Comparative Motor Design

Project Proposal

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Team number: 6

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1. Introduction

1.01. Statement of Interest

Today many induction motors are serving critical processes that do not have a back up. Since any failure is very costly, it is tempting to choose costly components not required for the specific situation while pursuing maximum reliability. The challenge is to maximize reliability without over spending. Therefore, it is necessary to come up with new rotor constructions with better efficiency.

1.02. Objectives

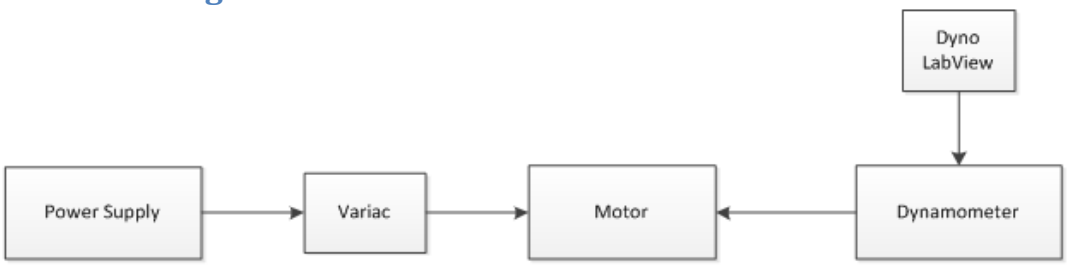
Our group will begin with a small commercial AC induction motor and design two improved rotor configurations that support comparative analysis in the lab. One rotor would be based on the commercial product, but would increase the amount of aluminum in the conductor bars to improve efficiency. The second would use copper in place of aluminum. Our team will develop and analyze the two rotor designs, arrange for rotor fabrication, and then test all three rotors for dynamic and steady-state performance. Finite element analysis software (e.g.ANSYS/Ansoft) will be used to do the computer simulation comparisons for the designed rotors.

1.03. Benefits & Features

- Obtain a detailed comparison data set for different motor designs
- Compare each design's cost to identify the best efficiency-cost ratio
- Provide a reference for future motor material selection and design

2. Design

2.01. Block Diagram



2.02. Block Descriptions

- Power Supply:
    - 60 Hz AC power supply up to 225 kVA
    - DC Power of ±120 V at up to 24 kW
- Variac ™: an autotransformer that varies the output voltage for a steady AC input voltage
- Motor: Current Selection 1/4 HP motor, Grainger #3N843
- Dyno LabView: controls Dynamometer
- Dynamometer: controls a torque and velocity for the testing motor

2.03. Performance Requirements

The basic goal for this project is to design 2 rotors based on commercial product and testing their characteristic data. In case to have a steady performance for the designed motors, the requirement for testing operation is 208-220/440 V, 60/50 Hz, maximum ambient temperature $40^{o}C$.

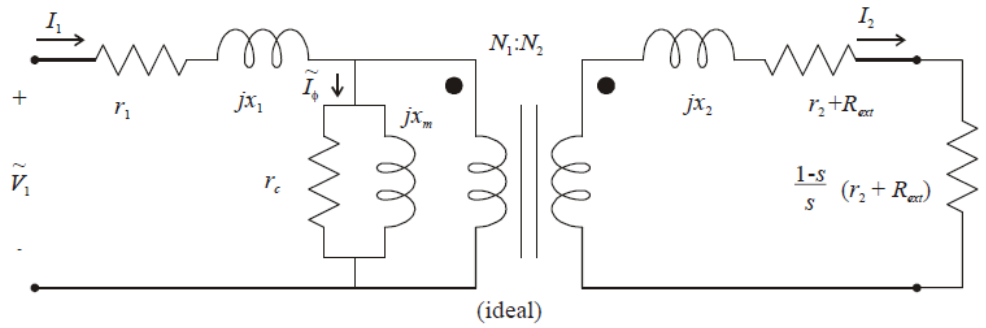
3. Verification

3.01. Testing Procedures

3.01.1. Simulation

An electromagnetic analysis software will be used to test the designed two rotors. In this project, we will use ANSYS Maxwell 14 and ANSYS RMxprt to analyzing the designed rotors, then comparing the analyzed data with the actual testing data.

3.01.2. Real Motor Testing



Equivalent Circuit of One Phase of A Three-Phase Induction Machine

Since we will test the operation characteristic for all three motors, several basic tests will be applied to obtain the basic machine operation data.

- DC Test

  Obtain line resistance for each phase.

- Open Circuit Test

  Obtain core loss (referred to stator) r_c and magnetizing reactance (referred to stator) x_m.

- Short Circuit Test

  Obtain $r_2 + R_{ext}$, (where r_2 is rotor single-phase winding resistance, and R_{ext} is External resistance), x_1 - stator single phase leakage reactance, x_2 - rotor single phase leakage reactance.

From the tests listed above, we will obtain the data that are needed to analyze the motor performance, such as torque-speed curve, motor speed control, motor efficiency, etc. These analyses will be applied on all three rotors that we have: reference rotor, aluminum rotor, and copper rotor.

3.02. Tolerance Analysis

In our project, the variation of casting material amount would affect greatly on motors' operation. The amount of aluminum and copper used in simulation may not actually matches the amount of casting material used in the real fabrication process. Therefore, in our tolerance analysis, we will examine how ideal simulation efficiency varies with the actual efficiency while $\pm$5% material amount difference may occur.

4. Cost

4.01. Equipment & Material Cost

Equipment & Material Cost			
Item Description	Item Price	Quantity	Total
1/4 HP Commercial Motor *	$185.5/unit	2 units	$371.00
Copper	$3.87/Lb	20 Lb	$77.40
Aluminum	$1.15/Lb	6 Lb	$6.90
Estimate Total Equipment & Material Cost			$455.30

* The motor type we choose for this project is Grainger #3N843, which is discontinued. Therefore for the price estimation, we choose the price for ¼ HP commercial Motor Grainger Item # 2K505.

Material Quantity Calculation

We estimated the volume for casting material is 1 liter. For Copper, whose density ρ=8.94kg/L, the mass for copper is $m_{Cu} = 8.94kg$, approximately 20Lb. Similarly, the density of Aluminum is $\rho = 2.7kg/L$, the mass for aluminum is $m_{Al} = 2.7kg$, approximately 6Lb.

4.02. Labor Cost

Labor Cost				
Item Description	Item Price	Quantity	Total	Total * 2.5
Foundary Labor	$200/unit	2 units	$400.00	$1,000.00
Xiaowen Bai	$20/hour	8 weeks	$1,600.00	$4,000.00
Li Cai	$20/hour	8 weeks	$1,600.00	$4,000.00
Cheng Xu	$20/hour	8 weeks	$1,600.00	$4,000.00
Estimate Total Labor Cost			$5,200.00	$13,000.00

4.03. Total Cost

Equipment and Material Cost	$455.30
Labor Cost	$13,000.00
Total Cost	$13,455.30

5. Schedule

Week	Tasks	Member
2/6	Proposal Research Background Paper Analyzing cost	Xiaowen
	Proposal IEEE Code of Ethics	Li
	Proposal Arrange appointments	Cheng
2/13	Sign-up for design review Preliminary Testing for Original Rotor	Xiaowen
	Contact local foundry Contact ECE stores and partshop	Li
	Preliminary Testing for Original Rotor Research IEEE Standard for Motor Testing	Cheng
2/20	Preliminary Data Analysis Prepare for design review	Xiaowen
	Prepare for design review	Li
	Preliminary Data Analysis Prepare for design review	Cheng
2/27	Test Aluminum Rotor Data Compile	Xiaowen
	Data Record Simulation	Li
	Data Compile	Cheng
3/5	Analyze Aluminum Rotor Data	Xiaowen
	Data Record Simulation	Li
	Test Aluminum Rotor Data Compile	Cheng
3/12	Test Copper Rotor Data Compile	Xiaowen
	Data Record Simulation	Li
	Data Compile	Cheng

3/19	Spring Break	
3/26	Sign-up for Mock-up Presentation	Xiaowen
	Simulation	Li
	Data Analysis	Cheng
4/2	Compare Data for 3 Rotors	Xiaowen
	Compare Data for 3 Rotors	Li
	Compare Data for 3 Rotors	Cheng
4/9	Analyze Real Time & Cost	Xiaowen
	Analyze Real Time & Cost	Li
	Analyze Real Time & Cost	Cheng
4/16	Sign-up for Demo and Presentation	Xiaowen
	Sign-up for Demo and Presentation	Li
	Sign-up for Demo and Presentation	Cheng
4/23	Prepare for Demo and Presentation Work on Final Paper	Xiaowen
	Prepare for Demo and Presentation Work on Final Paper	Li
	Prepare for Demo and Presentation Work on Final Paper	Cheng
4/30	Work on Final Paper	Xiaowen
	Work on Final Paper	Li
	Work on Final Paper	Cheng