Thesis Project at Chalmers in collaboration with Volvo Group and Sigma Energy & Marine (SEM)

Title: Fluid flow and magnet simulation in a model gearbox

Subject: Fluid dynamics, magnetism

Background

Wear in a mechanical system such as gearbox is unavoidable. The friction between the gear teeth, during torque transferring operation, produces metal debris that if left unchecked may increase the rate of the wear. In Volvo gearbox, a magnet was located in the oil sump as one way to ensure the cleanliness of the lubricant. The magnet is intended to capture and retain the debris. This study is aimed to provide additional information regarding the best placement of the magnet inside the oil sump.

Scope/ Task

- Investigation of the possibility to combine fluid flow and magnetism simulation, both in general CFD and specifically in STAR-CCM+ software.
    - A literature survey should be conducted on this topic
- Start with focus one phase flow simulation (only oil volume included in the model).
- Investigation of particle deposition.
    - Particle sensitivity analysis:
        1. Particle shape (how different shapes affects the drag force and thereby the deposit) A literature survey should be conducted on this topic
        2. Source location (how the location from where the particles are released affects the deposit)
- Magnetism (electrical charged particle) simulation.
- Defining the magnet efficiency and propose an equation for evaluating this.
    - The preliminary idea is to define it based on the percentage of deposit particles.
- Analyse the magnet deposition for different rotational speeds.
- If there is time left in the project, the air could be considered in the model (Multiphase flow simulation, VOF) to investigate the influence of a dispersed oil surface.

Model input data

- Particle / debris size and shape from experimental data and literature study.
- Volvo will provide the models needed for the analysis
    - Model including the primary gear wheel, housing, inlet/outlet and the oil surface level.
    - Possible additional model including both oil and air volume (VOF simulations)
- Constant temperature: 80 C
- Constant oil properties: Provided by Volvo
- rotational speed: 0, 1400, 2280 RPM

Introduction / learning case :	Key results :
○ solve the one phase flow (oil) with wheel rotation (MRF) and outflow/return flow ○ without magnet	○ Converged, robust, repeatable simulation ○ Recirculation regions? ○ Computational time and resources

Particle sensitivity analysis: o add particles to the simulation o sensitivity analysis on particle shape o sensitivity analysis on particle source o sensitivity analysis on how the particles are released (constant, pulsating)	Key results: o Converged, robust, repeatable simulation o Deposit location o Recirculation region
Case 1: o add a magnet to the simulation with standard placement of the magnet (below the gear) o solve the electro-magnetic (EM) field and then apply the EM-forces on the released particles o run simulation for no rotation, 1400rpm and 2280rpm	Key results: o Converged, robust, repeatable simulation o Deposit location o Recirculation region o Magnet performance
Case 2: o try different locations of the magnet. o run simulation for no rotation, 1400rpm and 2280rpm	Key results: o Converged, robust, repeatable simulation o Deposit location o Recirculation region o Magnet performance
Case 3 (if there is time left): o add air volume to the model (VOF simulation) and solve the flow with rigid body motion	Key results: o Investigation of the effect on the dispersed oil surface o Deposit location o Recirculation region o Magnet performance

Thesis overview

- Literature study / Training / introduction to simulation using STAR CCM+ and possibility to combine fluid flow and magnetism simulation
- Literature study / Particle sensitivity analysis
- Case 1
- Best practice document
- Case 2
- Case 3 (if there is time left)
- Thesis report and final presentation

Qualifications & Key Attributes

- Master student in any physics or engineering
- Positive attitude, willing to learn, disciplined, good communication skills, humble, result oriented
- Experience in CFD is a merit

Duration Student Background

The duration of the thesis work is 20 weeks. The diploma work gives 30 points.

Collaboration between Chalmers, Volvo AB and Sigma Energy & Marine

The master thesis project is a collaboration between Chalmers, Volvo AB and Sigma Energy & Marine (SEM). The student will sit at SEM's office and SEM is responsible for supervision within general CFD and software. Chalmers will provide a mail supervisor regarding literature and magnetism simulation. Volvo will provide models of the gearbox and oil sump needed to perform the simulations as well as required material data. When starting the master thesis project, a plan for collective meetings between all parts will be made.

Starting date	Number of students
First quarter of 2021	1

Contact person(s)

Huadong Yao, huadong.yao@chalmers.se

Henrik Hagerman, henrik.hagerman@volvo.com

Emelie Wallenstein, emelie.wallenstein@sigma.se

Application

Follow the link and apply on Volvo Group homepage:

https://xjobs.brassring.com/TGnewUI/Search/home/HomeWithPreLoad?partnerid=25079&siteid=5172&PageType=JobDetails&jobid=707562

Appendix

Illustration of the gearbox model