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Original Article

Performance Optimization of Compression Ignition (C.I.) Engine Powered by Recycled Plastic Oil Using Advanced Optimization Algorithms

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Abstract - *The current research focuses on the enhancement of a four-stroke diesel-powered apparatus powered by discarded plastic oil and different combinations of diesel fuel with discarded plastic oil. Powered plastic waste and its blends are among the most potential substitutes of fuels to meet the requirement of diesel fuel in CI engines in the upcoming future. In this paper single-cylinder diesel engine was tested and taken into account for optimisation by means of several input parameters. Advanced optimization algorithm considered, namely, teaching learning-based optimisation formula and Jaya algorithm, was, used for maximization of engine brake power, minimization of Brake specific fuel consumption and maximization of the thermal efficiency for selected input engine parameter. The comparison of proposed algorithms is used to find innovative optimization techniques for predicting and optimizing the performance parameter of a WPO fuel and its blends in a CI engine, which requires less experimental work. Also, it is used to identify the ideal blending of fuel for selected engine performance criteria. Convergence trends of JAYA and TLBO were compared, and the results obtained were 85.58% and 79.62 respectively. Finally, obtained results validated by experimental results and the Jaya algorithm proved a sense of more accurate results for selected input parameters from chosen optimisation techniques, in terms of reaching the objective function's optimal value with the lowest rate of convergence.*

Keywords - *Diesel engine, Engine performance parameter, JAYA algorithm, TLBO algorithm, Waste Plastic Oil.*

1. Introduction

Because of the diminishing supply of petroleum products and their significant contribution to emissions, however, because of the growing effects of global warming and the depletion of fossil fuels, researchers are looking for cheap and environmentally alternative sources of fuel for IC engines. Alternative fuels that might perform similarly to conventional fuels concerning the diesel fuel utilized in internal combustion engines [1].

It is now necessary to conduct research on alternative energy sources for internal combustion engines. Plastics are being used in more and more ways every day, and disposing of the waste plastic produces becomes a big issue. The annual demand for plastics in India alone is approximately 8 million tonnes.

Every day, India produces around 10,000 metric tons of plastic, also it imports nearly as much from other nations [4]. The majority of plastics are recycled, yet occasionally, this is not done because there is not enough market demand. About 43% of the waste plastics are not recycled [4], which causes it to effect environmental pollution. In this point of view, fuel produced from waste plastic is the best option for the present need for fuel.

To qualify waste plastic oil carbohydrates to be a more sustainable substitute for fossil fuels, they must be made from wastage of raw materials and have less environmental impact throughout their use. The main goal is to turn the process in order to extract the combustible fuel from plastic waste. Waste plastic may be better disposed of by pyrolysis, which results in less pollution to the environment pollution [2, 3].

The pyrolysis of waste plastics not only contributes to the disposal of tons of waste plastic, which creates a clean environment, but it also produces an alternate fuel that is a practical substitute for petrol or diesel. Which offers a dual advantage of dealing with the problems of waste disposal and energy independence in IC engines [1]. The most widely used form of power generation in the transportation industry is diesel engines because of their superiority.

However, they produce large amounts of ash and nitrogen Oxides, which are harmful to human health. To do this performance of the compression ignition engine for waste plastic oil and its various blends was assessed. From the assessment, Advanced Optimization Algorithms (AOALs), especially the Teaching Learning Based optimization (TLBO) algorithm and the JAYA algorithm, are used to foresee the performance characteristics of a compression ignition engine.

Due to shortcomings in the literature: first, performance analysis and CI experiments engines powered by mixes of diesel and WPO, followed by optimization (Load and Blend) for the most effective reaction of output parameters such as maximization of brake power, thermal efficiency and BSFC minimization. TLBO depends on the impact of a teacher's impact on pupils' academic achievement in the classroom. The method simulates how well professors and students learn and teach in a classroom.

A group of learners is considered the population in the TLBO technique, and various design factors are considered as different topics provided to learners. The outcome of the learners is comparable to the "fitness" value of the optimization issue. Also, within this work, an enhanced variant of the Jaya algorithm is suggested.

The fundamental Jaya algorithm needs the standard control parameters of population size and number of generations, just like any other population-based algorithm. After implementation of these two algorithms finally compared the results of both related to best prediction and optimization for selected parameters.

TLBO is an algorithm that was created and founded on how a teacher influences a class's performance. The algorithm simulates how well professors and students learn and teach in a classroom.

In the TLBO technique, a set of learners is referred to as the population and varied topics that are offered to them are attributed to different design variables. The outcome of the learners is comparable to the "fitness" value of the optimization issue. After the execution of these two algorithms finally compared the results of both related to best prediction and optimization for selected parameters.

2. Materials and Methods

In this work, Municipal Plastic Wastes (MPW) are gathered as household waste and is considered a component of solid plastic wastes that are disposed of MPW plastics emerge from a variety of household objects, including milk covers, water bottles, food containers, foam packing, disposable cups, plates, cutlery, CD and cassette cases, guttering and plumbing pipes, wire and cable, car wrecks, etc.

When choosing a plastic, it's important to take into account factors like easy feeding for machinery, efficient conversion and carefully managed combustion [6]. In this work, we preferred Polypropylene over Polyethylene and other polymers for the production of oil from waste plastics. WPO was produced by the pyrolysis process; the schematic structure of plastic pyrolysis is shown in Figure 1.

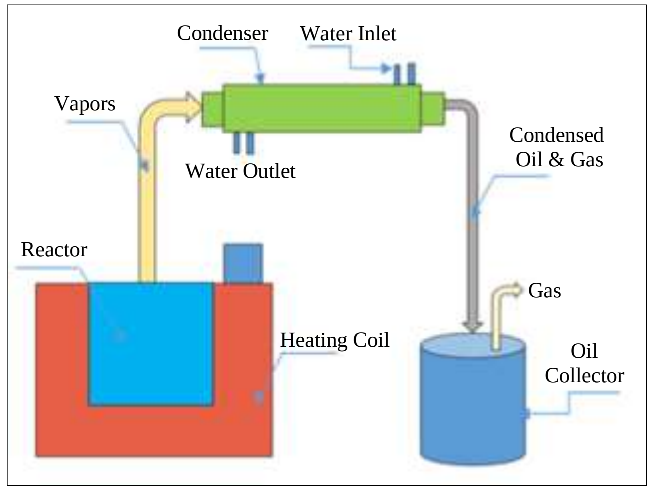


Fig. 1 Plastic pyrolysis process

The main components of the system are sorters and size tools such as shredders, crushers and cutters. The material is sorted into groups based on the shapes and sizes that are most suitable for chopping, shredding, and crushing. After the sorting process material was broken up, crushed and graded into uniform size.

The graded feed was stored in the reaction chamber or reactor and pyrolysed in an electrically heated. Pyrolysis was used to create WPO at a temperature ranging from 350°C to 500 °C at atmospheric pressure for 2 hours. Throughout this procedure, large molecules are broken down into smaller molecules, which cause produces small-molecular-weight hydrocarbons. With the help of condensation, the temperature dropped, and it was collected.

Next, a condensing portion was traversed by the condensable gases. Where they condense into a liquid oil known as Waste Plastic Oil (WPO). Figure 2 indicates the sample of waste plastic oil, which has a brown-black colour. Once the WPO is obtained then, blends of fuel are prepared by mechanical stirring with gallons of diesel fuel.

WPO 20 indicate 20% of WPO and 80% of diesel fuel similarly remaining sample of blends prepared for testing.The data presented in Table 1 displays the physical and chemical properties of the WPO as determined by ASTM standards. These properties include density, kinematic viscosity, calorific value, flash point, fire point and cetane number.

Fig. 2 Sample of waste plastic oil

Table 1. Crucial characteristics of test fuels

Properties	WPO20	WPO40	WPO60	WPO80	WPO100
Density (kg/m^3)	825	820	815	800	790
Kinematic Viscosity (cSt)	2.20	2.30	2.60	2.74	2.20
Calorific value (kJ/kg)	42900	42500	41400	40800	39600
Flash point (^{o}C)	49.5	47.8	45.4	42.6	40.4
Fire point (^{o}C)	55.8	53.6	48.6	44.3	42.2
Cetane Index	55.2	56.2	57	57.5	58

Table 2. Diesel engine setup specifications

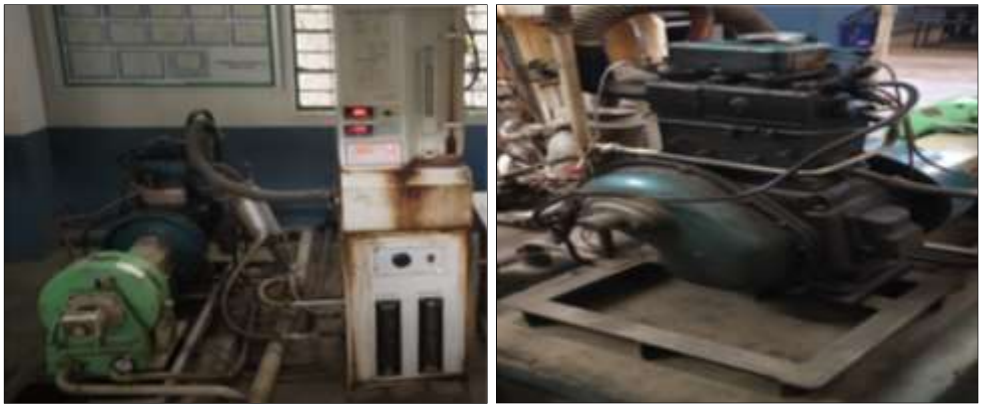
Parameters	Specifications
Engine Producer	Kirlosker Oil Engines Ltd.
Engine Type	One Cylinder, 4 Stroke, DI engine.
Stroke * Bore	110mm * 87.5 mm
Rated Power	5.2 kW
Start of Fuel Injection	24 BTDC
BHP	7 HP @ 1500 rpm
Compression Ratio	17.5:1

3. Experimental Test Setup

In this investigation, the experiments were performed on a single-cylinder direct water-cooled injection engine, which is mainly used for agricultural purposes in rural areas. Table 2 indicates the engine test setup specifications, the selected engine attached to the eddy current dynamometer and the required load for engine operation.

Several sensors were installed in the engine to track its load, speed, and cylinder pressures. Schematic layout of engine experimental setup as shown in Figures 3(a) and (b). In order to get the reference values for the assessments in the present investigation, the test engine was initially fuelled with conventional Diesel Fuel (DF).

Afterwards, diesel fuel was mixed with waste plastic oil in volumes of 20%, 40%, 60%, 80% and 100%, respectively and tested at a speed of 1500 rpm with a changeable load of 0 to 18 kg. Using the software application Engine soft version 2.4, all data of reading/observations are recorded from the responses of the engine in various performance parameters and saved on the computer.



(a) (b)

Fig. 3 Pictorial view of diesel engine setup

4. Advance Optimization Methodology

When engineering issues are solved by using optimization methodologies, the system's performance, time utilization, dependability, and cost are all improved. To address these issues, researchers have employed a variety of optimisation techniques, including sequential, dynamic, geometric, and nonlinear programming, etc. [15].

Traditional optimization methods have some limitations, but they have been successful in solving many real-world issues. These algorithms must have their unique parameters tuned; GA needs real-parameter SBX and mutation parameters. The right adjustment of the specific parameters greatly influences the performance of optimization algorithms.

If algorithm-specific parameters are not tuned properly, then the computational effort increases [16-18]. Each population-based algorithm has common control parameters, and these must be properly tuned. If there is no requirement to modify at least one element of the algorithms, then the developer's workload will be decreased. Consequently, to address the issue of setting [14].

The use of advanced optimization algorithms, such as TLBO, JAYA, and Rao Algorithm, were created by researchers as a means of addressing the shortcomings of algorithm-specific parameters in traditional optimization techniques. The current work uses this technique to optimize the performance parameters of the CI engine multi-objectively.

Multi-objective optimization means finding the vector of the factors used in decision-making and continuously optimizing (i.e., minimizing or maximizing) several goals using a collection of limitations. Three objective functions are optimized in the current work using multi-objective optimization: maximization of brake power, thermal efficiency and minimization of brake-specific fuel consumption.

The Jaya algorithm and the Teaching-Learning-Based Optimization (TLBO) algorithm are being used in the current effort to increase the CI engine's performance parameter for WPO fuel mixes. A total of three objective functions are used for the weight vector.

The reason for choosing this method is because, it's reliable and provides ideal outcomes with comparably fewer operation evaluations as well as fewer computational efforts. Finally decided, the best-advanced algorithm was decided on the basis of a performance comparison of tested fuel.

4.1. Algorithm with Teaching Learning-Based Optimization (TLBO)

Rao et al. created the Teaching-Learning-Based Optimization (TLBO) algorithm and it is predicated on how the teaching-learning process influences things. In this algorithm, the subjects (Decision variables of the optimization problem) from which the students would learn from the teacher are assumed to be a class (Population, P) with a given number of learners (L). There are two ways to teach: first, via direct teaching (teacher phase) and further, via student conversation (learner phase).

These algorithms have two most important components which are the teacher and learners. The student's performance and grades are based on the level of instruction of the trainer. The learners' outcomes are equal to the optimization problem's "fitness" value. Since TLBO is a population-based approach, the population is a group of students. It is believed that various design characteristics correspond to various subjects taught to the students [14, 15].

The teacher is considered as best respond throughout the entire population. TLBO algorithm needs a specific population and number of iterations. Sub-optimal solutions may originate from improper population size or number of iteration selections. The algorithm's performance is affected by the population size and iteration count; hence, it is necessary to run the optimization process with various population sizes and number of iterations in order to obtain the optimum values of objective functions.

This algorithm uses a few test functions and computes the global optimum associated with it to determine how effective an optimization is done. Figure 4 displays the TLBO algorithm flowchart [14, 15].

TLBO's working operation comprises of "teacher phase" as well "learner phase." This section describes how both phases work. Every independent variable in every potential solution x is changed throughout the teacher phase. The TLBO method is used in this study to optimize the performance parameter of the CI engine.

4.2. The JAYA Algorithm

In previous study, subsequently designed and released the Jaya algorithm in 2016. The algorithm continually tries to move farther away from failures (i.e., towards the ideal resolution). Details about the JAYA algorithm are discussed below.

Let 'I' be the number of design variables and 'n' be the population size. At any generation I, let the objective function be Z(x), which is to be maximized or minimized. Let Z(x)best, i and Z(x)worst, i represent the best and worst values of the objective function during a generation, respectively.

Equation (1) updates Xl,n,i, if it is the first value of the design variable for the nth populace in ith creation.

$$X'_{l,n,i} = X_{l,n,i} + r_{1l,i}\,(X_{l,best,i} - |X_{l,n,i}|) - r_{2,l,i}\,(X_{l,worst,i} - |X_{l,n,i}|) \quad (1)$$

In this case, the last variable value for the best candidate with population is represented by $X_{l,best,i}$ and the last variable value for the worst candidate with population is represented by $X_{l,worst,i}$. The two haphazard values, $r_{1l,i}$ and $r_{2l,i}$ which, are in the interval [0, 1].

Represent the changed value of $X_{l,n,i}$, which is $X'_{l,n,i}$. The proficiency of resolution to move towards the best solution is shown by the phrase "$r_{1l,i}(X_{l,best,i} - |X_{l,n,i}|)$"; on the other hand, the expression "$- r_{2,l,i}(X_{l,worst,i} - |X_{l,n,i}|)$" indicates the ability of the solution to move away from the least effective remedy.

If $X'_{l,n,i}$ provides an improved function value, it is accepted. All acceptable function values are saved at the end of each generation and used as input for the next generation. This algorithm eliminates the poorest option and looks for the best, most optimal one. For improved search space exploration, the absolute value of $X_{l,n,i}$ (i.e. $|X_{l,n,i}|$) is deducted from $X_{l,best,i}$ and $X_{l,worst,i}$ in Equation (1) rather than $X_{l,n,i}$. The flowchart of the fundamental Jaya algorithm is shown in Figure 5.

5. Mathematical Modelling for Engine Performance Parameters

With the help of empirical relations proposed by numerous researchers and authors, mathematical modelling was created for the advanced optimization technique in order to determine output parameters. Selected input parameters such as blend percentage, load percentage and calorific value of sample fuel, etc.

Conceptually, it was applied to solve it through advanced optimization techniques using MATLAB. Finally evaluated, the practically acquired results were evaluated after distinguishing the empirical relations.

5.1. Brake Power (B. P.)

The brake power of an engine is power developed by an engine which is available at the crankshaft for doing some useful work [15]. In this work brake power of the engine is measured by the eddy current dynamometer having a power is 20 kW.

The current is used to apply the variable load on the running engine so that the different engine operations calculate power and torque. Brake power is calculated with the help of the following formula.

$$B.P. = \frac{2\pi NT}{60000}\ kW \quad (2)$$

Where,
B. P. = Engine Brake Power
N = Engine speed in r.p.m.
T = Engine torque in N-m

But here, according to the Test Engine specification, torque is,

$$T = F \times R$$

Where,
F = Force acting on the engine in Newton

So, $F = W \times g$

Where,
W = Load applied on the dynamometer
g = Gravity due to acceleration
R = Radical arm length

As per the specifications of the test engine,

1. Engine Power = 5.2 kW
2. Engine Revolutions = 1500rpm
3. Arm Length = 0.195 m

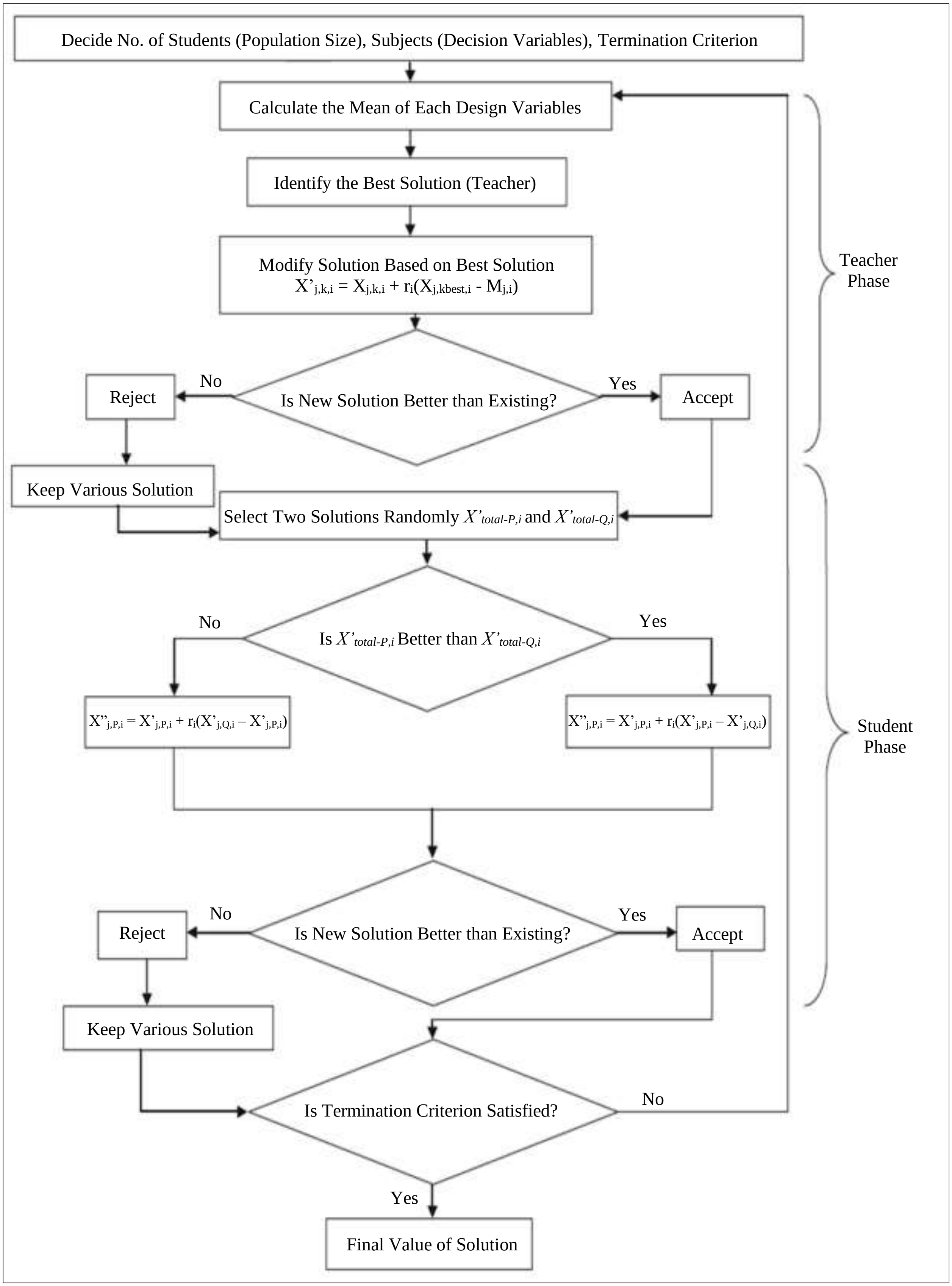


Fig. 4 Working flow chart of TLBO algorithm

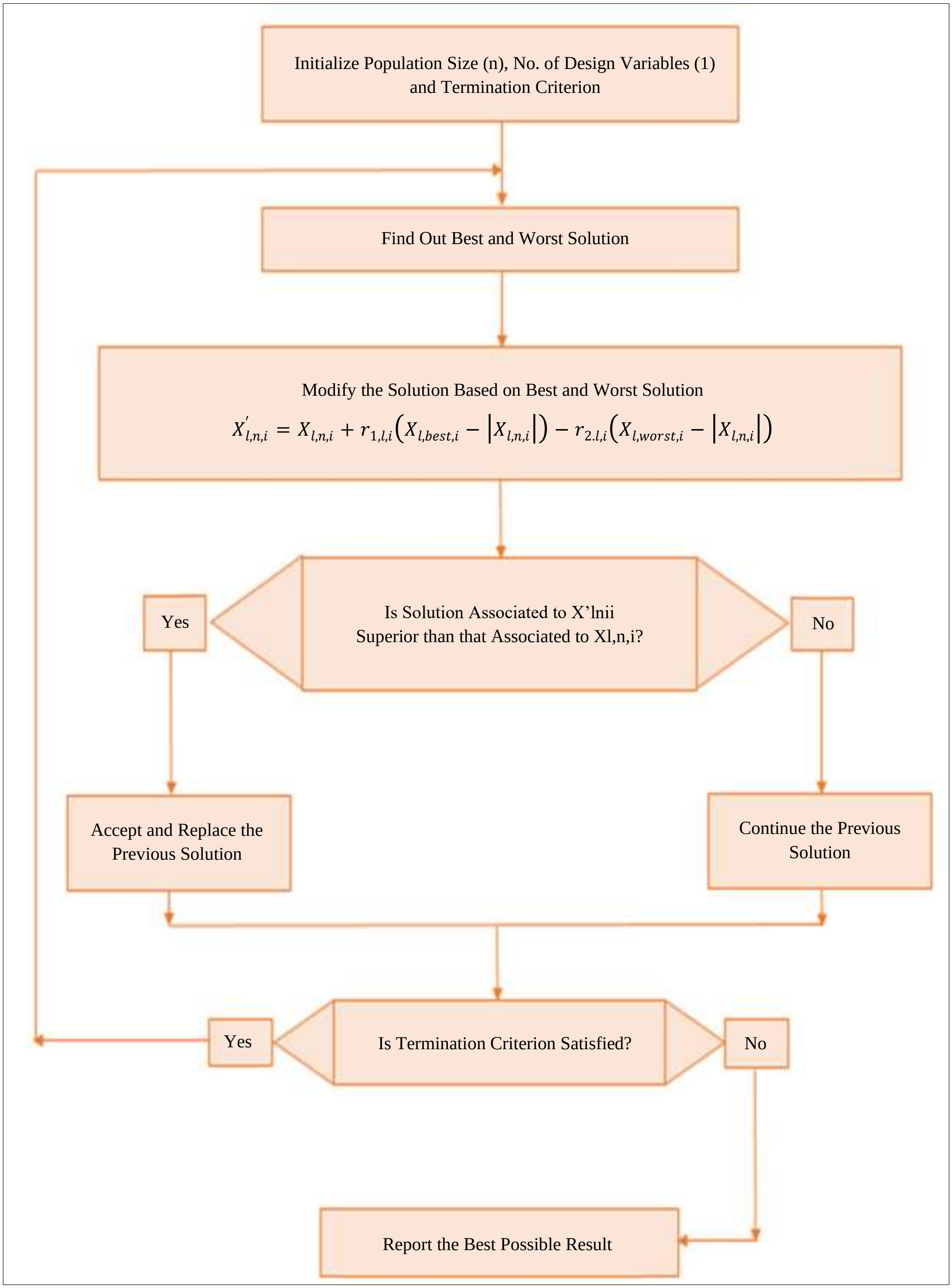


Fig. 5 Working flow chart of Jaya algorithm

So, the Torque and brake power at full load condition is calculated as,

$$P = \frac{2\pi NT}{60000}$$

$$5.2 = \frac{2 \text{ x } 3.14 \text{ x } 1500 \text{ x T}}{60000}$$

Torque = 33.12 N-m
Torque = W× R × 9.81
T = W × R × g
33.12 = W × 0.195× 9.81
W = 17.31 kg

Finally, the Full load torque of the engine is 33.12 N-m.

5.2. Brake Thermal Efficiency (BTHE)

Brake thermal efficiency is the ratio of braking power at engine crankshaft to power generated by fuel combustion [15]. Engine heat generation is indicated by brake thermal efficiency. Determine the proportion of BP to the product of fuel mass and fuel calorific value.

$$\text{BTHE} = \frac{\text{BP}}{\text{FC x Cv}} \text{ x } 100 \qquad (3)$$

Where,
BTHE = Brake thermal efficiency
FC = Fuel consumption mass (kg/sec)
C_V = Fuel calorific value (kJ/kg)

$$\text{BTHE} = \frac{5.2 \text{ x } 3600}{1.31 \text{ x } 43400} \text{ x } 100$$

BTHE = 32.17%

The maximum thermal efficiency for a single-cylinder diesel engine is in the range of 30 to 35 percent [15]. According to the standard requirement efficiency of the engine we have selected for target efficiency is 32.17 for optimization purposes.

5.3. Brake Specific Fuel Consumption (BSFC)

The term Brake-Specific Fuel Consumption (BSFC) refers to the measurement of fuel consumption in relation to engine brake power [15]. It is generally expressed in terms mass of fuel consumed per kW of power developed per hour. It was useful to decide the criteria of the economic power creation of an engine. It is used to measure both the quantity of fuel used and the quantity of energy generated by the engine. BSFC equations are presented as [13, 15].

$$\text{BSFC} = \frac{\text{FC}}{\text{BP}} \qquad (4)$$

Where,
BSFC = Brake Specific Fuel Consumption (kg/kWh)
FC = Mass of fuel in kg/sec
B.P. = Brake power in (kW)

BSFC for diesel fuel at the full condition of the engine is,

BSFC = 1.3/4.9 = 0.26

The target value for BSFC is selected in the range of 0.25 to 0.30 kg/kWh.

The above analysis demonstrates how the engine load, fuel calorific value and percentage of fuel blend in a CI engine all affect on engine. For the current study's optimization with several decision factors, three objective functions such as load, percentage of blending and calorific value are taken into consideration. The three goals are integrated into a single scalar aim function using a weight vector. The integrated target function (Z) for this problem is defined below.

5.3.1. Maximization

$$Z_{max} = w_1(Z_1 À Z_{1max})+w_2(Z_2 À Z_{2max})-w_3(Z_3 À Z_{3min}) \qquad (5)$$

The objective functions of brake power, thermal efficiency and brake-specific fuel consumption are denoted by Z1, Z2, and Z3, respectively. Whereas the weights assigned to the target functions 1, 2, and 3 are w1, w2, and w3, respectively. The objective functions can be given any weight by the designer. However, the requirement is that the total weight values must equal one. The following weights are applied evenly in this example, so w1 = w2 = w3 = 1/3.

The maximum brake power, maximum thermal efficiency, and minimum brake-specific fuel consumption are represented by the values Z1max, Z2max, and Z3 min. They are computed separately by accounting for single objective functions and solving the single objective function within the same constraints. The values of the maximization and minimization functions were considered for applying the TLBO and JAYA. The range of WPO blending of fuel varies from WPO0 to WPO100 in a breakup of 20% with diesel fuel. The optimization of the CI engine performance parameter in TLBO and JAYA algorithms techniques constraints and ranges of performance parameters, as shown in Table 3.

Table 3. Optimization parameter range

Input parameter	Range of Input Parameter	Output Parameter	Output Parameter Range
Load	0 to 17.3 kg	Brake Power	3.3 to 4.5
Calorific Value	39.2 to 43.4 MJ/kg	Thermal Efficiency	30 to 32.17
WPO Blend	WPO0 to WPO100	BSFC	0.25 to 0.30

Numerous function evaluations are needed for the optimisation once the TLBO and JAYA algorithms are applied to the objective functions. The output performance parameters of the CI engine Brake power and thermal efficiency are maximized, whereas the BSFC of the CI engine are minimized. The next section compares the obtained optimal values of the three objective functions that are attempted by the TLBO and JAYA algorithms.

6. Results and Discussion

Results and discussion are discussed in two sections: firstly, experimental testing and secondly, optimization technique results.

6.1. Experiment Testing Result

A number of performance and combustion tests were done on constant-speed diesel engines using WPO0, 20%, 40%, 60%, 80% and 100%, respectively, and results are discussed in detail below.

6.1.1. Brake Power

The variation in brake power for diesel and WPO blends at different loads is displayed in Figure 6. The brake power for diesel fuel (WPO0) varies from 0.25 kW at no load (0%) to 4.88 kW at full load. Whereas WPO100 brake power ranges from 0.47 kW to 4.98 kW.

Furthermore, at 75% full load and WPO20, brake power is similar to diesel fuel. This might be related to improved atomization of the blend, which releases more heat energy than diesel. The BP of waste plastic-derived WPO20 fuel blends is higher than that of diesel fuel.

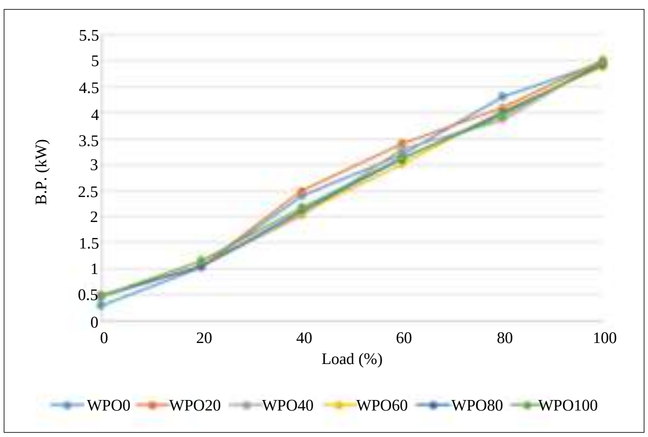


Fig. 6 Load vs. Brake power

The highest BP is found in WPO 20 blends at all engine loads mentioned while maintaining a constant speed. Due to the elevated viscosity and significant fuel injection atomisation, the increase in load brake power increases. Furthermore, overall circumstances, the trend for BP has been rising with load. The engine's thermal impact on brake power and additionally it changes with load.

6.1.2. Thermal Efficiency

Figure 7 illustrates how brake heat output changes with engine load for diesel and WPO mixes at different loads. The graph shows that WPO as the fuel affects a minor improvement in brake thermal efficiency when compared with diesel. When fully loaded, diesel fuel thermal efficiency is 30.08%, and the corresponding to WPO 31.91%.

Out of all the combinations, the WPO40 blend performs at its best, and this increase in efficiency is 30.24%, which is most noticeable at fully loaded conditions. WPO fuel's low calorific value could cause this.

Moreover, it should be mentioned that adding WPO to a diesel blend in greater amounts causes the fuels' viscosity, density, and total heat release rate to decrease in comparison to diesel fuel. This causes influences the fuel's atomization and vaporization, which consequently affects fuel atomization.

At full loads, diesel can be blended with WPO up to 60% without significantly changing overall brake thermal efficiency. Higher conversion and reduced heat loss from an increased load lead to higher brake thermal efficiency [8].

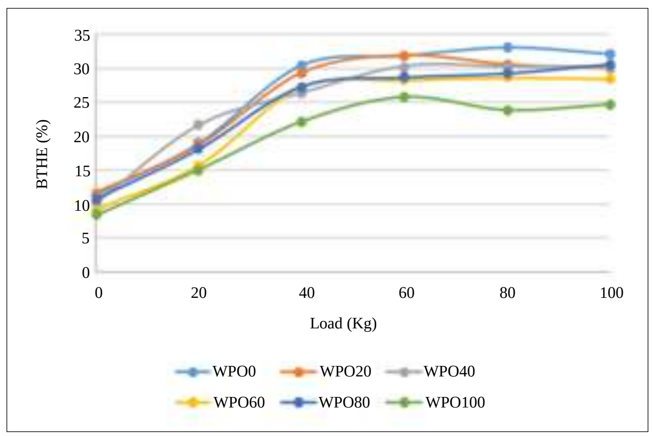


Fig. 7 Load vs. Brake thermal efficiency

6.1.3. Brake-Specific Fuel Consumption

Figure 8 shows BSFC for different diesel and WPO blends at various loads. It was noted that as soon as the load climbed then BSFC decreased. As the load rises for everybody, BSFC falls, blending of fuels. The BSFC value for diesel is 0.75 kg/kW-h at no load, and it drops to 0.27 kg/kW-h at full load. For WPO100 maximum value is 1.10 kg/kW-h at full load, whereas 0.37 kg/kW-h is the no-load situation.

WPO100 shows a higher BSFC than other blends. This pattern is dependable; at a high load, the brake power and thermal efficiency were raised; conversely, when the load grows, BSFC drops. At 40% load condition, the BSFC for WPO20 decreased by 6% in comparison with diesel and it closely remained the same trend at full load condition.

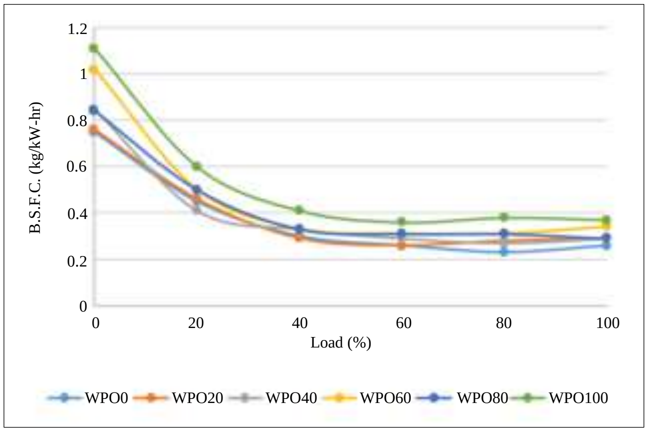


Fig. 8 Load vs. Brake specific fuel consumption

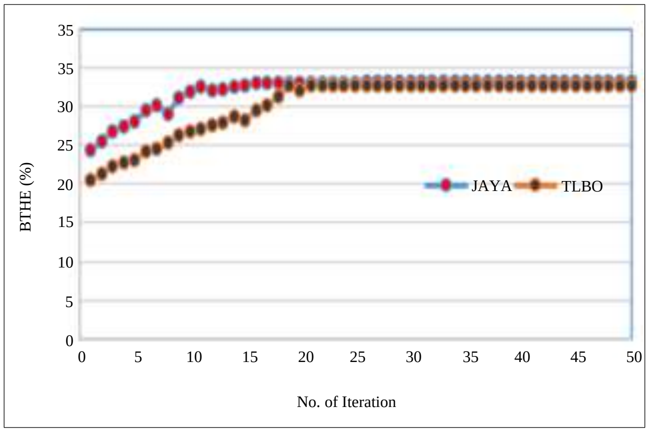


Fig. 10 Convergence graph of JAYA & TLBO algorithm for BTHE

6.2. Advanced Optimization Techniques Results

Table 4 demonstrates the results of the CI engine performance parameter using the TLBO algorithm, JAYA algorithm and experimental testing. Optimized and experimental results were compared. Mainly CI engine is designed with two goals in mind: first is to brake power, and second is thermal efficiency.

TLBO and JAYA algorithm optimization methods give the WPO25 the best blending of fuel for the CI engine by considering all performance parameter requirements. Table 4 shows that the three objective functions recommended by the JAYA and TLBO algorithms have their optimal values when the multi-objective optimisation problem is solved and transformed into a combined objective function.

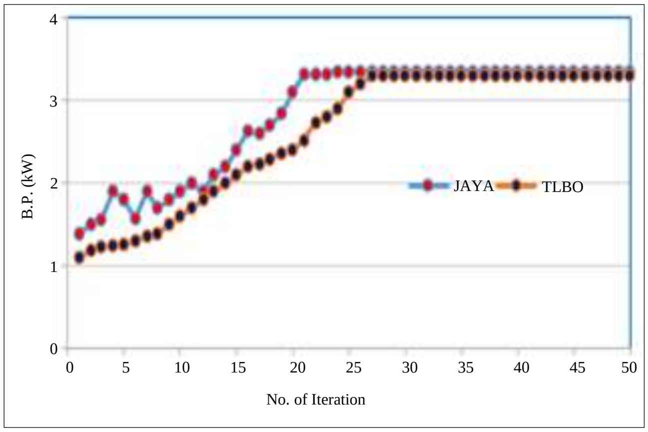


Fig. 9 Convergence graph of JAYA & TLBO algorithm for brake power

The outcomes of the JAYA algorithm are better than those recommended by the experimental strategy and other approaches of TLBO. The JAYA algorithm generated results are greater for 35% of brake power, 33.2% of brake thermal efficiency and 25.37% of BSFC. Overall 31.3% times better maximum performance than the TLBO results.

However, performing fewer function evaluations saves computing time and effort. The JAYA and TLBO method effectively solves both individual and multi-objective optimization problems utilising combined objective functions.

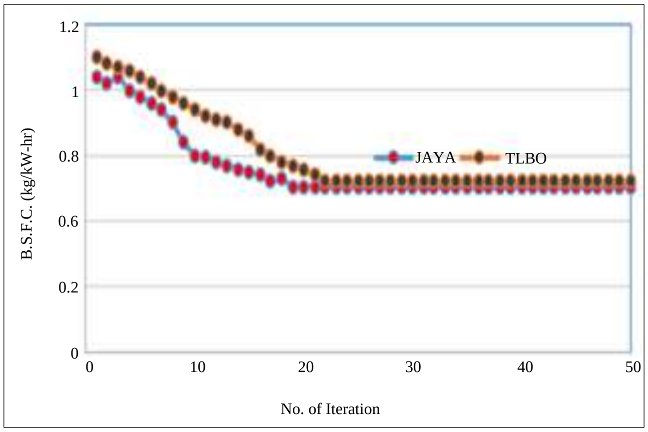


Fig. 11 Convergence graph of JAYA & TLBO algorithm for BTHE

Figures 9, 10, and 11 display the TLBO and JAYA algorithm degrees of convergence for every selected objective function. Figure 9 compares the convergence rates of brake power for Jaya and the TLBO algorithm. The Jaya algorithm achieves convergence after the 21st generation, while the TLBO algorithm achieves convergence after the 27th generation. Figure 10 illustrates efficiency; convergence occurred at the 16th and 21st iterations using Jaya and TLBO algorithms, respectively.

Figure 11 shows the convergence of brake-specific fuel consumption. The BSFC convergence takes place at the 19th and 22nd iterations, employing the JAYA and TLBO algorithms, respectively. It was noted that in the event of brake power most important design variables are the percentage of blending, which causes to decide the calorific value of fuel, applied load, and obtained torque of the engine.

Increased load on the engine led to higher peak pressure. WPO can reach a maximum pressure level of 75 bar, while diesel only reaches 68 bar. Likewise, with regard to thermal efficiency, the key design factors are brake power developed by the engine and the amount of fuel consumed per unit of time. The most significant design factors for brake-specific fuel consumption are the proportions of WPO, which is less volatile and has a lower heating value per unit mass than diesel fuel, which affects fuel mixture formation because of a higher amount brake specific fuel consumption than the diesel fuel. Finally, in this study, it was observed that the Jaya algorithm needs fewer iterations for convergence. The Jaya and TLBO algorithms perform better in this situation by maximizing brake power thermal efficiency and minimizing brake-specific fuel consumption. Jaya algorithms perform better results compared to the TLBO method. Also, it was found that WPO25 is the best blending of fuel for the CI engine.

Table 4. Optimization result of CI engine for waste plastic

	Decision Variables			Objective Functions			Computational Time (sec)	Population Size
	Load (kg)	Blend (%)	CV (MJ/kg)	BP (kW)	BTE (%)	BSFC (kg/kW-hr)		
TLBO Result	10.84	WPO25	42750	3.30	32.69	0.267	45	50
JAYA Result	10.90	WPO25	42750	3.35	33.2	0.253	57	50
Expt. result	11	WPO25	42750	3.25	32.27	0.270	-	-

7. Conclusion

Based on engine testing following conclusions are made related to WPO fuel for CI engines: Pyrolysis is the most effective method for extracting oil from undesirable plastic oil. The physiochemical characteristics of WPO and its blends are found to be within ASTM guidelines. The experiment was carried out using a single-cylinder diesel engine, and the brake power was found to be closer to the diesel fuel; this happened as the load increased with blends, causing better atomization of fuel to release more heat energy.

Diesel fuel has more brake thermal efficiency than blends made of WPO. Due to WPO blends, weaker combustion and lower heating value lead to decreased efficiency. BSFC of WPO blends is higher than diesel because it possesses a lesser heating value per unit mass of diesel fuel and is less volatile, which affects fuel mixture formation reason behind of. Based on advanced optimization technique following conclusion are made: In this investigation, three separate target functions are taken into account during optimizing. In multiple optimization strategies, the mathematical models have been developed for desired functions and the outcomes of. Jaya and TLBO algorithms are compared with experimental results and validated for the optimized values. The Jaya and TLBO algorithms provide successful options for optimizing the performance parameters of the CI engine.

The Jaya algorithm produces better optimal results than the TLBO algorithm with 5% to 6 % precise than TLBO. Also, the Jaya has better convergence behavior than the TLBO method. From these selected advanced optimization methods, WPO25 blending of fuel proved the best performance of fuel for CI engine than the other blending of fuel. WPO25 shows optimize results for selected parameters in the range 99.3% of Brake power, 98.6% of Thermal efficiency and 96.8% of brake specific fuel consumption.

The results of this endeavor could assist the researcher in finding the best blends of fuel for engines by the methods of JAYA and TLBO algorithms. Application of this is also useful to find the multi-objective function of different engine performance parameters in future.

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