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IMPLEMENTATION OF A WARNING SYSTEM AGAINST ENGINE OVERHEATING IN VEHICLES WITH MULTIPOINT INJECTION

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Abstract:

The temperature in a vehicle is a fundamental factor for its correct operation. When a failure occurs in the original temperature sensor, irreversible damage to engine components can occur due to overheating. In the present work, an auxiliary temperature system is implemented that alerts the driver before an eventual overheating of the engine by means of sound, visual and vibratory signals. The system compares the data provided by an LM35 temperature sensor and a Hall effect sensor in charge of counting the RPM in real time, using an Arduino, continuously processing the data and constantly informing the driver via an LCD screen. The system will start operating when the engine exceeds 650 RPM with a temperature of 94 °C and a reaction time of 0.05 seconds. When a critical temperature is exceeded, an audible alarm will sound and a vehicle injector will be disabled. The system does not turn off the engine and is efficient in its purpose of alerting the driver, being suitable to implement in vehicles with multipoint injection due to its low cost of implementation.

Keywords: alert system; engine overheating; temperature measurement; automobile.

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1. Introduction

Engine operating temperature is very important to optimize its efficiency (Mancaruso & Sequino, 2019). Controlling it can prevent damage to engine parts and components. Overheating can cause its parts to wear out quickly and even deform during operation. In addition there is a loss of power due to poor heat transfer in the system (Haro & Haro, 2018; Sequino et al., 2018).

Currently, temperature sensors located in the engine cylinder head have been used specifically with indicative fines and in other decorative cases (Romero et al., 2007). This system is relatively inexpensive and has no direct direct predecessors. Its construction and assembly in a vehicle, if the following specific configuration is respected, is simple and fast. Similar implementations are exclusive to high-end automobiles. Sensor constantly analyzes computer temperature while engine is running (Baker Perkins, 2016).

When exceeding a limit temperature within a crankshaft rotation regime, an injector is disabled. Thus giving an alert to the driver and preventing possible damage mainly to the cylinders and pistons. The driver of the vehicle will have to check if there are leaks of coolant in the pipes, tanks or that the gaskets are in poor condition (Haro & Haro, 2018).

Power losses occur due to the heat generated in the combustion chamber, which is transferred through the engine block to the surrounding parts and to the environment. For this reason, if the motor does not have a high degree of heat transfer, it will be inefficient and its components will subsequently fail (Dennis, 2004; Romero et al., 2007; Hideaki et al., 2009).

The cooling system represents a way to maintain its efficiency by minimizing the loss due to the heat generated (Zheng et al., 2016). This is accomplished by dissipating heat as it is absorbed and transported to the car's radiator, producing a closed cycle until the engine stops (Brace et al., 2005).

When a vehicle overheats due to a problem or failure in the cooling system, excessive temperatures can cause damage to engine parts, such as cylinder head gasket, engine block and cylinder head (Romero et al., 2007). The fundamental concept of this work is to keep the engine running by controlling the temperature generated in it (Cho & Niuwstadt, 2017).

Efficiency is not only affected by the effect of overheating, but also influences the temperature of the cold engine, which sends an incorrect reading from the ECT sensor. An incorrect reading on the computer will provide the injection of abnormal amounts of fuel, higher fuel consumption and lower vehicle performance (Paredes, 2011).

Tests conducted on the Daihatsu vehicle, Terios model show that the system constantly monitors the engine temperature. The system processes and displays the results in no more than 1 second in real time. Warning

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signals in case of excess temperature in the engine, show an infallible and immediate response by the driver.

2. Material and Methods

The system to be incorporated is novel in the automotive market, there are systems that identify the engine temperature visually. These classic systems have failed at the time of warning of a possible increase in engine temperature. When the driver is distracted or not in the good habit of constantly monitoring the dashboard while driving, a visual alert signal may go unnoticed.

The auxiliary system developed early alerts visually and audibly that there is engine overheating, and in the event that this is ignored, you will have to deactivate an engine system. This deactivation of the injector does not cause damage to the engine, the vehicle or its occupants. The inoperativeness of an injector will generate vibration in the vehicle, thus forcing the driver to stop and to analyze its poor condition. The system configuration is detailed below. Both the connection diagram in the vehicle and the main components of the designed system are shown.

2.1. Connection scheme

The configuration of the components must respect the established order, taking into account that it must be carried out on vehicles with multipoint injection. The system must necessarily be implemented in vehicles with multipoint injection because only one injector needs to be deactivated. This does not affect the engine in case of overheating and subsequent deactivation of the injector, does not cause damage to the vehicle or present risks to the occupants. The system connection diagram is represented by Figure 1.

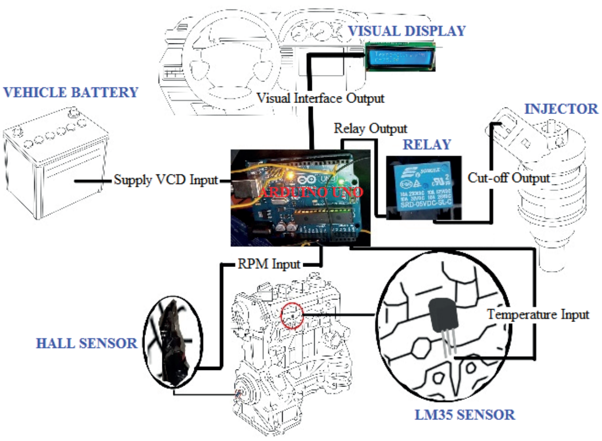

Figure 1: Connection diagram.

2.2. Hall Sensor (DRV5023)

The DRV5023 is a stabilized Hall effect chopper sensor that offers a magnetic detection solution with superior temperature sensitivity stability and built-in protection features (Texas Instrument, 2016). The main reason for using the element is its application to build a pulse counter, during full engine operation. The Hall sensor should be located in a place that can obtain the motor speed. The nearby camshaft or engine crankshaft is usually found.

2.3. Temperature Sensor (LM35)

The LM35 is a temperature device that provides a voltage output proportional to the temperature change in degrees Celsius. The device does not require a temperature conversion, allowing you to have better reading accuracy (Texas Instruments, 2017). By having its own ECT sensor in the vehicle's engine that permanently monitors engine temperature, and by incorporating the LM35, the similar reading on the engine is compared. To avoid involving the ECT sensor circuit in the engine, use the values measured by the LM35.

2.4. Arduino Board (UNO)

It is a microcontroller board that makes it easy to obtain and compare different input data, allowing you to control your programming from a computer. The design consists of two sensors placed at different locations on the engine. The first sensor, which is the Hall, is coupled to the crankshaft shaft of the engine and receives the signal from a magnet that is connected to a pulley thereof; this component is responsible for measuring engine speed. A second sensor is incorporated, which in this case is the temperature sensor, locating it in a specific place on the engine head.

The information with all the normal operating parameters of the implemented system will be stored on the arduino board. This component contains the signals from the sensors, in addition to sending the signal to cut off the fuel supply, if applicable.

2.5. Obtaining temperature as a function of RPM

Once the elements have been determined in the order and place specified according to the configuration established in Figure 1, the selected data is analyzed at different engine rotation speeds. The requested data collection is presented in Table 1.

Table 1: Temperature depending on motor RPM.

Test 1 Ralentí		Test 2 2000 – 2100 RPM		Test 3 2400 – 2600 RPM		Test 4 3000 – 3200 RPM		Test 5 3800 – 4000 RPM		Test 6 5000 – 5100 RPM	
Temp. (°C)	rpm	(°C)	rpm	(°C)	rpm	(°C)	rpm	(°C)	rpm	(°C)	rpm
93	677	98	2000	103	2400	105	3000	110	3800	115	5000
92	675	98	2050	103	2450	105	3000	110	3850	115	5000
94	678	99	2000	103	2500	105	3000	110	3850	115	5050
93	680	99	2000	103	2500	106	3000	110	3850	115	5050
93	677	99	2100	104	2500	106	3100	110	3900	116	5075
93	677	99	2100	104	2550	106	3150	111	3900	116	5075
94	678	99	2050	104	2550	106	3200	111	3900	116	5100
93	679	99	2100	104	2600	106	3200	111	4000	117	5100

2.6. Obtaining temperature as a function of RPM

The system is implemented in a Daihatsu vehicle, Terios 2002 model. The vehicle in particular has as its main feature that its injection system is multipoint, that is, an injector is incorporated in each cylinder. By locating one injector per cylinder, you have more precise control of the fuel supply to be injected.

This feature is essential when implementing the auxiliary temperature system, as explained above. Next, describe the location of the main elements of the system.

The LM35 sensor is placed on the right side of the engine cylinder head at the height of the fourth cylinder, as illustrated in Figure 2-a. It can be placed on any of the other three cylinders of the engine, but cylinder number four is chosen because the distance that this element presents is less with respect to the other components of the system to be implemented. When fixing the sensor to the cylinder head, it should be considered that when trying to drill to include this element, it may have modifications and negative behaviors both of the engine and of the implemented system. For this reason, it is recommended to use high temperature resistant adhesives. For fixing, silicone and high-temperature thermal tape are used to protect the connection cables closest to the engine cylinder head.

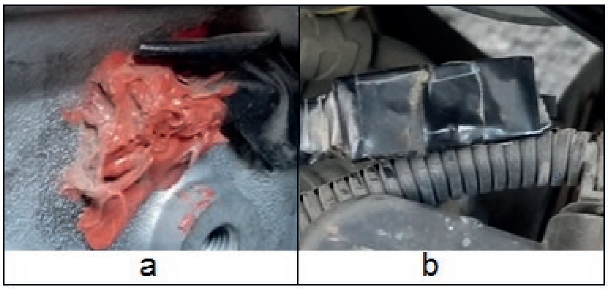

Figure 2: a) LM35 Temperature Sensor; b) Hall effect sensor.

In Figure 2-b, the Sensor Hall is located on one of the fan louvers at the height of the crankshaft pulley. A point is selected at which a magnet is fixed, which is in charge of giving the signal to the sensor and through which the RPM count is made. Care must be taken that the magnet is firmly attached to the rotating element, since this element directly influences the good behavior of the system at speed regimes.

The Hall effect and temperature sensors are connected to the Arduino UNO board shown in Figure 3-a. The board compares the data selected by the sensors with the information provided during programming. In the event that the motor is generating the highest temperature allowed, the system will begin to operate to meet its objective. When the system detects that the motor is running in abnormal temperature conditions, a signal is sent to the relay. The relay will immediately prevent the passage of voltage supply to the injector. This suppression of voltage prevents the injector from working and thereby suspends the fuel supply to the cylinder. As a result of this fuel cut, the vehicle will start to tremble, generating a malfunction warning signal for the driver. In parallel, the precise value of the engine temperature in real time will be shown to the driver by means of an LCD screen.

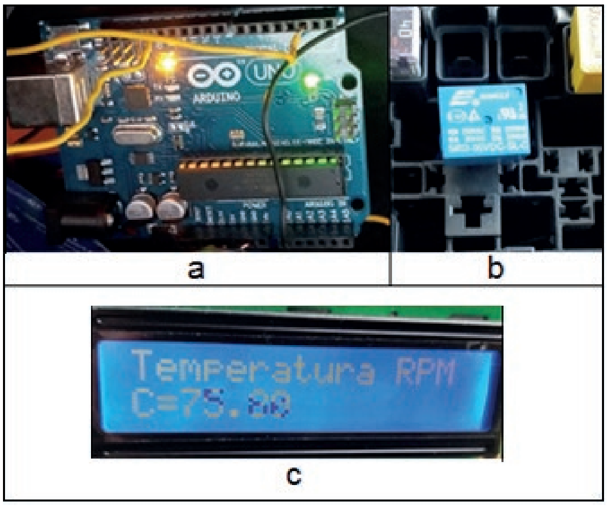

Figure 3: a) Arduino UNO Board; b) Relay; c) LCD 16×2 screen for visual interface.

The relay shown by Figure 3-b is connected to one of the Arduino's outputs, and a cable that controls the injector of the first cylinder. This configuration allows when the Arduino compares the values of the sensors and they exceed those established in the programming, the relay interrupts the current flow, disables the electric injector that supplies fuel to the number one cylinder. The relay can be included in the vehicle fuse box, taking into account that this component must be isolated from high temperatures.

The LCD screen illustrated in Figure 3-c shows the engine temperature in real time. This visual interface of the system with the user allows to display an accurate reading of the motor temperature in degrees CelsiusThis component must be located specifically within the vehicle interior. As it is an electronic element, it is highly susceptible to fluids and high temperatures that will cause system malfunction and especially loss of visual interface of the system with the user. The LCD screen should be located in a place where the driver can have permanent monitoring of the vehicle's temperature through the implemented auxiliary system.

3. Results

The tests of the built-in system and its direct influence on the behavior of the other vehicle systems were carried out at different revolutions of engine rotation, as occurs in the normal automobile operation. Figure 4 illustrates that tests performed under different speed regimes showed reading stability.

Table 2 shows that the system constantly monitors the motor temperature and guarantees that it is in its normal operating range regardless of its speed. The auxiliary system is 100% activated at all times of engine operation, from when the vehicle is switched on until it is switched off.

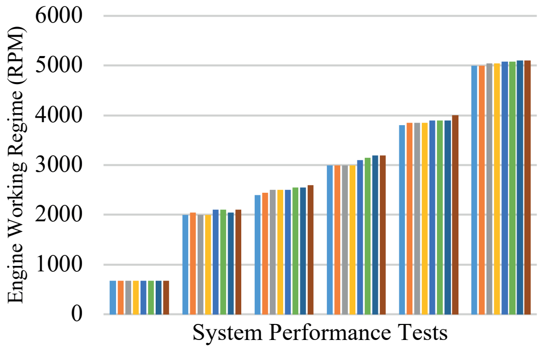

Figure 4: Stability of the system implemented under different revolutions per minute obtained from the Daihatsu Terios 2002 vehicle.

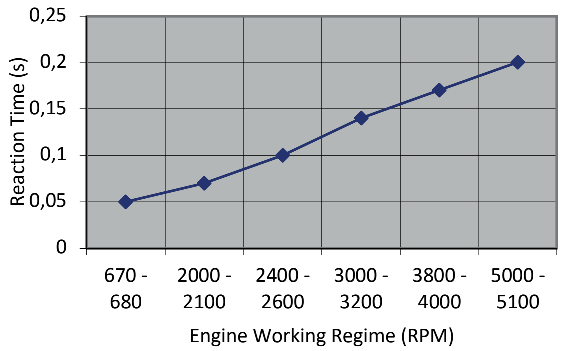

Figure 5: System response to rapid temperature variation.

Table 2: Activation test results.

RPM	Activation temperature	System activatión (%)
670 – 680	94	100
2000 – 2100	95	100
2400 – 2600	98	100
3000 – 3200	106	100
3800 – 4000	111	100
5000 – 5100	117	100

The implementation of the auxiliary system in the vehicle ensures that the ideal engine operating temperature is maintained. Its response time is approximately 0.01 seconds. This reaction time of the system allows the speed to vary abruptly obtaining permanent monitoring of the temperature, as illustrated in Figure 5. This constant and efficient monitoring will ensure that the driver receives an early warning and interrupts its operation, so that the engine is not damaged in the event of a malfunction caused by the increase in temperature.

Said results were obtained in the province of Cotopaxi in the city of Latacunga. The rpm ranges include controls for passenger vehicles and everyday driving. By obtaining the read correction of the RPM and temperature data, the system works properly powered directly via USB.

4. Conclusions

The abnormal temperature rise warning system is suitable for implementation in multipoint injection commercial vehicles, being an economical system that can be accessed by anyone who owns a vehicle with these characteristics.

The alerts generated are effective in warning the driver that the vehicle is at risk of being damaged. The reaction time of the system is less than 0.2 seconds, maintaining constant monitoring of the temperature during engine operation. The reliability provided by the warning system is 100%, communicating through auditory, visual and sensitive signals the unusual increase in temperature, so that the driver takes the necessary precautions and thus avoid overheating the engine.

This study reflects the behavior of the engine for the area of the Ecuadorian highlands, the correct operation is not ensured in other regions of the country, due to the conditions of temperature and atmospheric pressure that vary according to the relative height at which the engine is located is found the engine vehicle motor. The limitations and unreliability of the Arduino board can be compensated for by using PICs to control the input data, keeping the cost of implementation low. The study can be extended to vehicles with direct injection, using the same principle, but not to single-point injection vehicles or those that work with carburettors, so other options must be sought to alert the occupant.

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