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FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

LASER CUTTING OF ELECTRICAL STEELS

Process development for preservation excellent electro-magnetic material properties

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Task

In electrical machines excellent electro-magnetic properties are required for loss-reduced energy conversion of electrical into kinetic energy and vice versa. The laminations of electric motors and generators are mainly manufactured by punching, which is a method that achieves low costs per unit. However, the related long time to market is unfavorable and leads to an inacceptable loss of competitive advantage. That is exactly the reason why a flexible technique such as laser beam cutting is given a high priority in the process landscape. No additional tool costs and changeover times are caused and the engineer gains new possibilities to process additional alternative materials as he can design three-dimensional rotor and stator laminations. In order to preserve excellent electro-magnetic properties and thus a high efficiency in energy production or conversion it is essential to reduce the manufacturing related magnetic deterioration, even for laser cutting, by a specific process development. Furthermore, suitable methods for scaling up small series to large-scale production are highly demanded.

Solution

At the Fraunhofer IWS highly productive and accurate 2-D laser cutting machines with linear drives, combinable with modern CO_2 lasers or brilliant solid-state lasers, are available. The IWS engineers carry out sophisticated material testing and process development. Hence, all soft magnetic materials, independent of their chemical composition (silicon content > 4%) even with a thickness of 0.1 mm, can be easily processed.

Experimental results

The presented laser cutting process was evaluated by means of the following investigation methods:

- process modeling on the basis of high speed thermography (fig. 2)
- process parameter studies analyzing magnetic property manipulation (fig. 3)
- structural investigation in order to characterize geometrical aspects of cut samples with respect to the cutting edge quality and shape
- development of a modeling approach to forecast magnetic deterioration in the cutting edge region (mechanically deformed or laser induced)

Application examples

- cutting process optimization of manufacturing electrical steel laminations for electrical machines
- creation of design rules for suitable laser cutting assisted productions
- forecast of the manufacturing-related magnetic flux density depending on chosen stator design
- modeling approach considering magnetic deterioration for numeric simulation in designing magnetic circuits
- consideration of various deterioration mechanisms such as mechanical deformation or thermal damage
- development of further similar processes e.g. laser welding

Offer

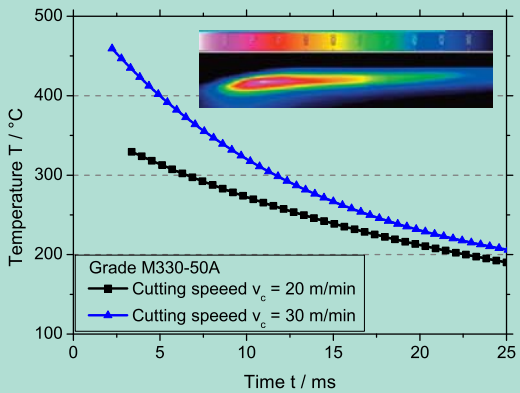
The Fraunhofer IWS offers support in designing and optimizing laser material processes, e.g.:

- laser cutting of all soft magnetic materials applying modern CO_2 and solid-state lasers with various maximum output power and beam quality
- magnetic material testing (hysteresis loop, B-H curve, magnetostriction)
- structural investigation, using scanning (SEM) or transmission electron microscopy (TEM) as well as X-ray diffraction analysis
- data acquisition for realistic numerical simulation
- modeling copper and iron loss changes through manufacturing-related mechanical or thermal deterioration

1 System TruLaser 7025

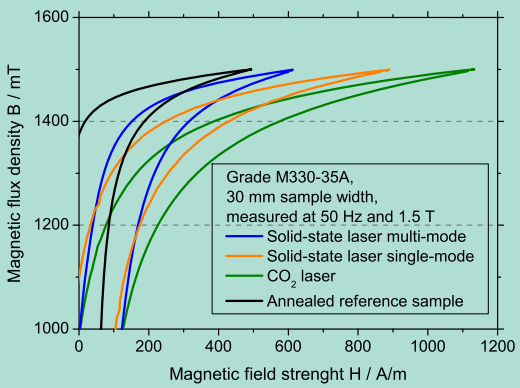
2 Application of a contour

Determination of the temperature profile in a fixed point with constant a distance of 100 µm to the cutting edge



3

The choice of the right beam source influences residual stress state within the sample (detail of the hysteresis loop)



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