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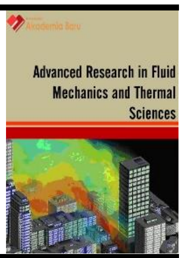

Investigation of The Effect Biodiesel-Butanol-Water Fuel Blend Pressure on A Single-Cylinder Diesel Engine

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Energy demand from the community, which continues to increase has resulted in depletion of petroleum (fossil) energy in recent years. Many researchers have sought to find alternative fuels to replace dependence on conventional energy. The mixing of alcohol into diesel fuel has also been carried out by several previous researchers. The main focus of this research is to investigate the combustion performance of diesel engines using a mixture of biodiesel-butanol-water and diesel (B5Bu5W5). This research experiment used a single-cylinder diesel engine with different speeds at 25% and 50% engine load. The experimental results show that the maximum cylinder pressure reaches 72.32 bar when the engine load reaches 50%. While at 25% engine load press the maximum cylinder 33.62 bar. The heat dissipation for 50% engine load is also higher than the engine load 25% respectively 34.39% and 33.62%. Overall results show that cylinder pressure increases when the load and engine speed increase. However, the combustion time is a little slower than when using pure diesel fuel.

Keywords:
Combustion; Alcohol blend; Diesel engine; Butanol; Water

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1. Introduction

The depletion of conventional fuel which continues to occur in recent years as increasing demand from people around the world. Conventional fuels that continue to decrease have forced various researchers to look for alternative fuels instead of petroleum (fossil) [1–4]. Alternative sources of fuel in the world and especially in Southeast Asia currently have sufficient availability [5,6]. A variety of conventional fuels and alcohols have been tested for combustion in diesel engines [7,8]. From various tests conducted by several previous researchers have shown quite good results. An investigation into the combustion and emission characteristics of a four-cylinder direct injection diesel engine using variations in the mixture of n-butanol and biodiesel fuels has been carried out by [9]. Tests in their study of fuel mixtures made with varieties of 0%, 10%, 20% or 30% at a brake load of 0.13-1.13MPa with an engine speed of 1800rpm. The results of experiments in their study showed that the addition of n-butanol could improve engine combustion performance.

Meanwhile, the use of nanoparticles as additives for diesel-biodiesel-alcohol fuel mixtures to improve the combustion performance of diesel engines has recently been carried out by [10]. In their experiments, the fuel additive used 50% volume of Jojoba biodiesel, 40% diesel, and 10% n-butanol (denoted J50D10Bu). The results of adding titanium dioxide (TiO_2) nanoparticles to the J50D10Bu mixture showed that the rate of heat release and peak pressure increased to 1.5% and 2%. Besides, experiments with n-butanol fuel with a low proportion of 5%, 10%, 15%, and 20% mixed into Karanja methyl ester have been studied [11]. Based on the experimental results of the four KME n-butanol fuel mixtures examined, KBB15 showed better engine combustion performance and produced fewer emissions.

Furthermore, trials of diesel engines with diesel-biodiesel and n-butanol as well as titanium dioxide (TiO_2) blends with various variations of each diesel (D100), biodiesel (B100), B20, B20, Ti20, Ti20, B20But10 and B20But10 + TiO_2 has also been investigated [12]. The diesel engine trials were carried out at 1400rpm and 2800rpm respectively for all fuels tested. The results of tests carried out showed an increase in torque up to 10.20% and 9.74% brake engine power. Besides, brake specific fuel consumption decreased by 27.73% and 28.37%, respectively without TiO_2 additives. The addition of n-butanol in safflower biodiesel fuel for diesel engines used to drive electric power generators has also been studied [13]. Mixed variations used in their experiments included 5%, 10%, and 20% butanol. The lower emissions and improved brake thermal output in the presence of a ternary blend up to 1.5%. Besides, the average fuel consumption increased by up to 5% and brake fuel consumption specifically 6%. However, for other fuels, the emissions and thermal efficiency of the brakes are shown to be worse. Three test fuel mixtures in diesel engines with variations of each C3 80% WB-20%, C4 80% WB-20%, and C5 80% WB-20% to investigate combustion performance have also been studied [14]. This test is carried out with four different engine loads (0, 3, 6, 9kW) at constant engine speed (1800rpm). Engine performance and exhaust emissions, adding C3, C4 and C5 to the WB can increase brake specific fuel consumption (BSFC) and exhaust gas temperature (EGT). However, the thermal efficiency of the brakes (BTE) for all trials conducted showed a decrease. The use of alternative fuels for diesel engines has also been carried out by several previous researchers [15–23]. Alternative fuels for diesel engines have shown excellent results. Based on several findings that have been studied and tested previously that many alternative energy sources can use for combustion engines.

Combustion of diesel engines using fuel additives has been done and researched before. Various variations and mixtures of fuels used for burning of diesel engines have also been carried out and the results showed also vary. The main focus of this research is to investigate the combustion performance of a single-cylinder diesel engine using a mixture of biodiesel-butanol-water into conventional fuel (diesel). Research is an experiment with different engine speeds and loads.

2. Materials and setup

This experiment uses a single-cylinder YANMAR TF120M engine with a compression ratio of 0.63 L and 17.7 shown in Figure 1. While the specifications of the engine used are shown in Table 1. Experimental data were analysed using the TFX Engineering DAQ system, which consists of in-cylinder pressure sensors and cranks angle sensors. The experiment was conducted with five speeds from 1200 to 2400 rpm with intervals of 300 rpm and two engine loads at 25% and 50%. The tests conducted with biodiesel-butanol-water and diesel blend (biodiesel 5%, butanol 5%, water 5% and diesel 75%) symbolised by B5Bu5W5.

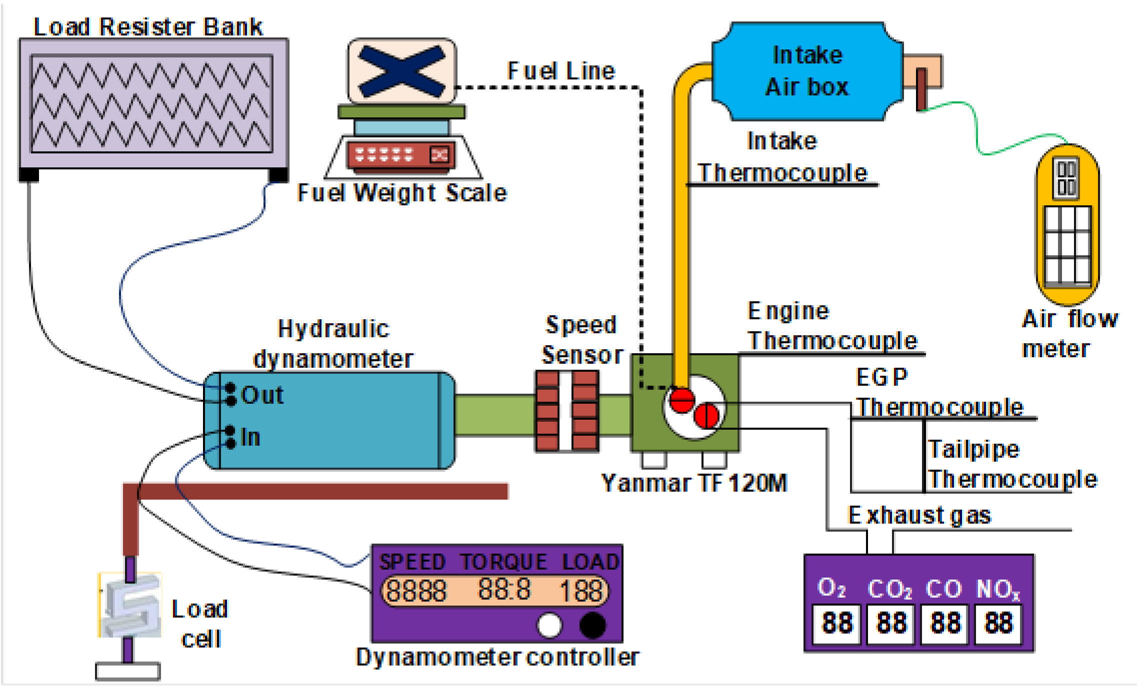

Fig. 1. Schematic diagram of engine diesel single-cylinder

Table 1
The values of Reynolds number and velocity

Description	Specification
Engine model	YANMAR TF120M
Engine type	diesel 4 stroke, one-cylinder engine
Bore x Stroke (mm)	92 × 96
Displacement (L)	0.638
Injection timing	17° BTDC
Compression ratio	17.7
Continuous output (HP)	7.82 kW at 2400 rpm
Rated output (HP)	8.94 kW at 2400 rpm

3. Result and Discussion

The investigation of combustion performance in this article carried out with two different engine loads and five different engine speeds. The first investigation carried out at a 25% engine load at 1200-2400 rpm. Next, investigate the 50% engine load with similar speeds and scenarios and variations. The experimental results at 25% load compared with trials at 50% engine load. Combustion performance at a capacity of 50% shows a higher yield of 72.32 bars at a speed of 1200 rpm. While at 25% engine load the maximum combustion, performance is recorded at 2400 rpm at 63.40 bar. As the engine speed increases, the combustion performance also increases for a 25% load as shown in Figure 2. However, on the contrary, the engine load reaches 50% engine speed which increases combustion performance. The decrease in engine performance strongly influenced by the engine load given. The higher the engine load, the water mixed into the fuel is uneven, resulting in decreased engine combustion performance. When engine speed and load increases, the maximum combustion is lower. These are because combustion occurs in the expansion period after TDC. The experimental results in this article show a little smaller than some previous studies [22,24–26]. However, several previous studies using different mixed fuels.

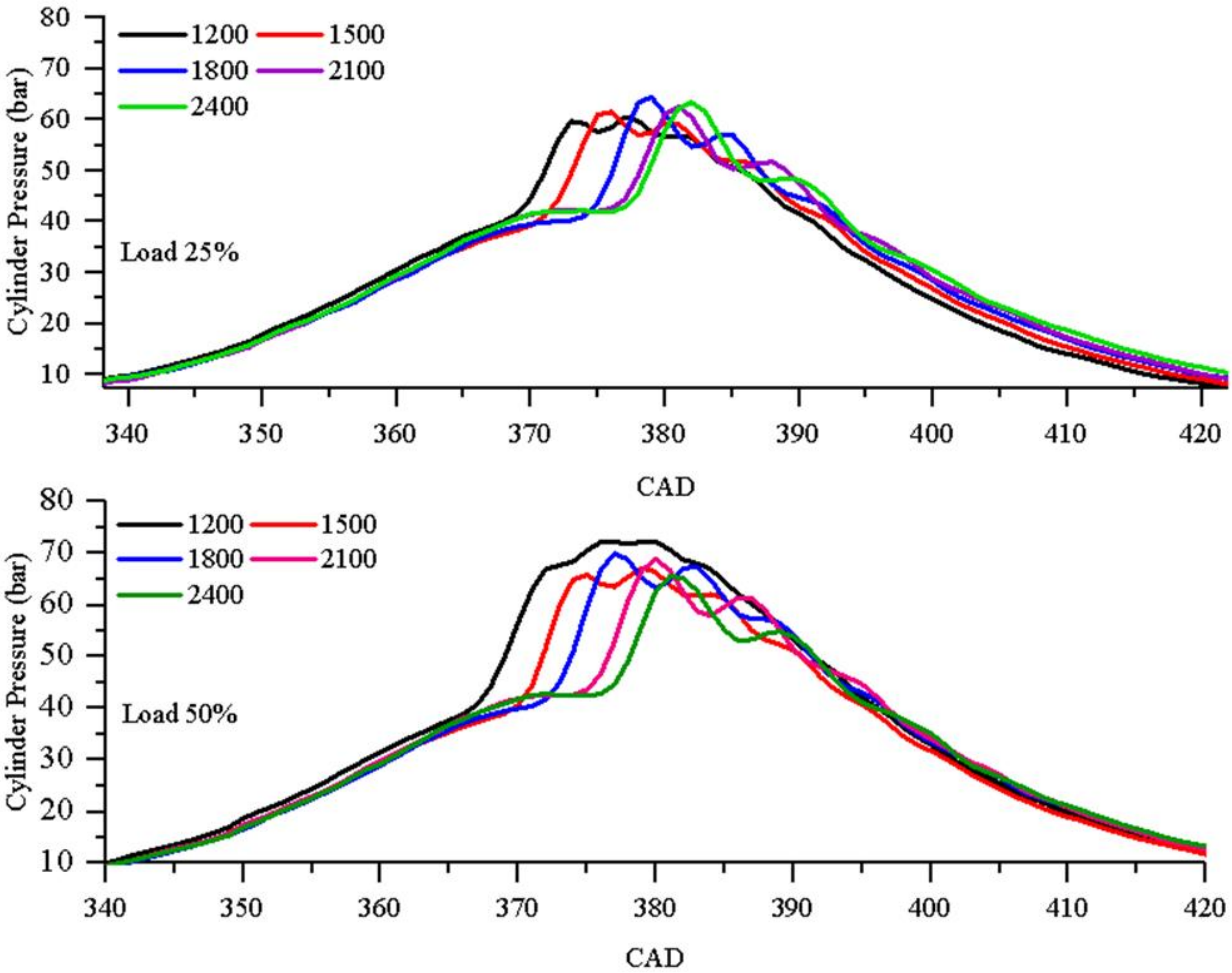

Fig. 2. The variation of cylinder pressure under different speeds according to the crank angle

The degree of pressure increases in experiments with mixed fuels with different engine speeds and loads also varies greatly. The pressure level at 50% engine load reaches 6.78% (1200 rpm), 8.35% (1500 rpm), 8.60% (1800 rpm), 7.99% (2100 rpm) and 6.90% (2400 rpm) higher than the load engine 25% namely; 6.05% (1200 rpm), 6.54% (1500 rpm), 7.99% (1800 rpm), 6.41% (2100 rpm) and 6.54% (2400) are shown in Figure 3. The experimental results in the study recorded delays when starting to burn. These are due to the lack of octane number found in the water mixture which put into the fuel. Investigations regarding the degree of pressure increase in diesel engines with different fuel mixtures have also been investigated by [27]. The results in their study showed BD20 or PD20 spray penetration greater than D100; the addition of PODE3-4 to BD20 causes further increase in spray penetration without a significant effect on the cone spray angle.

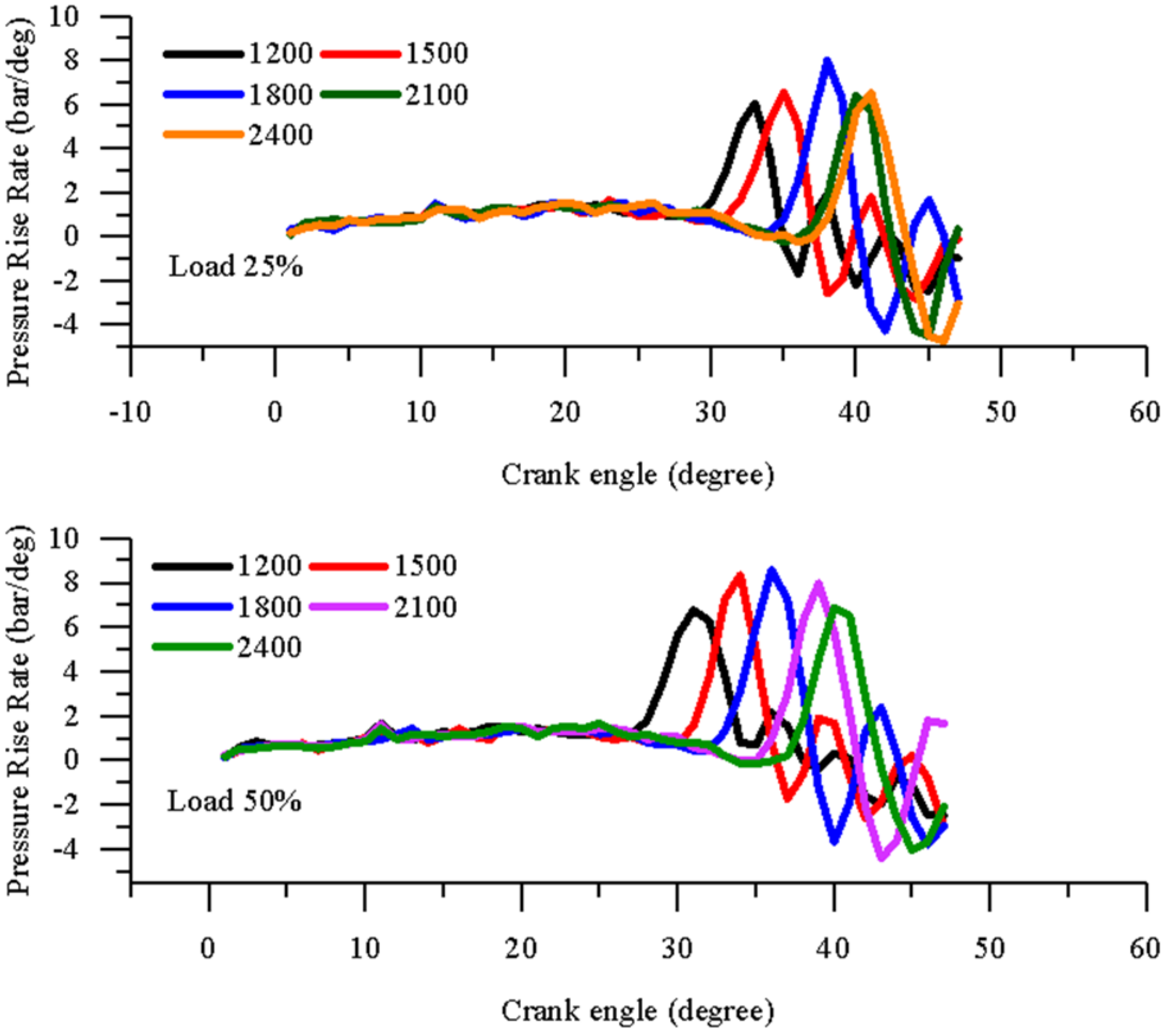

Fig. 3. The variation of pressure release rate under different speeds according to crank angle

The heat release rate (HRR) of the fuel test results adjusted for different engine speeds and loads shown in Figure 4. Where the premixed combustion phase controlled with B5Bu5W5 mixed fuel, as shown in Figure 4. Besides, the B5Bu5W5 fuel mixture for engine load 25% of the ignition system is slower than diesel fuel and a high HRR peak achieved. These are shows that the oxygen content of the fuel mixture that accumulates in the cylinder during the ID period burns faster. The rate of heat release increases with increasing engine speed given. Maximum heat dissipation for engine load is 50% 34.39% compared to 33.62% for engine load 25%. The maximum heat release at 25% load is obtained at 1800 rpm engine speed, while for 50% load is recorded at 2400 rpm. The maximum yield of heat release is slightly lower than research by [24]. The maximum heat release in their study was 41.05% for speeds of 1800 and 2400 rpm.

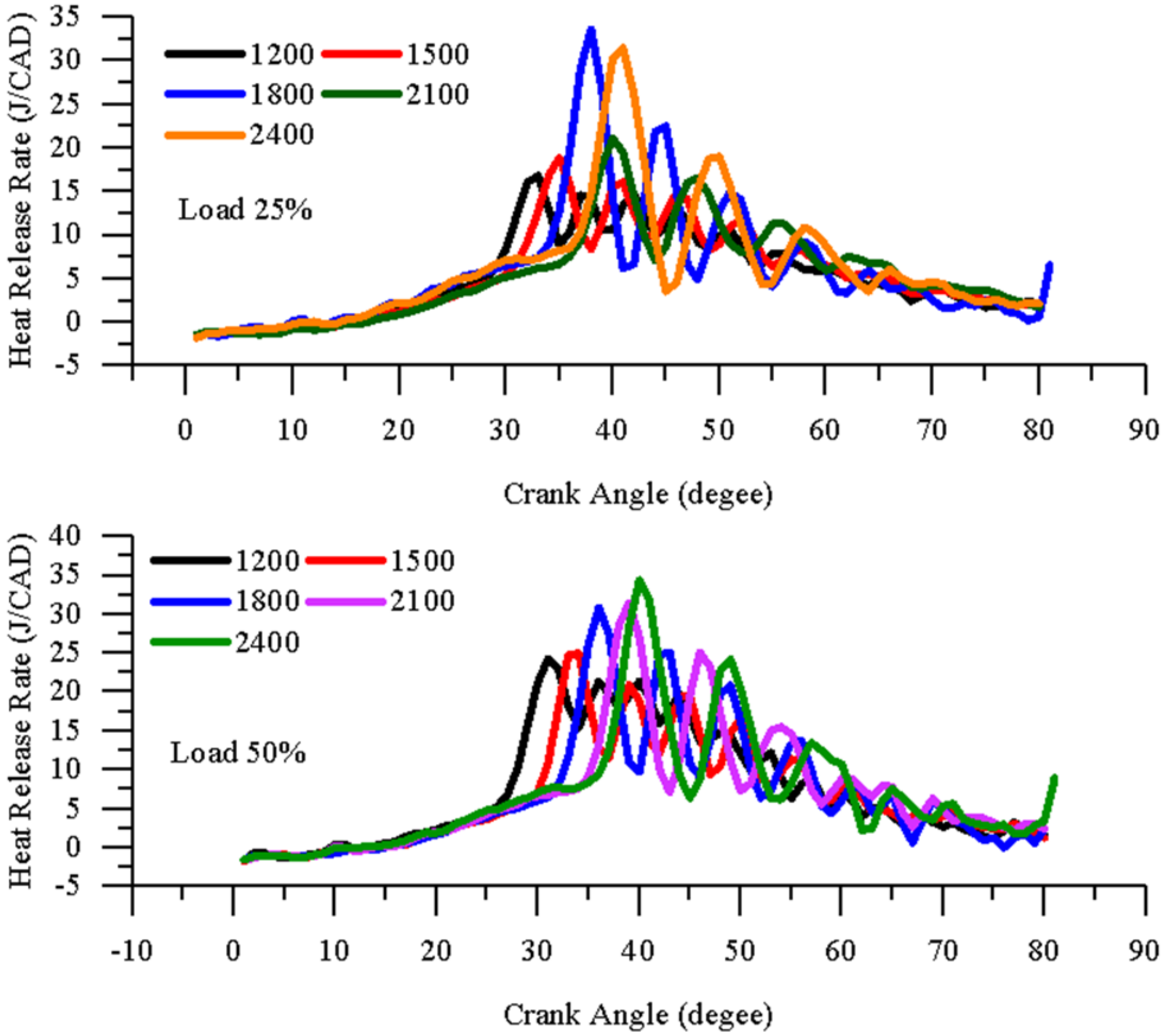

Fig. 4. The variation of heat release rate under different speeds according to crank angle

The combustion mass when testing with varying load and engine speed also analysed. The results of the combustion mass showed a less significant increase for the two engine loads tested. The highest maximum combustion period for an engine load of 50% is recorded at an engine speed of 1800 rpm at 1.00002%. While the highest combustion periods for engine speeds of 1200, 1500, 2100 and 2400 are lower, respectively 0.99945%, 0.99852%, 0.99844% and 0.99711% are shown in Figure 5. Meanwhile, the minimum combustion period for an engine speed of 1200 rpm shows a higher speed of 0.79970% compared to the speed of other machines tested for engine load of 50%. The maximum combustion period at the time of testing for engine load of 25% indicates lower than the engine load of 50%. Where it can be concluded that the increased engine load, the resulting combustion period will also increase. The maximum combustion period obtained during the test with an engine load of 25% is 0.99682% when the engine speed is 2400 rpm. While the minimum combustion period of 0.78062% is shown in Figure 5.

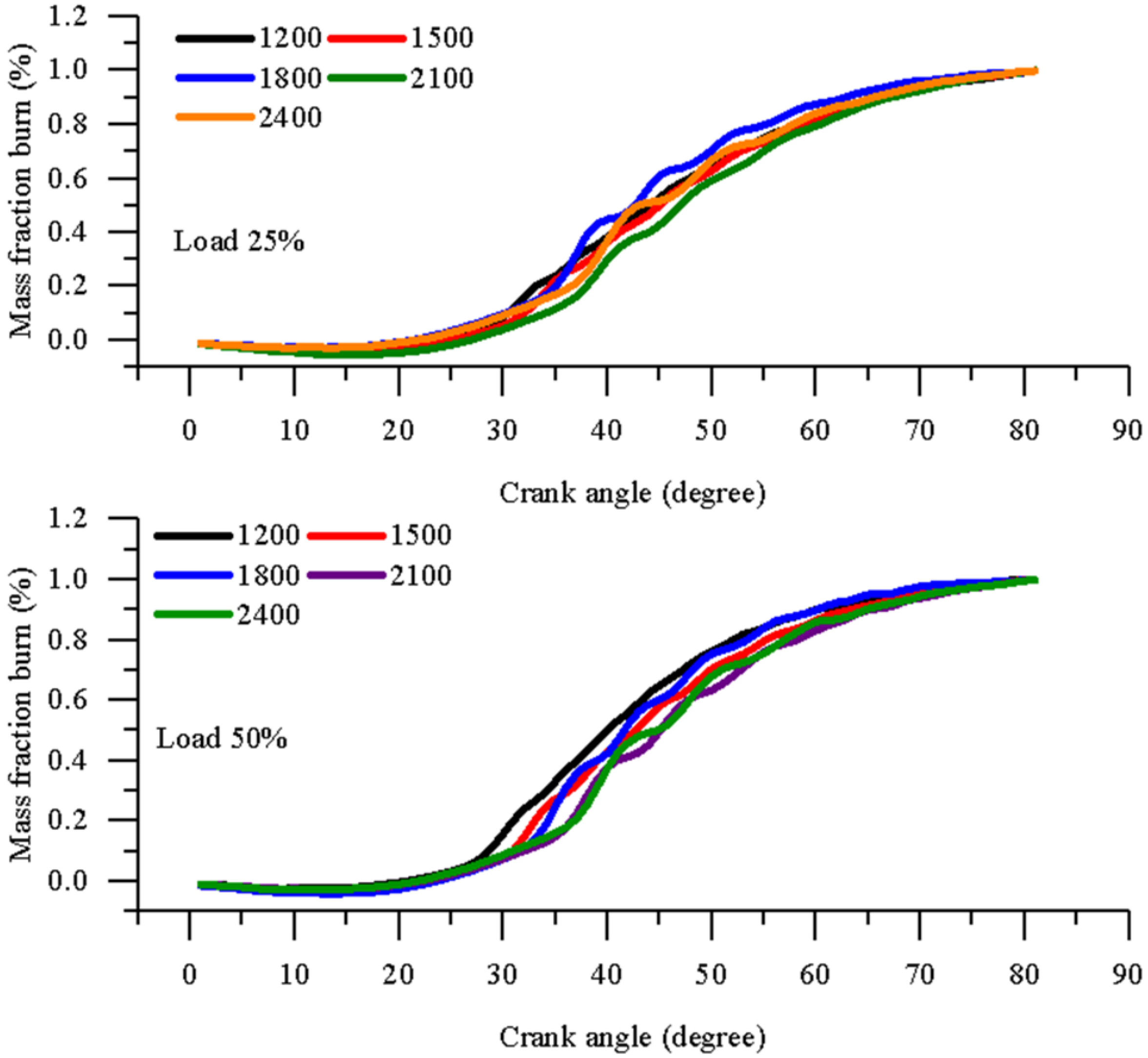

Fig. 5. The variation of mass fraction burn under different speeds according to crank angle

4. Conclusions

The conclusions we can obtain from this study are as follows

i. Cylinder pressure increases when the load and engine speed increase. The highest engine adherence in this experiment was 72.32 bars recorded at 1200 rpm when the engine load was 50%.

ii. At 25% engine load obtained maximum engine press at an engine speed of 1800 rpm 33.62 bar. Engine speeds of 2100 and 2400 rpm (21.06 and 31.47 bar) are slightly higher than engine speeds of 1200 and 1500 rpm (16.83 and 18.81 bar).

iii. The maximum heat dissipation for 50% engine load reaches 34.39% compared to 33.62% when the engine load is 25%.

iv. The combustion mass with B5Bu5W5 fuel is proportional to the combustion mass when using pure diesel fuel. However, the combustion is slightly delayed compared to diesel.

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