ESIEE AMIENS UNIVERSITÉ de Picardie Jules Verne	POST-DOCTORAL POSITION **Conception and test of magnetic circuits and prototypes with special magnetic materials treated by laser for the design of magnetic components and electrical machines** O. MALOBERTI / P. DASSONVALLE (ESIEE) J. FORTIN / S. PANIER (UPJV)	Laboratoire des Technologies Innovantes PhD ***2018***

KEYWORDS : Grain Oriented and Non Grain Oriented steels, textured and non-textured materials, surface laser treatments, power inductor and tranformers, rotating electrical machines, modeling, conception, specifying, optimisation, prototyping, electrical tests.

TOPIC :

The aim of ESSIAL (Electrical Steel Structuring, Insulating and Assembling by means of Laser technologies) is to improve some of the characteristics of soft magnetic materials in the magnetic circuits of electrical machines. Primarily, ESSIAL technology will increase magnetic permeability, reduce magnetic energy loss, magnetostriction and noise pollution, while preserving a high mechanical and thermal resistance. The ESSIAL consortium investigates and applies **advanced surface texturizing and structuring manufacturing processes to increase the performance and functionality of soft magnetic materials and magnetic circuits**. To this end, ESSIAL will use Laser technologies (surface texturizing and structuring, de-coating, welding) on electrical steel sheets of electromagnetic components and electrical machines (transformers, inductors, rotating electrical machines, …). Two PhD students heve been recruited to carry out the required physical studies on first samples. These studies should lead to the definition of optimized laser treatment processes as a function of the material (its metallurgical, magnetic and mechanical properties), the shape of sample (thickness and other geometrical parameters) and the working conditions (flux intensity, frequency and direction). Then, project partners are fully committed to demonstrate the **proof of concept**. Finally, **three prototypes** for different applications will be built and tested by end-users: **a voltage transformer coupled to a power inverter, a smoothing inductor coupled to an inverter or a battery charger and an electrical rotating machine**. For each kind of alloy, application and working condition, the project aims to implement a selective manufacturing and tailor made **process in a relevant industrial environment** (**TRL6**). **The objective targeted at the end of the project is to be able to adapt surface patterns quickly to any kind of soft magnetic alloy and sheet thickness and in several kinds of electromagnetic application**. In this context, substantial research is needed for exploring the proposed innovative approach aimed at producing high added-value functionnal surfaces by a superficial modification of sheets made of soft magnetic alloys. The cost efficiency of the novel surface manufacturing process, the development of an adaptable and up-scalable technology and the environmental aspects of the process will thus be addressed through both scientific and technico-economical studies.

This post-doc position is devoted to the design, simulation, manufacturing and tests on simple but realistic magnetic circuits and reduced scale prototypes. We propose to design between two and three kinds of magnetic circuits: one is a ring core usually adapted to current transformers, one is a E-core type magnetic circuit adapted to voltage transformers and the last U-core type magnetic circuit adapted to voltage transformers and cut and punched parts of a stator and rotor of electrical machines. These magnetic circuits equipped with primary and secondary windings should permit us to value the selective and modulated laser patterns as a function of the alloy (NO SiFe or CoFe alloy for non oriented materials and GO SiFe or NiFe alloy for oriented materials), the thickness and the working conditions. The post-doc will oversee this part and will develop simple concepts of magnetic circuits. The first year (12 months) should permit to provide the design, simulation, manufacturing and test of the first ring core type current transformers, the U core type voltage transformers and the stator/rotor with first application samples. The second year (12 months) should permit to detail the material specifications (alloys, thicknesses and laser patterns) and to provide the simulation, manufacturing and test of reduced scale prototypes (one power smoothing inductor 4 kVA, one power voltage transformer 2.7 kVA and one rotating electrical motor 1.7 kW) with optimized application samples.

MISSIONS and TASKS :

- **Bibliography**
  - **Soft magnetic materials (GO and NGO SiFe, NiFe and CoFe)**
  - **Laser scribing, irradiation, texturization and related techniques**
  - **Magnetic models and loss models compatible with desig and conception tools**
  - **Magnetostriction and vibro-acoustic models compatible with design and conception tools**
  - **Modeling tools : Semi Analytical methods and Finite Element Method**
- **Help the analysis of experimental results on samples**
  - **Work, reports and publications of PhD students**
  - **Measurements results of PhD students**
  - **Select and decide together for the proof of concept**
- **Provide the proof of concept magnetic circuits (first year)**
  - **Modeling, conception and specification tasks**
    - **Design, model & simulate the ring core, E-core and U-core magnetic circuits**
    - **Specify the first property gradients of materials induced by laser**
  - **Supervise or/and subcontract the following tasks**
    - **Elaborate, scribe, cut and insulate the magnetic sheets**
    - **Assemble the laminated magnetic circuits and wind the coils**
  - **Tests and measurements tasks**
    - **Carry out and analyze Magnetic tests and measurements**
    - **Carry out and analyze Electrical tests and measurements**
    - **Carry out and analyze Acoustic tests and measurements**
- **Provide the proof of concept reduced scale prototypes (second year)**
  - **Modeling, conception and specification tasks**
    - **Design, model & simulate the reduced scale prototypes**
    - **Specify the second property gradients of materials induced by laser**
  - **Supervise or/and subcontract the following tasks**
    - **Elaborate, scribe, cut and insulate the magnetic sheets**
    - **Assemble the laminated magnetic circuits and wind the coils**
  - **Tests and measurements tasks**
    - **Carry out and analyze Electrical and Magnetic tests and measurements**
    - **Carry out or sub-contract Acoustic tests and measurements**
- **Conclusions**
  - **Simulate the real size prototypes by using previous works and results**
  - **Specify the final property gradients of materials induced by laser**

REFERENCES :

[1] G. Bertotti, "General Properties of Power Losses in Soft Ferromagnetic Materials", *IEEE Transactions on Magnetics*, 1980, vol. 24(1), pp. 621-630.

[2] O. Maloberti, A. Kedous-Lebouc, O. Geoffroy, G. Meunier, and V. Mazauric, "Field Diffusion-Like Representation and Experimental Identification of a Dynamic Magnetization Property", *Journal of Magnetism and Magnetic Materials*, 2006, vol. 304, pp. e507-e509.

[3] P. Rauscher, J. Hauptmann, E. Beyer, « Laser Scribing of Grain Oriented Electrical Steel Under the Aspect of Industrial Utilization using High Power Laser Beam Sources », *Physics Procedia*, vol. 41, 2013, pp. 312-318.

[4] L. Lahn, C. Wang, A. Allwardt, T. Belgrand, J. Blaszkowski, "Improved transformer noise behavior by optimized laser domain refinement at Thyssenkrupp Electrical Steels", IEEE Transactions on Magnetics, vol. 48, n°4, April 2012.

[5] O. Maloberti, G. Meunier, A. Kedous-Lebouc, V. Mazauric, O. Geoffroy, "Vers une formulation de l'hystérésis magnétique dynamique vectorielle : *modélisation et identifications expérimentales*", *LA RIGE*, vol. 9, no. 4-5, 2006, pp. 515-529.

[6] T. Kajiwara, M. Enokizono, « Effect of laser stress on vector magnetic properties of electrical steel sheets », *IEEE Transactions on Magnetics*, vol. 50, no. 4, April 2014.

[7] L. Vandevelde and J. A. A. Melkebeek, « Magnetic forces and magnetostriction in electrical machines and transformer cores », », IEEE Transactions on Magnetics, vol. 39, no. 3, pp. 1618-1621, May 2003.

POSTDOC position – ESIEE/UPJV – ESSIAL PROJECT – 2018/07/02

EQUIPEMENT, SOFTWARE, SAMPLES AVAILABLE :

Software : Pack OFFICE (Open ou MS), MATLAB, FLUX-ALTAIR or/and COMSOL, CATIA, LABVIEW

Soft magnetic samples (23MOH GO SiFe, M40065A NGO SiFe, 50-50 textured NiFe, 80-20 non oriented CoFe)

Equipement for the measurement of magnetic properties and losses (Epstein frame, SST frame, Ring core tester)

Electrical engineering laboratory (test benches for inductors, transformers and electrical machines)

Classical electrical and vibro-acoustic probes and electrical equipment for measurements and analysis

PROFILE :

Ingineering or Master degree and PhD mandatory. The candidate must have a PhD, knowledges and education on electrical engineering and electrotechnics. The candidate should have at least one experience and a great interest on both analytical and numerical modeling tools, magnetic components (power inductors and transformers) or/and electrical machines (asynchronous and synchronous machines). Any experience and interest for magnetic materials and experimental tasks will be a very important advantage for this postdoc position. A good English speaking level is required.

DURATION : 1 year + 1 year

WAGES : around 2000 €/month

COLLABORATIONS : **ESIEE Amiens – LTI / UPJV**

ESSIAL PARTNERS :

France : ESIEE, IRT-M2P, UPJV-LTI, **JEUMONT (manufacturing of electrical machines)**, MATIKEM, EURONOVIA.

Belgium : CRM Group, MULTITEL, LASEA

Spain : UC3 Madrid, **SEPSA (manufacturing of power inductors and transformers)**, ANDALTEC

Germany : FRAUNHOFER IPT

SUBCONTRACTORS examples:

OXYMETAL, SEIBO, RBOURGEOIS, PFT Innovaltech, …

CONTACTS :

Olivier Maloberti (maloberti@esiee-amiens.fr, 06-46-39-19-23 ou 03-22-66-20-43)

Anne Lemaire (lemaire@esiee-amiens.fr, 03-22-66-20-00)