

MAGNETIC PROPERTIES MEASUREMENT OF NEW MAGNETIC MATERIAL: SOMALOY 700 (5P)

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This dissertation is submitted for the degree of

Doctor of Philosophy

April 2018

CERTIFICATE OF ORIGINAL AUTHORSHIP

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This research is supported by the Australian Government Research Training Program.

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8 April 2018

ABSTRACT

The everyday lives of people have been dramatically changed due to the evolution of technology. The invention of electrical machines has enabled human to do their chores with easier and more comfortable way. Presently, electromagnetic technology is improving day by day and most of the current electrical machines require the magnetic cores to operate at higher frequency to meet the demand of high-speed performance in catching up the aggressive technological evolution. On top of that, the researchers and engineers are aiming for the lower loss magnetic material in order to obtain the high efficiency of the electrical machines. Magnetic properties of soft magnetic material have been actively studied under 1-D and 2-D magnetic flux excitations to estimate the total core loss produced by the material during the magnetisation of electrical machine. In the past years, soft magnetic composite (SMC) materials were used in designing flexible electromagnetic devices due to their unique properties such as magnetic isotropy that consists of small insulated iron particles with low eddy current. SMC materials are suitable for these applications because of their properties like high electrical resistivity which leads to the low eddy current loss, and 3-D magnetic isotropy which provides great design flexibility of various electromagnetic devices. In this project, the magnetic properties of a new SMC material, SOMALOY 700 (5P) from Hogan has been studied since it offers low core loss during magnetisation. The magnetic properties should be properly measured as there are some variations of vector flux density in the rotating machine. 1-D and 2-D magnetic measurements are conducted by controlling magnetic flux densities to be in various shapes by using LabVIEW software. The x-, y- and z-axes of magnetic flux densities were generated by using the 3-D magnetic property testing system. The results of the measurement are analysed by using the Mathcad software before being compared to other materials. The performances of this material at wide range of frequency are exhibited by plotting the loss curves in the same graph. The finding indicates that the magnetisation at 1000 Hz contributes higher core loss for all types of magnetic flux excitation. At high frequency, the total core losses are dominated by hysteresis loss. The core loss curves with clockwise and anti-clockwise directions presented the similar rotational core loss. Besides that, the elliptical core loss with B_x and B_y as the major axes are similar in magnitude. All types of core losses are analysed and verified by comparing them with the calculation theory. The accuracy of the core loss has been obtained by considering Mean Absolute Percentage Error (MAPE) to compute the percentage error of the measurement. The details of SOMALOY 700 (5P) material provide good information to engineers in designing electrical machine at different variation of frequencies.

ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere gratitude to my supervisor Associate Professor Youguang Guo for the continuous support of my Ph.D study and related research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined to have a better supervisor and mentor for my Ph.D study.

Besides my supervisor, I would like to thank the co-supervisors of my Ph.D project, Prof. Jianguo Zhu, and Dr. Fatimah Sham Ismail for their insightful comments and encouragement, but also for the hard questions which triggered me to widen my research from various perspectives.

I am also grateful to the following university staff, Jan Szymanski and Russell Nicholson for their unfailing support and assistance during my Ph.D lab works in the CEMPE Lab. Without their support, I could not have imagined that I can finish my lab works smoothly and successfully.

A very special gratitude goes out to my sponsorship Majlis Amanah Rakyat (MARA) Malaysia and Universiti Kuala Lumpur (UNIKL) for helping and providing the funding of my Ph.D study and four years allowance for me and my family members during my stay in Sydney, Australia.

I am grateful to my parents and siblings, who have provided me through moral and emotional support in my life. I am also grateful to my other family members and friends who have supported me along the way from my home country, Malaysia.

And most of all for my loving, supportive, encouraging, and patient husband Azlan Zawawi whose faithful support from the beginning until the final stages of this Ph.D. is so appreciated. With a special mention to my sweet daughter, Fathanah Aisya Azlan, thank you for being a nice girl and always understanding my busy life. I owe you the precious quality time from the start of your existence in this world. I promise that I will compensate the missed moment after my submission of thesis.

Last but not the least, I would like to thank my colleagues for supporting me spiritually throughout the writing of this thesis. Thanks for all your encouragement!

ABBREVIATION

| Abbreviation | Full Term |
|--------------|---|
| SMC | Soft Magnetic Composite |
| HR | High Resistivity |
| SE | Steinmetz Equation |
| DC | Direct Current |
| AC | Alternating Current |
| iGSE | Improved Generalized Steinmetz Equation |
| GSE | Generalized Steinmetz Equation |
| SPG | Steinmetz Pre-Magnetisation Graph |
| EMF | Electromotive Force |
| FEA | Finite Element Analysis |
| UTS | University of Technology Sydney |
| NI | National Instrument |
| DAQ | Data Acquisition Card |
| 3-D | Three-dimensional |
| 2-D | Two-dimensional |
| 1-D | One-dimensional |
| A/D | Analog to Digital |
| D/A | Digital to Analog |
| ES&S | Enokizono, Soda and Shimoji Model |
| FEM | Finite Element Method |

NOMENCLATURE

| Symbol | Physical Quantity |
|--------------------------|---|
| H | magnetic flux density strength |
| B | magnetic flux density |
| H_c | coercivity |
| χ_m | susceptibility |
| μ | permeability |
| f | frequency |
| P_t | total power loss or core loss |
| P_α | alternating core loss |
| P_r | rotational core loss |
| $P_e/P_{e\alpha}/P_{er}$ | eddy current loss |
| $P_h/P_{h\alpha}/P_{hr}$ | hysteresis loss |
| $P_a/P_{a\alpha}/P_{ar}$ | anomalous loss |
| k | material parameter |
| A | material parameter |
| B | material parameter |
| $C_h/C_{h\alpha}$ | loss coefficient |
| N | loss coefficient |
| $C_e/C_{e\alpha}/C_{er}$ | loss coefficient |
| $C_{a\alpha}/C_{ar}$ | loss coefficient |
| B_s | saturation magnetic flux density |
| μ_0 | permeability of vacuum |
| K_H/K_B | coil coefficient |
| V_H | terminal voltage of the H sensing coil |
| V_m | scalar magnetic potential |
| l_{AB} | distance between points A and B |
| A_H/A_{sp} | cross-sectional area |
| n_c | number of turns per unit length of the coil |
| T | thickness of the plate |
| R_H | Hall constant |

| Symbol | Physical Quantity |
|---------------|-----------------------------------|
| C | specific heat capacity |
| ϑ | temperature of the sample |
| T | time period of magnetisation |
| M | magnetisation |
| ρ_m | sample mass density |
| E_B / E_H | excitation of current |
| a_r | radius of the bottom circle |
| b_r | radius of the upper circle |
| l_0 | half length of the air gap |
| Θ | cone angle with the axis |
| ε | axis ratio |
| v_{xr} | magnetic reluctivity coefficient |
| v_{xi} | magnetic hysteresis coefficient |
| v | magnetic reluctivity tensor |
| Φ | inclination angles |
| N | number of turns |
| I | current / magnetisation current |
| \varnothing | magnetic flux |
| l_m | mean length of magnetic flux path |
| V | induced electromotive force |
| d | thickness of the sample |

TABLE OF CONTENTS

| | |
|--|------------|
| ABSTRACT | I |
| ACKNOWLEDGEMENTS | II |
| ABBREVIATION | III |
| NOMENCLATURE | IV |
| LIST OF FIGURES | IX |
| LIST OF TABLES | XIV |
| CHAPTER 1: INTRODUCTION | 1 |
| 1.1 Research background | 1 |
| 1.2 Research aim and objectives | 4 |
| 1.3 Thesis structure | 5 |
| CHAPTER 2 : LITERATURE REVIEW | 8 |
| 2.1 Core loss calculation | 8 |
| 2.1.1 Core loss prediction by empirical equation | 8 |
| 2.1.1.1 Core loss in magnetic material | 8 |
| 2.1.1.2 Core loss in rotating electrical machines | 15 |
| 2.1.2 Core loss prediction by hysteresis loop | 17 |
| 2.2 Techniques measuring the magnetic flux density and magnetic field strength | 18 |
| 2.2.1 Magnetisation current method | 18 |
| 2.2.2 Sensing coil method | 18 |
| 2.2.2.1 Conventional H coil | 18 |
| 2.2.2.2 Two H coil arrangement | 19 |
| 2.2.2.3 The Rogowski-Chattock coil | 20 |
| 2.2.2.4 B Coil | 21 |
| 2.2.2.5 Embedded B coil | 21 |
| 2.2.3 Hall element | 22 |
| 2.2.4 B- tips | 23 |
| 2.3 Methods of measuring the rotational core losses | 24 |
| 2.3.1 Torque-metric method | 24 |
| 2.3.2 Thermometric method | 24 |
| 2.3.3 Field-metric method | 25 |
| 2.3.4 Watt-metric method | 25 |
| 2.4 Measuring apparatus of core loss | 26 |

| | |
|---|------------|
| 2.4.1 Disk and ring samples | 26 |
| 2.4.2 Cross and strip samples | 30 |
| 2.4.3 Epstein frame | 33 |
| 2.4.4 Toroid tester | 33 |
| 2.4.5 Square samples | 34 |
| 2.4.6 3-D Magnetic property testing system | 40 |
| 2.5 Magnetic properties measurement of soft magnetic material by using 3-D magnetic properties system | 51 |
| 2.6 Summary | 83 |
| CHAPTER 3 : PREPARATION FOR MEASUREMENT TESTING SET UP | 95 |
| 3.1 Introduction | 95 |
| 3.2 Calibration of sensing coils | 96 |
| 3.3 Software skills | 101 |
| 3.3.1 LabVIEW software | 103 |
| 3.3.2 Mathcad software | 105 |
| 3.4 Experimental set up | 105 |
| 3.5 Conclusion | 107 |
| CHAPTER 4 : CORE LOSS MEASUREMENT UNDER ALTERNATING MAGNETIC FLUX DENSITY | 110 |
| 4.1 Introduction | 110 |
| 4.2 Principle of alternating core loss | 111 |
| 4.2.1 Hysteresis loop | 111 |
| 4.2.2 Core loss curve | 112 |
| 4.3 Experimental results | 112 |
| 4.3.1 Hysteresis loops of alternating core loss | 113 |
| 4.3.2 Core loss of alternating magnetic flux density | 117 |
| 4.3.2.1 Loss coefficient | 120 |
| 4.3.2.2 Core loss curve | 121 |
| 4.4 Core loss separation | 125 |
| 4.5 Conclusion | 129 |
| CHAPTER 5 : CORE LOSS MEASUREMENT UNDER CIRCULAR LOCI OF MAGNETIC FLUX DENSITY | 132 |
| 5.1 Introduction | 132 |
| 5.2 Principle and production of rotating magnetic flux density | 133 |

| | |
|---|----------------|
| 5.3 Experimental results | 133 |
| 5.3.1 B-H loops of rotating core loss | 134 |
| 5.3.2 Core loss of rotating magnetic flux density | 135 |
| 5.3.3 Clockwise and anti-clockwise 2-D measurements | 140 |
| 5.3.4 Core loss under alternating and rotating magnetic flux densities | 143 |
| 5.4 Core loss separation | 146 |
| 5.4.1 Hysteresis loss, eddy current loss and anomalous loss | 146 |
| 5.4.2 Rotational hysteresis loss | 151 |
| 5.5 Conclusion | 155 |
| CHAPTER 6 : CORE LOSS MEASUREMENT UNDER ELLIPTICAL LOCI OF MAGNETIC FLUX DENSITY | 158 |
| 6.1 Introduction | 158 |
| 6.2 Rotating elliptical magnetic flux density | 159 |
| 6.3 Experimental results | 160 |
| 6.3.1 B-H Loci under elliptical magnetic flux density | 160 |
| 6.3.2 Core loss curve under rotating magnetic flux density | 163 |
| 6.3.2.1 Circular and elliptical core loss | 166 |
| 6.3.2.2 Accuracy of core loss measurement | 168 |
| 6.4 Conclusion | 172 |
| CHAPTER 7 : CONCLUSIONS AND RECOMMENDATIONS | 174 |
| 7.1 Conclusions | 174 |
| 7.2 Recommendations for future research | 177 |
| APPENDIX A: List of publications | 179 |
| APPENDIX B: Procedures applied in Software used | 180 |
| APPENDIX C: Figures and apparatus of experiment | 183 |

LIST OF FIGURES

| | |
|---|----|
| Fig. 2.1 The efficiency and loss percentage in (a) 110 kW permanent magnet high-speed generator (51000 rpm) (b) 11 kW induction machine (1470 rpm) (c) 1 kW slot-less permanent magnet motor (36000 rpm) [2.14] | 11 |
| Fig. 2.2 Rotational hysteresis loss of iron and steel obtained by Bailly in 1896 [2.20] | 13 |
| Fig. 2.3 (a) Alternating hysteresis loss (b) Rotational hysteresis loss [2.24] | 14 |
| Fig. 2.4 Comparison between (a) alternating core loss and (b) rotational core loss at wide range of frequency [2.25] | 14 |
| Fig. 2.5 One pole pitch of one stack of a claw pole machine [2.26] | 15 |
| Fig. 2.6 Hysteresis loops of the SMC sample with 5 Hz sinusoidal magnetic flux density on (a) x-and (b) y-axes [2.22] | 17 |
| Fig. 2.7(a) 1-D H coil (b) 2-D H coil (c) position of H coils on the sample surface [2.16] | 19 |
| Fig. 2.8 Two H coil arrangement [2.35], [2.36] | 19 |
| Fig. 2.9 The Rogowski- Chattock coil [2.39] | 20 |
| Fig.2.10 (a) Wound coil in uniform magnetic field, (b) threaded coil in non-uniform magnetic field [2.39] | 21 |
| Fig. 2.11 Structure of B coil and H coil [2.40] | 22 |
| Fig. 2.12 Relationship between magnetic field strength, current and EMF in the Hall Effect [2.41] | 22 |
| Fig. 2.13 Principle of measuring one component of B using tips [2.45] | 23 |
| Fig. 2.14 Torque magnetometer with the labelled parts [2.21] | 27 |
| Fig. 2.15 Layout of the experiment built by Fiorillo and Reitto (1988) [2.58] | 28 |
| Fig. 2.16 Rotational core loss versus flux density in three materials: (1) soft iron, (2) grain oriented silicon iron, and (3) non-oriented silicon iron [2.58] | 29 |
| Fig. 2.17 The set up apparatus of rotational power loss measuring system that uses a stack of ring sample built in 1987 [2.50] | 29 |
| Fig. 2.18 The circular diagram of the rotational power loss measuring system by [2.50] | 30 |
| Fig. 2.19 Cross sample used by Moses & Bleddyn Thomas (1973) [2.50] | 30 |
| Fig. 2.20 The measuring rotational core loss apparatus where A and B are the fixed ends and C and D are the spring loaded ends [2.59] | 31 |
| Fig. 2.21 Rotational core loss measuring system using cross samples [2.43] (a) Block diagram of the system (b) Arrangement of B and H sensing coils [2.43] | 32 |
| Fig. 2.22 Rotational core loss measuring system using an Epstein strip (a) configuration (b) magnetic flux search coils, and (c) system diagram [2.35], [2.60] | 33 |
| Fig. 2.23 Rotational core loss tester using square samples: (a) Arrangement of yoke, sample and sensors, and (b) details of sensor head for one component of H and B [2.21], [2.65] | 34 |

| | |
|--|----|
| Fig. 2.24 Rotational core loss measuring system was built by Enokizono and Sievert: (a) Outline of system and B tips, (b) magnetic circuit and B sensing coils, (c) H sensing coils, and (d) setting of H coils [2.44], [2.66] | 35 |
| Fig. 2.25 The square specimen tester with complicated auxiliary yokes: (a) position of specimen, B and H coils, (b) dimension of H coils, (c) flux flow parallel to the auxiliary yoke, and (d) flux flow perpendicular to auxiliary yoke [2.70] | 36 |
| Fig. 2.26 The structure of square specimen tester developed by Gumaidh et al.: (a) tester, (b) sample and sensor holder [2.71] | 37 |
| Fig. 2.27 Rotational core loss tester built by Kedous-Lebouc et al. (1991): (a) tester, (b) B and H search coils [2.72] | 37 |
| Fig. 2.28 Schematic diagram of square sample tester [2.16], [2.33] | 38 |
| Fig. 2.29 Sandwich arrangement of H sensing coils [2.16], [2.33] | 39 |
| Fig. 2.30 (a) 2-D Rogowski-Chattock [2.79]. (b) Position of the sample between the magnetisation poles with attached conventional H coils [2.22] | 39 |
| Fig. 2.31 (a) 3-D magnetic property testing system [2.86]. (b) Framework of 3-D Tester [2.82] | 41 |
| Fig. 2.32 A cubic sample and its B and H sensing coils [2.82] | 41 |
| Fig. 2.33 Calibration of H sensing coils in the long solenoid [2.86] | 43 |
| Fig. 2.34 Improved structure of H coils and B coils [2.40] | 44 |
| Fig. 2.35 Sample with sensing coils [2.40] | 44 |
| Fig. 2.36 Magnetic line of force through the coil [2.40] | 44 |
| Fig. 2.37 The EMF signals of B and H sensing coils under three axes excitation current [2.88] | 46 |
| Fig. 2.38 Structure of guarding pieces or field core shoes: (a) cubic sensing box with sample, sensing coils and guard pieces [2.83] (b) cubic specimen with homogeneous field core shoes [2.96] | 48 |
| Fig. 2.39 Schematic diagram and cross section of the 3-D tester [2.88] | 48 |
| Fig. 2.40 Magnetic field distribution of the specimen without (left) and with (right) guarding pieces [2.96] | 49 |
| Fig. 2.41 Model of 3-D magnetisation structure with “C-types” cores [2.96] | 49 |
| Fig. 2.42 (a) Prototype of laminated “C-type” core and excitation windings [2.96] (b) Schematic frustum structure of the core pole [2.96] | 50 |
| Fig. 2.43 Magnetic flux density distribution in the magnetic concentration model by finite element method [2.97] | 51 |
| Fig. 2.44 (a) Hysteresis loop at 50 Hz along x-, y- and z-axes (b) B and H loci of grain oriented Hi-B in the XOY-plane [2.82] | 52 |
| Fig. 2.45 (a) B loci when magnetic fluxes have been controlled to make B in circle shape (b) the corresponding of H loci [2.98] | 52 |
| Fig. 2.46 Misalignment of sensors [2.98] | 54 |
| Fig. 2.47 (a) B loci and (b) the corresponding of H loci at operating frequency of 50 Hz [2.83] .. | 55 |
| Fig. 2.48 The Hysteresis loop at 50 Hz along x-, y- and z-axes [2.83] | 55 |

| | |
|---|----|
| Fig. 2.49 Arrangement of B and H sensing coils (left) with consideration of planar structure for H coils (right) [2.85] | 56 |
| Fig. 2.50 (a) Circular B loci when the magnetic field has amplitude of 1.3 T at 50 Hz. (b) The corresponding of H loci in 3-D space [2.85]..... | 56 |
| Fig. 2.51 (a) B loci in spherical shape at 50 Hz lying in three orthogonal planes. (b) The corresponding H loci [2.85] | 56 |
| Fig. 2.52 Round B loci in (a) XOY-plane, (b) YOZ-plane, (c) ZOX-plane and the corresponding H loci in (d) XOY-plane, (e) YOZ-plane and (f) ZOX-plane at 50 Hz [2.99]..... | 58 |
| Fig. 2.53 Power core loss under (a) alternating magnetic fluxes along x-, y- and z-axes (b) rotational magnetic fluxes in three different planes at 50 Hz [2.99] | 59 |
| Fig. 2.54 Elliptical B loci with y as a major axis in (a) XOY- (b) YOZ- (c) ZOX-planes and their corresponding H loci in (d) XOY- (e) YOZ- (f) ZOX-planes [2.100]..... | 60 |
| Fig. 2.55 Ellipse B loci with x as a major axis in the (a) XOY- (b) YOZ- (c) ZOX-planes and their corresponding H loci in (d) XOY- (e) YOZ- (f) ZOX-planes [2.100]..... | 61 |
| Fig. 2.56 (a) Alternating flux condition. (b) Rotating flux condition [2.101]..... | 62 |
| Fig. 2.57 Comparison of core losses depending of θ_B for (a) grain oriented and (b) non-oriented electrical steel sheets [2.101] | 64 |
| Fig. 2.58 Relationship among maximum magnetic flux density B_m , axis ratio ε , and inclination angles φ of the elliptical B locus [2.104]..... | 66 |
| Fig. 2.59 Magnetic reluctivity tensor of one cycle in the XOY-plane when B is round rotating ($\varepsilon = 1$), (a) $B_r = 0.22$ T (b) $B_r = 1.32$ T [2.104]..... | 67 |
| Fig. 2.60 Magnetic reluctivity tensor against the magnitude of the maximum B when the circle angle $\theta = 45^\circ$. (a) Diagonal elements and (b) Off-diagonal elements [2.104] | 68 |
| Fig. 2.61 Magnetic reluctivity tensor against the magnitude of the maximum round rotating B [2.104]..... | 68 |
| Fig. 2.62 Relation among the instant values of magnetic reluctivity of off-diagonal elements, axis ratio and phase angle $\theta = 45^\circ$ [2.104]..... | 69 |
| Fig. 2.63 The hysteresis loops of SOMALOY 500 at (a) 5 Hz (b) 20 Hz (c) 500 Hz and (d) 1000 Hz under alternating flux densities [2.93]..... | 70 |
| Fig. 2.64 Hysteresis loops along the x-, y- and z-axes at 50 Hz [2.93] | 71 |
| Fig. 2.65 (a) B loci and (b) the corresponding of H loci at 50 Hz of operating frequency [2.93] .. | 71 |
| Fig. 2. 2.66 Loss curve along the y-axis at wide range of frequency up to 1000 Hz [2.93] | 72 |
| Fig. 2.67 3-D magnetic properties of SOMALOY 500 with elliptical rotating magnetic flux density at 200 Hz. (a) x, y and z as major axes for red, blue and green B loci, respectively.(b) The corresponding H loci for major axes x, y and z are represented by red, blue and green lines, respectively. (c) x, y and z as major axes for green, red and blue B loci, respectively and (d) the corresponding H loci for axes x, y and z are represented by green, red and blue lines, respectively [2.93]..... | 73 |

| | |
|--|-----|
| Fig. 2.68 The projection of (a) blue B loci with y as a major axis, (b) the corresponding blue H loci for y major axis (c) green B loci with x as a major axis and (d) the corresponding green H loci for x major axis [2.89]..... | 74 |
| Fig. 2.69 The core losses versus ratio axis of elliptical B loci (0-1) and amplitudes of round B loci [2.89]..... | 75 |
| Fig. 2.70 (a) Sphere B loci are controlled in 3-D space at 50 Hz of operating frequency (b) the corresponding H loci in 3-D space [2.89] | 75 |
| Fig. 2.71 The round B loci and H loci in the XOY-plane at (a) 200 Hz, (b) 500 Hz and (c) 1000 Hz [2.106]..... | 76 |
| Fig. 2.72 The core loss at 50 Hz, 100 Hz, 200 Hz, 500 Hz and 1000 Hz under (a) alternating magnetic fluxes (b) rotational magnetic fluxes [2.106] | 77 |
| Fig. 2.73 B locus in the middle part of SMC stator core with the blue line shows the no load motor, the green line is the B locus for half load motor and the red line represents the full load motor [2.28]..... | 78 |
| Fig. 2.74 Waveforms of B components from three different situations; no load, half load and full load [2.28] | 78 |
| Fig. 2.75 Round B loci and the corresponding H loci at (a) 5 Hz, (b) 20 Hz, (c) 200 Hz and (d) 500 Hz [2.107]..... | 81 |
| Fig. 2.76 Relationship between alternating and rotational excitations at 0.5 T of magnetic flux density [2.107] | 82 |
| Fig. 2.77 Spherical B loci of magnetic material on three planes [2.96] | 83 |
| Fig. 3.1 SOMALOY 700 (5P) cubic sample with sensing coils | 96 |
| Fig. 3.2 An acrylic sensing box and guarding pieces hold the sensing coils to locate on the surfaces of the cubic sample | 96 |
| Fig. 3.3 Calibration of B and H sensing coils..... | 98 |
| Fig. 3.4 Circuit diagram of calibration process | 98 |
| Fig. 3.5 Graph of V against I | 99 |
| Fig. 3.6 Excitation of magnetic flux density before and during the calibration | 100 |
| Fig. 3.7 The induced voltages of B and H coils during the calibration process..... | 100 |
| Fig. 3.8 A uniform wire of length L, and cross-sectional area A, [3.4] | 101 |
| Fig. 3.9 Block diagram of LabVIEW in recording the induced sensing voltages during calibration process..... | 103 |
| Fig. 3.10 Block diagram of LabVIEW in generating and controlling the magnetic flux density and determining the sensing voltages during magnetisation process..... | 104 |
| Fig. 3.11 Magnetic properties testing system [3.5] | 105 |
| Fig. 3.12 Op-Amp module with 10x, 100x and 1000x amplification gain | 106 |
| Fig. 3.13 Measurements of magnetic properties of SOMALOY 700 (5P) material | 106 |
| Fig. 4.1 The core loss curve of SOMALOY 500 at 50 Hz along the x-, y- and z-axes [4.5] | 112 |
| Fig. 4.2 The hysteresis loops of SOMALOY 700 (5P) and SOMALOY 500 at 50 Hz | 114 |

| | |
|--|-----|
| Fig. 4.3 The hysteresis loops of SOMALOY 700 (5P) in the x-axis at (a) 50 Hz (b) 100 Hz (c) 500 Hz and (d) 1000 Hz | 116 |
| Fig. 4.4 Three reading of alternating core loss with 0.405 of standard deviation | 118 |
| Fig. 4.5 Loss curve of SOMALOY 700 (5P) at 50 Hz for three different axes | 119 |
| Fig. 4.6 The alternating core loss at 50 Hz | 119 |
| Fig. 4.7 Loss curve of SOMALOY 700 (5P) material at 50 Hz, 100 Hz, 500 Hz and 1000 Hz .. | 120 |
| Fig. 4.8 Comparison between calculated and measured data at (a) 50 Hz (b) 100 Hz (c) 500 Hz and (d) 1000 Hz | 122 |
| Fig. 4.9 The core loss curve of measured data and manufacturing data from Hoganas at (a) 50 Hz (b) 100 Hz, (c) 500 Hz and (d) 1000 Hz | 124 |
| Fig. 4.10 Core loss components at (a) 50 Hz, (b) 100 Hz, (c) 500 Hz and (d) 1000 Hz | 126 |
| Fig. 5.1 Round B loci and corresponding H loci in the XOY-plane at (a) 50 Hz (b) 100 Hz (c) 500 Hz and (d) 1000 Hz | 135 |
| Fig. 5.2 Three times of rotational core loss measurements with 0.474 of standard deviation ... | 136 |
| Fig. 5.3 The individual core losses and total core loss at 50 Hz in (a) clockwise and (b) anti-clockwise directions..... | 137 |
| Fig. 5.4 Loss curve of SOMALOY 700 (5P) material in the XOY-plane when flux densities are controlled to in round shape at (a) 50 Hz (b) 100 Hz, (c) 500 Hz and (d) 1000 Hz | 139 |
| Fig. 5.5 The rotating core losses at low to high frequencies | 140 |
| Fig. 5.6 The loss curve of SOMALOY 700 (5P) material in clockwise and anti-clockwise 2-D measurements at (a) 50 Hz (b) 100 Hz (c) 500 Hz and (d) 1000 Hz | 142 |
| Fig. 5.7 The alternating core loss and rotational core loss of SOMALOY 700 (5P) at (a) 50 Hz, (b) 100 Hz, (c) 500 Hz and (d) 1000 Hz | 145 |
| Fig. 5.8 Separation of total core loss which contains P_h , P_e and P_a when B is controlled to be in round shape at (a) 50 Hz, (b) 500 Hz and (c) 1000 Hz..... | 149 |
| Fig. 5.9 The measured and calculated rotational core loss at 50 Hz, 100 Hz, 500 Hz and 1000 Hz | 151 |
| Fig. 5.10 The components of rotational core loss of SOMALOY 700 (5P) material in the XOY-plane (a) hysteresis core loss (b) eddy current core loss (c) anomalous loss..... | 153 |
| Fig. 5.11 The measured and calculated hysteresis losses per cycle at 50 Hz..... | 155 |
| Fig. 6.1 The induction machine (a) The stator and rotor parts (b) the inner part of stator [6.1]. | 158 |
| Fig. 6.2 B loci at 50 Hz, 100 Hz and 1000 Hz of operating frequency: (a) x- and (b) y-major axes | 161 |
| Fig. 6.3 H loci at 50 Hz, 100 Hz and 1000 Hz of operating frequency: (a) x- and (b) y-major axes | 162 |
| Fig. 6.4 Elliptical core loss curve of SOMALOY 700 (5P) material when B loci are elliptical at (a) 50 Hz, (b) 100 Hz and (c) 1000 Hz | 164 |
| Fig. 6.5 Elliptical core loss curves of SOMALOY 700 (5P) material when B loci are elliptical at 50 Hz, 100 Hz and 1000 Hz. | 166 |

| | |
|---|-----|
| Fig. 6.6 Comparison between elliptical and circular core losses of SOMALLOY 700 (5P) material when B loci are elliptical at (a) 50 Hz, (b) 100 Hz and (c) 1000 Hz | 168 |
| Fig. 6.7 Comparison between measured and calculated core losses of SOMALLOY 700 (5P) material when B loci are elliptical at (a) 50 Hz, (b) 100 Hz and (c) 1000 Hz | 170 |

LIST OF TABLES

| | |
|--|-----|
| Table 2-1 Diagonal coefficients of the B and H sensing coils in unit of m^2 [2.88] | 46 |
| Table 2-2 Off- diagonal coefficient of the B and H sensing coils in unit of m^2 [2.88] | 46 |
| Table 3-1 Parameters of the wide-range of frequency experiment | 107 |
| Table 4-1 The components of alternating core losses at 50 Hz, 100 Hz, 500 Hz and 1000 Hz | 128 |
| Table 5-1 The components of rotating core losses at 50 Hz, 100 Hz, 500 Hz and 1000 Hz | 147 |
| Table 6-1 The elliptical core loss for x- and y-major axes and their average at 50 Hz, 100 Hz and 1000 Hz. | 165 |
| Table 6-2 The absolute percent errors of elliptical core loss measurement at (a) 50 Hz, (b) 100 Hz and (c) 1000 Hz | 171 |
| Table 6-3 Criteria of MAPE [6.7] | 172 |