



RESIDUAL LIFE ASSESSMENT AND R & M OF STEAM TURBINES

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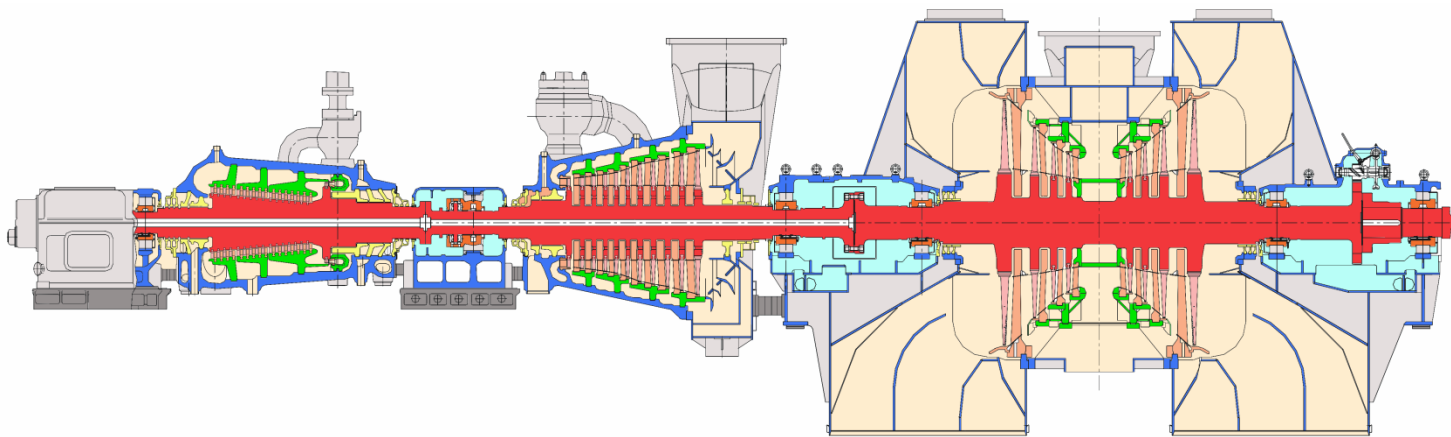
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- **UPGRATING OF 200/210 MW SETS**



RLA – When?

- **CREEP CONSIDERATION – 1,00,000 Hrs
(GUIDELINES – STATUTORY, INSTITUTIONAL,
MANUFACTURER etc)**
- **ESSENTIAL TO BUILD UP RECORDS & TRENDS FOR
CORRECT PREDICTIONS – HENCE START FROM
DAY 1, AND BUILD UP DATA DURING EACH
OVERHAUL**



RLA – Why?

- **TO ASSESS INTEGRITY OF MATERIAL**
- **HELP IN RISK MITIGATION**
- **TO ESTIMATE REMAINING LIFE OF CRITICAL COMPONENTS (ACCURATE LIFE CAN NOT BE PREDICTED)**
- **RLA HAS NO BEARING ON EFFICIENCY/OUTPUT**
- **MAY FORM BASIS FOR R&M**

RLA & R&M- The Need

- **THE COUNTRY NEEDS MORE & MORE POWER FOR GROWTH.**
- **AVERAGE PLF OF THERMAL UNITS AROUND 77% (>78% FOR BHEL SETS)**
- **MANY UNITS PERFORM AT MUCH LOWER PLF**
- **LONG TIME CYCLE FOR NEW INSTALLATION**
- **HUGE COST OF NEW INSTALLATION**
- **ENFORCEMENT OF GRID DISCIPLINE**

RLA & R&M- The Need

- **THE TURBINE COMPONENTS WERE DESIGNED FOR LIFE OF ABOUT 25 YEARS. 200/210 MW (LMW) SETS COMPLETING 2,00,000 Hrs. OTHER UNITS ARE FOLLOWING**
- **IT HAS BEEN EXPERIENCED THAT, TURBINES CAN BE OPERATED BEYOND THIS DESIGN LIFE AS THERE ARE INHERENT SAFETY MARGINS INBUILT.**
- **TO ENSURE SAFE, RELIABLE & ECONOMICAL OPERATION OF THE SET IT IS NECESSARY TO ACCURATELY ASSESS THE REMAINING LIFE OF TURBINE COMPONENTS.**
- **SUBSEQUENTLY, IF NEEDED, RENOVATION & MODERNIZATION CAN BE DONE ALONGWITH UPRATING.**

RLA & R&M- The Need

- **THE PURPOSE OF LIFE EXTENSION ACTIVITIES IS NOT TO CONTINUE OPERATION BEYOND ACTUAL USEFUL LIFE.**
- **IT IS TO ENSURE FULL UTILIZATION UP TO USEFUL LIFE, THE IDEA IS TO AVOID PREMATURE RETIREMENT BASED ON DESIGN LIFE.**



The Present Scenario- BHEL Make Turbines

500 MW	- 31 sets
500 MW (N)	- 02 sets
220 MW	- 10 sets
250 MW	- 16 sets
210 MW	-144 sets
120 MW	- 18 sets
110 MW	- 38 sets
100 MW	- 06 sets
60 MW	- 14 sets
67 MW	- 04 sets
70 MW	- 02 sets
	285 sets



**MANUFACTURED BY
BHEL : 78% OF
TOTAL INSTALLED
CAPACITY (THERMAL)**

The Present Scenario- BHEL Make

BUT, MANY OF BHEL SETS ARE MORE THAN 15 YEARS OLD, OLDEST BEING MORE THAN 35 YEARS OLD. SOME OF THEM HAVE BEEN *DERATED ALSO.*



Aging & RLA

- **AGING IS AN IRREVERSIBLE PROCESS. POWER PLANT EQUIPMENTS ARE NO EXCEPTION.**
- **FOR THE EXISTING POWER PLANTS, RLA STUDY IS THE FIRST STEP FOR DETERMINING REMNANT LIFE ASSESSMENT.**
- **RLA PROVIDES THE DATA FOR DECISION MAKING ABOUT THE PLANT WHETHER TO RETIRE OR REFURBISH OR RENOVATE & MODERNISE.**

Factors influencing Turbine Life

TIME INDEPENDENT

- ❑ DESIGN
- ❑ MATERIAL
- ❑ MANUFACTURING

TIME DEPENDENT

- ❑ WEAR & TEAR
- ❑ CORROSION
- ❑ EROSION
- ❑ DISTORTION
- ❑ AGING

Damage Mechanisms- Creep

Depending on the working stresses & working environment, turbine components are exposed to various damage mechanisms.

Creep is the slow & continuous deformation of materials due to high temperature exposure under load.

Causes:

Microstructural changes, leading to dimensional distortion and finally rupture.

Affects:

**HP – IP Rotors / Disks / Blades / Fasteners
Steam Chests / Valves
High Temperature Pipeline**



Damage Mechanisms- Stress Corrosion

SCC is the 'eating away' of a metal when exposed to a particular environment. The corrosion rate is enhanced when the component is under stress

Causes:

Material loss – may cause failure

Affects:

HP-IP-LP blades, LP Disks, Older Retaining rings



Damage Mechanisms- Fatigue

Fatigue is the failure of metal when subjected to repeated or fluctuating stresses much lower than required for failure at single load application.

When the stresses are due to thermal cycling it is called Thermal fatigue

Causes: Failure

Affects:

**HP – IP – LP Rotors / Disks / Blades / Fasteners
Steam Chests / Valves**



Detecting Physical Damages

Ideally, each individual component should be 100% examined by Non Destructive & Metallographic techniques during each RLA.

This is not possible because:

- Time/Resource constraints.. the work may take months & well exceed overhauling period.**
- A more extensive test does not necessarily mean a better test/result**

Detecting Physical Damages

Keeping these factors in mind & pooling the knowledge & expertise of designers & testing personnel, BHEL has drawn up a standard testing schedule.

This schedule addresses the various NDT & Metallographic tests to be conducted on each component.

There are different schedules for turbines of different designs & ratings

In drawing up this schedule it has been ensured that extensive tests, commensurate with the criticality of the component is carried out.

The schedules are being constantly updated based on site experience & feedback.

An Extract
This normally is
in 3 pages

The Schedule

NO.	COMPONENT	QTY	DIM	VIS	MPI	DPT	UT	HARD	REP
1.0	HP CYLINDER	1							
1.1	INNER SURFACE L/H	1		●	●	○	●	●	1
1.2	INNER SURFACE U/H	1		●	●	○	●	●	1
1.2.1	NOZZLE BOX	4		●	●	○		●	1
1.2.2	NOZZLE SEGMENT	4		●	●			●	1
1.3	HP DIAPHRAGMS	11							
1.3.1	BODY	11		●	●	○		●	2
1.3.2	BLADINGS	11		●	●				
1.4	HP LINERS	4		●	●	○		●	1
1.5	HP (F) SEALING HOUSING	4		●	●	○		●	1
1.6	HP (R) SEALING HOUSING	3		●	●	○			
1.7	HP P/P FASTENERS	30	●	●	●		●	●	1
1.8	HP ROTOR	1							
1.8.1	JOURNAL	1		●	●	●	●		
1.8.2	SHAFT SURFACE	1		●	●	○	●	●	1
1.8.3	BLADING OF STAGES	12		●	●	○		●	2x1 17

Typical Defects Observed



Thermal fatigue cracking of
HP cylinder

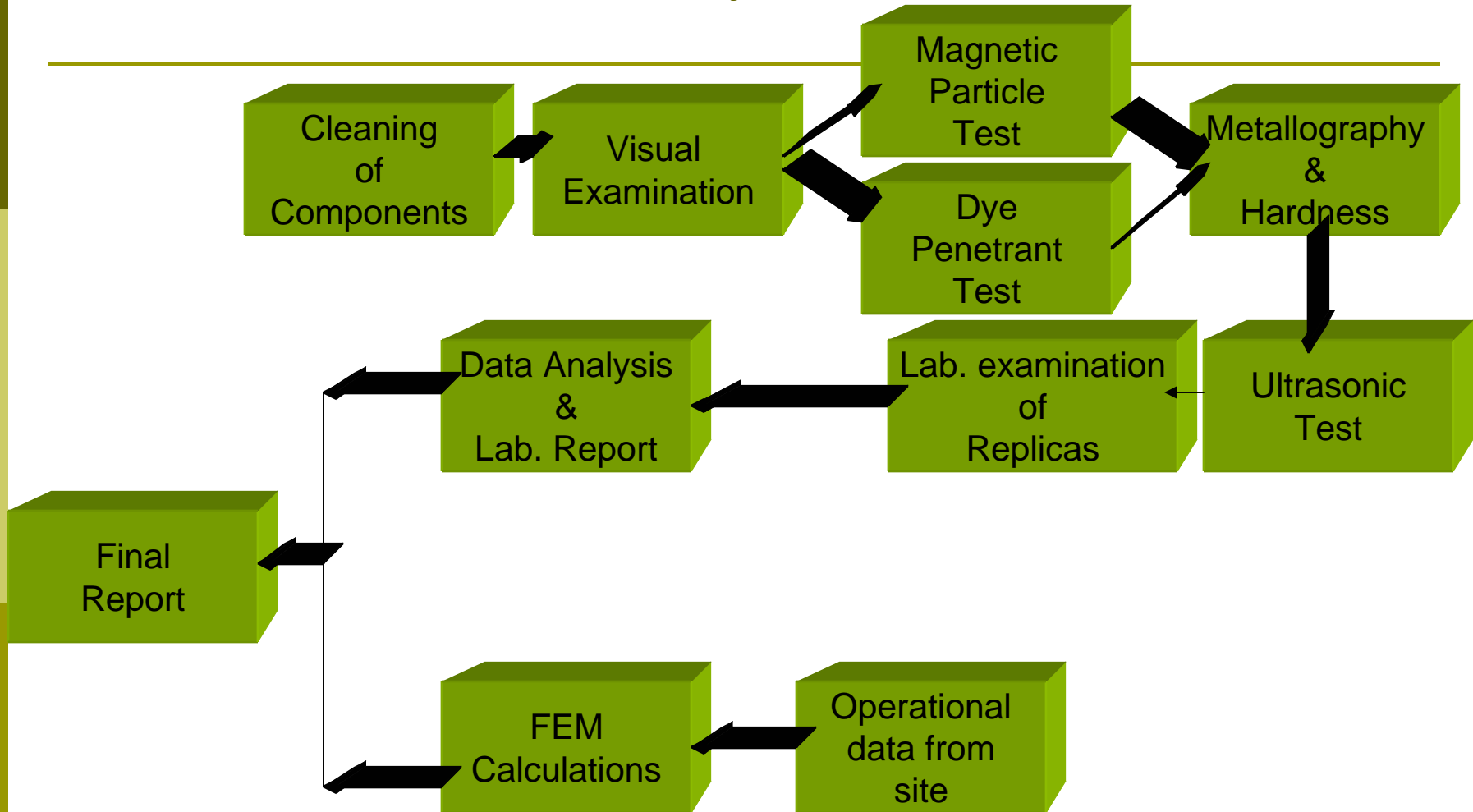


Fretting fatigue of LP blades



Fatigue cracking of valve
cone

RLA Studies- Activity Flow



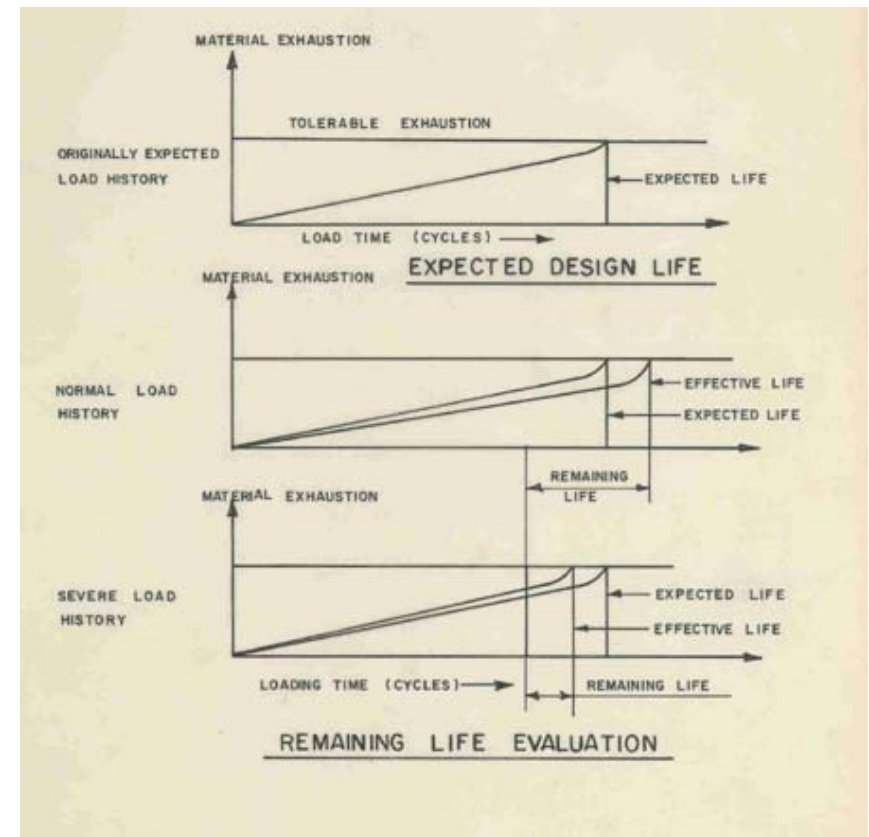
The Design Aspects

THE DESIGN LIFE OF STEAM TURBINES IS INFLUENCED BY :

- **THE EXPECTED LOAD HISTORY**
- **THE NUMBER OF OPERATING HOURS**
- **THE NUMBER & TYPE OF START UPS / SHUT DOWNS**

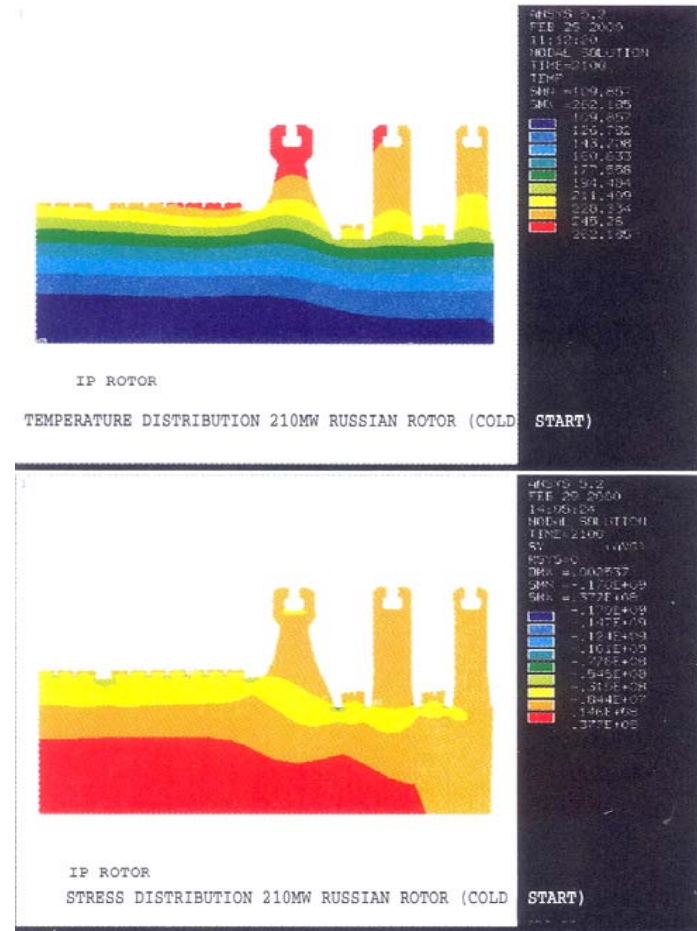
Calculating the Remaining Design Life

- THE TIME DIFFERENCE BETWEEN THE **EXPECTED WARNING POINT** AND THE **RECALCULATED WARNING POINT**, GIVES THE REMAINING LIFE OF THE COMPONENT
- THIS IS POSSIBLE BECAUSE OF THE **INBUILT LARGE SAFETY FACTORS** i.e. THE ACTUAL IN-SERVICE STRESSES ARE NORMALLY FAR LESS THAN THE MATERIAL CAPABILITY.



Calculating the Remaining Design Life

- Plotting of the temperature & stress distribution using FEM techniques.
- Using this data, calculations of the life consumed by creep & fatigue are performed.
- This refines the calculations using operational, NDT & material data to give the Residual Life.





R&M AND UPDATING

Renovation & Modernization

- RLA gives an idea of the remaining life of various components, but, when the situation so warrants, this has to be followed up by R&M to give the turbine a new lease of life.

- R & M results in:
 - Maximizing the efficiency
 - Extending intervals between inspections
 - Achieving greater reliability of operation

Renovation & Modernization – Current Focus

- **K-210-130 Steam Turbine (Impulse Design)**
 - **Designed in early 60's and formed the backbone of Power Generation**
 - **R & M aims at:**
 - **Improvement in performance :**
 - by use of improved blade profile which result into reduction in the aerodynamic flow losses e.g. profile loss, secondary flow loss & tip leakage loss.
 - More uniform flow distribution.
 - **Optimised flowpath.**
 - **Improvement in shaft sealing system.**
 - **Reduction in pressure drops.**
 - **Reduced friction losses.**
 - **Optimisation of inlet & exhaust section**
 - **Optimised exhaust loss**

Approach

- **RETAIN CYCLE PARAMETERS**
- **RETAIN SYSTEM CONFIGURATION**
- **USE PROVEN STATE-OF-ART BLADING FOR ENHANCING OUTPUT**
- **MINIMUM CHANGES IN MAIN & AUX. EQUIPMENT**
- **ENSURE SUSTAINED OPERATION AT 225 MW & BEYOND**

Renovation & Modernization

S.NO.	PARAMETERS	EXISTING 210 MW ST (IMPULSE)	UPRATED ST (HPT & LPT - REACTION))
1	OUTPUT (MCR)	200/210 MW	225 MW +
2	MS PR	130 ATA	130 ATA
3	MS TEMP	535°C	537°C
4	HRH STEAM TEMP	535°C	537°C
5	FREQUENCY	49.0 – 50.5 Hz	47.0 – 51.5 Hz
6	MAIN EJECTORS	YES	NO
7	VACUUM PUMPS	NO	YES

R&M - H.P. Turbine

- Impulse blading is retrofitted with state of art high efficiency reaction blading. In this design steam pressure drop takes place in guide blades as well as moving blades.
- Outer casing is replaced by new one of the same design.
- The internals i.e. **Rotor, Liners and diaphragms** are replaced with **Monoblock HP Rotor and Guide Blade Carriers** having more efficient reaction blading.

R&M- H.P. Turbine

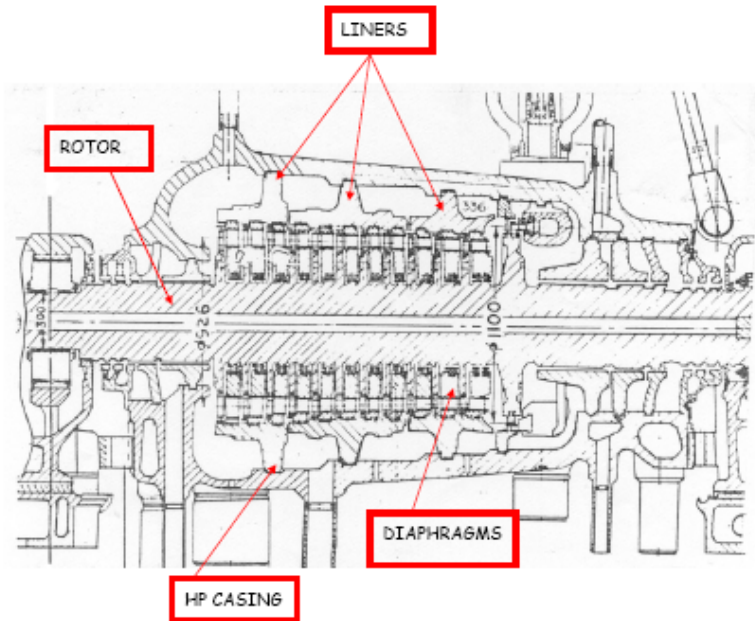


Fig. 1 : Existing HP Turbine with Impulse Blading

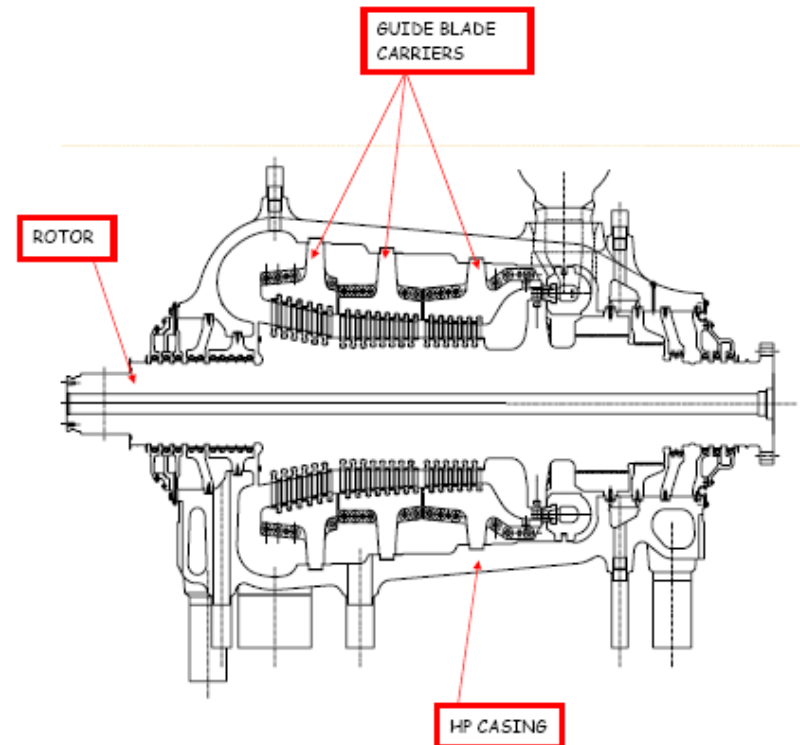


Fig. 2 : HP Turbine retrofitted with Reaction Blading



R&M - I.P. Turbine

- **Retain Original Design**
- **Replace internals with to ensure Performance & Life Extension**

R&M - L.P. Turbine

- Impulse blading is to be retrofitted with state of art high efficiency reaction blading. In this design steam pressure drop takes place in guide blades as well as moving blades.
- The LPT will have 2X4 stages.
- The existing internals i.e. **Rotor with impulse blading , Liners and diaphragms** are replaced with **Monoblock LP Rotor and Guide Blade Carriers** having more efficient reaction blading.

R&M- L.P. Turbine

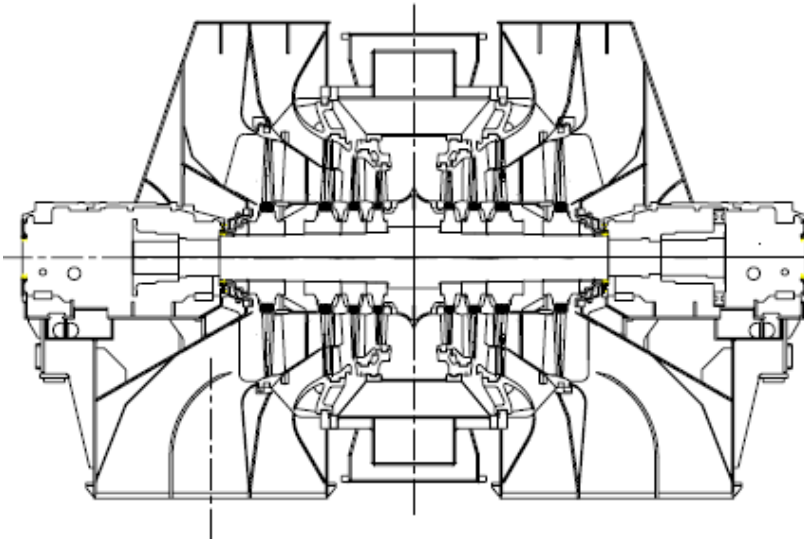


FIG-3 : DETAILS OF EXISTING DESIGN FLOWPATH

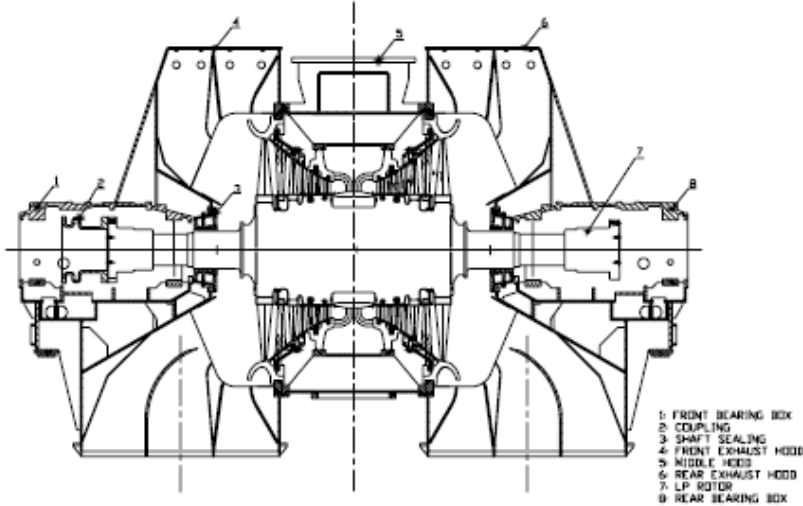
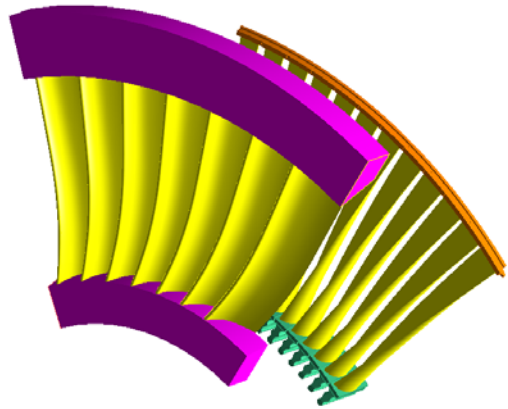
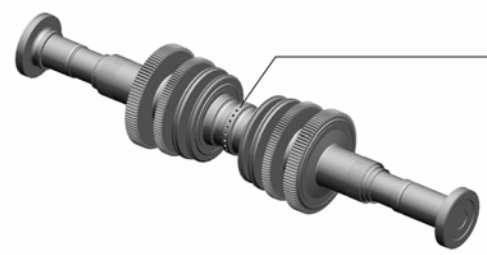
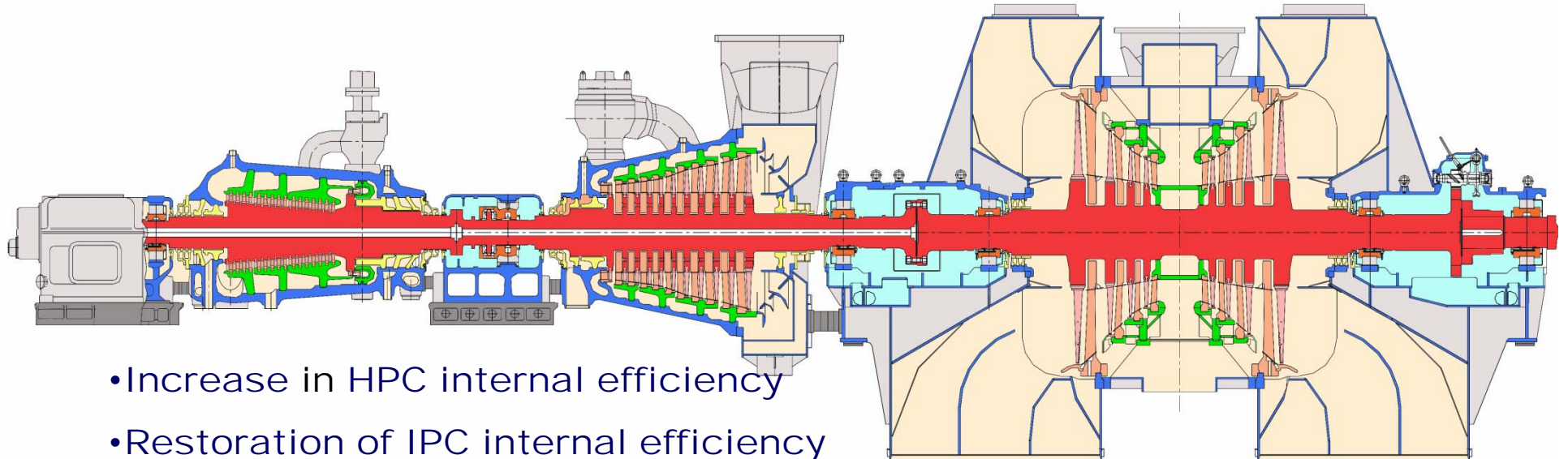


FIG-4 : DETAILS OF MODIFIED FLOWPATH



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Benefits of R&M....



- Increase in HPC internal efficiency
- Restoration of IPC internal efficiency
- Increase in LPC internal efficiency
- Continuous operation at 47 to 51.5 Hz
- Improved Heat Rate
- Output increase – 15 MW +
- Life Extension

Thank You

Boiler parameters at BMCR

Sl. No.	Descriptions	Existing	Uprated
1	SHO Flow T/Hr.	680-700	721
2	SHO PR. KG / SQ. CM(g)	137	137
3	SHO Temp .C	540	540
4	Reheater Flow T/Hr.	580	620
5	RHO Temp. C	540	540
6	FW Temp .C	246.3	245.7

Coal analysis considered

Description	Unit	Design Coal	Worst Coal
Fixed Carbon	%	26.0	26.8
Volatile Matter	%	24.0	16.2
Moisture	%	12.0	15.0
Ash	%	38.0	42.0
HHV	kcal/kg	3800	3400
HGI		55	50

STEAM GENERATOR

Modification in other auxiliaries:

- **Air heaters to be retained**
- **PA fans: to be retained**
- **FD fans: to be retained**
- **ID fans: to be retained**

Drive motors of few projects may require change

- **LRSB: to be relocated keeping total no. same as 18**
- **Duct / insulation / damper gates: to be redesigned & replaced**
- **ESP's: to be redesigned for worst coal - site specific**

Turbo Generator

Generators Type THW-2(200/210 MW)

	Existing		Upated
Rating (MCR)	200 MW	210 MW	233 MW
MVA	235 MVA	247 MVA	274 MVA
Voltage	15.75kV	15.75kV	15.75kV
Power factor	0.85	0.85	0.85
Cooling type			
- Stator	Direct water cooled		Direct water cooled
- Rotor	Indirect H₂ cooled		Indirect H₂ cooled
H₂ Pressure	3.0 bar (g)	3.5 bar (g)	4.0 bar (g)
Stator water flow	25 M³/Hr.	27 M³/Hr.	30 M³/Hr.
Cooling water temp. (Raw)	33 °C	33 °C	33 °C
Cold gas temperature	44 °C	44 °C	44 °C

Generator output will match with the steam turbine power at different cooling water temperatures.

Equipment capability

Sl. No.	Equipment	Max. Capability	Remarks
1	Condenser	Adequate	
2	CEP	Adequate	
3	Starting and main ejectors	Replace by vacuum pumps	
4	GC 1& 2	Adequate	
5	Drip pump	Adequate	
6	LP heaters 1 & 4	To be modified	Tube bundle
7	LP heaters 2 & 3	Adequate	
8	Deaerator	To be modified	Tray type to be replaced by spray cum tray type

Equipment capability

Sl. No.	Equipment	Max. Capability	Remarks
9	BFP	Adequate	
10	HP heaters	To be modified	To be replaced by shell & tube type
11	Extn. lines & NRVs	Adequate	
12	MS lines	Adequate	
13	CRH lines	Adequate	
14	HRH lines	Adequate	

Electricals

HT Motors:

- Existing motors are adequate
- All the motors with the class- B insulation will be replaced / rewound with class - F insulation

Generator Transformer:

- Existing Generator Transformer of 240 MVA will require replacement with 285 MVA transformer.

Bus ducts:

- Existing bus ducts to be replaced.

BOP, Station C&I and Electricals

Scopes to be finalised on project specific basis

Steam Turbine - H.P. Turbine

- ❑ **FOR HP TURBINE:**
- ❑ **Supply HP Casing.**
- ❑ **Supply of new HP Rotor with state of art reaction blading.**
- ❑ **Supply of new Guide Blade carriers having reaction blading.**
- ❑ **Supply of Shaft seals.**
- ❑ **Supply of one set of 1st stage Nozzle segments.**
- ❑ **One set of fasteners for HP Cylinder parting plane.**
- ❑ **Modified Cams for HPT Control Valves**

Scope of Supply

FOR IP TURBINE

- ❑ **Supply of IP Rotor.**
- ❑ **Supply of 1 set of diaphragms.**
- ❑ **Supply of 1 set of Nozzle ring.**
- ❑ **Supply of 1 set of fasteners of parting plane.**
- ❑ **Supply of 1 set of front & rear gland seal housings**

Scope of Supply

FOR LP TURBINE:

- ❑ **New design mono-block LP Rotor with blades.**
- ❑ **Guide Blade carriers in place of existing liners & diaphragms of LPT.**
- ❑ **Barring gear wheel fitted on new LP Rotor.**
- ❑ **Water spray system for LPT Exhaust hood temperature control**

STEAM GENERATOR

- **Pressure parts modification**
- **Second pass to be modified**
- **Milling & Firing system modification**
- **Auxiliaries like Fans, Ducts & ESPs – Site specific**



Turbo Generator

-
- Rotor to be redesigned
 - H2 cooler to be re-designed
 - Stator water cooler to be re-designed.
 - Existing Thrust type seals to be changed to Ring type
 - Stator with class B insulation to be rewound with class F
 - Class F insulated stators older than 15 yrs to be rewound