

# Development Trends of Soft Magnetic Iron

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Various soft magnetic iron alloys have been developed recently for automobiles. The demand is growing for soft magnetic materials that can provide a large electromagnetic force with low silicon content. This study will try to surface various types that have developed in combination of high DC electromagnetic properties such as cold crystallization and annealing. This paper describes the recent development trends of soft magnetic steel and the achievement of one developed steel (JIS 33C) series.

## Introduction

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

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, ABS and other high-speed fittings and movements coordinated among different systems. Hence, electrically and/or electrohydraulically operated components are becoming increasingly important.

Among these electrically and/or electrohydraulically operated systems, components that utilize electromagnetic force (magnets) are seen to have skills to generate magnetic fields. Many conventional cores consist of low carbon steel, containing about 0.1% of carbon, to improve the response to control signals and increase energy efficiency.<sup>3</sup> With the remarkable advancement of electromagnetic control in recent years, it has become essential to electrohydraulically components to have even higher performance and lower power consumption.

This paper describes the trend of soft magnetic materials, such as those for low carbon steel as electromagnetic components, and introduces the characteristics of the new, low-carbon soft magnetic materials in the JIS 33C (New Low Carbon Cold Heading Steel) series developed by Tokai Steel.

## 2. Trending of soft magnetic materials

Fig. 1 depicts the structure of a solenoid device

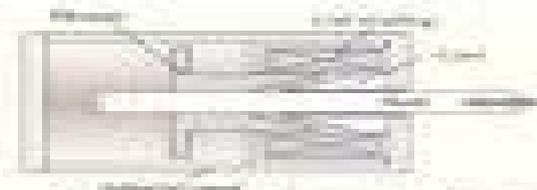


Fig. 1. Example of solenoid device.

by hydraulic control. This is a typical example of the electromagnetic components used in automobiles. Soft magnetic materials are usually used for low carbon steel (low magnetic content) and for the fittings including cores.

Early solenoid devices for automobiles were mainly used for controlling the oil flow by small pistons. Thus, the controllability and controllability of low cost materials were more important than their magnetic characteristics. As a result, low carbon steels such as S15C, S10C, S10B, S10C, S10B-C and S15C-C (JIS C 1000) were used for the steels.

Recent solenoid devices, however, must be able to control hydraulic media, and water. In solenoid coils, the small current is being replaced by large current in many cases.<sup>4,5</sup> On the other hand, the control current must be proportional to the galling force (electromagnetic force) of the low carbon steel, which increases with magnetic materials having low magnetic loss (magnetic loss) than steel. The latest low cost materials for these solenoids are required to have magnetic characteristics better than those of S15C (JIS C 1000), making it difficult to use low carbon steel directly used for small current, to satisfy the required characteristics of magnetic materials and accuracy (Fig. 2).

In the mid-1990s, Tokai Steel started to totally electric drive system that can effectively affect the magnetic characteristics of soft magnetic materials and developed a soft magnetic material, JIS 33C (New) steel series, which can achieve the best characteristics among all grades (S10C-S15C) steels.<sup>6,7</sup> The company has studied parts forming using a forging process and parts function from the material is being widely used as a soft magnetic material for coil forging.

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

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**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

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## **Development Trends Of Soft Magnetic Iron** Book Review: Unveiling the Magic of Language

In an electronic digital era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its capability to stir emotions, provoke thought, and instigate transformation is really remarkable. This extraordinary book, aptly titled "**Development Trends Of Soft Magnetic Iron**," written by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we will delve into the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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