University of Patras
Mechanical Engineering and Aeronautics Department
Division of Design & Manufacturing
Machine Design Laboratory

DIPLOMA THESIS
"DESIGN OF A MAGNETORHEOLOGICAL FLUID CLUTCH''

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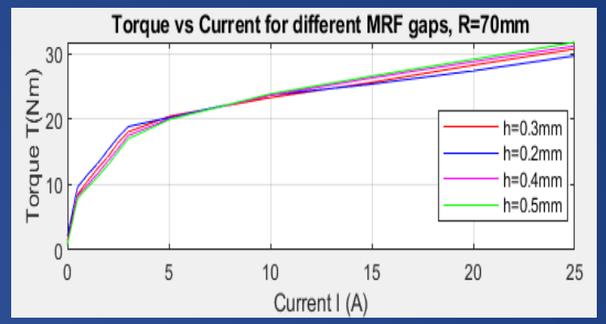
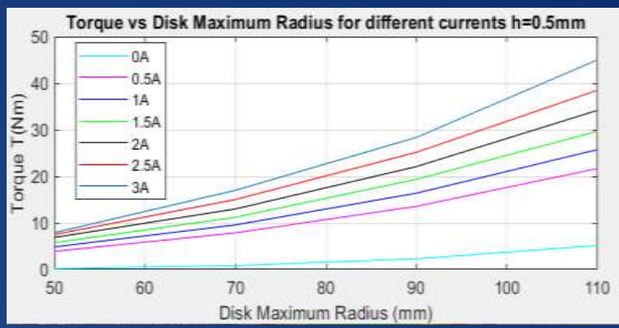
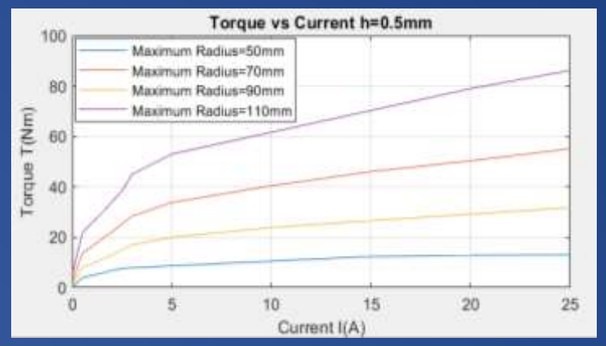
ABSTRACT

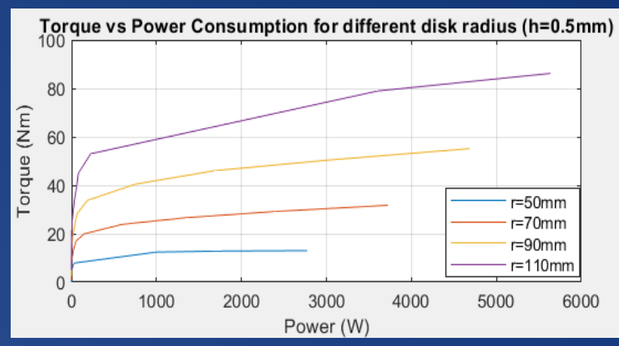
A Magnetorheological Fluid Clutch utilizes magnetorheological fluid to achieve the engagement and the torque transfer. Magnetorheological fluids are liquids in which ferromagnetic particles are immersed. When the fluids are placed within a magnetic field the particles form chains in the direction of the field, drastically changing the properties of the fluid. The flow model for these smart fluids is Bingham's model. In a MRF clutch an external magnetic field is generated in order to stimulate the MRF. In this diploma thseis, a magnetorheological clutch in various geometric configurations and input currents has been investigated. Initially, the magnetic problem was solved using ANSYS Magnetostatic software. Then after the magnetic field was known, it was used to find the yield stress. Finally fluid flow problem was solved using ANSYS Fluent. The shear stress of the MRF used to calculate the torque the clutch can transfer. Then the Torque Current curves are made for every configuration. Moreover Torque Radius curves were made in order to determine the best configuration. Finally it was calculated the power consumption for each configuration. In conclusion, the MRF clutches can controllably transfer large amount of torque.

RESULTS









BASIC EQUATIONS

$$\tau = \tau_y(\mathrm{B}) + \frac{\mu \Delta \omega}{h}$$

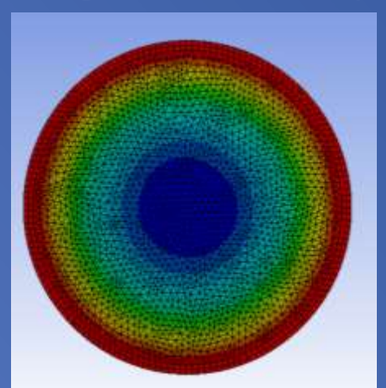
Bingham Model

$$T = \frac{2\pi \tau_y}{3}(r_{out}^3 - r_{in}^3) + \frac{\pi \mu \Delta \omega}{2h}(r_{out}^4 - r_{in}^4)$$

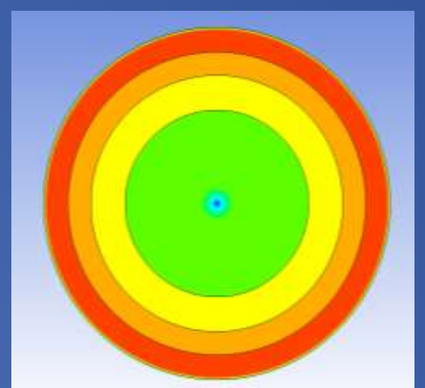
Torque Equation

ANSYS MODELS

Magnetic Field Intensity



Shear Stress



CONCLUSIONS

- Bigger discs can transfer more torque despite the weaker magnetic field
- Bigger discs enter in saturation for larger current inputs
- Small gaps between the discs perform better in low current inputs
- In saturation state larger gaps should be preferred
- Small discs consumes more energy for the same amount of torque in comparison to bigger discs
- Operating clutch in large current inputs leads to enormous power consumption without the significant benefits