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Optimization of *Chlorella vulgaris* Biodiesel usage in Diesel Engine

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The experimental investigation has been carried out on the diesel engine using *Chlorella vulgaris* algal biodiesel as blends with neat diesel. Two input parameters, such as load and fuel and four reaction parameters such as hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and smoke, were used for the emissions on the engine. The experimental results show that there's been less pollution from using algae oil blend in the diesel engine. It is employed to find the optimum level for multi-objective prediction carried out for CO, HC, NOx, and smoke. The outcomes after grey relational analysis (GRA) were tested using the response surface methodology (RSM), wherein the optimal combination has been found out using a particular behaviour.

Keywords: Algae oil, Taguchi, Grey relational analysis, RSM

Introduction

Now biodiesel use in the diesel engine has rapidly increased for days. In this study, we validated the extent to which the use of biodiesel is optimum in the operation of an engine. But it's difficult to run the engine with various fuels with different goals, and you need much experimentation. We used Taguchi design to design a series of experiments to reduce the effort, but Taguchi multi-response assessment is not more successful when the aim is to measure responses with different goals. Thus, for optimization, this research would use a gray relational study and found an optimum combination of the load as well as power. However, we cannot assume the obtained results as necessary, and some testing on the findings should be performed. Hence we used the surface response methodology (RSM) approach for validation purposes. The RSM's adequacy method was found to be the most efficient strategy for optimization. The RSM's desirability approach was used to analyze optimum parameters for performance optimization and smoke emission characteristics.[1] The objective of this study is to optimize performance parameters using grey relational analysis (GRA) and validation using RSM.

Materials and Methods

The oil extraction, biodiesel and experimental data were developed by following my previous study.[2]

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Results and Discussion

Grey relational analysis

The following steps are used for GRA

Phase 1: Calculate the S/N Ratio

i) Larger – the – better

S/N ratio (η) = -10 $\log_{10}\left(\frac{1}{n} \quad {}_{i=1}^{n} \frac{1}{y_{ij}^2}\right.$

Where n= number of replications

y_{ij} = Observed Response value where i = 1, 2, ….n; j = 1, 2…k

ii) Smaller – the – better

S/N ratio (η) = - 10 log $_{10}\left(\frac{1}{n} \quad {}_{i=1}^{n} y_{ij}^2\right.$

iii) Nominal – the – best

S/N ratio (η) = 10 log $_{10}\left(\frac{\mu^2}{\sigma^2}\right.$

Where $\mu = \frac{y_1+y_2+y_3+\cdots+y_n}{n}$; $\sigma^2 = \frac{\left.y_{i-\bar{y}}\right)^2}{n-1}$

This would be considered the nominal-best problem type in which one attempts to reduce the mean squared error about with a given target value. Some way to change the mean on goal reduces the problem to a restricted problem of optimization.[3]

Step 2: Y_{ij} is standardized as Z_{ij} (0) using the formula to avoid the adoption of the effect of various units and to eliminate variability

The original data must be standardized before the grey relationship theory is used to test them. In the same array, the correct value is subtracted from the value systems to calculate the value of that array to 1 correctly. When the standardization affects the location, we have also studied the response of the pre-processing phase to the sequencing outcomes. And we suggest following the definition of the S / N ratio even before data is standardized in the analysis of grey relationships.

$$Z_{IJ} = \frac{(Yij - Target) - \min(Yij - Target, i = 1,2,\ldots n)}{\max(Yij - Target, i = 1,2,\ldots n) - \min(Yij - Target, i = 1,2,\ldots n)}$$

Step 3: Calculate Grey relational Co-efficient for the normalized S/N ratio values

$$\gamma(y_0(k), y_i(k)) = \frac{\Delta min + \xi \Delta max}{\Delta_{oj}\ (k) + \xi \Delta max}$$

Where

(i) j=1,2…n; k=1,2…m, n is the number of experimental data items, and m is the number of responses.

(ii) $y_o(k)$ is the reference sequence ($y_o(k)$=1, k=1,2…m); $y_j(k)$ is the specific comparison sequence.

(iii) $\Delta_{oj} = \|y_0(k) - y_j(k)\|$= The absolute value of the difference between $y_o(k)$and $y_j(k)$

(iv) ξ Is the differentiating coefficient that is defined within the range

(v) is the distinguishing coefficient which is defined in the range

$0 \le \xi \le 1$ (The value can be balanced according to the system's realistic needs).

Step 4: Generation of Grey relational grade

$$\bar{\gamma j} = \frac{1}{k}\sum_{i=1}^{m} \gamma_{ij}$$

Where $\bar{\gamma}_j$ - the grey relational grade for the j^{th} experiment and

k-the number of performance characteristics.

Step 5: Determine the combination of the optimal factor and its degree

The higher grade of the grey relation means better quality products; thus, the impact factor could be determined based on the grade of the grey relation, as well as the optimal level could also be specified for each controllable factor. For example, we measure the expected grade values (AGV) to assess the impact of factor I for each level j, defined as AGV_{ij}, and therefore the effect, Ei, is defined as:

$E_i = \max(AGV_{ij}) - \min(AGV_{ij})$

The Taguchi method provides a solution that disagrees with the optimization of the main goal. The effect of process parameters like the load on the engine process has been studied using a mean ratio chart in a single objective optimization. While the multiple objective optimization techniques have all transformed the single objective into a single objective equivalent function using GRA. The objectives are to evaluate the multi-objective optimized process parameters (i.e.), minimum CO emissions, HC emissions, NOx emissions, and visibility of smoke. The calculation of the GRA is seen from Figs 1 & 2. It clearly show the process parameters at the optimum level. The higher delta value represents the most critical aspect of process response determination. The optimum condition of the process parameter is 100% load.

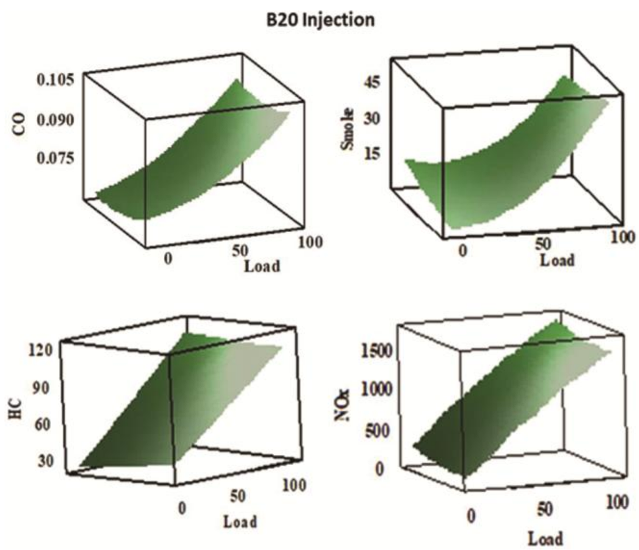

Fig. 1 — Effect of load on the response of injection

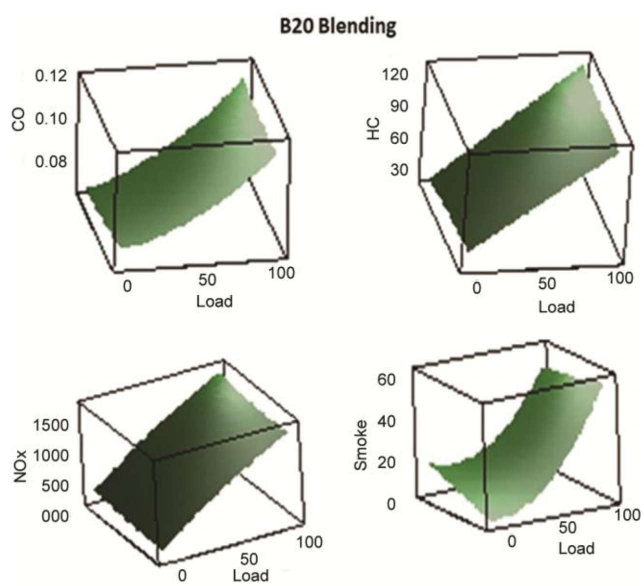

Fig. 2 — Effect of load on the response of blending

Conclusions

An effort was made to develop completely new biodiesel derived from algae oil from *Chlorella vulgaris*. In this analysis, the multi-response problem was transformed into the one with the implementation of grey relation analysis weighting factors; an optimum solution is found from the test results. The experimental method was of great help in planning and determine the important parameters that most affect emission characteristics. The RSM's approach to grey relational analysis and desirability was found to be the easiest and most effective technique of optimization. At optimum fuel and injection engine parameters, high desirability was obtained. The experimental results nearly coincided with minor deviations to the validation results.

References

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