E[illegible] D[illegible] D[illegible] N[illegible]-O[illegible] E[illegible] E[illegible] G[illegible] L[illegible] D[illegible] D[illegible]

ZAIZEN Yoshiaki[*1] OMURA Takeshi[*2] TODA Hiroaki[*3]

Abstract:

The influence of shearing process on the iron loss of non-oriented electrical steels with grain sizes of 10 µm to 150 µm was investigated. The deterioration ratio of iron loss was clearly smaller in sample with small grain sizes. The shear droop height, reflecting the amount of plastic deformation, displayed a good correlation with the deterioration of iron loss under the effect of the material grain size. To clarify the strain distribution around the sheared edge, elastic-plastic strain in a sheet sample with the thickness of 0.30 mm and grain size of 10 µm was evaluated by using synchrotron radiation. The width of the region of elastic strain due to shearing was two or three times of the material thickness. The results of the elastic-plastic strain distribution obtained by measurements were then used to estimate the iron loss deterioration rate in 5 mm width sheared samples. The estimated loss deterioration coincided with the actual measured iron loss.

1. Introduction

Non-oriented electrical steel is widely used as a core material for motors, generators and other electrical equipment, and is an important soft magnetic material which supports today's society. In recent years, requirements for higher efficiency and energy saving in motors have become increasingly strict from the viewpoint of high efficiency in energy use, and higher performance has also been demanded in non-oriented electrical steel. Moreover, in order to achieve high performance and high efficiency in motors, appropriate selection of materials for cores corresponding to their distinctive features and optimum material use are also considered necessary[1–3].

Although motor cores are generally manufactured by punching non-oriented electrical steel sheets, it is known that the magnetic properties of electrical steel sheets are deteriorated by the plastic strain and elastic strain that occur around the punched edge in the punching process[4–8]. The magnetic properties of non-oriented electrical steel sheets are generally measured and evaluated after shearing the material to obta ecC2e9ID 72 6eaJem(d)-0.7 ( )0.5artere few reports have addressed this issue[5,12]. Therefore, JFE Steel carried out strain measurements by using synchrotron radiation, which enables nondestructive measurement of strain around the punched edge.

spite of this strain distribution, it can be thought that the influence of plastic strain on iron loss deterioration may be predominant, or the size of the plastic strain introduced by punching/shearing may also be reflected in the s /La.8 (ed)bhL0Tm[sh58 (e w (ed)bhL10 0 e/Lang150 e/Lan54 BDC 411Cp)]TJ/Span/ActualText FEFF2008 hiU258 Tm(/)98

Figure 11 shows the results of a stress distribution analysis in the direction perpendicular to the page at the material centerline. Comparing the stress values in the plastic deformation region from the sheared edge to a point 0.1 mm from the edge, the tensile stress generated around the sheared edge is smaller in the materials tron radiation measurement correspond to the FEM analysis results shown in Fig. 11 (grain size: 10 μm), those results were compared with the strain distribution in the Y direction in Fig. 14. First, focusing on the region of strain introduction from the sheared edge, in the FEM analysis, the elastic-plastic strain region extended to around 0.5 mm to 0.6 mm from the sheared edge. In contrast, the synchrotron radiation measurement results showed that the elastic-plastic strain region extended to around 0.8 mm to 0.9 mm from the sheared edge. Next, looking at the stress values from the sheared edge, in the FEM analysis, the stress is tensile stress with a maximum value of around 50 MPa in the region 0.05 mm from the sheared edge. This changes to compressive stress with a maximum value of about 200 MPa in the region from 0.05 mm to 0.15 mm, and then to tensile stress of about 50 MPa in the region from 0.15 mm to 0.5 mm. On the other hand, the synchrotron radiation evaluation resu76(r)12.3 (eE (O)0.8 (n th)0.5 (e o)1.3 (th)0.5 (e)01r)34.9 13 BT055.3

2480.

8) Kaido, C.; Mogi, H.; Fujikura, M.; Yamasaki, J. Punching Deterioration Mechanism of Magnetic Properties of Cores. IEEJ Trans. FM. 2008, vol. 128, no. 8, p. 545–550.
9) Toda, H.; Oda, Y.; Zaizen, Y.;JFE Technical Report. 2015, no. 36, p. 24–31.
10) Toda, H.; Zaizen, Y.; Namikawa, M.; Shiga, N.; Oda, Y.; Motomoto, S. Iron loss deterioration by shearing process in non-oriented electrical steel with different thicknesses and its influence on estimation of motor iron loss. IEEJ Journal of Industry Applications. 2014, vol. 3, p. 55–61.
11) Omura, T.; Zaizen, Y.; Fukumura, M.; Senda, K.; Toda, H. Effect of Hardness and Thickness of Non-oriented Electrical