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

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Ashraf Rohanim Asari declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering and Information Technology at the University of Technology Sydney

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information source and literature used are indicated in the thesis.

This thesis is the result of a research candidature conducted with another University as part of a collaborative Doctoral degree.

This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

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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 Hoganas 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.

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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
$P_a/ P_{\alpha\alpha}/ P_{\alpha r}$	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
$C_{\alpha\alpha}/C_{\alpha r}$	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
$ø$	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
$\imath_0$	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
υ	magnetic reluctivity tensor
Φ	inclination angles
N	number of turns
I	current / magnetisation current
$ø$	magnetic flux
l_m	mean length of magnetic flux path
V	induced electromotive force
d	thickness of the sample

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