18th International Symposium on Applied Electromagnetics and Mechanics

Chamonix - Mont Blanc, France
3 to 6 September, 2017

ISEM 2017 Chairman's Welcome

On behalf of the ISEM 2017 organizing Committee, it is my great pleasure to welcome you to the 2017 International Symposium on Electromagnetics and Mechanics in Chamonix Mont-Blanc, the 18th conference in the ISEM series. The first ISEM symposium was held in Tokyo in 1988, and since then we have seen the conference continue to grow in numbers, significance and international renown and respect. We are honored, therefore, to carry on what has become a well-established tradition of presenting leading research and thought in the interplay between applied electromagnetics and mechanics.

For ISEM 2017 in Chamonix Mont-Blanc, 380 contributions were submitted to the editorial board, and 351 were accepted after a painstaking review by the referees. Seven keynotes will be delivered at plenary sessions and 100 presentations will be given during 20 parallel oral sessions, each starting with one guest contribution. 244 papers will have the opportunity to be presented in five poster sessions. More than 280 participants, including 79 students, from 22 countries have pre-registered to attend Chamonix Mont-Blanc for ISEM! These records show the significant interest and great importance of the topics covered by ISEM.

Chamonix's strong links with the scientific and medical worlds began in the 18th century: first with experimental expeditions, then the construction of high-altitude observatories and the theory on the major glaciations of the Quaternary period. In this extraordinary natural laboratory, many fields of investigation continue to attract scientists from all over the world, as witnessed by: The Ecole de Physique in Les Houches created in 1951 from which 26 students have been awarded the Nobel Prize; the creation of the Institut de Formation et de Recherche en Médecine de Montagne; the Ecole Nationale de Ski et d'Alpinisme; the Centre de Recherche sur les Ecosystèmes d'Altitude; and the network of players devoted to science, including several researchers based in the valley.

Many people have contributed to the success of the ISEM 2017 in Chamonix Mont-Blanc. I would like especially thank the Organizing Committee: Afef Kedous-Lebouc, Nora Dempsey, Riccardo Scorretti and Marc Lambert who served as co-chairs. Anne Pellissier, Géraldine Pignatelli, Corinne Matarasso and Damien Corral did a great job in organizing the invitation process, venue and accommodation, design and graphic chart, and website (http://www.isem2017.org/). And of course none of this would have been possible without the efficient just-on-time management provided by Catherine Auguet-Chadaj. The ISEM International Steering Committee, chaired by Toshiyuki Takagi, and the organizers of ISEM 2015 in Kobe (Japan) were also very helpful, providing us with valuable information and advice. The editorial board chaired by Christophe Geuzaine did an outstanding job in reviewing papers for the conference. Lastly, we are of course grateful to all of our colleagues who helped us as reviewers.

Vincent Mazauric

Chairman of ISEM 2017 in Chamonix Mont-Blanc

Date: Sunday, 03/Sep/2017

5:00pm - 8:00pm	**Welcome Party** - Location: **Hall Coutterand**		

Date: Monday, 04/Sep/2017

8:00am - 9:00am	**Registration**		
9:00am - 9:30am	**Opening Session** Location: **Michel Payot**		
9:30am - 10:15am	**O-PLE-1: Plenary 1 -** Location: **Michel Payot**		
10:15am -10:45am	**Coffee Break**		
10:15am - 11:30am	**P-NDE-1: Nondestructive Evaluation: Poster** Location: **Théodore Bourrit**	**P-SAM-1: Sensors, Actuators and Machines: Poster** Location: **Théodore Bourrit**	**P-SOC-1: Simulation, Optimisation and Control: Poster** Location: **Théodore Bourrit**
11:30am - 1:15pm	**O-NDE-1: Nondestructive Evaluation: Oral (Advanced Signal Processing)** Location: **Michel Payot**	**O-SAM-1: Sensors, Actuators and Machines: Oral** Location: **Isabella Straton**	**O-SOC-1: Simulation, Optimisation and Control: Oral** Location: **Paul Payot**
1:15pm - 2:45pm	**Lunch -** Location: **La Calèche**		
2:45pm - 4:00pm	**P-NDE-2: Nondestructive Evaluation: Poster** Location: **Théodore Bourrit**	**P-SMA: Smart Materials: Poster** Location: **Théodore Bourrit**	**P-TRA: Transport Phenomena under Electromagnetic Field: Poster** Location: **Théodore Bourrit**
4:00pm - 5:45pm	**O-MAT-1: Materials: Oral (Hysteresis and Coercivity)** Location: **Paul Payot**	**O-MNS: Electromagnetic Applications below the Microscale: Oral** Location: **Isabella Straton**	**O-NDE-2: Nondestructive Evaluation: Oral (Composite Materials)** Location: **Michel Payot**
5:45pm - 6:00pm	**Coffee Break**		
6:00pm - 7:30pm	**O-KEY: New Energy Lanscapes -** Location: **Michel Payot**		

Date: Tuesday, 05/Sep/2017

8:30am - 9:15am	**O-PLE-2: Plenary 2 -** Location: **Michel Payot**		
9:15am - 10:00am	**O-PLE-3: Plenary 3 -** Location: **Michel Payot**		
10:00am - 10:30am	**Coffee Break**		
10:00am - 11:15am	**P-NDE-3: Nondestructive Evaluation: Poster** Location: **Théodore Bourrit**	**P-SAM-2: Sensors, Actuators and Machines: Poster** Location: **Théodore Bourrit**	**P-SOC-2: Simulation, Optimisation and Control: Poster** Location: **Théodore Bourrit**
11:15am - 1:00pm	**O-BIO: Biomedical Engineering: Oral** Location: **Isabella Straton**	**O-MAT-2: Materials: Oral (Process and Structure)** Location: **Paul Payot**	**O-NDE-3: Nondestructive Evaluation: Oral (Computational Modeling)** Location: **Michel Payot**
1:00pm - 2:30pm	**Lunch -** Location: **La Calèche**		
2:30pm - 4:15pm	**O-NDE-4: Nondestructive Evaluation: Oral (Electromagnetic Methods)** Location: **Michel Payot**	**O-SMA-1: Smart Materials: Oral (Functional Materials)** Location: **Isabella Straton**	**O-SOC-2: Simulation, Optimisation and Control: Oral** Location: **Paul Payot**
4:15pm - 4:45pm	**Coffee Break**		
4:15pm - 5:30pm	**P-MAT: Materials: Poster** Location: **Théodore Bourrit**	**P-NDE-4: Nondestructive Evaluation: Poster -** Location: **Théodore Bourrit**	**P-SOC-3: Simulation, Optimisation and Control: Poster** Location: **T. Bourrit**
5:30pm - 7:15pm	**O-NDE-5: Nondestructive Evaluation: Oral (Mechanical Methods)** Location: **Michel Payot**	**O-SAM-2: Sensors, Actuators and Machines: Oral** Location: **Isabella Straton**	**O-SOC-3: Simulation, Optimisation and Control: Oral** Location: **Paul Payot**
8:00pm - 11:00pm	**Gala Dinner -** Location: **Le Cap Horn**		

Date: Wednesday, 06/Sep/2017

8:30am - 9:15am	**O-PLE-4: Plenary 4 -** Location: **Michel Payot**		
9:15am - 10:00am	**O-PLE-5: Plenary 5 -** Location: **Michel Payot**		
10:00am - 10:30am	**Coffee Break**		
10:00am - 11:15am	**P-BIO: Biomedical Engineering: Poster -** Location: **Théodore Bourrit**	**P-NDE-5: Nondestructive Evaluation: Poster-** Location: **Théodore Bourrit**	**P-SAM-3: Sensors, Actuators and Machines : Poster-** Location: **T. Bourrit**
11:15am - 1:00pm	**O-NDE-6: Nondestructive Evaluation: Oral (High Frequency Signal)** Location: **Michel Payot**	**O-SMA-2: Smart Materials: Oral (Fluids and Soft Matter)** Location: **Isabella Straton**	**O-TRA: Transport Phenomena under Electromagnetic Field: Oral** Location: **Paul Payot**
1:00pm - 2:30pm	**Lunch -** Location: **Théodore Bourrit**		
2:30pm - 4:15pm	**O-SAM-3: Sensors, Actuators and Machines: Oral -** Location: **I. Straton**	**O-SOC-4: Simulation, Optimisation and Control: Oral -** location: **Paul payot**	
4:15pm - 4:45pm	**Closing -** Location: **Michel Payot**		

Behaviour of Iron Loss Components Dependent on Mechanical Compressive and Tensile Stress in Non-Oriented Electrical Steel

Jan KARTHAUS, Silas ELFGEN, and Kay HAMEYER

Institute of Electrical Machines, RWTH Aachen University, 52062 Aachen, Germany

Abstract

Mechanical stress of diverse origin alters the magnetic properties of the core material of electrical machines during operation and, as a result, the magnetic flux path and particularly iron losses. In this paper, based on mechanical stress-dependent magnetic characterisation of non-oriented electrical steel sheet, the behaviour of specific iron losses and its components are determined and modelled. As a result, a high sensitivity of the components to mechanical stress can be observed.

1 Introduction

The magnetic properties of non-grain-oriented (NGO) electrical steels are prone to mechanical stresses, i. e. residual, external or thermal origin. This effect is called Villari effect and is in the scope of current research [1]. Particularly in electrical machines, where mechanical stress caused by material processing (e. g. shrinking or cutting edge effects) or during operation (e. g. centrifugal forces), the stress-dependency of magnetic properties leads to a variation in the iron losses and, as consequence, an influence on the machine's efficiency.

In [2], the behaviour of iron losses with focus on compressive stresses is studied. A model with parameters based on mathematical fitting describes the stress-sensitivity of hysteresis and excess loss component. In recent studies [3], the influence of mechanical stress on the excess loss component is modelled.

This paper discusses the effect of applied mechanical stress within the range of -20 MPa to 100 MPa on the iron loss components with the focus on high frequencies and magnetic flux densities. In contrast to [2], a stress-dependent non-linear loss component is added to consider the non-linear behaviour of the magnetisation curve for high magnetic flux densities.

2 Measurements

A single sheet tester (SST) equipped with a hydraulic pressure cylinder can load specimens of electrical steel sheet with a maximum force of ± 5 kN homogeneously. The SST is incorporated into a computer-aided set-up in accordance with the international standard IEC 60404-3. The samples of the material M400-50A are characterised using controlled sinusoidal magnetic flux density with a form factor error of less than 1 % in the frequency range from 10 Hz to 400 Hz. Each sample has a length of 600 mm, a width of 100 mm and a nominal thickness of 0.5 mm. Stress and magnetic flux are applied collinear (uni-axial loading). Specimens in rolling (RD) and transverse (TD) direction are used.

3 Modelling and results

The state-of-the-art semi-physical approach for modelling iron losses leads to a good prediction for high magnetic flux densities and frequencies [4]. Adding stress-dependency to the existing iron loss model which

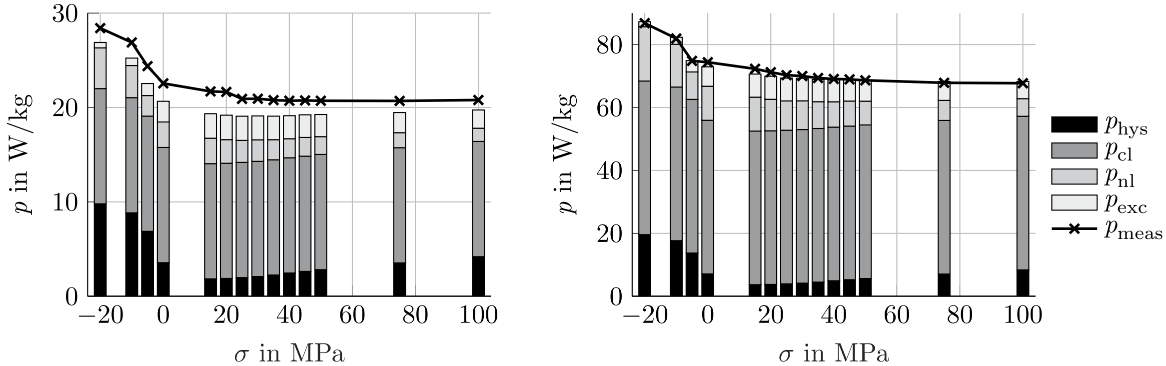

Figure 1: Measured iron losses and modelled loss components dependent on mechanical stress for $f = 200\,\text{Hz}$, $B = 1.5\,\text{T}$ (left) and $f = 400\,\text{Hz}$, $B = 1.5\,\text{T}$ (right) in RD.

consist of a hysteresis loss component p_{hys}, a classic (Foucault) loss component p_{cl}, an excess loss component p_{exc} and a non-linear loss component p_{nl}, the equation becomes:

$$p_{\text{tot}}(\sigma) = p_{\text{hys}} + p_{\text{cl}} + p_{\text{nl}} + p_{\text{exc}} = a_1(\sigma)\, B^{\alpha_0(\sigma)+\alpha_1(\sigma)B} f + a_2 B^2 f^2 + a_2 a_3(\sigma)\, B^{2+a_4(\sigma)} f^2 + a_5(\sigma)\, B^{1.5} f^{1.5}\,, \quad (1)$$

where $a_1 ... a_5$ and α_0, α_1 are the stress-dependent iron loss parameters, B the flux density and f the frequency. The parameters are determined by a semi-physical approach based on measurements. Except the classical iron loss parameter a_2, which is assumed to be independent on mechanical stress, a stress-sensitivity of each parameter is observed. These results are used to model the stress-dependent iron loss behaviour (Fig. 1).

4 Conclusions

The results show a good prediction of stress-dependent iron losses in non-oriented electrical steel sheets. It can be observed that dependent on the amount of mechanical stress, the distribution of iron loss components varies. In the full paper, the model will be presented in detail. As application, the prediction leads to a more exact calculation of iron losses in electrical machines.

References

[1] N. Leuning, S. Steentjes, M. Schulte, W. Bleck, and K. Hameyer, Effect of elastic and plastic tensile mechanical loading on the magnetic properties of NGO electrical steel, *J. Magn. Magn. Mater.* **417** (2016) 42-48.

[2] K. Ali, K. Atalla, and D. Howe, Predection of mechanical stress effects on the iron loss in electrical machines, *J. Appl. Phys.* **81**(8) (1997) 4119-4121.

[3] D. Singh, P. Rasilo, F. Martin, A. Belahcen, and A. Arkkio, Effect of mechanical stress on excess loss of electrical steel sheets, *IEEE Trans. Magn.* **51**(11) (2015) 1-4.

[4] S. Steentjes, M. Leßmann, and K. Hameyer, Semi-physical parameter identification for an iron-loss formula allowing loss-seperation, *J. Appl. Phys.* **113**(17) (2013) 17A319.

Acknowledgements

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