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Active Thermoelectric Cooling of Motorcycle Voltage Regulator Impelemented With a Peltier Element

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GOAL OF THE STUDY

The current study aims to design and implement a universal cooling system based on a Peltier module for motorcycle applications. Specifically, the cooling system is intended for thermal regulation of a motorcycle voltage regulator within a defined temperature range. The objective of this article is to integrate a Peltier element into the rear section of the voltage regulator's cooling radiator, thereby ensuring the motorcycle's proper and stable operation under all ambient temperature conditions, as well as guaranteeing the rider's safety and comfort.

METHODOLOGY OF THE INVESTIGATION

For realizing the project and conducting experimental studies, a YAMAHA XVS 1100 – DRAG STAR Classic motorcycle was used. Temperature measurements were carried out using a FLUKE 568 EX non-contact infrared thermometer. Experimental studies without forced cooling - graphical presentation of the results is shown on Fig. 1.

Integration of the Peltier module with the motorcycle's voltage regulator. To maintain an optimal temperature regime of the voltage regulator, ensuring stable motorcycle operation, active cooling via the Peltier module is set to activate at 40°C and deactivate at 25°C – Fig. 2.

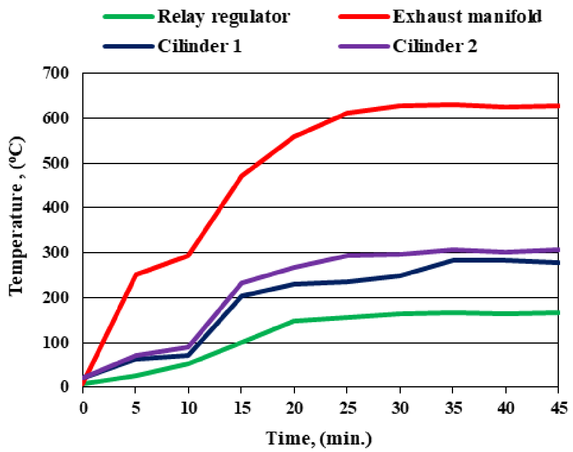

Fig. 1. Graphical presentation of motorcycle temperatures without cooling system of the voltage regulator as function of time during idling, T = f(t).

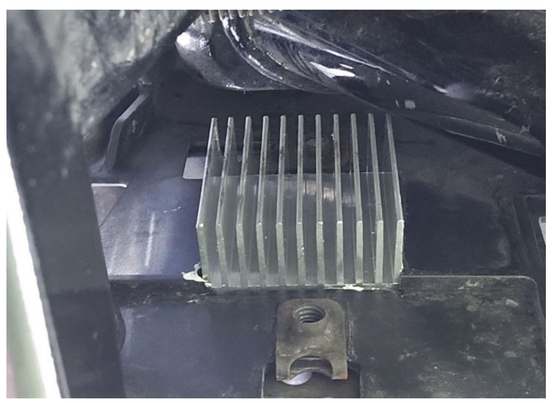

Fig. 2. Aluminum cooler with 11 fins, bonded to the Peltier element.

MAIN RESULTS FROM THE STUDY

Experimental studies during motion with forced cooling

The temperature measurement of the voltage regulator is performed by the temperature controller using a 10 kΩ NTC thermistor. The temperature controller's menu allows configuration of two threshold values – for high and low temperature – Fig. 3.

Measurements of the regulator's temperature were carried out after installing the cooling system, during a cold start, and while driving at a speed of 60 ÷ 90 km/h. To ensure maximum driving safety, during the measurements, the temperature controller was mounted on the motorcycle's handlebar. The data was recorded in a video file using a action camera attached to the rider's protective gear via model-specific accessories. Upon reviewing the video and synchronizing the data according to the recording timeline, the data is presented in Fig. 4.

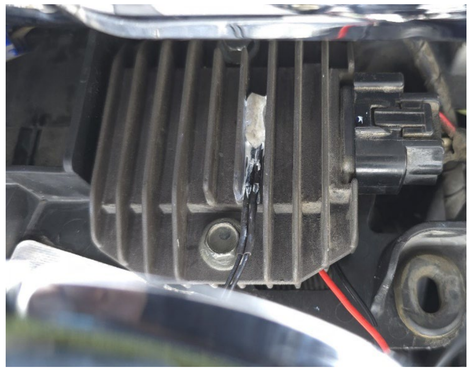

Fig. 3. The thermistor, mounted between the cooling fins of the voltage regulator with thermally conductive adhesive.

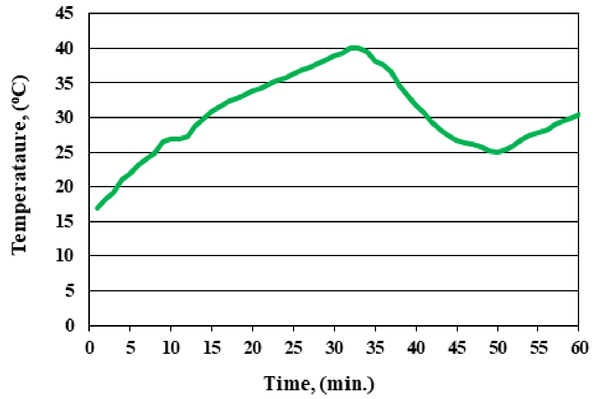

Fig. 4. Graphical presentation of the voltage regulator's temperature as function of time during driving of the motorcycle, T = f(t).

RESULTS AND DISCUSSION

From the graphical dependence in Fig. 8, it can be observed that during the first 13 minutes, there are slight fluctuations in the temperature rise due to urban driving conditions and uneven engine load. This is followed by a steady increase until the 32nd minute, when the setpoint of 40 °C is reached, triggering the activation of the Peltier element. Immediately afterward, cooling begins, reaching the target temperature of 25 °C over the next 18 minutes. Once cooled down to 25 °C, the power supply to the Peltier element is turned off, and the cycle repeats.

CONCLUSIONS

– An active cooling solution for the motorcycle's voltage regulator relay was successfully developed and implemented using a thermoelectric (Peltier) module. The system demonstrated effective thermal management under different load and environmental scenarios.

– The temperature control system is capable of achieving a minimum hysteresis of 0.1°C. Although such a high degree of precision is not critical for this application, it indicates the system's potential for use in more thermally sensitive environments.

ACKNOWLEDGMENT

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