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Preventing a Major Wreck on a New Reciprocating Compressor: *The importance of commissioning testing*

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Bio: Robert C. Eisenmann, Jr.

Currently the BP Refining Machinery Advisor and Downstream Segment Engineering Technical Authority (SETA) with Refining Technology and Engineering based in Houston, Texas. He provides technical advice to the BP global refining portfolio to support business delivery, company strategy, industry direction, and technical assurance to support business decisions. He also promotes technology solutions and development and implementation of best practices across the BP refineries. He is currently the API 618 Chairman, API 692 Chairman, serves as a SME for BP's Engineering Technical Practices and has been a member of the Texas A&M Turbomachinery Advisory Committee since 2012. Bob has over 25 years of experience in the industry. Bob graduated from Texas A&M University at Galveston in 1992 with a B.S. in Marine Engineering.

Bio: Luis Santos-Gutierrez

Currently the BP Rotating Equipment Engineering Superintendent at the BP Whiting Refinery in Whiting, IN. He leads the rotating equipment engineering team and acting subject matter expert for process rotating equipment at the site. Luis is responsible for the Life Cycle Management of the refinery's rotating equipment fleet and delivery of the rotating equipment strategy .

Luis has over 18 years of experience in the industry in various machinery engineering and project commissioning roles. He is a graduate from the University of Puerto Rico at Mayagüez with a B.S. in Mechanical Engineering.

Abstract

During commissioning testing of three new reciprocating compressors a fault was detected requiring the testing to be stopped. Debris was found in the bearing resulting in minor damage due to the early indication from the monitoring system.

This case study highlights the failure data, the monitored parameters, damage found and corrective action taken. However, the key learnings for the site was the justification of the commissioning process, the utilization of the monitoring system, and paying close attention to the available data from the monitoring system.

Hydrogen Make-up Compressors

- 3 new – 50% API 618 Reciprocating Compressors
- 10,500 hp (7.83 MW) 24 pole synchronous motors (300 rpm)
  - Single bearing motor with rigid coupling to compressor crankshaft
- 99.9 % Pure Hydrogen (2.03 MW)
- ~ 330 psi (22.8 bar) Inlet pressure
- ~ 2230 psi (154 bar) discharge pressure
- Rod load rating 348k lbf compression and 315k lbf tension

TPS

Protection System/Condition Monitoring

- Complete monitoring and protection system comparable to API 670 5th Edition Annex P
  - Cylinder Pressures
  - Frame, Crosshead and Cylinder Vibration
  - Rod Drop
  - Main Bearings, Connecting Rod Bearings, and Wrist Pin Bearings all monitored with radar temperature monitoring system
  - Packing and Buffer/Purge System Parameters
  - Process Parameters
  - Auxiliary Systems Parameters

No Load Test Run Procedure

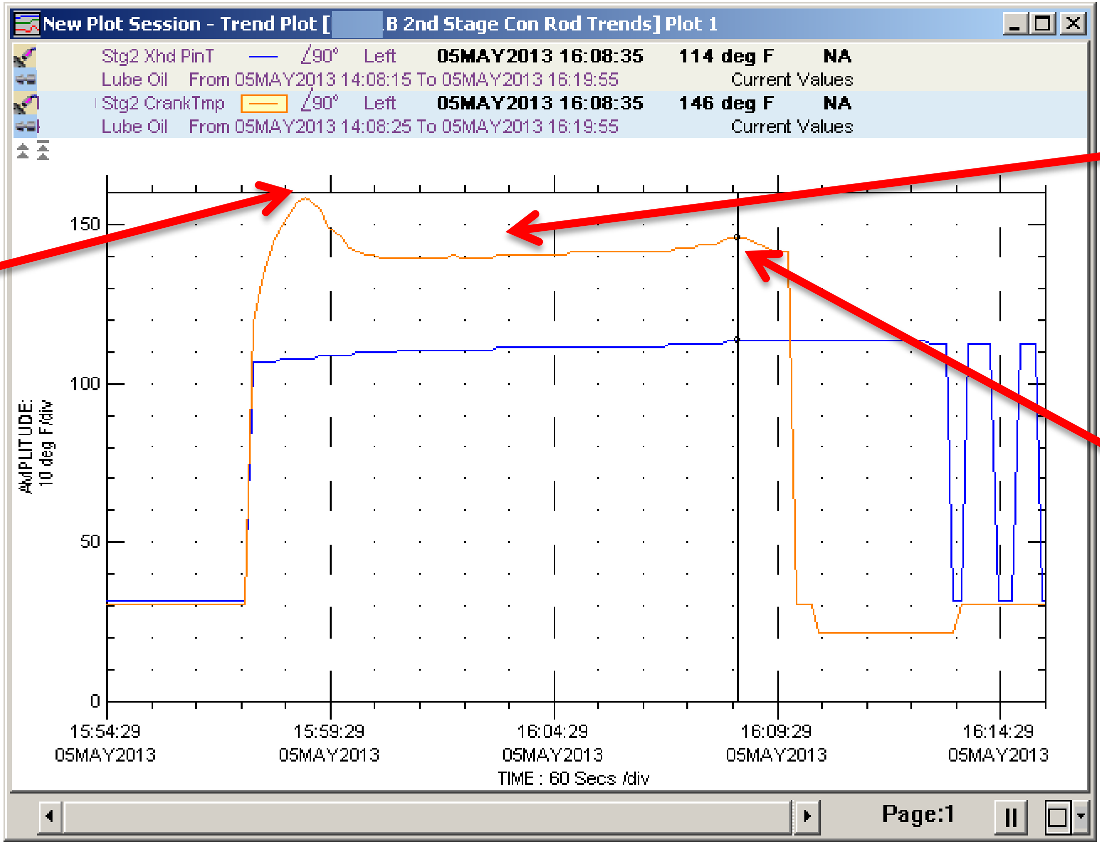
- Site developed no load run test procedure
  - Similar to API 618 5th Edition Procedure
  - Similar test to OEM factory acceptance test
  - Rotation Check
  - 5 /10 / 30 / 240 minute run steps with data collection and visual inspections
  - Protection/Condition Monitoring System required to be active
    - With exception of process instrumentation

Sequence of Events

- May 4th, 2013
  - Completed oil flushing and removed screens
- May 5th, 2013
  - Began no-load test run
  - Motor rotation was correct so continued with initial 5 minute run
    - No issues were noted during the run or visual inspection
  - Began 10 minute run
    - Noted 2nd Stage connecting rod bearing temperature higher than other stages (~19 deg F)
    - Test stopped after 10 minute run for investigation

2nd Stage Connecting Rod Bearing Temperature

~ 1 ½ Minute peak was noted.

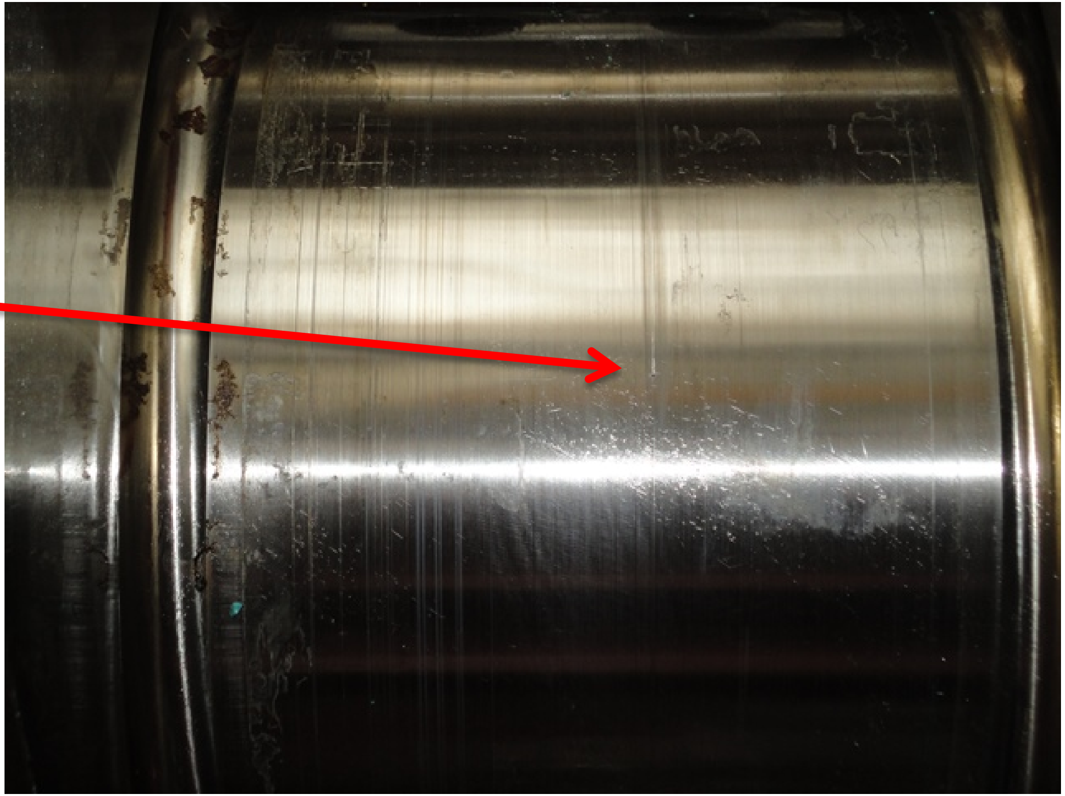


Temperature Dropped and leveled off

Slight increase near the end of the run

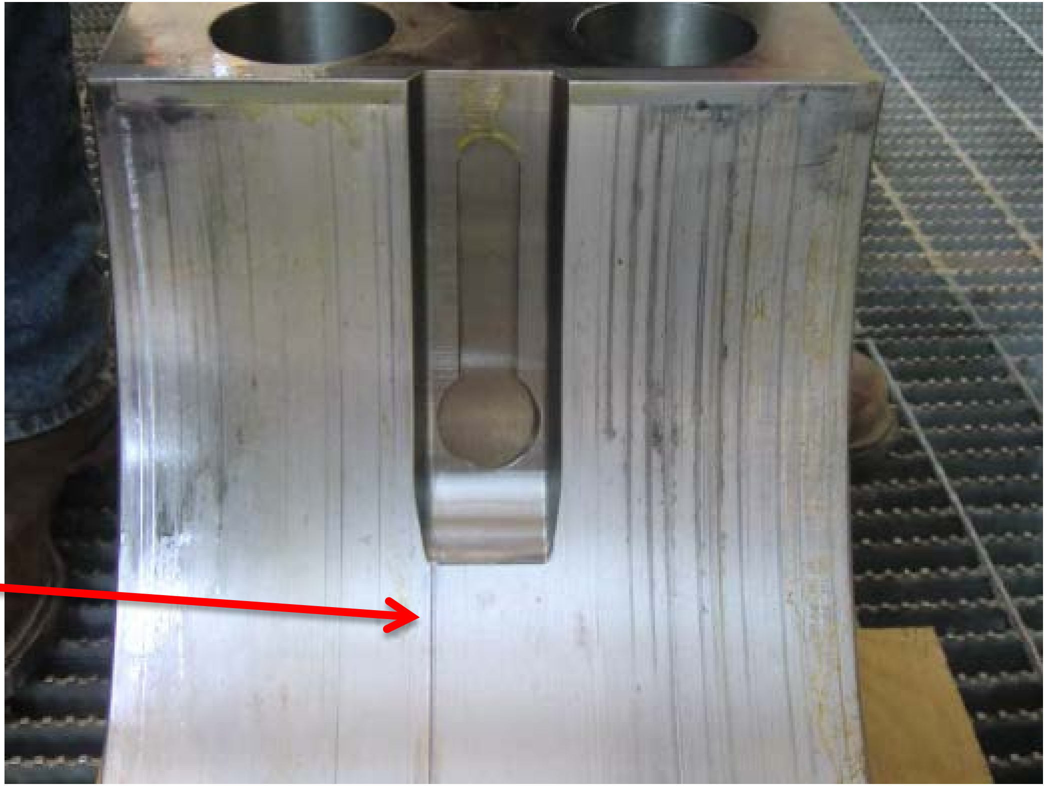
Debris in Crank Pin Journal

Embedded Particle



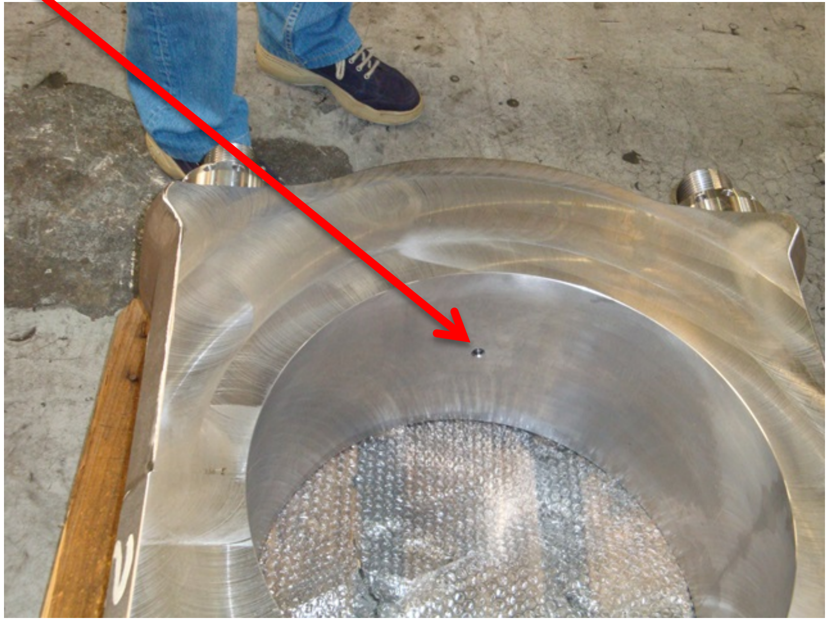
Debris in Crank Pin Journal Bearing

Damage due to embedded particle in shaft

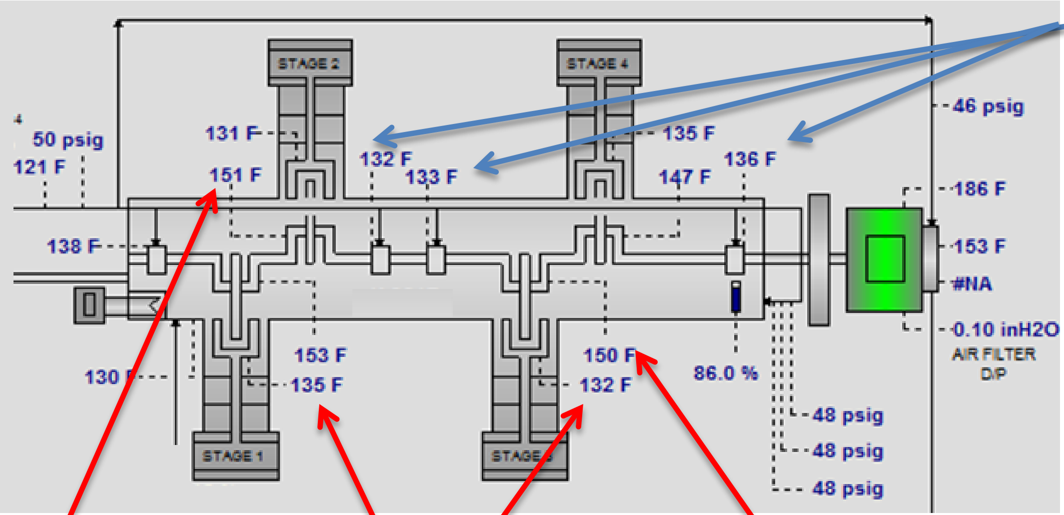


Location of Temperature in Connecting Rod Cap

Temperature Sensor Location



Bearing Temperature Schematic & Wrist Pin Sensor



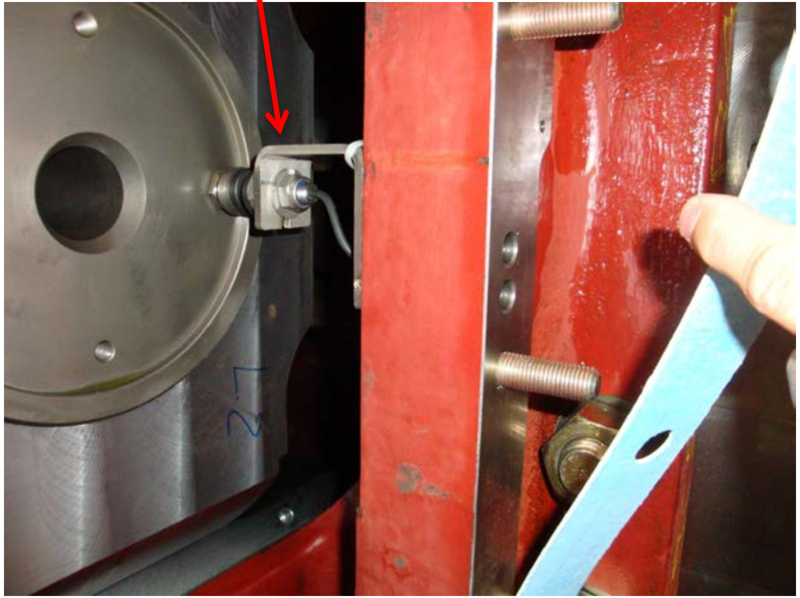
Main Bearing Temperatures

Crank Pin Journal Temperature

Wrist Pin Temperatures

Crank Pin Journal Temperature

Wrist Pin Temperature Sensor Location



Findings

- Protection/Monitoring system was active and alarmed during the test

- Debris Entered the bearing and embedded into crankshaft

- Location of temperature sensor was sufficient to measure the temperature rise

- Debris was removed and bearings replaced with out a major failure

Oil Flushing Procedure

- Reservoir was cleaned.
- Oil designated for normal machine operation used for oil flush.
- Oil skid designed for machine used for flush.
- Used both pumps and used 14 micron filter thru discharge piping.
- Ten micron sock filters were used at the end of the discharge piping. Oil was filtered until socks were clean.
- Oil was replaced at end of the flush (triggered by oil particulate sample results).
- 200 mesh at the inlet of the crank oil header was removed just prior to the no load test.

Conclusions / Recommendations

- Field no load run testing is a necessary and valuable test
- Monitoring/Protection systems must be active for the test
- System must be monitoring and data analyzed during all testing