ETM Magnet and Concentrator Loader System

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Problem Formulation and Project Plan

Document

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Contents

1.0 Client Background

Team 5 will be working with Electric Torque Machines, Inc. (ETM) which is based in Flagstaff, AZ and owned and managed by TN2, LLC. For the past six years the company has been developing a new class of Brushless DC (BLDC) electric motors known as transverse flux. Compared to conventional BLDC motors, the ETM motor offers reduced size, weight and material content per continuous torque. Essentially the flux in the motors travels transverse to the rotor's motion, while in a conventional machine the flux travels parallel to rotor motion. This enables the company to use a very simple, low resistance coil and unusually high pole count. The combination of these two features provides high continuous torque per motor size and weight, and superior efficiency. The company's innovative design is especially useful for various low-rpm/high-torque applications. One such application is designing and manufacturing motors for electric bicycles. The two main elements of the electric motor are the stator and the rotor. The rotor is made up of neodymium magnets and silicon steel concentrators precisely aligned in a circular pattern in an aluminum shell.

1.1 Need Assessment

The current process for loading the magnets and concentrators into the shell is described in detail in section 2.1. This process takes an operator approximately 15 minutes to complete. Decreasing stator and rotor manufacturing time increases profit margin and so the company desires to develop a new process or system that will complete the task less time.

1.2 Need Statement

Therefore the expressed need statement for this project is "Loading magnets and concentrators takes too long".

2.0 Problem Definition

Electric Torque Machines has tasked our team with decreasing the manufacturing time of their bicycle hub motor rotor shell. Currently the most time consuming part of the rotor assembly is the loading of magnets and concentrators onto the mandrel and it will be the one we will be improving upon. This process requires a technician to load 60 magnets in alternating orientation and 60 concentrators individually by hand. The magnets are very difficult to handle because of their powerful magnetic field and brittle characteristics.

2.1 Existing Step-by-Step Process

Below is a description of the current process used by ETM to load the magnets and concentrators onto the rotor:

1.0 Material Preparation:

- 1.1 Remove magnets from packaging.

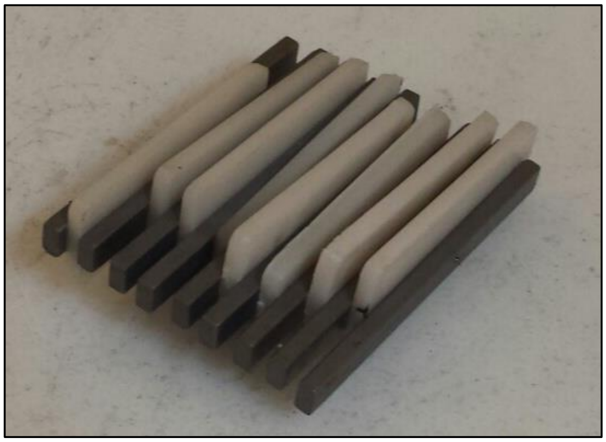

Figure 1: Unpackaged Magnets

1.2 Remove concentrators from packaging
1.3 Clean concentrators in acetone using the ultrasonic cleaner.

Figure 2: Ultrasonic Cleaner

1.4 Apply a light coat of Honey wax to the mandrel surface.

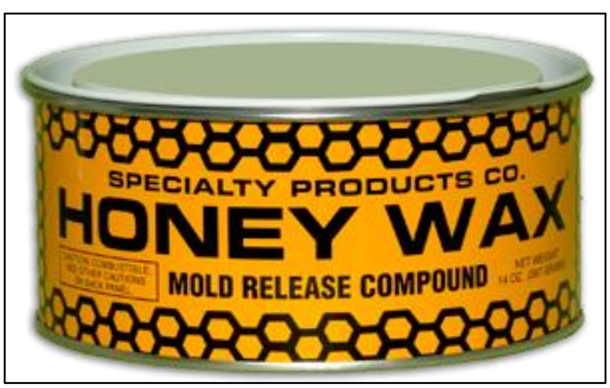

Figure 3: Honey Wax Mold Release

1.5 Put end caps onto the mandrel using the locating pins.

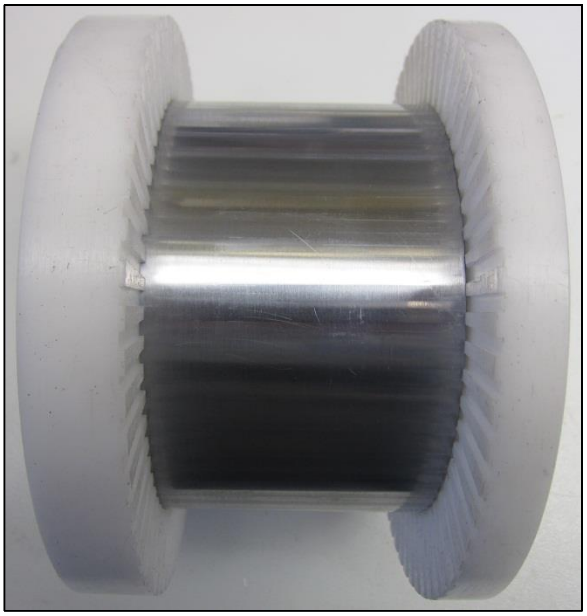

Figure 4: Mandrel with End Caps

1.6 Tighten end caps onto the mandrel using the aluminum washers and M4 counter sunk screws.

2.0 Assembly

2.1 Place 60 magnets in alternating orientation using the slots on the mandrel end caps.

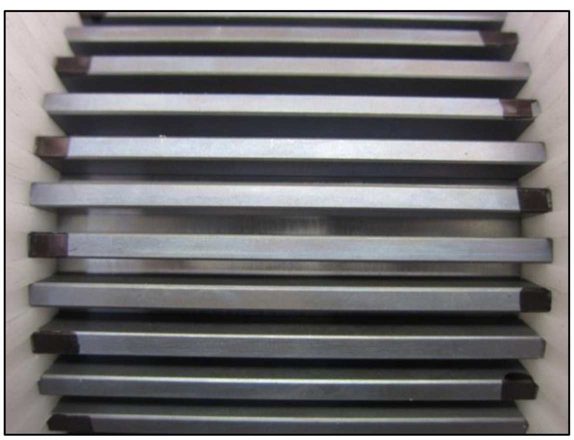

Figure 5: Loaded magnets

2.2 Place silicon steel concentrators between each magnet.

Figure 6: Loaded Magnets and Concentrators

2.3 Ensure all magnets and concentrators are completely seated onto the mandrel.

2.4 Ensure there are no chipped or broken magnets.

2.5 Remove end caps.

2.6 Clean magnets and concentrators with acetone.

2.2 Goal Statement

Given the existing process and ETM's expressed need, the team's goal statement to meet this need is "Design a system/process that decreases magnet and concentrator loading time."

2.3 Objectives

The following list outlines the major quantifiable objectives for the magnet and concentrator loader system.

- The magnets and concentrators must be loaded in less time than the existing processes is capable of
- The system must be inexpensive to build, operate, and maintain
- The magnets and concentrators must be precisely loaded into motor casing in terms of axial and rotational alignment

Table 1 shows how each of the previously mentioned objectives will be measured.

Table 1: Measurement basis of objectives

	Objectives	Measurement Bases	Units
1	Load magnets/concentrators faster than existing process	Time taken to load magnets/concentrators	Seconds
2	Inexpensive	Cost to build, operate, and maintain	Dollars
3	Magnet/concentrator alignment	Offset between magnet/concentrator ends, offset from motor's rotational axis	mm, degrees

The operating environments for each of the three objectives are listed below.

- Objective one will be evaluated in a series of timed field tests of the system
- Objective two will be evaluated in a cost analysis of the system
- Objective three will be evaluated in a post assembly measurement of the hub shell

2.4 Constraints

The following list gives the design constraints for the magnet and concentrator loader system. Note that two of the constraints have and X in place of a value, this is due to the fact that ETM is currently deciding on what they wish those tolerances to be.

- The system must load the magnets and concentrators within five minutes
- Entire system must fit on workbench
- The system must be operable by one person
- The magnets and concentrators must remain intact
- Magnets must be aligned within X degrees of the rotational axis of the motor
- The runout between the magnet ends must be X mm or less.

2.5 Quality Function Deployment

Table 2 displays the QFD matrix for the project. The customer requirements given by ETM are shown in comparison with the engineering objectives. The QFD illustrates the importance of the different objectives based on how many correlations the objective has with the customer requirements. The areas that showed great importance were the cost to build the device, the time of operations and completion, and precision. These objectives showed a higher correspondence with more requirements than other objectives making them crucial in designing our product

Table 2: Quality Function Deployment

Quality Function Deployment									
		Engineering Objectives							
		Cost to Build	Cost to Operate	Cost of Maintenance	Material Strength	Time	Space	Weight	Precision
Customer Requirements	Fit on Work Bench						X	X	
	Process completion in < 5 min.		X			X			X
	Aesthetics								
	Meets OSHA Requirements	X	X		X				
	Ease of Operation		X			X	X	X	
	System Lifespan	X	X	X	X				
	Concentrator Alignment	X				X			X
	Magnet Alignment	X				X			X
	Magnet Condition	X				X			X

3.0 Project Planning

The figure below displays our team's schedule up until the end of the fall semester.

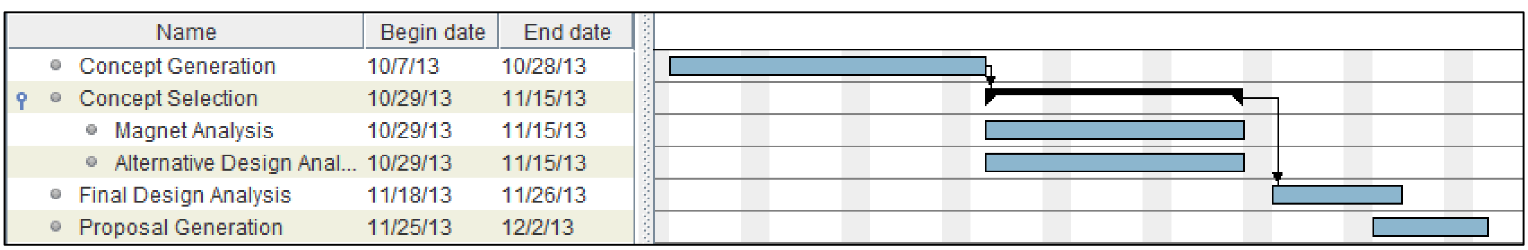

Figure 7: Project Schedule

The table below is a list of the tasks from the above schedule along with a description of each task.

Table 3: Description of Tasks

Task	Description
Concept Generation	During this task our team will develop several design alternatives.
Magnet Analysis	The characteristics of the magnets used must be analyzed in order for different designs to be evaluated.
Alternative Design Analysis	Each concept which was generated in task one must be analyzed and ranked.
Concept Selection	Once the alternative designs have been evaluated, the best option will be selected.
Final Design Analysis	Once the best design alternative has been selected, it will be analyzed in depth to evaluate performance.
Proposal Generation	Upon completion of the analysis and design selection, a proposal must be presented to the client.

4.0 Conclusions

Electric Torque Machines spends more time that it wishes loading magnets and concentrators onto rotors during the manufacturing of electric motors. They have expressed the need to shorten this process. Team 05 has responded to their need with the goal of designing and implementing a system which will decrease the time this process takes. The most important objectives are to minimize time and cost and to maximize precision during the loading process. By the end of the fall semester, team 05 will have a final design proposal for ETM.

Appendix A: References

Electric torque machines. (2013). Retrieved from www.etmpower.com

Crawley, J. (2013, Oct 03). Interview by Team 05. Electric Torque Machines meeting.