MIDDLE EAST TURBOMACHINERY SYMPOSIUM
15-18 FEBRUARY, 2015, DOHA, QATAR

Compressor rotor failure due to fouling at Qatargas condensate refinery

A Case Study

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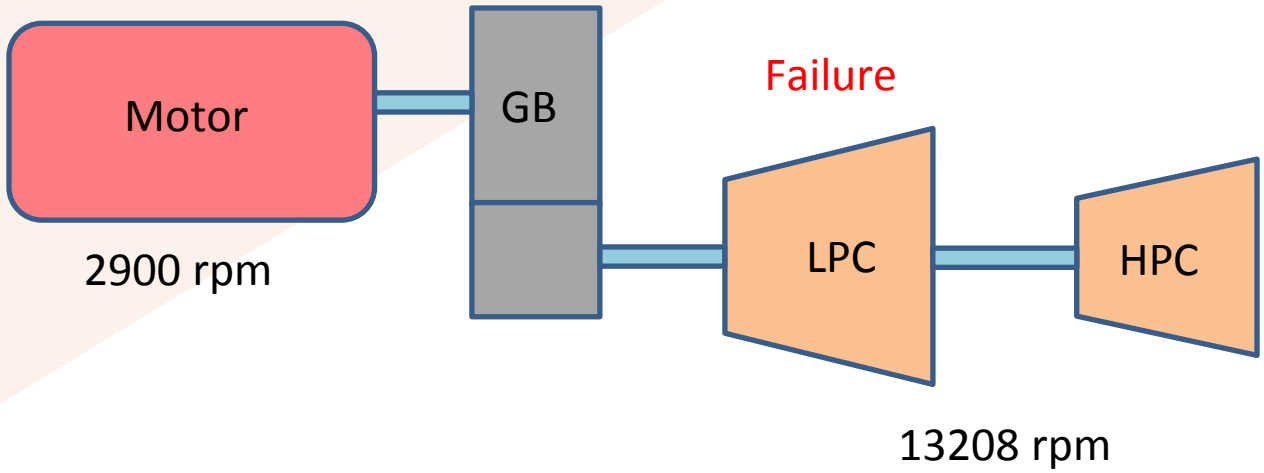
Contents

KHT Process Overview

Wash Water
(Stripped Sour Water)

Hydrogen Recycle Compressor

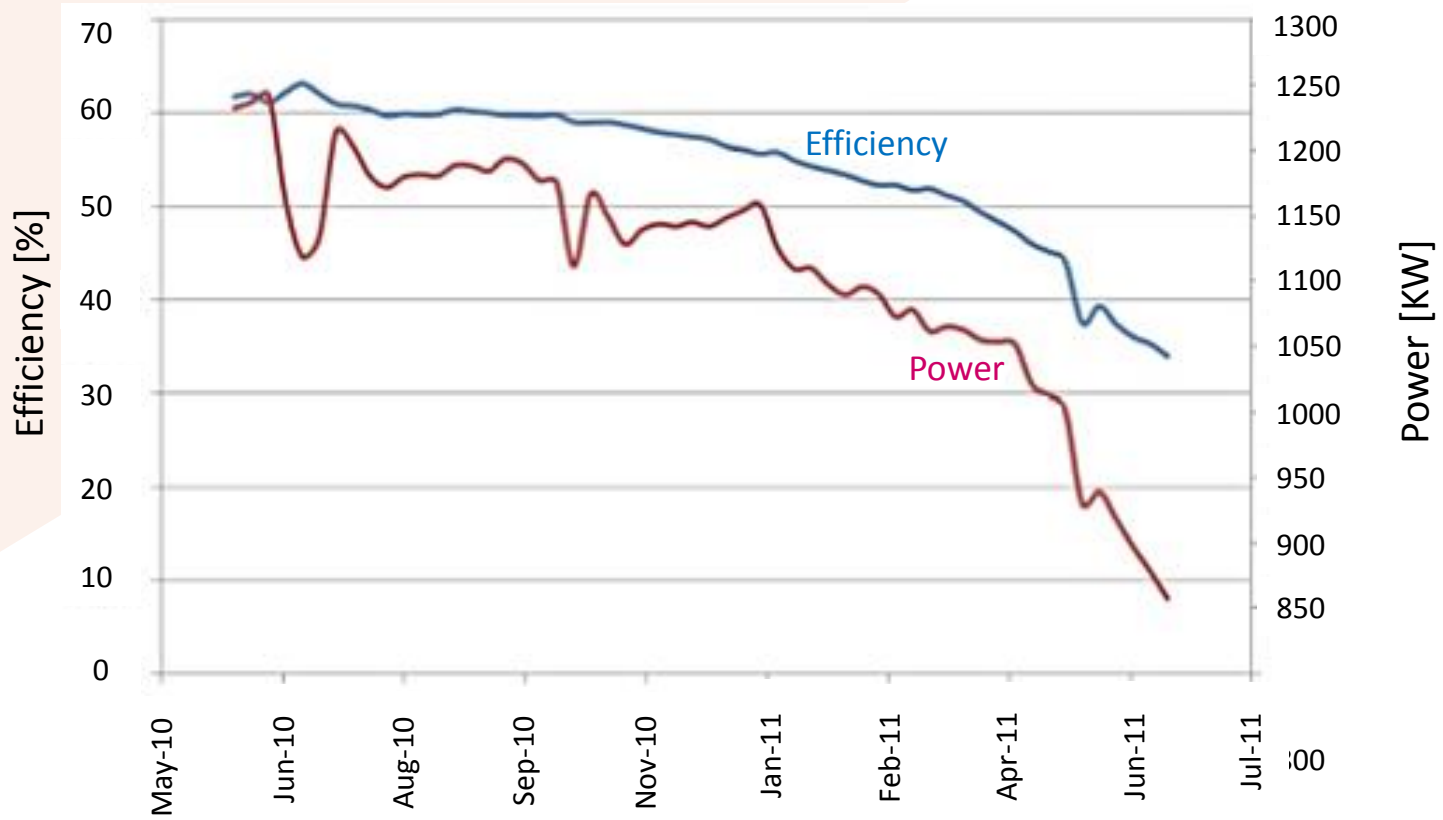


- **The compressor train is equipped with BN 3500 system**
- **The compressors are of barrel type construction**

The Problem

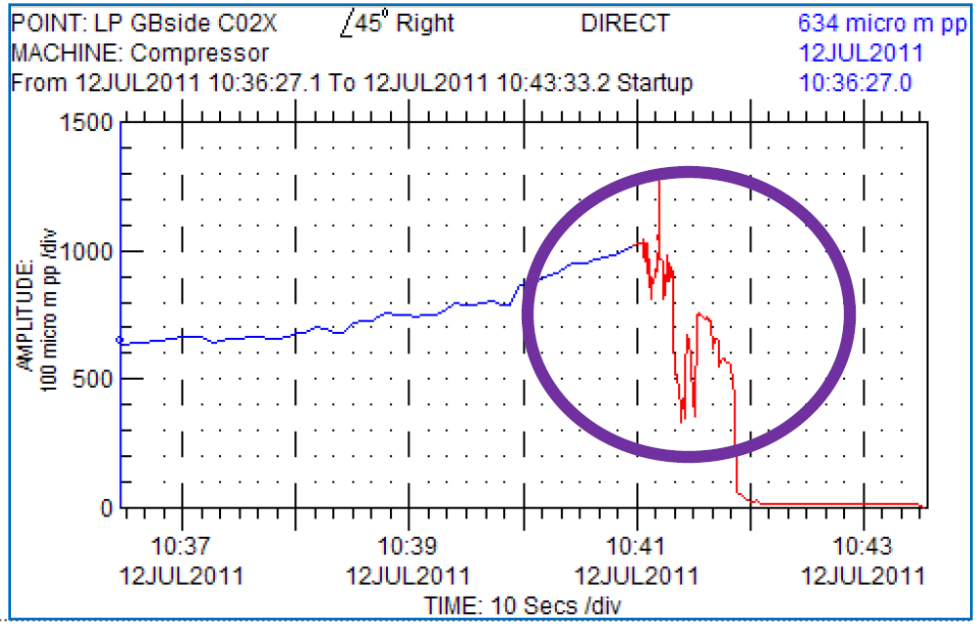
- About six months after commissioning in September 2009, LP compressor performance degradation was observed
- Degradation was slow initially accelerated with time
- Compressor efficiency dropped from 65% (new) to 35% (failure)

Performance Trends



LP Compressor Failure

- July 2011, after about 20 months in service, a sudden increase of LP compressor vibration from 10 mic to 75 mic at DE
- BN ADRE was installed on machine vibration rack to analyze the data
- However, meanwhile vibration quickly increased to danger levels (beyond 1000 mic) at DE
- Machine was manually shutdown because vibration trip did not function



Internal Inspection

- **First stage impeller found broken**
- **Heavy deposits / fouling of impellers and diffusers**
- **Damaged Journal bearings, DE was severe**

Note:

HP Compressor was not dismantled based on vibration, bearings temperatures and thermodynamic performance data analysis

Internal Inspection
Broken 1st stage impeller

Internal Inspection
Fouling

2nd Impeller

1st Impeller

3rd Impeller

5th Impeller

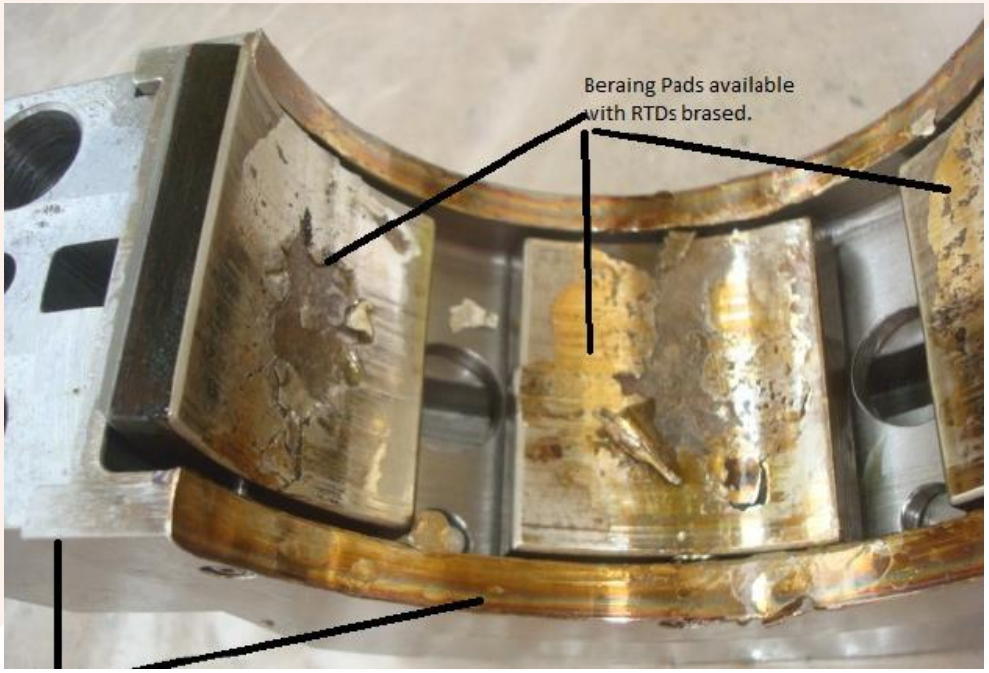
4th Impeller

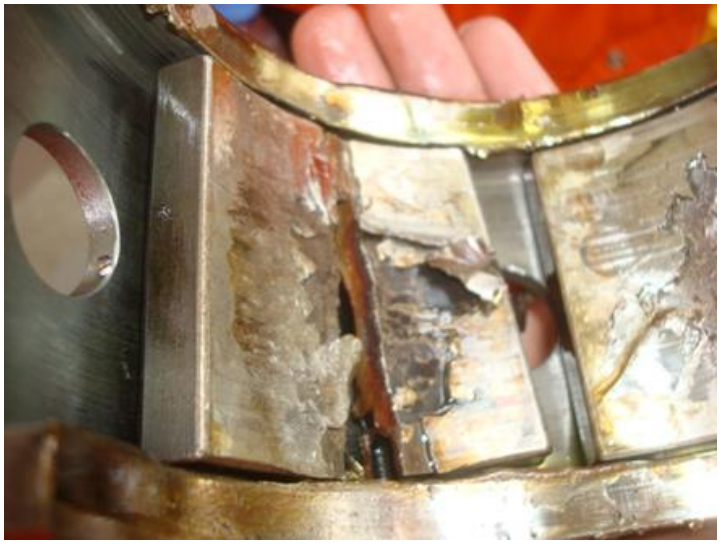
Fouling was most severe on 1st impeller and was progressively less to the 4th impeller.

Almost no fouling of 4th & 5th impellers

Internal Inspection
Fouling

Internal Inspection
Damaged Journal Bearings

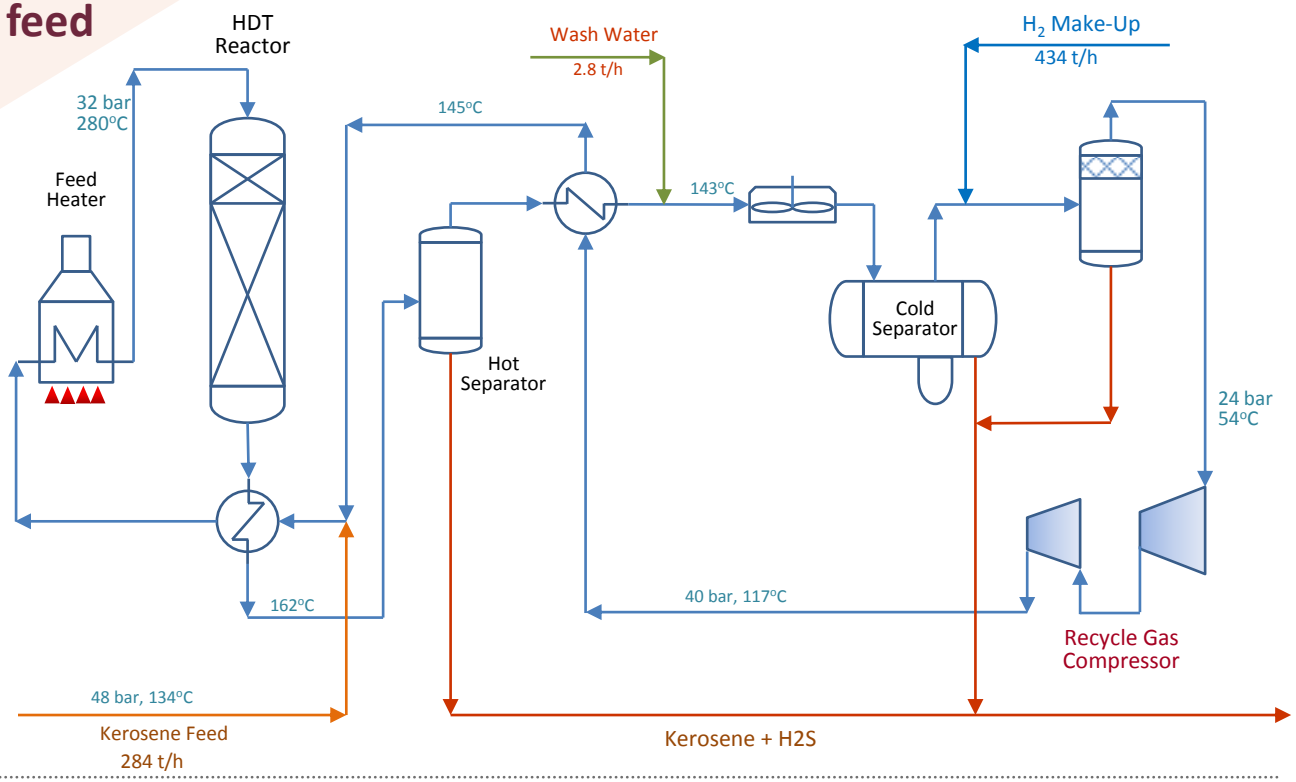




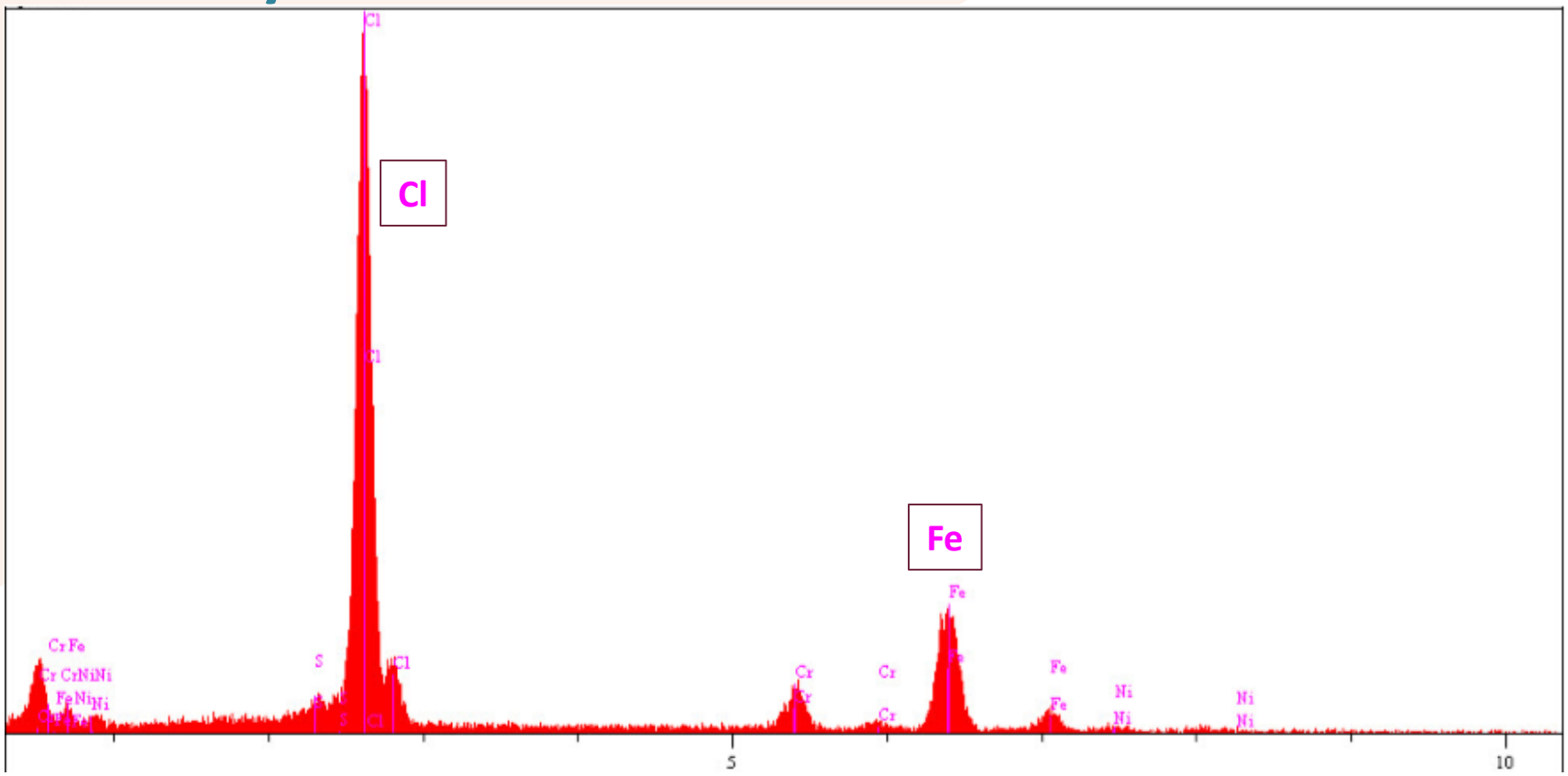
Journal bearings were subjected to very high cyclic load due to unbalance rotor after impeller breakage. Max bearing temperature recorded was 130^{o}C.

Investigation
Deposits Analysis

- The deposits were mainly Ammonium Chloride per laboratory analysis
- Ammonium Chloride is produced in traces in the reactor due to the presence of N_2, H_2 and chlorides in feed



Investigation
EDS Analysis



EDS Analysis of foulant on 1st Stage Impeller showing high Chlorides & Iron

Investigation
Metallurgical Analysis

"The fracture surface is smooth, relatively featureless, and contains some evidence of beachmarks and thumbnails which are all characteristics of a fatigue failure".

Investigation
Impeller Modal Analysis

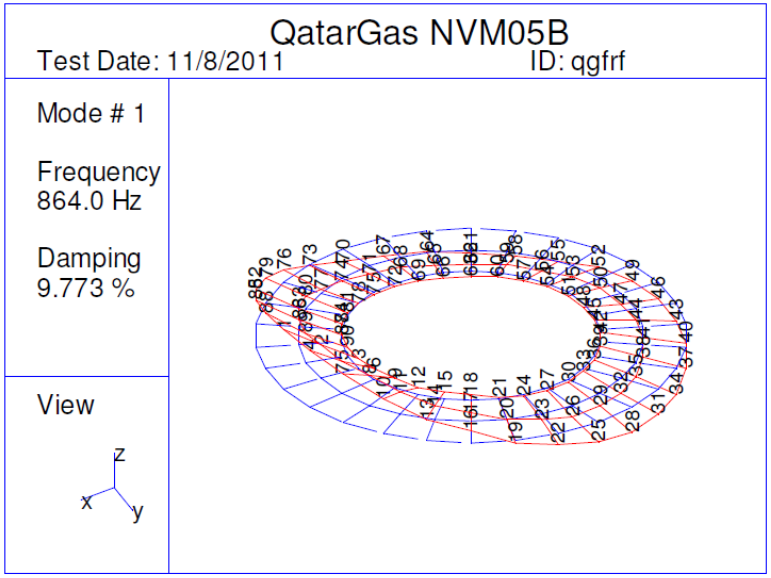


Figure 3 – 1st mode (1-Diameter Mode).

Modal analysis were carried out with the OEM to know if the impellers natural frequencies are close to the operating range and could be responsible for broken impeller. Sufficient margin was found.

Investigation
Root Cause of Failure

- Under deposits pitting corrosion of 17-4 PH SS impeller by chlorides
- The impeller failure was attributed to stress corrosion cracking and possibly combined with high cycle fatigue resulting from flow irregularities caused by excessive fouling of the gas flow passages and pitting.

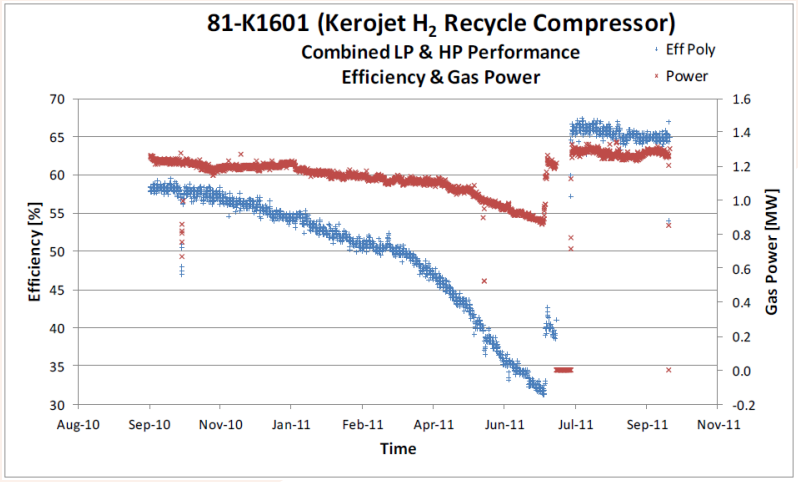
Investigation
Contributory Causes of Failure

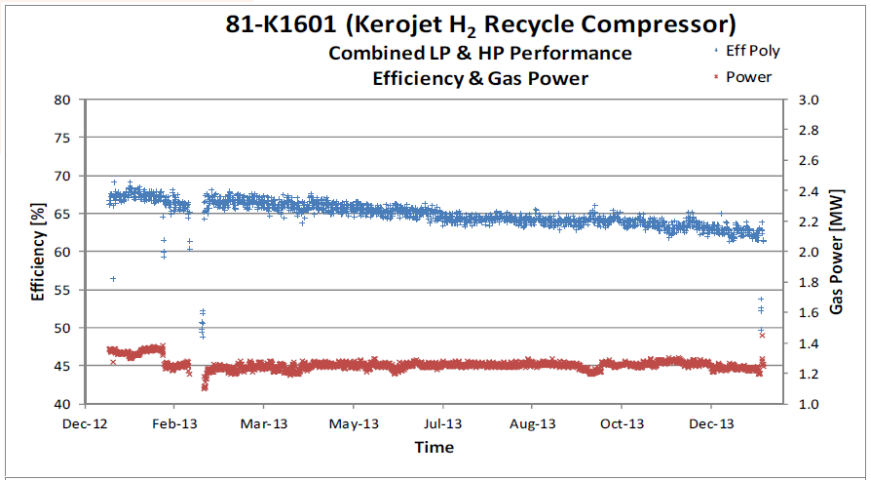
- Lack of understanding of fouling service and its harmful nature
- Insufficient process controls to prevent deposits formation
- Incomplete execution of vibration trip function by project team. BN3500 not connected to compressor ESD for trip on high vibration or journal bearings temperature

Resolution

- Compressor reassembled with spare rotor
- Vibration and bearing temp trip function commissioned per OEM guidelines
- Water injection upstream of compressor started on alternate days
- Compressor efficiency was closely monitored to see the effectiveness ……. remained steady at 65%
- After 3 years of service,
  - max 2% efficiency dropped, indicating water injection was working very good
  - Compressor was opened for inspection in a planned outage and the internals were in excellent condition which was in line with the efficiency trends
  - Rotor NDT revealed no defects

Resolution





Jan 2014

July 2011

Lessons Learned

- In addition to reducing throughput of centrifugal compressors, fouling can result in serious damage to vital components and cost heavy production loss
- Thorough understanding of process stream constituents and impact on equipment is very important for reliable plant operation
- Equipment surveillance for performance and mechanical health parameters can help in early detection of problem and preventing failures
- Process and Rotating engineers collaboration is important
- Gaps in project QA/QC

Q&A