Thermographic Measurement of Inter-Laminar Short Circuits and Related Losses

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The magnetic core of electrical machines and transformers are constructed from electrical steel sheets, which are punched and stacked together. On one hand, the punching process deteriorates the magnetic properties of the electrical sheets, in terms of permeability and hysteresis losses [1], [2]. On the other hand, the punching burrs at the edges of the sheet might destroy the sheet insulation layer during the stacking process and produce short circuits between the sheets [3]. Both phenomena are harmful for the operation of the machines and are challenging to detect and quantify. In this paper, we present a thermal camera-based measurement method to detect the inter-laminar short circuits and measure the related power losses. Furthermore, we present a preliminary investigation on the possibility of measuring local iron losses with the same thermal camera methodology. The objective of this second part is to assess the detectability of the losses at the damaged, punched edges of the electrical sheet and their quantification.

For the first part, dealing with the inter-laminar short circuits, we artificially implemented short circuits between two iron sheets and measured the related losses with a thermal camera through the initial temperature rise method [4]. Some challenges related to this methodology are explained and several methods to tackle them are presented. The methodology has also been assessed through exhaustive numerical simulations [4]. A major challenge of this method consists of estimating the initial slope of the temperature rise under convective and conductive heat dissipation. We tackled this by either averaging the slop over some periods or by estimating the heat dissipation effect from the cooling behaviour of the measured area. The results of these methods can be used in coupled magnetic and thermal finite element simulations aiming at determining the depth of the lamination short circuit.

Figure 1 shows the temperature distribution around the inter-laminar short circuit at an instant of time and the temperature rise at the location of the short circuit. Figure 2 shows the temperature distribution at the surface of an iron sample when it is magnetized at 1.5 T and 50 Hz and the corresponding temperature rise averaged over a small area in the middle of the sample.

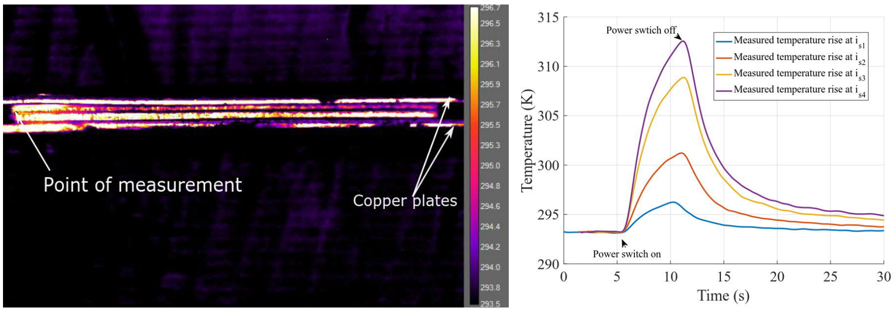

Figure 1: Temperature distribution (left) and filtered rise (right) at an artificial inter-laminar short circuit.

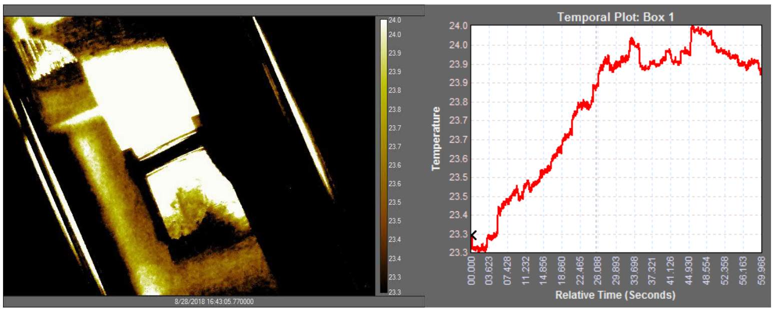

Figure 2: Temperature distribution (left) and rise (right) at the surface of a non-oriented iron sample under sinusoidal magnetization (1.5 T, 50 Hz)

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