Benefits of Nano-Powder Transformer Core

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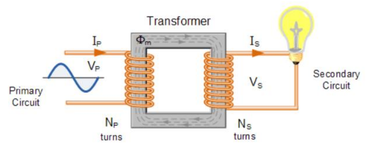
Abstract

An investigation was conducted to determine if nanoparticles increase the efficiency of magnetic cores. A direct comparison between off the shelf electrical steel (Fe-Si) has been done between cores made from iron (Fe) and Iron Oxide (Fe_3O_4) powder. A method of building nanoparticle cores without the need for heat or glue was developed, methods of coating nano powder were tested.

Introduction



1) Single Phase Voltage Transformer
https://www.electronics-tutorials.ws/transformer/transformer-basics.html

A magnetic core is a material used to contain and guide magnetic field so the field can be used or manipulated. A magnetic core also enhances the magnetic field. Ideal magnetic material for a magnetic core has a high magnetic permeability, a skinny hysteresis loop and high magnetic saturation.

Transformers are electrostatic devices used to change AC voltage which is essential in all industries. For years researchers have tried to increase efficiency in transformers. There are two ways to increase efficiency, one way is to reduce copper loss, and the other is to reduce the core loss.

To reduce core loss better materials are needed. Nanoparticle materials are becoming a focus of research in this area. This research is trying to find a way to build a magnetic core by using different nanoparticles.

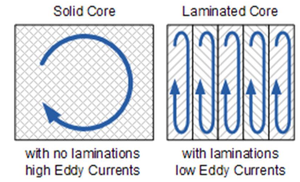
Transformer Equation

$$v_s(t) = \frac{N_s}{N_p} v_p(t)$$

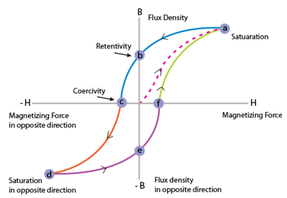
Ideal Transformer Equation

$$\frac{N_P}{N_S} = \frac{V_S}{V_P}$$

Theory



3) Eddy Currents
https://i.stack.imgur.com/cAvF7.gif



2) Hysteresis Loop
https://www.electricalengineering123.com/wp-content/uploads/2016/09/hysteresis-loop-in-transformer.png

Faraday's Law

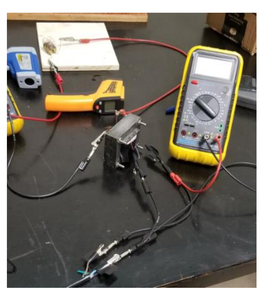
$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$$

Design

4) Coated Fe Core
Core material was pressed and put into a 3-d printed case that provided strength and durability to protect the core.

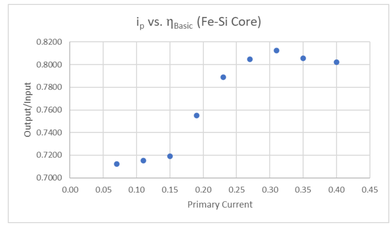
The powder was pressed into a mold that was built to the dimensions of the base line transformer. It was determined that 4 tons of pressure allowed for a density to hold the material together without any bonding agent, but still provided the density needed. Several outer coatings were attempted to provide additional strength to protect the core with a thin 3-d printed cover being the optimal choice.

5) Core material being checked for consistency after being pressed.



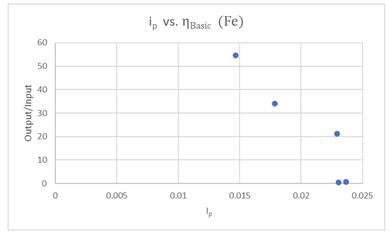
6) Data being collected from base line off the shelf transformer.

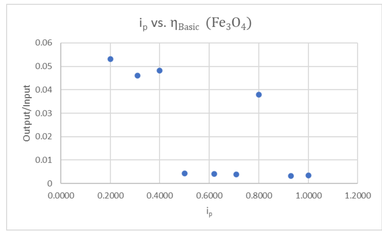
Results & Discussion



Baseline transformer proved to be 80%

The Fe core material was coating was not sufficient to fully coat the material.





Fe_3O_4 proved to have a low magnetic permeability.

Future Works

- Find a more efficient core material.
- Develop a method of evenly coating nanoparticles, in an insulating material that does not affect its magnetic properties.
- Determine the physical structure of the materials.
- Investigate feasibility of nanoparticle compounds.

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