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EFFECT OF CUMULATIVE HEAT RELEASE OF A VARIABLE COMPRESSION RATIO DIESEL ENGINE OPERATING WITH PONGAMMIA PINNATA OIL BLENDS FOR DIFFERENT CRANK ANGLES

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Abstract:

In this experimental study cumulative heat release of a variable compression ratio (VCR) Diesel engine operating with diesel and Pongamia pinnata oil blends were studied under different crank angle (-360˚ to +359˚), five different percentage loading conditions (0%, 25%, 50%, 75% & 100%), two compression ratio (17:01 & 18:01) and three different Pongamia pinnata oil blends (B10, B15 & B20) which are blended with diesel by volumetric basis (100 ml Pongamia pinnata oil: 900 ml pure Diesel, 150 ml Pongamia pinnata oil: 850 ml pure Diesel, 200 ml Pongamia pinnata oil: 800 ml pure Diesel) respectively. For comparative purpose initially the engine was run by pure Diesel. This study shows that the cumulative heat release is maximum (1.01 kJ//s) when the engine operates with Pongamia pinnata oil (B10 blend) which was blended with pure Diesel on full load conditions (100% load) at a crank angle of 42˚ and compression ratio 17:01. This study shows that the cumulative heat release is minimum (0.58 kJ/s) when the engine operates with pure Diesel on no load conditions (0% load) at a crank angle of 48˚ and compression ratio 17:01.

Keywords: - *VCR Diesel engine, cumulative heat release, pongamia pinnata oil blends, crank angles.*

1. INTRODUCTION

The preservation of energy is decreasing now a days and it alleged that it leads to energy demand. In the last two decades, alternative fuels have obtained and identified as essential. A potential biodiesel substitutes diesel oil, consisting of ethyl ester of fatty acids produced by the transesterification reaction of triglycerides of vegetable oils and ethanol with the help of a catalyst. In addition, biodiesel is better than diesel fuel in terms of very low sulfur content and it is also having higher flash and fire point temperatures than in diesel fuel. A lot of research work pointed out that biodiesel has received a significant attention and it is a possible alternative fuel. Biodiesel and its blends with diesel were employed as a fuel for diesel engine without any modifications in the existing engine [1]. The research on the production of biodiesel has increased significantly in recent years because of the need for an alternative fuel which endows with biodegradability, low toxicity and renewability [2].The biodiesel produced by transesterification showed similar properties to the standard biodiesel [3]. The process of transesterification is found to be an effective method of reducing viscosity of vegetable oil [4]. The lower blends of biodiesel increased the brake thermal efficiency and reduced the fuel consumption. In addition to this, biodiesel blends produce lower engine emissions than diesel [5].

The new fuel Die sterol (combination of diesel fuel, bio ethanol and sunflower methyl ester) as a fuel for diesel engines. The authors revealed that, as the percentage of bio ethanol in the blends is increased, the percentage of CO concentration in the emission is reduced. This trend is due to the fact that bio ethanol has less carbon than diesel [6]. The diesel engine runs with waste plastic oil as fuel. The authors concluded that, the smoke was reduced by 40% than diesel [7]. The new type of biodiesel is prepared from non-edible pongamia pinnata oil by transesterification and used as a fuel in C.I engine. The authors reported that blend B5 exhibits lower engine emissions of unburnt hydrocarbon, carbon monoxide, oxides of nitrogen and carbon dioxide at full load [8]. The experiments were performed in a single cylinder DI diesel engine fueled with a blend of pungam methyl ester for the proportion of PME10, PME20and PME30 by volume with diesel fuel for validation of simulated results. The authors observed that there is a good agreement between simulated and experimental results [9]. From the review of literatures, numerous works in the utilization of biodiesel as well as its blends in engines have been done. However, most of the literatures focused on single biodiesel and its blends. From previous studies, it is evident that single biodiesel offers acceptable engine performance and emissions for diesel engine operation.

2. Experimental plan

The biodiesel (pongamia pinnata oil and pure diesel) are prepared by the transesterification process. The biodiesel blends were prepared in three different proportions as: Diesel 90%, pongamia pinnata oil 10%; Diesel 85%, pongamia pinnata oil 15%; Diesel 80%, PPEE 10% by volume basis. The various properties like kinematic viscosity, specific gravity, calorific value, flash point temperature and fire point temperature of baseline fuel, raw oils and biodiesel mixed blends were determined by using ASTM methods and compared with diesel properties. The experiments were conducted on a stationary, single cylinder, vertical, four stroke, water cooled, variable compression ratio, diesel engine with electrical loading and the mean gas temperatures were compared with baseline data of diesel fuel.

Table-1 Test engine specifications

Sl.No.	Items	Specifications
1	Type	Vertical, four stroke, single cylinder, VCR engine.
2	Made	Kirloskar oil engines Ltd, Pune, India.
3	Loading device	Eddy current dynamo meter
4	Type of cooling	Water cooled
5	Speed	1500 rpm
6	Power	3.5 kW
7	Bore	87.5mm
8	Compression ratio	12:1to 20:1
9	Stroke	110mm
10	Fuel	Diesel

Tests were conducted at a constant speed and at varying loads for all biodiesel blends. Engine speed was maintained at 1500 rpm (d speed) during all experiments. The mean gas temperatures of the exhaust gases were measured by the AVL make smoke meter. The exhaust emissions were measured by the Crypton make five gas analyzer. The experimental set up is shown in Fig. 1 and the detailed engine specifications are also given in Table 1.

Figure 1 Experimental setup

3. Results and discussions

The following results were obtained from this experimental study which was carried out to evaluate the cumulative heat release of a Variable Compression Ratio (VCR) Diesel engine operating with Diesel and three Pongamia pinnata oil blends (B10, B15 & B20) under different crank angle (-360˚ to +359˚), five different percentage loading conditions (0%, 25%, 50%, 75% & 100%) and two compression ratio (17:01 & 18:01) respectively.

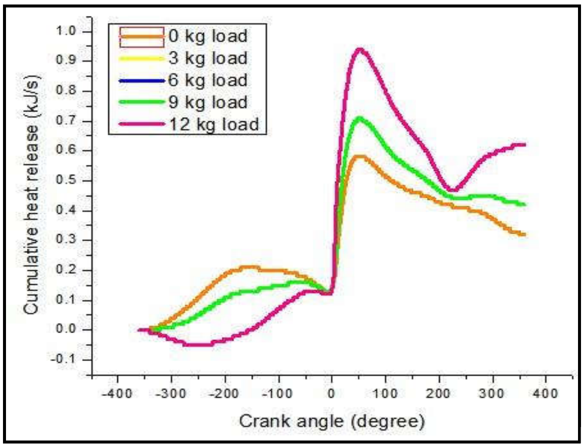

Figure 2 Effect of cumulative heat release of the VCR engine operating with diesel and compression ratio 17:01

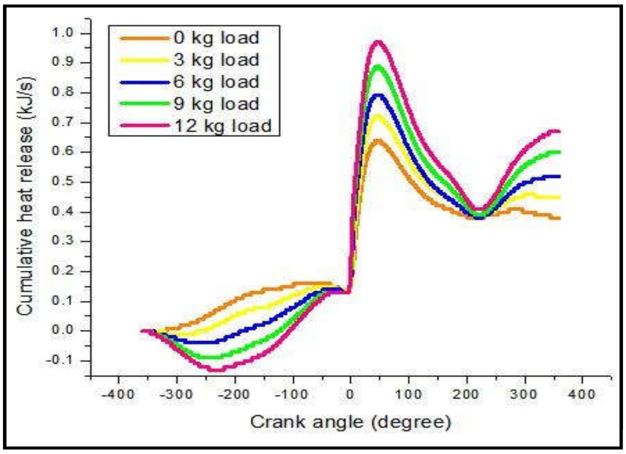

Figure 3 Effect of cumulative heat release of the VCR engine operating with diesel and compression ratio 18:01

3.1 Effect of engine cumulative heat release operating by pure diesel at a compression ratio of 17:01 under different loading conditions

Effect of cumulative heat release of the engine operating by diesel and compression ratio 17:01 for various crank angles were sown in figure.2. It shows that the cumulative heat release is maximum when crank angle is 48˚. The minimum and maximum cumulative heat release obtained in this case is 0.58 and 0.94 kJ/s at a crank angle of 44˚ & 48˚ and a load of 0 and 12 kg respectively. At full load and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 17:01.

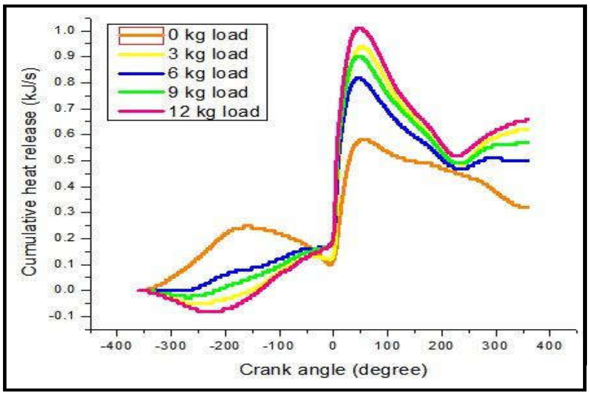

Figure 4 Effect of cumulative heat release of the VCR engine operating with Pongamia pinnata oil blend (B10) and compression ratio 17:01

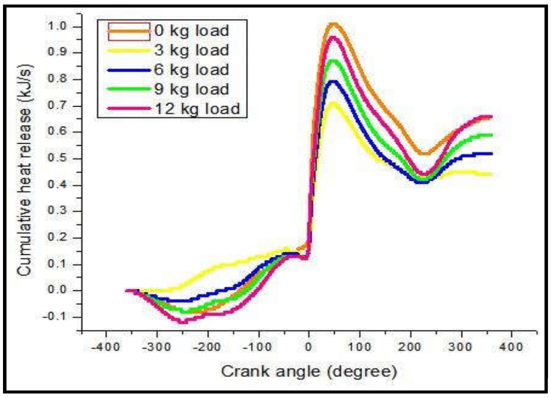

Figure 5 Effect of cumulative heat release of the VCR engine operating with Pongamia pinnata oil blend (B10) and compression ratio 18:01

3.2 Effect of engine cumulative heat release operating by pure diesel at a compression ratio of 18:01 under various loading conditions

Effect of cumulative heat release of the engine operating by Diesel and compression ratio 18:01 for various crank angles were sown in figure.3. It shows that the cumulative heat release is maximum when the crank angle is 42˚. The minimum and maximum cumulative heat release obtained in this case is 0.64 and 0.97 kJ/s at a crank angle of 42˚ at a load of 0 and 12 kg respectively. At full load condition and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 18:01.

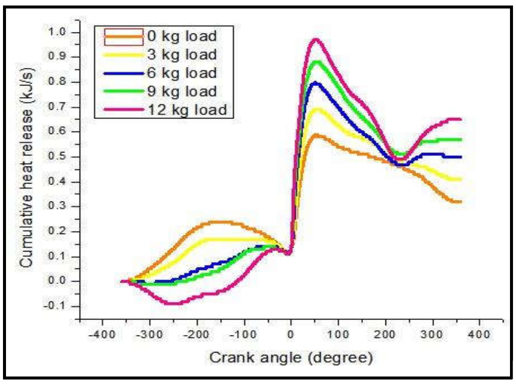

Figure 6 Effect of cumulative heat release of the VCR engine operating with Pongamia pinnata oil blend (B15) and compression ratio 17:01

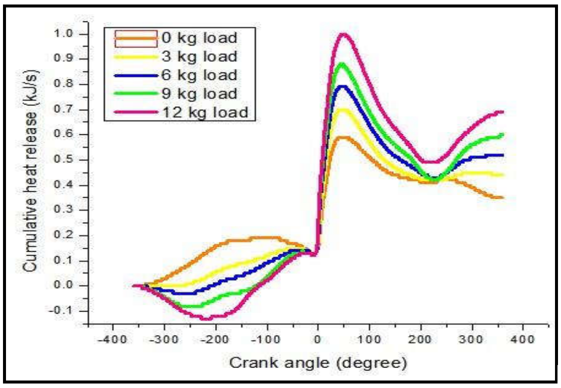

Figure 7 Effect of cumulative heat release of the VCR engine operating with Pongamia pinnata oil blend (B15) and compression ratio 18:01

3.3 Effect of engine cumulative heat release operating by Pongamia pinnata oil (B10) blended with Diesel at a compression ratio of 17:01 under various loading conditions

Effect of cumulative heat release of the engine operating by Pongamia pinnata oil (B10) blended with Diesel and compression ratio 17:01 for various crank angles were sown in figure.4. It shows that the cumulative heat release is maximum when the crank angle is 48˚. The minimum and maximum cumulative heat release obtained in this case is 0.58 and 1.01 kJ/s at a crank angle of 42˚ and 48˚ and a load of 0 and 12 kg respectively. At full load condition and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 17:01.

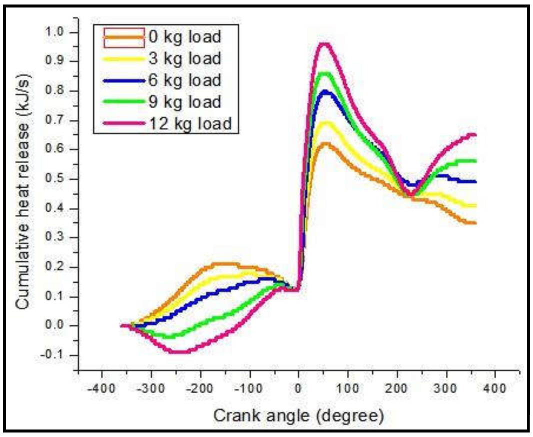

Figure 8 Effect of cumulative heat release of the VCR engine operating with Pongamia pinnata oil blend (B20) and compression ratio 17:01

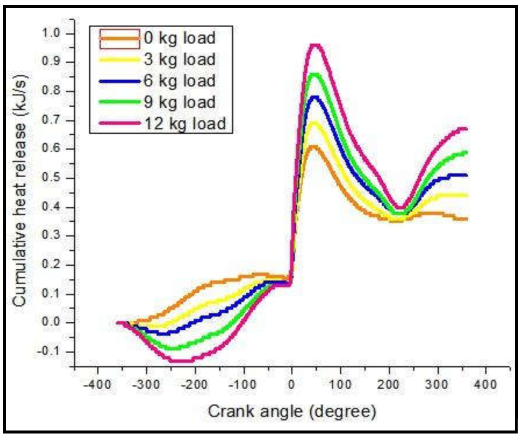

Figure 9 Effect of cumulative heat release of the VCR engine operating with Pongamia pinnata oil blend (B20) and compression ratio 18:01

3.4 Effect of engine cumulative heat release operating by Pongamia pinnata oil (B10) blended with Diesel at a compression ratio of 18:01 under various loading conditions

Effect of cumulative heat release of the engine operating by Pongamia pinnata oil (B10) blended with Diesel and compression ratio 18:01 for various crank angles were sown in figure.5. It shows that the cumulative heat release is maximum when the crank angle is 43˚. The minimum and maximum cumulative heat release obtained in this case is 0.71 and 1.01 kJ/s at a crank angle of 43˚ & 42˚ and a load of 3 and 0 kg respectively. At full load condition and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 18:01.

3.5 Effect of engine cumulative heat release operating by Pongamia pinnata oil (B15) blended with Diesel at a compression ratio of 17:01 under various loading conditions

Effect of cumulative heat release of the engine operating by Pongamia pinnata oil (B15) blended with Diesel and compression ratio 17:01 for various crank angles were sown in figure.6. It shows that the cumulative heat release is maximum when the crank angle is 47˚. The minimum and maximum cumulative heat release obtained in this case is 0.59 and 0.97 kJ/s at a crank angle of 50˚ and 47˚ and a load of 0 and 12 kg respectively. At full load condition and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 17:01.

3.6 Effect of engine cumulative heat release operating by Pongamia pinnata oil (B15) blended with Diesel at a compression ratio of 18:01 under various loading conditions

Effect of cumulative heat release of the engine operating by Pongamia pinnata oil (B15) blended with Diesel and compression ratio 18:01 for various crank angles were sown in figure.7. It shows that the cumulative heat release is maximum when crank angle is 45˚. The minimum and maximum cumulative heat release obtained in this case is 0.59 and 1.00 kJ/s at a crank angle of 38˚ and 45˚ and a load of 0 and 12 kg respectively. At full load condition and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 18:01.

3.7 Effect of engine cumulative heat release operating by Pongamia pinnata oil (B20) blended with Diesel at a compression ratio of 17:01 under various loading conditions

Effect of umulative heat release of the engine operating by Pongamia pinnata oil (B20) blended with Diesel and compression ratio 17:01 for various crank angles were sown in figure.8. It shows that the cumulative heat release is maximum when crank angle is 44˚. The minimum and maximum cumulative heat release obtained in this case is 0.62 and 0.96 kJ/s at a crank angle of 47˚ and 44˚ and a load of 0 and 12 kg respectively. At full load condition and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 17:01.

3.8 Effect of engine cumulative heat release operating by Pongamia pinnata oil (B20) blended with Diesel at a compression ratio of 18:01 under various loading conditions

Effect of cumulative heat release of the engine operating by Pongamia pinnata oil (B20) blended with Diesel and compression ratio 18:01 for various crank angles were sown in figure.9. It shows that the cumulative heat release is maximum at the crank angle is 40˚. The minimum and maximum cumulative heat release obtained in this case is 0.61 and 0.96 kJ/s at a crank angle of 38˚ and 42˚ and a load of 0 and 12 kg respectively. At full load condition and no load conditions the engine cylinder exhibits a maximum and minimum cumulative heat release at a compression ratio of 18:01.

4. Summary

The following conclusions were made from this experimental study which was carried out to evaluate the effect of Pongamia pinnata oil blends for cumulative heat release of a Variable Compression Ratio (VCR) Diesel engine operating with Diesel and three Pongamia pinnata oil blends (B10, B15 & B20) under different crank angle (-360° to +359˚), five different percentage loading conditions (0%, 25%, 50%, 75% & 100%), and two compression ratio (17:01 & 18:01) respectively.

- In all cases engine cumulative heat release is maximum at full load condition and minimum at no load conditions.
- At a crank angle of 48˚the engine exhibits a better cumulative heat release compared than other crank angles.
- In all cases the engine cumulative heat release is maximum when the engine operates at a compression ratio of 17:01.
- The engine cumulative heat release is gradually decreases with the increasing Pongamia pinnata oil blends.

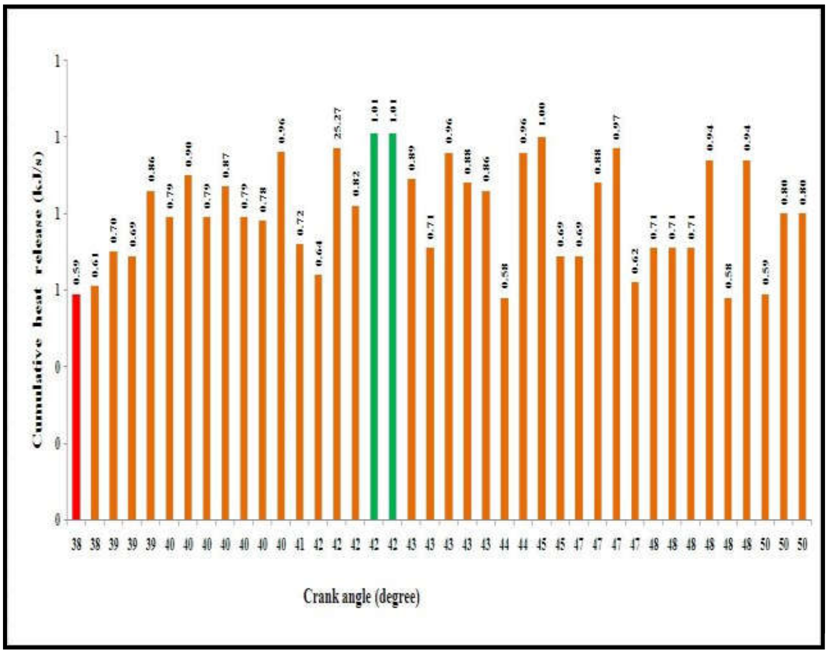

Figure 10 Maximum cumulative heat release for different crank angle

- The maximum engine cumulative heat release obtained from this experimental study is 1.01 kJ/s when the engine operates with pure Pongamia pinnata oil blend (B10) on full load conditions (100% load) at a crank angle of 42˚ and a compression ratio of 17:01.
- The minimum engine cumulative heat release obtained from this experimental study is 0.58 kJ/s when the engine operates with pure Diesel on no load conditions (0% load) at a crank angle of 48˚and compression ratio 17:01.

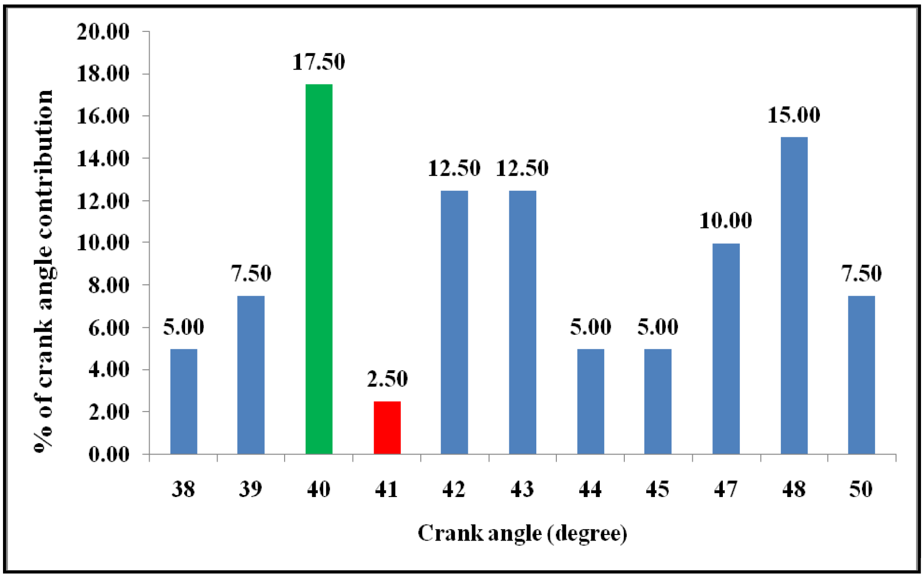

Figure 11 Percentage of crank angles contribution for better cumulative heat release

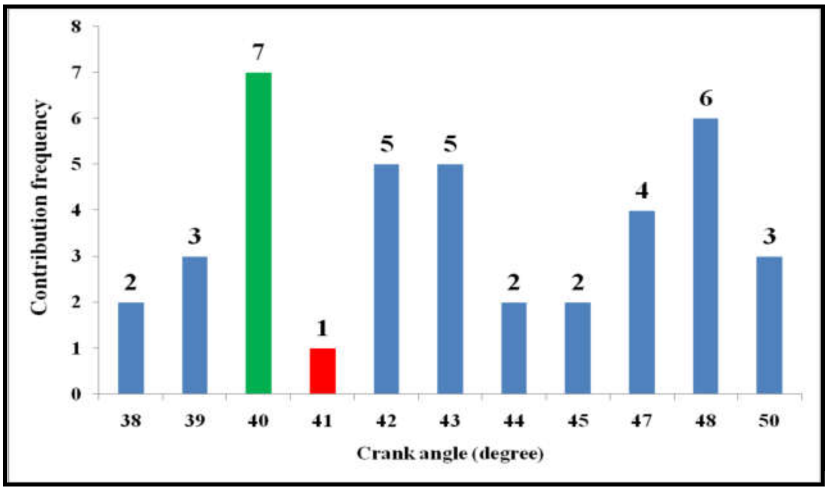

Figure 12 Contribution frequency of crank angles for better cumulative heat release

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