vibration behavior of a smart density meter for slurries.

DEMCON MULTIPHYSICS

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Goal

In the dredging industry, different types of materials can be dredged, for example to win construction materials or for reclamation. The dredged material is a mixture of water and typically sand, clay or gravel and this mixture is called slurry, which is transported through pipelines. Measuring the density of the slurry is important for process control. Traditionally, slurry density is measured from outside the pipe using gamma radiation, which naturally entails safety risks and complicates day-to-day operations. This drawback is overcome by the Alia Density Meter (ADM) developed by Alia Instruments. They developed a smart density meter together with Demcon that works more safely and reliably, non-nuclear. The instrument works according to a mechanical measuring principle and is equipped with an electromagnetic actuator and accelerometers.

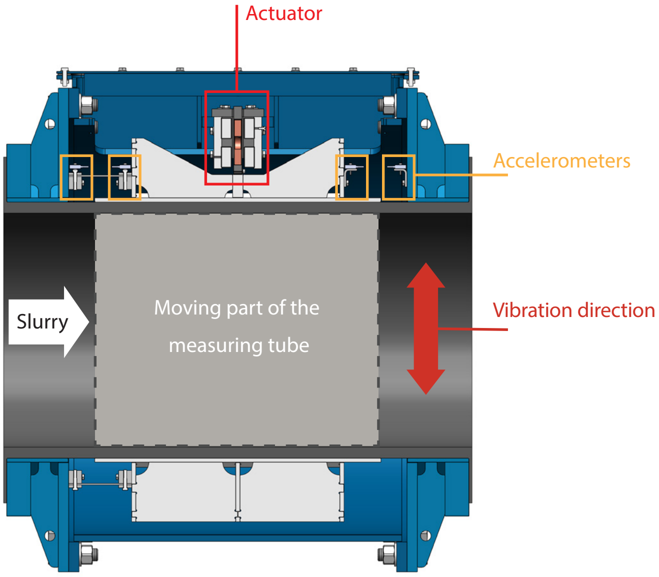

Figure 1: The rubber inner tube with passing slurry is brought into vibration perpendicular to the slurry flow by a construction (light gray) driven by an electromagnetic actuator.

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The working principle of the ADM is based on Newton's second law (F = m*a): an electromagnetic actuator exerts a force with a known value and frequency on a pipe segment through which slurry is flowing, and an accelerometer measures the acceleration of the pipe. The mass can then be extracted, and as the volume is known, the density can be extracted as well. For optimal performance, the dynamic behaviour of the vibrating tube should be determined and understood. Here, we modelled the vibrating behaviour of the tube to gain an understanding of different designs.
This will help to improve the accuracy of the density meter and reduce experimental characterizations.

Approach

Eigenfrequencies and their eigenmodes describe how the tube is sensitive to vibrations at a certain frequency. Hence, the eigenmodes are determined first, using Modal Analyses with Ansys Mechanical. Next, insight into the deformations of the vibrating structure is obtained then. It depends on the magnitude and direction of the actuation force which deformations and accelerations will be generated. These are important, to determine the relation between the electromagnetic actuator and the accelerometers and thus, to predict an accurate density of the slurry. This last part has been determined using Harmonic Response Analyses to generate Frequency Response Functions (FRF).

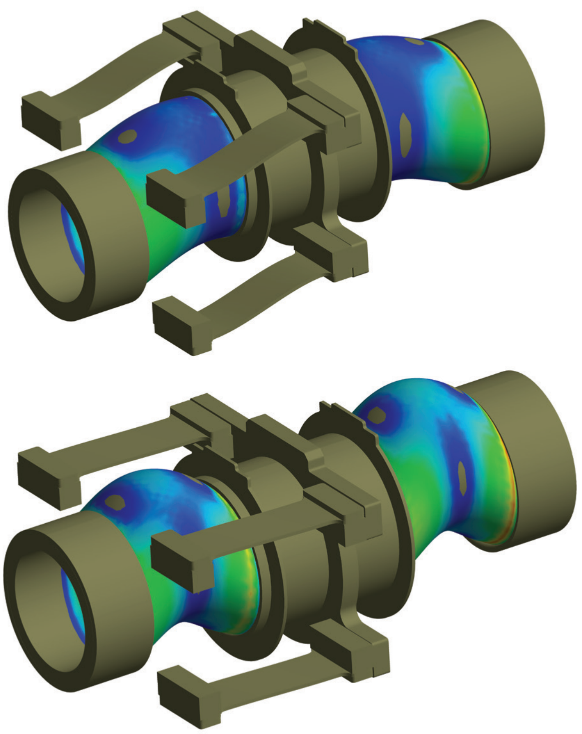

Figure 2: Vibration modes of the structure. Top image shows the main vibration mode of the tube which is used for measuring the density. Bottom image, shows a mode which may lower the measuring accuracy of the system.

Results

The enhanced simulation model is able to characterize the vibration behavior of the system. It predicts how the tube, filled with or without a fluid, will vibrate and which forces are required to actuate it, as can be seen in the video. (see separate file)

With these enhanced models, which include steel-reinforced rubber, fluid behavior and material dependent damping characteristics. Costly and time consuming experiments to characterize the vibration behavior can be reduced during the design cycle process.

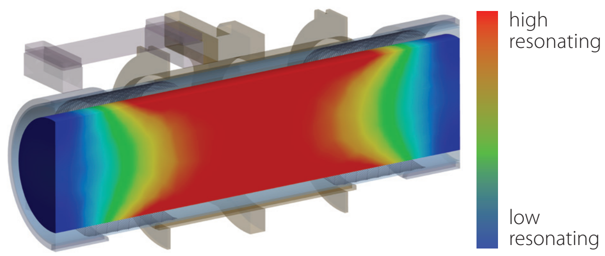

Figure 3: Simulation showing the resonating fluid inside the Alia density meter.