Design of power losses and control of a long slenderness ratio Active Magnetic Bearing (AMB) and comparison with an equivalent system consists of smaller AMBs

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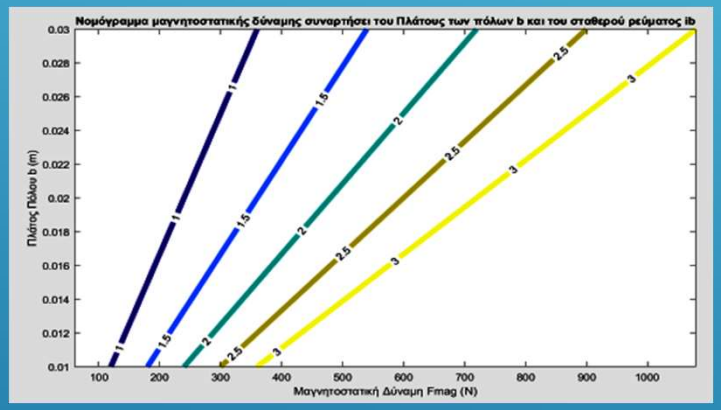
Slide bearings are the most popular machine component for bearing and shaft support. Their simple and economical design and high load lifting capacity are the reason for their extensive use. However, high sliding friction values lead to significant energy losses and the required lubricant usage has a negative environmental impact. These drawbacks leading researchers to study Active Magnetic Sliding Bearings (EMS) . The major advantage of AMB over conventional sliding bearings lies in their ability to support the moving shaft intact which means reduced mechanical losses and wear, significant energy savings, higher rotational speeds and no need for lubrication. In the context of this thesis we will deal with this innovative application and carry out a study divided into the following topics.

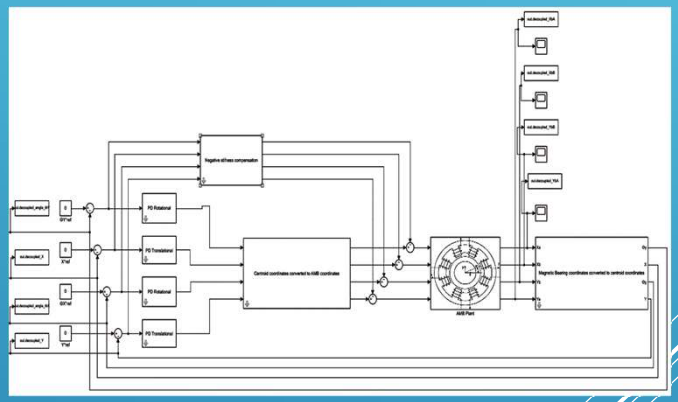
Energy Study



Theoretical background and computer modelling

In chapters 2 and 5 of this diploma thesis we establish the theoretical fundamental principles of mechanics. Starting from the basic principles of electromagnetism theory, we derive a linear equation that determines the generated magnetostatic force of a pair of electromagnets and then extract the power loss equation for an eight-pole AMB. In addition, we create a model of an AMB using ANSYS WORKBENCH.

Control of Active Magnetic Bearing



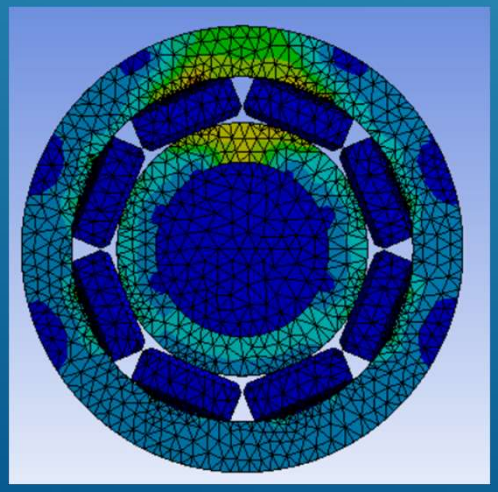
Magnetostatic Force

$$\mathbf{Fmag} = \frac{4\mathbf{bL}i_b\mu_0 N^2}{s^2}\left(i_c + \frac{i_b x}{s}\right)$$

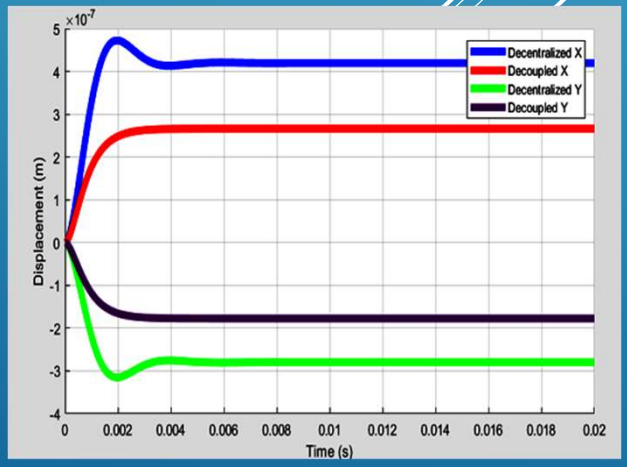
Power Losses

$$\mathbf{P_{cu}} = 4\frac{\rho \mathbf{N}}{\mathbf{A_d}} * (\mathbf{b} + \mathbf{L} + 2\mathbf{w})\left(2\mathbf{i_b^2} + \mathbf{i_c^2}\right)$$

Magnetic Flux Density



Comparison of decoupled and decentralized control



Conclusions:

- Extraction of a formula that determines the magnetostatic force and power losses of a pair of magnets
- The choice of the appropriate number of copper windings on the coil and the size of the constant current depends on the saturation effect
- Bearings with longer length and wider poles become more energy efficient
- The use of a PID controller versus PD is preferable in decentralized control
- Decoupled control shows better response and generally oscillatory behavior compared to decoupled control