An Improved Numerical Model of Heat Transfer Coefficient Corresponding to a Through Connector

Constantin Florin Ocoleanu, Ioan C. Popa
University of Craiova, Electrical Engineering Faculty, Craiova, Romania, focoleanu@elth.ucv.ro, ipopa@elth.ucv.ro

Abstract – **This paper is a continuation of a previous research in which was presented a method to determine heat transfer coefficient values corresponding to crimped connections. Because the differences between numerical values of temperature obtained with a mathematical model for h_Σ and experiments were high, authors considered that the model could be improved. Therefore, in the presented paper are shown the results obtained for heat transfer coefficient and temperature corresponding to crimped connections using an improved model. It was started from some values determinated previously and there were obtained new values of h_Σ which can give the possibility to attain the temperature values closed to experiments. The numerical model was developed considered a coupled problem – Magnetic- Steady State Heat Transfer. Using iteration there were determined new values for heat transfer coefficient which gave the possibility to find the Joule heat, heat flux and temperature distribution in the studied crimped connection. Thus, the numerical model can be used to determine the temperature values for several types of crimped connections with small errors.**

Cuvinte cheie: *model numeric, contacte sertizate, coeficient de transfer de căldură, regim termic, probleme cuplate, iteratii, determinari experimentale.*

Keywords: *numerical model, crimped connection, heat transfer coefficient, thermal regime, coupled problem, iterations, experimental determinations.*

I. Introduction

Crimped connections are widely used in the construction of electrical machines and equipments because of their reliability and stability at high currents (Fig.1).

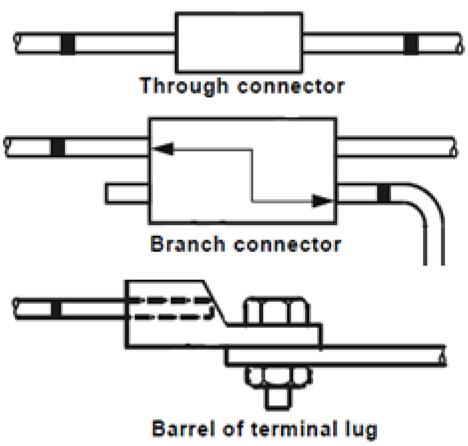

Fig. 1. Several types of crimped connections.

Before their implementation, they should be tested in different conditions imposed by standards. It is obviously that each test is a time and energy consuming process. Thus, if a numerical model could be validated a lot of time, energy and money could be saved. Unfortunately, numerical simulation process depends of some conditions.

One of the most important parameters in numerical simulation of steady state heat transfer regime is heat transfer coefficient h_Σ. With the right values and experimental validation of this coefficient it can be created a numerical model to simulate various regimes that might appear during the entire life of electrical machines and equipments. This means less time, energy and money. So, many researchers [3], [4], [5], [6], have tried to find the right values for different cases in order to achieve the best model possible.

This paper is a continuation of a previous research [1], [2] which presented a method to determine heat transfer coefficient values corresponding to crimped connections. It was observed that there are major differences between numerical values and experiments. So, authors considered that the model could be improved. In the presented paper are shown the results obtained for heat transfer coefficient and temperature corresponding to crimped connections using an improved model. More precisely, the solution came from using iterations in order to find the right values of heat transfer coefficient.

II. Previous Results

In [1] was calculated the heat transfer coefficient starting from a mathematical model (Fig. 2).

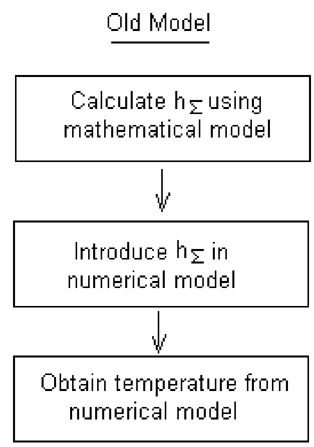

Fig. 2. Algorithm for h_Σ calculation.

It was considered a certain type of crimped connections and experimental results – through connector (Fig. 3).

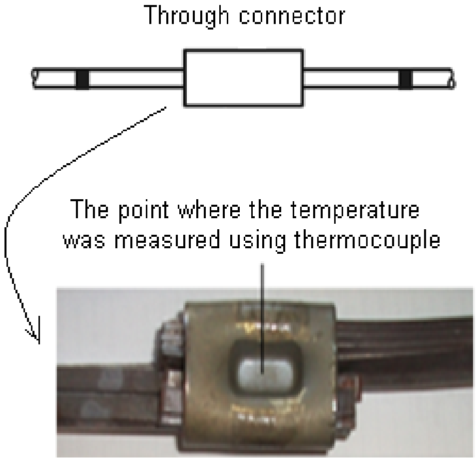

Fig. 3. The connector type used for study.

It was considered a coupled problem type Magnetic - Steady State Heat Transfer in Quickfield Professional. The magnetic model was used to generate the source term which was then introduced in Steady State thermal regime problem.

There were considered several values of electrical current: 510 A, 680 A, 850 A and 1110 A. Experimental determinations were also made at the same values of electrical currents in order to make a comparison between numerical and experimental temperature values.

Table I shows the calculated values for heat transfer coefficient.

TABLE I.
HEAT TRANSFER COEFFICIENT VALUES CORRESPONDING TO A CRIMPED CONNECTION TYPE THROUGH CONNECTOR

I [A]	h_Σ *[W/m^2 K]*
510	7.15
680	8.12
850	8.77
1110	9.76

Then, the values presented in Table I for heat transfer coefficient were used in a numerical model in order to obtain temperatures values for steady state heat regime. The results are illustrated in Fig. 4 – 7.

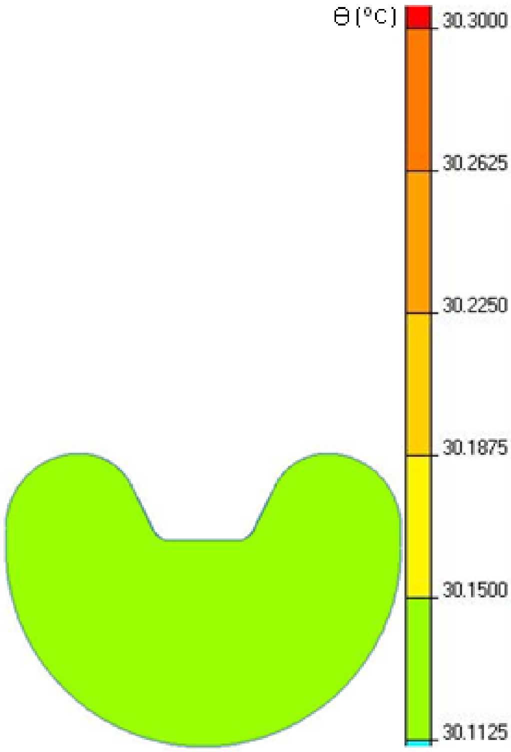

Fig. 4. Temperature values for I = 510 A.

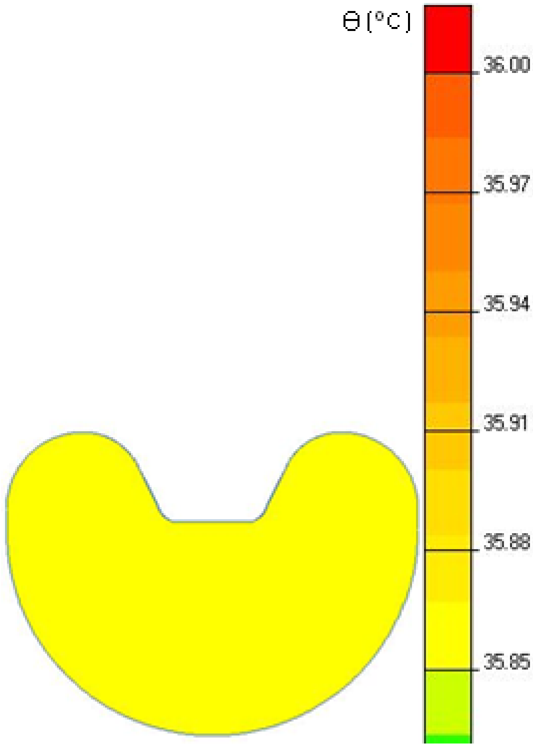

Fig. 5. Temperature values for I = 680 A.

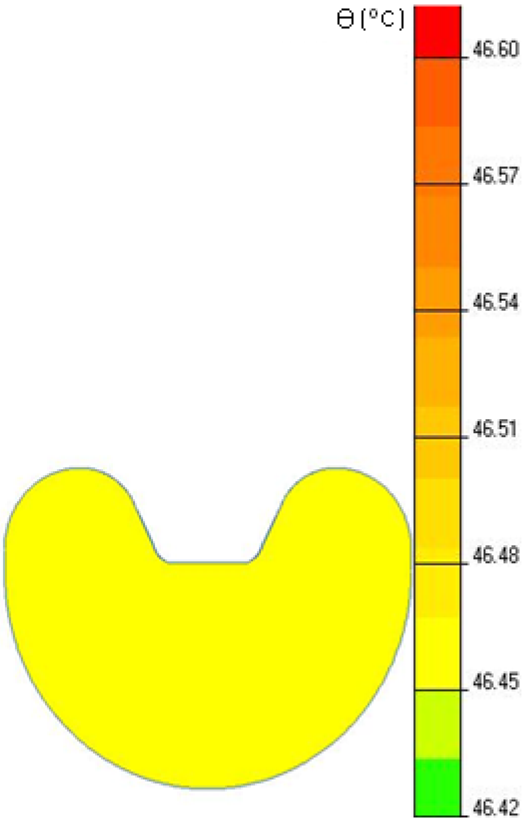

Fig. 6. Temperature values for I = 850 A.

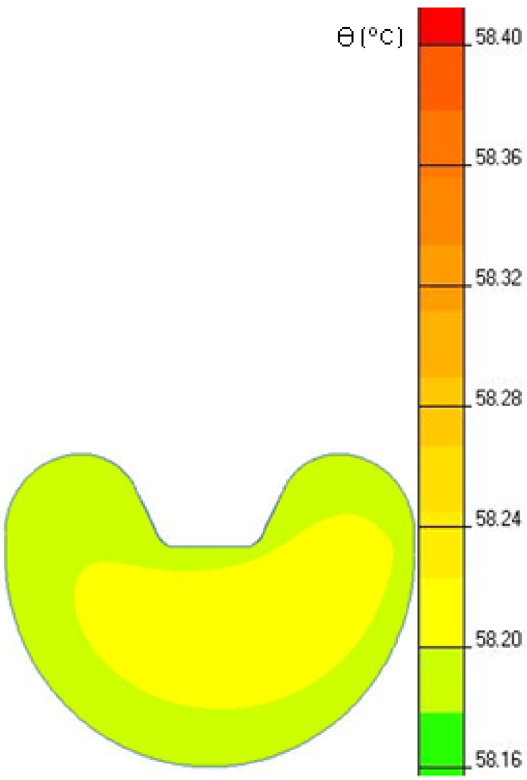

Fig. 7. Temperature values for I = 1110 A.

Differences between experimental and numerical values as are shown in Fig. 8 – 11.

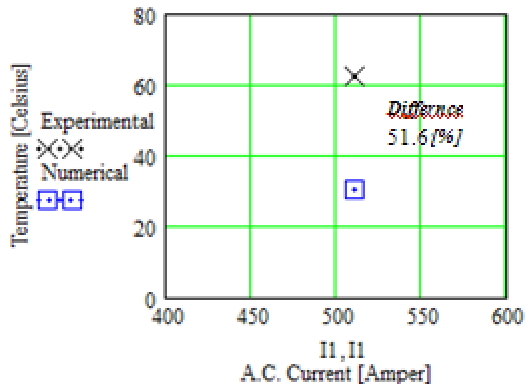

Fig. 8. Experimental vs numerical temperature values for I = 510 A.

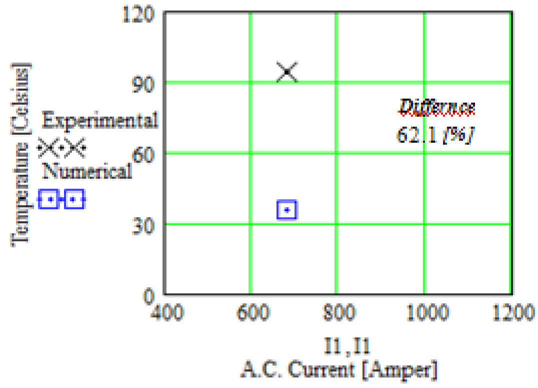

Fig. 9. Experimental vs numerical temperature values for I = 680 A.

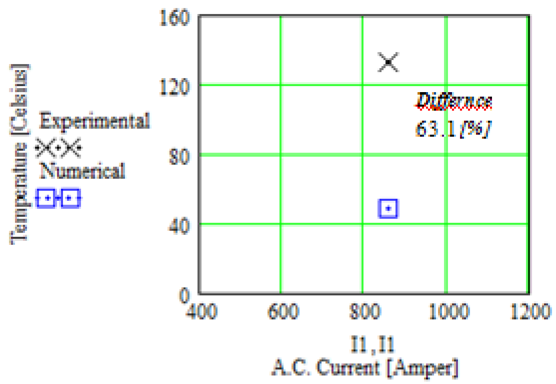

Fig. 10. Experimental vs numerical temperature values for I = 850 A.

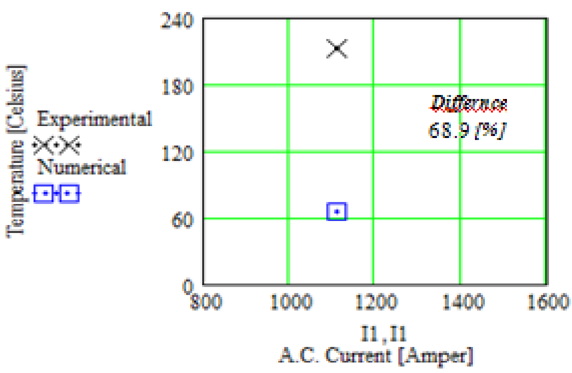

Fig. 11. Experimental vs numerical temperature values for I = 1110 A.

III. Improved Numerical Model

Starting from a mathematical model presented in [1], which gave some major differences between experimental and numerical temperature, it was created a numerical model in order to improve heat transfer coefficient values. Thus, the temperature differences can be reduced (Fig. 12).

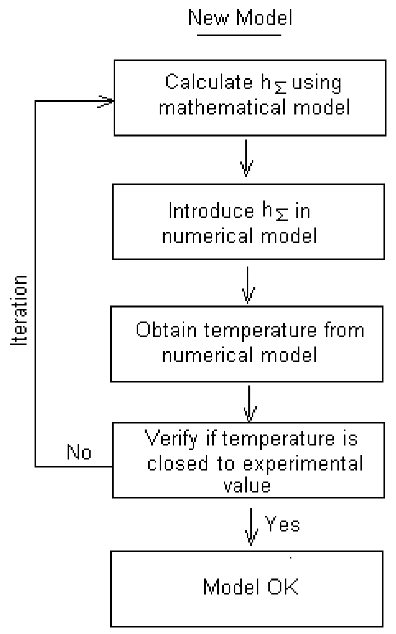

Fig. 12. Experimental vs numerical temperature values for I = 510 A.

Again, it was considered a coupled problem Magnetic-Steady State Heat Transfer, developed in QuickField Professional (Fig.13).

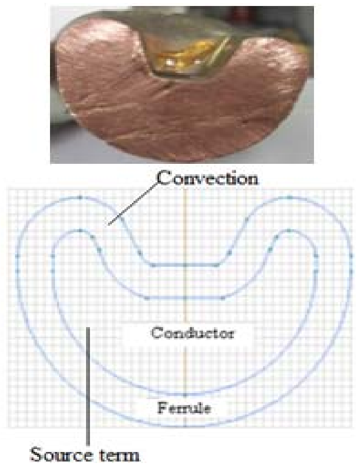

Fig. 13. Analysis domain and boundary conditions.

Then, started from the values of h_{Σ} calculated in [1] iterations were used and new values were obtained (Table II).

TABLE II.
Heat Transfer Coefficient Values after iterations

I [A]	510	680	850	1110
h_{Σ} [W/m^2 K]	3.187	3.14	3.43	3.4

By introducing these new values in numerical model, steady state temperatures and Joule heat were obtained. The results are illustrated in Fig. 14 – 21.

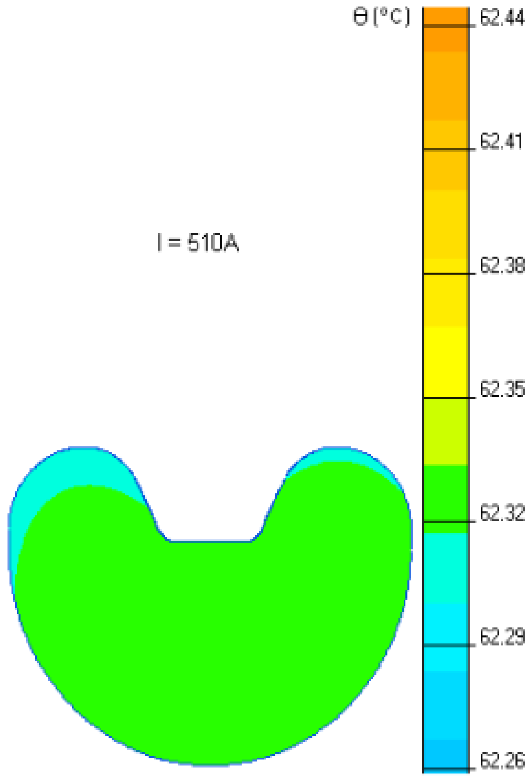

Fig. 14. Temperature values for I = 510 A after iterations.

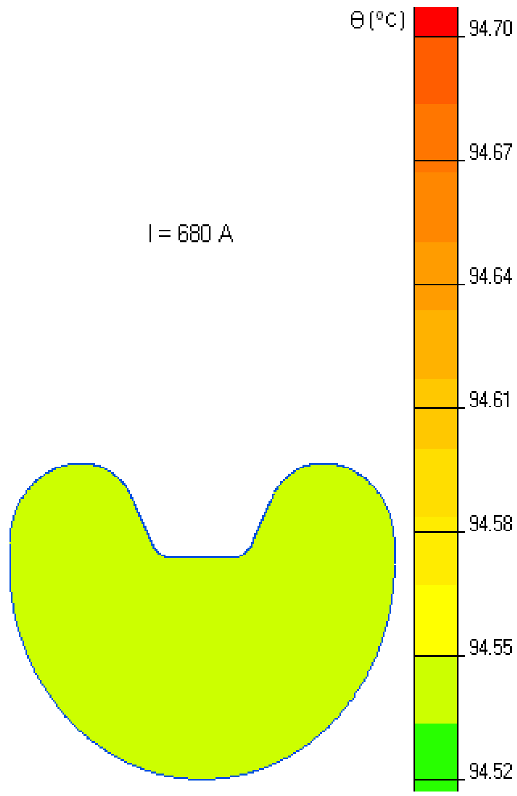

Fig. 15. Temperature values for I = 680 A after iterations.

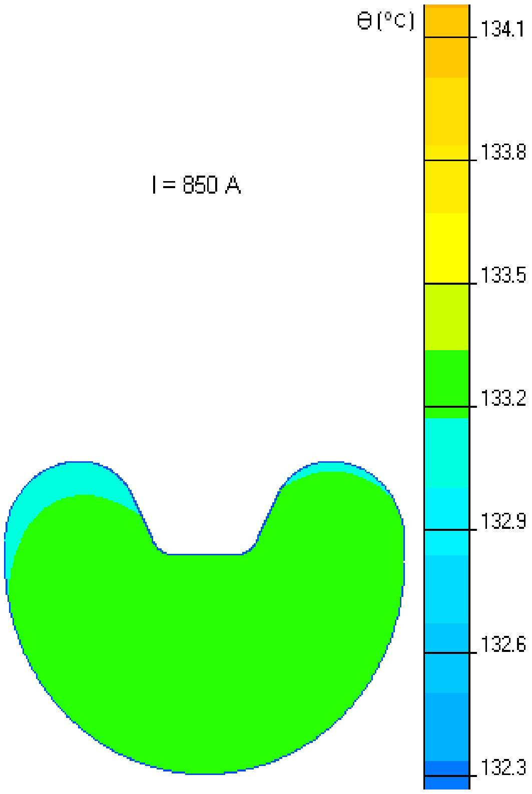

Fig. 16. Temperature values for I = 850 A after iterations.

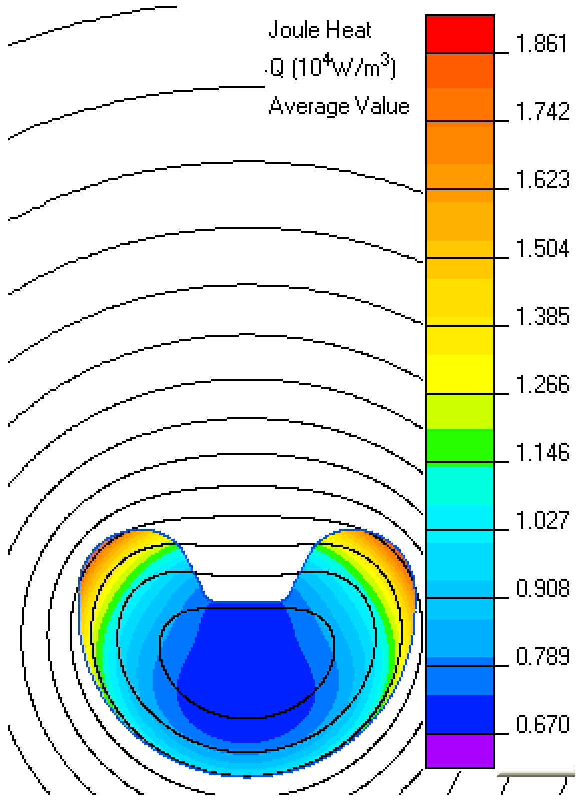

Fig. 18. Joule heat for I = 510 A after iterations.

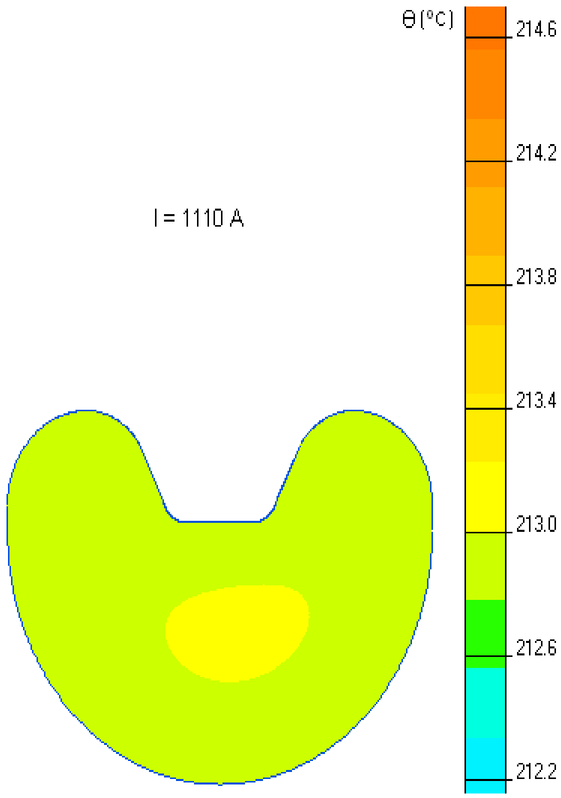

Fig. 17. Temperature values for I = 1110 A after iterations.

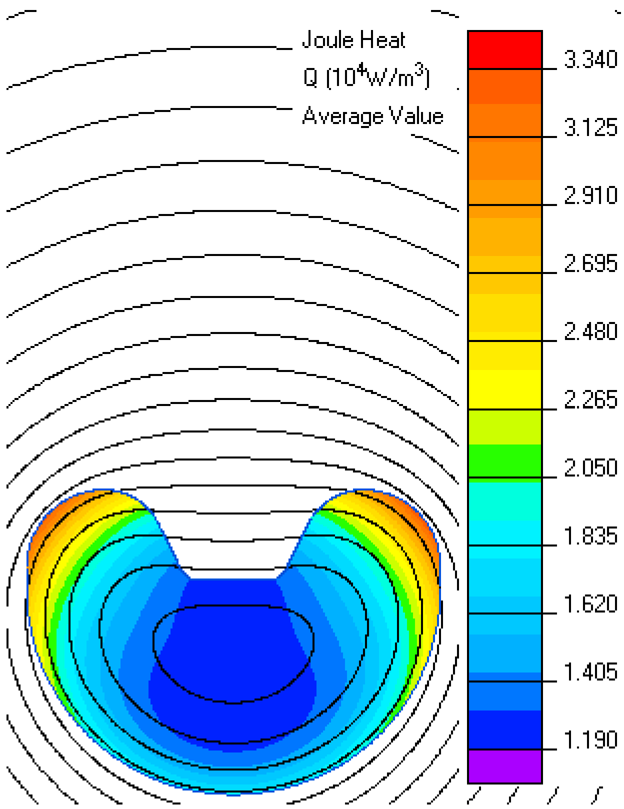

Fig. 19. Joule heat for I = 680 A after iterations.

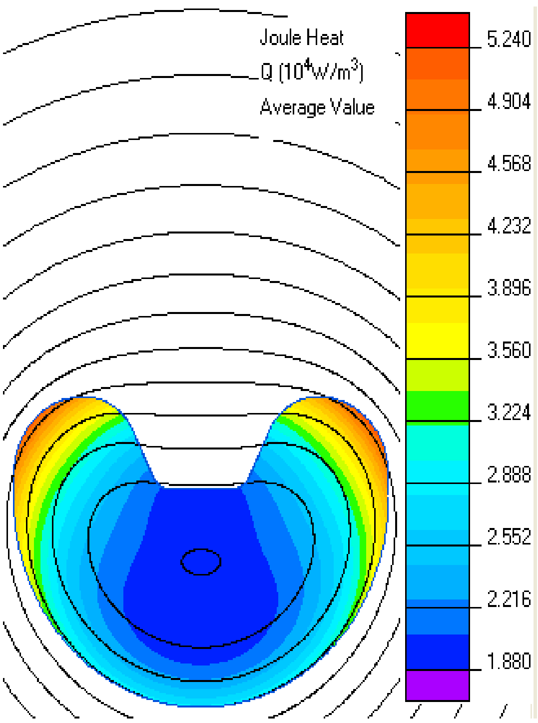

Fig. 20. Joule heat for I = 850 A after iterations.

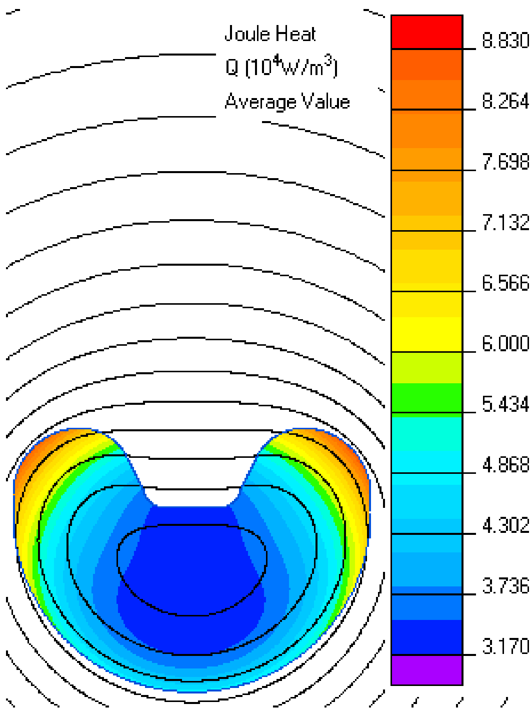

Fig. 21. Joule heat for I = 1110 A after iterations.

IV. Conclusion

As it was stated in the Introduction, one of the most important parameters in numerical simulation of steady state heat transfer regime is heat transfer coefficient $h_{\sum}$. With the right values and experimental validation of this coefficient, it can be created a numerical model to simulate various regimes that might appear during the entire life of electrical machines and equipments. This means less time, energy and money.

This paper is a continuation of a previous research which presented a method to determine heat transfer coefficient values corresponding to crimped connections. It gives new values for $h_{\sum}$ which could reduce the differences between experimental and numerical values of temperature in the case of the steady state heat transfer regime. In order to obtain $h_{\sum}$ there were used iteration and the figures above illustrate that the results provided are closed to the experiment.

Therefore, the numerical model is extremely useful to simulate thermal regime, for instance steady state or transient, corresponding to crimped connections. The values for heat transfer coefficient are valid only for the electrical current values presented above.

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Second author – 30%

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