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The Effect of Avgas Fuel Injection Pressure on Injection Temperature

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ABSTRACT

The use of internal combustion engines has become common in transportation, especially in aviation, one of which is the Cessna training aircraft with a piston engine. The effect of fuel injection pressure on injection temperature has been a focus of many studies because it has the potential to improve combustion efficiency. Increasing the fuel injection pressure in avgas causes an increase in injection temperature and also enhances temperature stability during injection.

Key words : Pressure, Temperature, Injection, Avgas, Engine

1. INTRODUCTION

The use of internal combustion engines has become common in transportation, especially in aviation, one of which is the Cessna training aircraft with a piston engine [1,2]. Increasing efficiency and reducing exhaust emissions are the main goals in the development of this engine technology [3]. One factor that influences efficiency and emissions is the fuel injection temperature in combustion engines [4–6].

The injection temperature of avgas fuel is an important parameter in the combustion process [7], and the effect of fuel injection pressure on injection temperature has been the focus of many studies because it has the potential to improve combustion efficiency. However, the role of fuel injection pressure in influencing injection temperature is not yet fully understood [8–10].

In essence, fuel injection pressure of avgas can affect the formation of the fuel-air mixture in the combustion chamber and the interaction between this mixture and the flame during the combustion process [11,12]. Higher injection pressure may produce several effects, such as increased combustion rate and better combustion quality. However, other factors also need to be considered, such as the characteristics of the avgas fuel itself, hydraulic forces involved in injection, as well as injector design and settings [3], [12–14].

In this study, we will further explain the effects of fuel injection pressure on injection temperature in controlled experimental testing and analysis. This research aims to provide a better understanding of the relationship between fuel injection pressure of avgas and injection temperature, which will be described in detail in the methodology section. The results of this study can contribute significantly to the development of more efficient and environmentally-friendly fuel injection technology, as well as influence the design and settings of fuel injection and combustion systems in internal combustion engines.

2 THE RESEARCH METOHOD

for this study will employ experimental methods to investigate the effect of fuel injection pressure on injection temperature [6], [15,16]. This approach will allow the researchers to control variables and obtain objective data.

2.1 The Prototype

In this study, a series of experiments will be conducted in the laboratory. A prototype of an internal combustion engine equipped with a fuel temperature measurement system will be used. The fuel injection pressure of avgas will be varied at predetermined levels as the independent [8–10]. The injection temperature will be the dependent variable, measured using an Arduino R8 temperature sensor with 3 temperature axis points as shown in Figure 1 [17].

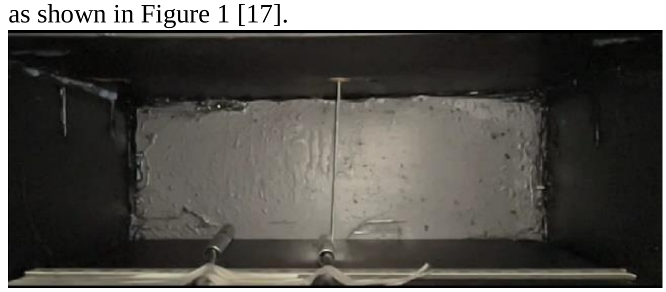

Figure 1: Spray prototype with the temperature sensor

2.2 The Experimental Procedure

• Prototype preparation: A prototype of the internal combustion engine chamber will be prepared with dimensions of 21x30x21 cm as shown in Figure 2 and painted with black dope [2,18].

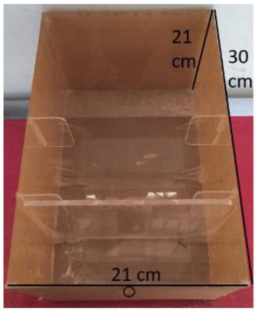

Figure 2: Prototype dimensions Figure

Figure 3: Arduino R8 with 3 temperature sensors

• Fuel injection pressure settings: The fuel injection pressure of avgas will be varied at predetermined levels of 2, 3, and 4 Bar.

• Injection temperature data collection: An Arduino R8 temperature sensor will be placed at 3 relevant points within the injection system to measure the injection temperature during the experiment. Temperature data will be collected shortly after injection and impact, and then waited for 40 seconds.

• Data repetition and analysis: Each variation of the injection pressure will be repeated to collect consistent and reliable data. The obtained injection temperature data will be analyzed using appropriate statistical methods. The injection temperature data will be analyzed using inferential statistics [19–21], such as hypothesis testing or regression analysis, to examine the relationship between fuel injection pressure and injection temperature. This will investigate whether there are significant differences in injection temperature when different injection pressures are applied [6,22,23]. Some limitations to consider in this study include: The research will be conducted under laboratory conditions that may differ from practical conditions in internal combustion engines. Other factors such as the characteristics of avgas fuel, nozzle design and settings, and other environmental factors may also

3. RESULT AND DISCUSSION

3.1 Research Results

In this study, the fuel injection pressure of avgas was varied at three levels: 2 bar, 3 bar, and 4 bar. Here are the results obtained and their discussion:

A. 2 Bar Pressure

The injection pressure of 2 bar The average injection temperature measured was 23°C. Data analysis showed a significant decrease in injection temperature, with the most noticeable decrease occurring in the middle of the injection. These results indicate that when the fuel injection pressure is set at 2 bar, it leads to a measurable decrease in injection temperature, as shown in Figure 4. It also suggests that there is energy loss during the travel before impact.

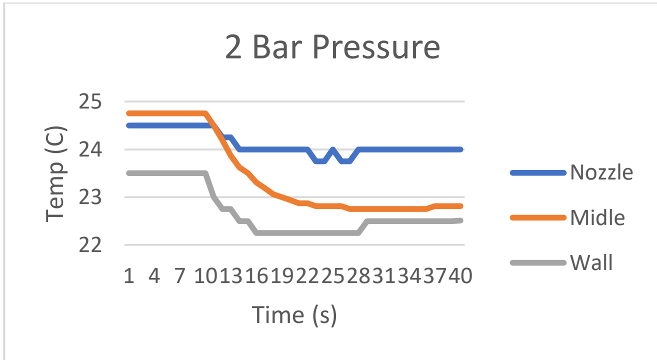

Figure 4: 2 Bar pressure chart

B. 3 Bar Pressure

The Burst Pressure is 3 bar The average spray temperature is measured at 23.5°C. In this case, there is a unique characteristic where the middle spray temperature is lower compared to the final impact temperature observed in Figure 5. The temperature difference can also be seen with higher average temperatures as the pressure increases from 2 bar to 3 bar.

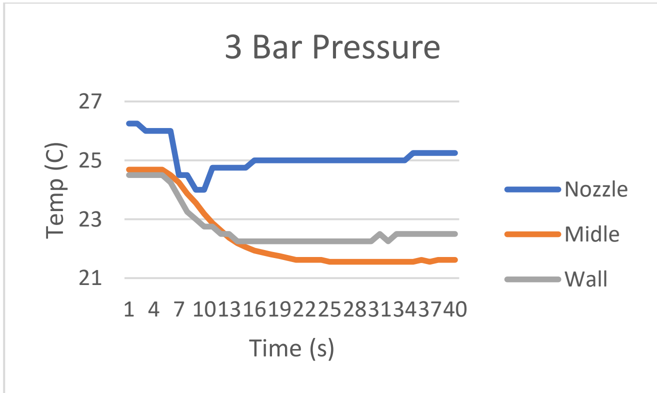

Figure 5: 3 Bar pressure chart

C. 4 Bar Pressure

The Burst Pressure is 4 bar an average spray temperature is measured at 26°C. Observations indicate that increasing the fuel spray pressure from 3 bar to 4 bar results in a significant increase in spray temperature. This finding confirms the initial hypothesis that increasing the spray pressure can have a positive impact on the spray temperature, as evidenced by the experimental conditions shown in Figure 6. The temperature appears more stable from the start of the spray to the impact, allowing for calculation and graphing.

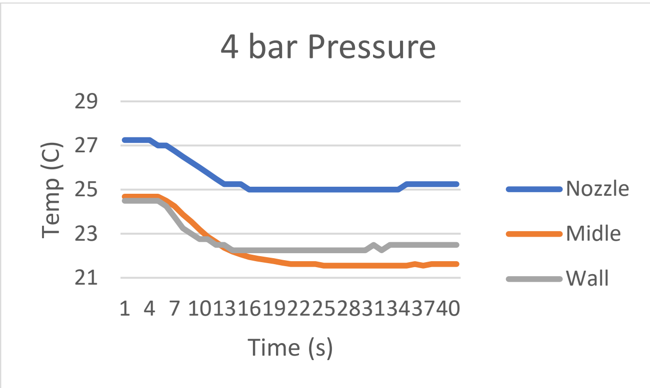

Figure 6: 4 Bar pressure chart

3.2 Discussion

The experimental results show several influences of varying the avgas fuel spray pressure on the spray temperature. There is a significant increase in the spray temperature as the fuel spray pressure increases. This phenomenon can be explained by the fact that increasing the avgas fuel spray pressure leads to an increase in the fuel volume entering the combustion chamber. This results in an increase in the volume of the fuel-air mixture that is burned. More fuel is burned and chemical energy is released, which in turn increases the spray temperature. Therefore, higher spray pressure is more effective in creating hot and efficient combustion conditions.

However, it is important to note that these results are associated with the conditions and experimental parameters used in this study. Differences in spray pressure can potentially cause complex changes in the combustion process, and the range of spray pressures observed in this study may not cover the entire spectrum that may occur in real-world conditions. The increase in avgas fuel spray pressure from 2 bar to 3 bar and 4 bar results in a significant increase in the spray temperature. This study can provide valuable insights into the development of more efficient fuel spray technology and help in efforts to reduce exhaust emissions and improve the efficiency of internal combustion engines. However, further research is needed to examine the effects of spray pressure beyond the tested pressure range.

4. CONCLUSION

Based on this research, it is concluded that the avgas fuel spray pressure has a significant influence on the spray temperature. As seen in Figures 4, 5, and 6, increasing the avgas fuel spray pressure leads to a significant increase in the spray temperature. This can be observed in Figure 5, where a spray with a pressure of 4 bar produces a more stable temperature. However, it should be noted that the temperature in the middle of the spray is lower than the impact temperature, as seen in Figures 4 and 6. This is because the fuel rate experiences significant energy loss, resulting in a significant temperature decrease in the middle of the spray.

These findings have important implications for the development of more efficient and environmentally friendly fuel spray technology. With a better understanding of the influence of spray pressure on the spray temperature, this research can help in efforts to reduce exhaust emissions and improve the efficiency of internal combustion engines.

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