



ASIA TURBOMACHINERY & PUMP SYMPOSIUM
MARCH 2018 | SUNTEC SINGAPORE

Steam Turbine Steam control valve failure
By
Vasanth Bhat & Thangavel Suthan
Singapore Refining Company Pte. Ltd.

Presenter/Author bios



Vasanth Bhat is a Integrity Manager at Singapore Refining Company (A joint venture refinery between Chevron & Petro China). During his last 9 years with SRC, his main role has been to support all technical and asset management issues with regards to rotating machinery in the refinery. Prior to this, Mr. Vasanth had over 19 years of experience in various roles as consultant , Sales , Reliability & Maintenance engineer in organizations in India , Middle east and Singapore. Mr. Vasanth has a Masters Degree in Rotating Machinery from the University of Zaragoza (Spain) ;B.E. degree (Mechanical Engineering, 1989) from Manipal Institute of technology – India and is a certified Category IV Vibration specialist by Vibration Institute USA .



Thangavel Suthan is a Lead Reliability Engineer at Singapore Refining Company. Mr. Suthan has over 12 years of experience in commissioning, maintenance and condition monitoring of rotating equipments in petroleum refinery, gasification plants and air separation units. He is a certified vibration analyst (ISO CAT-III) with hands on experience in trouble shooting of turbo machineries, reciprocating compressors and centrifugal pumps. Mr. Suthan holds a Master Degree in Systems and Project Management from Nanyang Technological University, Singapore (2015). Bachelor Degree in Mechanical Engineering (2005) from Coimbatore Institute of Technology, India.



Summary

The Wet Gas compressor is one of the most critical assets in a FCCU/RCCU of a oil refinery.

The back pressure steam turbine driver of this compressor faced two failures in the main valve stem of the steam inlet valve. Detailed study jointly between the OEM and the End User resulted in identification of the root causes causing the failure and applying relevant solutions.

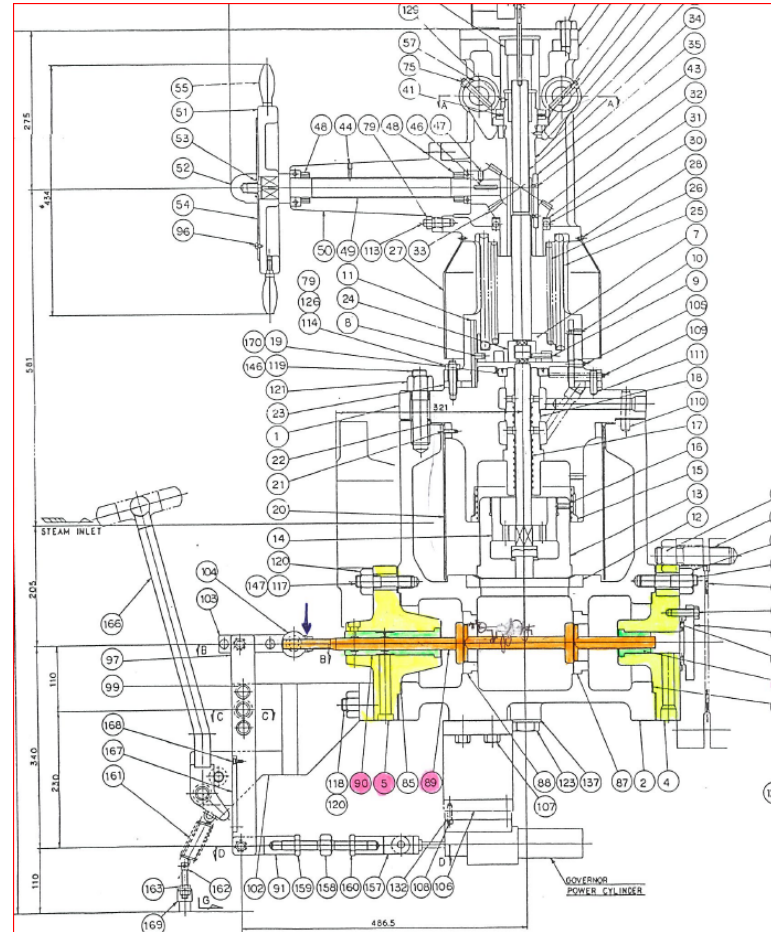
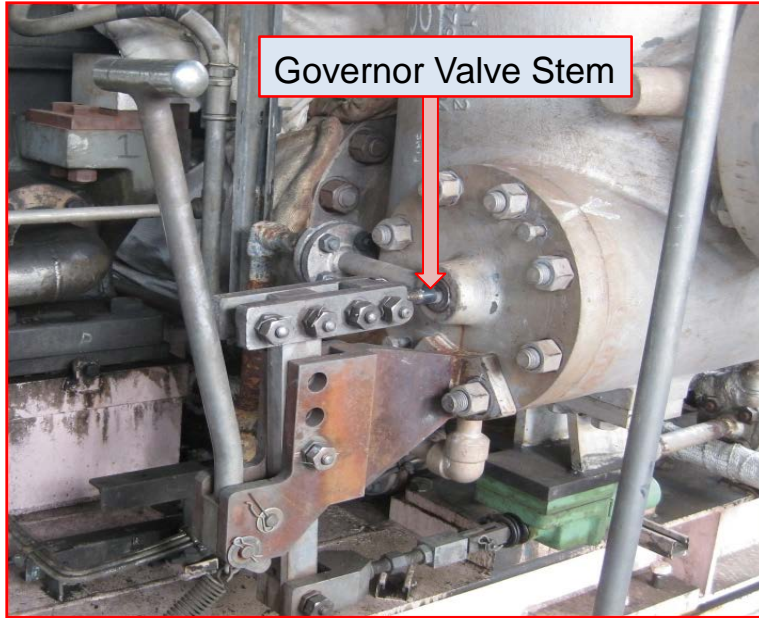


Wet Gas Compressor Steam Turbine Governor Valve Failure

- The Wet Gas compressor in the FCC unit is driven by a four stage back pressure turbine.
- The turbine is controlled by a dual port single stem slide valve using a Hydraulic governor.
- The turbine, after commissioning in 1993, was rerated in 2006 to take additional load from the compressor at end of run conditions.
- Prior to 2012 there were issues of abnormal wear observed in the governor valve stem bushing.



Governor Valve Stem Details



Governor Valve Stem Failure – Oct'12

Incident Summary:

On Oct'12, governor valve stem broke from the threaded portion which is exposed to atmosphere. Damaged parts were replaced with like to like spare.

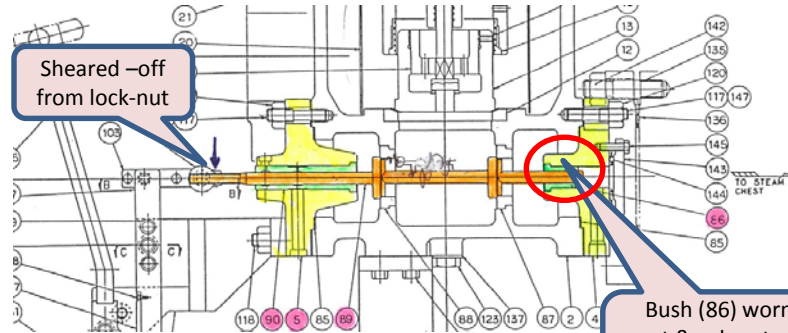
Findings:

1. Valve stem found broken at threaded section. Rear support bush was badly worn out. Front bush had relatively less wear compared to rear.
2. Stem surface found to have high wear at rear bush area.



Governor Valve Stem Failure – Oct'12

- Broken valve stem was sent for metallurgical analysis by OEM. It was concluded that the stem broke due to fatigue. (not due to metallurgical defects)



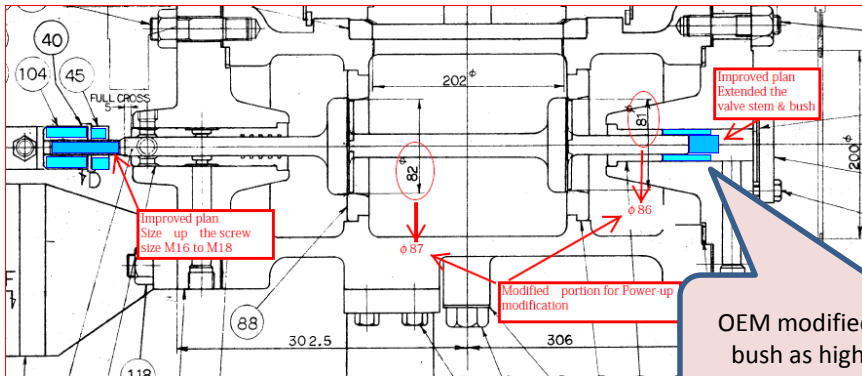
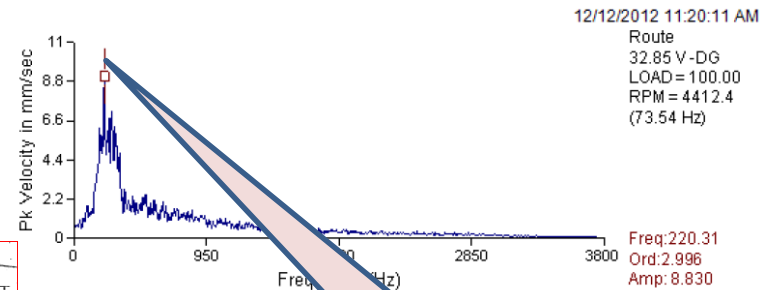
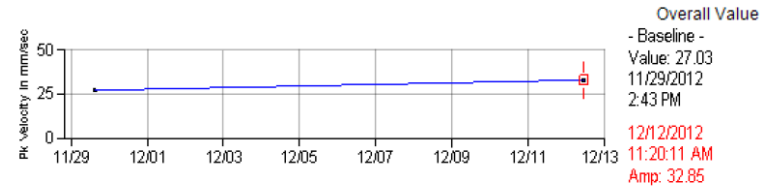
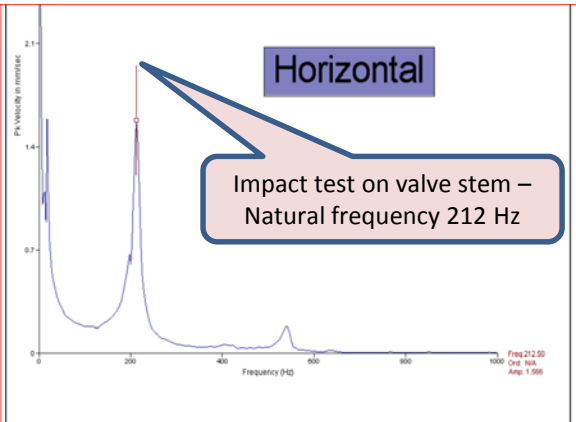
Governor Valve Stem Failure – Oct'12

First failure corrective actions:

1. Replaced stem and bush in kind
2. Carry out vibration monitoring of valve stem. Found on the higher side (25 to 30mm/sec pk).
3. Dominant peak around 200 Hz.
4. Impact test done and found the resonant frequency was 212 Hz.
5. OEM recommended Improvements to the threaded area and rear bush area for the spare stem.



Governor Valve Stem Failure – Oct'12



OEM modified valve stem and rear bush as highlighted in blue color

Vibration monitoring on routine basis – Overall vibration around 25 ~ 31 mm/sec pk
Dominant vibration frequency around 220 Hz



Governor Valve Stem Failure – June'14

June'14 Incident Summary:

- On 30th June'14, field operators observed abnormal noise & high vibrations from WGC turbine valve stem.
- A vibration check of valve stem indicated vibration amplitude well above 1000 mm/sec pk indicating resonance.
- Machine speed was reduced from 7600 rpm to 7000 slowly to check if the vibration subsides.
- Meanwhile, governor lost control when machine speed was around 7100rpm. WGC was shut down to inspect governor valve.



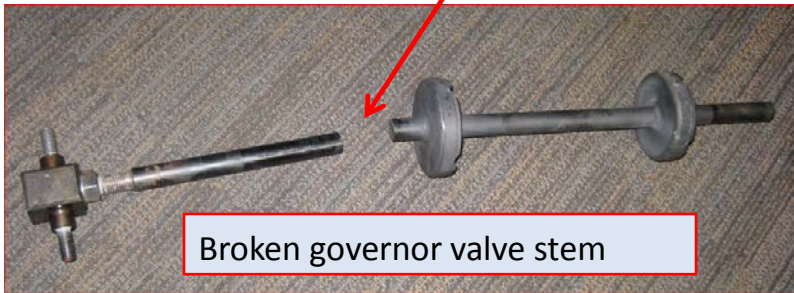
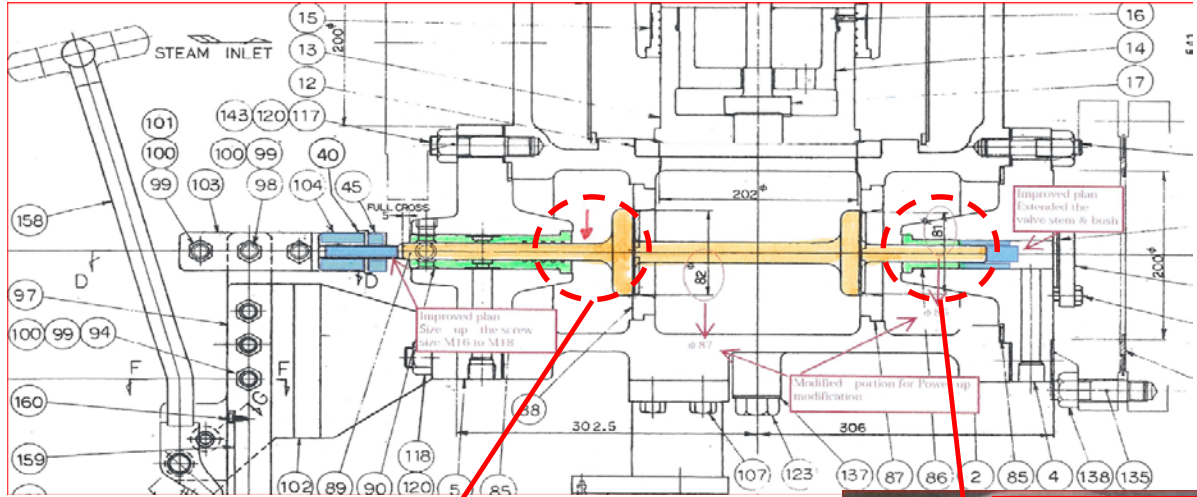
Governor Valve Stem Failure – June'14

Initial Findings:

1. On dismantling, governor valve stem was found broken from inside.
2. Valve stem rear bush found worn out excessively.
3. Hydraulic oil was leaking from valve actuator (power cylinder). Oil leak could be due to excessive vibration of valve stem.
4. These findings are similar to the failure occurred in Oct'12 except that the stem was broken from inside.



Governor Valve Stem Failure – June 2014



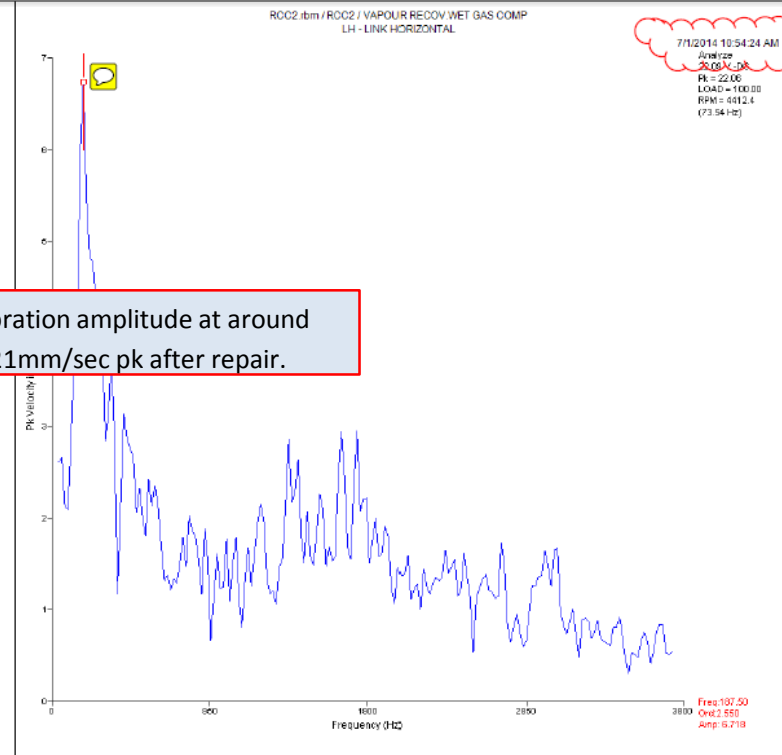
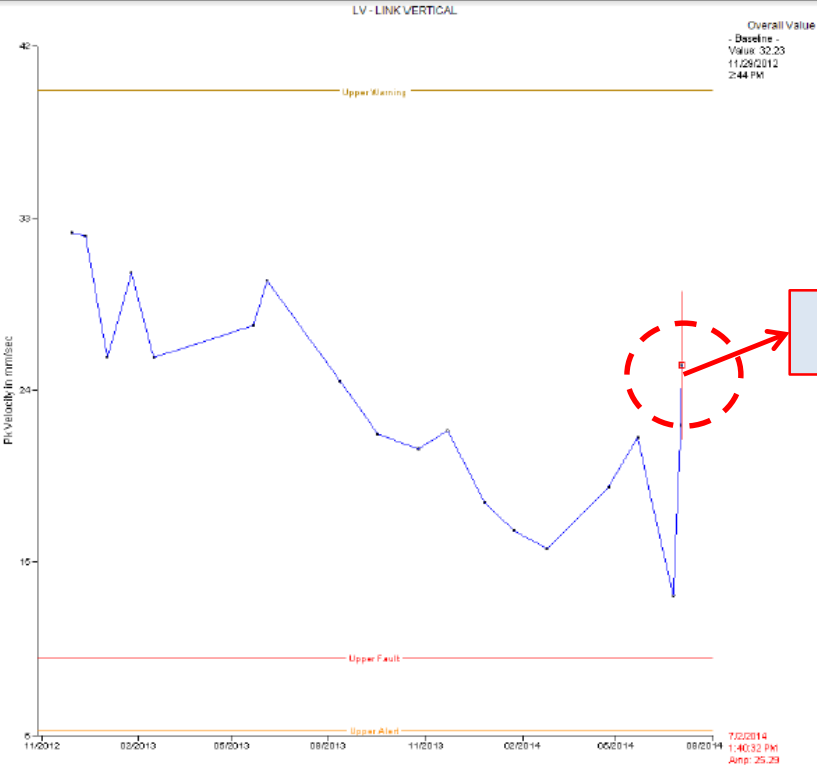
Governor Valve Stem Failure – June 2014

Immediate Corrective Actions Taken & Post Start up Observations

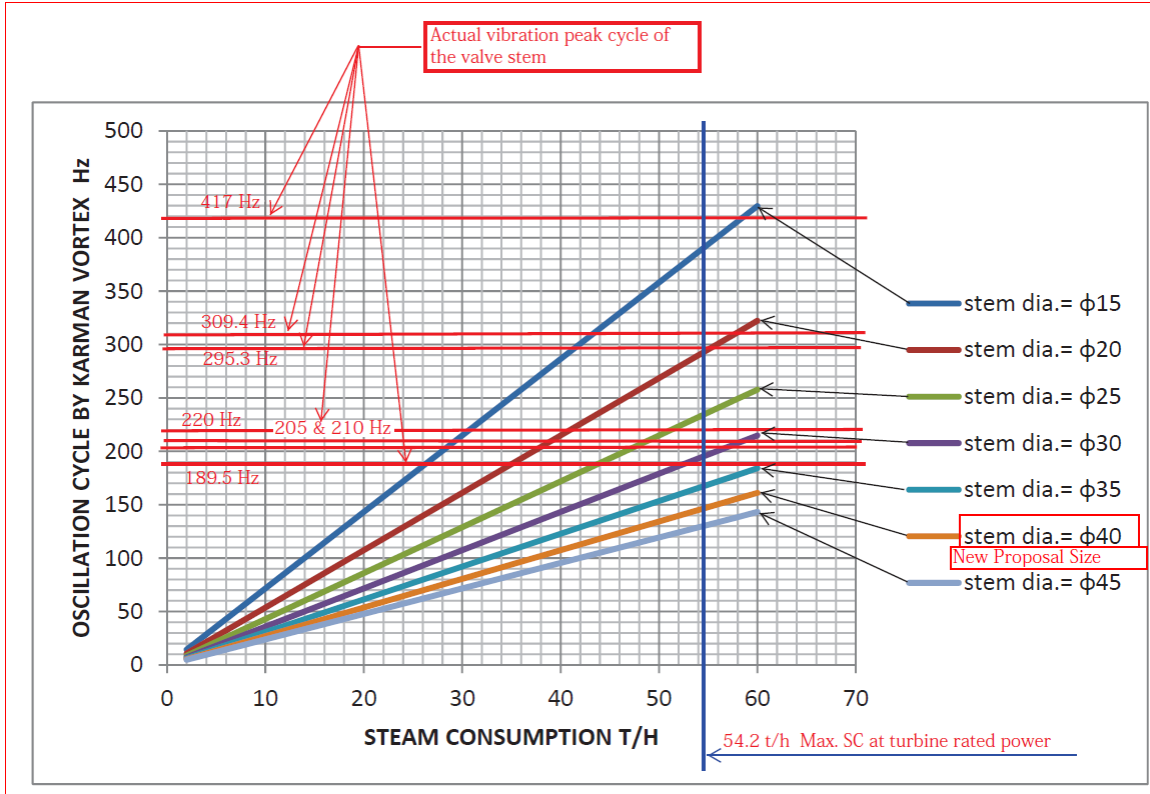
1. Replaced damaged governor valve stem with modified new valve stem & bush.
2. The vibrations on the stem did not show any significant reduction with the dominant spectrum in the peak remaining around the 200Hz.
3. OEM asked to carry out detailed analysis on the cause and recommend modifications to eliminate the issue



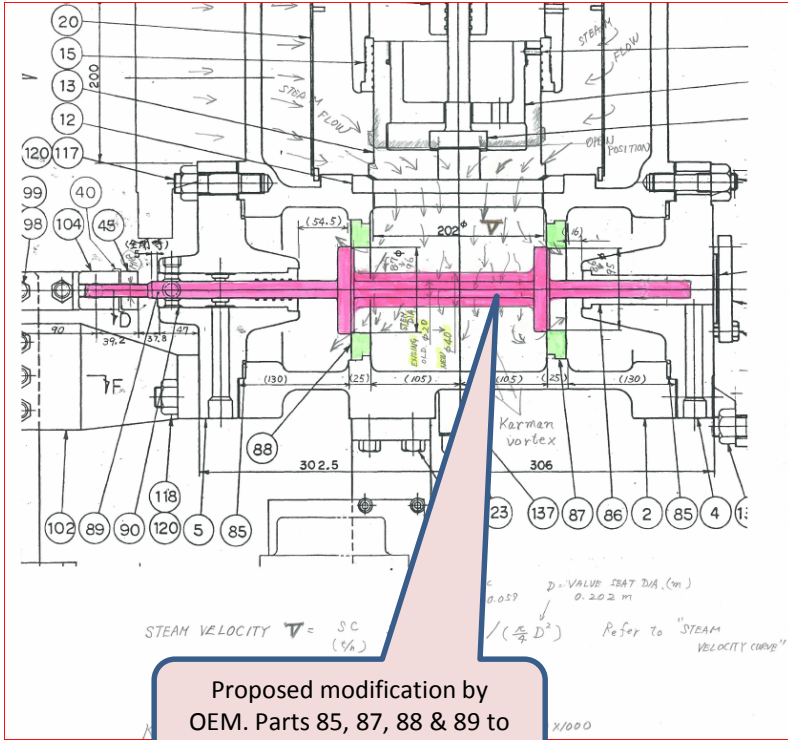
Governor Valve Stem Broken – June'14

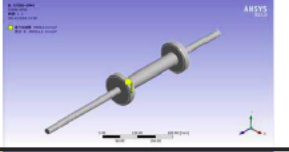
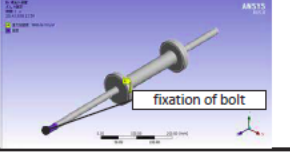
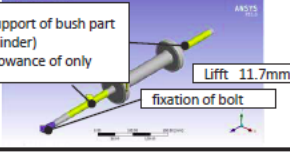
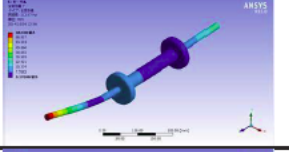
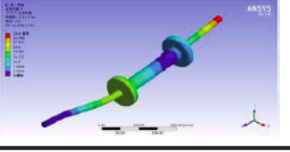
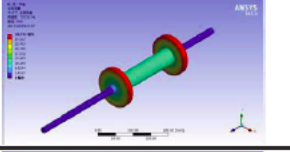
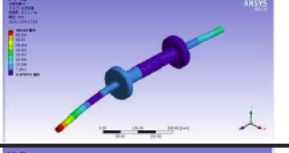
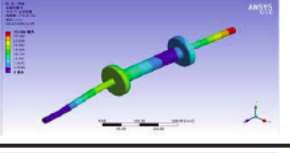
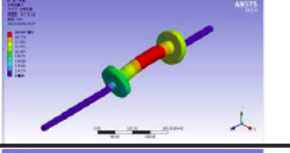
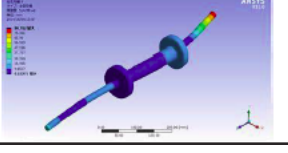
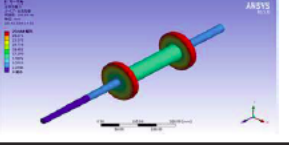
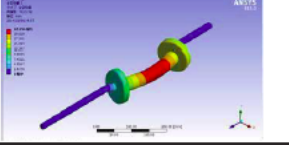


Karman Vortex Oscillation cycle calculation by OEM



Proposed Modification



	Provision valve stem (Free)	(fixation of bolt part)	(fixation of bolt part, fixation of interlevel bush cylinder, fixation of cylinder, fixation of end to side bush cylinder)
fixation condition		 fixation of bolt	 Lift 11.7mm fixation of bolt
MODE-1			
MODE-2			
MODE-3			



Proposed Modification

	Provision valve stem (Free)	(fixation of bolt part)	(fixation of bolt part, fixation of interlevel bush cylinder, fixation of cylinder, fixation of end to side bush cylinder)	Provision valve stem(Free)	(fixation of bolt part)	(fixation of bolt part, fixation of interlevel bush cylinder, fixation of cylinder, fixation of end to side bush cylinder)																																																													
MODE-4				MODE-8																																																															
MODE-5				MODE-9																																																															
MODE-6				MODE-10																																																															
MODE-7				Data	<table border="1"> <tbody> <tr><td>1</td><td>213 Hz</td></tr> <tr><td>2</td><td>213 Hz</td></tr> <tr><td>3</td><td>515 Hz</td></tr> <tr><td>4</td><td>515 Hz</td></tr> <tr><td>5</td><td>968 Hz</td></tr> <tr><td>6</td><td>968 Hz</td></tr> <tr><td>7</td><td>1660 Hz</td></tr> <tr><td>8</td><td>1661 Hz</td></tr> <tr><td>9</td><td>1884 Hz</td></tr> <tr><td>10</td><td>2574 Hz</td></tr> </tbody> </table>	1	213 Hz	2	213 Hz	3	515 Hz	4	515 Hz	5	968 Hz	6	968 Hz	7	1660 Hz	8	1661 Hz	9	1884 Hz	10	2574 Hz	<table border="1"> <tbody> <tr><td>1</td><td>175 Hz</td></tr> <tr><td>2</td><td>175 Hz</td></tr> <tr><td>3</td><td>199 Hz</td></tr> <tr><td>4</td><td>521 Hz</td></tr> <tr><td>5</td><td>521 Hz</td></tr> <tr><td>6</td><td>1078 Hz</td></tr> <tr><td>7</td><td>1194 Hz</td></tr> <tr><td>8</td><td>1194 Hz</td></tr> <tr><td>9</td><td>1751 Hz</td></tr> <tr><td>10</td><td>1751 Hz</td></tr> </tbody> </table>	1	175 Hz	2	175 Hz	3	199 Hz	4	521 Hz	5	521 Hz	6	1078 Hz	7	1194 Hz	8	1194 Hz	9	1751 Hz	10	1751 Hz	<table border="1"> <tbody> <tr><td>1</td><td>740 Hz</td></tr> <tr><td>2</td><td>743 Hz</td></tr> <tr><td>3</td><td>744 Hz</td></tr> <tr><td>4</td><td>1170 Hz</td></tr> <tr><td>5</td><td>1704 Hz</td></tr> <tr><td>6</td><td>1705 Hz</td></tr> <tr><td>7</td><td>2062 Hz</td></tr> <tr><td>8</td><td>2856 Hz</td></tr> <tr><td>9</td><td>2859 Hz</td></tr> <tr><td>10</td><td>4345 Hz</td></tr> </tbody> </table>	1	740 Hz	2	743 Hz	3	744 Hz	4	1170 Hz	5	1704 Hz	6	1705 Hz	7	2062 Hz	8	2856 Hz	9	2859 Hz	10	4345 Hz
1	213 Hz																																																																		
2	213 Hz																																																																		
3	515 Hz																																																																		
4	515 Hz																																																																		
5	968 Hz																																																																		
6	968 Hz																																																																		
7	1660 Hz																																																																		
8	1661 Hz																																																																		
9	1884 Hz																																																																		
10	2574 Hz																																																																		
1	175 Hz																																																																		
2	175 Hz																																																																		
3	199 Hz																																																																		
4	521 Hz																																																																		
5	521 Hz																																																																		
6	1078 Hz																																																																		
7	1194 Hz																																																																		
8	1194 Hz																																																																		
9	1751 Hz																																																																		
10	1751 Hz																																																																		
1	740 Hz																																																																		
2	743 Hz																																																																		
3	744 Hz																																																																		
4	1170 Hz																																																																		
5	1704 Hz																																																																		
6	1705 Hz																																																																		
7	2062 Hz																																																																		
8	2856 Hz																																																																		
9	2859 Hz																																																																		
10	4345 Hz																																																																		



Governor Valve Modifications

Corrective Actions Taken & Post Start up Observations

1. Modified stem and related parts installed during turbine overhaul in 2015.
2. The overall vibrations did not show a distinct reduction but there is no dominant peak at 200Hz.
3. Unit is under monitoring and no abnormalities observed.



Lessons Learnt

1. Need for closer review during rerates on issues such as flow related vibration on components in the flow stream.
2. Every failure in critical machine though rare and could be the first needs closer review and detailed analysis.

