Coupling between two different pipes for a gas network

Supervisor: Johan Romate (Shell/TUD)

Problem background

Oil and gas flowing out of a reservoir enter a production network of pipelines, compressors, pumps and other equipment which brings the gas and oil to their right destinations. This network flow is modelled in network simulators. The flow through pipelines can be modelled in various ways, depending on the physics and the detail that is required.

At the junction of two (or more) pipelines the flow models of the different pipelines need to be coupled. This coupling needs to be such that it represents as well as possible the physical flow behaviour at the junction and the interaction with the flow in the pipelines. For the network simulation the various models are turned into numerical models, and these resulting numerical approximations need to be sufficiently accurate and efficient. For the various couplings possible there are several research questions, one of which is the topic of this assignment.

Assignment

Here we consider the specific case of two pipelines meeting at a junction. In one pipe the flow is modelled via a Weymouth (or similar) equation, and in the other one it is modelled via the one-dimensional isothermal Euler equations. The Weymouth equation is an empirical equation, relating the flow rate and pressure drop for steady flow, and is of the form

$$Q = f(p_A^2 - p_B^2), \tag{1}$$

where Q is the volume rate and p_A and p_B are the pressures at both pipe ends. The isothermal Euler equations are a model for the transient behaviour of a compressible gas. It consists of the conservation laws for mass and momentum, in system form given by

$$u_t + f(u)_x = s, \tag{2}$$

which is a hyperbolic system of partial differential equations. The density and flow velocity at the pipe ends can be translated into pressure and flow rate data, and thus connected to the Weymouth pipe. The question is: what happens when these two models are coupled at the junction. In particular stability needs to be investigated, and also the response to transients. The assignment consists of the following parts:

1. Literature study.
2. Analysis of both pipeline models, and their coupling.
3. Setting up and testing the resulting numerical model.
4. Writing the thesis.