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# Combustion Temperature Effect of Diesel Engine Convert to Compressed Natural Gas Engine

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**Abstract:** Effect of combustion temperature in the engine cylinder of diesel engine convert to Compressed Natural Gas (CNG) engine was presents in this study. The objective of this study was to investigate the engine cylinder combustion temperature effect of diesel engine convert to CNG engine on variation engine speed. **Problem statement:** The hypothesis was that the lower performance of CNG engine was caused by the effect of lower in engine cylinder temperature. Are the CNG engine is lower cylinder temperature than diesel engine? This research was conducted to investigate the cylinder temperature of CNG engine as a new engine compared to diesel engine as a baseline engine. **Approach:** In this study, the combustion temperature was investigated in 7 cases engine speed. The engine speeds variation start from 1000 rpm until 4000 rpm with variation in 500 rpm. The engine conversion development and combustion temperature investigation was conducted at automotive laboratory, faculty of mechanical engineering, University Malaysia Pahang, Malaysia. **Results:** The results of the combustion temperature in the engine cylinder in variation engine speeds showed that diesel engine convert to CNG engine effect decrease the combustion temperature in the engine cylinder characteristics. **Conclusion/Recommendations:** In the low speed the conversion can be increase the combustion temperature, but the increasing engine speeds can be decrease the combustion temperature in the engine cylinder.

**Keywords:** CNG engine, combustion temperature, conversion effect, diesel engine, engine speed

## INTRODUCTION

The great problems of the world in the internal combustion engines usage until today are focuses on environment protection and economically fuel consumption. In the internal combustion engines there are any gasoline engines and diesel engines were used to generate the power in industries and transportations. This problems need the new design, research and technology to find the new design of the new engine or its components so its can use of the alternative fuels another gasoline and diesel, protect and friendly with the environment, high power and efficient in fuel consumption. So they were some engine designers did the any new design of the new concepts or new ideas to find the new better engines and have a high power and friendly with the environment and efficient on fuel consumption.

It is well known that the fossil fuel reserves all over the world are diminishing at an alarming rate and a shortage of crude oil is expected at the early decades of this century[1]. Probably in this century, it is believed that the crude oil and petroleum products will become very scare and costly to find and produce. Gasoline and diesel fuel will become scarce and most costly[2]. Alternative fuel technology, availability and use will become more common in the coming decades for internal combustion engines. Nowadays, the alternative fuel has been growing due to concerns that the reserves of fossil fuel all over the world are finite and at the early decades of this century will run out completely. Furthermore, the current world energy crisis made the fossil fuel price increases. In the other hand, the fossil fuel contributes large environment pollution. Many types of alternatives fuels available in the world. Compressed Natural Gas (CNG) as an alternative fuel is becoming increasingly important.

Natural gas is found in various locations in oil and gas bearing sand strata located at various depths below the earth surface[2]. Compressed Natural Gas (CNG) is the most favorite for fossil fuel substitution[3]. Compressed Natural Gas (CNG) is a gaseous form of natural gas were compressed, it have been recognized as one of the promising alternative

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fuel due to its substantial benefits compared to gasoline and diesel fuel. These include lower fuel cost, cleaner exhaust gas emissions, higher octane number and most certainly. Therefore, the numbers of engine vehicles powered by Compressed Natural Gas (CNG) engines were growing rapidly[4,5]. Natural gas is safer than gasoline in many respects[6-8]. The ignition temperature for natural gas is higher than gasoline and diesel fuel. Additionally, natural gas is lighter than air and will dissipate upward rapidly if a rupture occurs. Gasoline and diesel fuel will pool on the ground, increasing the danger of fire. Natural gas is non-toxic and will not contaminate groundwater if spilled. Advanced Compressed Natural Gas (CNG) engines guarantee considerable advantages over conventional gasoline and diesel engines[9]. Compressed Natural Gas (CNG) is a largely available form of fossil energy. The exploitation of full potential of Compressed Natural Gas (CNG) as an alternative fuels is means of reducing exhaust gas emissions. However, the research of applying natural gas as an alternative fuel in engines will be an important activity, because the liquid fossil fuels will be finished and will become scarce and most costly[2,10]. Compressed Natural Gas (CNG) has some advantages compared to gasoline and diesel fuel from an environmental perspective. It is a cleaner fuel than either gasoline or diesel fuel as far as emissions are concerned. Compressed Natural Gas (CNG) is considered to be an environmentally clean alternative to those fuels[6,9,11,12]. Another that, advantages of Compressed Natural Gas (CNG) as a fuel are octane number is very good for SI engines. Octane number is a fast flame speed, so the Compressed Natural Gas (CNG) engine can be operated in high compression ratio[7].

The objective of this research is to investigate the combustion temperature in the engine cylinder effect of diesel engine converted to sequential or multi point injection dedicated CNG engine based on variation engine speed.

## MATERIALS AND METHODS

The CNG engine conversion development is by using direct injection diesel engine with added new components. The new components are engine throttle, gaseous injector, spark system, Electronic Control Unit (ECU) and new piston with lower compression ratio. The combustion temperature in the engine cylinder is investigated in this research. The difference data of diesel engine and CNG engine are fuel, compression ratio, ignition system, injection system and added the throttle[13]. The fuel in the CNG engine is natural gas, the ignition system is using spark ignition and the fuel injection system is using sequential or multi point injection system and using throttle to control the intake air.

The investigation of combustion temperature in the engine cylinder characteristics investigation of the baseline diesel engine and sequential or multi point injection dedicated CNG engine spark ignition are conducted at Automotive Laboratory, Faculty of Mechanical Engineering, University Malaysia Pahang, Malaysia. There are three sub-system investigated in the sequential injection dedicated CNG engine spark ignition. The first is investigation of intake system performances, the second is investigation of engine cylinder and engine crank train performances and the third is investigation of exhaust system performances of multi point injection dedicated CNG engine spark ignition. After the sequential or multi point injection dedicated CNG engine spark ignition conversion is completed, then running to investigate the combustion temperature in the engine cylinder. The engine is running in variations engine speeds. The variation of engine speed is 1000, 1500, 2000, 2500, 3000, 3500 and 4000 rpm.

The diesel engine converted to sequential or multi point injection CNG engine data is shown in Table 1[13]. In Table 1, the engine geometries such as bore, stroke and displacement are in the same. The intake and exhaust valve size is in the same. The intake valve open degree and exhaust valve open degree is the same. The intake and exhaust valve lift is in the same. The ignition system is changed from compression ignition to spark ignition. The fuel injection system is changed from direct injection to sequential or multi pint injection. The fuel is changed from diesel fuel to natural gas fuel.

Table 1: Engine conversion data[13]

| Engine parameter | Diesel engine | CNG engine |
|---|---|---|
| Bore (mm) | 86.00 | 86.0 |
| Stroke (mm) | 70.00 | 70.0 |
| Displacement (cc) | 407.00 | 407.0 |
| Compression ratio | 20.28 | 14.5 |
| Intake valve close (CA) | 496.00 | 496.0 |
| Exhaust valve open (CA) | 191.00 | 191.0 |
| Intake valve open (CA) | 361.00 | 361.0 |
| Exhaust valve close (CA) | 325.00 | 325.0 |
| Ignition system | Compression | Spark |
| Fuel injection system | Direct | Sequential |
| Fuel | Diesel | Natural gas |
| Intake port diameter in (mm) | 40.69 | 40.69 |
| Intake port diameter out (mm) | 32.78 | 32.78 |
| Intake port length (mm) | 55.20 | 55.20 |

## RESULTS

The investigation results of the engine cylinder temperature characteristics of diesel engine converted to sequential or multi point injection dedicated CNG engine based on variation engine speed are shown in Fig. 1-7. In Fig. 1-7, the -180 -0° is for compression stroke, 0-180° is for power stroke, 180-360° is for exhaust stroke and 360-540° is for intake stroke. Figure 1 shows the engine cylinder combustion temperature characteristics of base diesel engine converted to CNG engine at 1000 rpm engine speed. Figure 2 shows the engine cylinder combustion temperature characteristics of base diesel engine converted to CNG engine at 1500 rpm engine speed. Figure 3 shows the engine cylinder combustion temperature characteristics of base diesel engine converted to CNG engine at 2000 rpm engine speed. Figure 4 shows the engine cylinder combustion temperature characteristics of base diesel engine converted to CNG engine at 2500 rpm engine speed. Figure 5 shows the engine cylinder combustion temperature characteristics of base diesel engine converted to CNG engine at 3000 rpm engine speed.

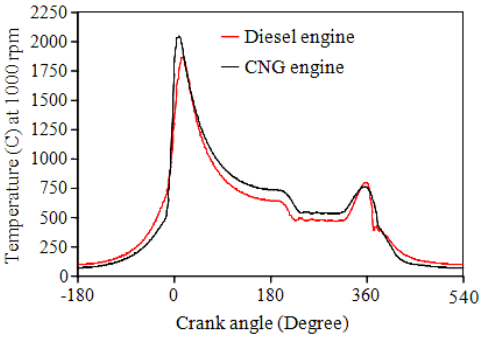


Fig. 1: Combustion temperature in the engine cylinder at 1000 rpm engine speed

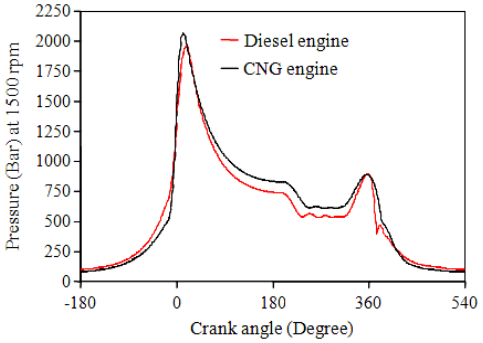


Fig. 2: Combustion temperature in the engine cylinder at 1500 rpm engine speed

Figure 6 shows the engine cylinder combustion temperature characteristics of base diesel engine converted to CNG engine at 3500 rpm engine speed. Figure 7 shows the engine cylinder combustion temperature characteristics of base diesel engine converted to CNG engine at 4000 rpm engine speed.

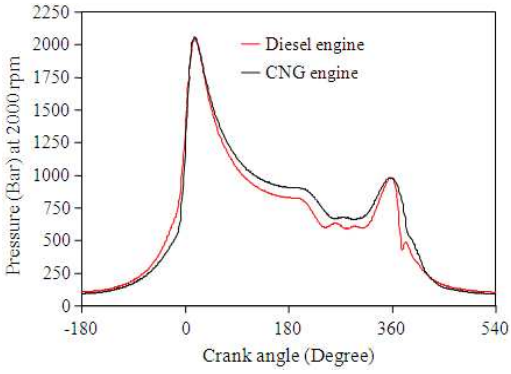


Fig. 3: Combustion temperature in the engine cylinder at 2000 rpm engine speed

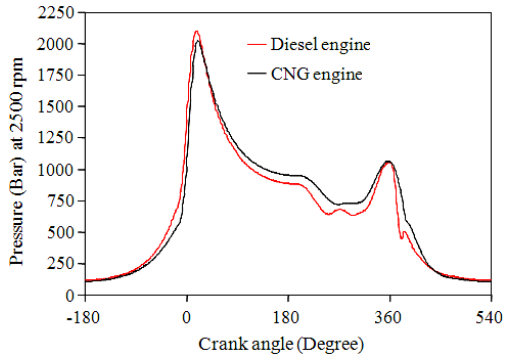


Fig. 4: Combustion temperature in the engine cylinder at 2500 rpm engine speed

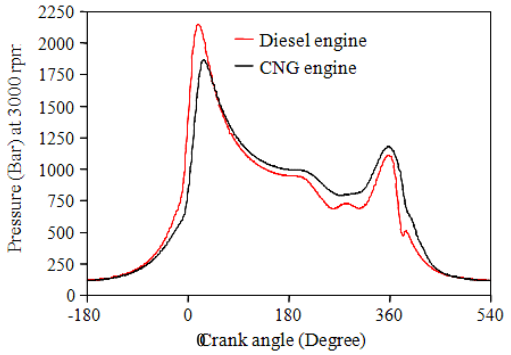


Fig. 5: Combustion temperature in the engine cylinder at 3000 rpm engine speed

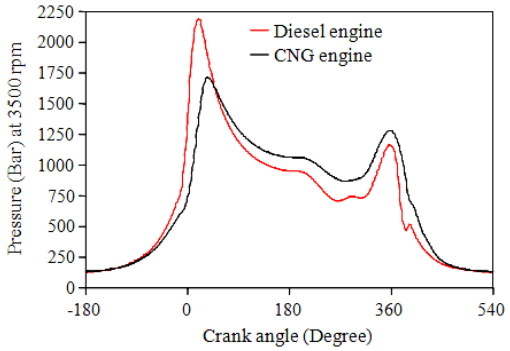


Fig. 6: Combustion temperature in the engine cylinder at 3500 rpm engine speed

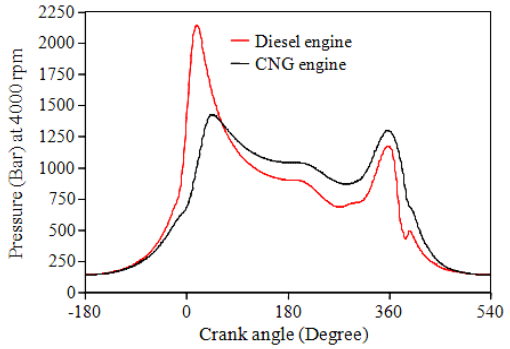


Fig. 7: Combustion temperature in the engine cylinder at 4000 rpm engine speed

Figure 1-7 shows the temperature characteristics in the engine cylinder profile of diesel engine converted to CNG engine. The results are plotted from investigation result output. The temperature profile in the engine cylinder is shown that temperature in compression stroke to ignition is increase. From ignition to product the engine power is decrease. The highest temperature in engine cylinder is declared in ignition process. In the low speed, the engine cylinder temperature of CNG engine is higher than diesel engine as shown in Fig. 1 and 2, but in the high speed the combustion temperature in the engine cylinder of diesel engine is higher than CNG engine as shown in Fig. 7.

## DISCUSSION

The maximum combustion temperature in the engine cylinder results are shown in Fig. 8. The results are shown that increasing engine speed of the diesel engine will be increase the maximum combustion temperature in the engine cylinder. Increasing engine speed of CNG engine will be decrease the maximum combustion temperature in the engine cylinder.

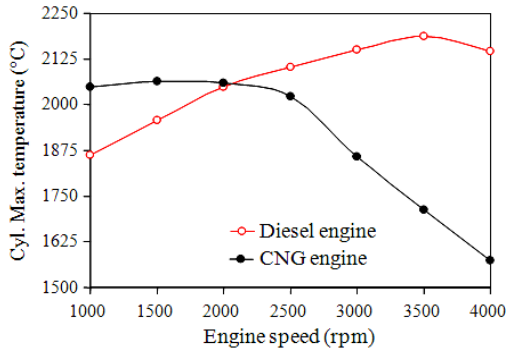


Fig. 8: Maximum temperature in the engine cylinder

Decreasing engine speed of diesel engine will be decrease the maximum combustion temperature in the engine cylinder. Decreasing engine speed of CNG engine will be increase the maximum combustion temperature in the engine cylinder. In this investigation results are shown that the highest maximum combustion temperature in the engine cylinder in combustion process is not declared in the highest engine speed. In the diesel engine, the highest maximum combustion temperature in the engine cylinder is declared at 3500 rpm engine speed, because in this case the combustion is most excellent than the other condition and unburned fuel is lowest, so the temperature product from the combustion is the highest. In the diesel engine, the lowest maximum combustion temperature in combustion process is in 1000 rpm engine speed. In this engine speed, the combustion process is not excellent and unburned fuel is highest than the other condition for compression stroke of compression ignition engine. In the CNG engine, the highest maximum combustion temperature in the engine cylinder is declared in 1500 rpm engine speed, because in this case the combustion process is most excellent than the other condition and unburned fuel is lowest, so the temperature product from the combustion is the highest. In the CNG engine, the lowest maximum combustion temperature in combustion process is at 4000 rpm engine speed. In this engine speed, the combustion process is not excellent and unburned fuel is highest than the other condition for compression stroke of compression ignition engine.

The effect of diesel engine converted to CNG engine on the maximum engine cylinder temperature based on engine speed is shown in Fig. 8. In the 1000 rpm engine speed, the conversion of diesel engine to CNG engine will increase the maximum engine cylinder temperature 9.94%. In the 1500 rpm engine speed, the conversion of diesel engine to CNG engine will increase the maximum engine cylinder temperature

5.40%. In the 2000 rpm engine speed, the conversion of diesel engine to CNG engine will increase the maximum engine cylinder temperature 0.52%. In the 2500 rpm engine speed, the conversion of diesel engine to CNG engine will decrease the maximum engine cylinder temperature 3.77%. In the 3000 rpm engine speed, the conversion of diesel engine to CNG engine will decrease the maximum engine cylinder temperature 13.57%. In the 3500 rpm engine speed, the conversion of diesel engine to CNG engine will decrease the maximum engine cylinder temperature 21.72%. In the 4000 rpm engine speed, the conversion of diesel engine to CNG engine will decrease the maximum engine cylinder temperature 26.72%.

## CONCLUSION

The combustion temperature in the engine cylinder investigation results of the four stroke direct injection diesel engine converted to sequential or multi point injection dedicated CNG engine are shown that the engine conversion can be decrease the maximum combustion temperature in the engine cylinder. For the diesel engine, the increasing engine speed will be increase the maximum combustion temperature in the engine cylinder. For the CNG engine, the increasing engine speed will be decrease the maximum combustion temperature in the engine cylinder. The highest maximum combustion temperature in the engine cylinder for the diesel engine is declared in the 3500 rpm engine speed. The highest maximum combustion temperature in the engine cylinder for the CNG engine is declared in the 1500 rpm engine speed. So, based on the increasing engine speed, the conversion of diesel engine to CNG engine will be reduce the maximum temperature in cylinder.

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