Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 01, January-2018

Trouble Shooting in Turbine Journal Bearing Vibration (A Case Study)

Prem Baboo
Sr. Manager (Prod)
National Fertilizers Ltd. India
Sr. Advisor for www.ureaknowhow.com

***Abstract* - This paper provides the basis for identifying and correcting turbine problem describes turbine front and rear journal bearing vibration problem and rectified in running plant by some modifications. The 31 CO_2 compressor turbine tripped on dated 01/01/2018 & 9/01/18 on rear journal bearing RJB (406 A/B) vibration high. The event analysed and preventive action was taken by some minor modification in running plant, this vibration was occurred due possibility of carbon deposition on the bearing in carbonization process of lube oil at high temperature. The event studied and rectification done by shielded Oxygen through purging of Nitrogen in bearing and also gland steam temperature raised about 5-7^{0}C from saturation temperature.**

Key words- Turbine, Journal Bearing, Vibration, Lubrication Carbon deposition, Nitrogen, Compressor. Gland steam.

INTRODUCTION:

National Fertilizers Ltd, (NFL) operates a fertilizer complex at Vijaipur, Distt. Guna (Madhya Pradesh) consisting of two units Vijaipur-I and Vijaipur-II, plants were commissioned in December 1987 and March 1997 respectively. Ammonia Plants are based on M/s. HTAS's Steam Reforming of Natural Gas and Urea plants are based on M/S. Saipem's Ammonia Stripping technology. NFL, a Schedule 'A' & a Mini Ratna (Category-I) Company. The Vijaipur unit, which is an ISO 9001:2000 & 14001 certified, comprises of two streams. The Vijaipur have two ammonia plant M/S. Haldor Topsoe Technology, Denmark capacity 1750 & 1864 TPD for Line-I & line-II respectively and four urea plant of M/S. Saipem ammonia stripping process, Italy. The capacity of Urea-I urea –II is 3030 & 3231 TPD respectively. The raw material used includes natural gas, water and power. Three Numbers Captive power plant of capacity 17 X 3 MW are used in this complex. Both the plants have consistently achieved high levels of capacity utilization. 31/41 Stream turbine were operated by 106 ata steam turbine for CO_2 compressor.

Description of the Carbon Dioxide (CO_2) Turbine Tripping

The complex has two stream line 1 & 2 and each lines have two numbers of CO_2 Compressor 11/21/31 & 41 stream supplied by Bharat Heavy Electrical Limited (BHEL). The line-1 turbine operated by 40 ata stream and line-2 turbine operated by 106 ata stream. 31 turbine tripped on dated 1/1/2018 and 09/01/2018 on turbine rear journal bearing Vibration high. However, all the vibration of front journal bearing & rear journal bearing also were gone to high as shown in the figure No. 1. At the time of tripping on dated 09/01/2018 following reading was noted.

1. 31 Turbine Front Journal bearing vibration (FJB 406 A/B)-94.1/91.2 µn
2. 31 Turbine Rear Journal bearing vibration (RJB 407 A/B)-**129**/98.2 µn

The trip values of RJB/FJB vibrations are 100 µn.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 01, January-2018

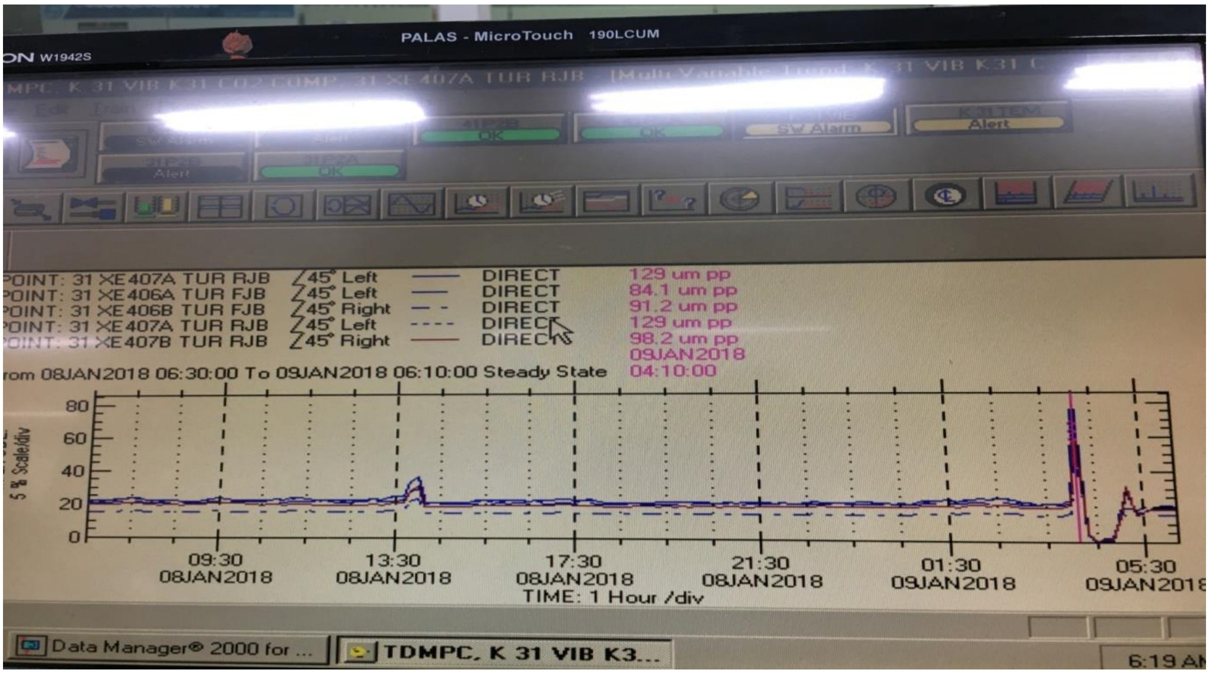

Fig. No.-1

All the value touched the trip value except 406 B. As shown in the figure No.-1.The vibrations low frequency vibration peaks were observed from November 2017 after annual turned around this value was not more than 80 µn as shown in the figure No.-3. Unlike discrete vibration that often indicate a serious problem. In each shut we were opened the journal bearing and removed the deposited carbon on the surface but this shut down that practice did not work out. The carbon deposition found as figure No. 4. Excessive rotor vibration can cause robbing and impact damage to components such as turbine seals, blades or bearings. Fatigue damage of some turbine blades, coupling bolts, steam or oil lines, etc. can also occur. Finally, the vibration can loosen some parts. Ego generator rotor windings supporting wedges. When damage occurs, the vibration levels can rise further causing more damage.

After detecting the problem, detailed measurements and analyses (evaluation of the trend, phase analysis, etc.) are carried out allowing a clearer view of the problem and its underlying cause. - Once the basic cause of the problem has been detected, economically acceptable corrective actions was taken and rectified the problem and following action/modifications done in running plant.

1. Shielding of Journal bearing with Nitrogen purging to protect Oxygen to avoid further carbon deposition.
2. Choked RJB steam gland sealing with ‘U’ shape got decoked.
3. Gland steam temperature raised by saturation Plus 7^0C to avoid condensation in gland.
4. The breather remove on FJB bearing housing, it’s breaking vacuum inside.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 01, January-2018

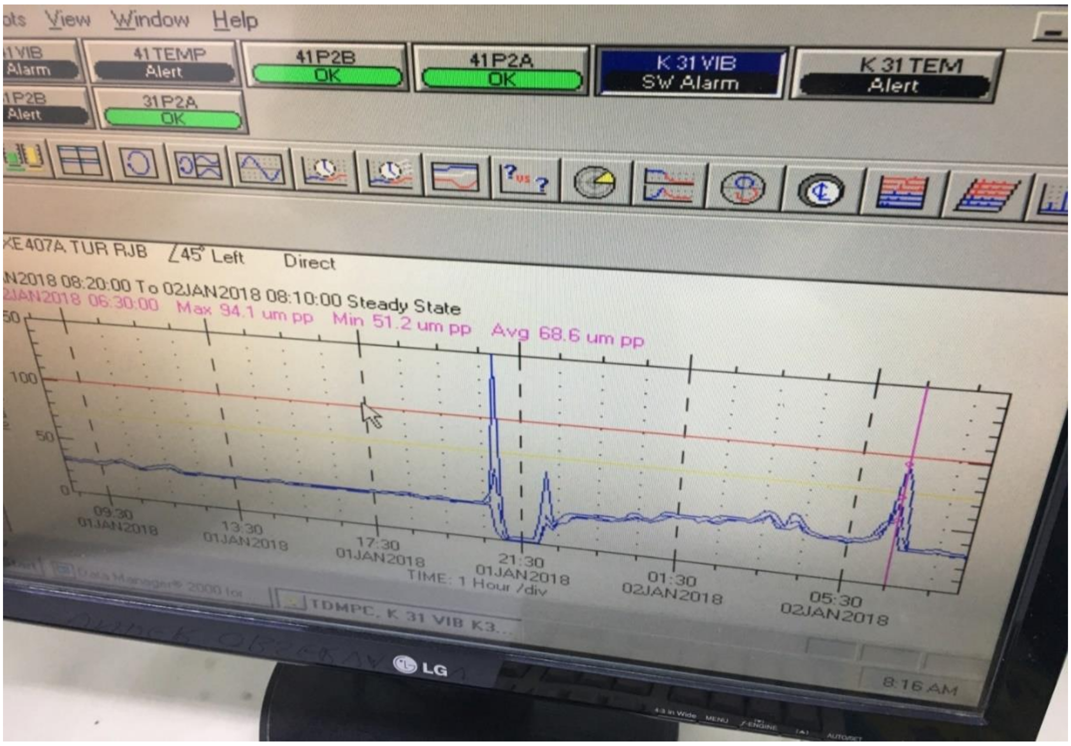

Fig. No. 2

It has been observed the saturated steam used for gland that was carryover to bearing side and that cause vibration the drain of gland steam also fond choked condition. It has been decided as and when in any opportunity the journal bearing will open for inspection and removing carbon deposition. In front journal bearing housing breather has been removed which was mounted on bearing housing for vapour elimination. A blind has been provided in place of breather, for supporting siphoning action for lube oil inside the bearing housing. This vacuum measured found 10 mm of water column. The detail design parameters of turbine are given in table No. -1

Steam flow through turbine is in the axial direction. After leaving the body of the emergency stop valve steam enters the valve chest with the control valve whish form an integral casting with the upper half of the outer casing. The steam chamber accommodates the nozzle groups and supports the packing gland around the balance piston. The steam enters the nozzle group via the valves of the outer casing. The packing gland contains caulked-in sealing strips forming a labyrinth seal which is free from mechanical contact. Alignment in the axial direction is achieved by a bore in the lower and upper casing compartment.

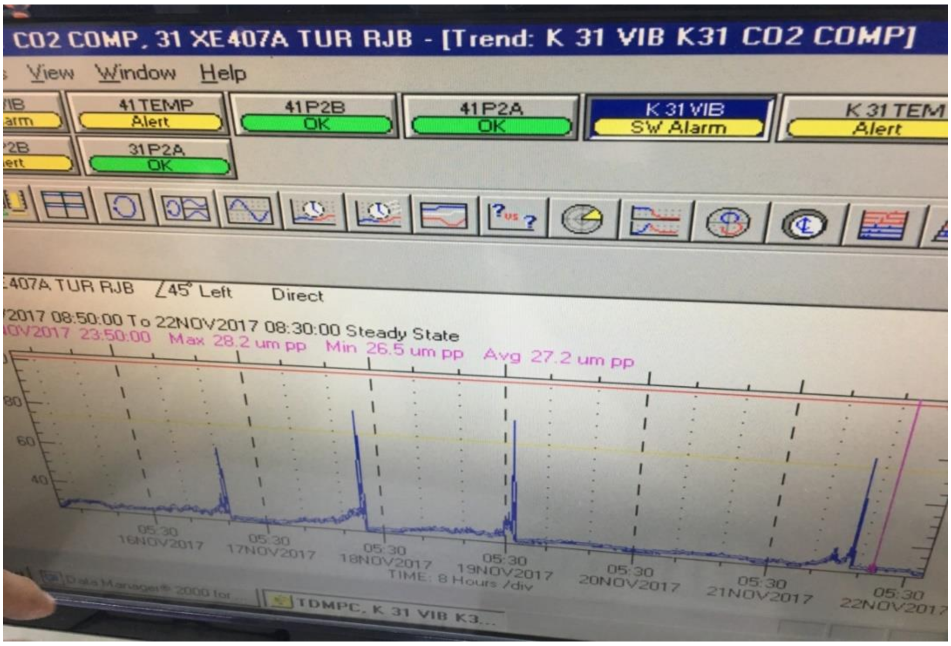

Fig. No. 3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 01, January-2018

Turbine Design Data			
Sr.No.	Parameters	Unit	value
1	Turbine Inlet pressure	kg/cm^2	106
2	Turbine Inlet Temperature	^{0}C	510
3	Extraction Pressure	kg/cm^2	25
4	Exhaust Pressure(at 18.5 t/h speed 8094)	kg/cm^{2}a	0.13
5	Turbine Speed (rated)	RPM	8435
6	Rpm, Min/ Nor/ Design	RPM	7285/8095/8791
7	No Load quantity	t/h	0.7
8	Area of one Nozzle	mm^2	5.18 X 12.6=65.27
9	Velocity coefficient		0.954
10	Absorbed Power(all losses)	KW	5822
11	Absorbed Power	KW	5684

Table No. 1

CO_2, Compressor Data

Centrifugal Compressor Specification sheet, Thermodynamic data (Rated)					Thermodynamic data (Normal) Guaranteed			
Inlet Condition	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Actual Flow,m3/hr	27121	7063	1532	257	21243	5720	1319	233
Pressure, ata	1.35	5.3	22.24	86.77	1.55	5.88	23.45	86.8
Temperature ^{0}C	45	44	44	52	45	44	44	52
Compressibility Factor	0.994	0.978	0.905	0.599	0.993	0.976	0.899	0.599
molecular Weight	41.615	43.033	43.358	43.418	41.85	43.07	43.36	43.42
Cp/Cv	1.286	1.288	1.305	1.311	1.286	1.289	1.306	1.31
Outlet Condition								
Pressure, ata	5.53	22.84	87.72	165	6.08	23.95	87.65	161
Temperature 0C	191.47	202.78	192.86	119.34	189.7	199.2	186.3	115.8
Actual Flow,m3/hr	10558	2412	601	184	8580	2048	540	168
Pressure ratio	4.0963	4.3094	3.9442	1.9016	3.923	4.073	3.738	1.855
Polytrophic head	11068	11037	9426	2931	10633	10526	8934	2786
polytrophic eff,%	77.4	73.9	72.8	49	75.7	72.3	72.7	49.8
Total Power Consume, kw	8247				7490			
Compressor Speed	8435		12653		8082		12123	

Table No. -2

Fig. No. 4

The purpose of the two journals bearing in the front and rear bearing housing is to support turbine rotor centrally in the outer casing and its guide carriers. The bearings carry a load perpendicular to the axis of rotation made of the weight of the rotor, constant or fluctuating steam forces and kinetic forces caused by unstable running or any residual unbalance.

Brief description of CO2 Compressor and turbine

Steam turbine driven centrifugal CO2 compressor is one of the critical equipment's of urea plant which compresses the CO_2 gas from 1.4 ata 160 ata pressures in four stages. In between the stages the gas is cooled in intercoolers and moisture is separated in moisture separators which are vane type design compounded with demister pads. MCL compressors are designed in several sizes and pressure ratings to cover different applications. The compressor casing and diaphragms are either cast (cast steel) or fabricated. The impellers and diffusers are selected from a wide range of standard stages in accordance with the application and desired performance. The radial and thrust bearings are of the tilting pad type. Shaft-end seals are mainly dry gas seals but can be labyrinths or oil film seals. Inter-stage leakages are controlled by labyrinths (static or rotating).

Journal Bearings

The journal bearings are of the tilting pad type with forced lubrication. Oil under pressure reaches the bearing radially, goes through holes to lubricate pads and blocks. Bearing pads are of steel, internally lined with white metal. They are integral with block of steel, and are located into proper seat formed by shell and by two oil guard ring. The pads can swing in the shell in both the direction of the movement. The shell is made of steel, and is divided in to two halves along the horizontal center plane.

Thrust Bearing

Our thrust bearings, built on the Kingsbury principle, withstand heavy thrust loads with very small friction losses and a low rate of wear. The Babbitt-surfaced, multi-segment shoes pivot during operation, providing a tilting action that forms a wedge-shaped oil film between the rotating thrust collar and the bearing surface. The thrust load automatically distributes in either direction equally to the several shoes, maintaining internal alignment as well as holding the rotor in its axial position. This means less maintenance to wearing parts.

Labyrinth Seal

The internal seals, used between rotating and stationary parts of the compressor to reduced gas leakage between areas of different pressure, are labyrinth type. The labyrinth seal consists of a ring the periphery of which is shaped on a series of fins having small clearance with the rotor. Labyrinth seals are assembled on shaft ends of the compressor to prevent the leakage of the gas from the inner compressor. These rings are manufactured in 2 halves as four quarters of as soft alloy resistance to corrosion to avoid damage to the rotor in the event of an accident contact. The upper halves of rings are fastened to relevant diaphragm. The lower half of rings can be easily removed by rotating them in their grooved seat in the diaphragms. The position of the rotor which face the labyrinth seals are the impeller disk, the shaft sleeves between the impellers and the balance drum. The same type of seal is located at the shaft end to limit the gas leakage out the compressor.

Casing

1. Bolt-On Split Carbon Ring Box.
2. Integrally Cast Casing.
3. Integrally Cast Casing with Removable.
4. Seal Housing.
5. Clamped in Housing

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 01, January-2018

These compressors have been designed to meet the range of flow and compression ratios required by gas pumping stations. A variety of standard casing sizes are available to cover a wide range of gas flow. The same casing can house different numbers of impellers to optimize performance in terms of efficiency, compression ratio and operating range. Field modification of the impeller configuration can be made to accommodate changes in operating conditions. The compressor casings are made of forged steel to provide maximum material strength and metallurgical stability. Vibration-free operation is assured by positioning bearings at both casing ends which provides the necessary rigidity to the rotor. Dry gas seals are normally used to prevent gas leakage. The suction and delivery nozzles are generally located opposite each other to meet station layout requirements. Axial inlet is also available when the pressure ratio allows for a single impeller.

Labyrinth Gland

Purpose:
The purpose of the gland shown in figure is to seal internal casing against the atmosphere at the point where the shaft passes through the casing.

Design:
The shell of the packing gland is axially split into two half-shells. It is effectively locked against rotation in the turbine housing and against displacement of the half shells with respect to each other. The sealing strips of stainless steel have been caulked into grooves on the periphery of the inter shell surface by means of a special tool with square cross sections.

Auxiliary Steam Network
The auxiliary steam (Pressure-15-17 kg/cm2) is used for creating vacuum in exhaust side (hot well). This steam let down from 24 kg/cm2 header this connected to 100 kg/cm2 let down (PV-266) plus Extraction Header. This auxiliary steam de-superheated with Control valve TV -253. For gland steam sealing this steam further let down to 0.05 kg/cm^2 to 0.08 kg/cm^2 through PV 252 A and 252 B is dump valve when leakage is more from HP side then this valve will open to control the gland steam pressure. The PV 252 A & B are controlled by PIC 252 in split range. The drain valves also provided in gland steam with 'U; bend sealing so that vacuum will be maintained. As shown in the figure No.-5. After the gland steam pressure is maintained the controller PV 252 put on auto mode and set value given 0.02 to 0.06 kg/cm^2.In case of increase in leakage of gland during running PV 252 B will open and excess steam above 0.08 kg/cm^2 will be connected to condenser.

Two identical ejector condensers maintain the condenser pressure. The ejector condenser is equipped with following safety instrument.

1. Temperature safety valve TSV-247,248
2. Local Pressure Indicator
3. Flow indicators FI-243 & FI-244.

The start-up (Hogging) ejector is also provided with silencer. The final discharge and condensate is controlled by the valve LV 244 A.

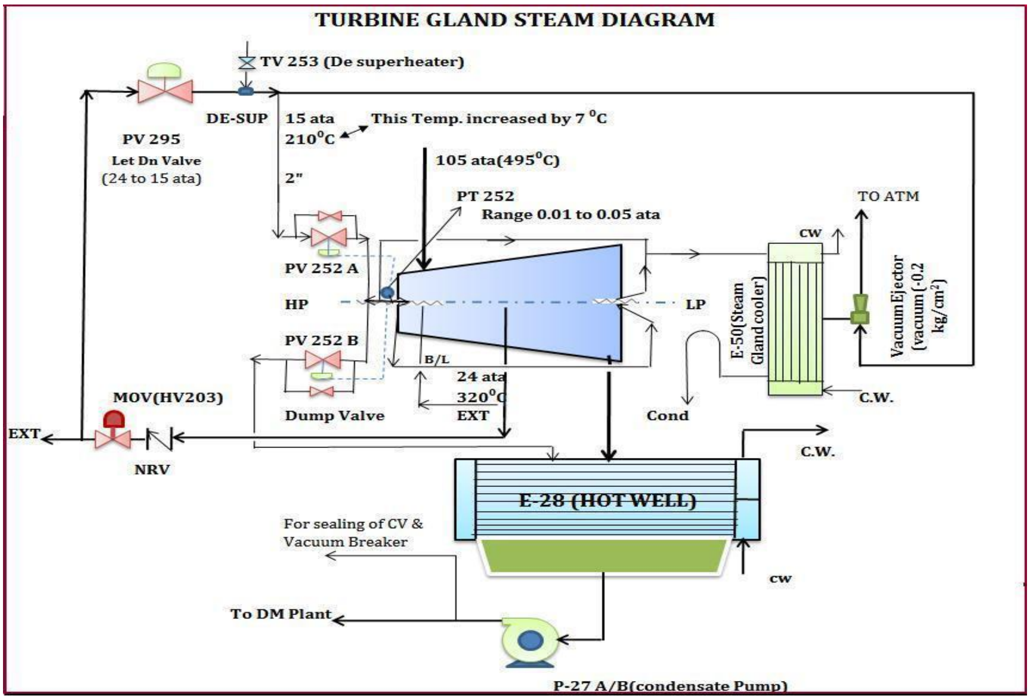

Fig. No.-5

The Cooling water also provided in ejector condenser to condense the steam vapour and uncondensed vapour out from vent which is also sealed. The outlet condensate through trap connected to hot well. The pressure is maintained at about 15.5-17.5 kg/cm^2. Through PV 295 from MS 24 kg/cm^2 header.

The rear bearing side to turbine is to be sealed against entry of air into casing. This is done by injection steam during start up. The M.P steam is reduced to the required pressure by controlled valve PV 252 A. The steam turbine inlet pressure 106 kg/cm2, but when the steam exit, the pressure drops to either well below atmospheric pressure (Condensing Turbine) or at relatively lower pressure (Extraction turbine). Our Turbine is compound i.e. combination of extraction plus condensing.

Since the Turbine shaft has to rotate freely there has some gap between the shaft and the turbine casing, from where either steam will try to escape out or Atmospheric air will try to sneak in. As per the figure number 5 explains, during turbine start up the gland seal steam has to be given at both the ends, so that condenser is isolated from the atmosphere and vacuum pulling can be started. But as the turbine started taking load, steam at inlet side will try to come outside due to difference of pressure across the gland seals at that point the gland sealing steam can be stopped to HP end seals and self-sealing will be achieved whereas at Low pressure zone the sealing steam has to be maintained always.

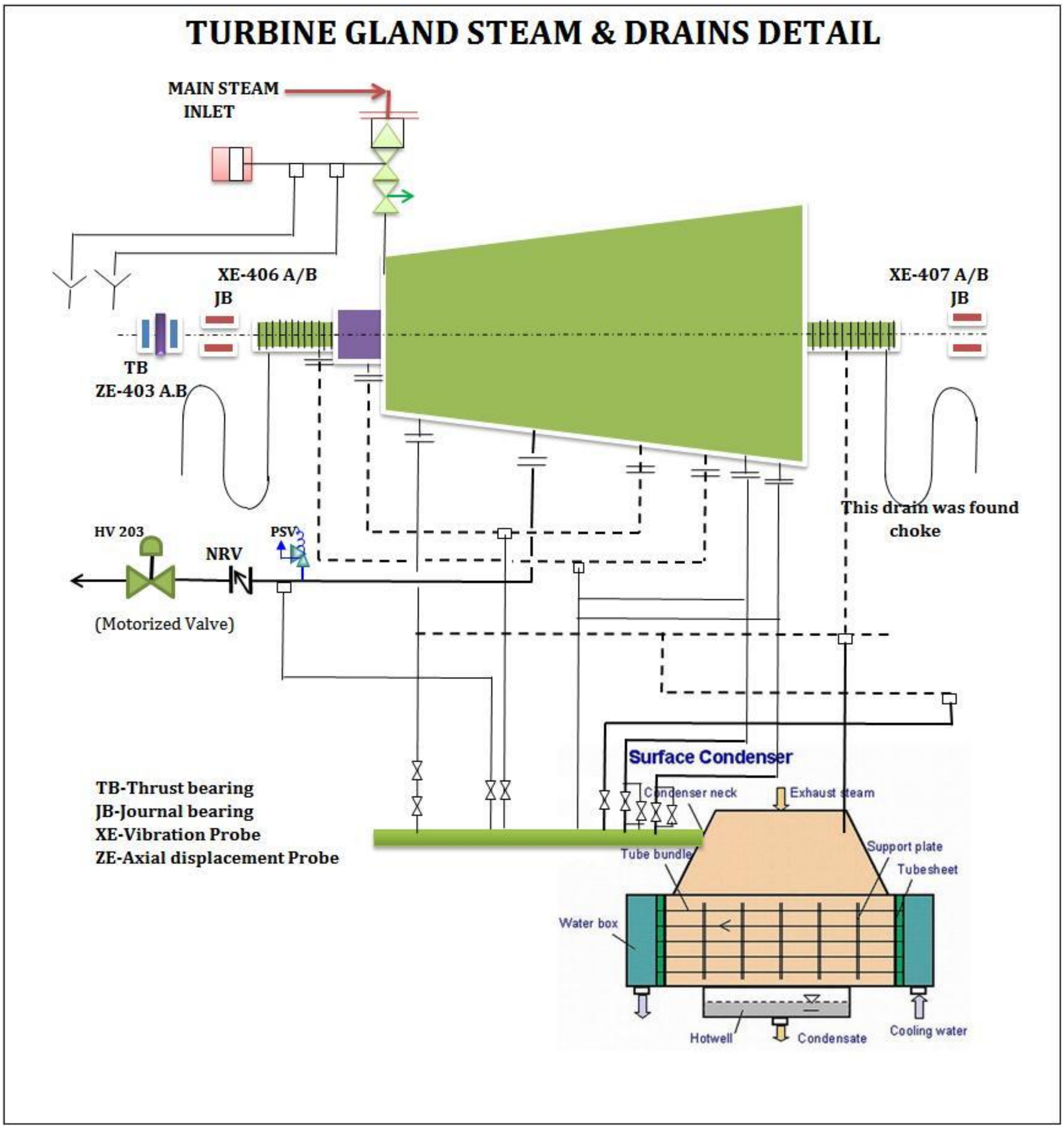

Fig. No. 6

The middle section of the gland seals is usually (for higher rating turbine) connected to Sealing fan system (gland condenser fan), which sucks air + Steam from the gland seals, and pumped into a heat exchanger where the steam is condensed and thereafter air will be vent out into the atmosphere. As turbine exhaust is connected to a condenser

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 01, January-2018

which is operated below atmospheric pressure so there are chances of air ingress or vacuum brake in turbine which is eliminated by gland sealing.

All the reading of turbine vibration axial displacement of compressor connected to TDM with second of trend available as figure No. -7.

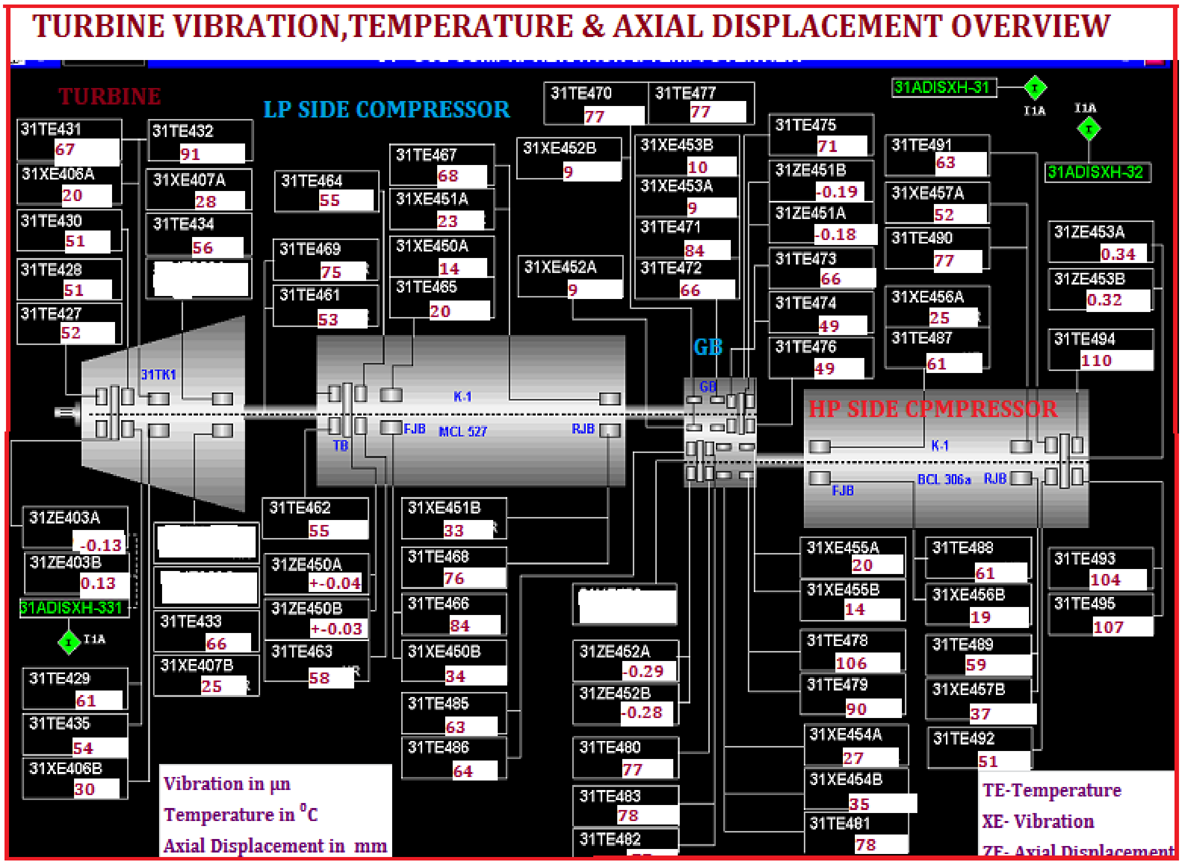

Fig. No.-7

The BHEL centrifugal compressor is designated by series of capital letters and numbers. The capital letters describe the casing feature, 2MCL indicate a compressor with the casing in two halves horizontally split. 2BCL indicates a compressor with the casing having vertically split of end cover location having two stages. Carbon Dioxide compressor is having four stages. The CO_2 received from Ammonia plants at pressure 0.55 kg/cm^2.There are two stages each having two internal stages. First stage discharge pressure is 5.5 kg/cm^2 and temperature 188^{0}C.This discharge cool down to 40^{0}C in interstate cooler and send to 2nd stage for further pressurization. 2nd discharge pressure is 23 kg/cm^2 and temperature-180^{0}C.Third stage pressure is 90 kg/cm^2 and temperature is 185^{0}C and final stage pressure is 160 kg/cm^2 and temperature 120^{0}C and sent to reactor as shown in the detail diagram figure No.-8.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 01, January-2018

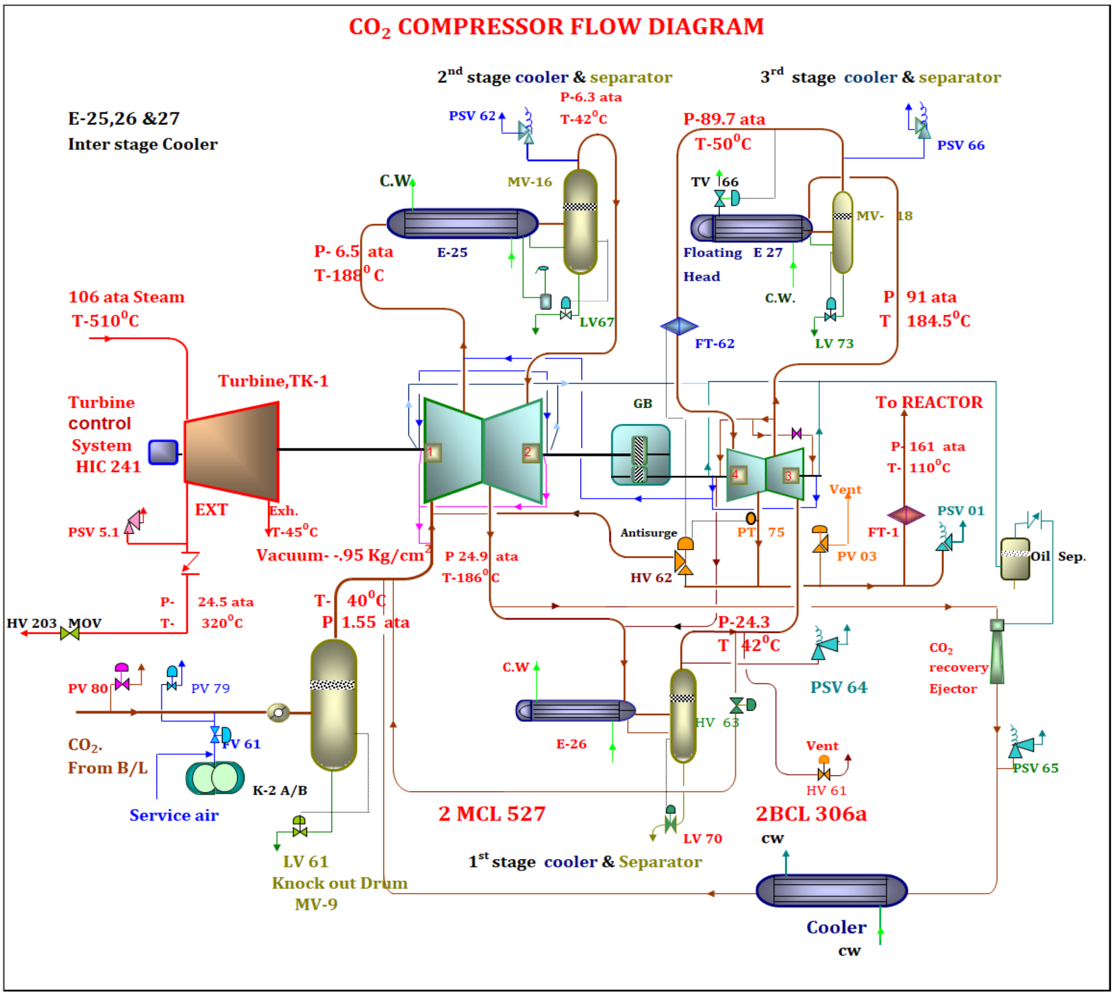

Fig. No.8

CONCLUSION

The problem of journal bearing vibration has been solved in running plant, no shut down was taken, however we will open the journal bearing for removing carbon deposition whenever we will get chance. Vibration signal involves information about the cause of vibration and through its analysis using different methods; an emerging or developing fault can be detected. Each machine, if it has to work reliably throughout its planned life, must be maintained. For all large and expensive equipment, to which the vibration diagnostics mainly applies, operational life is an essential and often neglected part of the life of the machine. All essential parts are manufactured with certain tolerances or even with allowances, so preliminary assembly is done in the manufacturer's plant in order to ensure that the entire device can be mechanically assembled. Whenever possible, the device that is factory-assembled is not disassembled any more. The role of maintenance is not to repair damaged equipment, but to prevent its damage. Equipment maintenance is essential for long-term trouble-free operation. For more expensive equipment with more costly operation, the method with periodic maintenance inspections or repairs has been established.

LEGENDS-

Ata- absolute pressure, RJB-Rear Journal bearing, FJB-Front Journal Bearing. TB-thrust bearing, TPD-Ton per Day, MW-megawatt, µn-micron(micrometre), KW-Kilowatt, MCL-(code) low pressure side of CO_2 compressor, BCL-(code) High pressure side of CO_2 compressor.MS-medium pressure (24 ata) steam. PV-pressure Valve, TDM –transient data management.