Title: Multiphase damping
Assignment: MSc thesis 6 – 9 months
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Introduction:
Pipes carrying fluids will show flow induced vibrations. In case of internal multiphase flow the excitation can be that large that pipe failure can occur [1]. The final resulting vibration amplitude is a combination of the excitation force and the mechanical response. In the last decade a huge amount of work is done on the prediction of the excitation force in case of multiphase flow. However, the mechanical response is still difficult to predict. This is mainly caused by the effect that due to the internal multiphase flow also the effective damping characteristics are modified (Figure 1).

This additional damping is caused by different mechanisms:

- the fact that due to the pipe movement, also the gas liquid interface moves and this means additional interfacial friction.
- If the pipe vibrates perpendicular to the flow, a sloshing motion is introduced.
- Slugs/waves travel in the pipe. This means the total mass of the system changes as function of time. This in itself means that the natural frequency of the pipe changes as function of time. The excitation of the pipe occurs therefore at different frequencies compared to the natural frequency which means more or less effective excitation. This mimics damping.

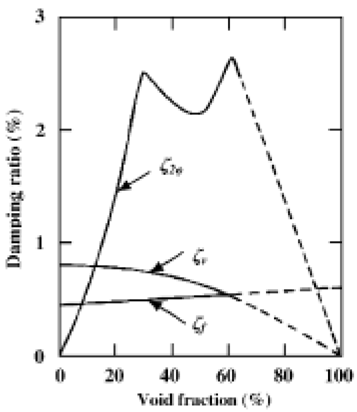

Figure 1: Added damping due to multiphase flow $\zeta_{2\varphi}$ [2].

TNO has built a setup (Figure 2) consisting of a simple pipe which can be excited either via impulse or a shaker (at fixed frequency or with noise). Special is that a 3D tomography sensor is included in the setup. This allows visualization of the flow. This can also be done in case the pipe vibrations are excited. The sensor can be installed half way the pipe such that exciting occurs at the sensors location or the sensor can be installed at the pipe inlet or outlet (in the fixed non-vibrating part of the setup) such that the multiphase flow in non-disturbed conditions can be measured.

Excitation can be done in different modes:

- Impulse (you hit the pipe wall and the amplitude decays).
- Shaker at fixed frequency. This frequency can be lower/higher than the natural frequency and can be lower/higher than the critical sloshing frequency.
- Shaker with white noise.

In 2022, a short set of experiments were done with the setup where the biggest hick-ups have been eliminated (such as the finding that the eigenfrequency of the optical table was similar to the pipe with sensor). However, the initial findings are complex and need deeper attention. Therefore, this student assignment is made. The main goal of the assignment is to evaluate the effect of the excitation method at different flow conditions (stratified, slug and annular flow) on the obtained damping result. Based on these experiments, correlations to predict the damping as function of parameters such flow regime, sloshing frequency, wave height need to be developed.

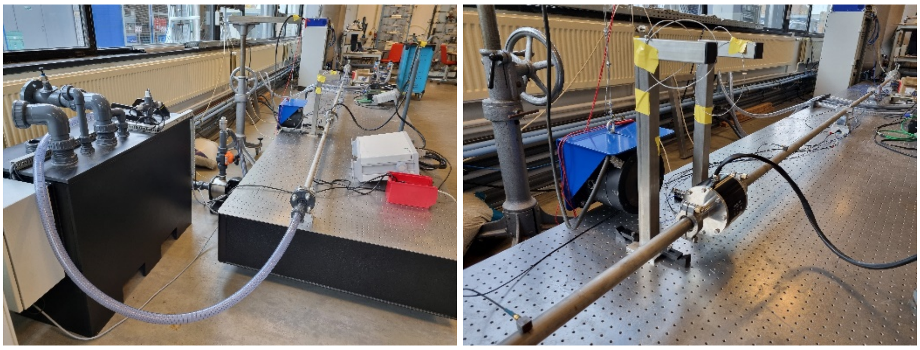

Figure 2: Experimental setup with tomography sensor.

<u>Activities and research question</u>

The focus in this student assignment is on the experimental evaluation of the multiphase induced damping.

Research questions:

- What is the influence of the excitation method on the multiphase induced damping
- What is the influence of the excitation direction on the multiphase induced damping
- What is the influence of the flow regime on the multiphase damping

The ultimate goal that this works in aiding to make a better prediction model for the estimation of flow induced damping.

Activities:

- Literature review experimental data on multiphase induced damping .
- Literature review on previous work TNO.
    - Previous lab experiments
    - Previous field experiments
    - Previous student work on theoretical background
- Upgrade the experimental setup (adapt outlet, add pressure sensors).
- Perform experiments on multiphase damping at large range of flow conditions.
- Evaluate influence excitation method on damping results.
- Evaluate influence excitation direction on damping results.
- Derive flow correlations to estimate the damping.

<u>References</u>

[1] For example: S. Belfroid, E. Nennie, A van Wijhe, H. Pereboom, M. Lewis. Multiphase forces on bend structures – overview of large scale 6”experiments. FIV2016, The Hague

[2] Gravelle, A., Ross., A., Pettigrew, M.J., Mureithi, N.W., Damping of tubes due to internal two-phase flow, J. of Fluids and Structures 23 (2007) 447, 462, doi:10.1016/j.jfluidstructs.2006.09.008