Development of a Fluid-Structure Interaction model for Plasto-elastohydrodynamic lubrication in dry wire drawing

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MOTIVATION

A large number of process industries involves cold, hot rolling, wire drawing and deep drawing. Tribology plays a crucial role in 1) energy efficiency and 2) surface quality of the end product.. As an example, the applications of wire drawing are highly divers, from cables used to support bridges to springs used in automotive sector. This wide scope of use involves a cost, ecological and quality efficient production process.

The process of wire drawing is a cold work hardening process. A metallic wire is pulled through a series of dies, in order to reduce progressively its cross section. As a consequence, the crystal structure of the material changes and thus the related mechanical properties such as strength and hardness. In "*dry wire drawing*", a carrier agent prepares the surface of the wire for better adhesion of the soap granules. When pulled into the die, the soap granules provide adequate lubrication to the wire.

The primary purpose of the lubricant is to reduce friction between the wire and the die by avoiding adhesive bonding of the metal with the die wall. Besides a significant increase in energy efficiency, this also results into a reduction of generated frictional heat. Second, the lubricant reduces the wear at the die and will extend its service life. By applying a custom lubricant a reduced production cost will be achieved while ensuring the surface quality of the wire by reducing adhesive and abrasive wear and making the deformation uniform.

Dry drawing process operates on high drawing speeds conditions, under the so-called Plasto-elastohydrodynamic (PEHL) lubrication regime, referring to the plastic deformation of at least one of the two surfaces. In PEHL the surfaces are assumed to be entirely separated by the lubricant.

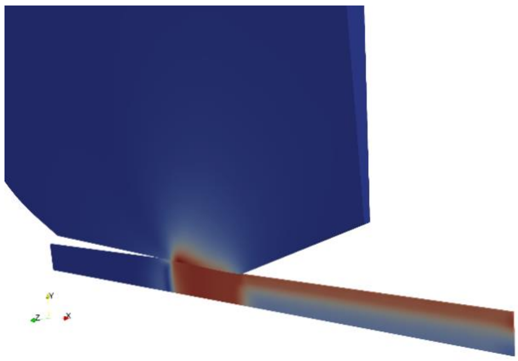

Figure 1 : Simulation wire deformation in a dry drawing configuration

OBJECTIVES

The project encompasses two objectives:

1. Development of a steady 2D axisymmetric CFD-FSI model for PEHL in wire drawing and parametric analysis.

2. Development of a transient 3D CFD-FSI model for PEHL in wire drawing with the aim to investigate undesirable vibrations during wire drawing.

Approach

In the first phase of this project, an isothermal axisymmetric and stationary FSI model is built in OpenFOAM in which the die is approached as a solid body, and the normal and shear stress, which occur in the incompressible lubrication film, are imposed as a boundary condition of the deforming wire. Next, viscosity modelling is applied in the fluid film, where compressibility, thermal effects and shear rate are taken into account. In a later step, the die will be considered as elastic deformable, instead of rigid. At last a transient 2D case will be developed, where the wire is pulled through the die. The built of the FSI will be validated by Bekaert.

The FSI calculation is done by the use of *CoCoNuT* (https://pyfsi.github.io/coconut/). *CoCoNuT* is open-source FSI-coupling software developed at Ghent University by the Sustainable Thermo-Fluid Energy Systems Research group, and stands for ***Co**upling **Co**de of **Nu**merical **T**ools*

The lubricant is simulated by the use of OpenFOAM 8 and the structural part has been executed by the use of a structural solver developped by Dr. Philip Cardiff of the University College Dublin in cooperation with Bekaert in the open-source software Foam-Extend 4.1.

Figure 2: CoCoNuT

In a second phase, a thermal 3D FSI-model will be developed of the lubricant film and FSI calculated will be executed. In this calculation an investigation will be done concerning instabilities of the fluid film in the narrow gap between the wire and the die.

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