

Development Trends of Soft Magnetic Iron

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Recent developments in electronically controlled systems for automobiles are focused on providing for soft magnetic materials that can provide a larger electromagnetic flux with less eddy current losses than steel with very low carbon content. New steel developed in combination of this soft electromagnetic properties such as cold crystallization and mechanicality. This paper describes the recent development trends of soft magnetic steel and the achievement of steel developed steel (JIS G 3035).

Introduction

Recently automobiles are being heavily equipped with various systems operated electrically, electronically and/or electromechanically to control engine, gearbox and fuel economy. Such systems include integrated controlled automatic transmission, electronic power steering (EPS) and anti-lock braking systems (ABS) [1].

In the early years (1970s, 1980s) when electric and electronic devices started to be used in automobiles, the main purpose was to improve and upgrade the performance of individual systems. Highly complicated vehicles started to appear from then on, however, as integrating various high-speed linkage and movement coordinated among different systems. Hence electronically and/or electromechanically controlled management are becoming increasingly important.

Among these electronically and/or electromechanically controlled systems, components that utilize electromagnetic force (permeable iron core or thin coils to generate magnetic fields, many conventional ones consist of low carbon steel, containing about 0.05% of carbon, to improve the response to control signals and increase energy efficiency [2]. With the remarkable advancement of electromagnetic control in recent years, it has become essential to electronically components to have even higher performance and lower power consumption.

This paper describes the trend of soft magnetic materials, such as those for iron cores used in electromagnetic components, and introduces the characteristics of the new, low-carbon soft magnetic materials in the HLCSD (Ultra Low Carbon Cold Heading Steel) series developed by New Steel.

2. Transition of soft magnetic materials

Fig. 1 depicts the structure of a solenoid device

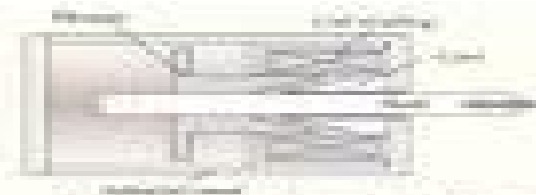


Fig. 1. Example of solenoid structure.

by hydraulic control. This is a typical example of the electromagnetic components used in automobiles. Soft magnetic materials are usually used for iron cores that form magnetic circuits and for the housings (including cores).

Early solenoid devices for automobiles were mainly used for controlling the oil flow by small sections. Thus, the stability and reliability of iron core materials were more important than their magnetic characteristics. As a result, low carbon steels such as S45C (JIS G 3045), S50C (JIS G 3045) and S45CM (JIS G 3045) were used for the iron cores.

Recent solenoid devices, however, must be able to control hydraulics exactly and stably. In contrast this, the control system is being replaced by linear control in many cases [3]. On linear control, the control current must be proportional to the plunger force (characteristic force) of the iron cores, which increases with magnetic materials having low coercivity (low hysteresis) at high flux density. The latest iron core materials for linear solenoids are required to have magnetic characteristics better than those of S45C (JIS G 3045), making it difficult to use carbon steel. Recently used for small control, to satisfy the required characteristics of magnetic flux density and coercivity (Fig. 2).

In the mid-1990s, New Steel worked to totally eliminate factors that can adversely affect the magnetic characteristics of soft magnetic materials and developed a soft magnetic material, HLCSD, based on pure iron, which can achieve the best characteristics among 99 grade (99.99% Fe) materials [4]. The company has studied parts having using a large pressure and pure solution. Now the material is being widely used as a soft magnetic material for cold heading.

In the late 1990s, there was an increasing need for

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