

Low Temperature Fluidity and Performance Evaluation for Sensor Unified Fuel Heater

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Abstract- This paper has developed the low temperature fluidity and its performance evaluation for sensor unified fuel heater. In order to overcome an initial start problem of the diesel engine, the sensor unified fuel heater in waxing material like paraffin which may be generated at extremely low temperature in winter can decide the car's life. Such a sensor unified fuel heater is suggested to improve the efficiency as well as robustness of heater by combining a fuel filter with a heater and is compared to previous heaters. The proposed sensor unified fuel heater consists of plastic body including lower/upper plates, stopper, PTC-based heater and heater/water sensors. Also, in order to evaluate the performance of the proposed car's goods, a performance evaluation system is constructed, which can check the operation of fuel heater at room temperature as well as at extremely low and high temperatures and to measure delay times of resistance and current according to test resistances, delay time of bimetal according to temperature change and current/resistance of fuel heater.

Keywords : sensor unified fuel heater, diesel engine, low temperature fluidity test, performance evaluation , efficiency

I. Introduction

A fuel heater is necessary for the fuel heating like diesel oil. The heating sensor is detecting the fuel temperature, which is located at the outside of the heater body in existing fuel heaters(Byungchul Na and Jinyong Kim, 2003; Byungchul Na et al., 2004)[1-3].

Diesel engines are widely used in various fields like the construction machines, generators, and vehicles that due to some advantages like better fuel economy and lower carbon monoxide emissions than gasoline engines(Zheng et al., 2004; Fang et al., 2009)[4-6]. Some issues, including emission of pollutants like particulate matter, nitrogen oxides, sulfur oxides, and polycyclic aromatic hydrocarbons and low performance, have significantly improved with the

advancement of technologies for combustion control and exhaust gas treatment during last decades (Armas et al., 2013; Broatch et al., 2010; Fahd et al., 2013). There, however, is still a problem related to starting at cold conditions below the ambient temperature of 0°C (Broatch et al., 2010; Pastor et al., 2011; Piperel et al., 2013; Starck et al., 2011)[7].

When the diesel engine is under freezing temperatures, the paraffin contained in diesel and biodiesel can be crystallized(Byungchul Na and Jinyong Kim, 2003; Byungchul Na et al., 2004; Mohammad et al., 2013). It leads to reduce the fluidity of the fuel. The starting problem and engine power loss can eventually be caused by blocking a fuel filter. There exist several approaches to solve this problem. First method is adding the fuel additives to prevent the crystallization (Zhang et al., 2009). However, It has some negative effects on the engine's performance and life cycle. Second method is using the winter diesel(Lamprecht et al., 2007). It does not guarantee the efficiency. Second method is heating the diesel in the circuit for the fuel supply. It is considered as the effective and permanent solution to operate the diesel engines at cold conditions. It can cause to reduce the stability and reliability for the fuel heaters[8-10].

In this study, we developed the sensor unified fuel heater (heating sensor and heater are located in the heater body) to efficiently improve the stability and thermal efficiency of the heater. We also fabricated an evaluation system to check the quality of the fuel heater. The evaluation system included the large place to ensure the throughput and effective algorithm to minimize the required time. Among various heating types, a positive temperature coefficient (PTC) type heater is mainly used for both passenger cars and sport

utility vehicles (SUV), whose heating power is up to 65 W equipped with the high pressure pump of flow rate of 60L/min.

II. Low temperature fluidity for sensor unified fuel Heater

A. The Sensor unified fuel heater

Figure 1 show the sensor unified heater. When starting a diesel engine, the proposed sensor fuel heater plays a role in enhancing the liquidity of diesel, which consists of a plastic body, a lower plate, an upper plate, a stopper and PTC. The given power and test voltage are 200W with 5% allowable deviation and DC 13V, respectively with on ($-3^{\circ}\text{C} \pm 4^{\circ}\text{C}$) and off ($17^{\circ}\text{C} \pm 4^{\circ}\text{C}$) switch conversion. Specially, leakage tests are repeated with 3bar, 5bar and 7bar per minute.

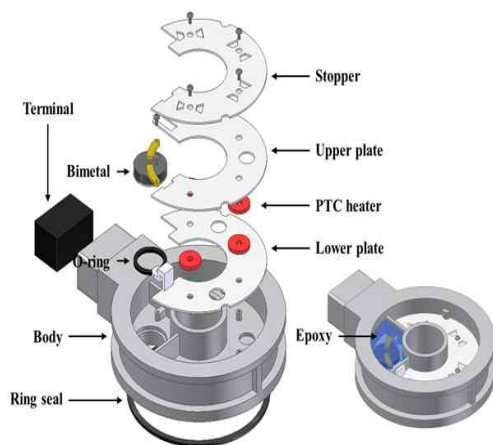


Figure 1. Sensor unified heater

In figure 1, it explains the assembling procedure of unified heater, where the main body is first combined with the lower plate and then, four PTC is installed and the upper plate together with the stopper are finally integrated with the main body. When fixing the screws, the torque of $6 \sim 7 \text{ kgf} \times \text{cm}$ is applied to fix the screws and the durability test will follow. And the assembling procedure of bimetal with the main body of fuel heater, where the O-ring is first combined with the main body and then, fixer and bimetal are incorporated sequentially.

Whether the filtered water becomes over certain level or not, a water sensor is installed below the fuel filter [5]. Also, the thermistor is used to control the

current by using the fact that the resistance is proportional to the temperature so that the current is shut off for high temperature [6, 7]. Figure 2 present the sensor unified heater with fuel filter.

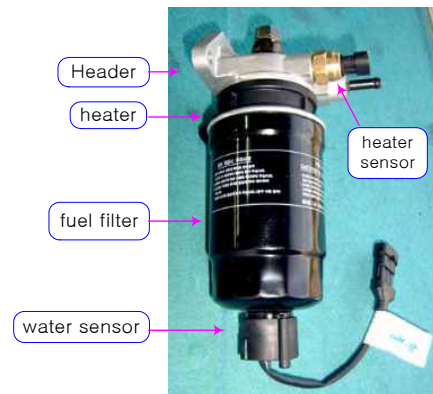


Figure 2. Sensor unified heater with fuel filter

B. Low temperature fluidity system

In this research, we have developed the low temperature fluidity test system that is not only to evaluate the heat efficiency but also to guarantee the robustness as well as stability of heater. Furthermore, the performance evaluation system is to carry out efficiently quality test of large quantities of heaters with the help of the time-efficient algorithm. Figure 3 show the low temperature fluidity system, the sensor unified fuel heater is installed in yellow circle.



Figure 3. Low temperature fluidity system

Figure 4 explain the important function of low temperature fluidity system, we can display several electrical characteristics in terms of these function with measurement sensor.

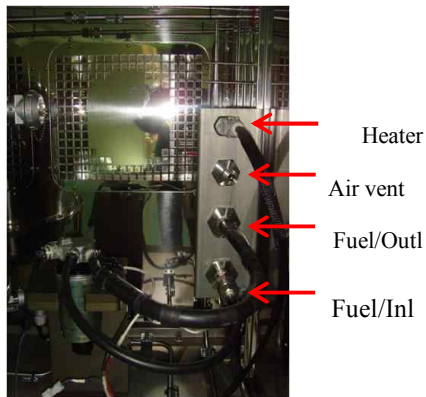


Figure 4. Performance evaluation point

The contents of performance test consist of the operating test at room temperature, extremely low/high temperatures, the resistance/current operating delay tests according to test resistance setting, the bimetal delay time test according to the temperature changes, the heater current/resistance test and the heating test, etc. Specially, since all components used for the car are fully inspected, the capabilities of lots of samples tests as well as minimum time operation are very important. On system turning, its mode is converted into the heating check mode and both the test temperature and the test resistance are chosen. The control parts consist of the blower, the refrigerator and the control panel. According to the PLC control flow for heater test, the roles of port 0 ~ 2 are to turn on and off the evaluation system, respectively and include to stop the system in case of emergency. In order to check the current of sensor unified fuel heater, IC components applicable to the PLC are chosen, which can display the voltage proportional to the current measured by using the hole-effect. The output voltage may increase or decrease linearly in proportion to the measured current and it is given to the MCU through A/D converter. Based on the converted data, MCU gives a command according to the current change. To prevent the inverse current flow, a diode is added to the output port and a bypass filter is also adopted to reduce the noise. The figure 4 diagram for the power control, where DC is used for chamber with 2-channel of 0~30V, and AC 220V for the board is rectified to DC 12V/0.9A by using SMPS. The rectified DC 12V is reduced to 5V for MCU and IC components by using linear regulator.

III. Experimental results

We measured the resistance with bimetal and without bimetal at the room temperature and 2. This measurement is performed at least 7 times to ensure the repeatability of the data. The error bars, based on these independent realizations, indicate the statistical bounds with a 95% confidence. At the room temperature, the passing resistance cannot be measured and the non-passing resistance has 4.3Ω . At the temperature of 2.5°C , the passing and non-passing resistances through the bimetal have the 4.9 and 4.8Ω , respectively. They are a little difference.

Figure 5 shows the resistance, current and power for the heat generation before and after the test at the temperature of 2.5°C .

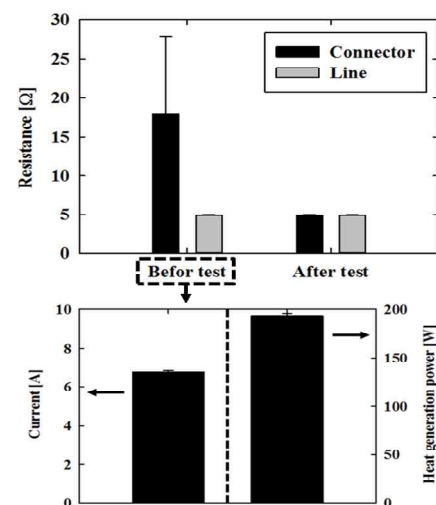


Figure 5. The resistance and current of the heater

Figure 6 shows Ref. CEC M-11-T-91 (Cold Weather Performance Test Procedure for Diesel Vehicles), the evaluation of low temperature fluidity have good starting time of 23 % at -30°C .

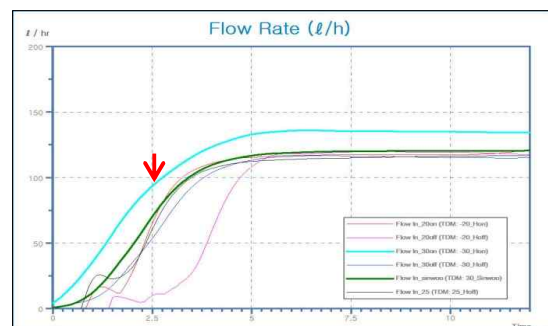
Figure 6. Starting time at -30°C and flow rate

Figure 7 show variables of flow quantization and pressure. In the low temperature driving performance, the temperature difference is level up, but the pressure is downing, and the better driving point is playing in -30 °C more than -20 °C. Then the better low temperature fluidity Q of unified type than separate type heater is supplied for 19%.

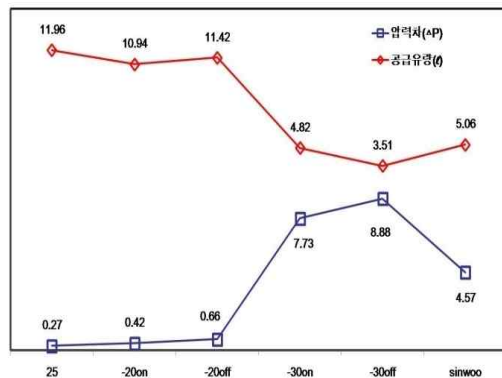


Figure 7, Variable of flow quantization and pressure

Figure 8 shows starting time, oil flow quantity, voltage and pressure of heater at key on status.

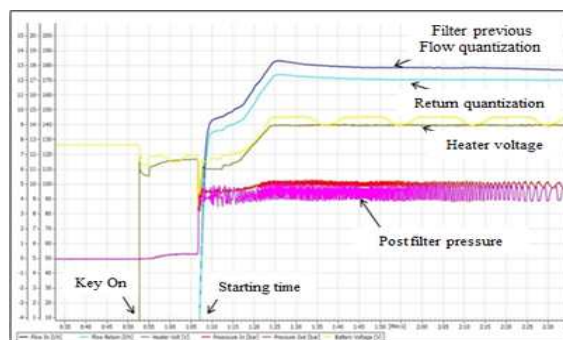


Figure 8. Starting time, oil flow quantity, voltage and pressure of heater at key on status

IV. Conclusion

In this study, we developed the unified fuel heater for diesel cars. It could efficiently improve the stability and thermal efficiency due to integration of the sensor in the heater body. We also developed the performance evaluation system which has five inspections. Especially, this system could contribute the improvement of the productivity because various tests were performed in the internal chamber.

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