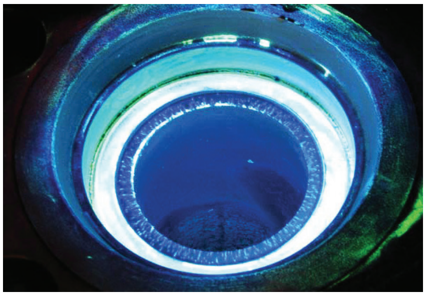
TechTalk

Fatigue cracking in high cycle applications

Thermal and Mechanical Cycling Lead to Cracking in the Inlet and Outlet Bores

Dye penetrate check of thermal cracks to valve bore.



UV light showing thermal cracks to valve bore.

Heavy oil applications subject valves to high thermal and mechanical cycles. They also experience large pressure drops on both sides of the valve as a result of process flow being bi-directional. After several years in service, customers noted thermal fatigue cracking in the inlet and outlet bores. MOGAS solved the problem with the use of thermal sleeves in the inlet and outlet bore. These sleeves are designed to reduce the temperature gradients experienced by the valve.

Application Challenges

The nature of heavy oil applications subjects the valves to high pressure and high temperature cyclic conditions. This includes pressures from both directions resulting in excessively high forces.

During an outage opportunity overhaul, surface cracks were discovered on the inner diameter of several valve housings and connectors of 3-inch ball valves in catalyst addition and withdrawal service. It was suspected these surface cracks were caused by thermal cyclic stresses. A detailed FEA (finite element analysis) was performed to investigate into the root cause of these indications. Findings from the FEA showed that high stresses were predicted in the area where surface cracks were reported. The striations show that the crack deformations were caused by cyclic thermal fatigue.

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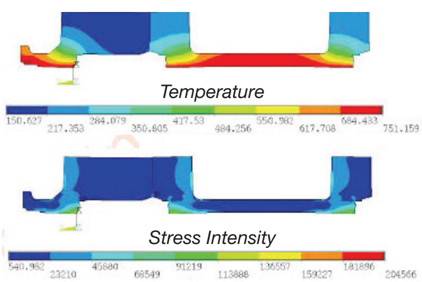
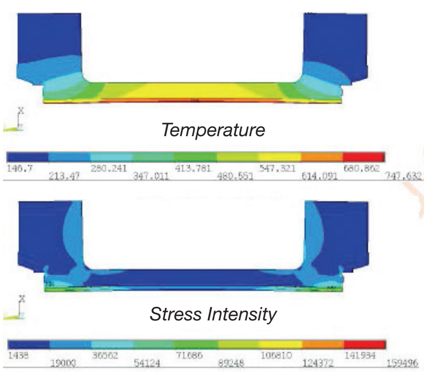


Results of structural and thermal FEA without thermal sleeves.



Results of structural and thermal FEA with thermal sleeves.

MOGAS Solution

MOGAS worked closely with one of the leading ebullated bed technology companies and a worldwide major oil company to find the proper technical solution. Material selection and application methods were carefully analyzed and chosen based on extensive computer modeling and laboratory analysis. This patented technology combination is currently installed in many installations around the world.

A thermal sleeve design feature was added as a result of previous valves installed in this location having thermal cracks in the bore of the valve inlet and outlet connections. The cracks were caused by high cycling and thermal gradients imposed on the valves during normal operation. The thermal sleeves served to minimize the thermal gradients imposed on the valve end connections.

An Yttria-stabilized Zirconia ceramic thermal barrier coating was applied to the Inconel sleeve to reduce the transfer of heat from the process media to the body and valve end connections. The coating was selected based on its high relative coefficient of the thermal expansion, ability to withstand thermal shock and low thermal conductivity. The thermal barrier coating is applied to the outer surface of the sleeve and ‘captured’ between the valve body and the substrate of the Inconel sleeve to which it is applied.

The coating is operating as intended to reduce the thermal gradients that would be imposed on the base material. Thus, the thermal cracking seen on past valves in this application without the thermal sleeves has been remedied. FEA analysis shows there are significantly lower stress intensities and fatigue life increased to greater than 30,000 cycles.