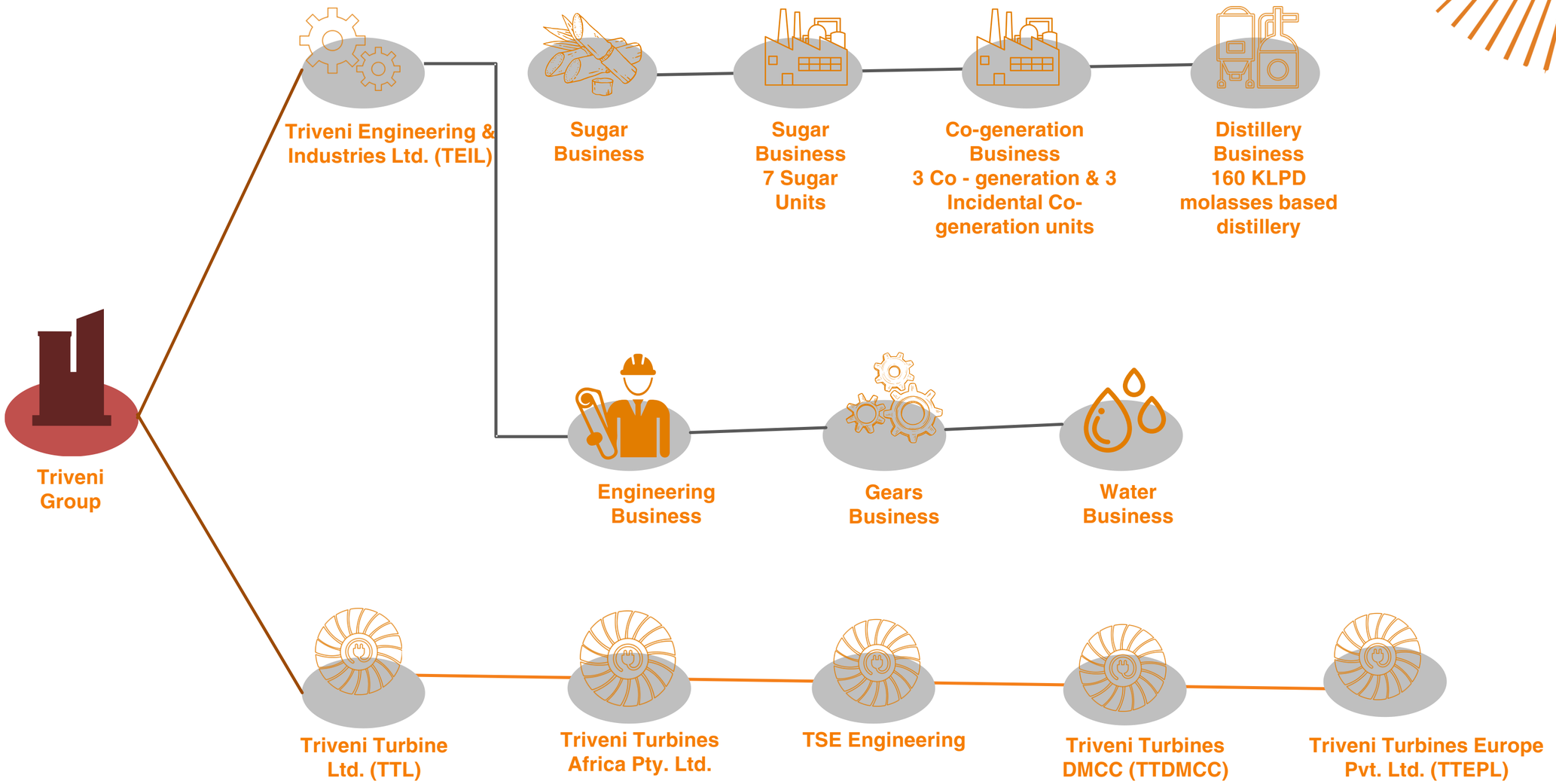
Triveni TURBINES REFURB

A partnership for the progress of Rotating equipment’s

Triveni Group Organization



Triveni Turbine Ltd Fact sheet

50+ years

Of Excellence in Industrial Steam Turbine

16000+ MWe

Global Installed Power Generation Capacity

6000+

Global Steam turbine Installation

20+

Industries Served

330+

Total Intellectual Property Rights Filed

80+

Countries of presence

The global leader in steam turbine manufacturing, dominating the market with the world's largest capacity of up to 100MW, specializing in industrial and renewable power solutions, and maintaining a dominant 60% market share in India for the past decade.

Triveni Turbine Ltd. headquartered in Bengaluru for designs, supplies and services advanced technology steam turbines Upto 100 MW range for power generation applications globally

Applications

Cement

Sugar

Palm

Textile

IPP Barge

Oil & Gas

Fertilisers

Metals

Solvent Extraction

Petrochemicals

Pulp & paper

Distillery

Food Processing

Iron/steel

Palm Oil

Steel

Defence

Waste to energy

Geothermal Power Plant

Biomass

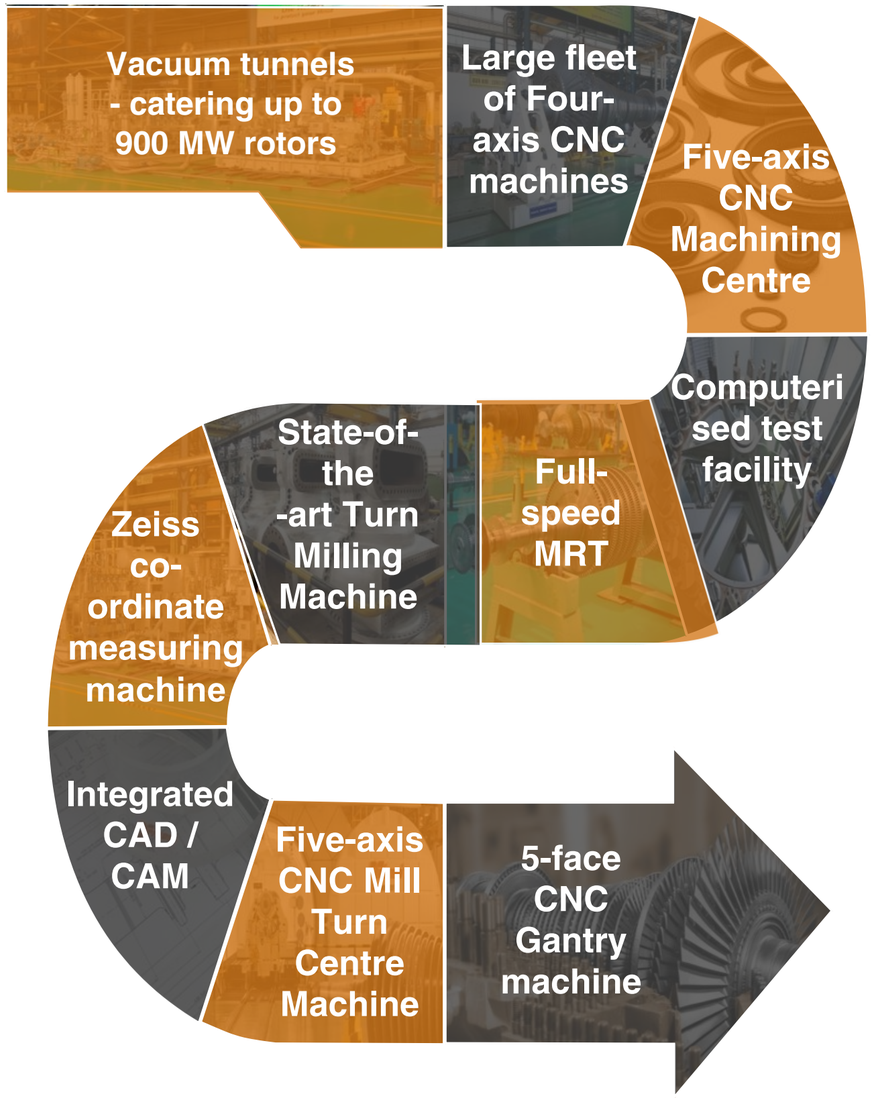
Turbine Blade Machining Centre

Manufacturing Bay View

Infrastructure

State-of-the-art facilities equipped to provide manufacturing of critical components, assembly, testing and refurbishing services

Latest design tools and software to deliver innovative solutions to customers



2 Vacuum tunnels for Dynamic Balancing

Parameters	DH 4	DH 7	DH 8	DH9
Job Weight	1.2 Tons max	0.6-12.5 Tons	1.6 - 37 Tons	30 – 55 Tons
Job Length	2800 mm	8700 mm	8700 mm	11000 mm
Max Diameter	900 mm	2900 mm	2900 mm	4100 mm
Max Speed	12000 RPM	12000 rpm	8000 rpm	8000 RPM

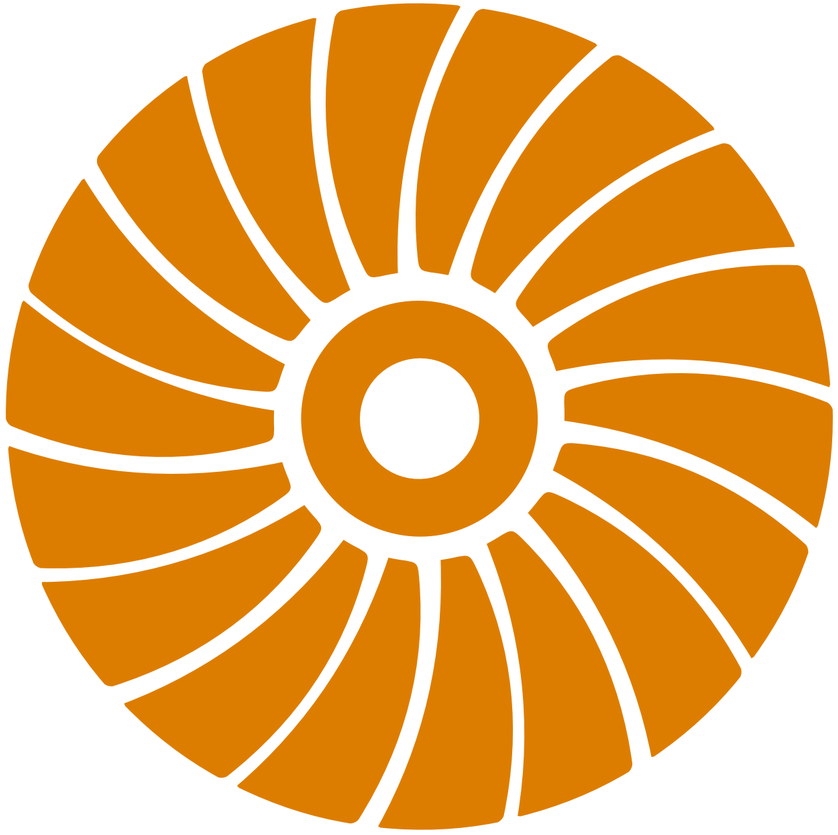
Typical turn around is 10 days if bearings are provided

Triveni Works

Global footprint

CAGR of 17% in Exports sales in past 5 years

Introduction to Triveni-REFURB



- Repair
- Modification
- Efficiency improvement
- Reverse engineering, manufacture and supply
- Overhauling, AMCs
- Remote monitoring system.
- Residual life Assessment (RLA and NDT)

WHY Efficiency improvement / Modification is required in older Turbines

- **De-gradation/pitting of the Blade profile during operation** - Blade profile gets rough due to pitting, leading to loss of energy carried by the steam. Which ultimately leads to low power generation and high steam consumption.
- **Old generation Blades** - There is a continuous development happening in the blade profiles for best efficiency. Sometimes, the existing turbine blades are having old generation blades which can be replaced with the latest generation blades having better performance.
- **Rubbing of Steam Seals** - Due to fluctuation in the load/steam flow, the rotor expansion varies leading to rubbing of steam seals, which leads to steam leakage and loss of efficiency.
- **Increased Clearances:** Due to wear and tear of the blade/rotor material over a period of time, the clearances increase and lead to loss in efficiency.

Technology for retrofit

- **Retrofit/uprate technology required for process industry:**

In this case, process steam and power requirements are combined. Driver and driven equipments are from different OEMs and throws up integration challenges. Plant wide, steam balance and energy efficiency study will be the key.

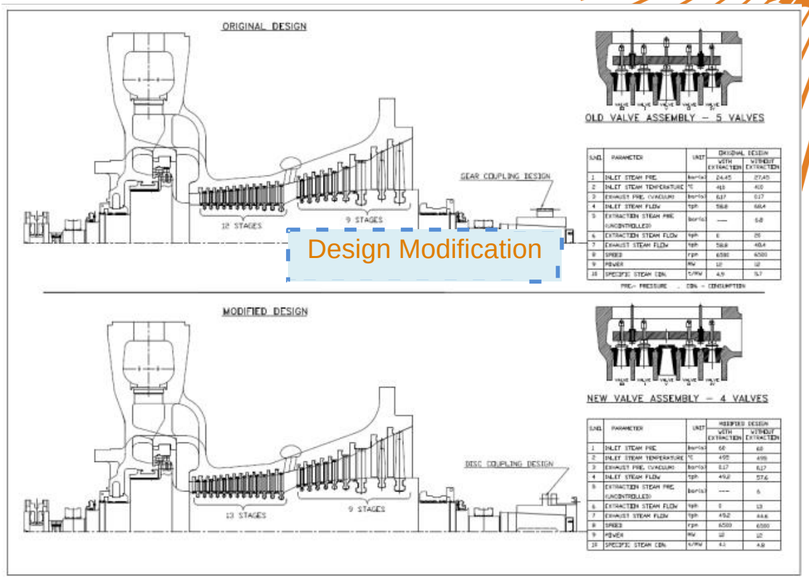
We workout, retrofit solution modules with minimum payback period and loss of revenue for process/power down time.

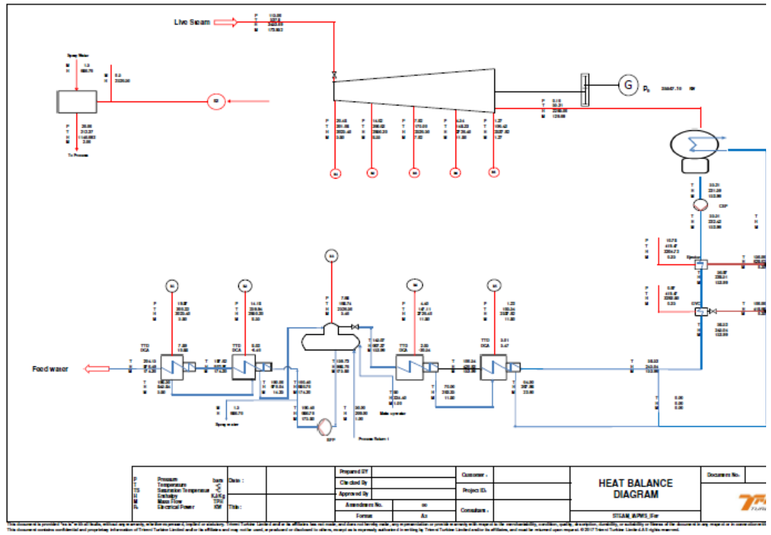
To reduce down time, phase-wise delivery model is required wherein, two or more short outages are planned to take measurements in the first outage and replace the internals/components in later planned outages.

- **Plant efficiency improvement:**

Analytical capabilities like thermodynamic plant cycle studies using software like GateCycle and Hysys for taking up plant level improvements.

Recommendations based on current operation requirements of the plant optimises supply of critical equipment like power block and important auxiliaries for efficiency improvements and better ROI for the customer.





Efficiency improvement / Modification jobs on Non-Triveni turbines

Advantages:

- Up to 15% improvement in efficiency
- Reuse old / existing assets
- Minimum downtime at site, existing asset continues to produce power till replacement
- No modification in the deck foundation
- Increase in span between 2 overhauls
- Extension of life of asset
- Faster ROI / Payback period
- Lower carbon footprint & environment friendly

Reuse of assets

Minimum downtime

Better performance

Efficiency improvement / Modification jobs on Non-Triveni turbines

Economic Benefits:

- The Refurbished Turbine was approximately 30%-35% cheaper than buying a new Turbine set.
- ROI of the is less than 2 years.
- No civil modification was required for the refurbished Turbines, as the base frame exists. A new Turbine would have added up the additional cost implications to the customer for the Civil Modifications.
- The existing Cooling system, Generator, Panels, Mechanical Equipment, etc were used resulting in a lesser cost impact.
- During operation, Customers don't necessarily have to approach the OEM for any kind of spare parts. We will provide the spare parts for future requirements.

Technology for customer centric retrofit solutions

- **Thermal performan**ce:

In depth turbine thermal analysis and cycle optimization for heat rate improvement guarantees for other OEM retrofitted turbines.

Leverage on library of OEM nozzle / blade profiles and metallurgy base is in progress and augmented with TTL blade path library.

Applicable tools: AxTurbo, GateCycle / HMBD, R&D System1

- **Market segment based retrofit kit solution:**

Based on aging analysis of field fleet of older generation OEM turbines, specific blade-path replacement solution.

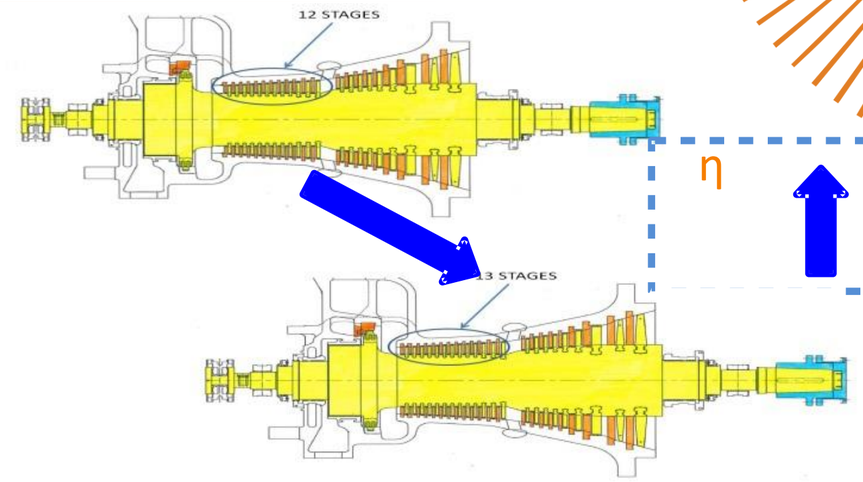
Segment-wise (Fertilizer, Cement, Process etc.) solutions can be offered and solution capability thro' sector specific bulletins.

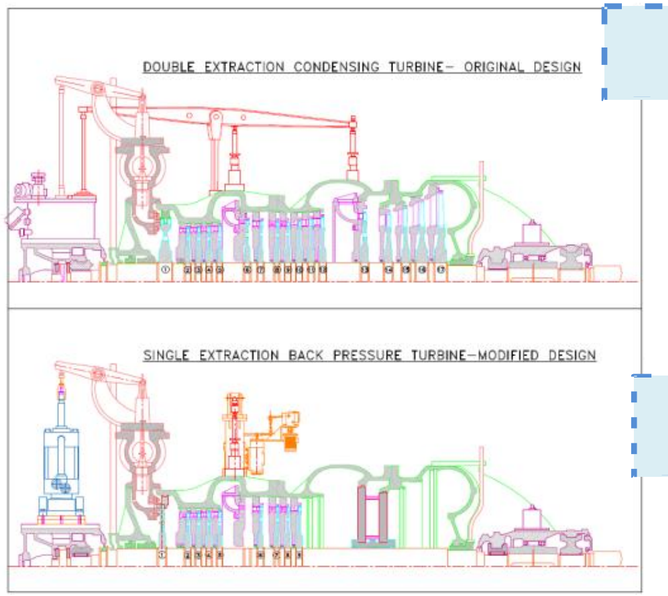
- **Rotordynamic and bearing system:**

Using R&D System1 kit. Capability for bearing property estimations and lateral / torsional rotor train analysis with inadequate field data.

Bearing replacement solutions with old geometry constraints. Manage rotor changes from condensing to back pressure conversion projects.

Applicable tools: DyRoBeS, XLRotor, ARMD.





Condensing

Back Pressure

Technology for retrofit

- Residual life and structural reliability numbers:

For effective residual life analysis (RLA), combination of metallurgical diagnostic study (NDT techniques) with FEM techniques (LCF, HCF, Creep) is necessary.

Metallurgical studies can be done at site/factory. It may include civil structures like foundations frequency tuning.

Applicable tools: ANSYS, Creo, NDT equipments.

- Life extension technologies:

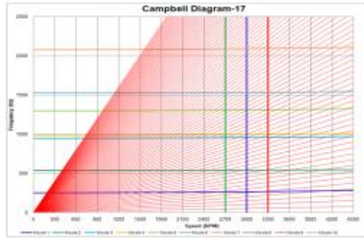
This includes component repair technologies as alternative to replacement. These include casing welding, rotor welding, blade welding based on micro-pulse TIG welding and Plasma process.

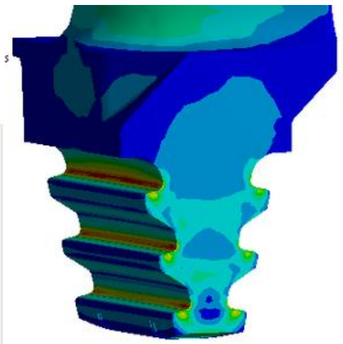
In addition, coating technologies for erosion and corrosion resistance being offered.

- Control system automation:

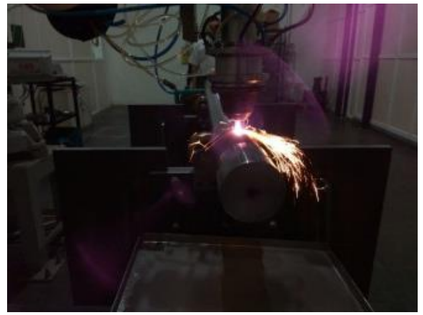
New control system upgrades employed for operability enhancement. Internal expertise developed in Electro-hydraulic servos (Moog, Voith, Woodward), digital control systems and interface studies with old hardware.

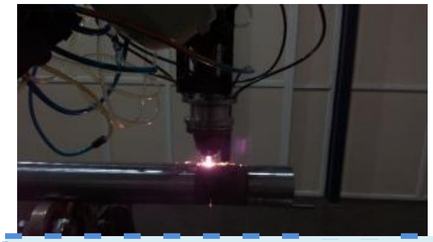
RLA of Bladed Disk





LASER Cladding





HVOF Metal Building

Inhouse Design and Engineering Capability - Structural

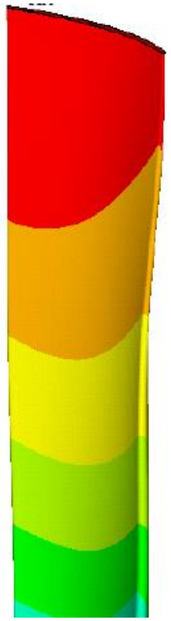
Blade

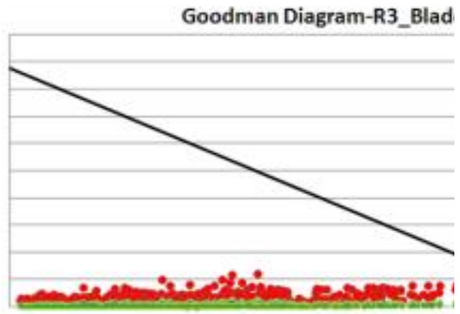
- **Aeromechanical Analysis**
  Modal analysis to calculate the Fundamental Natural Frequencies and Margins wrt the Operating Speed. Harmonic Analysis to calculate the Vibratory Stresses and corresponding High Cycle Fatigue (HCF) Life.

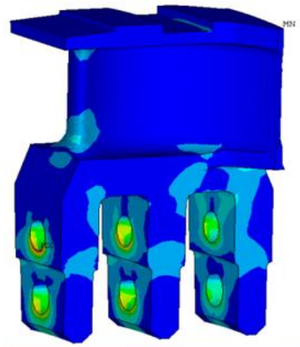
- **Thermo-Structural Transient Analysis**
  Cyclic Fatigue Loads induced by Thermal Cycles, Flow and Pressure Variations

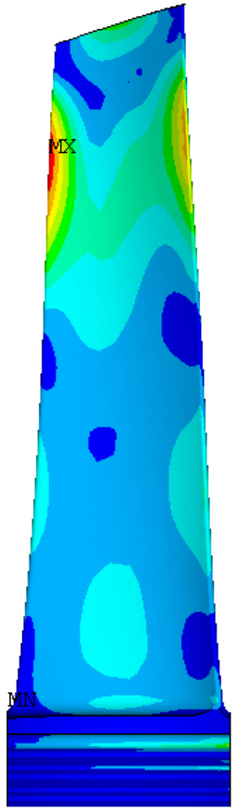
- **CREEP-Fatigue Damage Analysis**
Life estimation considering CREEP-Fatigue interaction

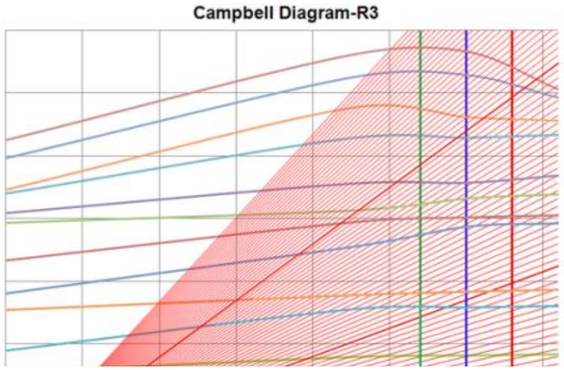
- **Blade Root Selection Criteria**

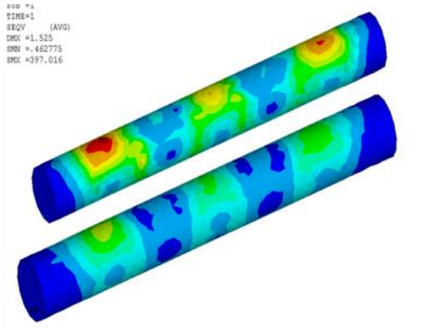










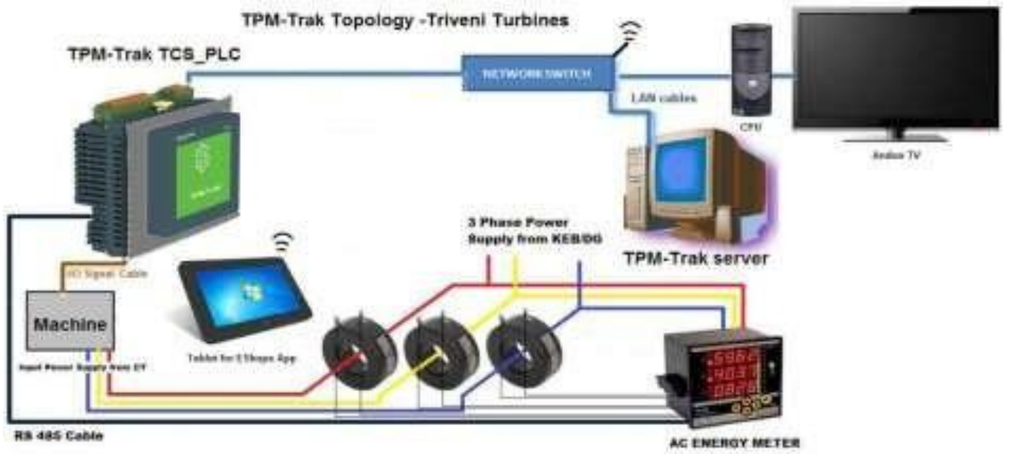


Machine Monitoring System

Provides visibility for all critical and value added activities of the shop floor

Measures downtime and makes shop floor losses visible to the top- floor

Ensures real time production data



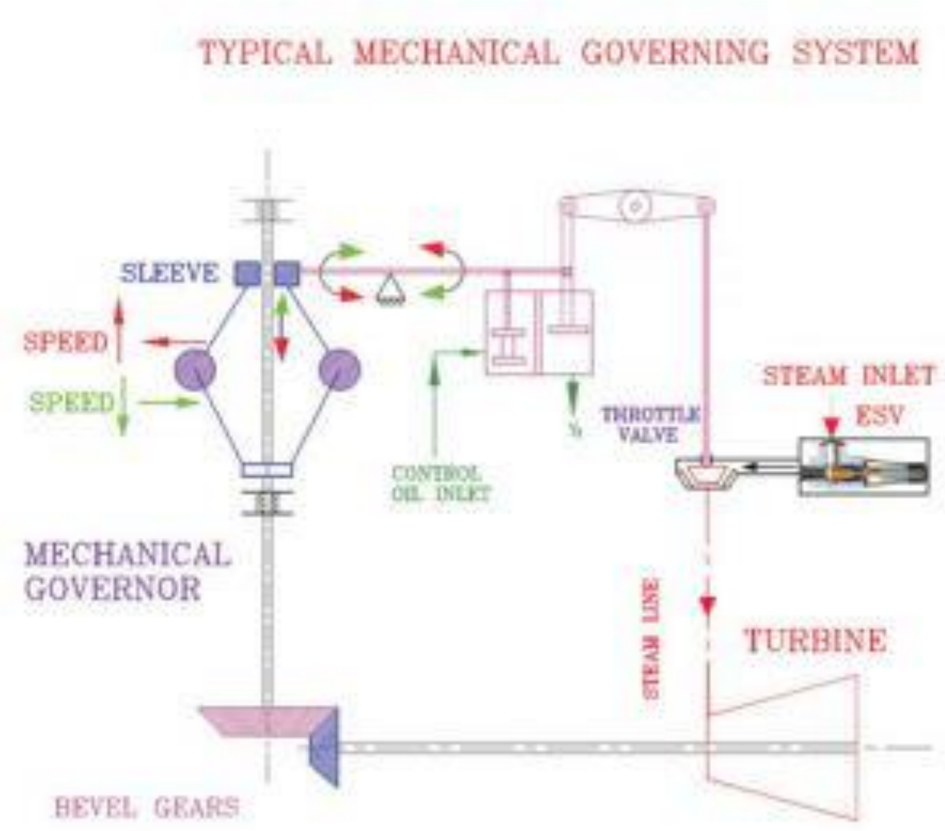
Reporting of productivity and production data becomes system dependent rather than person dependent

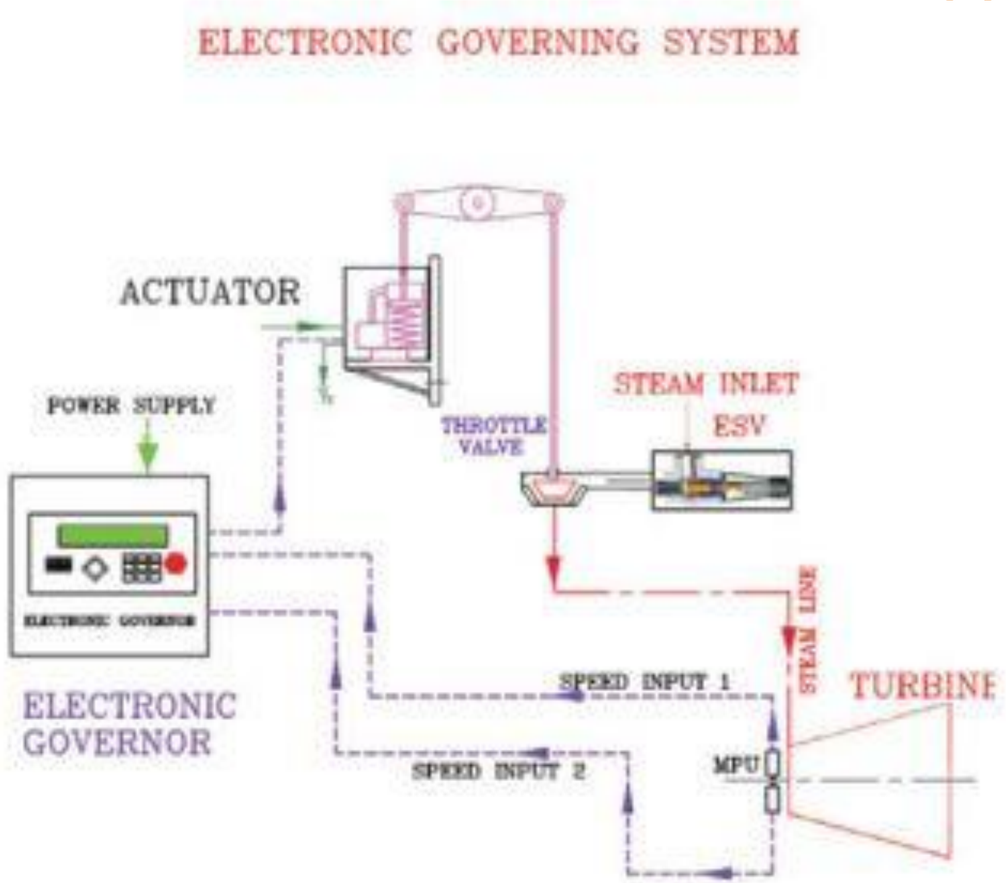
Generates TPM OEE and other key performance reports automatically

Breakdowns / Idle time reported instantly through SMS alerts and E-Mails

Modernization of Governing system

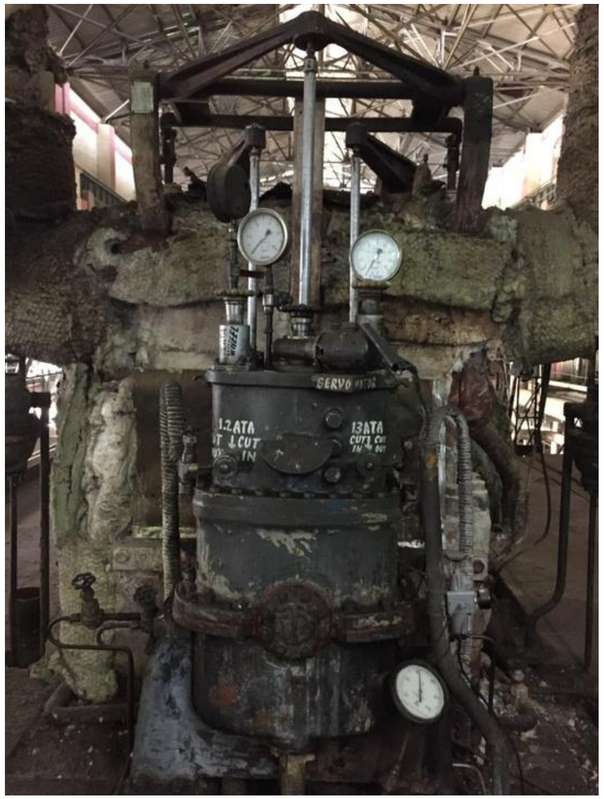
Modernization of Governing system



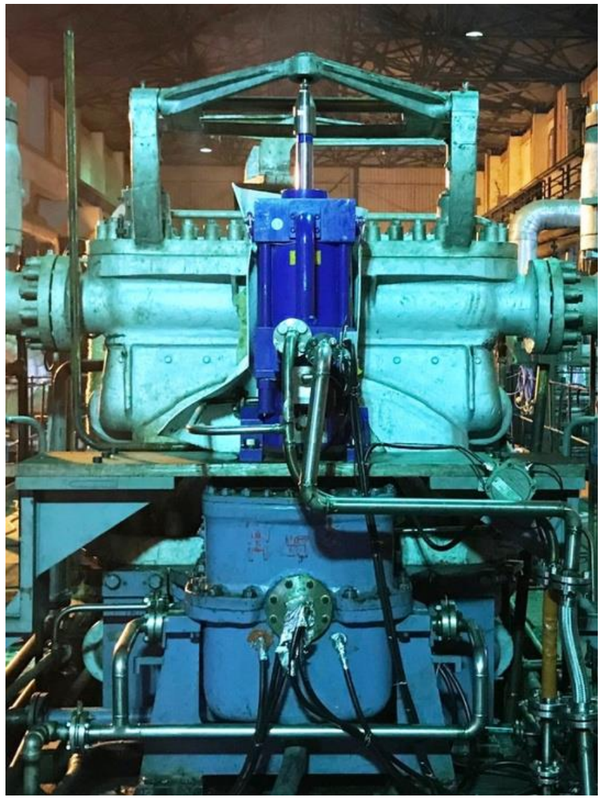


Modernization by Converting Mechanical Governing system to Electronic Governing system by Re-Engineering.

Case Study



OLD DESIGN
HYDRO MECHANICAL ACTUATOR



LASTEST DESIGN
ELECTRO HYDRAULLIC ACTUATOR

Provided electro-hydraulic actuator which is highly reliable having advantage of quick response time and feedback system

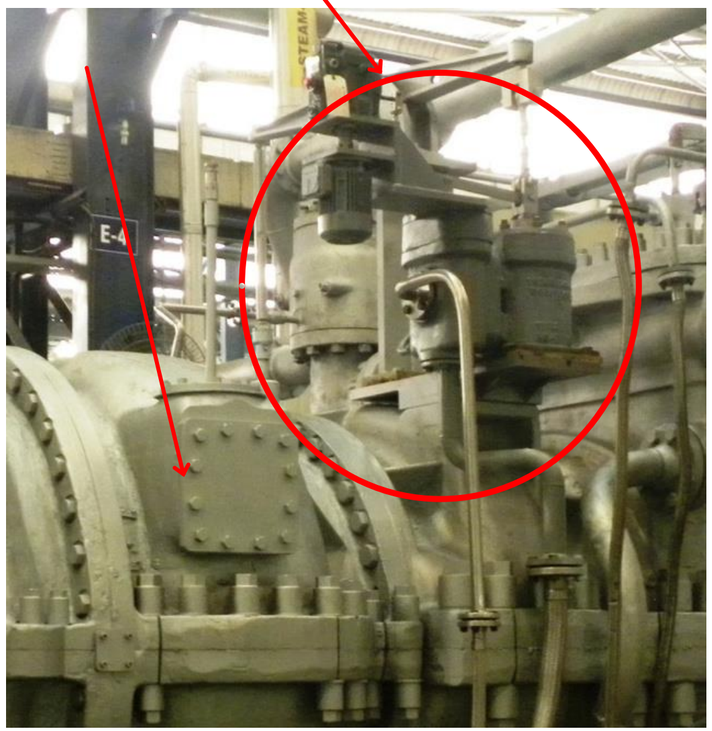
Case Study

- PROVIDED AN LP ACTUATOR WITH RELAY CYLINDER FOR 1ST EXTRACTION
  - VALVE. THE ACTUATION OCCURS BY THE SIGNAL FROM ELECTRONIC GOVERNOR THROUGH PROGAMMING
- 2ND EXTRACTION VALVE LINKAGE IS ELIMINATED

ORIGINAL DESIGN

1ST EXTRACTION VALVE LEVER

2nd EXTRACTION VALVE LEVER



MODIFIED DESIGN

Reverse Engineering, Manufacturing and supply of Impeller assemblies

IMPELLER 1 - PROCESS GAS

Challenge:

- Scan of Damaged impeller using 3D Laser scanner, generate a 3D model for new impeller manufacture.
- Once the scanning is done, the manufacturing model is rendered based on the data of other vanes and superimposed to achieve the final model.

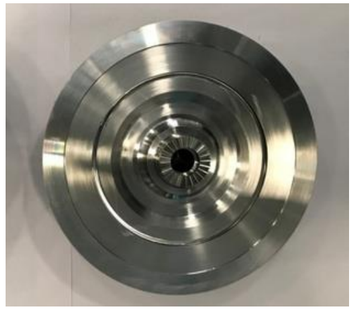
Old damaged Impeller

New Impeller

Final Assembly of the Impeller with new pinion shaft and Balancing setup

PINION SHAFT AND HIRTH TEETH MANUFACTURE

Old damaged Impeller – Hirth teeth side



New Impeller - Hirth teeth side

Manufactured new pinion shaft and individual Balancing setup

IMPELLER 2 - PROCESS GAS AND COOLING GAS

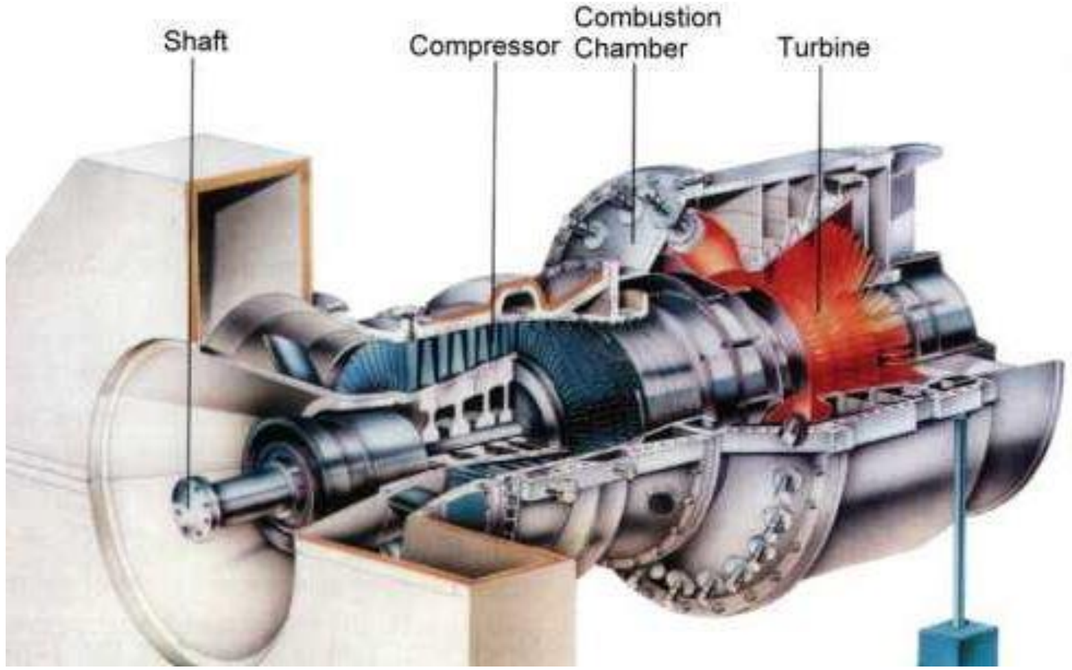
Reverse engineering of damaged Impeller at site

Final Inspection of New Impeller

Final Assembly of the Impeller with new pinion shaft and Balancing setup

Rated Speed : 8481 rpm

GAS TURBINES- SPARES AND SERVICE SUPPORT



Spare parts for complete train

Service support

References

Maintenance contract from Brunei for 2 years for services of 20 gas turbines from GE, John Brown, Hitachi and European Gas turbines (20-40MW range)

Spare parts supply for Bangladesh customer for GE make GT

Thank You