# Ferrofluid Bearing Modelling (FEM/CFD)


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Fig. 1. The figure presents a ferrofluid bearing demonstrator. Three ring magnets with ferrofluid are placed on an iron plate with a glass plate on top of it. The setup shows the ease with which a ferrofluid bearing can be build. The configuration is capable of carrying a load of about 1kg with a bearing surface of only 10cm².

## 1 Introduction

A ferrofluid is a type of fluid that due to its magnetic properties is attracted to a magnet. These properties are generated by suspending tiny magnetic particles (~10nm) in a fluid resulting in a suspension that shows no sedimentation. Subjecting the fluid to a magnetic field develops an internal pressure in the fluid that can be used to carry a load in a bearing (Fig. 1). This bearing distinguishes itself from other bearings by its low cost, compactness, inherent stability, low (viscous) friction, absence of pumps and absence of stick-slip. These properties make the bearing interesting to be used for applications that require fast and precise positioning or special applications in space: vacuum and no gravity.

## 2 Problem definition

Recent work at the department of PME generated some methods to predict bearing characteristics like load capacity, stiffness, damping and friction of a ferrofluid bearing. This has resulted in an improved insight in what defines certain bearing properties and has provided some models to predict the behaviour for simple geometries (for example circular). The next step in the research is now to extend these models to also be able to predict the behaviour for more complex geometries.

## 3 Project deliverables

The research will focus on building a full model of the ferrofluid pocket bearing. This will practically mean that a FEM/CFD model shall be build that includes different material phases (solid/fluid/gas) and different physics (fluid/mechanics/magnetics). A test setup is available to validate these models by measuring the different bearing parameter.

## 4 Expectations for the student

The students can expect to iterate the design cycle at least once, meaning that they will at least design, model, build and validate one bearing configuration and the underlying mathematical model. The different steps that the students will take can be summarized with the following points:

1. Literature study on ferrofluid pocket bearings.
2. Literature study on magnetic fluid modelling
3. Model interface: solid/fluid/gas interface
4. Model physics: fluid/mechanics/magnetics
5. Combine interface model with physics model.
6. Measurements on experimental setup.
7. Compare measurements with model
8. Model fine-tuning

The students can furthermore expect to receive guidance from experienced supervisors that are known in the field of ferrofluid bearings and modelling.

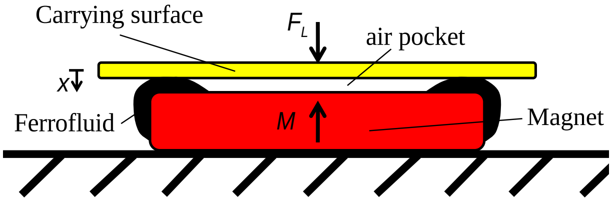


Fig. 2. The figure presents a cross section of a disk shaped magnet. The ferrofluid is attracted to the corners of the magnet because the field intensity is highest there. The ferrofluid forms a seal that encapsulates a pocket of air. The air pocket increases the load capacity of the bearing since the pressure is defined by the largest value of magnetic field intensity, which is at the corner of the magnet.

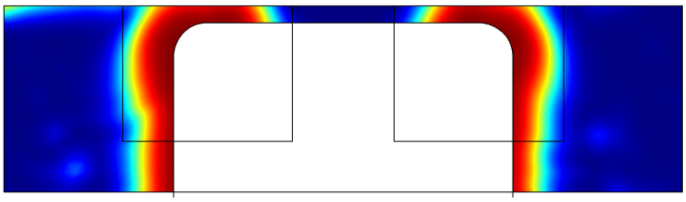

Fig. 3. Example of a ferrofluid bearing CFD model. The red coloured parts can be interpreted as the location of the ferrofluid and the blue coloured parts can be interpreted as air. The colours in-between represent a phase transition of liquid to gas which is non-physical but a consequence of the methods of modelling. The white part of the model presents the magnet to which the ferrofluid is attracted. The ferrofluid is attracted to the corners of the magnet since the magnetic field strength is largest there.