# DEVELOPMENT OF HIGH EROSION-RESISTANT GATE VALVE FOR GEOTHERMAL GATHERING SYSTEM

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SUMMARY - Gate valve is widely used in many fields because of its high shut-off character, low pressure drop with full opening and relatively low cost. In geothermal gathering system, it is required to control the flow rate with the opening from the small to the half during the well test, start up and heat up operation. However, conventional gate valve is not able to control the flow rate with the opening from the small to the half. In addition, it has a problem of erosion with the opening from the small to the half. Then, conventional gate valve is not preferably applied in the geothermal gathering system in spite of many good points mentioned above.

So as to improve these points, we modified the shape of gate and seat-ring of through conduit gate valve. This modification made it possible to develop a high erosion-resistant gate valve with good flow rate controllability for geothermal gathering system.

## 1. Introduction

Many gate valves are used in geothermal gathering system because of their high shut-off character, low pressure drop with full opening and relatively low cost. However, it is required for the valves used in the geothermal field to have the high erosion resistance for high speed geothermal fluid which carries small substances such as sand, mud, scale and so on.

Especially for the well head second valve located next to the master valve, it is required to control the flow rate with the opening from the small to the half during the well test, start-up and heat up operation. Even during the normal operation, it is necessary to control the pressure balance among the wells which has different well head pressures by adjusting the opening of this well head second valve.

The comparison of the suitability of various types of valve as the well head second valve is shown in the Table-1. This table shows if the gate valve had the controllability of the flow rate and high erosion resistance, it would be the most suitable for the well head second valve in the geothermal gathering system.

Table-1 Comparison of Valve as Well Head Second Valve

| Valve Type | SHUT-OFF | PRESSURE DROP Full open | CONTROL | EROSION RESISTANCE Full open | EROSION RESISTANCE Half open |
|---|---|---|---|---|---|
| Gate Valve (Wedge Gate) | ○ | ○ | × | ○ | × |
| (Through Conduit) | ○ | ○ | △ | ○ | × |
| Butterfly Valve | △ | × | ○ | × | × |
| Ball Valve | ○ | ○ | × | ○ | × |
| Globe Valve | △ | × | ○ | × | × |
| Angle Valve | △ | × | ○ | × | △ |

○:GOOD △:With some Condition ×:NOT GOOD

## 2. Development of New Type Gate Valve

It is known there are two types of gate valve, i.e, wedge gate valve and through conduit gate valve. The structure of wedge gate valve is shown in Fig-1. The wedge gate valve has the character that the small movement of gate with the small opening causes a large expansion of opening area. Therefore,it is not easy to control the flow rate by the wedge gate valve with the opening from the small to the half. In addition, since the flow is concentrated to the lower part of valve, the seat-ring and valve body are apt to have the erosion damage by the high speed geothermal fluid.

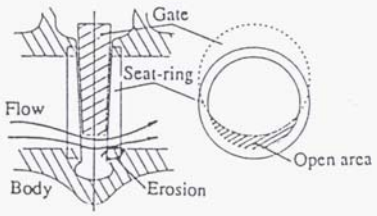


Figure-1 Wedge Gate Valve

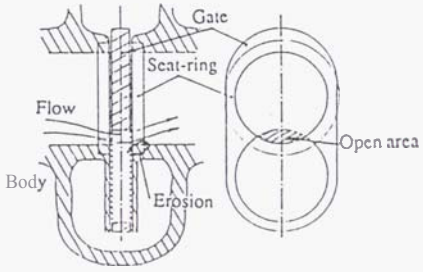


Figure-2 Through Conduit Gate Valve

The structure of through conduit gate valve is shown in Fig-2. The through conduit gate valve has the character that the small movement of gate with the small opening makes a little expansion of opening area. Then, flow control with the small opening can be achieved by the through conduit gate valve. However, since the flow is concentrated to the lower part of valve same as the wedge gate valve, this will cause the erosion problem.

Newly developed gate valve is a modified through conduit gate valve. We modified valve gate and seat-ring to make a projection at the bottom of the valve body (see Fig-3). Because of this projection the opening point of the valve starts near the center of bore and the fluid flow starts from the center of pipe. As a result, the high speed geothermal fluid flow does not come into collision with the seat-ring and valve body. This makes the newly developed gate valve high erosion-resistant.

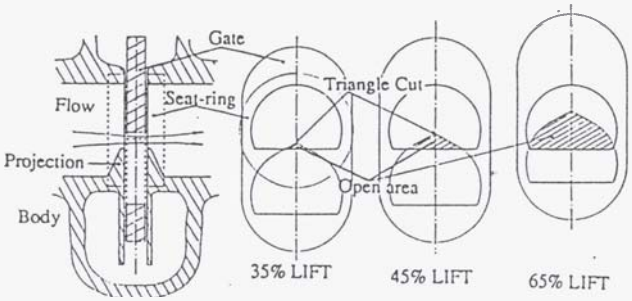


Figure-3 Newly Developed Gate Valve

In addition, we made the gate opening shape nearly triangle cut as shown in Fig-3. By this triangle cut, the expansion of valve opening area increases gradually as the valve gate is lifted. The relation between the valve lift and valve opening area is shown in Fig-4. This figure shows the newly developed gate valve has the better controllability of the flow rate with the small opening than other gate valves.

Since this newly developed gate valve has the projection at the bottom of the valve, the fluid flow does not start until the gate is lifted up to 30% and it has about 15% less opening area compared to the normal full bore valve of the same size (see Fig-4). However, the increase of the pressure drop by this modification is negligible because the pressure drop through the gate valve itself is very low.

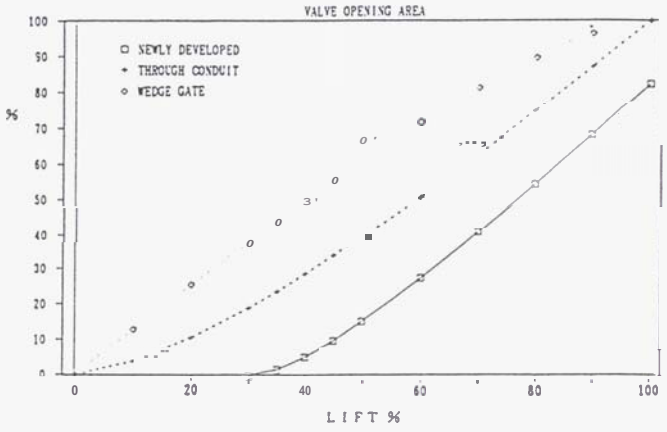


Figure-4 The Relation between the Valve Lift and Valve opening *Area*

These changes mentioned above can be made by partially modifying the mould of gate and seat-ring for the normal through conduit gate valve. It costs about 10% up of the price for the high pressure geothermal wellhead valves.

## 3. Fluid Flow Analysis

As for the modified shape of valve gate and seat-ring, the flow pattern is analyzed through the three dimensional compressive fluid calculation. It is assumed that the steam is the one phase ideal gas. The flow *speed* pattern calculated around the opening area is shown in Fig-5. As shown in this figure, the high *speed* fluid is concentrated at the center of flow and its direction is parallel with the pipe. Then, the high speed flow after expansion does not come into collision with seat-ring and valve body. So it is supposed that this newly developed gate valve has high erosion resistance.

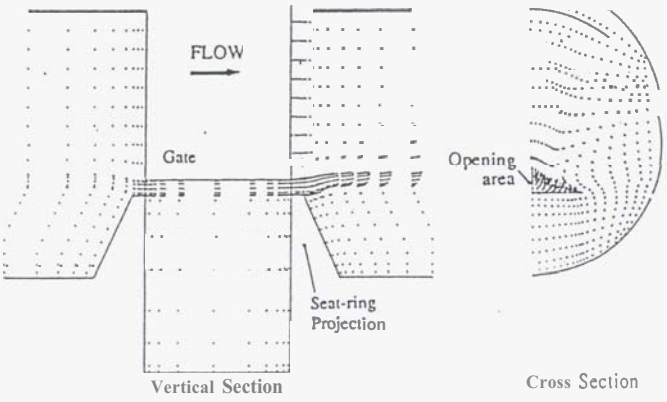


Figure-5 Flow Speed Pattern around Opening *Area*

The flow speed at the top of projection is rather high, so it may result that erosion is caused at this point. But the erosion of this projection is free from the lowering of shut-off performance and damage of body. This projection will be useful as the margin for erosion.

## 4. Cv Value

In order to estimate the controllability of this newly developed gate valve, Cv value is measured for 6 inch valve by water test. Based on this measurement, the Cv values for the practical size valve such as 10 inch and 12 inch are calculated. The result is shown in Fig-6.

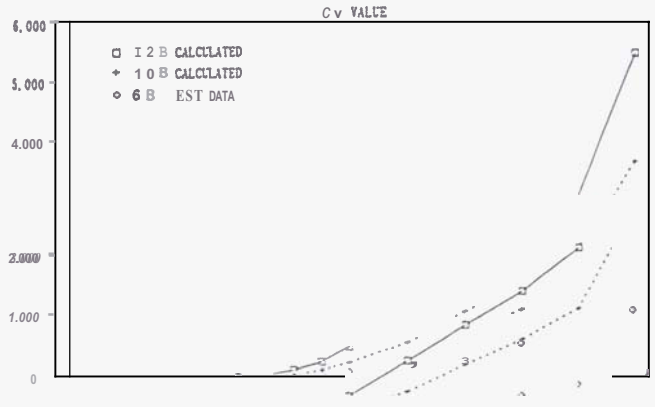


Figure-6 Cv Value of 6B, 10B and 12B Newly Developed Gate Valve

This figure shows the newly developed gate valve has the character that Cv value. increases gradually as the lift of valve gate is increased with the small opening. This means the newly developed gate valve has good controllability of flow rate with the small opening and this valve has an equal-percentage character.

## 5. Field Test and Practical Use

Three. newly developed gate valves of 6 inch size were used in YANAIZU geothermal field in 1987 as well head second valves in the breathing line for shut off and flow control of the first gushing fluid which contains mud and sand. As a result of this field test, it became clear that this newly developed gate valve has good controllability of flow rate and high erosion resistance.

Following this field test, three newly developed gate valves of 10 inch size were used in the long span flow test line in 1989 and 1990. These valves were used with the half opening over 100 days. The disassemble check after the field test showed there was a remarkable erosion damage at the projection of seat-ring (see Fig-7).

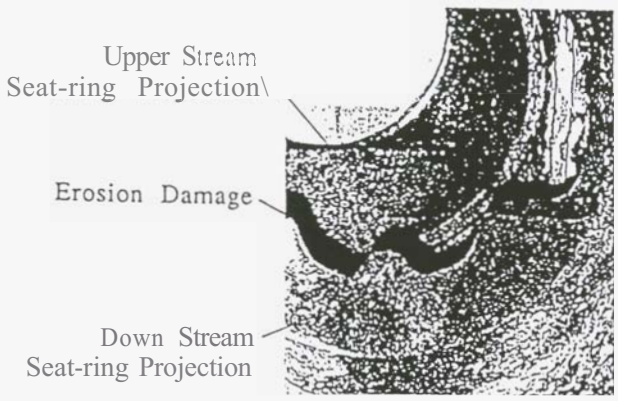


Figure-7 Seat-ring after Long Span Flow Test

However, there was nearly no damage at the seat-ring face and valve body itself. This means the shut-off ability of the valve was kept in spite of the damage at the projection of the seat-ring. It was made sure this modification of the through conduit gate valve is effective in the geothermal field. Based on these field test results, some improvement of detail size was made. These valves are under the service for another phase of flow test.

This year (1993) nine newly developed gate valves of 12 inch size were installed at UENOTAI geothermal field as well head second valve. The commissioning of this power plant will be started in coming October.

## 6. Conclusion

Practical high erosion-resistant gate valve which has good controllability of flow rate is developed by modifying through conduit gate valve based on mathematical flow analysis and flow rate experiment and 6 years field test.
Geothermal well head system is not usually stopped except periodical maintenance shut down. Therefor, gathering systems are required high performance and reliability. We expect this newly developed gate valve will be used in many geothermal fields and keep them in safe and easy operational conditions.

## 7. Acknowledgement

We made up a prototype of this newly developed gate valve in cooperation with Hitachi Metals,Ltd.
Practical models were made by Takamizawa Valve Co.,Ltd.
Field tests were supported by Okuaizu Geothermal Co.,Ltd.
This results are recognized by Akita Geothermal Energy Co.,Ltd. and this type of valves were used in their geothermal gathering system.
Their cooperation is highly appreciated.