

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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Outline

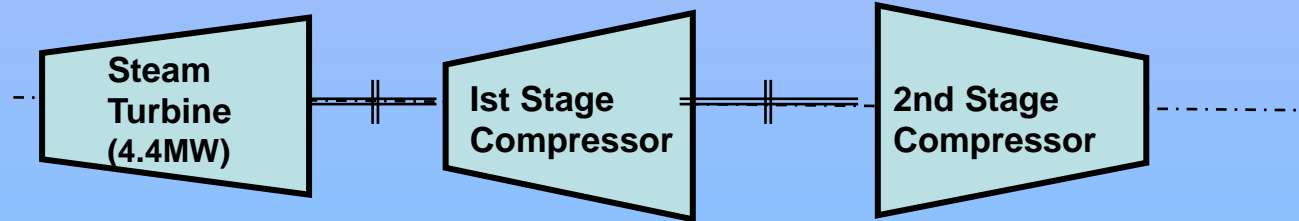
- **Pressure difference across the compressor casing, can cause reverse rotation of complete train, while drive steam turbine is in shutdown condition**
- **Reverse rotation can cause major damages**

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: 7300RPM



STAGES	1st	2nd
Model	2MCL 807	
Gas Handled	Hydrocarbon	
Capacity Nm³/ Hr.	36640 (wet)	9043 (wet)
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)**

Case study detailed Problem- cont'd



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)

ANALYSIS

- **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**

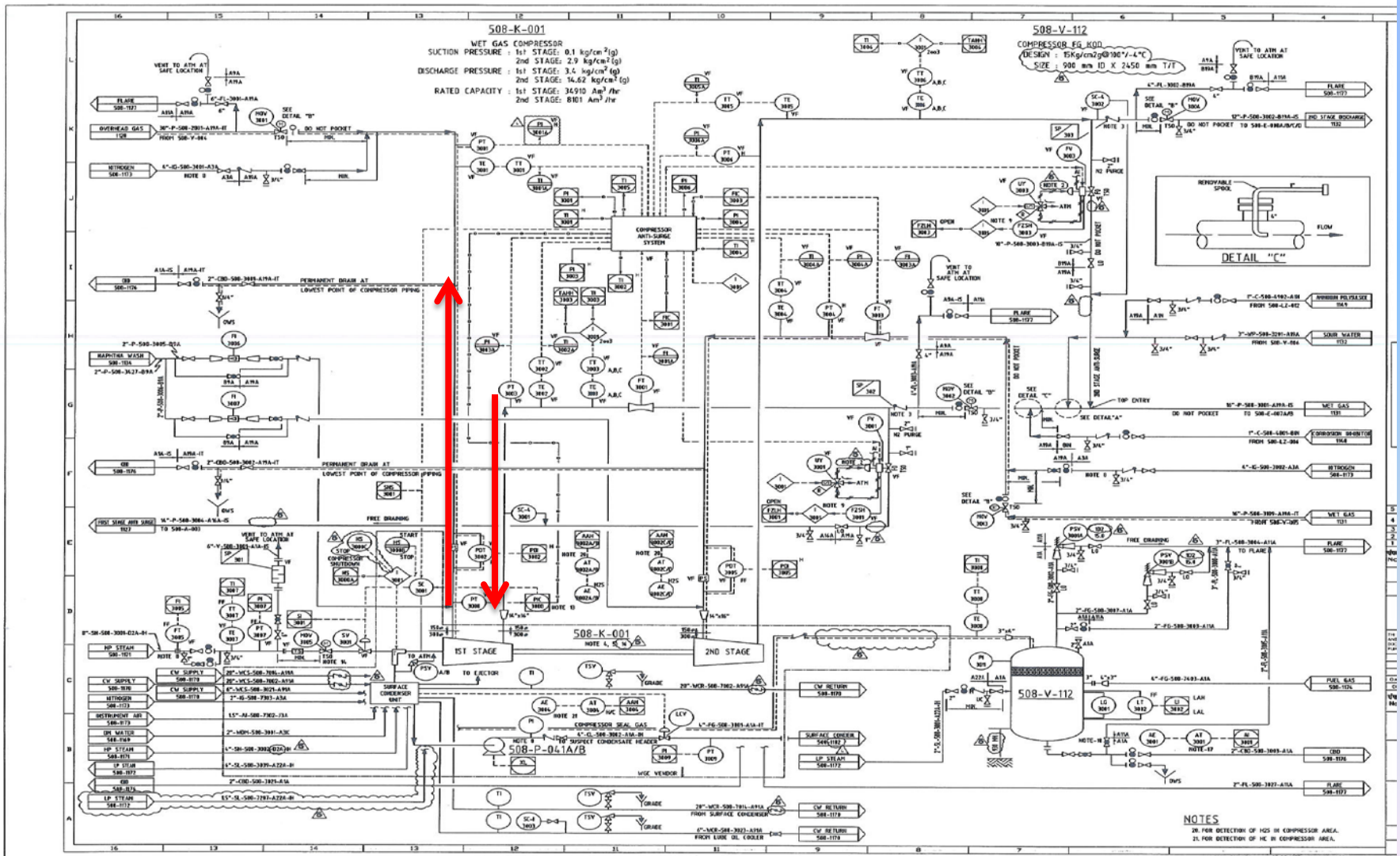
 - **Compressor rotor is configured as a balanced opposed construction**

ANALYSIS – cont'd

- 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

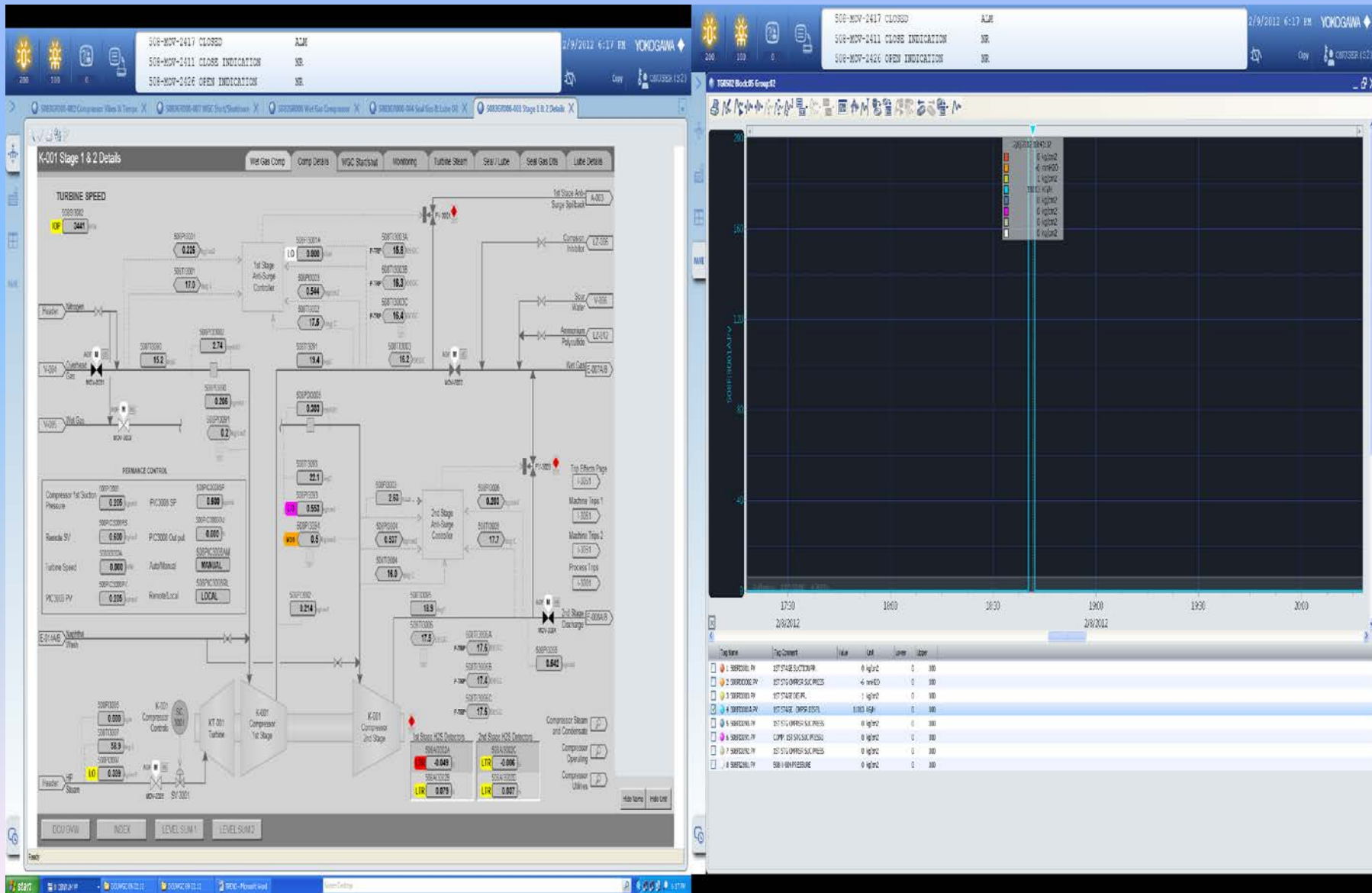
P & ID of compressor showing the direction of gas flow across the casing



Gas flow causing reverse rotation marked in Red color

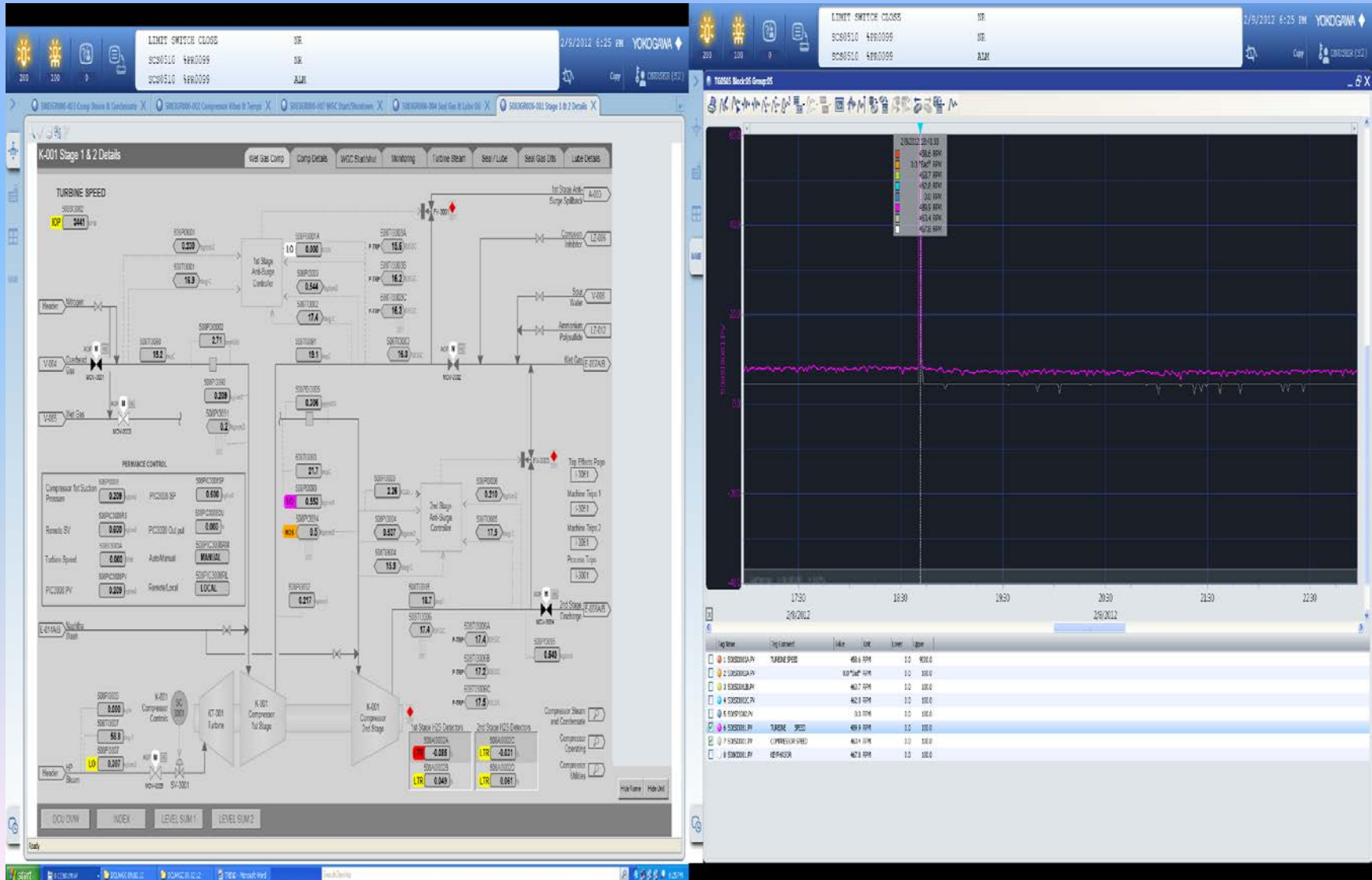
ANALYSIS - cont'd

Trend indicating flow from 1st Stage:



ANALYSIS – cont'd

Trend indicating speed pick up during shutdown of unit
(reverse rotation at 427 RPM)

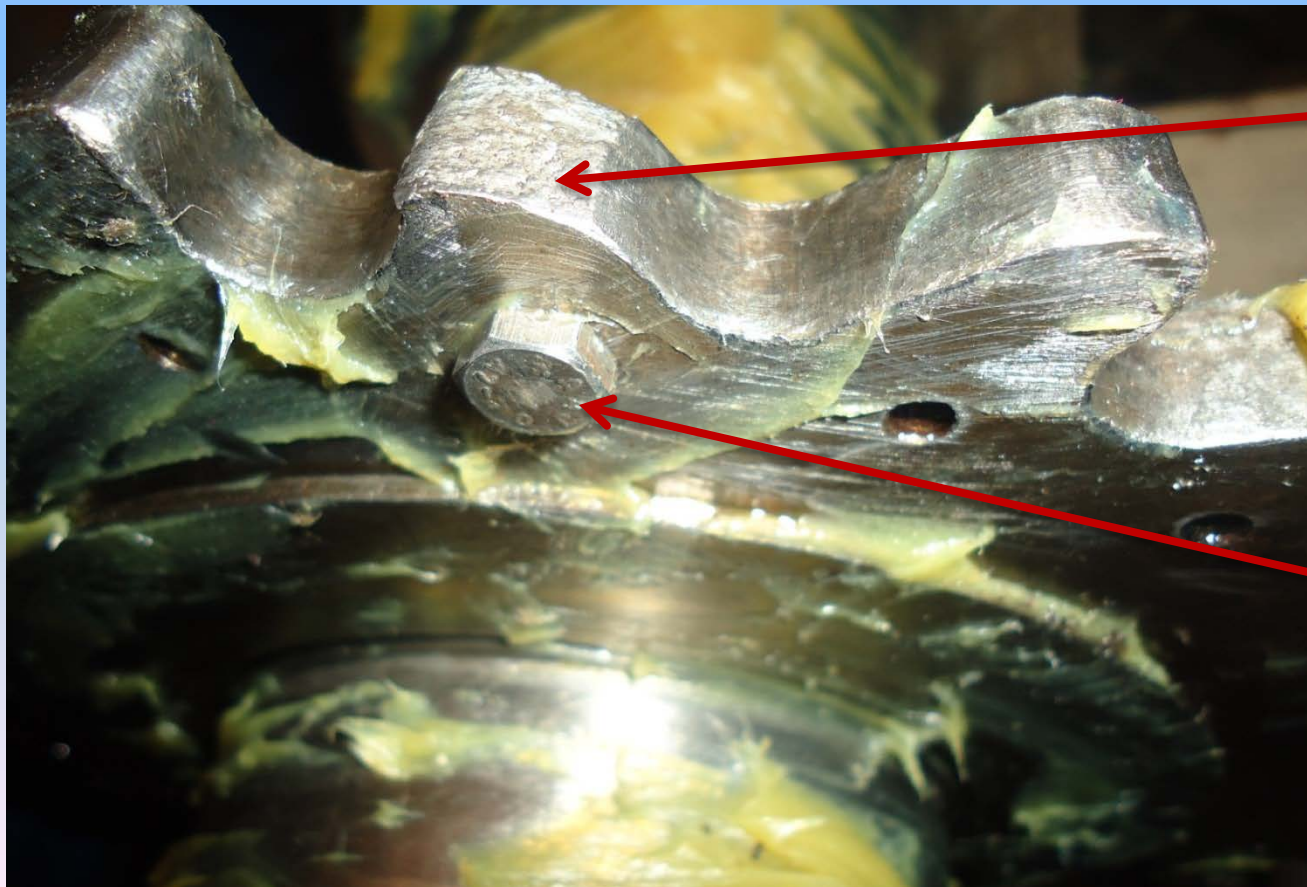


CONCLUSION

- **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)



**Broken
tooth**

**Bolt of equivalent
mass**

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



Demonstration of turbine rotor barring done manually

Exhibit # 5

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.**