Elliott provides expander solution where others fell short

Customer:

Oil Refinery - Fluid Catalytic Cracker Process (FCC), Texas

Equipment:

Non-Elliott Expander

Problem:

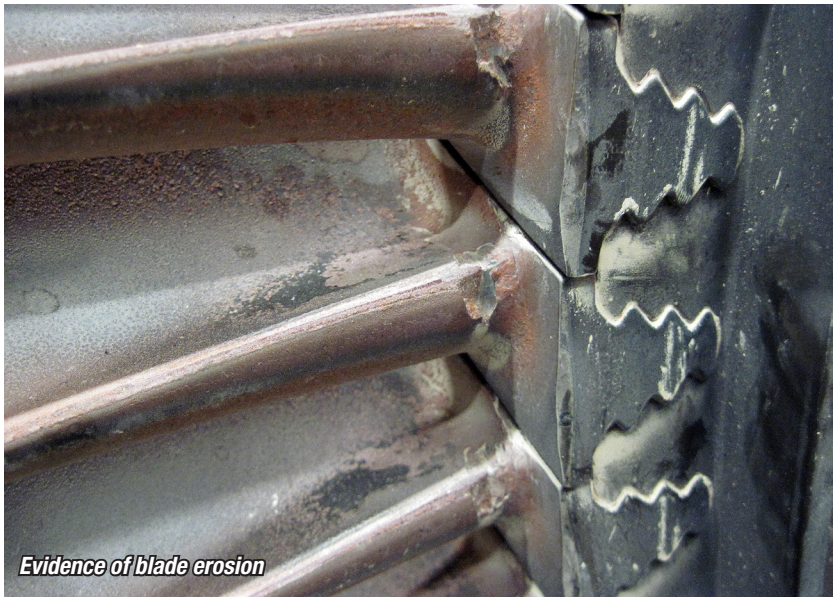
Customer experienced primary and secondary blade erosion, and significant vibration issues with both the equipment and the process piping.

Solution:

Elliott replaced the inlet and internal expander components with Elliott designed components, redesigned a new baseplate, and recommended modifications to process piping.

Elliott was contacted by a Texas refinery to consult on a vibration issue with an FCC process expander. During the visit, the customer mentioned a recurring issue with blade erosion on the same expander, which limited them to runs of only two years between shutdowns. The FCC process is the heart of the refinery. When the process is down, the refinery loses 60-70% of its production capability, a reduction of up to 100,000 barrels per day.

The original non-Elliott equipment string began operation in 1979. It consisted of a motor, gear, axial compressor, and expander. Soon after commissioning, the customer began experiencing erosion issues. In 2000, all new rotating equipment and some piping components were rerated by the OEM since the expander had reached the end of its design life, and in an attempt to increase plant capacity. In 2005, the machine was rerated again due to persistent problems and severe catalyst erosion. The catalyst erosion continued, forcing the customer to replace blades, stators, and the inlet casing in 2009. The 2005 and 2009 rerates were performed by a third party service provider. Over the course of the equipment rerates, the power generating capability of the expander was reduced by over 25% in an attempt to eliminate the erosion.



Evidence of blade erosion

After multiple unsuccessful rerates by the OEM and the third party service provider, the customer turned to Elliott. The previous rerates failed to solve the erosion issue and created the vibration issue.

Elliott performed a site audit in 2010 to review equipment design conditions and operational data. Elliott engineers performed a walk-through of the FCC process alongside the customer's reliability engineers, noting areas of concern and possible causes of the vibration and erosion issues.

The walk-through revealed that the vibration was located in the process piping, not the expander itself. The entire tower around the process piping was shaking due to acoustic vibration caused by an upstream valve which was nearly closed. This acoustic vibration had caused a crack in the expander exhaust casing.

Casing damage due to piping vibration

Elliott identified the causes of both the erosion and vibration issues:

Erosion

- Secondary erosion from small particles entrained in the gas
  - Caused by flow separation and vorticing
  - Disruption of process flow by steam injection

Vibration

- Vortex shedding (turbulent flow) from the inlet valve impacting the process piping
  - Expander was "oversized" causing throttling on inlet valve
  - Large pressure drop (45 psi – 24 psi) across the inlet control valve generating vortices
  - Improper support of piping structure
  - Close proximity of control valve to elbow

Elliott proposed two options to correct these problems. The first option would replace the rotor and existing aero components with Elliott-designed components. This would result in a power increase of approximately 7%, reduce secondary erosion, reduce or eliminate cooling steam, and reduce throttling at the inlet valve. Option two would replace the inlet casing with an Elliott TH100 inlet and install Elliott stators and blades on a new rotor assembly. This would result in a power increase of approximately 11%, reduce cooling steam, reduce throttling at the inlet valve, improve blade containment for operator safety, and remove internal superalloy bolting which is costly to keep on hand. In addition to the expander overhauls, Elliott recommended that the inlet valve be relocated closer to the expander, since the current location was too far away to prevent equipment overspeed.

While the customer was reviewing Elliott's recommended options the expander experienced an uncontrolled overspeed event due to a broken coupling. Elliott's prediction of this unfortunate event provided credibility to the analysis. The customer invited Elliott back to the site to provide a firm quote for the second option.

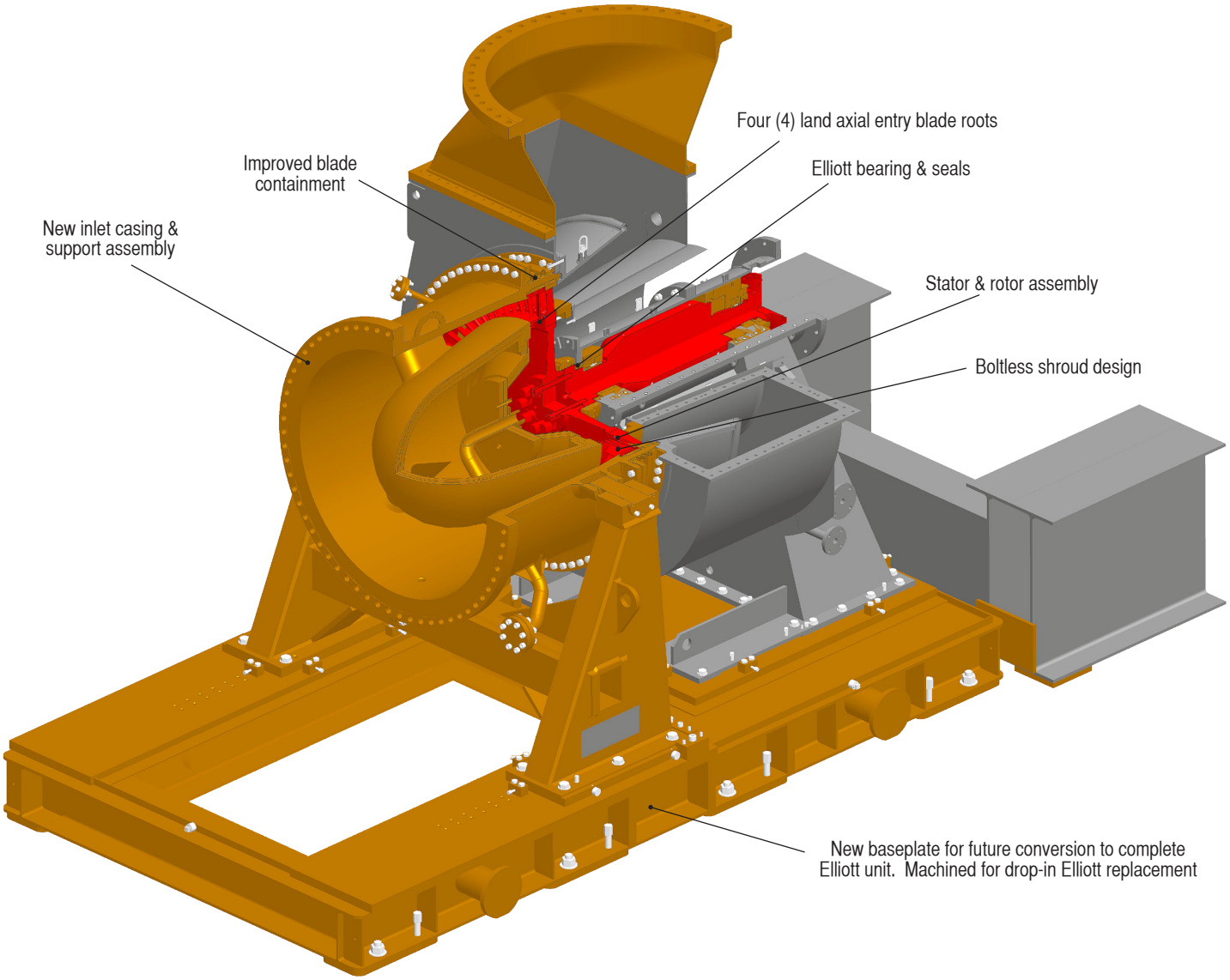
Damaged coupling due to overspeed event, predicted by Elliott

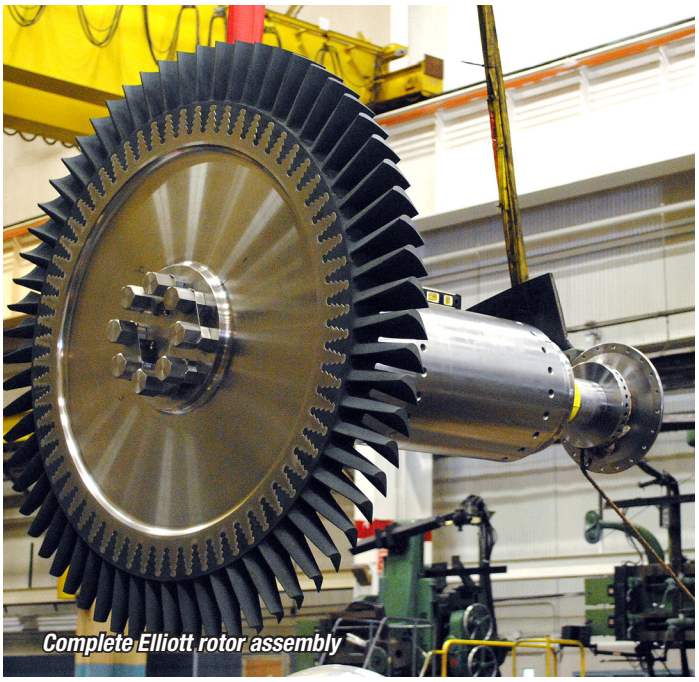
The second option provided the following advantages:

- Increase from 15,300 hp to 17,000 hp
- Significant reduction of required steam cooling
- Reduced throttling at inlet butterfly valve
- Upgraded rotor design with a Curvic coupling
- Four land axial entry blade root for reduced stress and disc erosion
- Increased safety and load capability with multiple tie bolt design in place of single central tie bolt
- Full Elliott TH100 flow path and disc
- Improved blade containment
- Elimination of internal superalloy bolting with Elliott's boltless design

Elliott's proposal also included a new baseplate, redesigned to eliminate bowing and sized for the new Elliott exhaust and bearing pedestal. The baseplate was intentionally oversized to allow for future modification to a complete Elliott unit. Elliott Field Service supervised and coordinated the pouring of a new foundation under the existing equipment while in operation, which allowed for fast installation once the expander work was completed. All wearing parts (bearings and seals) were converted to the Elliott design. A boltless shroud design was chosen for its cost effectiveness, reduced complexity, and elimination of costly bolting and spare bolting. This was the first boltless design ever used by Elliott.

Due to the abbreviated shutdown window, Elliott repaired the spare pedestal in advance, allowing the entire project to be completed within the allotted two week window.





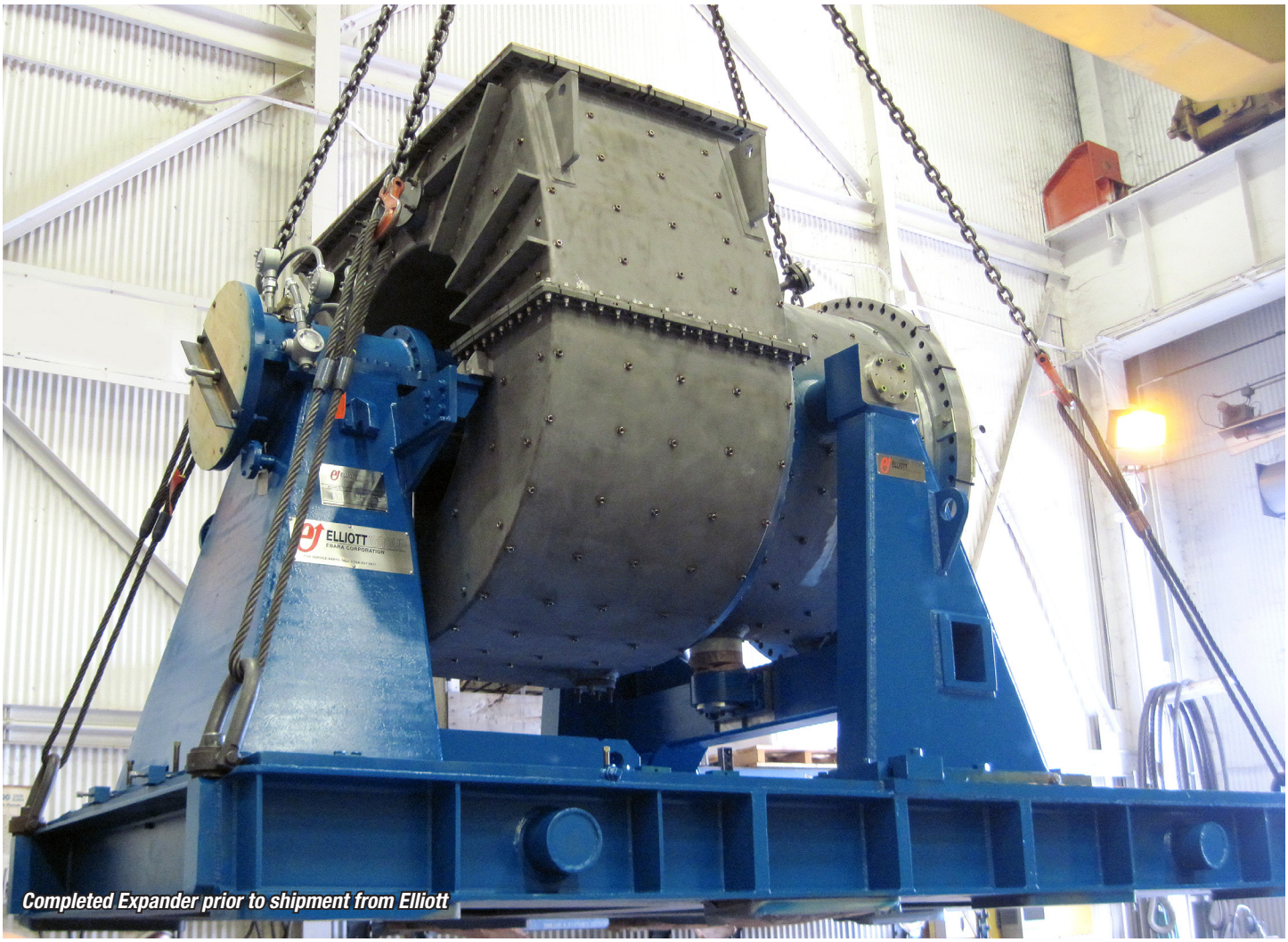
Complete Elliott rotor assembly

The expander has been in operation for more than two years and the erosion issues have not recurred. The customer sends online inspection photos of the blades to Elliott for review. The customer has also seen a significant reduction in vibration levels. Elliott has received praise from the customer on the performance and the modifications made to the expander that now provides:

- Increased power recovery
- Reduced secondary erosion
- A more robust piece of rotating equipment
- Smooth equipment operation
- Less complexity and ease of maintenance
- Simple installation compared with previous overhauls
- Cooling steam flow reduced from 4500 lb/hr to only 250 lb//hr.

Once the customer successfully reaches their 5 year operating goal, they plan to consider Elliott overhauls of expanders at other facilities that have been plagued with similar vibration and erosion issues.

Elliott's first rerate of a non-Elliott expander was not only a technological achievement with the use of a boltless shroud design, but also marks a significant execution achievement for Elliott's Engineered Solutions group. The world turns to Elliott for the experience, resources, and turbomachinery expertise.



Completed Expander prior to shipment from Elliott

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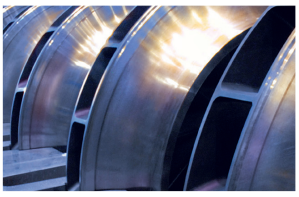
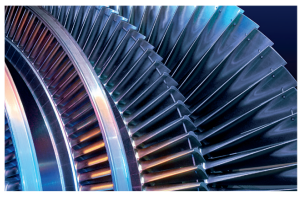
THE WORLD TURNS TO ELLIOTT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