best blend among all the blends, since the fuel characteristics are closer which creates contradiction to meet the emission norms and fuel economy.

CONCLUSION

The selection of best blend plays an imperative role for diesel usage in internal combustion engines. There are number of performance and emission parameters that are to be considered. Before choosing the best blend which involves a multi-dimensional perspective. Therefore effective decision-making approach is essential to resolve the problem. AHP integrated PROMETHEE II decision making methods have been used to evaluate the best blend. AHP is used to compute the evaluation criteria weights and PROMETHEE is employed to determine the priorities of the alternatives. The proposed decision methods can help the decision makers such as engine manufacturers and R&D engineers to analyze and choose the best blend for the IC engines. The outranking methods are used for precise ranking results of alternatives. Its evident that the proposed approaches are different from the existing literature for the selection of best blend.

REFERENCES


