Fraunhofer IWS Dresden

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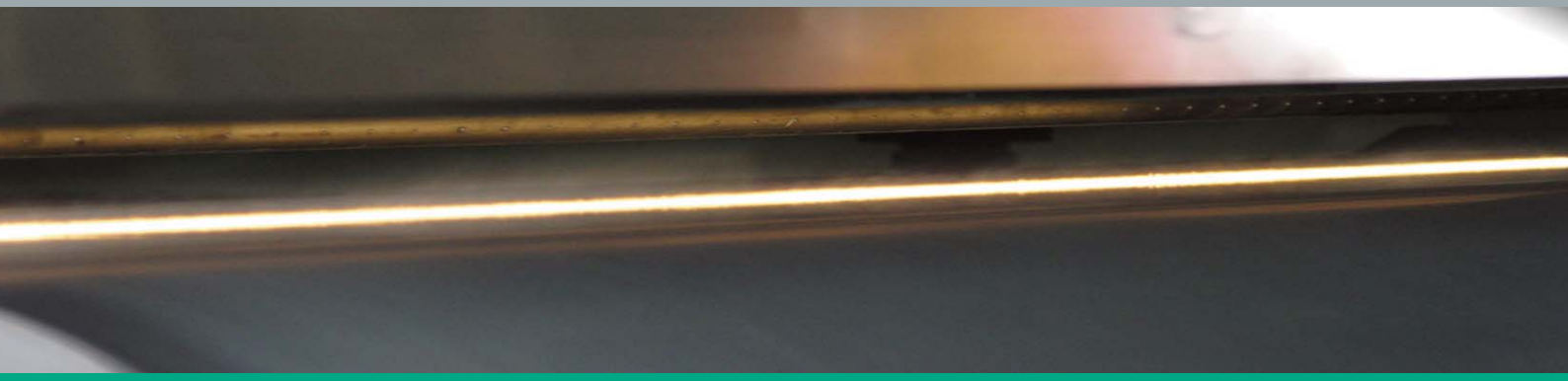


LMDR – LASER MAGNETIC DOMAIN REFINEMENT

Surface treatment of grain-oriented electrical steel using high power laser beam sources for core loss reduction

Fraunhofer Institute for Material and Beam Technology IWS
Winterbergstraße 28, 01277 Dresden, Germany

Fax +49 351 83391-3300
www.iws.fraunhofer.de

Contact:
Dipl.-Ing. Peter Rauscher
Phone +49 351 83391-3012
peter.rauscher@iws.fraunhofer.de

Dr. Jan Hauptmann
Phone +49 351 83391-3236
jan.hauptmann@iws.fraunhofer.de

info 400-8

Task

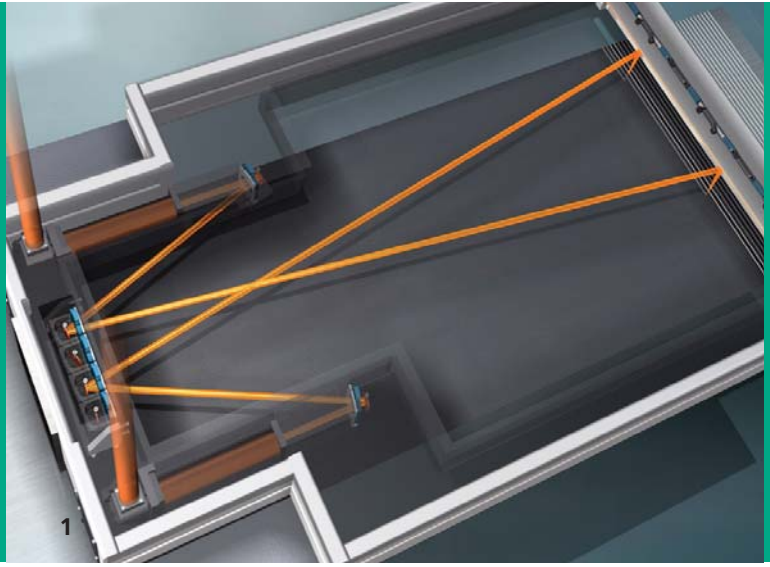
The magnetic properties of grain-oriented high permeable silicon steel, used for transformer cores, can be improved with a laser treatment. A local and time limited heat treatment refines the magnetic domain structure and reduces the core loss. The worldwide growing energy consumption and the ambitions of efficient energy usage lead to a rising demand of high quality materials.

Therefore a technology- and system engineering solution is required, which can be integrated into existing production processes and lines. Furthermore, the motivation of energy saving requires technologies with highest possible improvements of magnetical properties to reduce losses and to increase efficiency.

Solution

The laser beam optical deflection system lasertronic®SAO x.x/6D was developed for laser domain refinement of continuously moving grain-oriented silicon steel coils. The laser radiation of two laser sources are focalized on the material surface. The laser spot is moved perpenticularly to the direction of the running coil with velocities up to 250 m s^{-1}. The light energy absorbed by the metal sheet generates thermal stress at the structure of the material. As a result the magnetic domains are refined. The system lasertronic®SAO 10.6/6D consists of 6 galvanometer scanners. Two independent laser beams are deflected in an one dimensional way.

The material is alternately treated by each laser over the full width.



Test system

The LMDR test system, developed at the Fraunhofer IWS, is used to treat grain-oriented electrical steel under process conditions. The system consists of an optical beam deflection system, comparable to Fig. 1, and a movement axis to apply the laser radiation to sample probes and sheet material. Different laser sources are available and can be integrated, e.g. to investigate the wave length influence.

For the integration of the LMDR test system in an existing production line, the movement axis can be removed and the optical box is placed above the running coil material. All necessary process parameters are monitored and already integrated in the LMDR test system for an easy transfer of the treatment process.

Benefits

- treatment under process conditions
- identical intensity distribution at the material surface (optical beam path comparable to industrial solutions)
- integration of different laser sources (CO_2 laser, fiber coupled, solid state laser)
- treatment of single sheets up to 1 m x 1 m (lab application)
- sample speed up to 90 m min^{-1}
- high spot velocity up to 300 m s^{-1} due to new scanning mirrors and technology
- easy transfer into existing production lines for material tests support of material developments and improvements
- approval and optimization of the treatment process before the production

Measurement capacities

- specific hysteresis loss
- maximum polarization
- effective polarization
- maximum field strength
- effective field strength
- Remanence
- coercive field strength
- permeability
- specific apparent output
- measurement of elongation in soft magnetic materials due to measuring categories
- zero-to-zero magnetostriction
- peak-to-peak magnetostriction
- magnetostriction vs field strength
- magnetostriction vs polarizations

Epstein samples and stripes
up to 600 mm x 100 mm x 1.5 mm

1 Beam deflection system (optical box) lasertronic®SAO x.x/6D
2 LMDR test system based on the lasertronic®SAO x.x/6D
3 Optical box LMDR test system

LMDR test system specification

Working width:	up to 1000 mm
Coil speed or axis speed:	0.5 – 90 m min^{-1}
Laser spot velocity:	up to 300 m s^{-1}
Laser beam source:	2 x laser beam sources selectable (CO_2 laser, fiber coupled solid-state laser)
Max. laser power:	1000 W – 5000 W (dependent on laser beam source)
Line distance:	2 – 20 mm
Material:	single sheets up to 1 m x 1 m