

Development Trends of Soft Magnetic Iron

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Thanks to advances in electronically controlled systems for automobiles, the demand is growing for soft magnetic materials that can process a large electromagnetic flux with low eddy current losses. This study will try to surface various types of iron developed in combination of state-of-the-art electromagnetic properties such as permeability and resistivity. This paper describes the recent development trends of soft magnetic steel and the achievement of one developed steel (JIS 4922 series).

Introduction

Recently automobiles are being heavily equipped with various systems operated electronically, electronically and/or electrohydraulically to control valves, control and fuel economy. Such systems include integrated controlled automatic transmission, electronic power steering (EPS) and anti-lock braking systems (ABS)^{1,2}.

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, however, in steering, fuel injection, high-speed valves and movements coordinated among different systems. Hence electronically and/or electrohydraulically controlled components are becoming increasingly important.

Among these electronically and/or electrohydraulically controlled systems, components that utilize electromagnetic force (permeable iron core or thin shell to generate magnetic field, thin conventional core coated of thin surface shell, containing about 0.1% of carbon), to improve the response to control signals and increase energy efficiency.^{3,4} With the remarkable advancement of electromagnetic control in recent years, it has become essential for 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-loss soft magnetic materials in the JIS 4922 Series Low-Carbon Cold-Changing Sheet series developed by Tokai Steel.

2. Trending of soft magnetic materials

Fig. 1 depicts the structure of a solenoid device

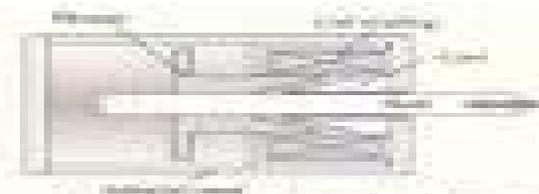


Fig. 1. Example of solenoid device.

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 use magnetic circuits and for the fittings including cores.

Early solenoid devices for automobiles were mainly used for controlling the oil flow by small orifices. Thus, the stability and reliability of iron core materials were more important than their magnetic characteristics. As a result, low carbon steels such as SAE 1008, 1009, 1010, 1011 and SAE 1012 (JIS-C 1008) were used for the iron cores.

Recent solenoid devices, however, must be able to control hydraulic media, and water. In solenoid coils, the small orifice is being replaced by larger orifice in many cases.^{5,6} On the other hand, the control current must be proportional to the galling force (electromagnetic 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 these solenoids are required to have magnetic characteristics better than those of SAE 1010 (JIS-C 1010), making it difficult to use carbon steel directly used for small control, to satisfy the required characteristics of magnetic materials and coercivity (Fig. 2).

In the mid-1970s, Tokai Steel started to study electronic devices that can effectively affect the magnetic characteristics of soft magnetic materials and developed a soft magnetic material, JIS 4922 Series iron core, which can achieve the best characteristics among 30 grades (0.005% to 0.020% carbon).⁷ The company has studied parts forming using a forging process and parts fabrication from the material is being widely used as a soft magnetic material for coil forging.

In the late 1970s, there was an increasing demand for

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Soft Magnetic Materials 8 Roger Wäppling,1988 Wide Bandgap Power Semiconductor Packaging Katsuaki Suganuma,2018-05-28 Wide Bandgap Power Semiconductor Packaging Materials Components and Reliability addresses the key challenges that WBG power semiconductors face during integration including heat resistance heat dissipation and thermal stress noise reduction at high frequency and discrete components and challenges in interfacing metallization plating bonding and wiring Experts on the topic present the latest research on materials components and methods of reliability and evaluation for WBG power semiconductors and suggest solutions to pave the way for integration As wide bandgap WBG power semiconductors SiC and GaN are the latest promising electric conversion devices because of their excellent features such as high breakdown voltage high frequency capability and high heat resistance beyond 200 C this book is a timely resource on the topic Examines the key challenges of wide bandgap power semiconductor packaging at various levels including materials components and device performance Provides the latest research on potential solutions with an eye towards the end goal of system integration Discusses key problems such as thermal management noise reduction challenges in interconnects and substrates *Amorphous Magnetism and Metallic Magnetic Materials - Digest* A.R. Ferchmin,S. Kobe,1983-09-01 This unique book provides the reader with the only comprehensive overview of the subject It is an indispensable reference source in that it attempts to compress into one single volume the whole body of basic and applied research on amorphous magnetic metallic materials Supplements to the Journal of Magnetism and Magnetic Materials appear regularly keeping the information contained in this book as up to date as possible The book has been designed for easy use and is a must for researchers in the field *Soft Nanoferrites for Biomedical and Environmental Applications* Atul Thakur,Preeti Thakur,2024-10-11 Spinel nanoferrites have emerged as an advanced class of nanostructured materials in the domains of nanoscience and technology over the past decade This book covers the fundamentals of spinel ferrites and their applications in the health sector and the environment It focuses on the key applications of spinel ferrites in the health sector such as hyperthermia cancer diagnosis treatment and antimicrobial activity as well as in environmental issues like water purification wastewater treatment and air pollution remediation Features Covers the classification synthesis properties structures and applications of spinel ferrites Provides exclusive coverage of biomedical and environmental applications Includes discussions on environmental pollution types of pollutants and the removal of those pollutants using spinel nanoferrites Reviews applications in cancer diagnosis and treatment MRI hyperthermia and related fields Recommends building environmentally friendly ferrite materials for a clean environment This book is aimed at graduate students and researchers in materials science nanotechnology environmental science and bioengineering *Rapidly Solidified Alloys* Howard H. Liebermann,1993-05-20 This volume details the principles underlying rapid solidification processing material structure and properties and their applications This practical resource presents a manifold approach to both amorphous and

crystalline rapidly solidified metallic alloys Written by over 30 internationally acclaimed specialists in their respective fields

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