Electrical Steel Structuring, Insulating and Assembling by means of the Laser technologies

Reporting

Project Information

ESSIAL

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ECOLE SUPERIEURE D'INGENIEURS EN ELECTROTECHNIQUE ET ELECTRONIQUE D'AMIENS
France

Periodic Reporting for period 2 - ESSIAL (Electrical Steel Structuring, Insulating and Assembling by means of the Laser technologies)

Reporting period: 2019-05-01 to 2021-04-30

Summary of the context and overall objectives of the project

Classical soft magnetic materials, made from stack of steel sheets separated by insulating layers, are widely used in magnetic circuits of electrical components and machines (transformers, sensors, actuators, motors, generators …). According to a report issued by Market & Markets in 2015, the global soft magnetic material market was valued at 18.02 billion US dollars, and is projected to reach 28.15 billion dollars by 2021 at an annual growth rate of 7.8%. The use of soft magnetic materials is becoming crucial in the various end-user industries and applications based on the aforementioned electrical equipment, as it maximizes power density. It is unfortunately also the cause of energy losses (called iron losses in addition to copper and mechanical losses) and noise (due to induced constraints and vibrations). This important growth in the demand of soft magnetic materials calls for a quick improvement of the performance and functionalities of laminated soft magnetic circuits to reach the objectives of the energy transition agenda. Moreover, these new materials should be eco-friendly without emitting any pollutant during their working life; and ought to be made of materials that are easy to recycle.

The aim of ESSIAL (Electrical Steel Structuring, Insulating and Assembling by means of Laser technologies) is to improve some of the characteristics of these 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 laminated soft 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, …) in order to reach the following expected specific impacts:

1. Improvement of product performance:
• Improvement of energy conversion efficiency by using higher performance magnetic circuits. In this respect, the iron losses due to magnetic reversal processes should be reduced by 20% (excess losses).
• Control and reduction of mechanical vibrations and decrease of acoustic noise by 20%.
• Deposition/removal of insulating layer for sustainable manufacturing process chains made easier
2. Integration of new laser process with maximum 10% price increase
• The cost of the new laser-based technologies will not exceed the cost of conventional production by more than 10% (magnetic circuits).
3. Strengthening of the global position of European manufacturing industry
• Implementation of innovative technologies along the European manufacturing value chain.
• Transfer of technology to European companies

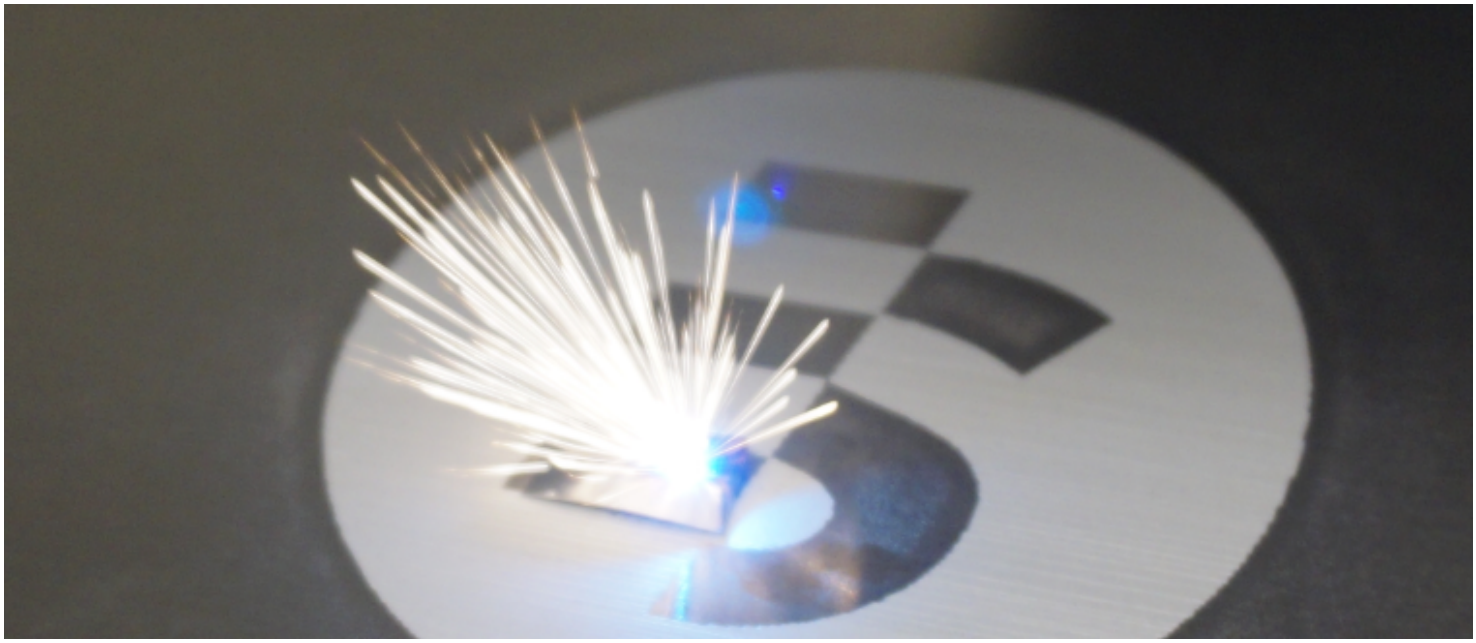
Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

WP2: WP2a(casting, rolling, 1st recristallization, decarburization, partial 2nd recristallization, cutting, thermal annealings), WP2b(SPL(irradiation, scribing), USPL(ablation, LIPSS)), WP2c(coating, texturization + hybrid welding, disassembling, partial decoating)

WP3: WP3a&b(process models, magnetic & magneto-mechanical models, exp. data, identification of materials properties, process optimization and specification (power, speed, frequency, spot size, patterns ...))
WP3c(insulating, thermal, mechanical properties with/without laser treatment, with/without coating, stress analysis, aging, wettability, compatibility between insulating materials and impregnation resin ...)
WP4: Design of stacks, ring cores, segmented model and prototypes at the lab scale / cutting of all strips / laser selections / ring core windings, partial manufacture of 1st ref. prototypes / Launching laser treatments & manufacturing at the lab.scale / preparation of tests
WP5: Design of inductors, transformers and electrical machines at the industrial scale / cutting of strips / laser selections / preparation for windings and assembling / preparation of tests
WP6: Off-line monitoring , Upscaling
WP7: website, leaflets, events, Market study, PI patents proposals, LCA-LCC

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

- Tailor made USPL ablation process for GOES, NGOES and special alloys.
- Single composition and 2 routes metallurgical process dedicated to the manufacturing of either a GOES or a NGOES.
- New laser hybrid joining solution and application for stacking, insulating, assembling/disassembling and life cycle of laminated magnetic circuits for electrical equipment.
- New formulation in a FEM software based on the Tensor Magnetic Phase Theory: simulation of the mesoscopic magnetic structure of a ferromagnetic material submitted to a field inside a magnetic circuit.
- New customizing method for surface laser treatment of electrical steels.
- Experimental set-up and software tool to measure the magnetostriction on strips with an SST.
- Consider new manufacturing process and adapted product design to include the laser treatment and bring a benefit on the life cycle of the electrical machines and transformers of end-users.



ESSIAL - Laser treatment

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