Evaluation of DC Machine Armature Winding Temperature Estimation Using Temperature Measured on Brush and Bearing

M. A. H. Rasid
Faculty of Manufacturing & Mechatronics Eng. Tech,
Universiti Malaysia Pahang

M. N. A. Zulkafli
Faculty of Manufacturing & Mechatronics Eng. Tech,
Universiti Malaysia Pahang

Daing M. Nafiz
Faculty of Manufacturing & Mechatronics Eng. Tech,
Universiti Malaysia Pahang

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***Abstract*—The armature of a dc machine rotates inside the machine, making it expensive and complex for physical temperature instrumentation and visual thermography. A real-time temperature estimator using the temperature data measured on non-moving parts like the brush and bearing could be developed by determining beforehand the temperature difference between the winding and the brush or bearing. This study evaluates the temperature difference between the armature winding in comparison to the temperatures of the brush and the bearing. It is shown that the temperature difference are much higher between the winding and bearing in comparison to the temperature difference between the winding and the bearing. The temperature differences increase with the increase of losses, at 26.9°C and 13.8°C for winding-bearing and winding-brush average temperature differences respectively. It was also shown that the temperature gradient on a component can have a large range, leading to an error of estimation depending on the positioning of the thermocouple. The error computed using the error of the sum shows an estimation error for the winding temperature estimated by the bearing temperature and the brush temperature to be at 14.22°C and 12.9°C respectively at a current of 5A. These results show the impracticality of the armature winding temperature estimator proposed.**

I. Introduction

Armature winding in a brushed DC motor is the component that generate losses, thus heat in the machine. Unlike the steady state operation, in dynamic application in which they are more and more employed today such as for light electrical mobility such as scooter and electric bicycle, frequent acceleration means that maximum current is drawn regularly. This dynamic acceleration draws high current, generating high losses thus high temperature.

It is important to be able to monitor its temperature to ensure that the machine is always operating below the maximum temperature that may damage the winding insulation. As the temperature increases, the winding insulation lifetime is heavily reduced by the thermal-aging degradation effect [1], [2], [3]. In general, as the temperature rises, the longevity of the insulation decreases. As a result, thermocouple and thermal images may be used to identify an overheated motor [4], [5], [6], [7], [8].

While obtaining the stator temperature is simple, estimating the machine's rotor temperature has been a major difficulty for decades. As described in [9], [10], [11], [12], [13], [14] , major efforts have been devoted in recent years in the creation of thermal models that can forecast rotor temperature with high precision, particularly for induction motors. Due to inaccessibility to the armature for thermocouple implementation, the usual method employed is estimation of its temperature. Instead of using a thermal model in real-time, which needs several onboard computing capabilities attached to the machine monitoring system, estimating the armature winding temperature by proxy using the temperature measured on non-moving part such as the brush and the bearing outer run can be proposed. In this study, we are evaluating the possibility of estimating the armature winding temperature using the temperature measurement on bearing and brush of a brushed dc machine. This could potentially reduce the cost of real-time temperature monitoring of the armature.

There are two objectives of the study. The first one is to evaluate the temperature distribution on the three components of interest (armature winding, brush and bearing): finding the hot spot, the average temperature and the range of temperature. The second objective is to identify the difference between the temperature of the winding with the temperature of the brush and bearing and potential errors due to temperature gradient on the components. This will allow us to conclude on the adequateness of observing the bearing and brush temperature to estimate the armature winding temperature.

II. Methodology

To attain the objectives mentioned in the introduction, the temperature of the components mentioned will be observed using thermal imaging to capture the complete temperature gradient as losses being injected into the armature.

The flow chart in Figure 1 explains the process.