HIGH TEMPERATURE NITRIC ACID EXPANDER INLET SCROLL DISTORTION

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High temperature expanders in nitric acid power recovery service are specialized pieces of equipment designed for the particular service. They receive tail gas from the process in the temperature range of 1100°F to 1350°F at pressures from 60 psi to 250 psi. Most discharge at a pressure just above atmospheric. Because shutting down the process is necessary to change the catalytic gauze in the ammonia burner several times a year, the expander is cycled up and down frequently between operating temperature and ambient.

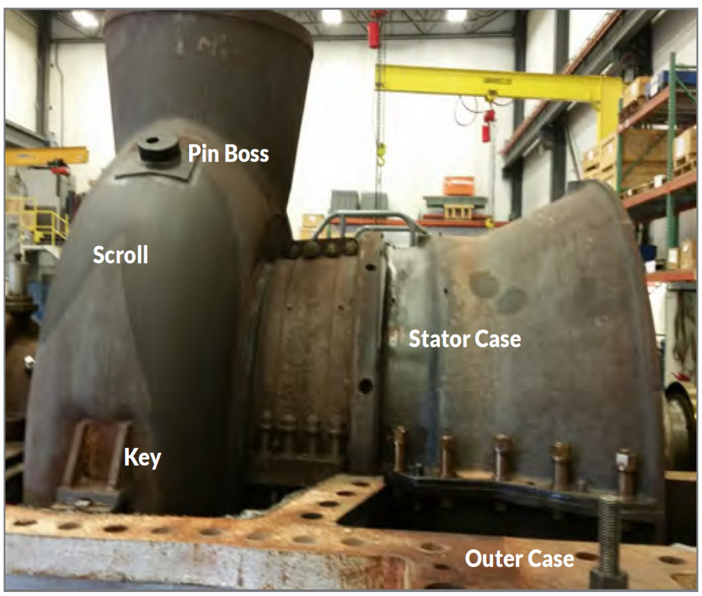

Figure 1: Disassembly of I-R Nitric Acid Expander

In order to shield the outer casing from the gas temperatures, the expander is designed with inner casings. The inlet casing is commonly referred to as the scroll because it is usually a complex toroid shape. The scroll is intended to direct and distribute the flow of gas from the inlet flange into the first stator which is often attached to the scroll. The scroll is not designed to be a pressure containing element so it is manufactured from relatively thin stainless steel or nickel alloy material as a spinning and/or fabrication. Large variations in thickness are avoided to reduce thermally induced stresses.


Figure 2: Scroll Removed from Outer Casing

The combination of these factors results in large differences in thermal growth between the inner and outer casings. With the tight operating clearances of nitric acid expanders, it is imperative to maintain alignment between rotating and stationary components from cold assembly conditions to hot operating conditions. For the scroll to casing this may be accomplished with radial pins and keys between inner and outer parts. These keys and pins allow the hot scroll to expand without restriction while maintaining relative position to the rotor. In theory.

In practice, these alignment features frequently bind due to misalignment, tight clearances, component distortion, corrosion, etc. and prevent the scroll from freely expanding resulting in distortion and cracking of the scroll and affecting alignment to the rotor.

Binding can occur relatively quickly during the operating cycle depending on the severity of the cause. The cracking is sometimes exacerbated by embrittlement of the material from thermal aging. Because this is a common problem, time during the overhaul should be allowed for repair of the scroll.

Figure 3: Scroll Distortion from Keyed Support Foot

Figure 4: Scroll Cracking from Keyed Support Foot

Repair often includes removal of the old key feet and pin bosses and patching in new or repaired parts. Reinforcing the shell of the scroll in the area of the attachment has been effective in preventing excessive distortion as well. Casings that have experienced embrittlement can often be rejuvenated through a solution anneal heat treatment. Embrittled material can be impossible to weld because cracks will propagate from the heat affected zone so solution treatment should be done first. Aside from welding difficulties, embrittlement can be identified through metallurgical analysis. The thin wall construction of the scroll makes bracing during heat treatment critical in preventing and correcting distortion. Remachining of the feet and nozzle fit will be necessary after weld repair.

Prevention of in-service distortion is not always possible. However, by ensuring adequate design clearances, using appropriate materials and designs in the alignment features and aligning the scroll correctly, damage and distortion can be minimized.

Figure 5: Scroll in Oven for Solution Anneal Treatment

Figure 6: Assembly of Repaired Scroll with Reinforced Features

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