Rotating Machinery Services, Inc.

SOLVING A DESIGN FLAW THROUGH INNOVATIVE ENGINEERING ON A NASH HP-9 COMPRESSOR

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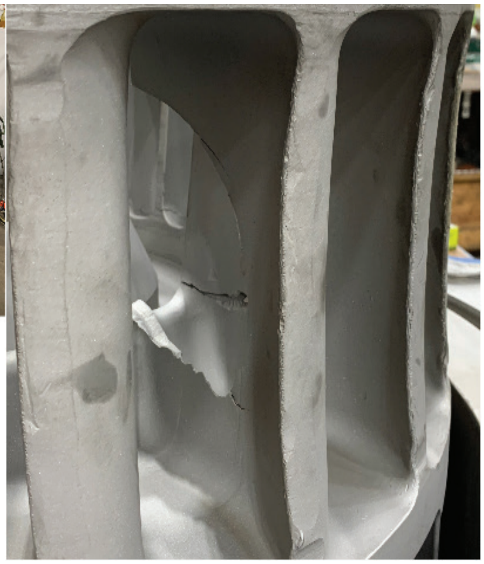

RMS MEPCO has had a long history of repairs and engineered upgrades to all makes and models of liquid ring compressors. A liquid ring compressor is a positive displacement device which uses a "liquid ring" to form the compression chamber seal. Gas enters the compressor through the suction side, water enters through a nozzle in the top of the compressor or end of the compressor (depending on model), trapped gas in the compression chamber created by the impeller and the water (liquid ring) reduces in volume. The rotation of the impeller vanes, along with the liquid ring, compresses the gas which exits through the discharge port. Most liquid ring compressors have an "eccentric" section in the case which enhances the compression of the gas with each revolution of the impeller.

Our repair and upgrades to these compressors focuses on several areas of the compressor:

- Material upgrades to impellers and shafts
- Rotor dynamics (especially in the overhung configurations)
- Bearing upgrades to reduce thrust bearing failures
- Laser overlays to prevent rotating and non-rotating components from galling
- Repair of expensive replacement components (i.e. impellers and distribution cones)
- Restoration of efficiencies due to mechanical misalignment
- Impeller redesign based on FEA analysis (excitation of natural blade frequencies)

RMS MEPCO is ready to repair and upgrade liquid ring compressors and vacuum pumps, encompassing all makes and models:

- All Nash and Garo models
- Devi
- Flowserve/Sihi all models
- Bergeron
- Travaini

The RMS MEPCO team recently took on a NASH liquid ring compressor failure for a customer in the oil and gas industry. This NASH compressor was sent to the South Houston shop for a detailed inspection to determine the root cause of the failure as well as a path forward for repairs and upgrade opportunities.

The initial inspection started with a detailed visual inspection, photos, and critical measurements. The compressor was received locked up. With the split line bolts loosened, the team was able to separate the casing halves to expose the damaged impeller and distribution cones. The team dry stacked the compressor to measure the total float. Extensive damage was noted on the DE of the impeller; OD of the DE impeller blades indicated severe FOD damage and visual cracks. A large portion of a single vane catastrophically failed and remnants of the blade material were found at the bottom of the NDE case. The blade fragment lodged between the eccentric portion of the case and the impeller, causing the blade damage on the DE impeller vanes. Improper rotor running position and facial misalignment of the distribution cone caused the contact rubs on the DE of the impeller and the DE distribution cone taper, which locked up the impeller. No damage or cracks were noted on the NDE side of the impeller or distribution cone.

Vane cracks all emanated from the inlet side of the vanes and progressed outward toward the discharge side. All of the components were blasted clean, PMI'd, and tested using NDT methods for a detailed report of the damage.

An FEA study had been performed by a third party to identify possible blade failure modes in previous incidences of blade failures common to these compressors. FEA analysis confirmed process spikes and contact rubs with the distribution cones can excite the natural frequency of the impeller vanes, initiating a low-cycle fatigue crack which can progress to a ductile failure. The FEA analysis and identified high stress point correlated exactly with location of the vane cracks found on this rotor. The team was also able to confirm through frequency testing that the customer's forged impeller had almost identical natural frequency responses as their cast impeller.

NASH (the OEM) and the customer had replaced the original cast impeller (316 SS) with a forged impeller (AL6XN material). The forged design was a duplicate of the original cast impeller, which contained the same inherent design deficiencies. In the end, the forged impeller suffered the same failure mode as the cast impeller.

To correct this design flaw, the RMS Engineering team will work on a joint project with the customer to redesign the high stress areas of the impeller to avoid these problematic frequency responses going forward. RMS engineering team will confirm the redesigned impeller vanes with additional FEA analysis. Along with a redesigned impeller, the RMS team will correct the compressor's misaligned case components, repair and upgrade the impeller distribution cones, eliminating costly new replacements.

RMS is currently working on this upgraded compressor and has plans to send it back to the customer by the end of the month. The joint engineering project will begin after the compressor rebuild is completed.

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