AVARIS: An innovative process to repair seal seat surfaces in gate and check valves

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ABSTRACT

AREVA Valve Repair in situ – AVARIS in short – is an innovative process for repairing valves in situ, i.e. in the assembled state. This novel technology allows the body of seal seats of gate and check valves to be worked on and reconditioned in the power plant, in their position without extracting them. An application for a patent has already been filed for AVARIS on a global scale.

Until now, damaged seal seat surfaces were grinded off to recondition them and to restore their planity. However, each grinding process also reduces the thickness of the residual hardfacing layer. Finally, the residual hardfacing layer disappears completely and parts of the base material are worn. As the valve's base material is much softer than the hardfacing material, the valve's sealing function is no longer guaranteed.

Instead of replacing the valve body and cutting it out of the piping system, AREVA has developed the AVARIS valve repair process and filed an application for patent. This new process is used to recondition the bodies of gate and check valves while they are in place, and it is even applicable in places that are difficult to access. The essential steps of the refurbishment include turning down of the worn seal seats, overlay welding of the new hardfacings and finish turning. A grinding process is used to finish the surface quality.

AVARIS offers great advantages for the global maintenance market because time, effort and costs are saved.

This new technology has been successfully applied in various valve reconditioning projects in German and French nuclear power plants since 2010. Further follow-up orders in German and international plants such as in France and Sweden show that valve refurbishment with AVARIS heads to establish itself as a reliable and flexible process in power plants worldwide.

1. INTRODUCTION

AREVA Valve Repair in situ – AVARIS in short – is an innovative process for repairing valves in situ, i.e. in the assembled state. This novel technology allows the body seal seats of gate and check valves to be worked on and reconditioned in the power plant, in their position without extracting them. An application for a patent has already been filed for AVARIS on a global scale. This article outlines the causes and degrees of wear of gate and check valves in both nuclear and conventional power plants first and shows options for restoring the sealing capability in the following. After that the new AVARIS technology for valve repair is presented. The method and the technique used are described and the work steps outlined. Subsequently, the authors report on the first implementation of AVARIS in a German nuclear power plant.

2. GATE AND CHECK VALVES AND THEIR CAUSES OF WEAR

Gate and check valves (Figure 1) are crucial components in a piping system. The safety of the system and even of the entire plant depends on their function and sealing capability. They are used where high medium flow rates with low friction losses are desired. Depending on the pressure and temperature range, gate valves are divided into 2 basic forms: parallel slide and wedge gate valves. The seal seat surfaces of parallel slide valves are positioned vertically to the pipe axis whereas the angle of wedge gate valves is smaller than 90 degrees.

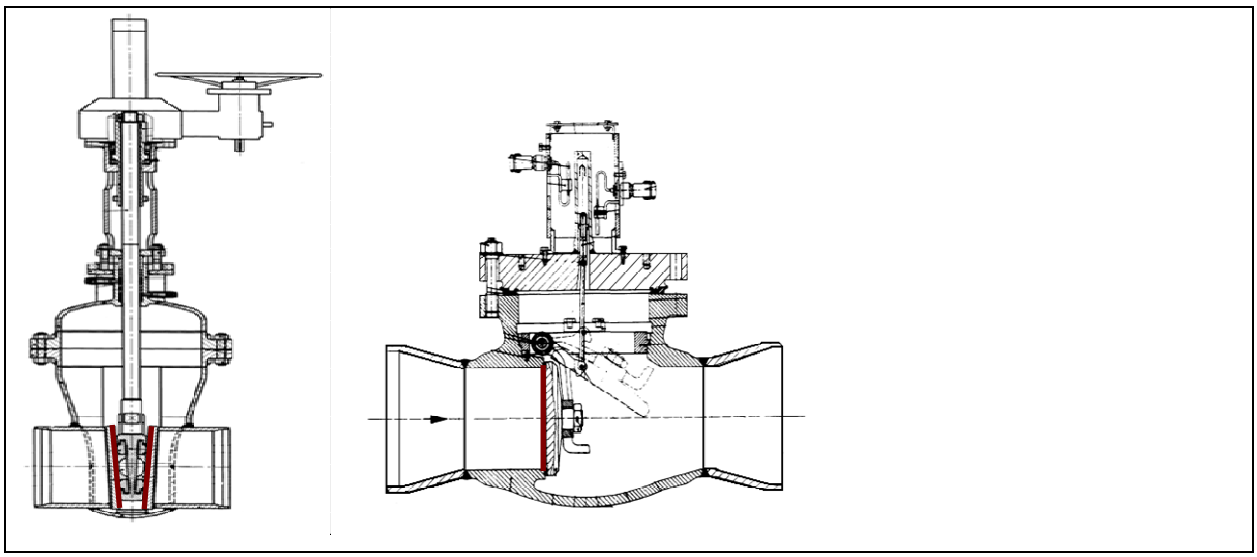

Figure 1: Gate valve (left) and check valve (right). The seal seat surfaces are marked in red.

Over time, the seal seat surfaces of the valve bodies suffer from wear due to the opening and closing of the isolating valve in combination with the contact pressure occuring during operation (Figure 2). System parameters such as pressure, the type of medium flowing through the pipes and the temperature also play an important role. With increasing wear, the seal seat surfaces (often also referred to as hardfacing layers) can no longer ensure the valve's sealing function. Wear to hardfacing layers most often occurs in 3 forms: score marks due to

- insufficient surface hardness of the remaining hardfacing layer
- stress-induced cracking
- the hardfacing layer exhibits disruptions

or is completely worn away.

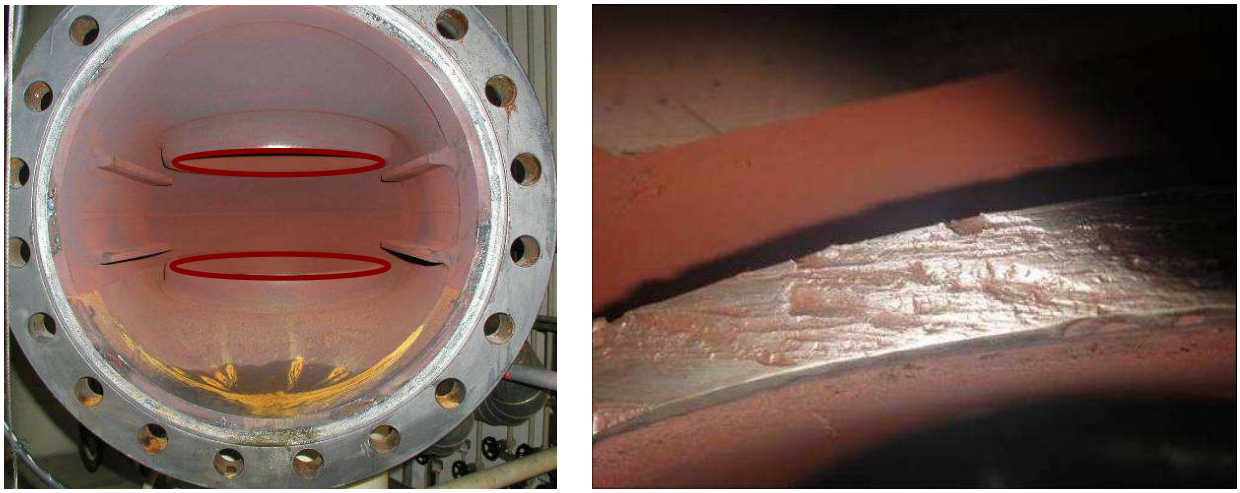

Figure 2: Top view through the valve neck on the body sealing seats. The seal seats each are marked in red (left). Damage at the sealing seat of a gate valve due to wear (right).

3. POSSIBILITIES TO RESTORE THE SEALING FUNCTION

Until now, damaged seal seat surfaces were grinded off to recondition them and to restore their planity. However, each grinding process also reduces the thickness of the residual hardfacing layer. Finally, the residual hardfacing layer disappears completely and parts of the base material are worn. As the valve's base material is much softer than the hardfacing material, the valve's sealing function is no longer guaranteed. Grinding off seal seat surfaces is thus a measure that only produces short-term benefits. This method cannot compensate for unilateral wear of an e.g. oblique seal seat. So far, the valve bodies with worn down seal seats had to be cut out and removed from the piping system. Afterwards, there were 2 alternatives: replacing the valve body by a new component that is identical to the original component or refurbishing the component outside the plant (ex situ) and re-installing it afterwards. Cutting out components from the piping system is a laborious task because special machinery is required, and the installation position of the valve can make the job even more difficult. Interfering edges may complicate the removal. If the worn valve body is cut out to be reconditioned, it needs to be transported to the supplier's workshops outside the power plant. However, transports often involve high effort, especially in case of contaminated valve bodies from the primary system of nuclear power plants. Both options, reconditioning a worn valve body outside the power plant or replacing it, require a comparatively high planning and implementation effort. Another aspect has to be considered: many valve manufacturers from the time when the plant was built are no longer on the market as suppliers today. On the one hand this means that new valve bodies can differ from those already in use in terms of geometry, weight and material. The new bodies have thicker walls as a result of more stringent safety requirements derived from present guidelines. Change requests and the associated new design of the entire piping system require a lot of time and resources, hence causing considerable costs. On the other hand, new valves often have delivery times of 1 to 2 years. A valve body replacement consequently requires a rigid outage planning on a mid-term basis. An ad hoc approach is therefore not possible.

4. NEWLY DEVELOPED AVARIS – A FLEXIBLE SOLUTION

Instead of replacing the valve body and cutting it out of the piping system, Areva has developed the AVARIS valve repair process and filed an application for patent. This new process is used to recondition the bodies of gate and check valves while they are in place, and it is even applicable in places that are difficult to access.

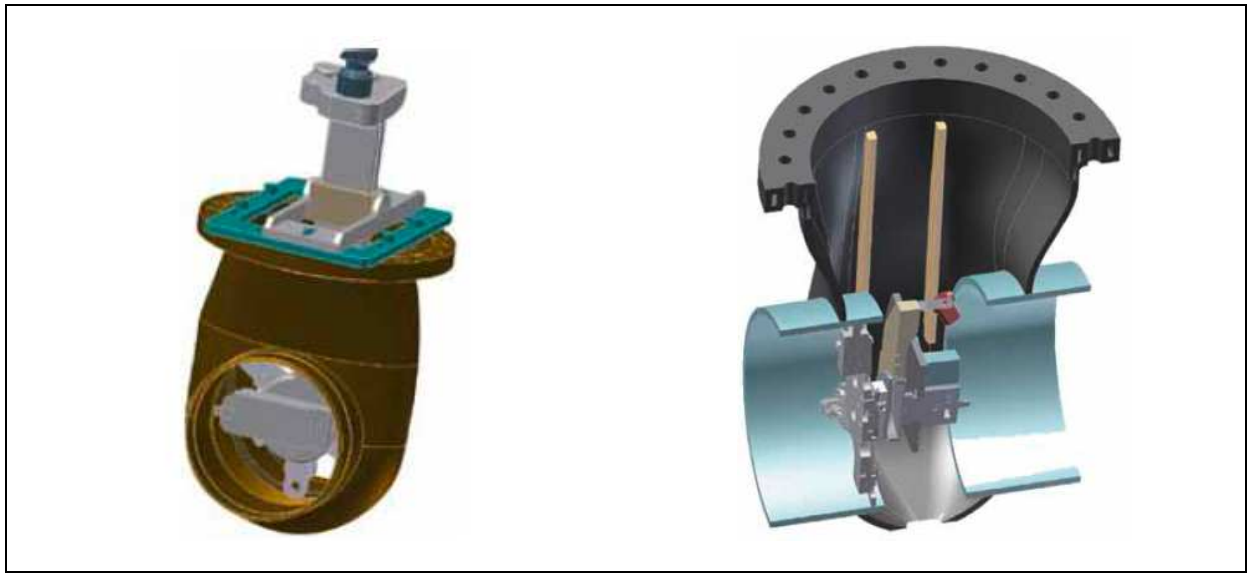

Figure 3: AVARIS turning (left) and welding solution (right).

When using AVARIS to restore the sealing function, the seal seat surfaces are reconditioned directly in the piping system inside the power plant. The essential steps of the refurbishment include turning down of the worn seal seats, overlay welding of the new hardfacings and finish turning (Figure 3). A grinding process is used to finish the surface quality. Result of the refurbishment process: the valve's original condition is restored in accordance with the technical drawing. This means that a gate valve refurbished in this way has the same qualities in terms of sealing function and wear resistance as a new gate valve. By applying a new hardfacing material, a Vickers hardness between 340 and 400 HV can be achieved. This significantly improves the lifetime and the wear behavior of the seal seats. In most cases, the seal seat surfaces are accessible through the body's opening positioned vertically to the valve's center plane. For this reason, the special machinery must perform a force and motion deflection by 90 degrees. In case of double disk gate valves, the machines can be adjusted according to the angles of inclination. The AVARIS modules cover nominal internal pipe diameters from 200 to 1,000 millimeters. It is possible to process system pressures in the low-pressure (max. 40 bars) and medium-pressure range (40 to 100 bars). The special machinery has smaller dimensions than the dome of the upper valve part when it is in place. They can therefore be installed and removed through the body's opening and consequently be deployed regardless of the installation situation.

5. WORK STEPS OF THE AVARIS VALVE REFURBISHMENT

1. Disassembly: to obtain access to the body seal seat surfaces in order to perform a general inspection on the valve, the valve internals have to be removed.

2. Initial assessment and analysis: a detailed initial assessment is performed using special measuring equipment. The present condition of the valve body is designed in an extremely accurate, digital 3D model. Additionally, the thickness of the residual hardfacing is determined via paint imprint. A dye penetration test is used to detect cracks or inclusions at the seal seat surfaces. All valve data collected in this way are analyzed with the aim to derive concrete measures for refurbishing the valve.

3. Developing a specific refurbishment concept: this concept also takes specific customer requirements into account such as to preserve the present body geometry (actual condition) and not to restore the original condition delivered ex works (according to the technical drawing).

4. Implementing the concept: the clamping fixture of the welding and turning machine is installed through the body's opening. The mobile turning device for conditioning the body's seal seat surface is first attached to this fixture. After turning down the residual hardfacing, another dye penetrant test is performed. Subsequently, the new hardfacing is applied in several layers by means of WIG (Wolfram Inert Gas) overlay welding according to the specifications of the welding plan previously coordinated with quality assurance. A special turning device is used to eventually turn the hardfacing to the final dimensions. To obtain a high surface quality, the seal seat surface is finished using a special grinding machine.

5. Processing the sealing plates: the sealing plates are either reconditioned or replaced depending on the customer's requirements and subsequently fitted into the refurbished body.

6. Overhauling the valve inserts and reassembly: the valve is overhauled generally, meaning wear parts are replaced.

6. FIRST APPLICATION IN THE ISAR 2 NUCLEAR POWER PLANT

In July 2010, AVARIS was used in a project in the German Isar 2 nuclear power plant: 2 gate valves in the condensate and main feedwater system were successfully reconditioned. The expectations of the operator, E.ON, in terms of technology and flexibility were fully met. This novel approach had the benefit that the power plant operator did not have to replace the valve body. And the advance planning period in Isar 2 was short: there was no need for complex engineering and new design of the entire piping system as would have been required had the valve bodies been replaced. Valve refurbishment using AVARIS thus is much more cost-efficient compared to the other alternatives. Another benefit: the refurbished gate valves were as good as new afterwards in terms of their sealing function.

As a result, this new technology has been successfully applied in various valve reconditioning projects in German and French nuclear power plants since 2010. Further follow-up orders in German and international plants such as in France and Sweden show that valve refurbishment with AVARIS heads to establish itself as a reliable and flexible process in power plants worldwide.

7. SUMMARY

Areva has developed an innovative process: AVARIS. This special technology allows the bodies of gate and check valves to be reconditioned in situ in the power plant. This offers great advantages for the global maintenance market because time, effort and costs are saved. The new refurbishment method is suitable for valves in the primary and secondary circuit of nuclear power plants but also for the conventional power plant market. If valves in the primary circuit are refurbished, complex and expensive nuclear transports are no longer needed. The technology satisfies the quality specifications of the German and international authorities. A valve that has been refurbished with AVARIS equals an original valve as far as the sealing function is concerned. The new technology was successfully used on various gate valves in German and French nuclear power plants since 2010. Further follow-up orders in German and international plants such as in France and Sweden show that valve refurbishment with AVARIS heads to establish itself as a reliable and flexible process in power plants worldwide.