YEARS OF
IIT ROORKEE
Estd. 1847

HYDRAULIC TURBINE RESEARCH & DEVELOPMENT LABORATORY

Sponsored by :
Ministry of New and Renewable Energy
Government of India

Department of Hydro and Renewable Energy
Indian Institute of Technology Roorkee
Roorkee

INTRODUCTION

Real turbines can be tested at site in real conditions for which it is designed, only after installation and that too with relatively high inaccuracy. Practically no improvement can be done once the machine has been installed. The tests are therefore conducted on scaled models, on scaled hydraulic conditions. Such model tests process is a time consuming job and it demands well calibrated precision instruments, which are costly and often tailor made. Larger turbine manufactures such as BHEL, Andritz, Voith, GE and Dongfang have their own test facilities. However, smaller developers and consultants concerned with hydro power cannot afford such a big investment. Consequently, several projects have faced surprises during their operation.

HYDRAULIC TURBINE R&D LABORATORY, HRED, IIT ROORKEE

A fully automatic SCADA based Hydraulic Turbine R&D Laboratory sponsored by Ministry of New and Renewable Energy, Government of India has been commissioned in 2018 at HRED, IIT Roorkee, Uttarakhand. HRED is a center of excellence for small hydropower in the country, to validate the homologous hydro turbine models designed & fabricated by various turbine manufacturers. IIT, Roorkee is one of the oldest technical institute set up in 1847 and has played an important role in the development of Water resources in India, both through education of competent engineers as well as research work.

OBJECTIVES

The laboratory supports the Indian hydropower industry (government as well as independent) to grow and compete in the International market in various aspects of hydroelectric power development:

1. Spearheading research and development activity in the country for hydro turbine / reversible pump turbine.
2. Developing human resources for small hydropower in respect of entrepreneurs, engineers, plant operators and researchers.
3. Generating data and building expertise for solving site specific problems.
4. Providing affordable facility to small hydro manufactures for design verification.
5. Validating designs of small hydro turbine and layouts using CFD technique.
6. Developing and validating flow-measuring techniques leading to optimum utilization and generation.
7. Providing flow calibration facility for measuring instruments used for both, field-testing and power-plant operation.
8. Providing facilities for testing and certification of turbines.

The method used is simulating conditions similar to those around the runner of the turbine in a real hydro power plant. Two VFD driven large pumps are used for varying the water discharge, head and measuring various parameters such as power, discharge, head and speed in complete operating range.

HIGH–TECH FACILITY

Both CFD and experimental tests are carried out to validate the forecast performance and output test results obtained by calculation methods. The experimental tests are conducted for Francis, Kaplan Pelton and pump turbine by using a scaled model of the turbine. This stage of the hydraulic testing process provides a unique opportunity to verify the complete turbine operating range, taking into account complex operating phenomena, which are not covered in the theoretical calculation and tests carried out in previous CFD stages. This high-tech scaled model test laboratory is designed to test model of Turbine/ Reversible Pump Turbine/Large Pumps. Vertical model is directly coupled to dynamometer while horizontal Model is coupled using bevel gear box. The test rig is capable of simulating Conditions identical to those in a real hydropower plant.
The guiding parameters in setting up this Lab are as follows:

- Excellent overall accuracy in turbine efficiency measurement (target better than 0.25%)
- Repeatability (target better than 0.15%).
- Limiting the normal power consumption in the Laboratory to 300 kW level.
- Meeting IEC60193:2019 and ISO/IEC 17025:2017 requirements.
- Flexible rig to accommodate many types and designs of turbine models.
- Test conditions and parameters to be stable.

Model Pump Turbine Runner

The key parameters measured on this test-rig are Input hydraulic power i.e. head & discharge, output power i.e. runner speed and torque. This test-rig can measure mechanical power up to 132 kW, for speeds up to 1600 rpm, with maximum test heads of 70m with discharge 200 l/s and minimum test head of 10m with 907 l/s. For Pelton model testing, main pump-1 is replaced by high head pump, driving motor remaining same.

TESTS ON SCALED MODEL

- Weighted average efficiency and turbine output / pump input
- Cavitation's performance
- Pressure pulsation
- Run away speed

Besides above following tests are also conducted:

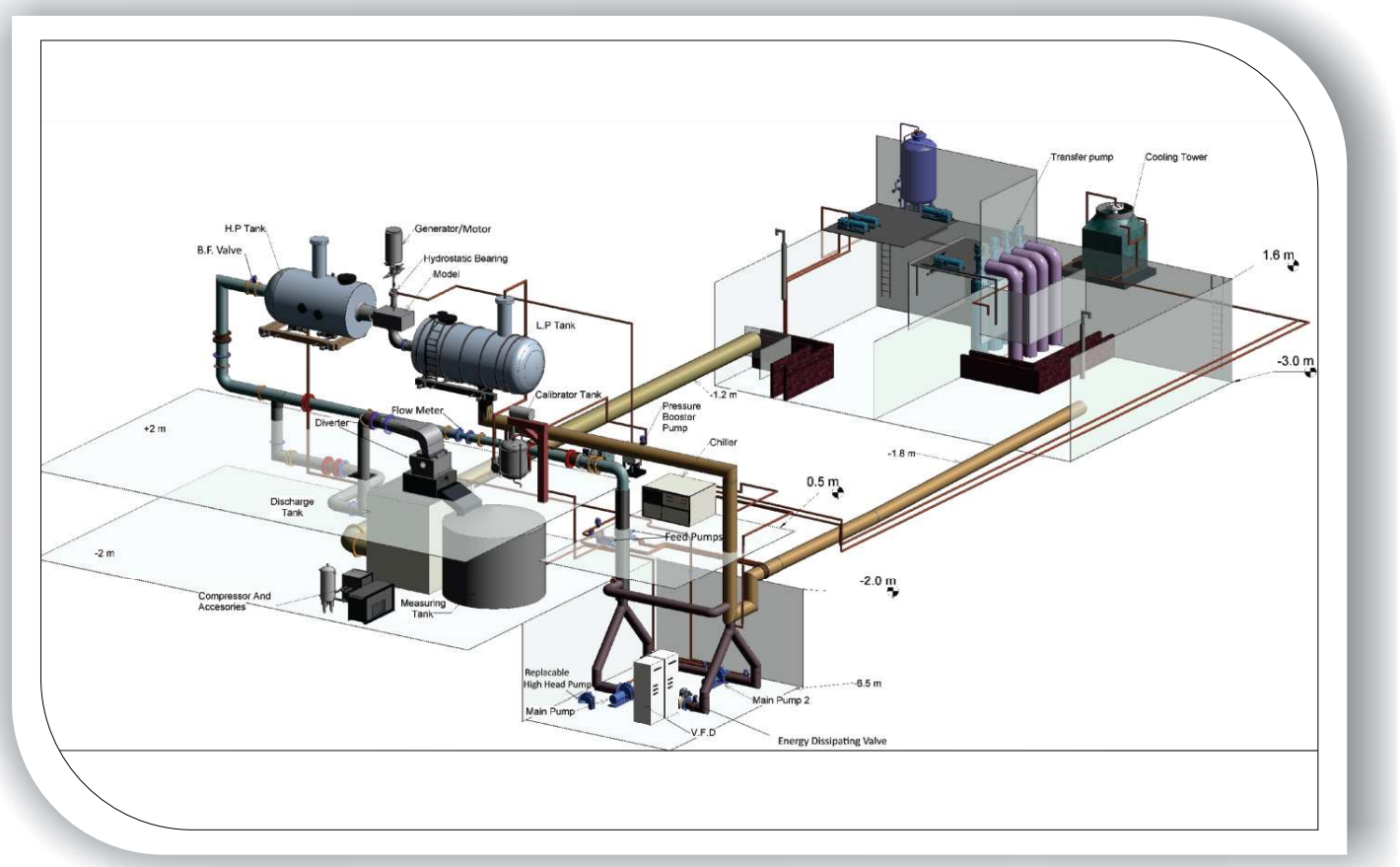
- Characteristic Curves for the Turbine Quadrant / four quadrant for reversible turbine
- Hydraulic Thrust
- Torque

The laboratory is equipped with state of the art SCADA based automatic control system with electromagnetic flow meters, pressure transducers and sensors. The Laboratory has flow measurement tank and calibration tank. There is a provision to calibrate flow meter by gravimetric method.

SALIENT FEATURES OF TEST RIG

Max Net Head at model	60 m with discharge 110 lt./s. (Both pump in series) 70m with discharge 200 lt./s (with High Head Pump)
Max, discharge	907 lt./s. at head of 10 m(Both Pump in parallel)
Max speed	1600 RPM
Hydro Static Bearing	Voith, Germany Make
VFD	Siemens Make
Universal Frequency counter/timer	Agilent Make, 350 MHz, 12 digits, 100 PS
Weights	Calibrated F2-Class Standard weights
Flow Calibration	Gravimetric (Weighing)
Flow measurement	ABB Make Electromagnetic Flow meter, velocity range 0-10m/s
Head measurement	Yokogawa Make Differential pressure Transmitter
Torque measurement	By HBM Make T12 torque meter capacity of 2 kNm and HBM Make Z6 Load cell capacity of 10 kg
Speed measurement	By HBM Make T12 torque meter
Measuring Tank and calibrator tank calibration with load cell	Measuring tank; 3 Nos. 22T capacity RTN Type, HBM Make load cell, calibrator tank; 1No. 2T Capacity, S-type HBM Make load cell
Cavitations Coefficient Measurement	Yokogawa Make Diff. pressure transmitter for suction pressure
Typical Runner Size of turbine model	Francis Turbine 250 mm - 350 mm up to 385 mm Kaplan Turbine250- 350 mm for Kaplan Turbine Pelton Turbine Bucket size 80 mm-90 mm Reversible Turbine Inlet Diameter 250mm -350 mm
Flow calibration loop	Can also be configured as calibration loop by bye-passing the rig through diverter unit in measuring tank/discharge tank.
Model testing	Closed loop. Vertical model as well as Horizontal model
Building size	39.6mX15mX21m (Height -6.5m to 13.5m)
Reservoir / Sump size and capacity	12.1mX8mX4.45m, Volume 217.8m^3/12.1mX7.1mX4.45m, Volume 300.69m^3
Transfer pumps motors-4 nos.	WPIL Make, Water lubricated, Speed 1450 rpm, Capacity 900 m^3/hr, total head 3.0m Motor: ABB Make
Main pump-motor -2 nos. High Head Pump- 1no.	WPIL Make, Pump: Suction 400NB, Discharge 350NB, Duty point at rated speed 1440 m^3/hr, head 24m Motor: 160 kW, V415 V, Siemens Make Andritz Make, Pump : Suction 300NB, Discharge: 200NB
Dynamo-motor and Fourth quadrant VFD	Siemens Make 132kW AC Drive and induction motor
Feed pump-motors -2 nos.	Kirloskar Make, 415V, 50Hz, 0.85 pf, 11 kW, 1470 RPM
Side Channel Pump-1no.	Speck-Pumpen, Germany Make, 415V,50Hz,0.85 pf, 1.5 kW,1440 RPM
Energy Dissipating Valve	Jash India Make, Dia-400mm in line valve with Auma Electric Actuator
Liquid Chiller	Drycool systems Make, 40TR, water temp. 31^{0}C max.

THREE DIMENSIONAL VIEW OF TEST RIG



HIGH ACCURACY CALIBRATION SYSTEM

Calibration tank with load cell

Measuring tank with load cell

Electromagnetic Flowmeter

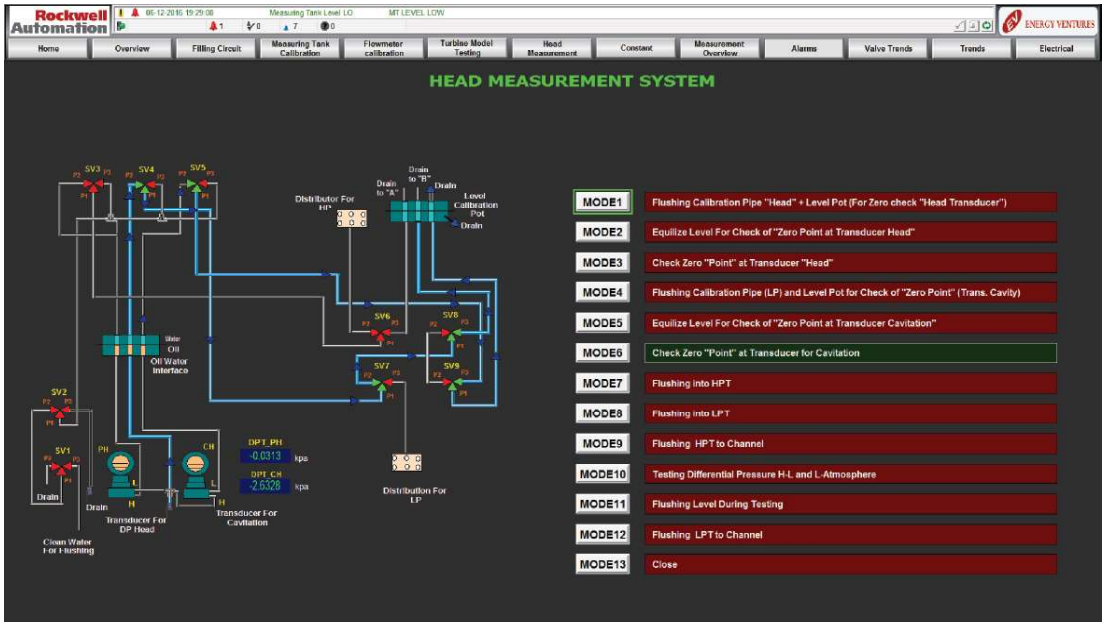
Flow diverter

Control Panel with Precision timer

Flowmeter calibration system

1. Calibration tank capacity 1.5 ton water with 1 No. 2.0 tons HBM make S40A load cell used, which is calibrated by the F2dass standard weights.
2. Measuring tank capacity of 45 tons of water with 3x22 tons HBMmake RTN load cell used, which is calibrated by the 2.0 ton load cell.
3. Flow Diverter unit is operated by a Compressed air.
4. High accuracy precision timer is used for actual time measurement up-to-12 decimal in Flowmeter calibration.

MEASUREMENT AND CALIBRATION FOR HEAD



Head measurement and calibration SCADA screen

Pressure and suction transducers

Head measurement Panel

TORQUE MEASUREMENT AND CALIBRATION SYSTEM

Shaft Torque Calibration System

Friction Torque Calibration system

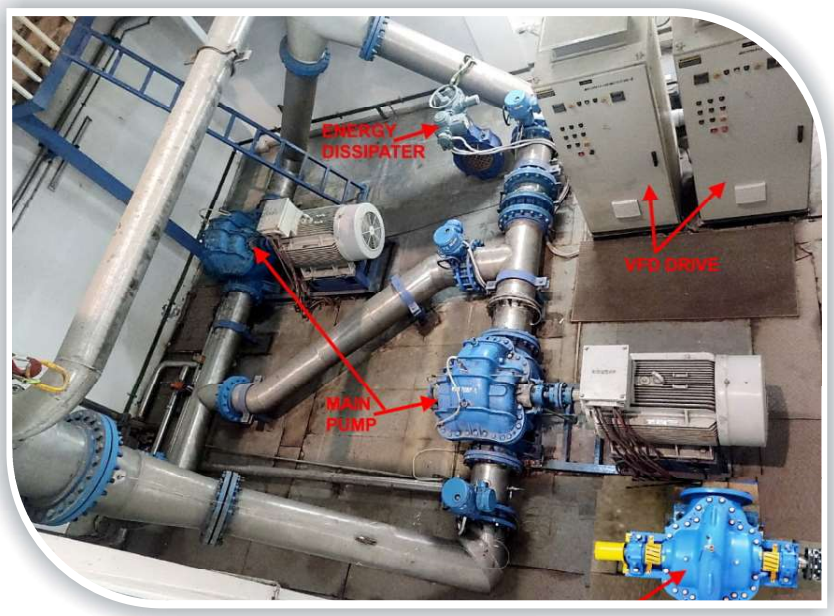
SPEED MEASUREMENT AND CALIBRATION SYSTEM

Measurement of Turbine Speed by rotary Speed transducer

Speed Calibration System

1. Friction torque is measured by 10 kg load cell and calibrated by F2 class standard weights.
2. Shaft torque is measured by 2 kNm torquemeter and calibrated by F2 class standard weights.

LABORATORY TEST RIG SAILENT FEATURES

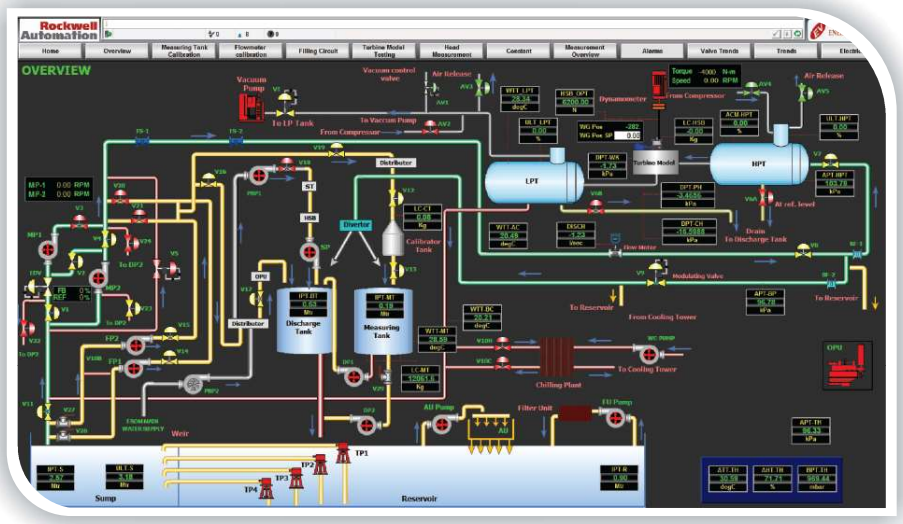


Main Pump, High Head Pump and motor driven by VFD (SINAMICS G120-Siemens)

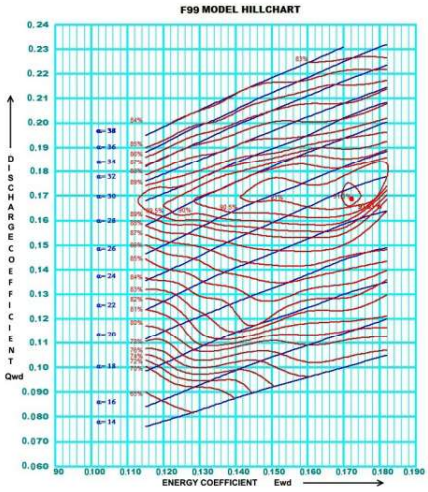
Dynamometer on movable trolley driven by VFD (SINAMICS S120-Simens)

Horizontal Kaplan model with Bevel Gearbox

SUPERVISORY CONTROL AND DATA ACQUISITION



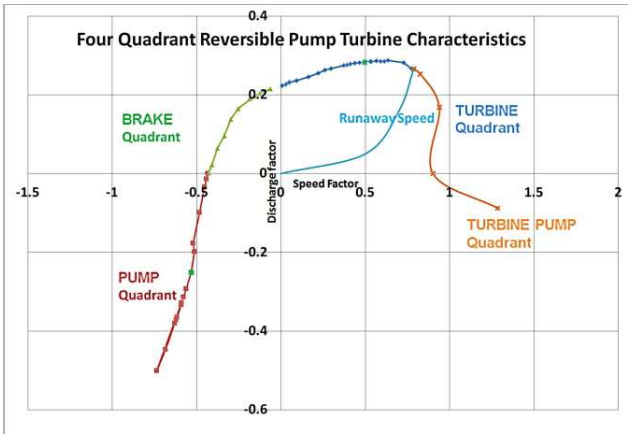
MODEL HILL CURVE



CONTROL ROOM

Data acquisition, control and operation of model testing are done by PLC based SCADA system. Results and graphs related to model as well as prototype are plotted simultaneously in NI-Lab VIEW System.

FOUR QUADRANT REVERSIBLE PUMP TURBINE CHARACTERISTICS

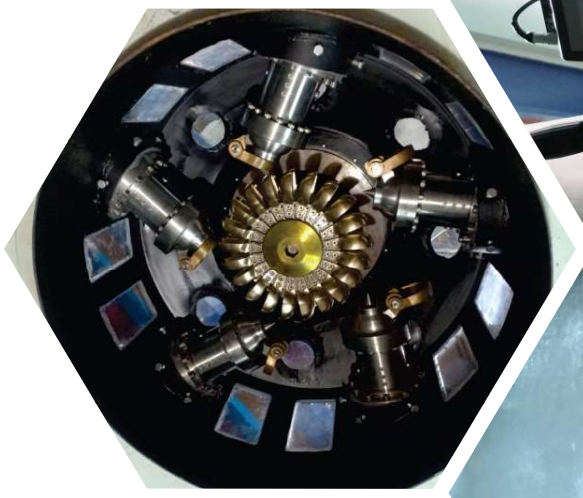


VORTEX AND FLOW PATTERN OBSERVATION SYSTEM

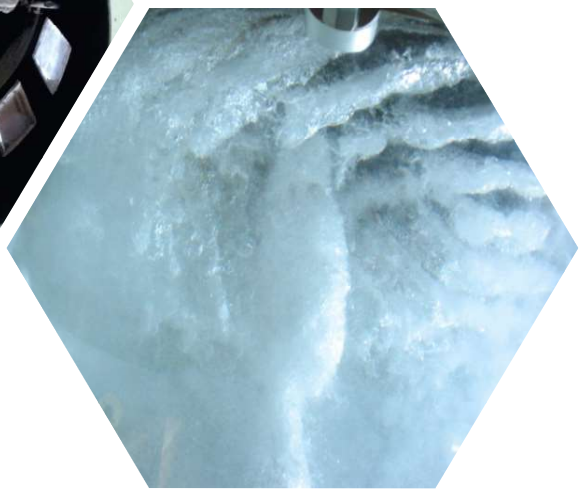
Latest image watching instruments like High speed camera, Stroboscope and Borescope are used for observation.

Observation of the incipient Cavitation on Runner Blade

Visualization of flow pattern inside draft tube using High Speed Camera



Flow pattern observation window in Pelton Model



Observation of the Cavitation bubbles Inside Draft tube cone

CFD SERVER ROOM

SYSTEM DETAILS

Master Node: 1 no. IBM x3550 M4 Server

Intel XEON processor E5 2680 (20 cores) @ 2.8 GHz, 25MB Cache, 1200 MHz
2 numbers IBM 600GB HDD SAS 10K RPM
64GB DDR3 1866 MHz
1 No's Dual Port FDR HCA Infinite band.
4 numbers Quad Gigabit Ethernet port.
1 number IMM port
1 number DVD RW drives

Storage Node: 2 nos.of IBM x3550 M4 Server

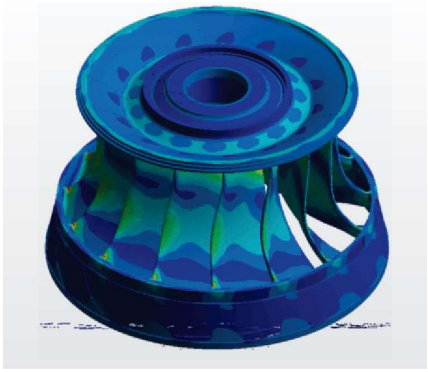
Intel XEON processor E5 2609 V2 (2x4 core) @ 2.5 GHz, 10 MB Cache, 1200 MHz.
2 No's IBM 300GB HDD SAS 2.5"
32 GB DDR3 1833 MHz
1 No's of HCA Infinite band quad port
2 numbers Gigabit Ethernet port
1 number IMM port

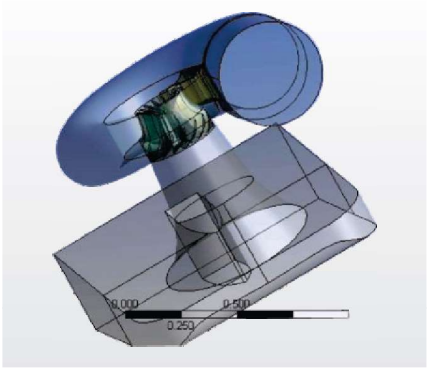
Compute Node: 12 nos. of IBM x3550 M5 Server

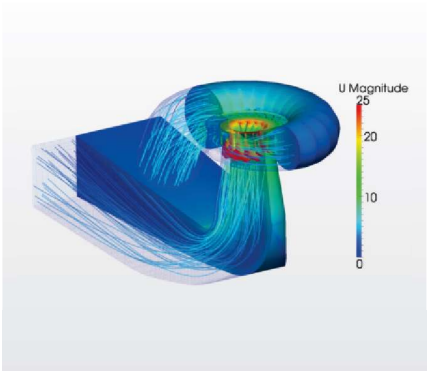
Intel XEON processor E5 2680 (2x12 core) @ 2.5 GHz, 30MB Cache, 2500 MHz
1 No's 500GB HDD 7200 RPM SATA 2.5"
96 GB DDR4 2133 MHz
1 No's Dual Port HCA FDR Infinite band
Dual Gigabit Ethernet port
1 number IMM port

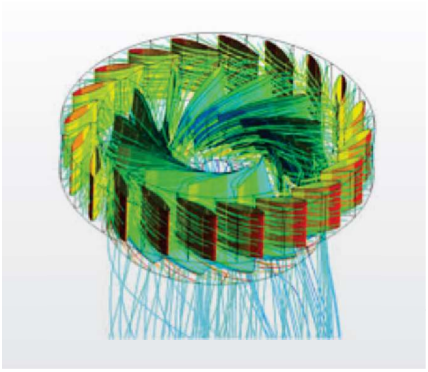
SOFTWARE INSTALLED ON HPC SERVER

1. Ansys-17
2. Matlab









RESEARCH SCOPES

In hydraulic turbine R&D laboratory of HRED, IIT Roorkee, the research fields include multi-phase hydro dynamics, water power project, hydraulic machinery etc. At present, mostly research scopes are shown as follows:

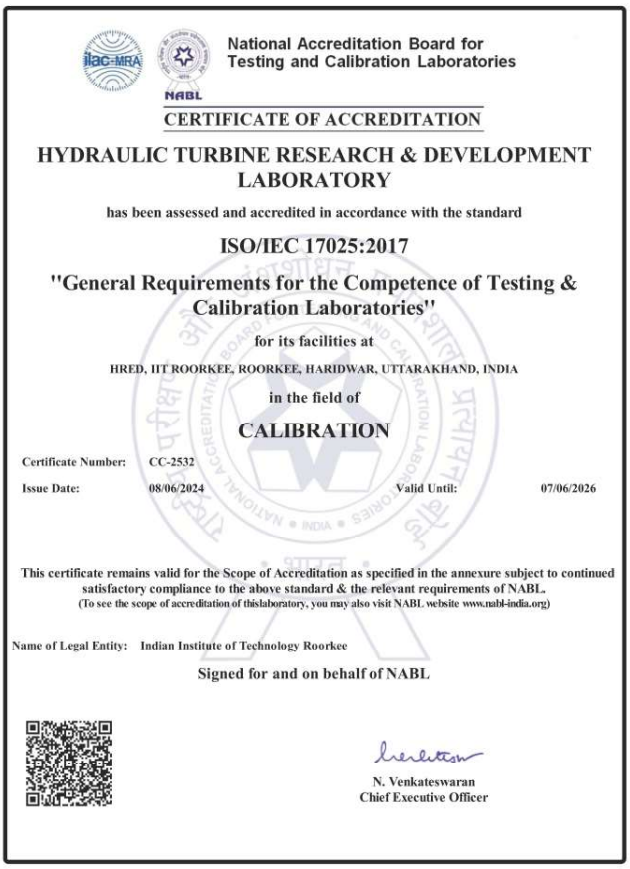
- Computational analysis of intensity of hydraulic turbine.
- Application research of hydraulic optimization and analysis of internal flow.
- Flow field display technique of hydraulic turbine.
- Model test and acceptance test inland and overseas.
- Research on cavitation mechanism and anti-cavitation measures.
- Measurement and control technique for measurement of pressure fluctuations in hydraulic turbine.
- Hydraulic vibration stability test in hydraulic machinery.
- Measurement of dynamic pressure velocity field in hydraulic turbine.

NATIONAL ACCREDITATION BOARD FOR TESTING AND CALIBRATION LABORATORIES

ACCREDITATION CERTIFICATE

Hydraulic Turbine R&D Laboratory is accredited since 2018 by National Accreditation Board for Testing and Calibration Laboratories (NABL) in accordance with ISO/IEC 17025:2017 for Hydro Turbine Model Testing as per IEC 60193:2019 and Fluid Flow Calibration as per ISO 4185:1980. Accreditation is renewed every two years.

NABL is part of Asia Pacific Laboratory Accreditation Cooperation (APLAC) which in turn is part of International Laboratory Accreditation Cooperation (ILAC).



National Accreditation Board for Testing and Calibration Laboratories

NABL

CERTIFICATE OF ACCREDITATION

HYDRAULIC TURBINE RESEARCH & DEVELOPMENT LABORATORY

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

HRED, IIT ROORKEE, ROORKEE, HARIDWAR, UTTARAKHAND, INDIA

in the field of

CALIBRATION

Certificate Number: CC-2532

Issue Date: 08/06/2024 Valid Until: 07/06/2026

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of thislaboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Entity: Indian Institute of Technology Roorkee

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer

National Accreditation Board for Testing and Calibration Laboratories

NABL

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in the field of

TESTING

Certificate Number: TC-13618

Issue Date: 06/05/2024 Valid Until: 05/05/2026

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
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N. Venkateswaran
Chief Executive Officer

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January 2024