



HAL
open science

Surface ablation of the GO FeSi Electrical Single Sheet: Impact on the Static/ Dynamic Magneto-Mechanical Behavior and Optimization

Elias Salloum, Stéphane Panier, Olivier Maloberti, Manar Nesser, Julien Dupuy, Marc Lamblin, Jérôme Fortin

► To cite this version:

Elias Salloum, Stéphane Panier, Olivier Maloberti, Manar Nesser, Julien Dupuy, et al.. Surface ablation of the GO FeSi Electrical Single Sheet: Impact on the Static/ Dynamic Magneto-Mechanical Behavior and Optimization. 2022 Joint MMM-INTERMAG, Jan 2022, Los Angeles (CA), United States. , 2022. hal-04536832

HAL Id: hal-04536832

<https://hal.science/hal-04536832>

Submitted on 8 Apr 2024

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.



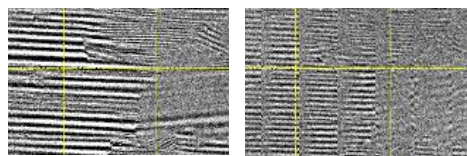
Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

ABLATION TECHNIQUE

Surface ablation technology: the ultra-short pulse laser, material and coating removal by sublimation with a laser tracing line without significant thermal effect [1].

Impact on the structure: energy levels modification: magnetoelastic, magnetocrystalline anisotropy, magnetic exchange and magnetostatic demagnetizing energy. Reduction of the fraction volume of disoriented domains, Domains refinement and Demagnetization effect increase.

Impact on the macroscopic behavior: iron loss reduction [2], permeability change & magnetostriction reduction [3].



Before ablation

After ablation

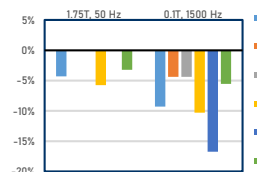
PARAMETRIC STUDY

- Different laser configurations conducted by several optimized laser parameters.
- Each configuration is characterized by a different cumulative energy density and a power density.
- Results are compared before and after ablation.

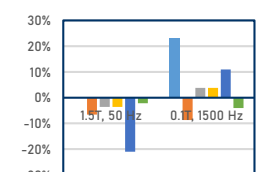
Conf.	Nb pass	Power P/Pref	Speed V/Vref	Line spacing D/Dref
1	2	1	1	1
2	1	1	1	1
3	1	1	1	0.8
4	1	1	1	0.6
5	2	1	1.3	0.6
6	1	0.8	1.1	0.6

RESULTS

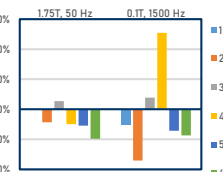
- Comparison of the iron losses variation with the magnetostriction variation
- Iron losses reduced up to 15% at high frequency: due to the domains refinement
- Permeability decrease at high induction: due to the increase of the demagnetizing energy.
- Permeability increase at low induction/high frequency: decrease of the fraction volume of disoriented domains.
- Noise reduction (RMS velocity) up to 50%: decrease of the fraction volume of disoriented domains with means decrease of magnetostriction.



Iron losses Variation

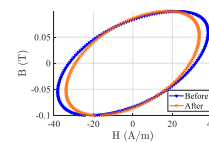


Permeability Variation

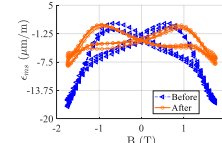


RMS Velocity Variation

- Best Configuration for 50 Hz frequency/high induction: 6
- 1 laser pass and small lines spacing.
- Best Configuration for high frequency/low induction: 1
- 2 laser passes and big lines spacing.

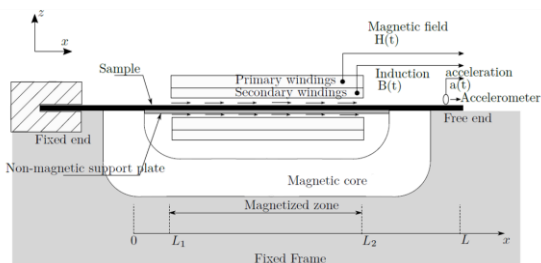


Hysteresis at 0.1 T 1500 Hz (Conf.1)



Butterfly loop at 50 Hz (Conf. 6)

MEASUREMENTS



- Grain Oriented Electrical Steel 280mm x 30mm plates.
- Magnetic signals measured using a Single Sheet Tester.
- Mechanical signal (acceleration) measurement using piezoelectric accelerometer on a fixed-free plate [4].
- Synchronous measurements.
- Collected signals: induction, magnetic field and acceleration
- Collected data: iron losses, permeability and effective velocity (V_{rms})

REFERENCES

- [1] M. Nesser et al., Correlation between laser energetic parameters and magnetic properties of GO laminations under surface treatments with long and short pulsed lasers, *J. Magn. Magn. Mater.*, 503(June 2020), 166696.
- [2] M. Enokizono T. Kajiwara. Effect of Laser Stress on Vector Magnetic Properties of Electrical Steel Sheets.(50(4)):2002404, 2014.
- [3] A. Allwardt et al. Improved Transformer Noise Behavior by Optimized Laser Domain Refinement at ThyssenKrupp Electrical Steel. (48(4)):1453-1456, 2012.
- [4] E. Salloum et al., Identification of Magnetic Induced Strain of Electrical Steels Using Non-Destructive Acceleration Measurement and Inverse Vibration Modeling., *J. Sound Vib.*, 492(February 2020), 115806.