Flowmaster
Fluid thinking for systems engineers

Case Study

General

Fjarhitun

Flowmaster helps Iceland Pipeline Design in Reykjavik.

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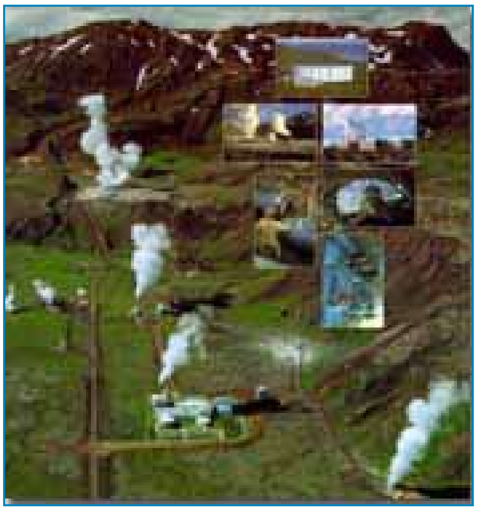
Fjarhitun provides general and specialised consulting and engineering services in the fields of civil, structural and mechanical engineering. From the outset they have been involved in projects related to the utilisation of geo-thermal energy. It has designed the main part of the 500 MWth geo-thermal district heating system of the Reykjavik District Heating Utility, including the main transmission pipelines, pumping stations, storage tanks, peak boiler stations and the distribution network. In co-operation with other Icelandic consulting engineering firms, Fjarhitun designed the Nesjavellir Geothermal Power Plant.

This case study describes a small part of the overall project: prevention of water-hammer in the transmission pipeline system. The most common hazard situation of a pipeline operation is probably caused by uncontrolled pump trip, often due to power failure. A sub-atmospheric pressure in the pipeline can occur and often the pressure can drop down to the vapour pressure of the pipeline liquid causing large vapour cavities to form. The rapid pressure rise, following collapse of the vapour cavities, is a serious problem and can cause high pressure shocks.

These can cause equipment damage and even rupture the pipes. Therefore, a reliable means of preventing water-hammer and the associated damage

to equipment and injuries to personnel is essential. The normal means of providing this is to use surge tanks or vessels. The design approach adopted by Fjarhitun was to use well established theory to compute the pressure transients in the system and to design a surge tank assembly to tackle this.



A computer model was then used to simulate real systems alternatives. For this portion of the work a different computer code from another supplier was used. Flowmaster was obtained after the design portion of the work was completed and was used to validate the tests. A predictive tool, such as Flowmaster, allows the rapid and accurate sizing of the surge tanks. It may also be used to simulate their operation. In order to establish the validity of the computer model, pressure tests were performed before the surge tanks were installed. These were done at flow rates of 490 l/s, close to a quarter of the total design flow rate. The pipeline was instrumented and pressures recorded at the pumping station and midway in the pipeline.

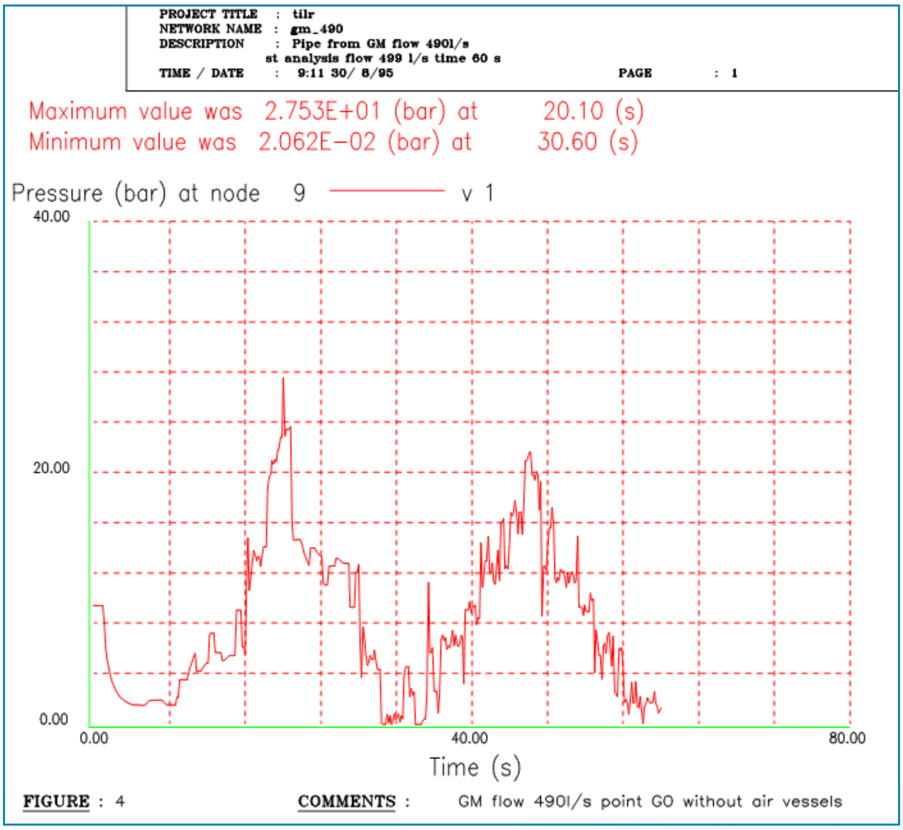


Figure 1

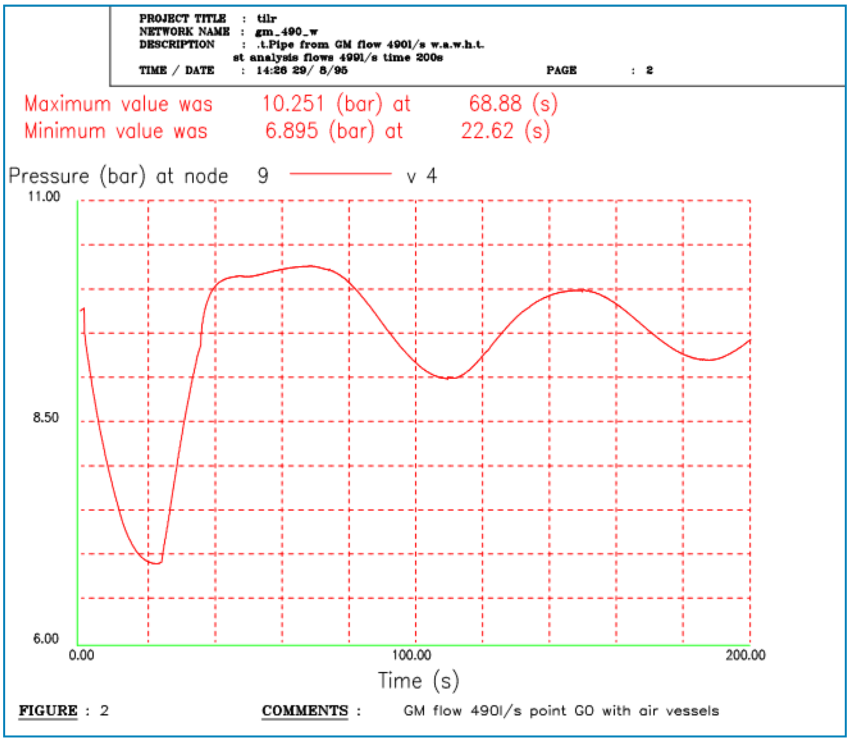


Figure 2

Flowmaster figures are presented which show the pressure transients after a pump trip. Figures 1 and 2 show pressures at the pumping station.

In Figure 1, without the air-vessel, the initial pressure of about 10 bar drops rapidly to about 2 bar. The pressure rises very rapidly to a peak pressure of 27 bar and then undergoes a number of very rapid transients. This peak pressure exceeds the design pressure, 16 bar, for the ductile iron pipeline even at these low flow rates. When a suitably sized air-vessel is added, Figure 2, the pressure time history is very different. The reduction in peak pressure is dramatic. The initial 10 bar pressure drops to about 6.9 bar and then rises smoothly to a peak of no more than 10.25 bar. The pressure then oscillates with a long period, about 80 seconds. This illustrates the damping effect and also the large increase in natural period due to the air vessel. Similar results, but with reduced pressures, may be observed in Figures 3 and 4 which show pressures midway in the pipeline. After using Flowmaster for this work Dr Oddur B. Björnsson's Chief Engineer said "the software is easy to implement and [Fjarhitun] can give it our best recommendations".

The design process, model studies and pipeline measurements have taken place over a number of years. At the beginning of 1994, the thermal output of the Nesjavellir geo-thermal power plant is close to 200 MW. The corresponding flow rate in the pipelines is about 900 l/s, about half the design flow rate. The pipeline design, including the water-hammer prevention, has proved to be very successful.

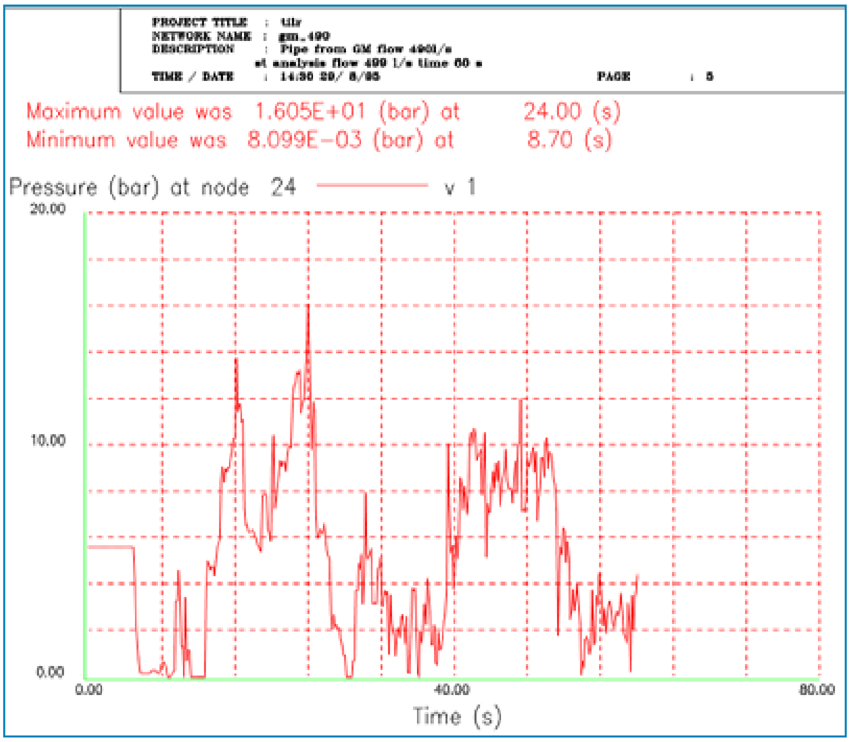


Figure 3

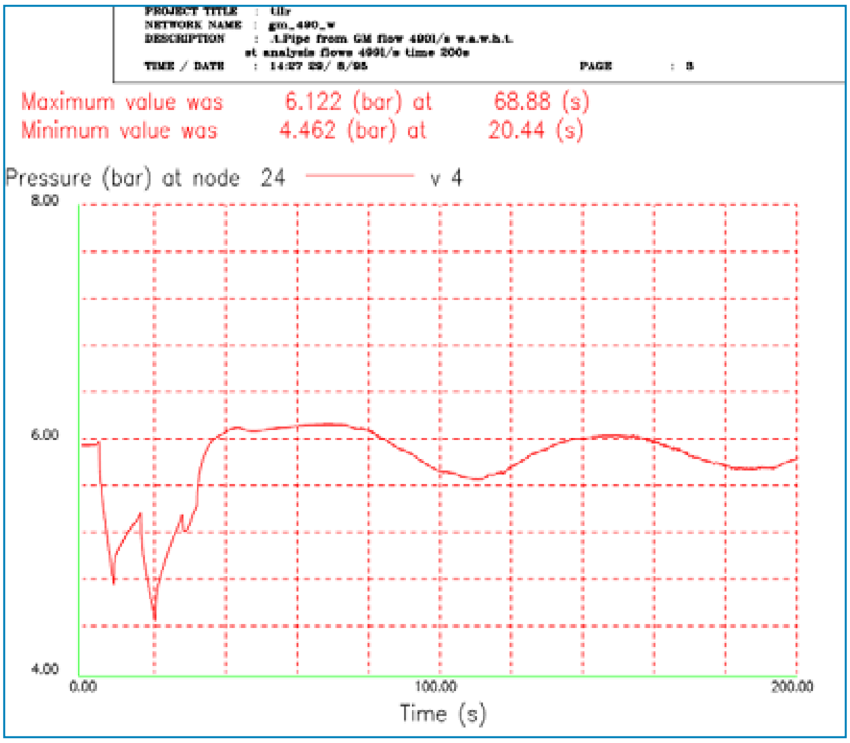


Figure 4