An Electronic Device for Controlling of Diesel Engines Temperature

Case Study: Effect of Fan and Water Radiator

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***Abstract*- Diesel engines are extensively used in agricultural machineries such as water pumps and power generators. The protection and maintenance of these engines have been a major concern especially in remote areas. In this paper the relation of diesel engine temperature with fan belt and radiator water was investigated. In the normal condition, the fan and radiator control the engine temperature, so temperature increase would be limited. If, by any reason, the fan belt snaps or radiator leaks, the engine temperature will overflow the defined limit leading to weak operation. An electro-mechanical system was designed to protect diesel engine based on the critical temperature. The system constituted an electro-valve and electronic devices which were supplied by two voltages from an electronic circuit. This circuit switched the diesel engine off if the engine temperature exceeded the critical temperature.**

Keywords- Diesel Engine; Radiator; Temperature Sensor

I. INTRODUCTION

Diesel engine is one of the most application engines in agricultural field. Water pumps, power generators, tillers and tractors are all driven by diesel engines. While the presence of an operator is necessary for using of some diesel engines, in many cases it can be used for fixed equipments such as generators, CHP [1], water pumps and desalination systems [2], so that the presence of an operator is not required. Diesel engine is the internal-combustion piston engine. An internal-combustion engine is one in which combustion, or burning, of air and fuel takes place inside the engine. Based on the type of ignition of combustible mixture, combustion process may result from pressure ignition or spark ignition. In pressure ignition engines, the air is compressed within the combustion chamber until air temperature becomes more than the fuel incineration temperature. At this moment explosion will happen with the fuel injection. In spark ignition systems, air-fuel mixtures are involved inside the combustion chamber and the explosion is made by spark [3]. In both cases, combustion of air-fuel mixture in the cylinders generates high temperature near 1800-2000 ℃ [4]. The thermal efficiency in diesel engines varies from 25 to 35 percent [5]. Therefore, only a section of the produced thermal energy is turned into the useful work [4]. Since this temperature is more than melting temperature of the cast iron, a kind of cooling system would be used to reduce the additional heat [6].

To maintain proper temperatures, an engine cooling system is provided. Most engines are water-cooled by a liquid. Some engines are air-cooled. A water-cooled system uses coolant. Coolant is a fluid that contains special chemicals mixed with water [7]. Radiator and fan are major components in cooling systems [8]. Coolant flows through passages in the engine and through a radiator. The radiator accepts hot coolant from the engine and lowers its temperature [9, 10, 11]. Air flowing around and through a radiator takes heat from the coolant [8, 9, 10]. The lower temperature coolant is returned to the engine through a pump [12]. The warm water, due to density gradient, moves up (Thermo-siphon or heat circulation). That's why the radiator is located above the engine. The water is cooled by water circulation in the radiator by using of fan blowing [11]. This procedure will not allow the engine temperature to rise [8].

If the engine temperature exceeds the allowed level, engine failure may occur since the heat produced is not absorbed by the cooling system. Consequently, three major problems appear in the operation of the engine: firstly, poor lubrication leading to friction, wear and abrasion. Secondly, knocking in spark ignition engines because of premature ignition in combustible mixture and finally moving parts expansion which increases the friction of the bearings.

Increasing of temperature of diesel engine may have two reasons: fan belt rupture and low level of water within the radiator. Pouring the fuel on the belt during fuel filling at the fuel tank may rupture fan belt. Just as aforementioned, some of the applications of the diesel engine are rotation of the water pumps for irrigation of rice paddy or power generators. In these cases, the engines work for a long time (sometimes more than 10 hours) in the absence of an operator or a safety system. Such a condition makes these engines difficult to be maintained or repaired. As a result the performance will be reduced. Therefore, it would be highly essential that a system is designed to obviate or announce any such type of problem.

In this paper, the engine and radiator temperature increase is considered at the different working conditions, including: normal condition that the fan belt works properly and radiator is full of water, radiator is full of water but the fan belt does not work properly and the fan belt works properly and radiator is not full.

Considering the obtained results, a critical temperature was defined and an electronic circuit announced the temperature overrun. If the engine temperature increases more than the critical temperature, then the engine will turn off and alarm system will announce. Furthermore, the relation of engine temperature with fan belt and radiator water is considered. Finally, an electro mechanical system is proposed.

II. INVESTIGATION OF TEMPERATURE INCREASING

A Mitsubishi engine of 7.5 *hp* power, a four-stroke cycle engine and water-cooled system with tube radiator is tested (Fig. 1). Two available points on the engine were selected for investigation: at the bottom of the radiator (point A) and on the engine's cylinder head (point B). Temperature of these points is measured by two thermocouples. The experiments were conducted at the three operating conditions, i.e. normal operation, engine working without the fan belt and engine working without radiator water. The experiments were performed in 1700 rpm and environmental temperature 17 ℃ with three replicates. Since the purpose is prevention of excessive increasing in the engine temperature, the results will not fluctuate by changing the ambient temperature. If the ambient temperature drops below 17 ℃, it will take longer time to reach critical temperature and vice versa. The results of three operating conditions are as follow:

Fig. 1 A sample line graph using colours which contrast well both on screen and on a black-and-white hardcopy

A. Normal Condition

In this case, the temperature of the two points A and B is measured when radiator has enough water and the fan belt works properly (Fig. 2). The radiator temperature is shown with dash line and the cylinder temperature is shown with solid line. The radiator temperature is increased to 66 ℃ and then kept constant. The cylinder head temperature is also increased to 61 ℃ before being steady.

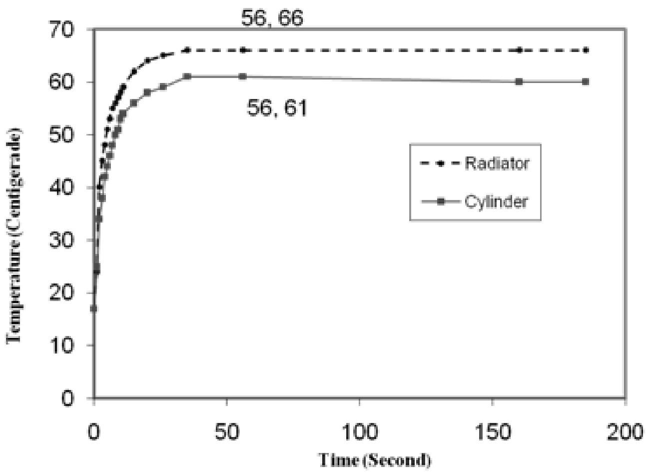

Fig. 2 Cylinder head and radiator temperature in normal engine working condition

B. Without Fan Belt and with Radiator Water

In this stage, the fan belt is separated from the engine and the radiator is filled by water. The test results are detailed in Fig. 3. As results show, temperature of the radiator and cylinder head increased. This experiment was continued till the radiator temperature and the cylinder head temperature show 83 ℃ and 75 ℃, respectively. This figure demonstrates that the increasing of temperature lasted for few minutes as the radiator temperature took 9 minutes to increase from 66 ℃ in normal condition to 83 ℃ in the present condition.

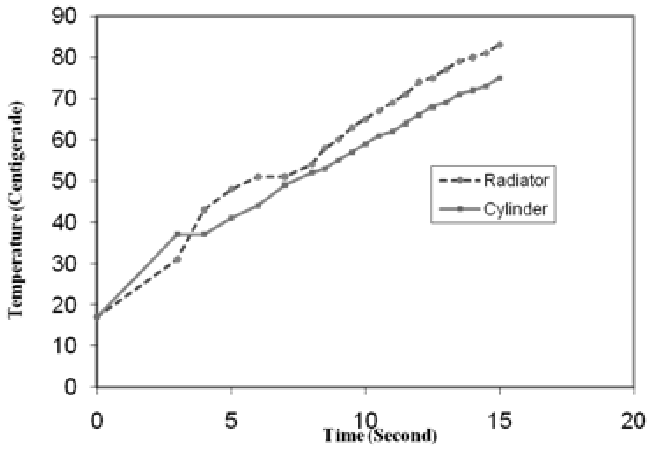

Fig. 3 Cylinder head and radiator temperature with radiator water and without the fan belt

C. Without Radiator Water and with Fan Belt

The radiator water was discharged while the fan belt was operated. Fig. 4 depicts the cylinder head and radiator temperature when the radiator is empty but the fan belt is running. As shown in this figure, preliminary the temperature remained constant, but after 2 or 3 minutes temperature started to increase. Accordingly, after a few minutes the temperature of the radiator and cylinder head appeared to be 80 ℃ and 85 ℃, respectively.

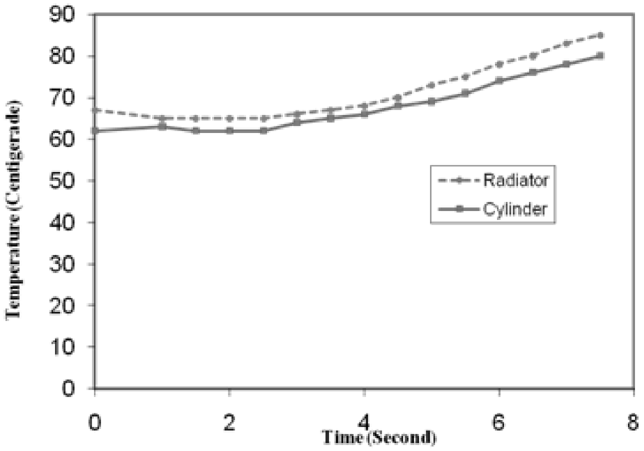

Fig. 4 Cylinder head and radiator temperature without radiator water and with fan belt

III. ELECTRO-MECHANICAL SYSTEM

Analyzing the data obtained from the earlier section proves that if by any reason the fan belt stops working or the radiator is discharged, only after a few minutes the engine temperature will increase. So, to guarantee the safe operation of the engine, it should be switched off. The cylinder head (B point in Fig. 1) is selected for the location of temperature sensor since its installation is easy. Moreover, 75 ℃ is considered to be the critical temperature on the cylinder head. As a result, if, by any reason, fan belt is ruptured or radiator is perforated, then the cylinder head temperature will increase up to critical temperature. At this moment, an order is necessary to turn off the engine and send alarm. Three methods were premeditated for turning off the engine: 1- Mechanical system prevails spring force connected to gas chassis and turns off the engine. 2- Mechanical system pushes engine dump and turns off the engine. 3- Mechanical system cut off the fuel and turns off the engine.

The first method requires more power. Also designing a mechanical system will be costly. In the second method a spring is necessary to push dump and therefore turn the engine off. However, pressing dump maybe sheared the valve. At the third method, the fuel way is chosen to turn the engine off. This method is cheaper and less hazardous. An electrical valve was used and an electronic system operator was designed for implementing this method. Fig. 5 shows the designed electronic circuit. If cylinder head temperature reaches critical temperature, then an electrical pulse will produce and the fuel way is closed by electrical valve.

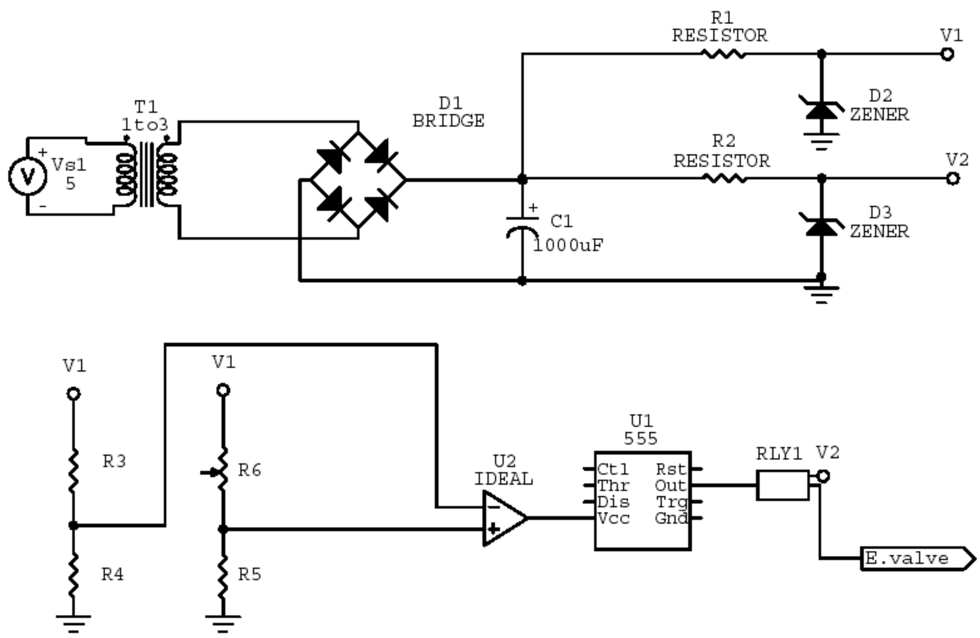

Fig. 5 Fuel control circuit design

IV. CONCLUSION

In this research, an electro-mechanical system was designed to show any unusual increasing of the engine temperature. This increasing may happen by any abnormal condition such as the fan belt rupture or discharged radiator water. Therefore, some experiments were conducted to obtain the relation of the engine temperature with three defined operating conditions. Results showed that at the state of normal condition of engine, the increasing of the temperature remained constant. The electro-mechanical system was designed to protect any failure of the diesel engine based on the critical temperature. The system included an electro-valve and electronic devices which were supplied by two voltages from an electronic circuit. This circuit will turn off the diesel engine when the engine temperature exceeded the critical temperature.

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