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The Orifice Wellhead Control Valve of HS Orka.

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ABSTRACT

In this paper the Ellaloki, a certain type of valve is described. The background of the Ellaloki and the need for it, will be discussed as well as its function and construction explained.

When the pilot plant of the Svartsengi Powerplant started in November 1976, the flow from the wells was controlled with orifices, existing gate valves could not be used for throttling. Back then, the only method available for changing the flow from a well, was by replacing the orifice plate, requiring a shutdown of the well. During the first years of operation, a few types of control valves were tested. All of them failed, mostly because the two-phase jet downstream of the valve cut through the valve body or pipe.

A unique valve design was developed, consisting of an orifice with a cone pushed into the hole. This design enabled the varying of the opening area, the Ellaloki design will be further described in detail. An overview will be provided over the problems and advantages encountered during the roughly two decades of operation of Ellaloki.

1. INTRODUCTION

HS Orka operates two geothermal power plants, the Svartsengi plant with 64 MW power and 120 MJ/s hot water production and the Reykjanes plant with 100 MW (Albertsson et al., 2010). During the first years of operations at the Svartsengi plant, the orifices at the wellheads were changed twice a year. The changing required a shutdown of the wells. Thus, a “summer” operation was arranged and a different “winter” operation. Excess steam was vented, and excess production of hot water reinjected. Using a fixed diameter orifice on wellheads hampered the operations of the steam field and the power plant. We also experimented with some types of control valves, but all the valves cut through the metal on the downstream side of the valve or the pipe.

In 1995 various problems with control valves on wellheads were discussed. A prominent question emerged regarding what to install. At the time, I, Geir, was the power plant manager and Elli the steamfield mechanic. Elli and I, discussed how to make a useful reliable control valve for the two-phase flow wells in Svartsengi (Gudmundsson, 2019). Our discussion went along these lines:

E: How can we make a valve which works?”

G: “Well, we must have an orifice and maybe we could use a giant needle, or a cone, to increase or decrease the opening of the orifice”.

E: “We probably have to have a side inlet because the end opposite to the orifice must have the valve stem and stuffing box”.

Within a week, Elli had already made a prototype (Gudmundsson, 2019), he had seen a valve in Mjólkárvirkjun, a Hydro Power Plant. The idea for the cone design originated there, that is, inspired by high pressure drop inlet nozzle to a Pelton wheel.

The geothermal companies in Iceland use various types of control valves. In the Hellisheiði plant, orifices are used on some wells and Metso control valves on others. There, orifices are used on wells where the control valves have developed a leak (Gudleifsson, 2019). At the Krafla plant, only orifices are used.

Currently HS Orka´s wellheads consist of, see Figure 1, a gate valve with an expanding gate, a top tee, a gate valve, and the orifice valve, Ellaloki.

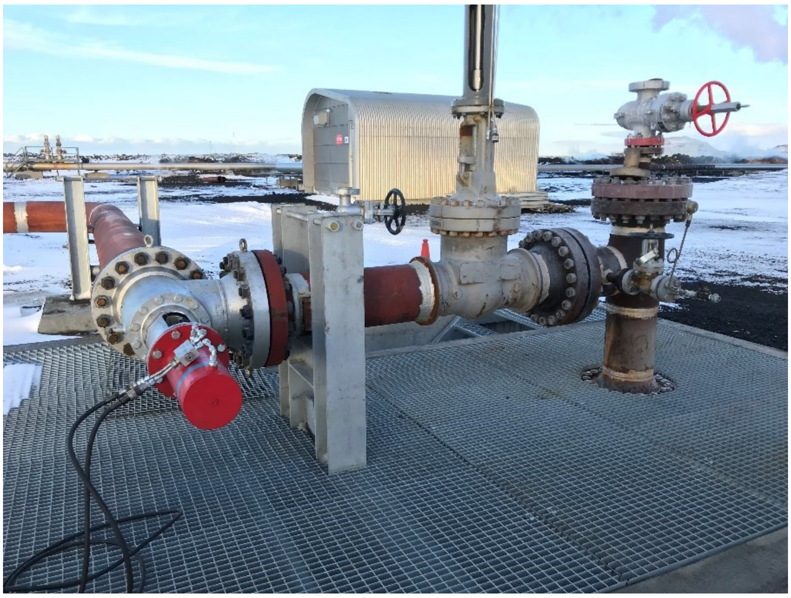

Figure 1: Wellhead of well REYH 36. Ellaloki to the left, gate valve center, top tee to right. In the basement below the tee, is the expanding gate valve.

2. DEVELOPMENT OF AN ORIFICE CONTROL VALVE

The first prototype of the Ellaloki was 8 inches in size and installed on a bypass pipeline at the wellhead on well 7 in Svartsengi. The Ellaloki quickly proved to function satisfactory. Then, it was decided to make a full size Ellaloki valve. The full size is 12-inches in diameter with DIN PN63 DN 300 flanges, see Figure 2. During 1998 this full-size valve was tested for 6 months and the results were promising. Therefore, all nine wells in Svartsengi were equipped with the 12-inches valve. In 2001, when planning the 100 MW Reykjanes power plant, the valve was upgraded to PN160 (equivalent to ANSI class 900). The PN 160 prototype has since then been used as a part of the well-testing equipment. Consequently, all the wells supplying water the Reykjanes plant were equipped with an Ellaloki valve.

2.1 Valve Design

Important aspects of the valve design are its simplicity and robustness. The original idea of Geir and Elli still is the main feature of the valve.

Originally, the assumption was that constructing the valve required standardized fittings only, see Figure 2. However, two fittings were slightly modified. The outlet flange and the tee are shortened to make the valve stem as short as possible. The inlet flange is left unaltered. A bearing in the throat of the stuffing box is provided to hold the weight of the cone. The valve stem is connected to the cone with threads and a grub set screw, used to lock the threads together.

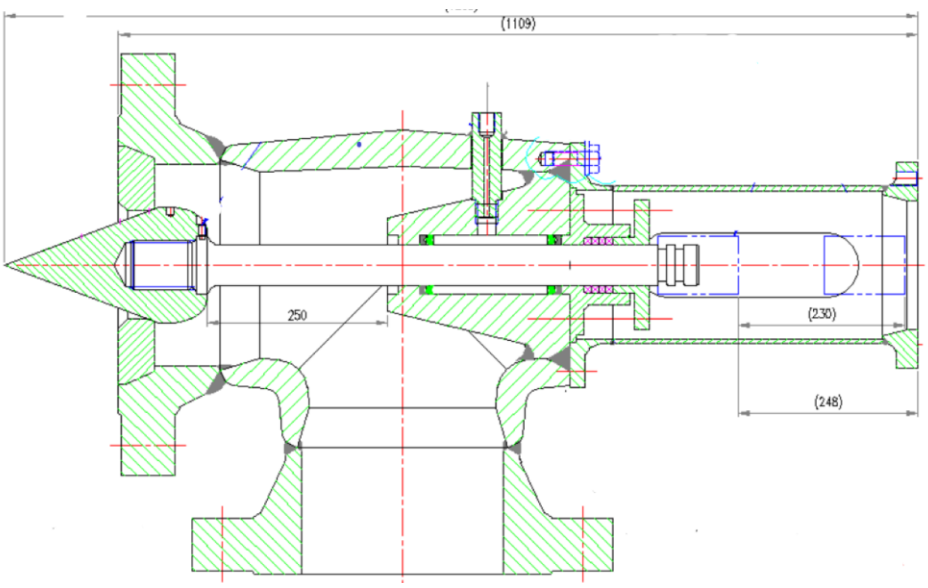

Figure 2: A section through the PN 160 DN 300 Ellaloki.

The stuffing box is two stage, there is an inner and an outer part. The internal chamber is for plastic packing and the outer part contains ordinary graphite packing rings. An injector fitting is provided for injecting the plastic packing material to the internal stuffing box.

On the outlet, that is, the downstream side, provision is made for a 50 mm thick orifice plate. A spiral-wound gasket seals both the flange face and the orifice plate, see Figure 3. The size of the orifices can be from 60 mm up to 150 mm. The most common orifice size in HS Orka´s systems is 120 mm.

Figure 3: This picture shows how a spiral-wound steel gasket seals both the flange and the orifice plate.

2.2 Valve Materials

The body of the valve, Ellaloki, is a tee, made from forged 16Mo3 material. PN 160 DN 300 flanges are welded to the body.

In Table 1, the materials used in Ellaloki are listed.

Part	Standard	Material	Size
Body: Tee	EN 10253-2 Type B	16Mo3	323,9x16
Flange	EN 1092-1 PN 160	C 22.8	DN 300
Orifice		Hardox 400	Ø330 x 50
Cone		Carbon steel	
Stem	SEW 400	W.no. 1.4462	
Stuffing box		Carbon steel	

Table 1: Materials in the main parts of Ellaloki

The Ellaloki is connected to a hydraulic jack. The jack operates the valve stem through a coupling inside a coupling tube, see Figure 4.

Figure 4: The coupling tube with improvised position indicator.

3. OPERATIONAL EXPERIENCE

The Ellaloki valve has been in service for over 20 years and has proven to be a reliable part of our operations. On a daily basis, the valve runs at a pressure of 12 to 30 bar and a temperature of 180 °C to 240°C. The maximum values obtained in operation are 70 bar and 290°C. All of the valves are hydraulically operated. The highest temperature wells produce considerable scaling on the downstream side of the orifice. The scaling is easily removed by closing and opening the valves. The Reykjanes valves are overhauled every two years during plant turnarounds, but the Svartsengi valves last up to a decade with only minor maintenance.

Remote control of the opening and closing is important. Otherwise, excess steam would have to be blown off when turbines are fully loaded. The remote control is also important when starting up the steam system from cold, for example following plant turnaround.

Some leak problems have occurred in the stem stuffing box. The stuffing box was originally of WKM type with injected plastic sealing paste. For fixing the leaks, the old design was replaced with a stuffing box with graphite rings and a lantern ring with a grease injection nipple.

The flow characteristic is reasonably linear up to over 50% opening, making the valve ideal for bringing the wells smoothly on line, and accurately adjusting the flow from each well, see figures 5 and 6.

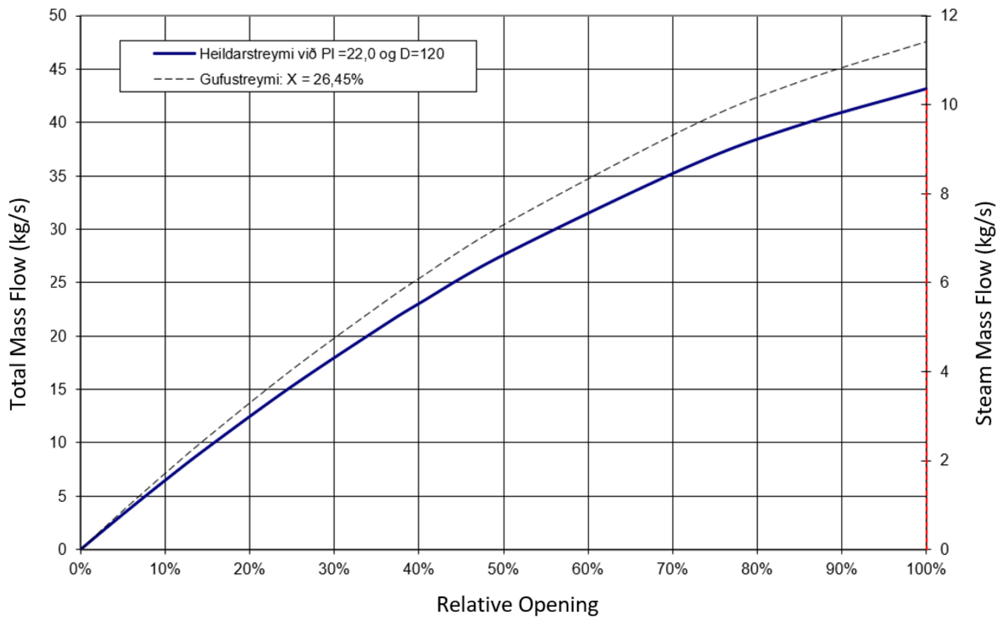

Figure 5: The solid line relates to the left scale and the dashed line shows the steam flow on the right scale. The graph shows results calculated for 22 bar well pressure, 19 bar downstream pressure, and enthalpy of 1400 kJ/kg.

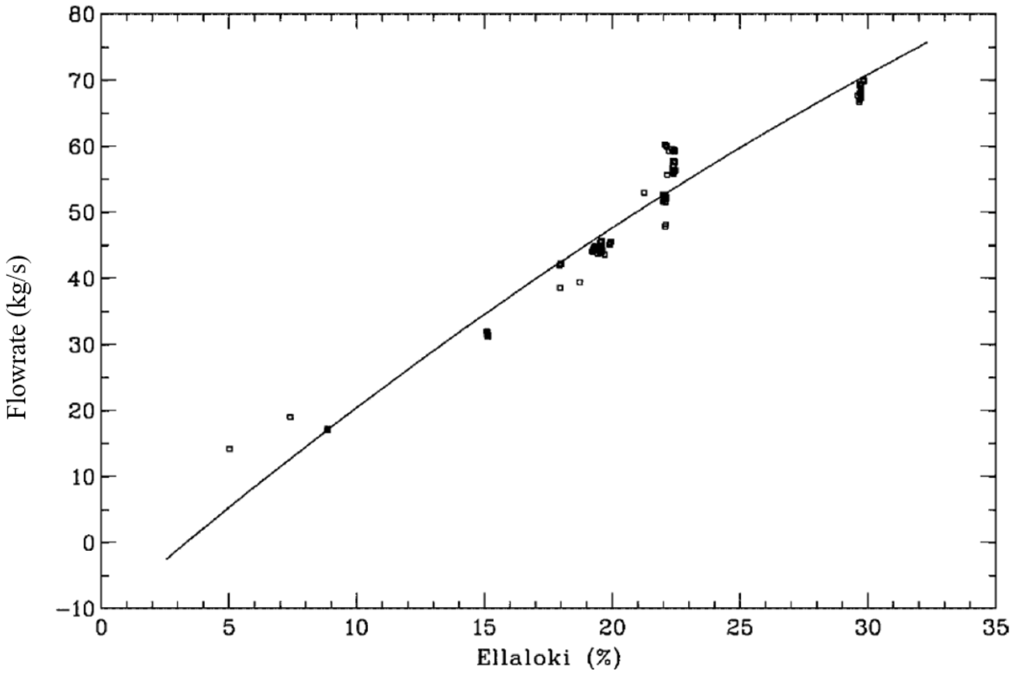

Figure 6, from Björnsson et al., 2004: Flow testing of well REYH 10 in 2003. The valve had a 150 mm orifice. The well enthalpy was 1400 KJ/kg, the wellhead pressure 40 to 50 bar, and the downstream pressure 4 to 15 bar.

Although stellite is welded on the valve´s cone, serious abrasions have occurred on some of the valves. This sometimes occurs when newly drilled wells are opened for the first time. This happens when well cuttings are carried with the well fluid, especially in wells where much gel has been used when drilling blind for several hundred meters. During the 20 years of Ellaloki operations we have two times seen abrasions on valve housings, when using a 150 mm orifice and a fully open valve. Supposedly, this did happen where the velocity was too high, caused by a narrow clearance between the valve body and the widest section of the cone.

CONCLUSION

The orifice valve has proven itself a valuable inventory in HS Orka's operations. Ellaloki has an outstanding reliability and robustness. Constructing the Ellaloki is easy, but still expensive, because only few items have been produced so far.

The IDDP-1 at Krafla was flow tested with orifices to control the flow. When the flow there had to be changed the well had to be shut down for changing the orifices. Currently, HS Orka is having an Ellaloki built for the IDDP-2 well at Reykjanes for use during the flowtest, when the well will be opened for the first time. Preparation for this flowtest will be finished in August 2019.

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