Nitish Industrial Machinery Diagnostics Centre Private Limited
Deals in (A HOUSE OF CONDITION MONITORING & RENEWABLES ENERGY TURBINE TROUBLESHOOTING & BALANCING)
(ENGINEERING SERVICES, CONSULTANCY & CONTRACTS)

CIN: U93090DL2017PTC315656 PAN: AAFCN5783R | TAN: DELN16573E GST : 07AAFCN5783R1ZJ

Ref: NIMDC/2018/54/2
DATE 29.04.2018

TO.
SHRI. P.K. NIGAM
EXCUTIVE ENGINEER TG-M-I,
DEEN BANDHU CHHOTU RAM THERMAL POWER PROJECT (DCRTPP),
HARYANA POWER GENERATION CORPORATION LIMITED
HPGCL, YAMUNANGAR VILLAGE
HARYANA, PIN - 135001

Subject :-High Vibration Problem of TG#1 (BRG#9) OF DCRTPP

Dear Sir,

Thanking you for giving an opportunity to "**NIMDC Private Limited** " to carryout study on High Vibration Problem of TG#1 (BRG#6) which was initially noticed on 24th Jan 2018 before overhauling and reoccurred on 22nd April 2018 even after overhauling. The steady state and transient vibration data recorded before and after overhauling by the on-line system alongwith operation parameters were analyzed in detail and our conclusion and recommendations are enclosed in the report for your kind information and necessary action please.

With kind Regards,

Yours Sincerely

29/4/2018

(C.G.Porwal)
Chairman & Managing Director
NIMDC PVT. LTD.

Copy for kind information pl
SHRI. ANIL DUA
CHIEF ENGINEER,
DEEN BANDHU CHHOTURAM THERMAL POWER PROJECT
(DCRTPP), YAMUNANAGAR, VILLAGE
HPGCL, YAMUNANGAR
HARYANA, PIN – 135001

SHRI. D L ROHILA
SUPERINTENDING ENGINEER,
DEEN BANDHU CHHOTURAM THERMAL POWER PROJECT
(DCRTPP), YAMUNANAGAR, VILLAGE
HPGCL, YAMUNANGAR
HARYANA, PIN – 135001

STUDY REPORT
ON
HIGH VIBRATION PROBLEM OF TG#1 (BRG #6)
AT DCRTPP

Prepared By

"Nitish Industrial Machinery Diagnostics Centre Private Limited"

27th April to 28th April 2018

DEEN BANDHU CHHOTURAM THERMAL POWER PROJECT (DCRTPP), YAMUNANAGAR, HARYANA

REPORT ON TG#1 (BRG#6) DCRTPP

SUBJECT:-HIGH VIBRATION PROBEM OF TG#1 (BRG NO#6) AT DCRTPP

1.0 INTRODUCTION

Deen Bandhu Chhotu Ram Thermal Power Project (DCRTPP), is located at Yamunanagar in the district of Haryana. The installed capacity of DCRTPP is 2X300 MW (600 MW). The Unit#1 and Unit#2 have been commissioned on 14th April 2008 and 24th June 2008 respectively. TG #1 comprises of several turbine casings and rotors (HP/IP, LPs, Generator and Exciter) which are supported by six journal bearings along with an additional journal bearing provided for the main exciter as shown in Figure no 1. These units were supplied by M/s Shanghai Electric Corporation (SEC) China.

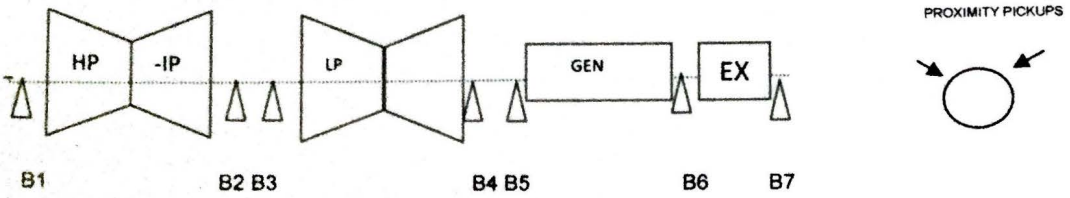


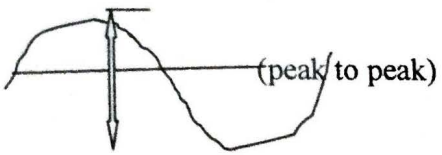
Figure No 1

Turbine generator (300 MW) comprises of seven pressure-lubricated bearings and is having on-line one absolute shaft vibration pickup mounted on Y and one relative shaft vibration pickup mounted on X (installed at 90 degree apart) on each bearing for monitoring of steady state and transient vibration data.

a) Vibration Limits for Operations

The vibration limits for "turbine control settings", as stipulated by OEM, are as follows:-

- Shaft Vibration Limits (Pk-Pk) ↕
  - ✓ 0.07mm for satisfactory operation
  - ✓ 0.127mm-for alarm
  - ✓ 0.254mm-for trip



- Bearing Pedestal Vibration Limits recommended by OEM
  - ✓ 25 microns pk-pk for healthy
  - ✓ 50 microns pk-pk for alarm
  - ✓ 80 microns pk-pk for trip manually.

b) The Name Plate critical speeds of complete rotor bearing system.

The critical speed value /balance resonance is defined by OEM are as follows (Fundamental/second critical).This machine is having all flexible rotors and their balance resonance speed are as follow:

BGR#1	BRG#2	BRG#3	BRG#4	BRG#5	BRG#6	BRG#7
1st	1st	1st	1st	1st /2nd	1st /2nd	1st
1725	1725	1725	1725	875 /2325	875/2250	2700

2.0 CHRONOLOGICAL INCIDENTS

Unit was running normal before overhauling up to 31st Jan 2018. The steady state and transient data taken just before overhauling were found normal as follows.

i) 24th Jan 2018: Before overhauling

The vibration data taken at full load 301 MW at 3001 RPM were as follows-

	B1	B2	B3	B4	B5	B6	B7
Shaft vibration X/Y	54/65	29/42	38/30	36/38	44/63	40/53	40/59
BRG Casing Vibrations (Y-29.1.2018)(pk-pk)	0.5	8.73	11.08	17	28.6	*46.0	20.26
Babbitt Metal Temp (L/R)	63/56	78/75	56/49	76/75	71/x	75/x	70/x
Drain oil temperature	45	51	51	53	56	50	48

*It was reported that during run-up, the Bearing shaft vibration 6(Y) was touching 170 microns pk-pk at critical speed i.e 2250 rpm (approximately).

Corrective Action

No correction was done because shaft vibration had a tendency to rise at critical speed not at operating speed.

i) 1st Feb 2018 to 22.4.2018 The overhauling work Carried out at BRG No #6

The TG#1 was shut down for capital overhauling. HP-IP, LP and Generator & Exciter rotor were overhauled. During inspection, Generator rotor seal area was found in damaged condition at exciter end.

Corrective Action

During this overhaul, Generator rotor seal area was built up (near Brg#6) to this dimension (0.25mm x 40 mm around the periphery) for matching the original dimension of the rotor at exciter end by OEM for maintaining the hydrogen seal clearances. The bearing top oil clearances were kept 0.59 against the limit of (0.55- 0.66) and the side oil clearances kept (0.40-0.42) against the limits of 0.39 to 0.447.

ii) 22nd April 2018 AFTER OVERHAULING

At 18.32 hrs the machine was rolled to 600 rpm and subsequently rolled to 2040 rpm, which was the soaking speed of the machine. The vibration readings recorded on 22.4.2018 at 21.30 hrs at 3000 rpm are as follows-

Bearings	B1	B2	B3	B4	B5	B6	B7
Shaft vibration X(SW)/Y(BS)	-/59	19 /32	34/27	34/53	**47/86**	**94/86**	43/35
BRG Casing Vibrations (Y) (pk-pk)	0.3	9.3	07	07	**26.9**	***106.5**	34.8
Babbitt Metal Temp (L/R)	59/59	81/77	46/52	75/74	66	70	68
Drain oil temperature	41	46	48	50	52	53	45

The shaft vibration data taken at Bearing no 6 (X/Y) are showing increasing trend but within the normal limits except bearing #6 casing vibration which has gone up to 106 micron pk-pk from 46 microns pk-pk (recorded before overhauling) beyond acceptable limits (50 microns pk-pk). The critical speed vibration amplitude went up to 204 microns pk-pk at 2260-2290 rpm during coasting down at BRG#6. Earlier it was recorded 170 microns pk-pk before overhauling.

Corrective Action

Since high vibration at pedestal noticed at bearing no 6(Y), as a corrective measure OEM removed the sleeves, which was provided both sides below the generator holding down bolts as well as changed the bearing #6 casing housing sensor to check the effect on vibration pattern of the Bearing no#6

iii) On 23th April 2018

The machine was rolled again and synchronized 16.22 and loaded up to 80 MW after the removal of sleeves from Generator holding down bolt each side (exciter end). The final vibration readings recorded at 80 MW at 2995 rpm at 17.50 PM **(Annex-II)** are as follows

Bearings	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**
Shaft vibration X/Y	59/60	28/45	30/26	33/49	48/82	75/62	28/31
BRG Casing Vibrations (Y) (pk-pk)	0.3	17	08	06	22	*70	35
Babbitt Metal Temp (L/R)	62/59	77/77	49/55	81/78	69	72	71
Return oil temperature deg C	45	51	51	54	55	55	49

* The machine tripped on electrical fault at 17.53 and subsequently rolled and synchronized at 20.37 hrs

iii) On 23th April 2018

The machine was re-rolled again and synchronized 20.37 PM and loaded up to 102 MW and auto tripped on generator electrical problem at 21.32 hrs but vibration recorded before the auto trip at 21.28 pm are as follows –

Bearings	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**
Shaft vibration X/Y	65/50	19/30	32/26	33/47	45/77	77/52	31/ 37
BRG Casing Vibrations (Y) (pk-pk)	0.3	10	08	08	23	* 76	40
Babbitt Metal Temp (L/R)	61/59	79/77	48/54	80/76	68	71	71
Return oil temperature deg C	44	50	51	53	54	54	48

* The machine tripped on electrical fault at 21.32 hrs

3.0 OBSERVATIONS & ANALYSIS

Following points observed before and after overhauling:-

a) **Before overhauling**: -All bearings absolute shaft vibrations were within the limits & the bearing babbitt metal temperatures and drain oil temperatures were normal, indicating all bearings loaded adequately. The vibration signatures and orbits taken at Bearing no 5 (X/Y), 6 (X/Y) and 7(X/Y), revealed that the machine vibration were within the prescribed limits.

b) **After overhauling**: At any occasion, no changes in critical speed amplitude noticed in all other bearings except 2nd critical speed of generator at BRG No#6.

- ✓ All bearings & absolute shaft vibrations were within the limits except BRG#6 .
- ✓ There is no relationship between shaft and bearing vibration with load and speed.
- ✓ The bearing babbitt metal & drain oil temperature were found normal at all occasions, indicating all bearings loaded adequately even before and after overhauling.

c) **Critical Speed Amplitude & Calculation of SAF:** The vibration response at critical speed at bearing #6 (X and Y) have been measured by Bode plots before and after sleeve removal, to know whether system has sufficient stiffness and adequate damping. SAF can be calculated as follows using half power bandwidth method

$$SAF = \frac{\Omega \text{ Res}}{\Omega\_\text{High} - \Omega\_\text{Low}}$$

Ω res =Amplitude at resonance 2nd critical of generator .

The Ω_high – Ω_low can be calculated by multiplying critical speed maximum amplitude by 0.707 (using half power bandwidth method). You may get two frequencies Ω_high – Ω_low respectively. The acceptable criteria for Synchronous Amplification factor (SAF) is as follows:

ACCEPTABLE CRITERIA FOR SAF

The general guidelines for evaluation of damping in the rotor-bearing -system are as follows:

	SAF Qs	Remarks
d)	Qs < 5	Exceptionally well designed and having sufficient stiffness and damping.
e)	Qs <5-8	Qs Values between 5 and 8 Indicate that rotor system have marginal damping at resonance.
	Qs > 8	Qs Values in excess of 8 indicate that the system has low Quadrature Stiffness at resonance and is susceptible to large amplitude excursions at resonance. High Quadrature Stiffness is desired because it limits vibration amplitude at resonance.

A high Qs indicates a low quadrature dynamic stiffness, and a low Qs indicates a high synchronous quadrature stiffness.

SYNCHRONOUS AMPLIFICATION FACTOR

SN	Before Sleeve Removal	After Sleeve Removal	SAF Normal
	22.4.2018	23.4.2018	
	SAF calculated using measured data Qs	SAF calculated using measured data Qs	Standard norm Qs API
BRG #6 X	22	16.2	< 5-8
BRG #6 Y	12	10.25	<5-8

*The SAF calculated from actual measured data indicate that bearing #6 has inadequate and insufficient damping.

d) **The steady data & transient data analysis**

The Orbit/Bode/Spectrum taken at BRG no #6 before and after overhauling and are compared which revealed the following:-

- ✓ Pedestal vibration at BRG#6 increased to 106 microns pk-pk from 46 microns pk-pk .
- ✓ The Orbit analysis at BRG#6, indicates that high vibration is observed at 1x rpm i.e 3000 rpm which could be due to slight residual unbalance at generator rotor.
- ✓ The critical speed design value given in the drawing/Manual is 2250 by OEM but measured critical speed value is 2269. There is a discrepancy observed when comparing design critical speed value (2250) with measured value (2269). **If the critical frequencies are not where they should be then it is a clear indication that the generator has been incorrectly put together or assembled.* The critical speed amplitude at BRG #6 recorded 284 microns pk-pk after sleeve removal of generator holding down bolts on 25.04.2018 .

4. CONCLUSION:

The based on the above observations following points were concluded –

i) The sharp rise in 2nd critical speed amplitude at BRG#6 is only due to issue on stiffness and damping, which has been validated by calculation of SAF (above). The normal SAF at turbine Journal bearing should be less than <5 for normal damping and less than < 5-8 for marginal damping. But in this case, SAF is more than >10. This shows the system has low Quadrature dynamic Stiffness at resonance indicates insufficient damping.

ii) No relationship could be established with any operational parameters with BRG#6 high shaft vibration.

5. PROBABLE CAUSES OF THE 2nd GENERATOR CRITICAL

i) Rise in amplitude at 2nd critical speed at BRG#6 may be due to effect of bearing support crack, loose or over clearances bearing which could be due to improper support stiffness and damping of rotor - bearing system.

6. RECOMMENDATIONS

i) Increasing lube oil viscosity (adding lube oil with a higher SAE grade) will increase the amount of damping and should reduce vibration at the 2nd critical speed of generator; however, this is not really a solution to the root cause of the problem.

ii) Field balancing even at 2nd critical or normal speed may sometime not solve the problem.

iii) Inspect the bearing No#6 for its top and side oil clearances.

iv) Inspect the supporting structure of bearing no#6 and associated Generator stator holding down bolts. To increase the supporting stiffness, sleeves at both sides of Generator holding down bolt may be refitted which may reduce 2nd critical of Generator.

v) Shaft average centre line is not available in the online system supplied by Meggitt, which can identify the shaft position in the bearing and will be helpful to understand bearing is taking load or inadequately loaded.

28/4/2018

(C.G. PORWAL)
NIMDC PVT. LTD