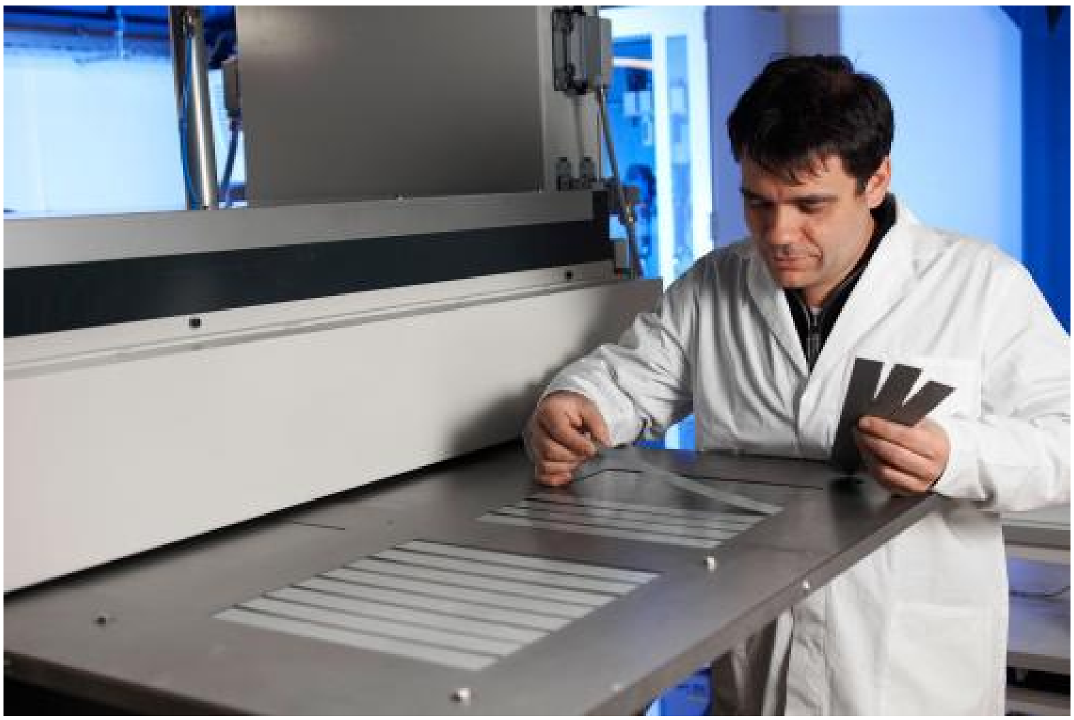
More efficient transformer materials

October 1 2014



A scientist removing samples of electrical steel from the test facility at Fraunhofer IWS; this type of material is one of the main components of transformers. Credit: Fraunhofer IWS

Almost every electronic device contains a transformer. An important material used in their construction is electrical steel. Researchers have found a way to improve the performance of electrical steel and manufacture it more efficiently, using an optimized laser process.

Transformers convert the standard voltage from the wall outlet into the lower voltages required by electronic devices. Similar but more powerful transformers are used in electricity substations to convert the high voltages of the transmission grid into the standard AC power supply delivered to households. All transformers have the same basic structure: a pair of iron cores, around which wires of different lengths are wrapped. These are the transformer coils, one of which generates an oscillating magnetic field, while the other converts this magnetic field into a voltage. To minimize the energy loss associated with this process, special types of iron-silicon alloy known as electrical steel are used to make the core. In their native state, these alloys have a grainoriented structure which determines their magnetic properties.

Grain-oriented means that the material has a crystalline structure in which each crystal or grain is arranged in a regular periodic order. "By heating selected areas of the material, it is possible to reduce the size of the domains with the same magnetic orientation, which in turn alters the magnetic structure of the steel. This results in a lower heat development and thus reduces the material's hysteresis loss," says Dr. Andreas Wetzig, who heads the laser ablation and cutting department at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden, describing the complex changes that take place inside the material. Laser processing has long become established as the preferred method for this type of heat treatment. While the steel sheet, measuring around one meter in width, moves forward at a rate of more than 100 meters per minute, a focused laser beam travels at very high speed (approximately 200 meters per second) from side to side across the surface of the material along paths spaced a few millimeters apart.

Flexible control of the laser beam

The Dresden-based research team has optimized this process: "We have developed a means of deflecting the laser beam that allows the distance between the paths to be controlled flexibly and adapted to different parameters," reports Wetzig. To do so, the researchers make use of galvanometer scanners. These devices consist of galvanometer driven mirrors attached to one end, which is used to deflect the laser beam. This increases the flexibility of the machining process and allows it to be adapted to specific conditions, such as the quality of the raw material, and to different production rates. The main aim of this research is to facilitate the integration of laser processing in existing production environments, in order to save time and costs.

In a further effort to reduce hysteresis loss in electrical steel, the researchers have recently started working with a new type of solid-state laser: the fiber laser. "The results we have obtained so far are very promising. This type of laser offers better heat absorption characteristics than traditional CO2 lasers," says Wetzig. It cuts hysteresis loss by up to 15 percent, compared with the 10 percent normally achieved until now. The optimized process is currently being implemented by the first commercial customer.

Possible energy savings of up to 25 percent

The IWS experts are currently working on the next important stage: that of expanding the applications of their technology to electrical steel for engine components. However, unlike transformer steel, these materials do not have a grain-oriented structure and therefore possess different magnetic properties. "This means that we cannot transfer our process one-to-one without modification," explains Wetzig. The benefits of laser processing in the case of non-grain-oriented electrical steel vary according to the working point of the specific engine or motor. The working point is the point of intersection between the torque curve and rotational speed curve of the drive system and the driven machine. In high-performance machines such as vehicle engines, which are designed to run at high rotational speeds, energy loss can be reduced by a few percentage points. In high-torque electric motors such as those used to operate pumps, the reduction in energy loss can be as high as twentyfive percent.

Provided by Fraunhofer-Gesellschaft

Citation: More efficient transformer materials (2014, October 1) retrieved 23 April 2024 from https://phys.org/news/2014-10-efficient-materials.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.