The magnetic and magneto-optical effects of laser cutting and spark eroding in electrical steels

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Spark erosion and laser-cutting processes were examined in terms of their effects on the magnetic properties of grain-oriented electrical steels at working frequencies. The maximum permeability value in each case was considered as a reference to determine the quantitative effect of cutting and eroding methods as well as the effects of heat treatment. To minimize the deterioration that appears after the piercing process is implemented, the specimens were subjected to heat treatment at the most appropriate temperature. The influence of stress-relief annealing could be observed throughout the domain refinement on the surface by using magneto-optical Kerr microscopy. Additionally, it was clearly seen that the domain contrast at the cut edge of the spark-eroded sample was more uniform than that provided by laser cutting upon applying a high AC-field amplitude.

When the deterioration in magnetic properties as a result of spark erosion and laser cutting was compared, the maximum permeability was found to show remarkable changes of 20% (without heat treatment) and 30% (with heat treatment) depending on the demagnetization forces and thermal stress. Furthermore, rates among Hc values of all samples were stable even at higher working frequencies before annealing. However, this stability more or less broke down when heat treatment was carried out. One of the remarkable findings is the drastic reduction of the μmax-value by as much as 70% after the samples were pierced by EDM. This unexpected drop originated from strong demagnetization effects, where the flux density distribution is locally blocked by antiparallel or perpendicular forces. Apparently, an annealing temperature of 900 °C was the most suitable for the spark-eroded sample in terms of both microstructural relaxation and, accordingly, the magnetic properties. Moreover, the effect of heat treatment on the magnetic properties was no stronger in the BC sample than in the laser-cut and spark-eroded specimens. The rates of increase after treatment of BC, laser-cut and spark-eroded samples were found to be 6, 49 and 59% compared to the cases before annealing. Therefore, after any cutting operation, heat treatment should be implemented to enhance the magnetic properties during manufacturing of laminated transformer cores. Thus, attention should be paid to the treatment of cut edges and the hole size must be optimized according to the customer requirements.

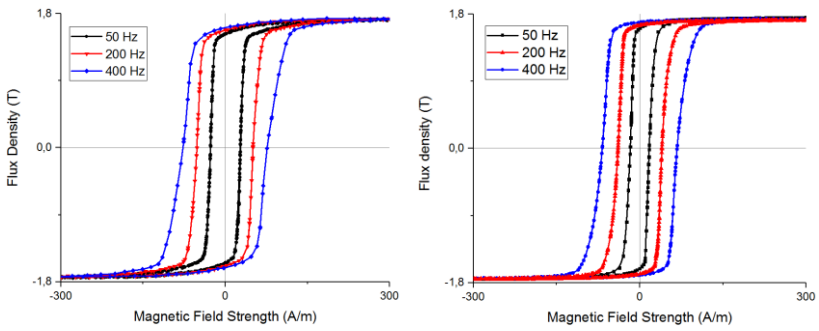

Figure 1. Ascending Hysteresis loops before (a) and after (b) annealing for the samples without hole.