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

Reporting

Project Information

ESSIAL

Grant agreement ID: 766437

Project website

Status
Ongoing project

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

Periodic Reporting for period 1 - ESSIAL (Electrical Steel Structuring, Insulating and Assembling by means of the Laser technologies)

Reporting period: 2017-11-01 to 2019-04-30

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

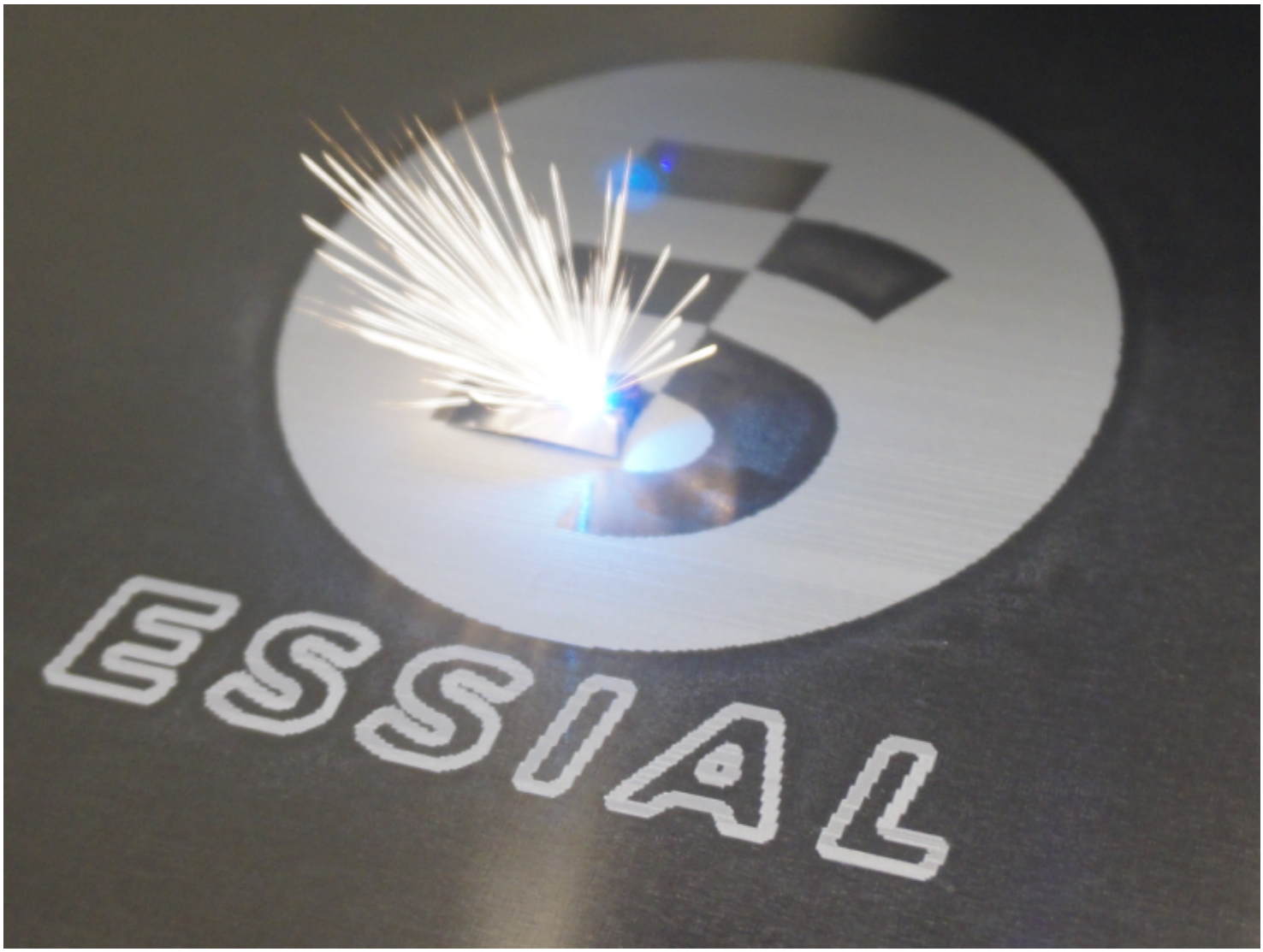
In WP2, CRM Group and IRT-M2P were in charge of the metal processing task and performed the cutting and physical analysis of the first samples. They have also achieved the hot and cold rolling and decarburization of the lab samples and electrical steels required for the complete investigations planned for the project.
In WP2 and 3, AC&CS and UC3M specified and performed the coating of the first samples with and without laser treatment. Performance analyses have been performed to achieve the industrial specifications. Their research helped us understand how to deposit an insulating coating after any laser treatment that might damage coating.

In WP2-3-4, MULTITEL, LASEA, ESIEE Amiens and UPJV designed the experimental plans for the different laser treatments. Three experimental plans have been proposed and laser parameters have been optimized to be able to reduce the iron loss by a factor up to 20%.
In WP2 and 6, LASEA and ANDALTEC investigated the best laser parameters and patterns dedicated to the texturization and the laser welding technique. Both the insulating tape and the welding area have been determined to achieve the mechanical specifications. Trials are encouraging for both the welding and the separating techniques between the metal and the insulator. The manufacturing of a complete laminated stack and magnetic circuit for both WP4 and WP5 is now ongoing.
In WP3, ESIEE Amiens and UPJV built both first versions of the magnetic and mechanical models that makes it possible to identify the laser sensitive material properties as a function of the working conditions. These models help us orientate the experimental plans and understand the physics behind the magneto-mechanical mechanisms influenced by both the laser treatments and the magnetization field.
IN WP6, IPT-FRAUNHOFER and LASEA worked on solutions for the off-line and in-line monitoring strategies that will help the upscaling of the laser process.
In WP7, ESIEE Amiens, MATIKEM, ANDALTEC and EURONOVIA assumed the dissemination and exploitation tasks of the project.

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)

The work carried out in the first RP led to the development of:
- a Laser irradiation process thanks to a short pulse InfraRed laser implemented on both sides of a magnetic sheet able to reduce iron losses in Rolling Direction of 0.23 mm thick Grain Oriented (GO) electrical steels (23M-0H) by a factor of more than 20% in most of the working conditions investigated from 1 to 10 kHz and up to 1.8 T.
- a tailor made Pulsed laser scribing and ablation process with very short pulses prior to coating for GO and Non Grain Oriented (NGO) electrical steels. The process leads to a loss reduction up to 20% and more than 40% for some working conditions. Unfortunately, the coating is damaged by this process so we had to develop an insulating coating solution after the laser treatment. The loss reduction is achieved for large samples up to 150 mm.
- advanced investigations on a 2 directional discrete and continuous laser treatment of NGO and GO electrical steels. The 2D Laser patterns and dots optimization allows to reduce iron losses of 0.65 mm thick NGO electrical steels (M400-65A) with two directions and rotating fields by a factor of around 5-10% for 0.65 mm thick samples.
- an alternative use of previous laser treatments to increase the magnetic permeability of the materials parallel to the loss reduction. First results on both 0.23 GO samples and 0.65 mm NGO samples show that the percentage of increase in the magnetic permeability can achieve more than 400%. The sound power being proportional to the frequency to the power of 2, the noise reduction potential of the laser treatments is significant.
- a tailor made non uniform laser treatment method adapted to flux density and orientations sensitive losses and vibrations optimized by FEM analysis inside the geometry of a magnetic circuit.
- a new laser technique for the assembling and disassembling process of laminated stacks. This

hybrid polymer-metal laser welding and melting solution can: avoid short circuit problems, be performed with a controlled contact pressure between the sheets, and allow some assembling and disassembling automation while facilitating some material recycling steps.



ESSIAL - Laser treatment

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