Investigating R&D Committee on Technology Utilizing Power Magnetic Materials for High Performance Electromagnetic Equipment

Technical Committee on Magnetics

1. Objective

Electromagnetic equipment, e.g., transformers and motors, requires improved characteristics in power magnetic materials used in iron cores. In recent years, it has become essential to thoroughly ascertain magnetic properties of these materials during operation of these devices under high magnetic flux density and pulse width modulation (PWM) excitation, which are becoming increasingly prevalent worldwide, to enable high performance of these devices. This will enable the optimal design and development of cores, help realize low power loss and high efficiency of these devices, and help contribute to solving global environmental problems. This demands the development of magnetic materials for electrical power, including high magnetic flux density and power electronics for PWM excitation, and techniques for the practical use of these materials.

This investigation committee shall investigate domestic and foreign trends in the development of these materials, including those for high magnetic flux density and power electronics, and clarify the position of Japan by investigating techniques to measure magnetic properties under diverse conditions in which these materials are used. The objective is to summarize the technologies for effective use of power-based magnetic materials.

2. Background and internal and external research activities

At the 21st Conference of the Parties to the United Nations Convention on Climate Change (COP21) held in 2015, governments made a commitment to reduce greenhouse gas emissions by 26% from the fiscal 2013 level within 2030. In addition, although the sustainable development goals formulated in 2015 set "Goal 13: Specific measures for climate change", the achievement of this goal has been insufficient domestically and globally (June 2019 report). Carbon dioxide originating from energy production contributes to 90% of domestic greenhouse gas emissions. For global environmental measures, efforts are being made to conserve energy on the demand side and introduce renewable energy on the supply side.

Against this background, to effectively use power magnetic materials in electromagnetic device cores for electric power, mainly under commercial frequency excitation, studies have been conducted on trends in the development of these materials, standard methods of measuring these materials, and techniques for measuring magnetic properties under diverse conditions that mimic actual device operation. The results showed a need for new power magnetic materials corresponding to high frequencies; these materials should be used based on the characteristics of material properties. In addition, these studies clarified the necessity of nonstandard measurement techniques, such as vector magnetic properties and the necessity of stress dependence on magnetic properties. In other countries, particularly in the UK, Germany, Italy, Belgium, and other European nations, similar studies have been pursued by universities and national research institutes for a long time. Moreover, in recent years, research on stress magnetic properties has been vigorously carried out at the Royal Institute of Technology in Sweden. It will be important in future to investigate research trends in foreign countries, e.g., China, and upgrade the performance of transformers and motors to maintain domestic competitiveness.

In future, miniaturization, weight reduction, and high torque for low loss and high efficiency in power magnetic device will be required from the viewpoint of system performance in industrial fields such as robots, as well as onboard installation in electric vehicles and aircraft. It is essential that power magnetic materials, including those for high magnetic density and power electronics, and techniques for the application must be established for Japan to maintain global competitiveness.

3. Investigative matters

To summarize techniques to use power magnetic material properties in power electromagnetic devices,

e.g., transformers and motors, the following trends will be investigated domestically and abroad.

(1) Trends in the development of power magnetic materials, including those for high magnetic flux density and power electronics, as well as trends in standard measurement methods for those materials and IEC standardization

(2) Evaluation methods for magnetic properties corresponding to the conditions in which power electromagnetic devices of the aforementioned materials are used

(3) Methods of elucidating the physical mechanism of power magnetic material properties under complex magnetic flux conditions within power electromagnetic devices

(4) Low loss and high efficiency through techniques of using power magnetic materials during the design and manufacture of transformers and motors

4. Expected effects

(1) Understanding of trends in the development of power magnetic materials, including those for high magnetic flux density and power electronics, and the establishment and dissemination of corresponding standard measurement methods

(2) Establishment of methods of evaluating magnetic properties under the conditions in which power electromagnetic devices corresponding to the aforementioned materials are used

(3) Establishment of techniques to design power electromagnetic devices based on the physical mechanism of power magnetic material properties

(4) Realization of low loss and high efficiency in power electromagnetic devices such as transformers and motors

(5) Assurance of international competitive advantage for Japanese-made power electromagnetic devices

5. Term of investigation

May 2020 to March 2023 (2 years and 11months)

6. Committee members

Position	Name	Affiliation	Member/Non-member category of IEEJ
Chairperson	Yuji Tsuchida	Oita University	Member
Member	Junichi Asama	Shizuoka University	Member
〃	Kazushi Ishiyama	Tohoku University	Member
〃	Shinichi Inoue	Metron Technology Research Co., Ltd.	Member
〃	Shinya Urata	Toyota Central R&D Labs., Inc.	Member
〃	Masato Enokizono	Vector Magnetic Characteristic Technical Laboratory	Member
〃	Mohachiro Oka	National Institute of Technology, Oita College	Member
〃	Yoshihiko Oda	JFE Steel Corporation	Member
〃	Yuichiro Kai	Kagoshima University	Member
〃	Yosuke Kawazoe	Yasukawa Electric Corporation	Member
〃	Akifumi Kutsukake	Oita Industrial Research Institute	Member
〃	Toshinari Kondo	Mitsubishi Electric Corporation	Non-member
〃	Masahiko Shimamura	Japan Electric Measuring Instruments Manufacturers' Association	Member
〃	Osamu Fukuyama	Kuroda Precision Industries, Ltd.	Member
〃	Naoya Soda	Ibaraki University	Member
〃	Ryoichi Takahata	Hitachi, Ltd.	Member
〃	Takeshi Tanaka	Daihen Corporation	Member
〃	Keiichiro Nukada	Panasonic Corporation	Non-Member
〃	Keisuke Fujisaki	Toyota Technological Institute	Member
〃	Tatsuya Masuda	Aichi Electric Co., Ltd.	Member

Position	Name	Affiliation	Member/Non-member category of IEEJ
Member	Tetsuji Matsuo	Kyoto University	Member
〃	Daisuke Miyagi	Chiba University	Member
〃	Hisashi Mogi	Nippon Steel Corporation	Member
〃	Makoto Yamaguchi	Pulstec Industrial Co., Ltd.	Member
〃	Taizo Yamamoto	Sumitomo Heavy Industries, Ltd.	Member
〃	Daisuke Wakabayashi	Nippon Bunri University	Member
Secretary	Takeshi Yanai	Nagasaki University	Member
〃	Kenichi Yamamoto	University of the Ryukyus	Member
Assistant secretary	Kyyoul Yun	Gifu University	Member

7. Activity schedule

Committee meetings: 5 times/year; Secretariat: 2 times/year; Technical Meetings: 2 times/year

8. Reporting format

The results of investigations conducted by this committee will be reported in a symposium at the Annual Meeting of IEEJ.

Reason:

The investigation results of this committee benefit materials, measurement, design and development of power electromagnetic equipment such as transformers and motors, application of these devices, and engineers and researchers. In cooperation with relevant Society D committees, reporting will be done in the form of symposiums and national conventions. This is expected to increase the number of participants from the transformer and motor fields in Society D, and furthermore, participants from material fields, e.g., members of the ISIJ; participants from the electromagnetic engineering field, e.g., members of the MSJ; and participants from electromagnetic device, e.g., members of the JSAE are expected to increase the number of IEEJ memberships and contribute to Society A.