High Vibration Failure: H2 Recycle 14,000 HP 9000 RPM Centrifugal Compressor Innovative Repair

By Abdulrahman Alkhowaiter

Introduction

The Refinery Hydrocracker Recycle Compressor K-100 experienced a sudden jump in radial bearing vibration of its recycle compressor from 1.5 mills to 5.7 mills, which is practically above shutdown limit in 2014-2015. The steam turbine driven recycle compressor was installed in year 2000 and had been fairly reliable apart from shaft DGS seal failures. The plant engineering and management studied the various possible causes and reached the conclusion that it is a real; not false vibration. However, they did not want to shut down the unit until reaching new trip level due to high daily plant shutdown losses of USD 2.00 Million.

Machinery consultant was requested to study the vibration causes by performing a field inspection and attending meetings with technical personnel. He recommended a shutdown as the levels were far too high to sustain with high speed machinery at 8000 to 9000 rpm speed range. The consultant looked at safety first: it is not recommended to use a run to failure philosophy as large mechanical or plant damage may occur with such high power, high speed machines, and unsafe condition of Hydrogen gas at 2250 psig. The analysis led to several possibilities for the vibration including mostly external components such as Bearing pad failure, bearing housing bolting looseness, coupling bolt failure, coupling hub looseness,

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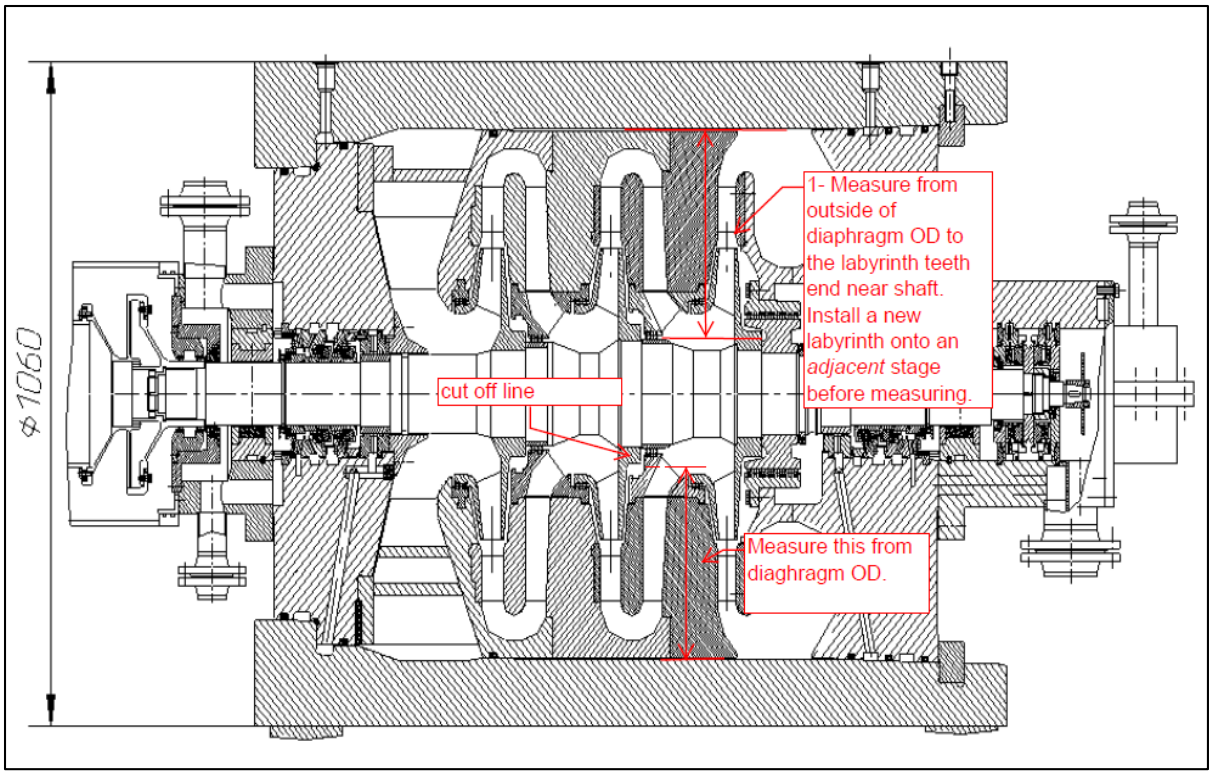
coupling spool crack, broken shim pack, or secondary dry gas seal face damage. Internal possibility is primarily a foreign object in rotor, or cracked impeller.

During overhaul at the repair shop the compressor cast iron diaphragm labyrinths were found **to** have severe damage due to liquid erosion and cracks from high turbulence vibration**.** No spare bundle was available. The failed components were non-weldable; this meant that the refinery must wait 3 months for new castings with USD 2.00 Million per day.



High Vibration Failure Mechanisms Found:

1. **Foreign Object found** in second stage impeller was causing very high unbalance. It was a heavy wire mesh, of about 80-gram weight, broken off from the suction piping strainer**.**
2. **Radial Drive-End bearing had fretted pads** under shaft due to the high vibration over several months, but this is a secondary damage which amplifies vibration more.

An innovation repair was proposed: New Labyrinth Carrier insert to be fabricated at shop and installed after machining of all cracked, thin x-section of diaphragms. The design process was difficult taking about two weeks of development since the dimensions and attachment methods were limited. The new part shown below was designed to eliminate the weakness of OEM design, resist all forms of liquid erosion, and provide higher efficiency compared to original.

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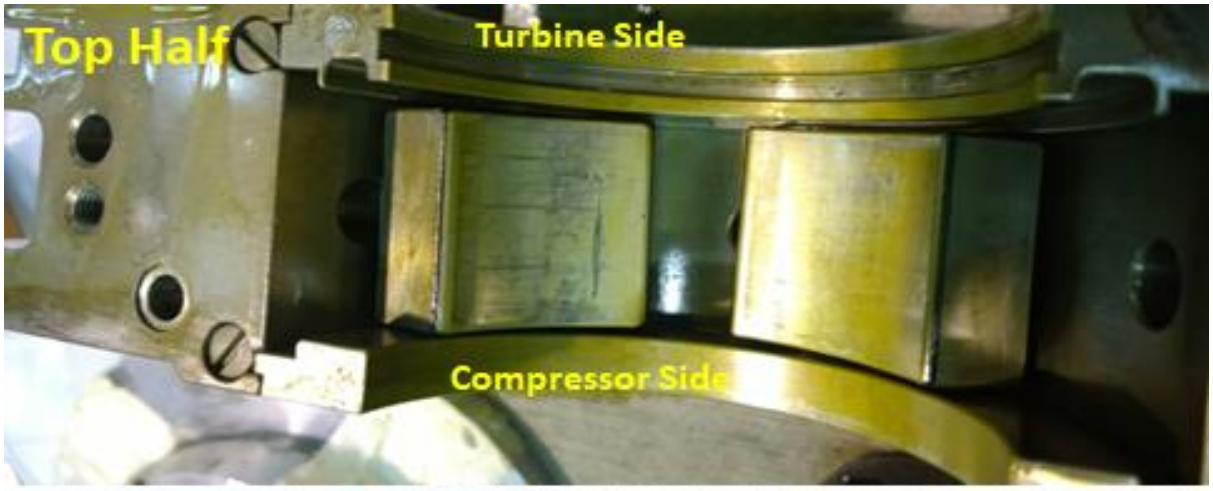
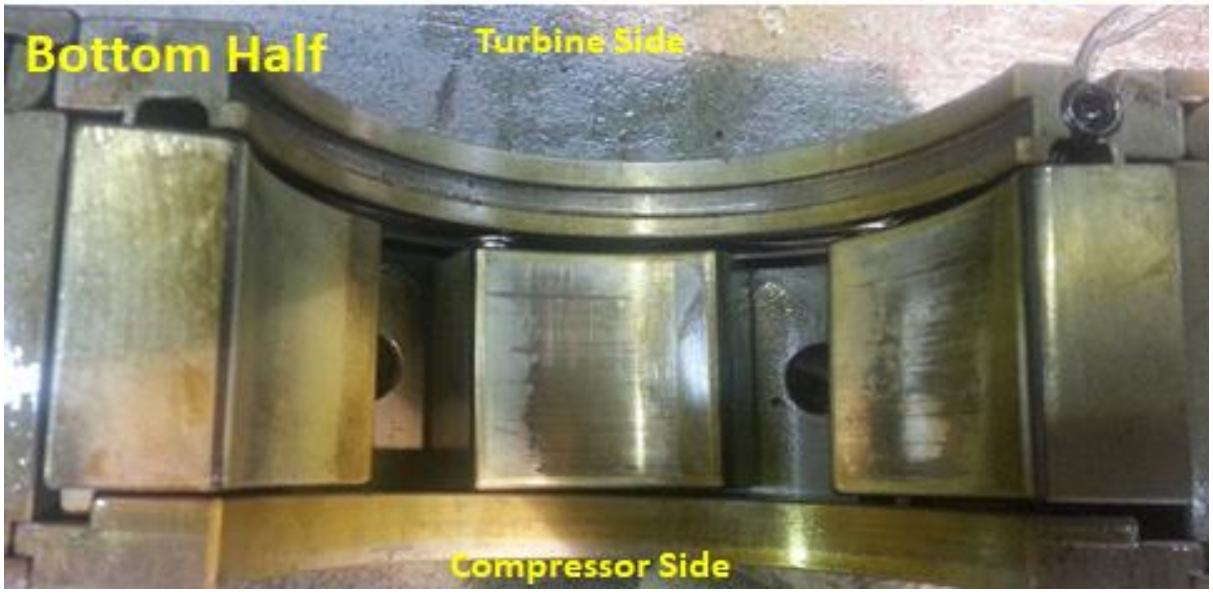
Machine repair was completed in June-2015 and resulting radial vibration in service became a maximum of 0.70 mills radial vibration amplitude on all channels up to December-2015. Performance was highest recorded since installation according to Reliability unit. Savings was approximately 3 months' x USD 2.00 MM per day = USD 180.0 MM.

Conclusion:

The Compressor is still operating smoothly in year 2020 after five years with no failures recorded. The new Diaphragms were received from manufacturer but not installed yet. In this case, the root cause of failure was plant-designed mesh-strainers of poor mechanical design.

Drive End Compressor Radial Bearings: Fretting Wear Under the Lower Pads





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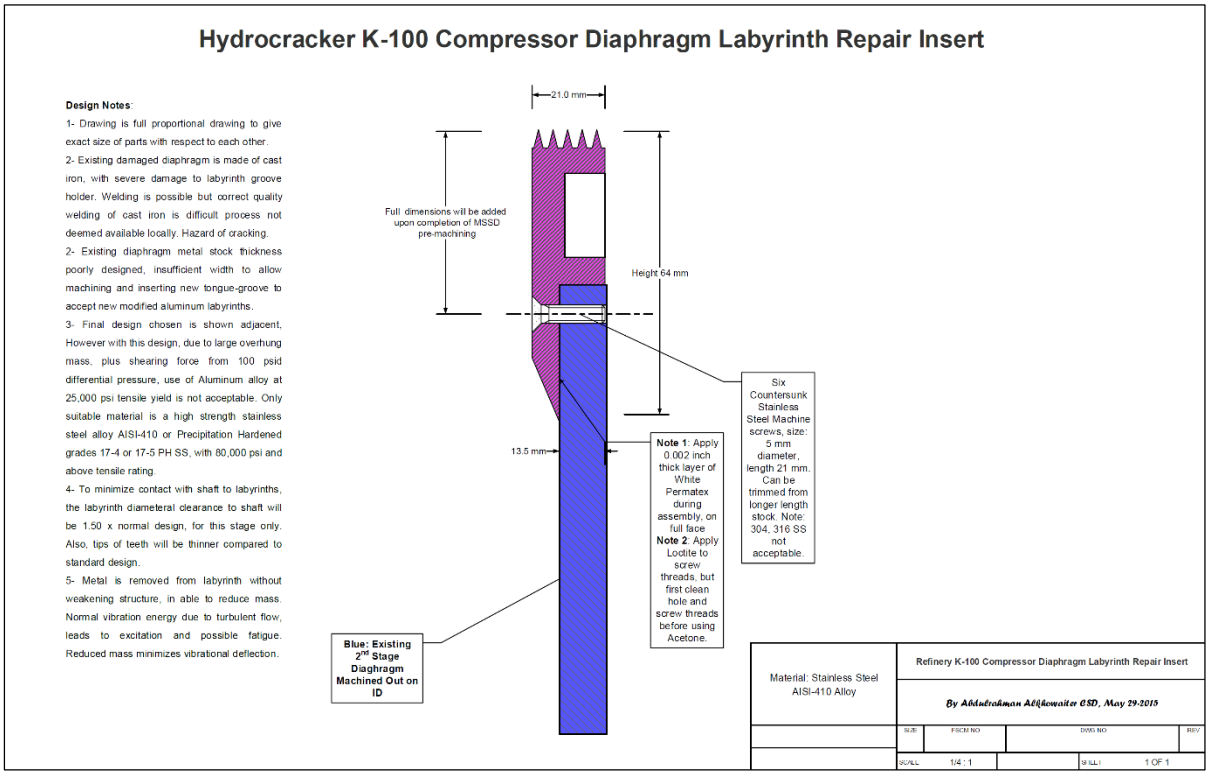
Damaged Cracked Diaphragm Labyrinth Holders; Cast Iron Not Safely Repairable

First Design Proposal New Part to attach to Diffuser Casing



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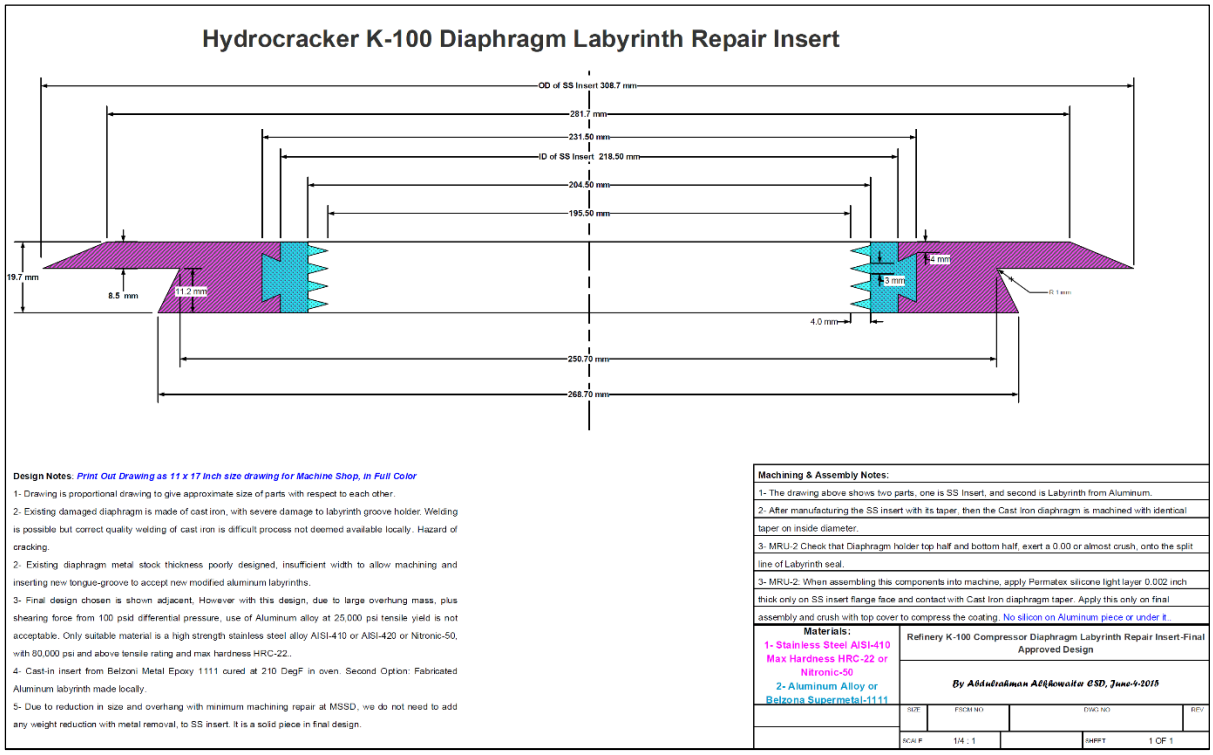
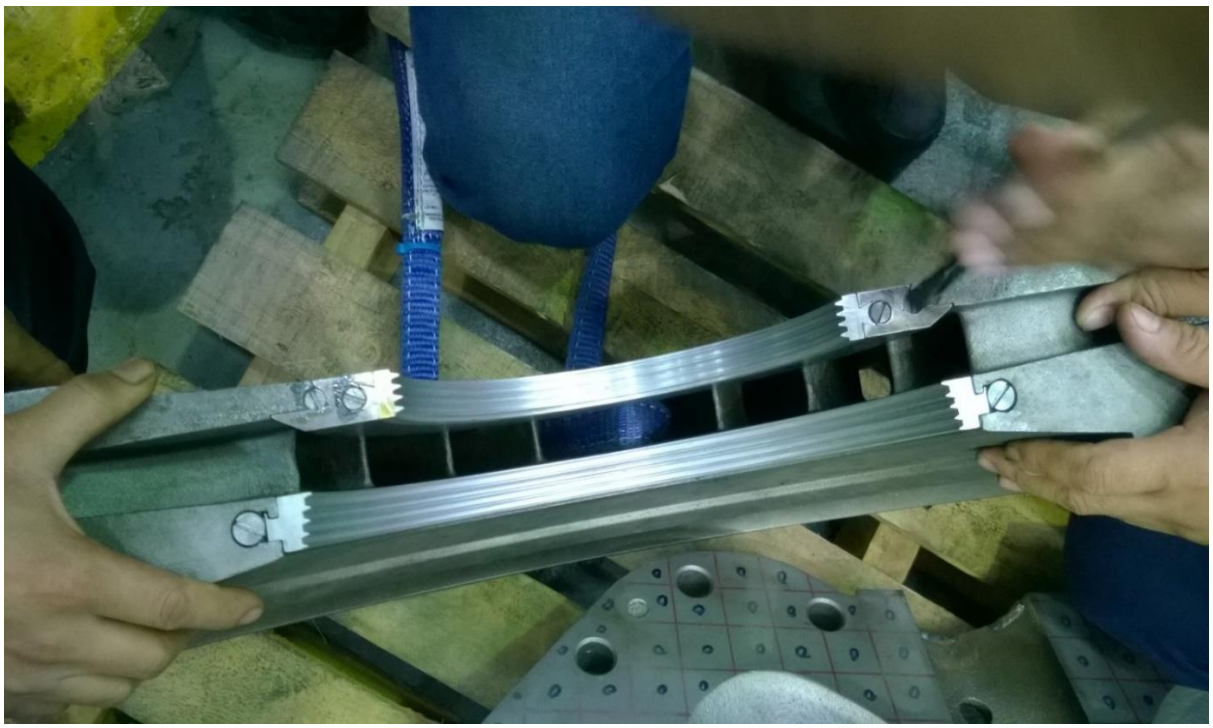
Final Design is much Improved: New Insert Labyrinth Holder



New Finished Insert Installed in Diaphragm



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Detail Picture: Part is Made of AISI-410 Stainless Steel