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Realization of Change of Hysteresis and Eddy Current Losses, with Change of Electrical Parameters, by using Matlab and Simulink

Writwik Balow[*1], Bhaskar Lodh[2]

[*1] Assistant Professor, Department of Electrical Engineering, Ideal Institute of Engineering, Kalyani, Nadia, West Bengal, India

[2] P.G. Student, Department of Electrical Engineering, Bengal Institute of Technology & Management, Santiniketan, Birbhum, West Bengal, India

writwik.balow@gmail.com

Abstract

Hysteresis and Eddy current losses are most common losses occurring in static and rotating electrical machines. These losses depend on different variable and constant parameters. In this article, we will discuss variation of Hysteresis and Eddy current losses with changes in different parameters.

Keywords: Eddy Current Loss, Frequency, Hysteresis Loss, Lamination thickness, Matlab, Simulink.

Introduction

Hysteresis and eddy current losses are the common losses of the Electrical machines. The losses depend on various parameters e.g. flux density of the medium, supply voltage, supply frequency, thickness of the laminations, volume of the materials, nature of the materials. In this paper we are discussing how Hysteresis and Eddy current losses vary when the parameters change. We will be using the MATLAB simulation software and its Simulink environment. We will change the supply voltage, supply frequency, lamination thickness and observe the variations of the above said losses.

Introduction to Matlab- Simulink

In this analysis, simulation software named MATLAB is used for writing the programs, and simulink is used to construct various models. It is a very powerful tool in modern engineering field. MATLAB was first introduced in 1970 by a numerical analyst Cleve Moler, who wrote the first version of it. SIMULINK is a commercial tool furnished by MathWorks Inc. that comes with MATLAB. It is used for modelling and analyzing different types of static and dynamic systems. Both MATLAB & SIMULINK are successful computational and profit-making software. In this paper, we have constructed different models with help of different building blocks available in Simulink environment.

Hysteresis and Eddy Current Loss – an Overview

In this analysis we are programming in MATLAB. We will vary the supply voltage, thickness of the lamination of the materials and resistivity of the materials and observe change of Eddy current loss graphically. Similarly we will alter the supply voltage and supply frequency and observe the variation of the Hysteresis loss of the materials. The variations take place according to the following equations given below-

Hysteresis Loss (P_h) = $k.B_m^{1.6}.f.V$ in Watt (1)

Where B_m=Magnetic flux density in Wb/m^2. Its value varies from 1.5 to 2.5; here the value taken is 1.6.
k=Steinmetz co-efficient. Its value generally lies between 1.5 to 2.5.
f= Frequency magnetization in Hz.
V= volume of core in m^3.

Eddy Current Loss (P_e) = $K_e f^2 B_m^2$ in Watt (2)

Again, $P_e = (\Pi^2 / 6\rho).t^2.\ f^2\ B_m^2$ Watt. (3)

B_m= Magnetic flux density in Wb/m^2
f= Frequency magnetization in Hz.
K_e= $(\Pi^2 / 6\rho)$
t= thickness of lamination in mm.
ρ= resistivity of the materials.

Apart from the MATLAB programs, we have made Simulink models for observing the variation of the losses with respect to the above mentioned parameters.

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Characteristics Curves

By using the MATLAB program we have changes of the Hysteresis loss with increasing Supply Voltage and increasing Supply Frequency given by the following figures-

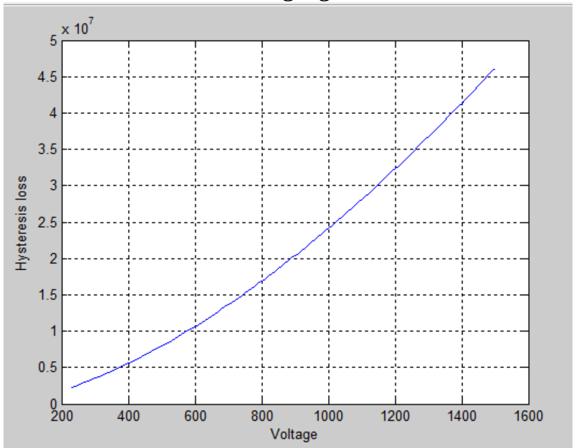

Fig-1: Supply Voltage Vs. Hysteresis Loss

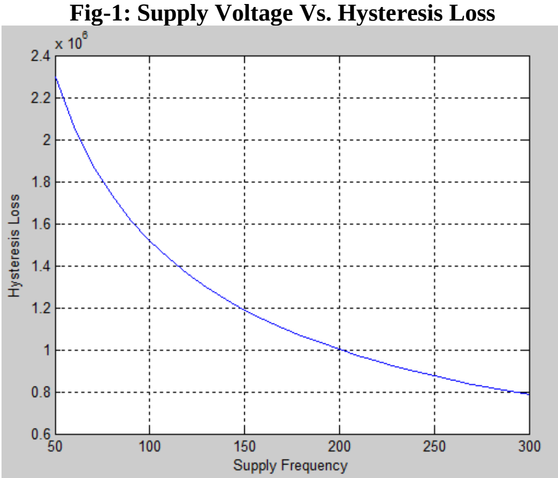

Fig-2: Supply Frequency Vs. Hysteresis Loss

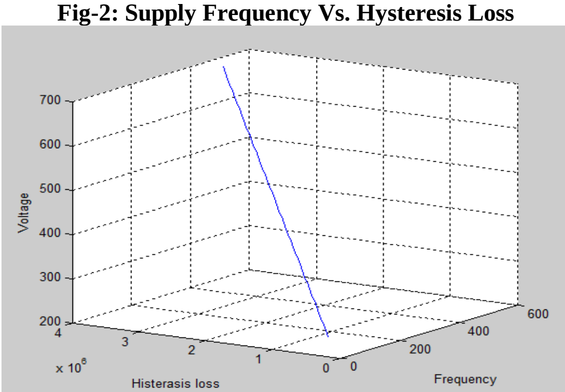

Fig-3: Graph between Change of Supply voltage, Supply Frequency and Hysteresis Loss

By using MATLAB program we have the change of the Eddy Current Loss with increasing Supply Voltage & increasing Lamination thickness of the materials described by the following figures-

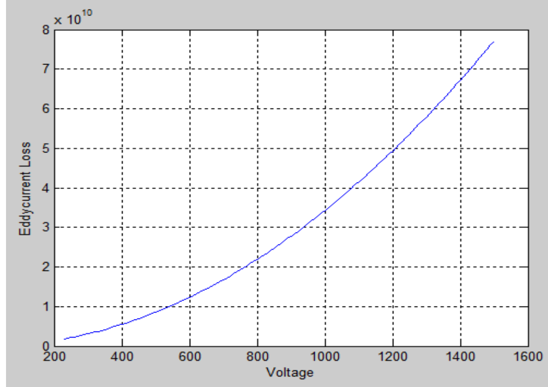

Fig-4: Supply Voltage Vs. Eddy Current Loss

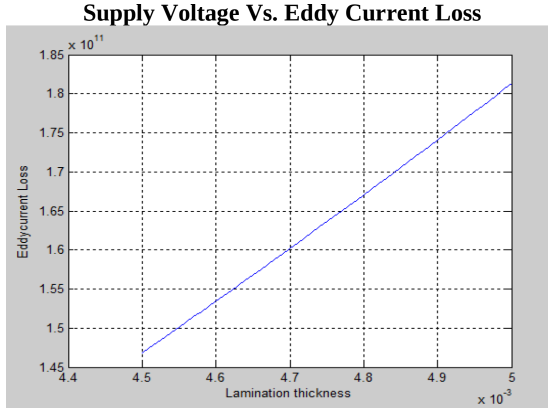

Fig-5: Lamination Thickness Vs. Eddy Current Loss.

In case when both the parameters are increasing in the nature then the 3D figure will be as-

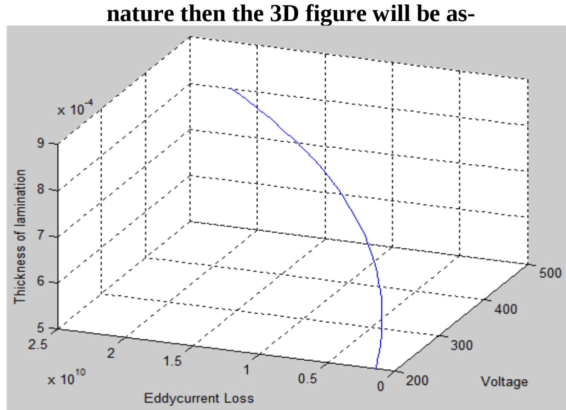

Fig-6: Graph between Change of Supply voltage, Lamination thickness and Eddy current Loss.

Following figure is representing the change of eddy current loss of the materials with the increasing of resistivity of the materials.

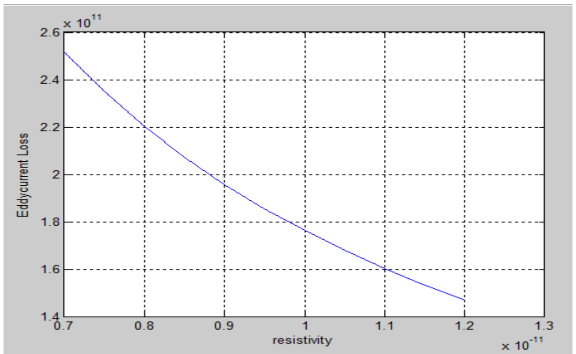

Fig-7: Change of eddy current loss with increasing of resistivity of the materials.

Analysis in Simulink Environment

Here Simulink model is given from where we get the change of hysteresis loss with respect to time and hysteresis loss with respect to change of supply frequency (increasing) and supply voltage (increasing).

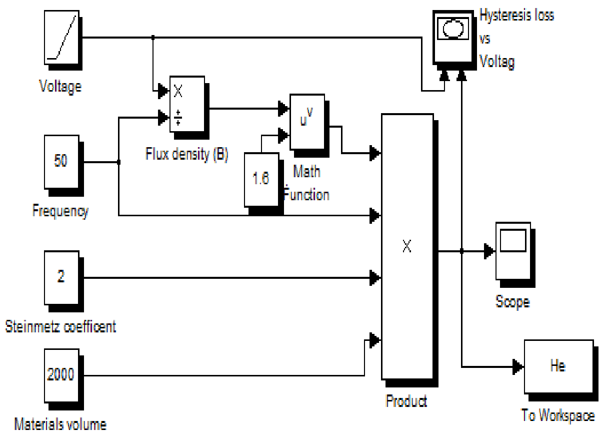

Fig-8: Block diagram for variation of Hysteresis loss with change of supply voltage.

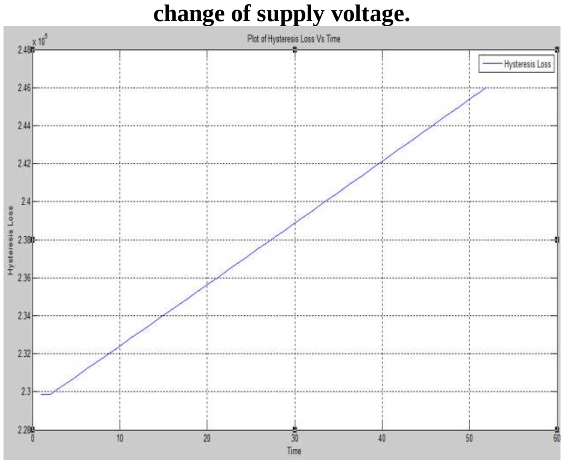

Fig-9: Change of Hysteresis loss vs. Time (when voltage is increasing).

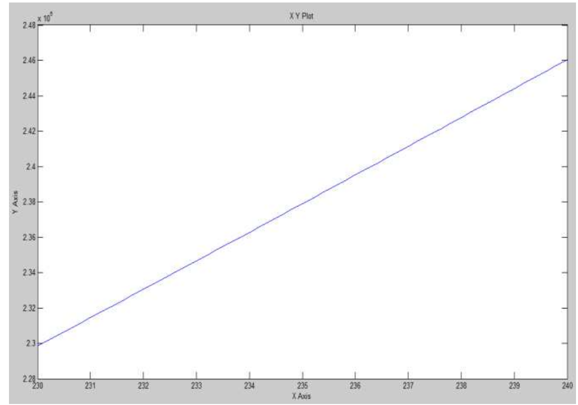

Fig-10: Change of Hysteresis loss vs. Change of voltage (X axis voltage and Y axis is hysteresis loss.)

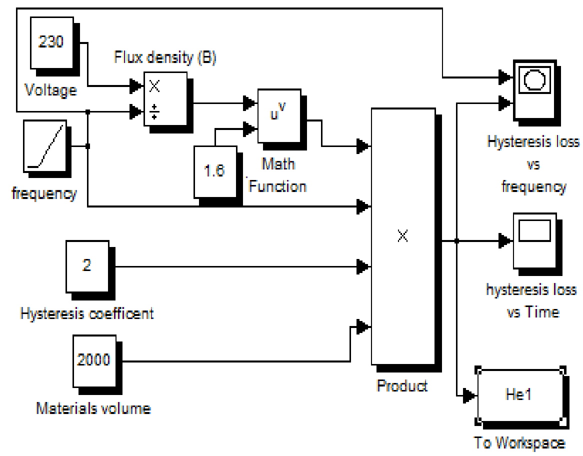

Fig-11: Block diagram of hysteresis loss variation with change of supply frequency.

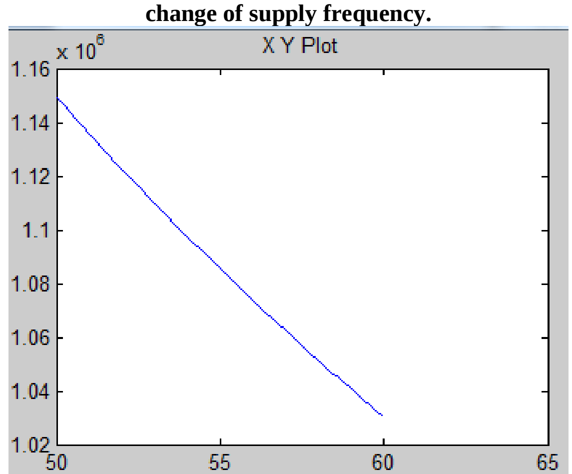

Fig-12: Change of hysteresis loss vs, supply Frequency (X axis is loss and Y axis is freq.)

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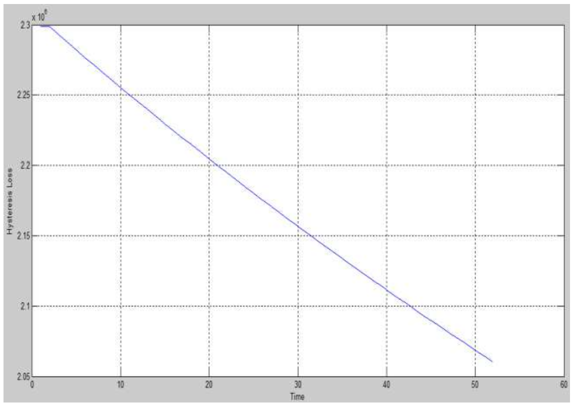

Fig-13: Change of Hysteresis loss vs. Time (When frequency is increasing).

Here a Simulink model is proposed from which we get the change of Eddy current loss with respect to time and eddy current loss with respect to change of supply voltage (increasing), change of lamination thickness (increasing) and resistivity (increasing).

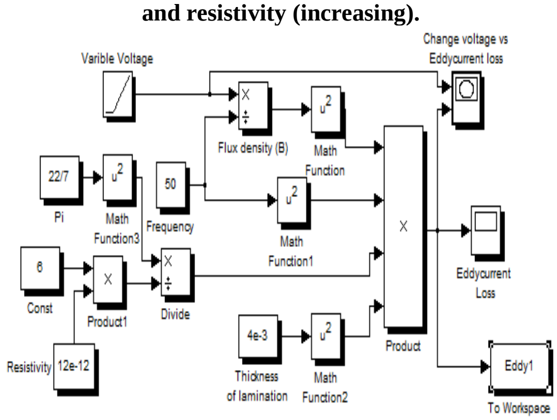

Fig-14: Block diagram of Eddy current loss variation with change of supply Voltage.

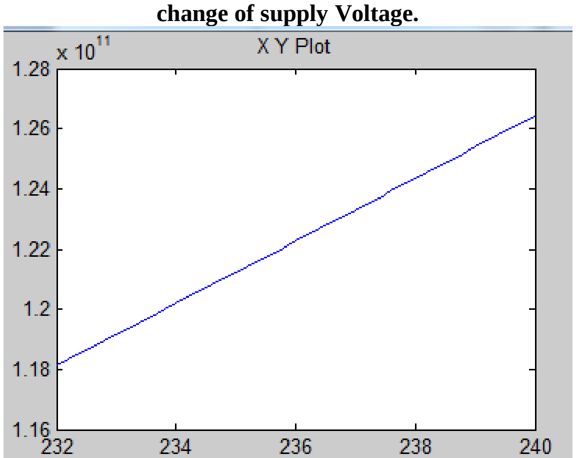

Fig-15: Change of Eddy current loss vs. Change of Voltage (X axis=voltage and Y axis=eddy current loss)

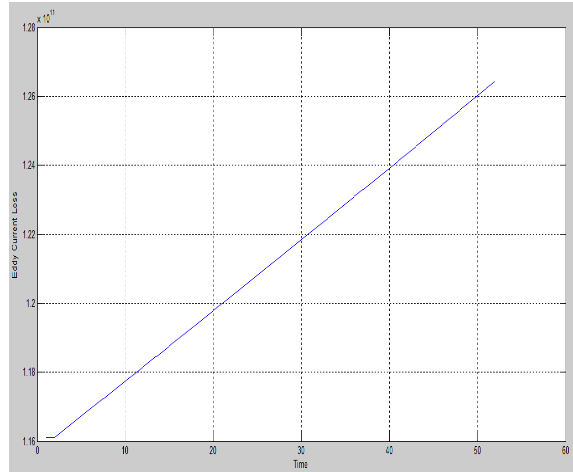

Fig-16: Change of Eddy current loss vs. Time (When supply voltage is increasing).

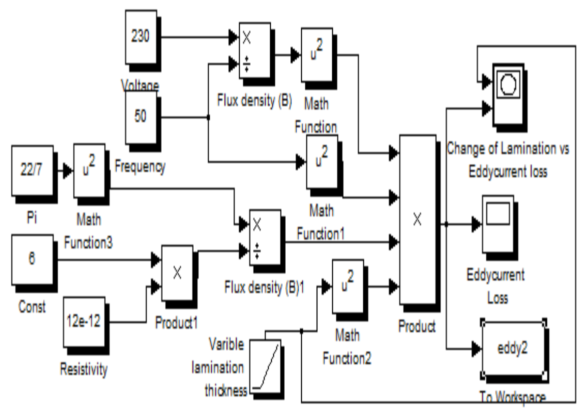

Fig-17: Block diagram of eddy current loss variation with change of lamination thickness

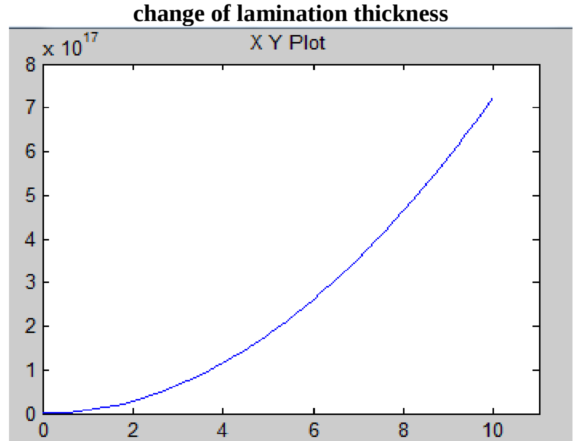

Fig-18: Change of Eddy current loss vs. of change of lamination thickness (X=thickness & Y=eddy current loss.)

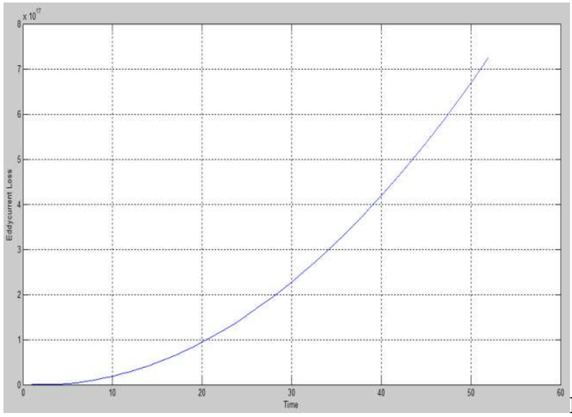

Fig-19: Change of Eddy current loss vs. Time (when lamination thickness is increasing)

Now, we observe the change of Eddy current loss with increasing the resistivity.

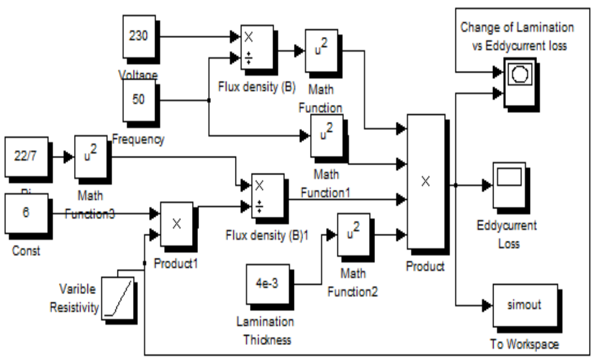

Fig-20:Block diagram of eddycurrent loss with change of resistivity of materials.

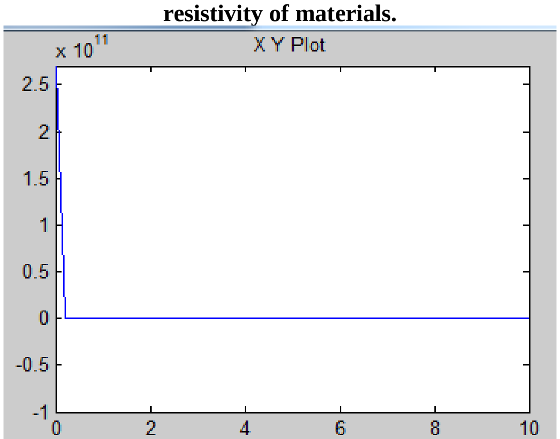

Fig-21: Change of eddy current loss vs. resistivity.

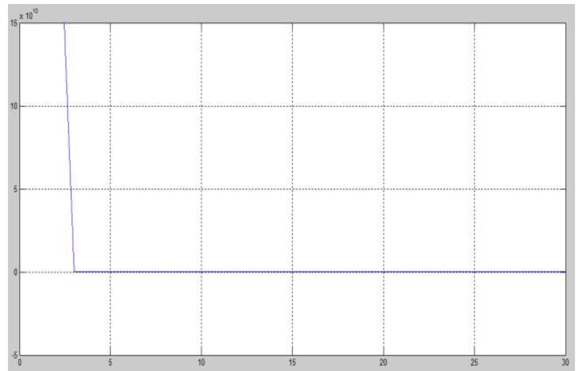

Fig-22: change of Eddy current loss vs. Time (when resistivity is increasing).

Conclusion

From the above discussion and obtained graphs we have the following conclusions. As the supply voltage is increased, the Hysteresis loss and Eddy current loss are increasing. Secondly, when the supply frequency is increasing then the Hysteresis loss is decreased. In case of loss is dependent on the thickness of the lamination; if thickness of the lamination is increased then the Eddy current loss is also increased. Finally, it can be concluded that Eddy current loss depends on the resistivity of the materials. If we use a material that possesses higher resistivity, then that material will produce low Eddy current loss.

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