



**HAL**  
open science

## Modelling of stator sheets punching effect on EV motor performances

Patrick Lombard, Olivier Hubert, Pierre-Christophe Masson, Abderrahmane Aboumada

► **To cite this version:**

Patrick Lombard, Olivier Hubert, Pierre-Christophe Masson, Abderrahmane Aboumada. Modelling of stator sheets punching effect on EV motor performances. 25th Soft Magnetic Materials Conference - SMM25, May 2022, Grenoble, France. hal-03773022

**HAL Id: hal-03773022**

**<https://hal.science/hal-03773022v1>**

Submitted on 8 Sep 2022

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Modelling of stator sheets punching effect on EV motor performances

Patrick Lombard<sup>a,\*</sup>, Olivier Hubert<sup>b</sup>, Pierre Christophe Masson<sup>a</sup>, Abderrahmane Aboumada<sup>a</sup>

<sup>a</sup>Altair France Engineering, 18 chemin de Malacher, 38246 Meylan, France

<sup>b</sup>LMT ENS Paris-Saclay, 4 avenue des sciences, 91190, Gif sur-Yvette, France

The effect of punching of electric motor sheets on electrical machine performances is addressed. The approach is using measurement and modelling of mechanical stress effect on B(H) curves. A new coupled magneto-elastic Preisach model is proposed and implemented in FEM software. Modelling of EV motor highlights a torque reduction due to residual stresses after stator sheets punching.

**Keywords:** B(H) curve versus stress, Preisach model, punching

## 1. Introduction

When modelling electric motors, the computation of efficiency must be as accurate as possible. Strong discrepancies are however usually observed between measured and computed efficiency. After deep analysis, it seems that the punching of electrical steels influences the available flux density that is crossing slot between coils. The flux density is not uniform in this part, due to residual stresses. The goal of this work is to quantify the residual stress effect.

## 2. Measurement and method

Experimental data consist of B(H) curves of steel strips subjected to different mechanical stress levels applied along the magnetic measurement direction (fig1). The Preisach model has then been used to find out a set of stress-dependant coefficients. The variation of coefficients with stress is in close relationship with the variations of coercive field, remanent induction, and permeability with stress. A coupled magneto-mechanical approach allows physical based functions to be proposed to describe the evolution of Preisach parameters with stress.

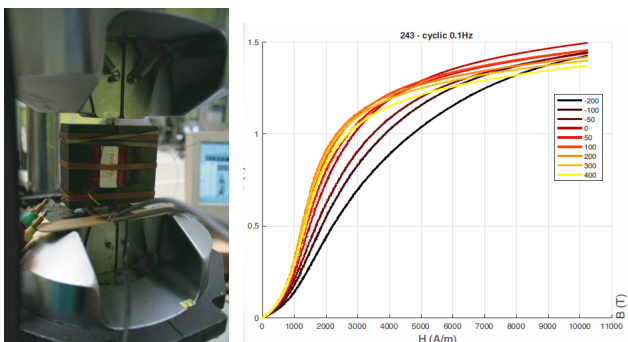


Figure 1 : device for B(H) curve versus stress measurement and first magnetization experimental results

## 3. Modeling

The punching of the stator slot has been modelled using a Johnson-Cook constitutive law implemented in Altair® Radioss®. A multiaxial residual stress has been extracted

leading to the calculation of a magneto-elastic equivalent stress. This stress level has been introduced in Altair Flux and applied to the calculation of a complete EV motor where the magnetoelastic Preisach model has been used. Impact of residual stresses due to punching on the machine torque has been evaluated (fig 2).

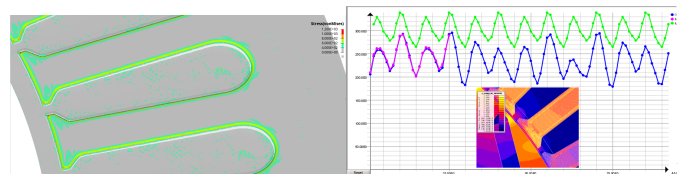


Figure 2 : remaining stress after punching and impact on torque

## 4. Conclusion

A new method is proposed to analyze effect of punching on cutting edge of stator slot, based on FE method with Preisach model depending on mechanical stress. After matching with measurement, the new model is applied to evaluate the punching effect on electric motor torque.

## Acknowledgement

This project has received funding from the Research Fund for Coal and Steel under the grant agreement N° 847296.

## References

- [1] G. Crevecoeur, P Sergeant, L. Dupré, L. Vandebossche and R. Van de Walle, "Analysis of the local Material Degradation Near Cutting Edges of Electrical Steel Sheets", IEEE Trans. On Magnetics, Vol 44, N°11, November 2008
- [2] O. Hubert, F Sorel, Mballa-Mballa, Song He, S. Depeyre, "Influence of Biaxial Stress on Magnetic Behavior of Dual-Phase Steel-Experiments and Modelling", IEEE Trans. On Magnetics, Vol 52, N°5, May 2016
- [3] R. Sundria, D. G. Nair, A. Lehtikainen, A. Arkkio and A. Belahcen, "Loss Model for The Effects of Steel Cutting in Electrical Machines", ICEM, 2018

\* Corresponding author: plombard@altair.com