The flow of a viscous fluid through an external gear pump

The flow of a viscous fluid through an external gear pump

Vincent G. de Bie, Martien A. Hulsen , and Patrick D. Anderson

Gear pumps are often used for the transport of high viscosity fluids, for example in the production of car tires. In the extrusion process of the tire compounds, the flow rate is controlled by an external gear pump. The flow of a fluid through the pump is numerically studied using the finite element method.

Method

The flow of a fluid through a gear pump (Fig. 1) is described using the mass and the momentum balance. The fluid behavior is represented by a viscous constitutive model, which assumes a constant viscosity. The pressures at the entry and the exit are prescribed, resulting in a constant pressure difference over the pump.

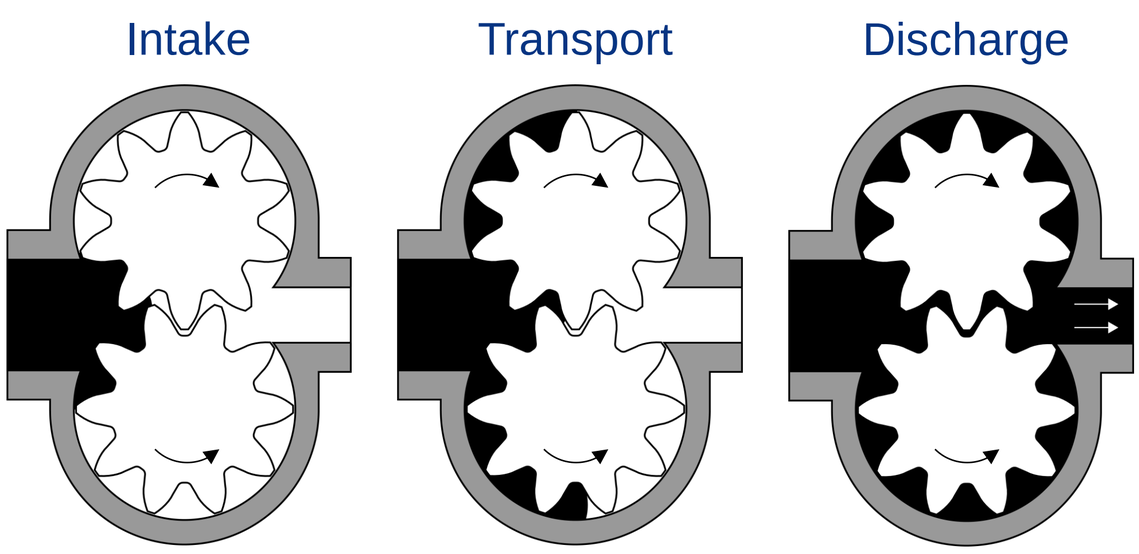

Figure 1: Schematic overview of the working principle of the external gear pump.

The domain of the pump is filled with triangular elements (Fig. 2). Adaptive local mesh refinement is needed due to the moving boundary and the relatively narrow gaps.

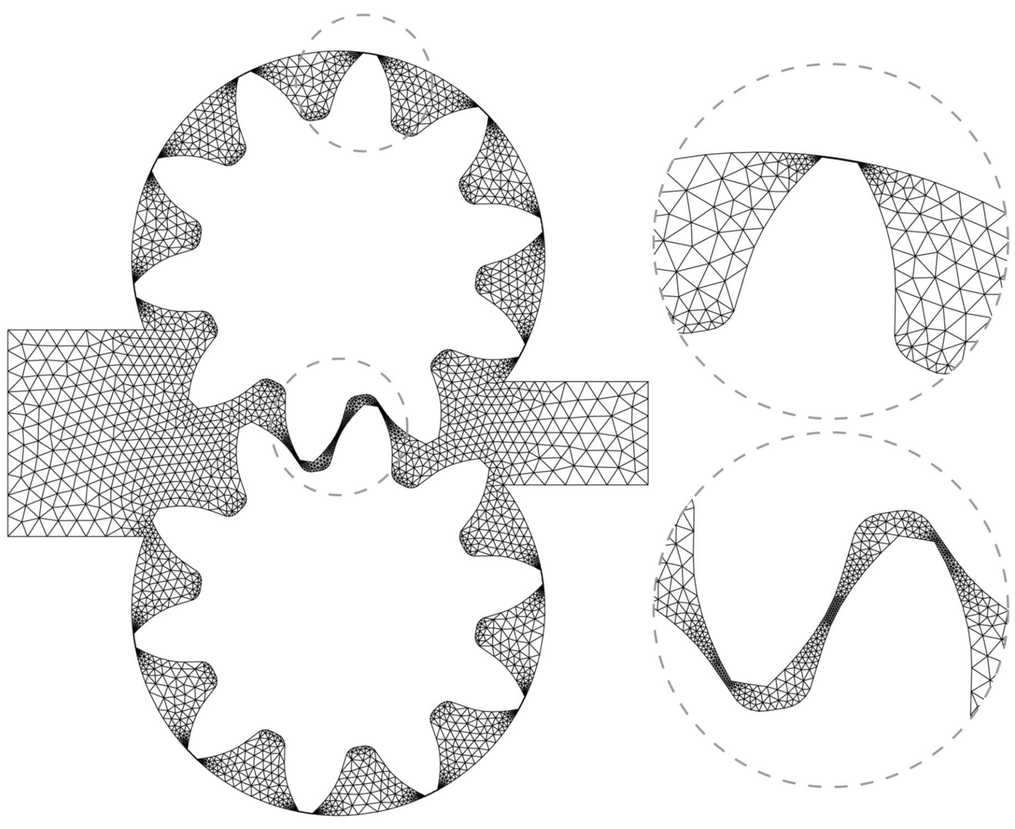

Figure 2: The finite element mesh with local refinements in the narrow regions, which is generated using Gmsh and consists of triangular elements.

Stokes flow

From numerical simulations, the flow rate over time is obtained (Fig. 3a), which shows that a fluctuation is present. The frequency of this fluctuation is related to the number of teeth of the gears.

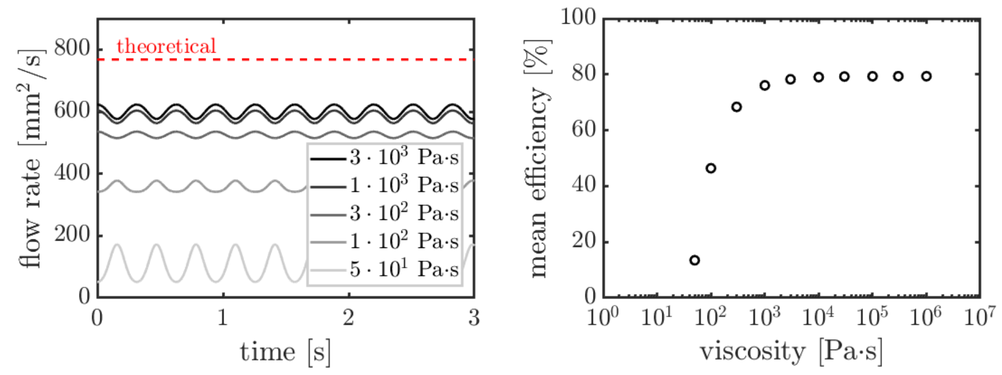

Figure 3: The flow of a viscous fluid through a gear pump with a rotation speed of 1 rad/s: (a) flow rate over time, and (b) mean efficiency versus the fluid viscosity.

The ratio of the flow rate and the theoretically achievable flow rate results in an efficiency of the pump (Fig. 3b). For low viscosities, the efficiency of the pump drops due to fluid leaking backwards (Fig. 4).

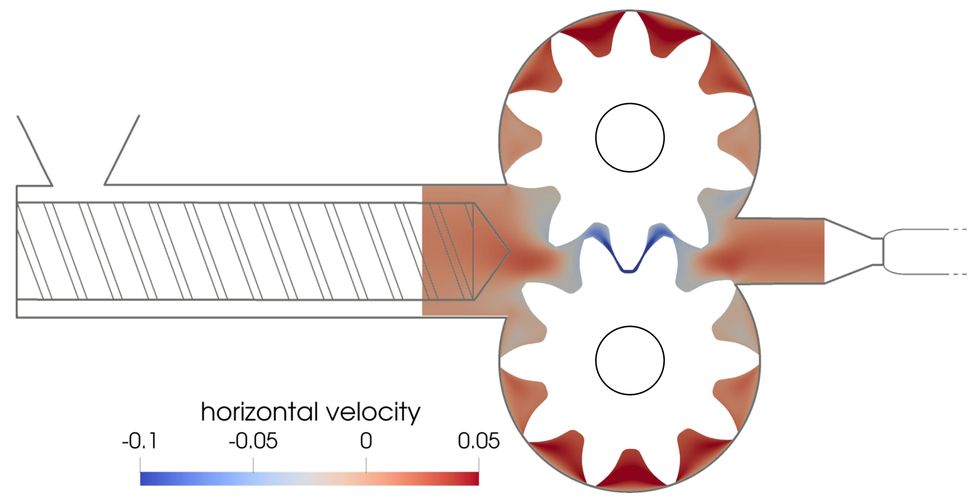

Figure 4: The horizontal velocity of a fluid with a viscosity of 10^2 Pa·s flowing through an external gear pump with a rotation speed of 1 rad/s.

Conclusions

A 2D numerical model of the external gear pump has been developed to study the effect of processing conditions and material properties on the flow of the fluid. The viscosity function in the model can be easily extended to account for the effect of deformation rate, temperature and/or pressure.