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Numerical and experimental understanding of wet three-body abrasive wear in pumps

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Submersible pumps are used all over the world as the first stage in transporting water from wells in the ground up to the surface. All wells will to some degree contain particles in the form of sand or silt which is filtered out at a later stage, however in this first stage the submersible pump must bring both water and particles out of the well. These particles are a major enemy to the lifetime of a pump's components, with contacting parts at internal seals and bearings being especially vulnerable to wear. Due to complexities involved in modelling wear, validation of new pump designs in terms of sand wear relies on accelerated wear tests that can run for months as components are meant to last several decades. Together with industrial partner Grundfos we work towards developing/improving on existing methods to predict abrasive wear which could significantly reduce the time spent on iterating between new designs, and we specifically look at abrasive wear as this form of wear looks to be one of the main contributors as the cause/initiator of failure in submersible pumps in Grundfos' case.

We analyse the problem by utilizing mainly two methods:

- Develop an experimental setup for wet abrasive wear and carry out tests for different design parameters (relative velocity and normal force in the contact region for different material combinations, rubbers on steel).
- Perform single-particle simulations to analyse the interaction between a circular rigid particle that is compressed and sheared between two deformable solids.

In this way we look at the problem in both a macroscopical and microscopical context, with the plan being to combine knowledge and results from both methods to develop or improve on existing means of modelling abrasive wear.

Early results from the experimental setup indicate that as the relative velocity between materials in the contact region is increased, we also see a significant increase in wear on the contacting materials, while the contact normal force for example looks to be a less significant parameter.

In the single-particle simulations we've so far looked at the simple case of steel and steel compressing a rigid particle and have so far been able to identify a semi-analytical expression for how much an assembly like the one we use in our simulations can be compressed before one or both deformable materials exceed their yield limits. Future work will see one steel material replaced by a polymer rubber as well as adding on the shearing motion.