

# Electromagnetic Hysteresis Clutch

Marine Engineering Technology, Texas A&M University at Galveston,  
Undergraduate

Authors: Eric R. Schmidt, Ethan Barlow, Karlsten Bruner, Luke Urbik, and  
Mason Farmer

Faculty Advisor: Dr. Rudy D. Martinez



## Introduction

When a current is applied to an electromagnetic clutch, it creates magnetic flux. This passes into the rotor portion of the field. The hysteresis disk physically passes through the rotor without touching it. These disks have the ability to become magnetized depending upon the strength of the flux. This means, as the rotor rotates, magnetic drag between the rotor and the hysteresis disk takes place causing rotation. In a sense, the hysteresis disk is pulled along after the rotor. Depending upon the output torque required, this pull can eventually match the input speed, giving a 100% lockup.

When current is removed from the clutch, the armature is free to turn and no relative force is transmitted between either member. Therefore, the only torque seen between the input and the output is bearing drag.

## Magnetic Hysteresis

The magnetizing force in a material is defined to be the magnetomotive force per unit length of that material. Hysteresis is a characteristic of a magnetic material whereby a change in magnetization lags the application of magnetizing force. The magnetizing force (H) can be readily increased or decreased by varying the current through the coil of wire thus changing its flux density (B). The path the force follows is called a hysteresis loop and is seen in figure one.

The ability of a material, once magnetized, to maintain a magnetized state without the presence of a magnetizing force is called retentivity. This is why we designed our circuit to have the ability of creating a direct current of both polarities. When we use the opposite polarity of DC we can hit the magnetic with a coercive force. A coercive force is the magnetizing force required to make the flux density zero.

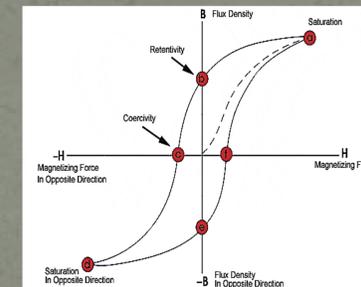


Figure One

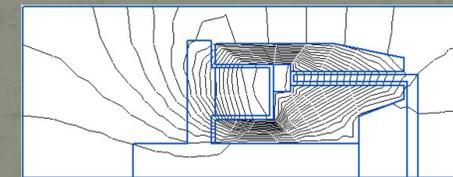


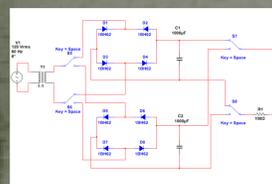
Figure Two

## Electromagnetism

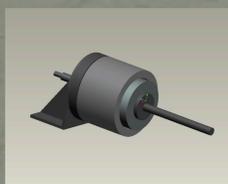
The magnetic field consists of lines of force, or flux lines, that radiate from the north pole to the south pole and back to the north pole through the magnetic material. The group of force lines going from the north pole to the south pole of a magnet are called the magnetic flux. The number of lines of force in a magnetic field determines the value of the flux. The more lines of force, the greater the flux and the stronger the magnetic field. The magnetic flux density is the amount of flux per unit area perpendicular to the magnetic field.

Figure two is a representation of the magnetic field lines flowing through our EM clutch assembly.

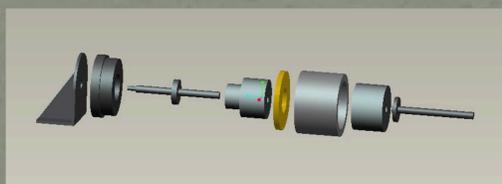
## Design Phase



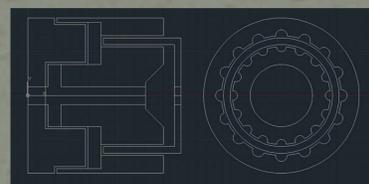
Armature Power Circuit



Assembled View



Three Dimensional Exploded View



Two Dimensional Split View

## Building Phase



Armature Power Circuit



Water Jetting



Synthesized Motor Control



Lathing the Charge Shaft

## Calculative Breakdown

In order to analyze a project of this depth we used a process called "converging iteration through the use of closed form analytical analysis." This allowed us to attack this mutli-headed hydra of an engineering project from all sides, meet in the middle, examine our findings and go back as necessary to fine tune our calculations. Some of the calculations we used during our analysis include: Potential electromagnetic force (EMF), inductance of a coil, effective armature wire wrapping, circuit analysis for max amps, circuit analysis without a transformer, air gaps and their effects on magnetizing forces allowable normal and shear stresses on the shaft, shaft failure, safety factor, heat transfer using Fourier's Law of Conduction, mass moment of inertia for output rotor, stress concentration, notch sensitivity, bolting and welding.

## Application

Electromagnetic clutches are already used in several systems in today's world. You can find them in lawnmowers, copy machines, compressors and even some automobiles. Our hope is to prove this equipment's worth in shipboard applications, specifically marine propulsion usage.

## Results and Conclusions

Malcolm S. Forbes said "Victory is sweetest when you've known defeat," and we have discovered our fair share of it. Despite our best efforts, electromagnetism is a difficult subject to comprehend, analyze, and perhaps most importantly, it is very costly. Making a working model with such a small budget was difficult. We find it unlikely that an EM clutch will ever be used in a main propulsion system on board a ship due to their high initial cost and heat generation.

However, the advantage to this concept is that all torque is transmitted magnetically, there are no mechanically contacting parts. This means that little wear occurs to any of the torque transfer components, and that there is virtually no exhausting of parts on a hysteresis clutch. Therefore, they have an extremely long service life with barely any maintenance requirements to counteract their initial high cost.

## Acknowledgments

The members of the Electromagnetic Group (EMG) would like to extend a special thanks to:

Dr. Rudy D. Martinez – Senior Design Professor – Texas A&M University at Galveston  
The Farmer Family – Farmers Copper  
Kevin Win – Tech. Lab Coordinator - Texas A&M University at Galveston  
Henry Fredrickson – Chief Engineer – Texas Maritime Academy