Reverse Rotation of Compressor - Drive Turbine train can cause major damages

(A Case Study of Delayed Coker Unit Wet Gas Compressor Drive turbine Barring Gear damage due to Reverse Rotation: Its Detection, Diagnosis & Correction)

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Pressure difference across the compressor casing, can cause reverse rotation of complete train, while drive steam turbine is in shutdown condition

Reverse rotation can cause major damages

Case Study:

Steam Turbine barring wheel damage in Wet Gas Compressor unit, located in delayed coker unit of Bathinda Oil Refinery of HPCL- Mittal Energy Limited, India
# WET GAS COMPRESSOR – A brief Description

**Type:** Centrifugal, Horizontal Split Case  
**Speed:** 7300 RPM

<table>
<thead>
<tr>
<th>STAGES</th>
<th>1st</th>
<th>2nd</th>
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<tbody>
<tr>
<td><strong>Model</strong></td>
<td>2MCL 807</td>
<td></td>
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<tr>
<td><strong>Gas Handled</strong></td>
<td>Hydrocarbon</td>
<td></td>
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<tr>
<td><strong>Capacity Nm³/ Hr.</strong></td>
<td>36640 (wet)</td>
<td>9043 (wet)</td>
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**Intake Conditions:**
- **Pressure (kg/cm² abs.):** 1.13, 3.96
- **Temperature (Deg.C.):** 40, 40

**Discharge Conditions:**
- **Pressure (kg/cm² abs.):** 4.4, 15.6
- **Temperature (Deg.C.):** 118, 140

**Compressor end seal type:** Dry Gas seal (Unidirectional)
Case study detailed Problem

• Compressor – Steam Turbine train was under barring mode after unit shutdown

• After 3 hours into the shutdown, it was reported that the hydraulic barring of turbine rotor had stopped.

• During the investigation, it was discovered that one tooth of barring gear wheel on turbine rotor was broken (exhibit # 1 & 2)
Exhibit # 1: Barring gear wheel on turbine rotor with one tooth broken

Exhibit # 2: Broken piece of tooth

Exhibit # 3: Hydraulic barring latch arrangement (rotor could not rotate due to broken tooth)
The speed trends of turbine and compressor were obtained from DCS and studied in detail.

Outcome:
- Speed trend indicated that the compressor had rotated at 427 RPM during incident.
- Flow across the 1st stage casing was measured at 11013 Kg/hr at time of incident.

- Barring gear construction & failure pattern indicated reverse rotation.
- Compressor rotor is configured as a balanced opposed construction.
Before the incident, sudden depressurization was done by opening the drain line of 2 inches size, at the 1st Stage compressor suction.

Flow created during depressurization across impeller eye resulted in rotor reverse rotation during barring gear in engaged condition, causing barring gear tooth damage.
ANALYSIS – cont’d

P & ID of compressor showing the direction of gas flow across the casing

Gas flow causing reverse rotation marked in Red color
ANALYSIS – cont’d

Trend indicating flow from 1st Stage:
ANALYSIS – cont’d
Trend indicating speed pick up during shutdown of unit
(reverse rotation at 427 RPM)
CONCLUSION

• Compressor acted as a driver, due to reverse flow of gas and rotated the coupled unit at 427 RPM in the reverse direction

• At same time, turbine barring gear wheel was in the engaged position with the hydraulic latch, this led to breaking the tooth of the turbine barring gear wheel
Temporary solution- In situ balancing

• Due to the urgency of Unit Start up, temporary solution was thought off & executed:

• The broken piece of gear tooth was weighed and a bolt of equivalent mass was fixed on gear wheel (refer exhibit # 4)
Result with temporary solution implemented

- Manual barring arrangement was made and the machine was commissioned successfully with vibrations within acceptable limits
  (Refer Exhibit # 5)
- With above temporary solution the delayed coker unit of Refinery had successful start up
Permanent solution:

• Rotor was replaced with new rotor during planned shutdown of the unit

• Recurrence was avoided with solution, following logic was implemented:
  - Closure of 1st Suction and Final Discharge motor operated valves (MOV) with coast down after trip / stop, when machine comes to standstill.
  - Closer of Antisurge valve on trip/stop, when speed reaches below 400 RPM
  - Drain case pressure only through case diaphragm drains to avoid condensation
Lesson Learnt & Recommendations

• Sudden pressurization or de pressurization across the compressor casing can result in reverse rotation of train due to gas flow through compressor impeller eye.

• Such reverse rotation can result in severe damages like breaking of turbine barring gear, damage to dry gas seal of compressor (in case it is unidirectional).

• Avoid reverse rotation in all circumstances, in this case by a change in operating procedure & logic.

• Temporary innovative repair resolutions in Turbomachinery can save a significant amount of downtime. Permanent resolution can implemented at a later opportunity like a planned turnarounds etc.