Modelling of interaction between multi-phase fluid and mill structure in a tumbling mill

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ABSTRACT

Free surfaces in fluid structure interaction (FSI) with multiple fluids are difficult to numerically predict. Hydro and wind power turbines and lubrication of mechanical components are examples of engineering applications where FSI can be important to consider. This work investigates the possibility to use a node (particle) based finite element method coupled to a standard finite element method (FEM) to simulate a tumbling mill partly filled with a pulp fluid and the FSI between solid mill casing and pulp fluid. Modelling of wet milling is a complex multi-physics problem; wet milling is often used in the mining industry. For better understanding of the tumbling mill process numerical methods can be used, and the process has previously been modelled with a combination of other numerical methods, [1].

The tumbling mill has four equally spaced lifters and measures Ø300 x 450 mm, see Fig. 1. A mixture of magnetite and water was filled to 30 % of the total volume of the mill. In this work, the mixture was considered as one homogeneous fluid with a density of 2500 kg/m^3 and with a dynamic viscosity of 267 mPa·s. Air in the tumbling mill was considered as a second fluid phase. In this work the mixing of air into the pulp fluid and its impact on the dynamics of the pulp phase is investigated.

Experimentally measured driving torque from the laboratory tumbling mill was compared with numerically predicted torque from the multi-phase fluid simulations. It was clear that the node (particle) based finite element method, using multiple fluid phases and coupled to the FEM solver, was capable of predicting torque from FSI. It was also concluded that the interface between fluids with large differences in viscosity and density could be modelled.

The interface tracking between air and magnetite pulp and the mixture of air into the magnetite pulp phase in the form of bubbles is shown in Fig. 2. From the experiments it was concluded that the pulp fluid had a tendency of sticking to the mill structure, this was also predicted by the multi-phase model as can be seen in Fig. 2.

Figure 1. Laboratory tumbling mill used for experimental torque measurements.

Figure 2. Free-surface, multi-phase model of magnetite pulp-air mixture in tumbling mill.

REFERENCES

[1] P. Jonsén, B.I. Pålsson, J.F. Stener and H-Å. Häggblad, “A novel method of interactions between pulp, charge and mill structure in tumbling mills”, *Minerals Engineering*, **63**, 65-72 (2014)