



THE TEMPERATURE MEASUREMENT OF A SINGLE PHASE INDUCTION MOTOR UNDER DIFFERENT CONDITIONS

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ABSTRACT

Infrared thermography is one of the most widely accepted non-destructive testing (NDT) and condition monitoring tools which is generally used in all sectors of the modern society such as the infrastructure, industries, service functions and the domestic sector. Electrical thermography is the most widely performed application of Infrared thermography. It is used in order to evaluate the condition of electrical systems and equipment. In this article the temperature measurement on a small induction single phase motor under different scenarios has been realized.

Keywords: thermography, electric motor, temperature measurement, measurement errors.

1. INTRODUCTION

All objects with a temperature above absolute zero (-273.15° on the Celsius scale) emit infrared radiation. The human eyes cannot see the infrared energy but a thermographic or infrared camera, is a camera that forms an image capturing these wavelengths. Thermography is a technique of producing a live thermal picture of an object based on the infrared radiation received from it. Because of its advantages of being non-contact, reducing the maintenance expenditure of equipment, increasing the life time of equipment, safe, reliable and can provide large inspection coverage, in terms of being non-contact, free from electromagnetic interference, safe, reliable and can provide large inspection coverage, infrared thermography has become an important and widely accepted condition monitoring tool such as electrical, industrial, mechanical, building, human and veterinary fields (Huda and Taib, 2013; Zou and Huang, 2015; Jadin and Taib, 2012).

Generally the life time of electrical equipments is significantly reduced as temperatures increase. Electrical current passes through a resistive component generates heat which is proportional to the square of the current passing through it ($I^2 \cdot R$). For these reason a small increase in electrical resistance consequences a bigger increase in heat. With the time the condition of the electrical component gets deterioration and as component deteriorates, its resistance increases and also generates more heat. Faults of electrical equipment such as overheating of conductor contacts and connectors, overload, load imbalance and improper equipment installation can produce overheating, which may cause a catastrophic failure or serious damage. Thermography can reveal the existence of any thermal anomalies in electrical equipments increasing operational reliability (Huda and Taib, 2013; Zou and Huang, 2015; Huda *et al.* 2014).

Today rotating electrical machines play a major role not only in many domestic appliances but also cover many industrial applications. Because of the requirement of increasing production in the manufacturing industry, rotating machinery is essentially required to run uninterruptedly for extended hours. With no doubt today the sudden failure of the electrical motors has become

more costly and time-consuming than ever before. For these reasons, condition monitoring of rotating machines is crucial for any system (Fantidis *et al.* 2013; Lei *et al.* 2008, Lei *et al.* 2009; Huda and Taib, 2013).

The primary goal of this work is to study the thermal profile of a small single phase induction motor under different operating conditions. All the experiments realized in the electrical machine laboratory of the Eastern Macedonia and Thrace Institute of Technology (Figure-1).



Figure-1. The experimental test bed.

2. CASE STUDY

For the purposes of this study the Jenoptik VarioCAM[®] 7800 was used. It is a high-resolution, portable, digital-colour, infrared and visual camera with a non cooled Focal Plane Array microbolometer which is used as an infrared radiation sensor. The thermographic system has a standard 30mm lens with minimum focus 0.3m IFOV 0.8 mrad, FOV (30×23)° and resolution of 640×480 pixels. It communicates with the PC via FireWire which are later processed in the suitable analysing software IRBIS[®] 3 professional. The main technical specifications of the thermal camera are listed in Table-1. In the present study the temperature in a single phase induction motor Black and Decker realized under different load conditions. The technical specifications of the motor are shown in Table-2 [Karakoulidis *et al.* 2015].

**Table-1.** Technical characteristics of the VarioCAM® 7800 thermographic camera.

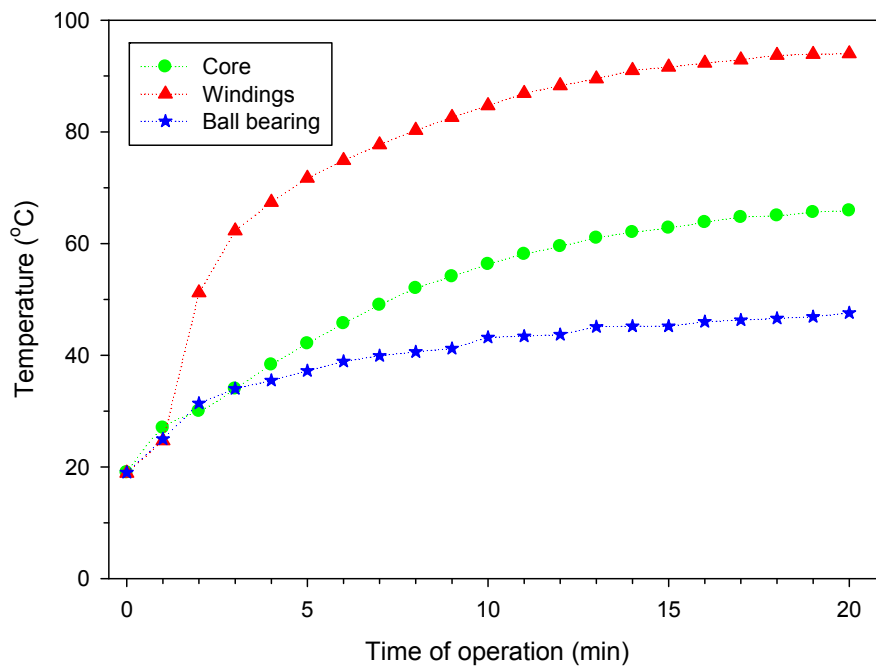
Parameter	Value
Spectral range	7.5 - 14 μm
Resolution	640 \times 480 pixels
Temperature measuring range	-40 – 1200 $^{\circ}\text{C}$
Temperature resolution at 30 $^{\circ}\text{C}$	Better than 0.08 K
Measurement accuracy	± 1.5 K (0 – 100 $^{\circ}\text{C}$), $\pm 2\%$ (< 0 and > 100) $^{\circ}\text{C}$
Spatial resolution/IFOV	0.8 mrad
Field of view/FOV	30 $^{\circ}$ (H) \times 23 $^{\circ}$ (V)
Protection rating	IP54, IEC 529

Table-2. Motor specifications.

Parameter	Value
Power Supply	single phase 230 V 4.3 A 50 Hz
Power	0.8 kW
Temperature Class	F (155 $^{\circ}\text{C}$)
Cos ϕ	0.8
Speed	2820 rpm
Capacitor	12 μF

3. RESULTS AND DISCUSSIONS

In order to study the thermal behavior of the small electric motor different scenarios has realized. The first test was the measurement of the temperature of the motor with 80% of the maximum load. The temperature measured with more detail-using masks, in the core, in the windings and in ball bearing of the motor. Figure-2, illustrates the measured temperatures in this scenario for 20 minutes of continuous operation. As expected the maximum temperatures occurs in the windings. In the next scenarios the motor has tested for the maximum load (100%) and the temperature with slight higher (Figure-3).

**Figure-2.** The measured temperatures in the motor for 80% load.

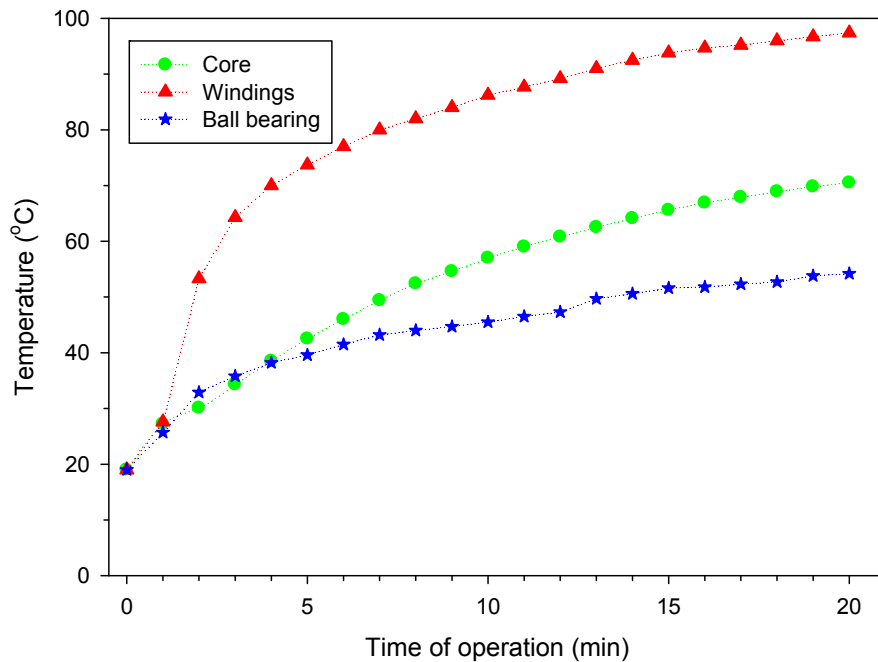


Figure-3. The measured temperatures in the motor for full load conditions.

Very interesting was the third scenario in which the small motor has operated in the maximum load without cooling system. Just in 10 minutes of continuous operation the electric machine presented highly temperatures (Figure-4). The real thermal images after 20 minutes of

continuous operation with 80% and 100% load and after 10 minutes of operation in maximum load without cooling are shown in Figure-5. The importance of the cooling system for a small electric motor is obvious; the motor can be burned within a few minutes of operation.

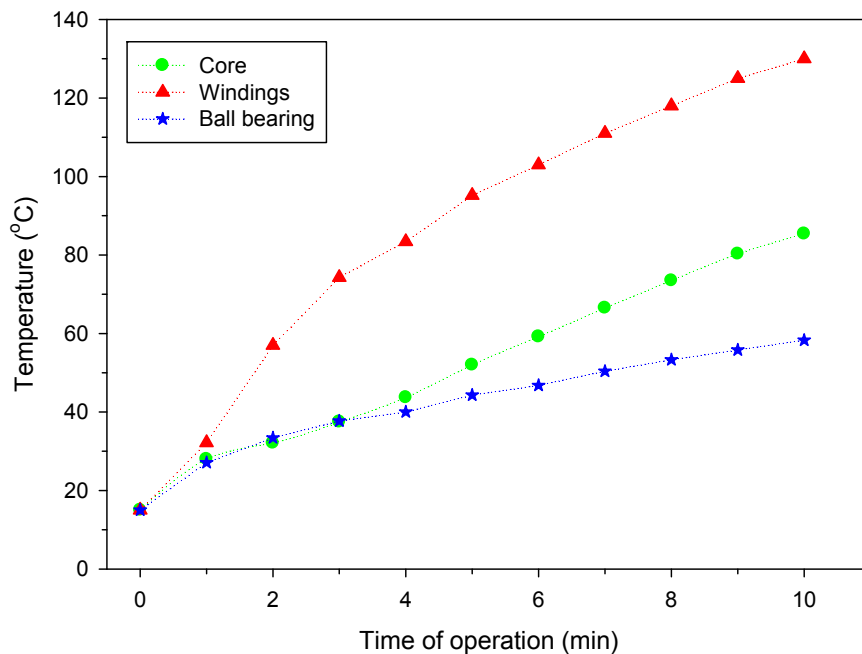
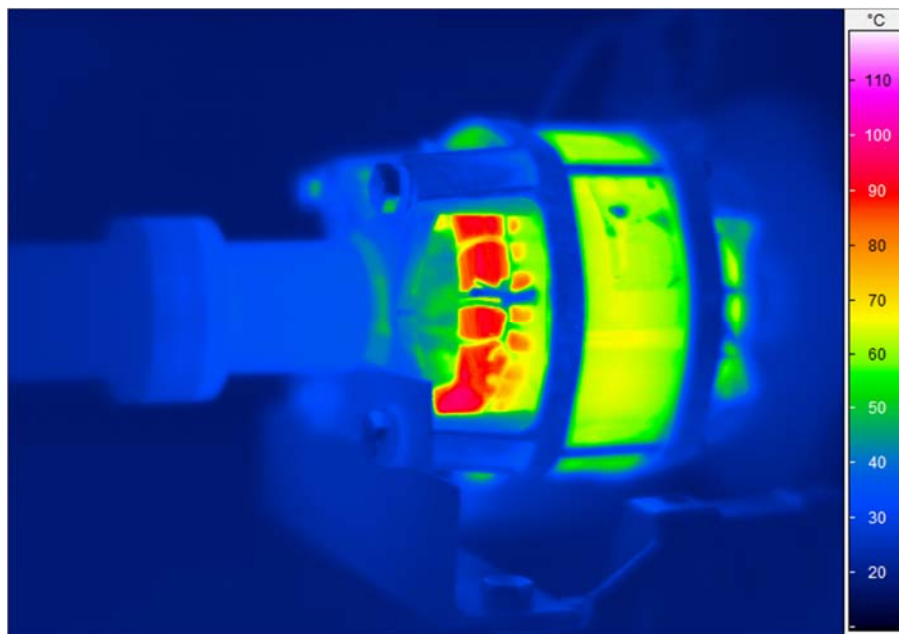
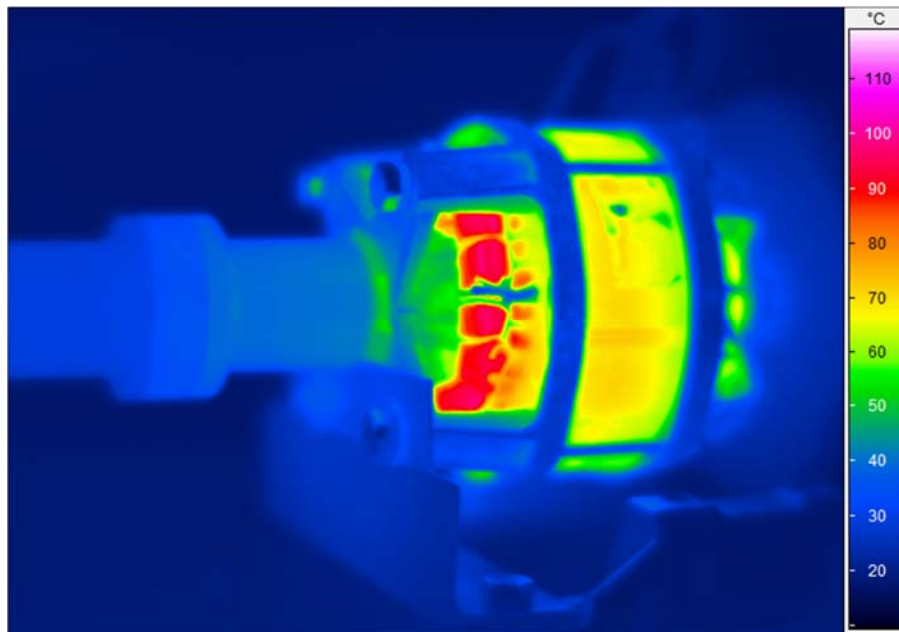


Figure-4. The measured temperatures in the motor for full load conditions without cooling system.



(a)



(b)

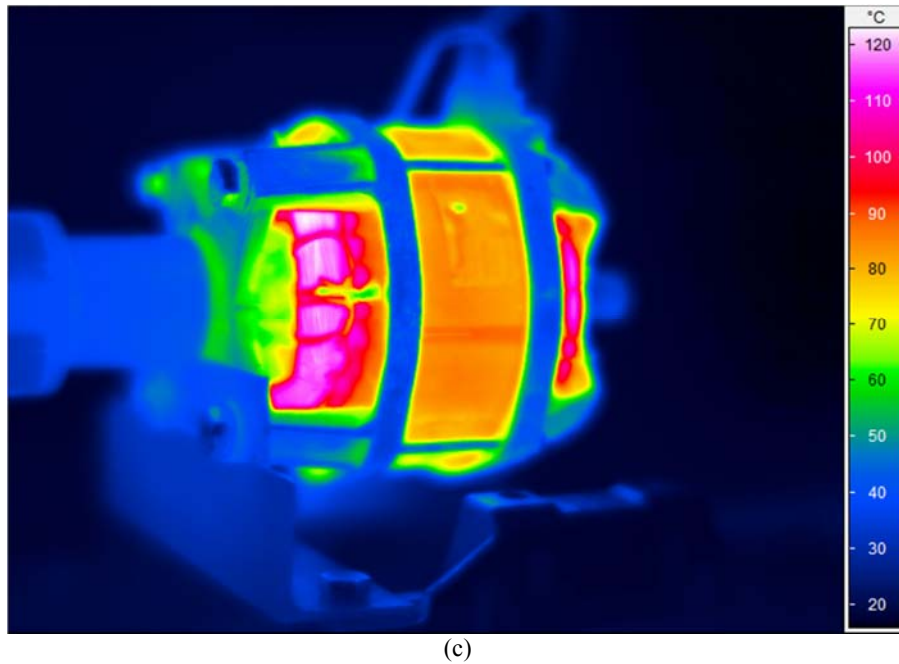


Figure-5. Thermal images of the motor after 20 minutes of operation for zero load (a) for full load (b) and after 10 minutes of operation for full load without cooling system (c).

The same measurements (80% load, 100% load and 100% load without cooling system) are also realized with voltage 200 V. Figures 6 and 7, are shown the temperature profile

figures concluded that the higher voltage gives higher temperatures. The differences in the temperatures are broader when the motor has lower load.

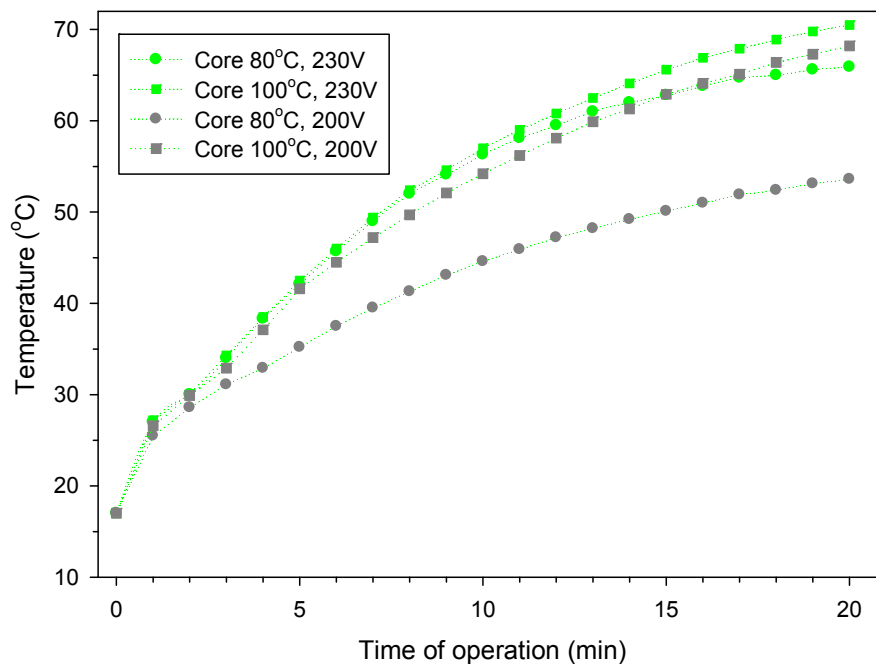


Figure-6. The temperature profile in core for 80% and 100% load both for 200V and 230V.

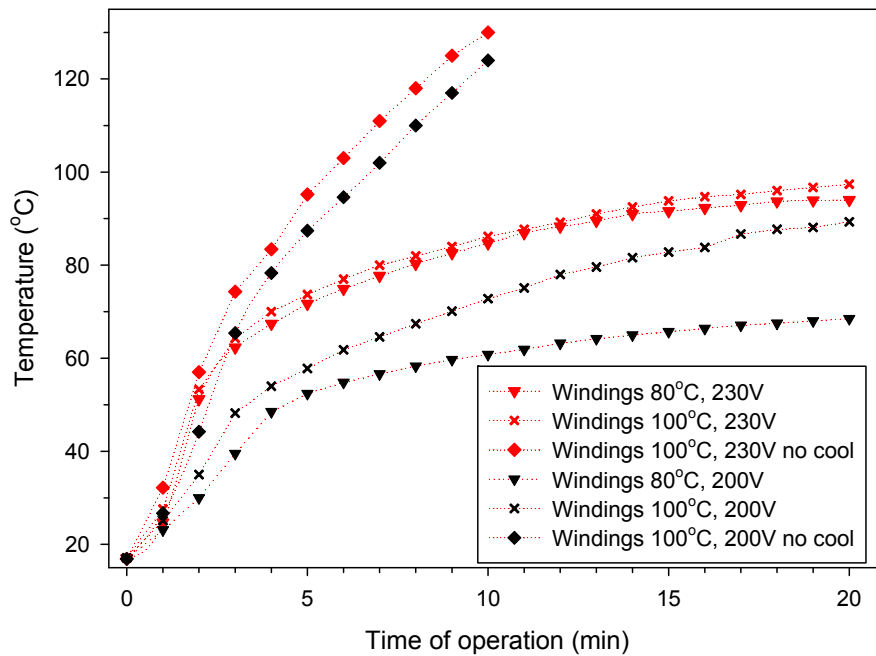


Figure-7. The temperature of the windings of the motor under 80% load, full load and full load without cooling system for 200V and 230V.

In the last scenario the normal windings of the motor replaced with another with better quality. Figure-8 illustrates the temperature in the windings in the case of 80% relatively with the standard windings. From the

Figure we can see that the better quality windings have considerable lower temperature. The real thermal images are shown in the Figure-9.

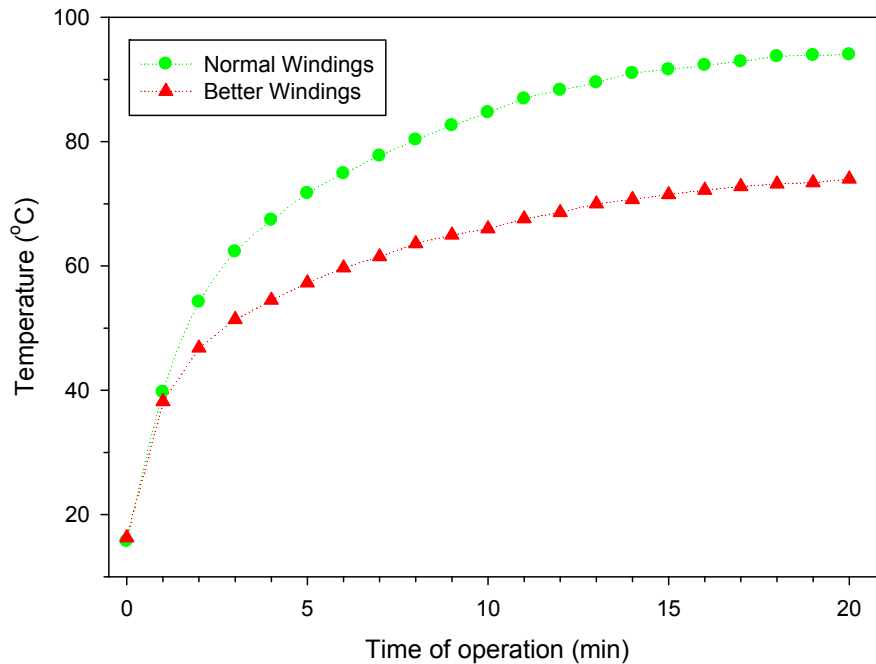


Figure-8. The temperature of the windings of the motor under 80% and 230V for the factory windings and for windings with better quality.

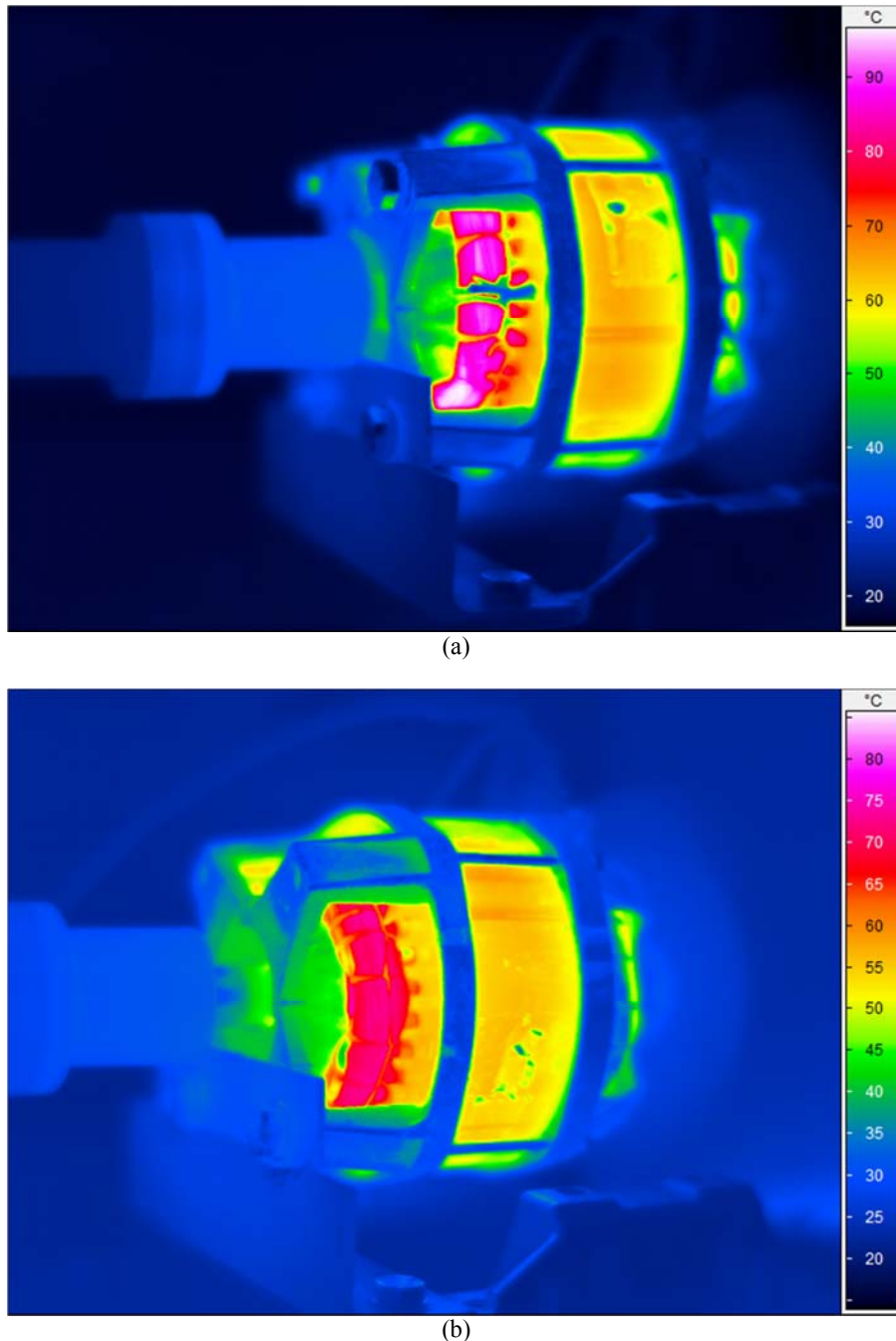


Figure-9. The thermal images of the motor under 80% and 230V after 20 minutes operation for the typical factory windings (a) and for qualitative windings (b).

4. CONCLUSIONS

In the present work with the aid of a portable and high-resolution infrared thermographic system a small single phase induction motor was tested in seven different scenarios. First the motor tests with the rated voltage under 80%, 100% load and with 100% load without cooling system. In these small electric motors the presence of the cooling system is necessary because the motor can burned in less of 15 minutes. The same scenarios have also realized with lower voltage and the machine has lower

temperature especially if it works with lesser load. In the last scenario the windings of the machine replaces with another with better quality and the results have shown that the new windings ensure that electric motor operate with considerable lower temperatures.

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