PERFORMANCE LOSS INVESTIGATION USING THERMAL IMAGING

PRESENTER AND AUTHOR: SCOTT MCPHERSON
LEAD FIELD ENGINEER – SULZER PUMPS (US) INC
Tel: 281 417 7109
E-MAIL: Scott.Mcpherson@Sulzer.com

ABSTRACT

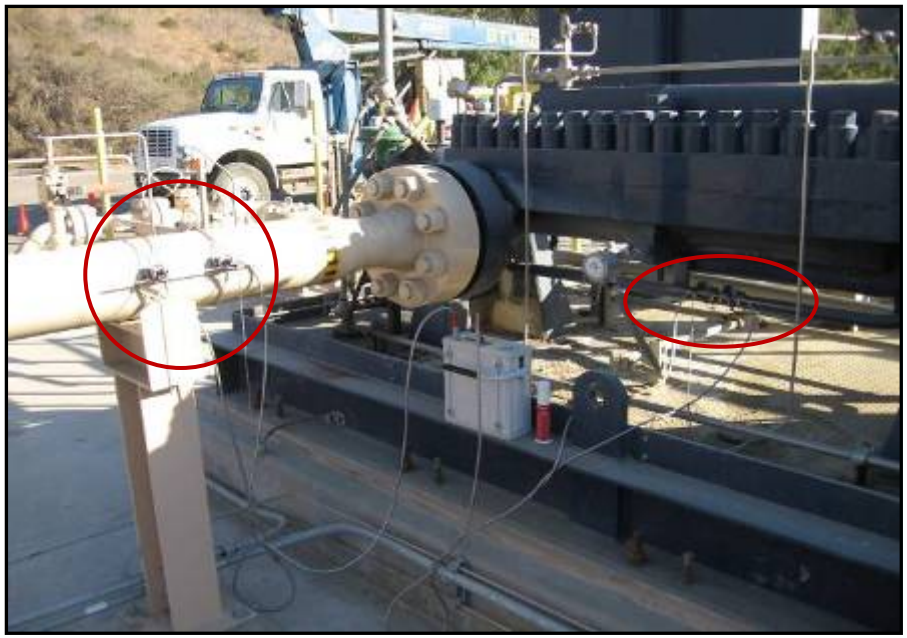
An axially split, opposed impeller, high speed water injection pump ran well for several months. Head, capacity and efficiency started to degrade markedly, but the pump turned freely and was relatively smooth. It was disassembled and inspected. All the wear parts, impellers, casing and other components were in like new condition. The impellers were underfiled and the pump returned to service - with the same unacceptable performance results. A thermal image camera was used to check for hot or cold spots and those images will be presented. The detected hotspot resulted in a bore scope inspection of the cross over passage, and uncovered the cause of the performance problem.

PROBLEM SYNOPSIS

- High speed high pressure water flood injection pump was reported to be severely underperforming.
- Pump is an API BB3, 13 stage
- Pump rated for 410 usgpm @ 10,000ft @ 5400rpm.
- Pump is variable speed via VFD drive
- Initial reservoir pressure requirements resulted in initial pump operation at only 3600rpm
- As reservoir pressure increased, pump speed was increased to meet increased pressure demand
- Low performance was only noticed after approximately 10 months operation, when pump speed approached rated speed and was found to be low on pressure

FIELD PERFORMANCE TESTING

- Field performance testing was utilized to assess underperformance
- Flowrate obtained using an ultrasonic flowmeter attached to the suction line
- Developed head obtained utilizing field pressure gauges and converting to head based on estimated specific gravity of the produced water

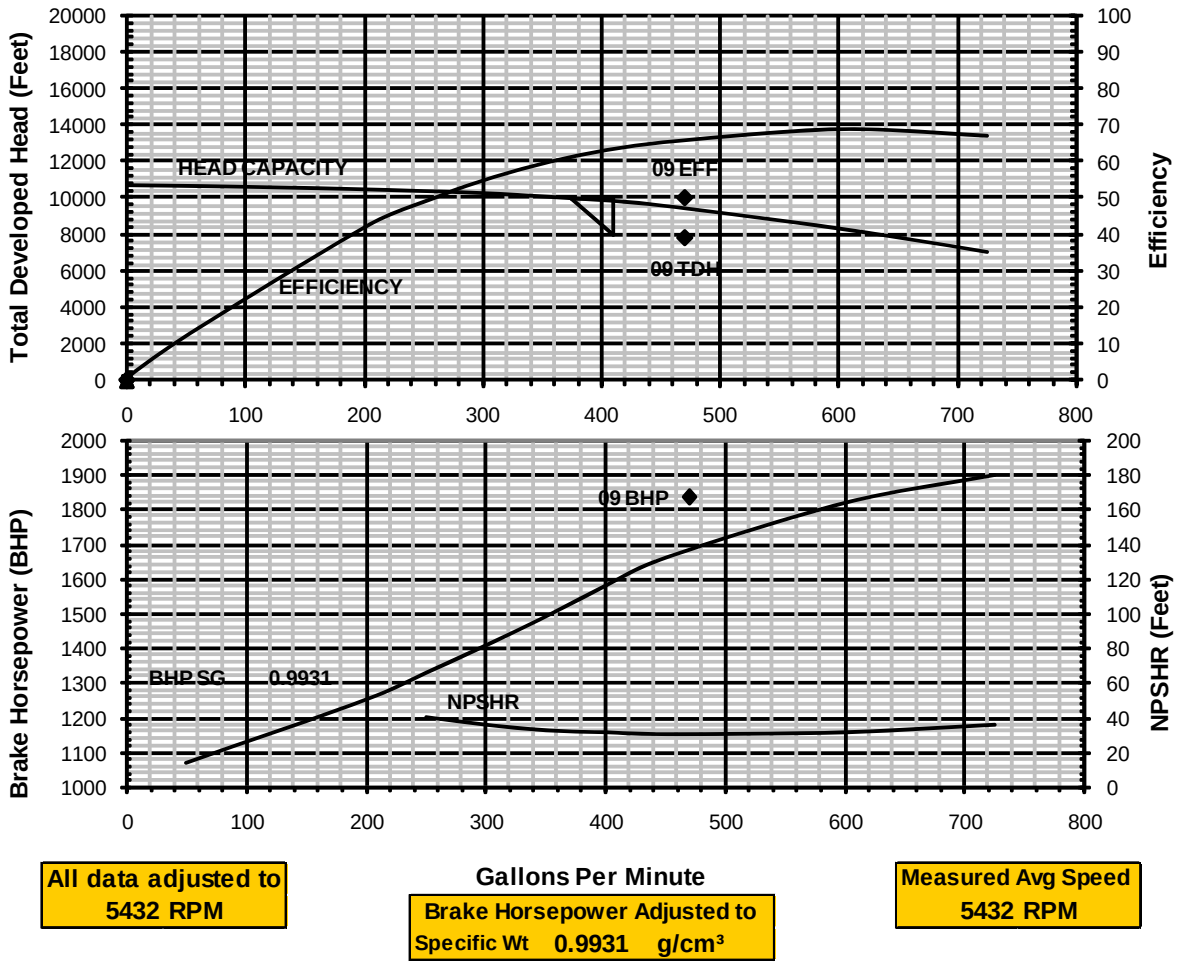


Dual traverse flow cells installed on the suction and balance line leak-off piping

- Pump absorbed power estimated from motor voltage and amp loads

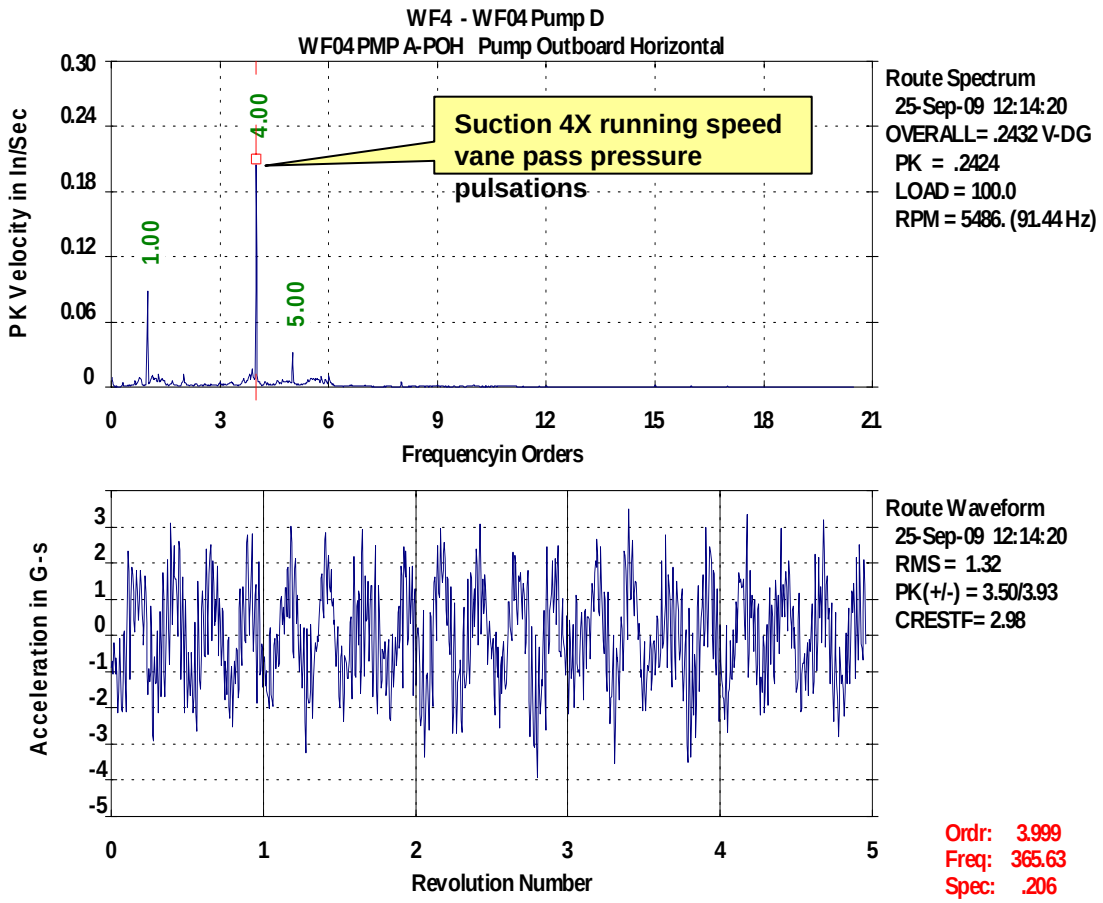
PERFORMANCE

- Field testing suggested severe performance loss. Head low by approximately 20%!!!
- Efficiency down by approximately 30%!!!



FIELD VIBRATION READINGS

- Vibration spectrums showed no abnormalities that could explain performance loss.
- No readings more than 0.24 in/s overall
- All spectrum characteristics were explainable and typical of normal pump operation



Pump POH spectrum and time waveform indicating the dominance of the 4X suction impeller vane pass pulsations

INITIAL CORRECTIVE EFFORTS

- Initial postulations were focused in internal pump recirculation across the center bushing, possibly due to wear or swelling of the pump casing
- Pump was sent to local service facility for inspection
- Sadly, no smoking guns were found
- High pressure bushings clearances were all in as shipped condition. No material loss noted.
- Wear part lift checks indicated no loss of material at wear ring clearances.

INITIAL CORRECTIVE EFFORTS

- Some precautionary modifications were made, though unlikely to resolve entire problem
- Impeller underfile added to all impeller discharge vanes
- Case crown added to force improved sealing of the pump split line. One possible cause thought to be swelling of casing at high pressure. Could be a problem that arises with increased speed
- Top and bottom half casing matching reviewed and refined

RESULTS AFTER INITIAL MODIFICATIONS

- No improvement was observed!!
- Pressure gauge added to pump discharge nozzle. Reading compared well to gauge on discharge line
- Pressure gauge was added to a vent on the long cross over with interesting results!!!!
- Suction side of pump found to be performing as expected
- All losses isolated to the discharge side of pump
- Pump run down at 3600rpm to allow comparison to factory performance test results. Pump still 20% low at factory test speed!!!
- Further investigation was required

TROUBLE SHOOTING FOR POSSIBLE CAUSES

- Further investigation of pump performance history was carried out. DCS archives researched to identify when performance loss occurred
- Investigation revealed that the pump did perform according to the factory performance curve during first months of operation
- Performance slowly degraded with time

<u>CONCLUSIONS (or not)</u>

- Problem seemed to be located at high pressure side of pump
- Degradation with time could be caused by foreign debris build up, but no build up noticed during recent shop inspection?????
- Degradation with time could be caused by excessive wear, but no wear was observed during recent shop inspection?????
- What do to next?????
- **Generally speaking, energy losses translate to temperature rise. Why not try looking at the pump with a thermal image camera?**

THERMAL IMAGING

Bottom half of pump was found to be warmer than the top half

No exceptionally high localized hot spots apparent, however, left of thermowell boss appears cooler

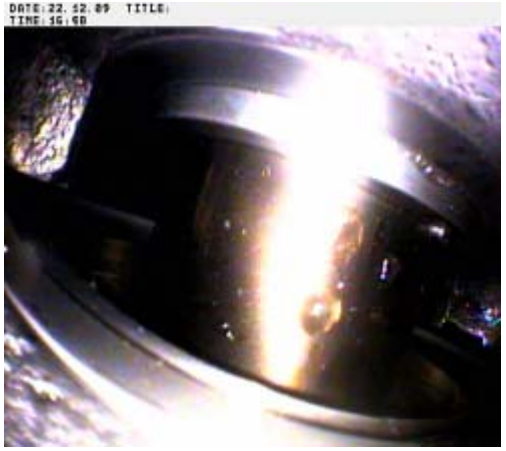
Zoning in

Definite relative difference across thermowell

BORESCOPE INSPECTION

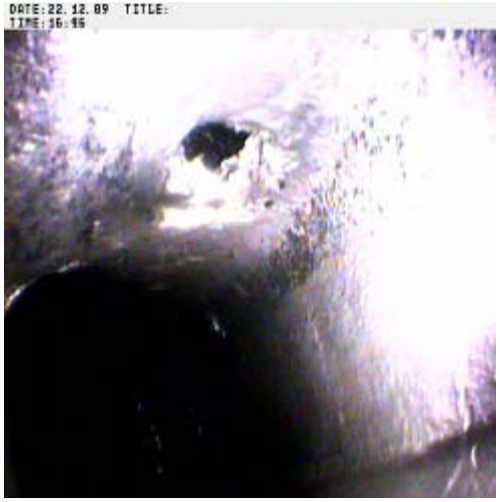
- Borescope with articulating head was utilized to perform internal pump inspection in the field.
- Camera fed through drain point on bottom half long crossover

BORESCOPE INSPECTION



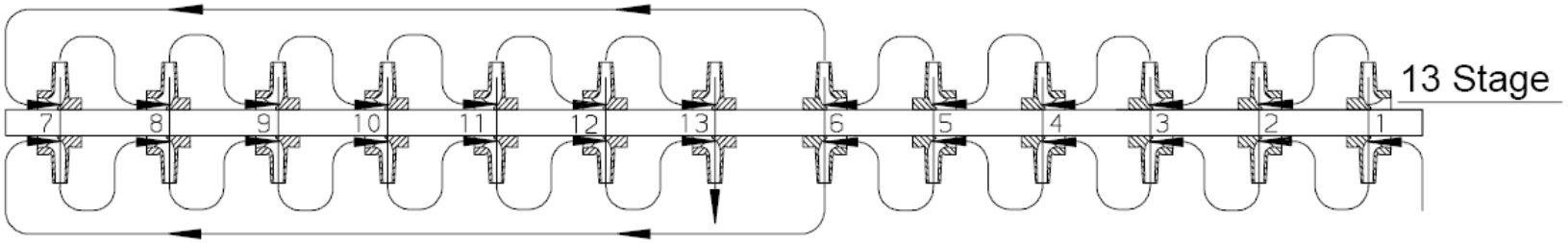
Outlet of long cross over inspected first for obstruction. Nothing found.

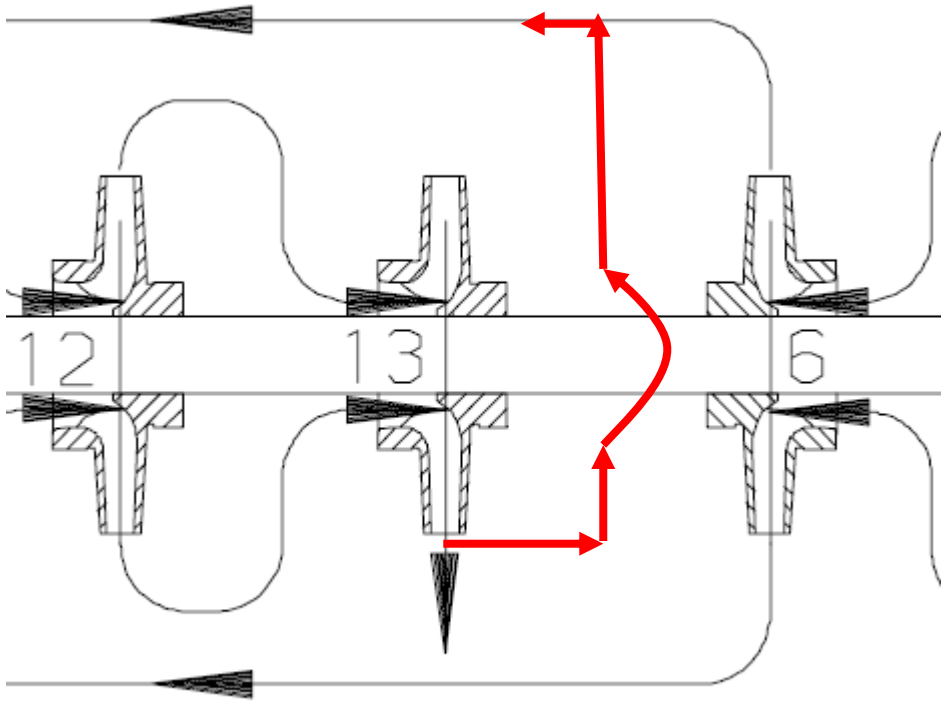
Outlet of long cross over inspected first for obstruction. Nothing found. But what is that we see in the distance?



A BIG HOLE!

EXPLANATION OF FINDINGS





- Last 7 stages recirculating additional flow due to 1 inch hole from discharge to cross over
- 7 stages worth of differential pressure across 1 in hole = lots of flow
- Excessive temperature rise due to fluid recirculation passing through 7 stages x 2!!

REPAIR PROCESS






ROOT CAUSE

- CHAPLETS (SHOWN BELOW) ARE USED TO POSITION SAND CORE BOXES DURING THE CASE CASTING PROCESS.
- THE CHAPLETS SHOULD BE MADE OF THE SAME MATERIAL AS THE CASTING AND IS INTENDED TO FUSE INTO THE CASTING AND BECOME A PART OF THE FINISHED COMPONENT
- IN THIS CASE IT APPEARS THAT THE CHAPLET MAY HAVE NOT FUSED, OR POSSIBLY BEEN MADE OF THE WRONG MATERIAL
- NOTICE THE SQUARE RECESS AROUND THE HOLE FOUND IN THE CROSS OVER