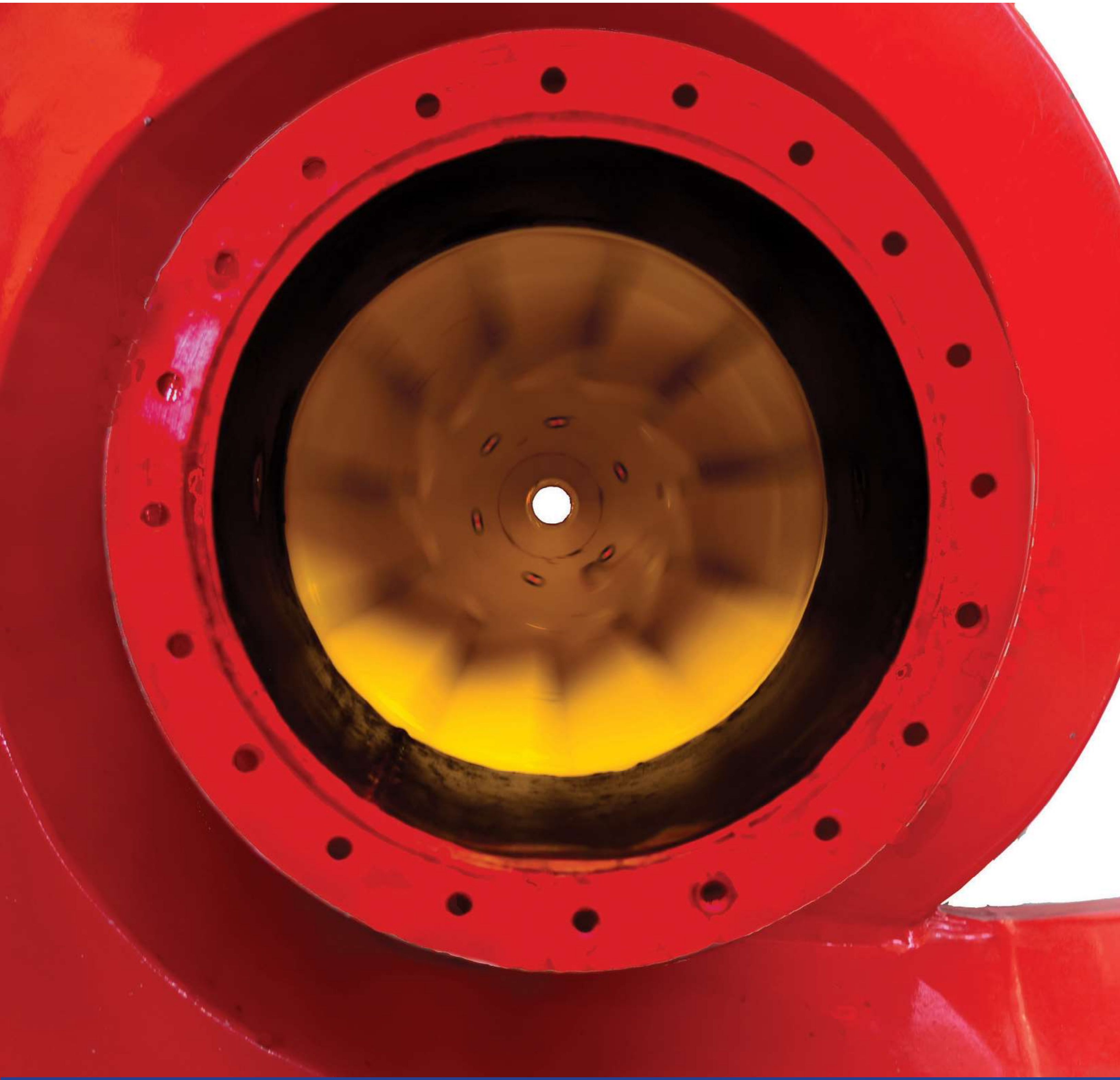
Turbine Testing Lab

Kathmandu University
School of Engineering
Dhulikhel, Nepal



TENTH ANNIVERSARY ISSUE-2021


TURBINE TESTING LAB

Message from the Vice Chancellor, KU

Let's Dream and Commit!

TTL has become a common name at KU. It has completed 10 full years and is now entering into 11 years of establishment. Fortunately, I have been a part of TTL through all these years. When the idea of TTL was conceived, we had limited knowledge of how to build such a lab. Apart from expatriates, most of the Nepalese faculties were young and we'd just completed the Bachelor's degree. We were, to some extent, ignorant about the importance of research activities in university and what would be the impact of such a research lab in industrial and economic development of a country. It was as if we were continuously insisting on developing TTL at KU without even knowing all the possible outcomes of such a research lab.

After 10 years of inaugurating the lab, now I wonder why we gave the name as TTL, why not Water Power Lab, why not Hydraulic Machine Lab? The name Turbine Testing Lab was in the minutes of the meeting initiated by late Prof. Inge Johansen and we just happened to follow it. After all these years, I feel that it is not just a testing lab, but this in fact is the lab dedicated for strengthening the quality of education, it is for research and development, it is for providing trainings to stakeholders and of course, it is for testing turbines for assuring performance of the new turbines. TTL, as one of the unique labs at KU, is fulfilling many of its objectives, but it is also true that we have not been able to do everything.

Several undergraduate and graduate students are trained in this lab, and we have been able to conduct research and produce PhD level graduates. However, in spite of the hard work, we have not been able to bring its fruit to the industry. We should be satisfied, what we have achieved through TTL so far, but at the same time we need to feel that we could have done more, we could have done better and we can diversify the services of TTL in other engineering applications. This is a challenge and opportunity for the future generation. Twenty five years can be one complete generation and starting from conceptualization to the present stage, it is actually a journey of one generation. Now it is the responsibility of the next generation to take care of this lab. I have complete faith that the lab will reach its new height in the new generation.

Personally, my academic and professional journey was aligned with the development of TTL. I express sincere thanks to all stakeholders of TTL and university family, management, staff and students for all the love and support we have received during all these years. TTL can be an example in the Universities of Nepal in terms of raising funds to develop such a specialized lab, operation and management model, engagement in research, connection with industry and agent for transformation of economy of the country.

All TTL members!! Let's dream and commit, the second decade of TTL will bring us to the international arena and bind us strongly with the industries. We will see the impact of TTL in society.

Prof. Bhola Thapa, Ph.D.

Vice Chancellor

Kathmandu University

Message from the Chairman, TTL

Turbine testing lab is one of the exemplary research laboratories in the context of achieving the international standards of turbine testing and research publications while also addressing the local hydropower challenges. It has been able to narrow down the bridge that exists between academia and industry through partnerships in the research and development projects, technology and knowledge transfer as well as prioritizing on applicability of the project outcomes.

The lab is also contributing on building an academic excellence by engaging graduate and PhD level students in the research projects. Out of the 8 full time researchers in the lab at present, there are 1 PhD and 2 MS by research candidates who are involved in different projects. 1 PhD and 1 MS by research candidates successfully completed their studies in 2021. Besides, there will be 3 PhDs and 4 MS enrollments in 2022 under TTL's supervision through Hydro-Himalaya project, as well as 1 PhD and at least 2 MS enrollments through other projects. Counting from 2020 only, there are 16 new publications in EI or SCI indexed Journals containing the research findings of TTL. These are some remarkable achievements in the global scientific community.

As the Chairman of the TTL's Operation and Management Committee, it is my pleasure to present the 10th Anniversary issue of the lab, containing the details of the activities that are conducted in the lab in the previous years.

Prof. Manish Pokharel, Ph.D.
Dean, SOE
Kathmandu University

Message from NTNU

Congratulations !!!

TTL is a success for Nepal, Kathmandu University and its partners. TTL is producing valuable knowledge and personnel to Nepal's hydropower industry which results in building the bridge between academia and the industry.

Students who have worked in TTL are proud of their BSc-, MSc- or PhD-thesis and many of them are now working for the hydropower industry. It warms my heart when I see previous students return to TTL to share their professional experience, problems and challenges. We all know that this is the basis for the future research at TTL. This is the cycle that makes TTL unique and highly valuable for Nepal.

Many people have been valuable for TTL's development, and I would like to especially mention KU's former Vice Chancellor, Dr. Suresh Raj Sharma and today's Vice Chancellor, Prof. Bhola Thapa. Without their efforts, TTL would not be made at all.

I am proud to say that my university in Norway, NTNU has taken part in TTL's development through its collaboration with the Waterpower Laboratory. Here, curriculum has been developed, personnel have been trained and the detail planning of the TTL's infrastructure has been developed.

I am even more proud to say that I have been following TTL's development from its cradle to what it is today. In 2003, I was visiting professor at TTL for one year, and started to work with the design of TTL in this period. I remember having many discussions about the layout of the laboratory with a water reservoir in the basement and an upper reservoir at the top of the campus. It was certainly not obvious for all that this such an infrastructure was necessary for a turbine testing laboratory. However, it is this layout that makes TTL unique and highly relevant for its research. Today, it is fair to say that TTL is one of the world's best laboratories for research on hydropower turbine technologies.

Future solutions for Nepal's hydropower will be developed in TTL.
Please take good care of it.

Prof. Ole Gunnar Dahlhaug, Ph.D.
Dept. of Energy and Process Engineering
Norwegian Institute of Science and Technology

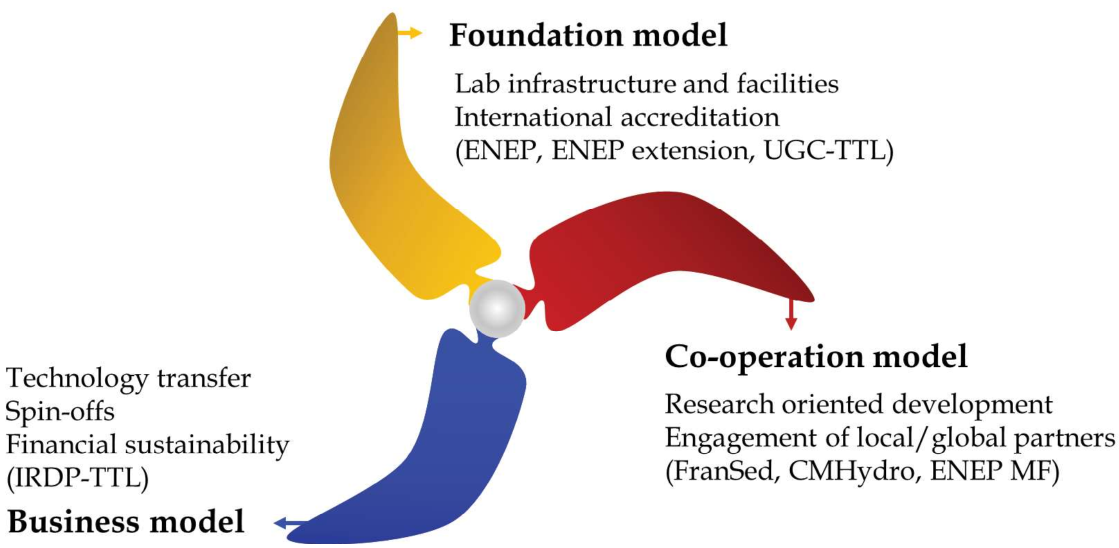
R&D at TTL on a Broader Perspective

The research activities that are carried out at TTL are focused on achieving two aims: i) Develop a research standard that can be accredited from international scientific community, and ii) Become a knowledge sharing hub between academia and industries so as to solve the local challenges of hydropower plants. With the support from various national and international funding agencies, the foundation for model testing of the hydraulic turbines is gradually taking a competent shape. The EnergizeNepal project (2016-2021) funded by Royal Norwegian Embassy made it possible to arrange the necessary components to develop test rigs in the lab. The turbine for this rig is planned to be fabricated through the funding of EnergizeNepal extension project (2022-2024), such that the international accreditation of IEC 60193 for testing of the hydraulic turbines at TTL can be finally obtained. Apart from these rigs, the lab is also equipped with a Non-Recirculating type of the sediment erosion rig, where the erosion of turbines can be tested more realistically compared to the accelerated rigs. This rig was developed with the main funding of UGC, Nepal (2018-2021).

Owing to the inevitable hydropower challenges in Nepal, the research opportunities for TTL is highly substantial to be implemented directly in industries. All the R&D activities in the lab are more or less related to the operational and maintenance challenges in the hydropower turbines of Nepal, or any country which has the problem of excessive sedimentation in rivers. The PhD and Masters studies hosted by TTL are mostly focused on knowing the flow physics inside the turbines when operated with high sediment load, its consequences on the turbine's wear and mitigation measures. FranSed (2018-2022) is one of such projects which aims at changing the design philosophy of the turbine's components such that the flow physics inside the turbine is more favorable for sediment laden conditions. TTL is conducting this research together with the Waterpower Laboratory of NTNU and IIT-Roorkee under the HydroCen project. Recently, TTL has also been conducting several consulting projects for the hydropower industries of Nepal, such as design of the hydro-mechanical components of the new power plants, laboratory testing of micro-hydropower turbines, as well as investigation of the erosion problems in the turbines. Such projects are expected to help sustain the lab in a long run.

Apart from the R&Ds in the sector of sediment erosion in the hydraulic machineries, TTL is also looking to expand its research domain and focus on the O&M challenges of the power plants. This includes fatigue failures, pressure oscillation or vibrations that are mostly the outcomes of erosive or cavitation wear in turbines. Using suitable condition monitoring tools with provision for fault detection and diagnosis, operational strategies of the turbine along with their preventive maintenance can be made possible. Such strategies would help prolong the lifespan of the turbines. CMHydro project (2020-2023) currently running in the lab is focused on condition monitoring aspects of the power plants of Nepal. This project is funded by Nepal Electricity Authority (NEA) and the reference sites chosen for this project are owned by NEA.

The new innovations and research outcomes are connected with a successful business-model, which is a top priority strategy of TTL. A recent project of TTL-IRDP (2010-2021) was related to developing a river water pump which could be commercialized for the irrigation purpose in Nepal. This project completed its pilot phase and the technology was found to be suitable for upto 15 meters head and around 15000 lts/day discharge. In the second phase, the project intends to expand the applicable range by introducing other types of the pumps that could also attract the hydropower industries of Nepal. There are also many projects which emphasize on transferring the technology to local industries so as to build up competences for turbine design, manufacturing and testing using national resources.



Operation and Management Committee

Prof. Manish Pokharel, Ph.D.
Chairman
Dean, School of Engineering
Kathmandu University

Asst. Prof. Sailesh Chitrakar, Ph.D.
Faculty-in-Charge & Member
Secretary
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Prof. Hari Prasad Neopane, Ph.D.
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Mr. Kulman Ghising
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Prof. Ole Gunnar Dahlhaug, Ph.D.
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Department of Energy and
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Engineering
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TTL: Team Members

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Researchers/ Technical Support

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Mr. Dadiram Dahal
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Ph.D. Candidate
CMHydro

Mr. Bhuwan Prasad Bhattarai
Technician
ENEP Project

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Ph.D. Candidate

Ms. Aasma Bhattarai
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Candidate

Mr. Pawan Bijukchhe
MS by Research
Candidate

Mr. Kushal Shrestha
Ph.D. Candidate

Mr. Ravi Paudel
MS by Research
Candidate

Mr. Suprim Shrestha
MS by Research
Candidate

Interns at TTL

Mr. Ashim Joshi
Undergraduate Student
Mech. Engg (III Year)

Mr. Arun Pandey
Undergraduate Student
Mech. Engg (IV Year)

EnergizeNepal Project

"Establishment of Center for Design, Operation and Maintenance of Mechanical Equipment for Hydropower Plants in Himalaya Region of Kathmandu University"

NTNU

Hydro Lab

ROYAL NORWEGIAN EMBASSY

Project Leader	Dr. Hari Prasad Neopane	KU
Activity Leader	Dr. Ole Gunnar Dahlhaug	NTNU
	Dr. Biraj Singh Thapa, Dr. Sailesh Chitrakar	KU
Researcher	Mr. Atmaram Kayastha	KU
	Mr. Nischal Pokharel	KU
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	Dr. Bjorn Winther Solemslie	NTNU
Project Date	August 2016 to December 2024	
Funding Agency	Royal Norwegian Embassy in Nepal (RNE)	
Partner Agencies	Royal Norwegian Embassy Kathmandu University (KU) Hydro Lab Pvt. Ltd. SINTEF Energi AS Norwegian Institute of Science and Technology (NTNU)	

Summary

An agreement was signed between Royal Norwegian Embassy (RNE) & Kathmandu University (KU) on 27th July, 2016 to support the Energize Nepal project. TTL, KU being one of the major partner for Hydropower Development Component in Energize Nepal

project, activities sprung from August 2016 in the lab.

Overall project planning was done in the earlier stage which includes defining the project objectives and methodology. The major milestones and deadlines were redefined and set. Human resource management was done with the available manpower in the laboratory in the initial phase. Detailed financial break down was done and after series of meeting in lab and abroad, detailed procurement plan was developed. During the process, technical specifications were studied and several contacts were made with the manufacturer/ supplier for the specific products. IEC documents were studied which includes testing procedures and methods. The execution of this project aims in developing the capacity of TTL for research, design verification and model test certification to provide technical solutions and intellectual support related to hydro- mechanical components.

To gain the confidence in the test rig and testing procedure, inspection and refurbishment of existing 92 kW Francis turbine test rig in the lab was started. It included the pipeline and valve inspection, dismantling of the existing setup and structural analysis of the same. After dismantling, thorough cleaning was done for the various parts of the rig which included pickling, buffing and grinding. The process hydraulic and mechanical design of the rig components for closed and open loop operation was completed. The design and analysis of pressure tanks (high pressure tank and low pressure tank) required for the lab was accomplished and tanks were procured accordingly. The air compressor system required for variable head operation at constant has been integrated into the system. The factory grade coating of reservoir floors of the lab was accomplished. The new components added to the setup include new set of stainless steel bearing block with high precision bearings and a provision for measurement of axial thrust in the turbine.

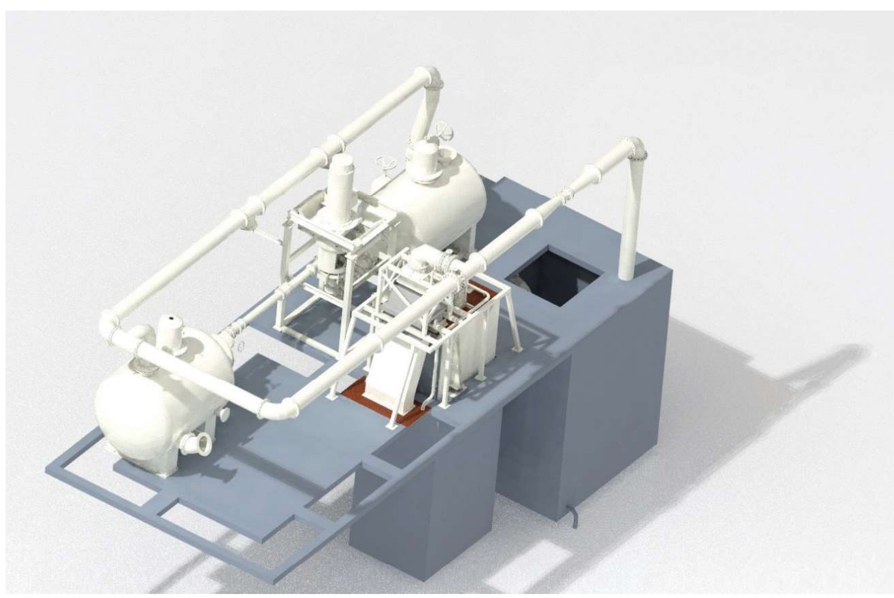


Fig. 1 3D CAD Model of IEC Test Setup at TTL

A set of pressure taps are added in the inlet pipe and draft tube diffuser to measure static head and calculate net head of the turbine. The pressure transducers installed in the setup are procured recently with uncertainty up to ±0.05% to ±0.075% compatible with Standards specified by IEC. A DN 400 flow meter is also procured for central flow measurement system. A 150 kW motor is also procured with 4 quadrant VFD system for performance analysis of the model runner. The motor and runner shaft is connected with a precision coupling with T40B flange type torque transducer for measurement of torque and speed values. The pipelines of TTL are being upgraded as well, with which tests of model turbine in open and closed loop can be done. The dead weight pressure calibration system is also available in lab for calibration of pressure transducers.

Coming up to this time, TTL gained different sorts of competences in designing and installation for IEC standard test rig including testing of locally manufactured turbines. The partner university NTNU has always been there by side in design supervision and quality control. In order to go complete into IEC, the existing facilities in the lab has to upgrade to meet its standard.

On 26 October 2021, at Kathmandu University), Vice-Chancellor of Kathmandu University Prof. Dr. Bhola Thapa and H.E. The Ambassador of The Royal Norwegian Embassy in Kathmandu Ms. Torun Dramdal inked for an Addendum 1 for EnergizeNepal with a time extension of 39 months and an additional fund of 23.547 MNOK. With this up scaling TTL component has also been funded for three years and the remaning works are expected to be completed from this project.

Fig. 2 EngerizeNepal up scaling project agreement moment.

The flow calibration system of which design has been completed is to be procured and installed. Similarly the existing Francis turbine testing have various connection accessories with mild steel material which is to be replace by stainless steel in order to completely go in IEC. Model turbine fabrication and testing will be an achievement of this project. Finally after the complete establishment of IEC standard rig and testing facility, TTL will work the accreditation process so that model testing for different hydropower industry will be self-sufficient within the country itself.

Modification of Model Francis Test Rig as per IEC Standard

A 92 kW Francis turbine test rig, downscaled model of a 4.2 MW Francis turbine of Jhimruk Hydropower Project was designed and installed at Turbine Testing Laboratory (TTL) in association with Norwegian University of Science and Technology (NTNU) and

Kathmandu University (KU), so as to evaluate the performances of the turbine designed to minimize sediment erosion effect.
Scaling effects of such downscaled model of large size turbines need to be standardized as per IEC. The tolerances and level of precision also need to be scaled down which provides a challenge of getting a model turbine with very high tolerances and precise machining. So, modification of turbine based on the revised design has been carried out under the Fransed Project at TTL which aims to come up with the design and manufacturing drawing as per IEC standards.

This test rig consist of the adjustment system which gives the flexibility to test two different runner: reference runner and the optimized. Although the basic dimension like the inner diameter, outer diameter and runner inlet height are same, the height of shroud and hub section of the two runners are different due to different manufacturing processes used for each runners.

Two downscaled model of 4.2 MW Francis runner of capacity 92 kW will be tested in this test rig. The reference runner had already been designed and manufactured and is available at TTL, it is manufactured by using casting and welding procedures. However, the optimized runner will be manufactured by using a different approach which will allow flexibility for further test as the hub and shroud can be reused for further optimized runner blades. Seventeen periodic sections of the blades are made and these sections will be attached to the hub and shroud section with the help of bolts. There are two bolts for the upper section of each periodic section attached to the hub, one near the leading edge and other near the trailing edge of blade. The chances of leakage of water from the narrow gap between the periodic sections of runner, and if passes to the shaft line, it will create operational difficulties. So, it need to be sealed perfectly which is made possible with the help of the bushing having one O-ring at bottom and one at top.

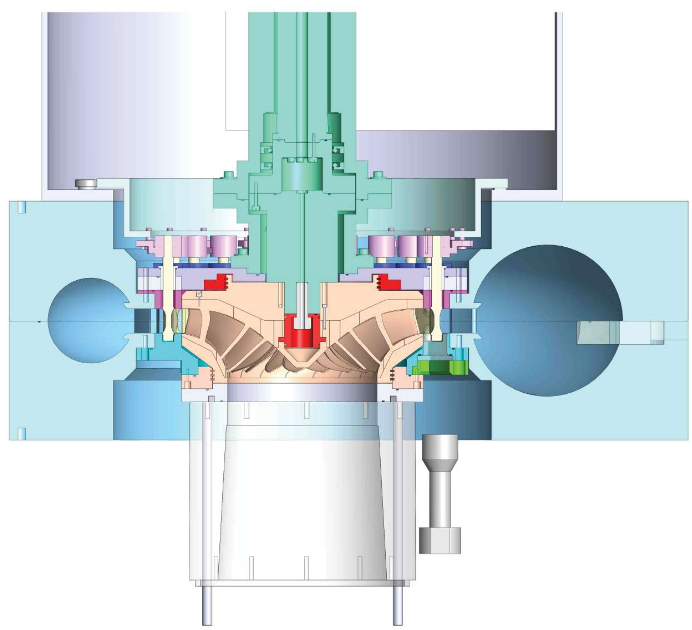


Fig. 3 Modified Francis turbine test rig at TTL

The spiral casing is made up from two halves which allows flexibility for both assembly and mounting other provisions for various experiments. The stay vanes are an integral parts of the casing which will be milled out of aluminum. The upper and lower half will be assembled with the help of two row of bolts, one row towards outside and another row towards inside passing through the stay vanes. In order to seal the gap between the two case-halves, an o-ring is be used at the bottom casing. Furthermore, provision for one inspection port, one laser port for PIV and a set of Winter Kennedy sensors are provided.

The head cover for this rig have to be adjustable so that the reference and optimized runner can be tested. This is the reason why the head cover is made in two part: the lower part act as guide vane ring and upper as main part. And for the compensation of increase in the height of the hub, one adjustment ring is placed between the upper and lower ring which will be taken out when the reference runner will be in use. The labyrinth ring is attached to the upper head cover and four inspection ports are located in the upper head cover to facilitate checking the rotor/stator gap.

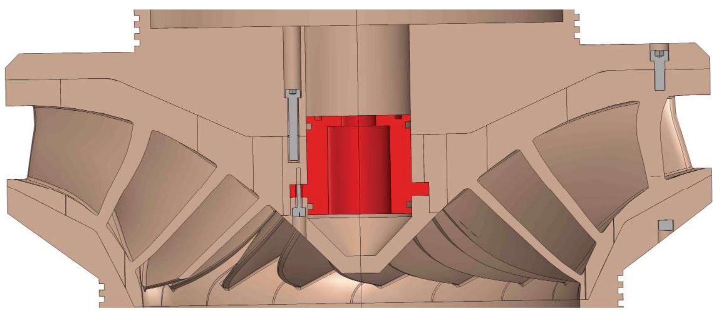


Fig. 4 Francis runner with sectional view

Subsequently, the bottom covers are also divided into two parts so as to make provision for the installation of a PIV measurement system. Another major reason for making the bottom cover into two parts is due to the increment of the thickness of shroud section of the optimized runner which requires larger diameter of lower labyrinth rings than that of the reference runner. Furthermore, two lower bottom cover is made: one for reference and one for the optimized runner. A section of the upper bottom cover is made out of plexi glass so as give the opportunity to observer different flow patterns with the help of PIV.

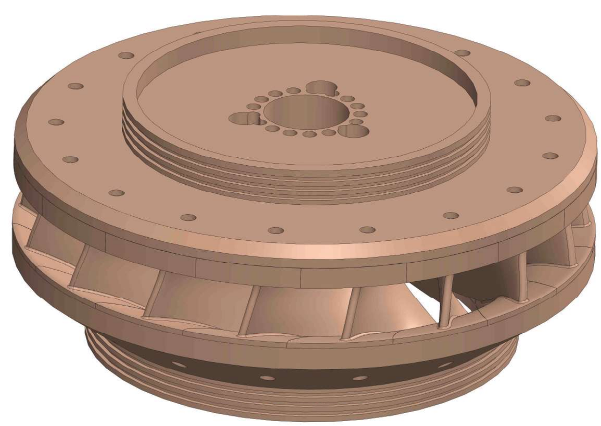


Fig. 5 Full 3D model of Francis runner

The leakage is restricted by the use of an O-ring which is covered by support structure. Provision for the study of rotor-stator interaction has been made with three inspection ports in between runner and guide vane. In addition, there are four taps as a provision for insertion of the jet to make sediment concentration as low as possible so as to minimize erosion at labyrinth. After the installation of the runner and other systems that are to be installed before the head cover, the gap between the runner and the upper labyrinth ring can be checked by using feeler gauges .If this gap is not within the limits, the system can be adjusted by using...adjusted by using the three number of jacking bolts placed 1200 to each other. The total adjustment of about 2 mm can be achieved for that the hole in the flange of bearing block is made wider by 2 mm. Similarly after the installation of the bottom cover the gap between the runner and the bottom cover need to checked and if found unsatisfactory can be adjusted by the four number of equally spaced jacking screws placed at the bottom cover.

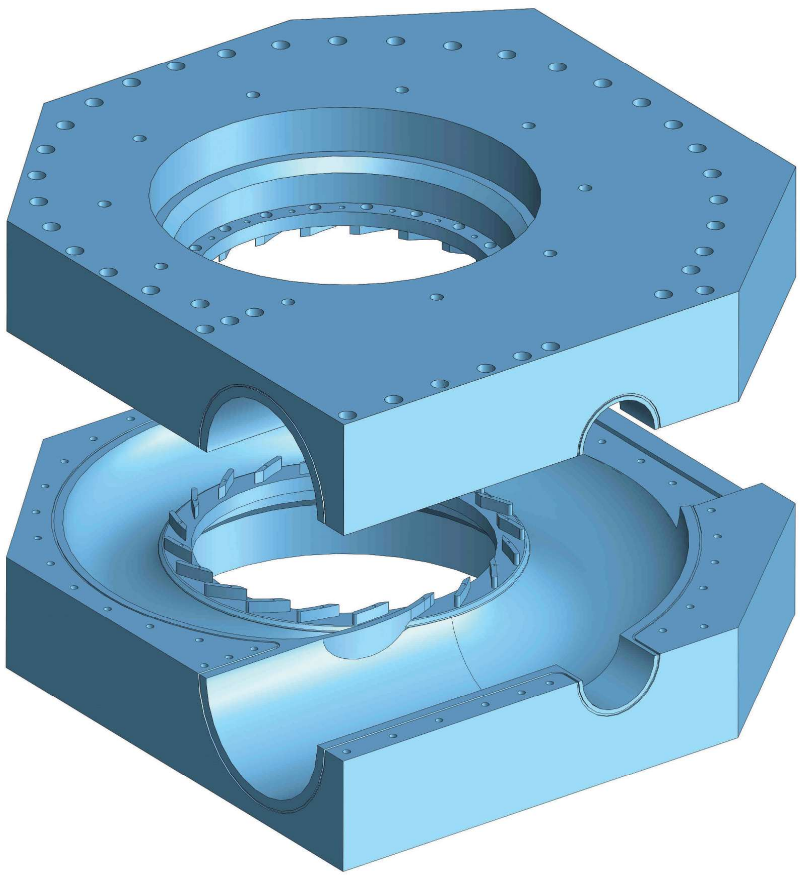


Fig. 6 Two halves of spiral casing

EnergizeNepal RenewableNepal Phase II

"Capacity and Competence Development for Introducing Francis Turbine in Nepalese Micro Hydropower Projects"

Objectives:

- Development of design and manufacturing procedures of Francis turbines for micro hydropower projects in context of Nepal.
- Local manufacturing and installation of Francis turbine at one micro hydropower station in Nepal.
- Technology transfer to Nepalese turbine manufacturer for design and manufacturing of Francis turbine.

Project Leader	Dr. Biraj Singh Thapa	KU
Activity Leader	Mr. Atmaram Kayastha	KU
Researcher	Mr. Amul Ghimire	KU
Technical Support	Mr. Bhuwan Prasad Bhattarai	KU
Supporting Researchers	Dr. Ram Lama Mr. Dadi Ram Dahal Mr. Nischal Pokharel	KU
Project Date	December 2018 to May 2021	
Funding Agency	Royal Norwegian Embassy in Nepal (RNE)	
Partner Agencies	Turbine Testing Lab, Nepal (TTL) Korea Maritime and Ocean University, Korea (KMOU) Mokpo National University, Korea (MKU) Thapa Engineering Pvt. Ltd., Nepal (TEI) Shinhan Precision Co. Ltd., Korea	

Summary

Manufacturing of Francis turbine has been a bottleneck for the turbine manufacturing industries in Ne-pal, mostly due to lack of design knowledge and manufacturing techniques. In order to address the issue and to develop the capacity and competence of the Nepalese industries to start manufacturing Francis turbines for micro hydro power and subsequently larger hydropower, this project was envisioned. From the very start of the project, the project team has worked on the development of a simplified Francis tur-bine that can be manufactured without sophisticated manufacturing equipment and techniques. The de-sign developed is open source and is published in IOP Science Journal of Physics, with the title: "Design of Francis turbine for Micro hydropower applications".

Chauri Khola II MHP, a micro hydro located in Kavre district, was selected as a reference site for the in-stallation of the Francis turbine. The local community benefitting from the project agreed to contribute on the development of the micro hydro. The civil structure and generator for the project are being contribut-ed, while the turbine shall be manufactured through the project budget. A simplified Francis turbine was designed for the reference site, at Turbine Testing Laboratory in Kathmandu University. The turbine was manufactured by the Thapa Engineering Industries Pvt. Ltd., a partner agency of the project, using the lo-cally available technology. Most of the manufacturing work was accomplished during the pandemic. The turbine has been tested at the laboratory, the results of which are being presented in IAHR Asia 2021 con-ference. The installation of the turbine at site, however, has been stalled due to pandemic and flood in the location of the micro hydro. The installation of the turbine has been planned to be completed by Decem-ber 2021. After successful installation of the turbine and generation of electricity, it will mark a milestone in Nepalese turbine manufacturing history.

Fig. 1 Laboratory testing of Francis turbine of Chauri Khola II MHP

FranSed

"Francis Turbine for Sediment Laden Waters"

Objectives:

The FranSed project aims towards scientific and technological breakthroughs to enable hydropower turbines to operate with high sediment concentration and sediment load. The project will create the technical basis for successful future industrial developments by performing well-focused research and innovation activities on the key bottlenecks of hydropower units that restricts their operating range due to high sediment concentration in the water.

Principal Investigator	Dr. Ole Gunnar Dahlhaug	KU
Project Co-ordinator	Dr. Sailesh Chitrakar	KU
Workpackage Leader	Dr. Hari Prasad Neopane (I)	KU
	Dr. Ole Gunnar Dahlhaug (II. IV)	
	Dr. Bhupendra Gandhi (III)	
	Dr. Biraj Singh Thapa (IV)	
	Dr. Arun Kumar (V)	
Ph.D. Candidate	Mr.Nirmal Acharya (NTNU); Mr. Prajwal Sapkota (KU); Mr. Shubham Sharma (IIT-Roorkee)	KU
Researchers	Mr. Dadi Ram Dahal; Mr. Saroj Gautam	KU
Project Date	December 2018 to May 2022	
Funding Agency	Norwegian Research Council	
Partner Agencies	Kathmandu University (KU) Norwegian Institute of Science and Technology (NTNU) Indian Institute of Technology, Roorkee (IIT)	

Summary

In the power plants of the Indian sub-continent, excessive sediments carried by Himalayan rivers is one of the major challenges from the perspectives of operation and maintenance. Due to hard mineral contents such as quartz and Feldspar present in the sediment, the turbine parts undergo erosion, leading to financial losses due to loss of efficiency or drop in power output. In the case of power plants with Francis turbines, it has been studied in recent research works that the presence of a gap between guide vanes and top-bottom covers and rotating-stationary geometries induces the secondary flows in Francis turbines. The secondary flow developed in the clearance gap of guide vanes induces the leakage vortex that travels towards the turbine downstream affecting the runner. Likewise, secondary flows from the gap between the rotor-stator component enter the upper and lower labyrinth region. Francis turbines when operated with the sediment-laden water, sediment contained flows affect these gaps thus increasing the size of the gap and increasing the leakage flow.

The collaborative research works have started between NTNU and KU for investigating the erosion wear in the labyrinths of Francis turbines and ways to minimize these erosion losses. A reference Francis turbine severely affected by sediment erosion problem is selected for this study. All the components of the turbine are modelled and a reference numerical model is developed.

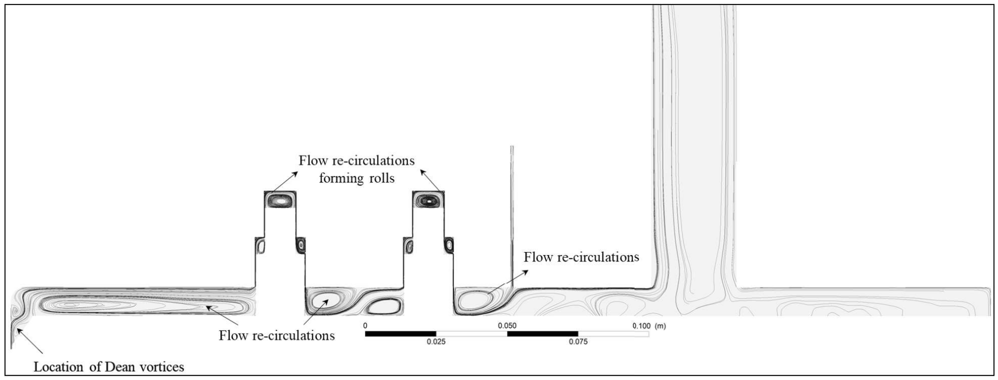


Fig. 1 Vortices regions in upper labyrinths

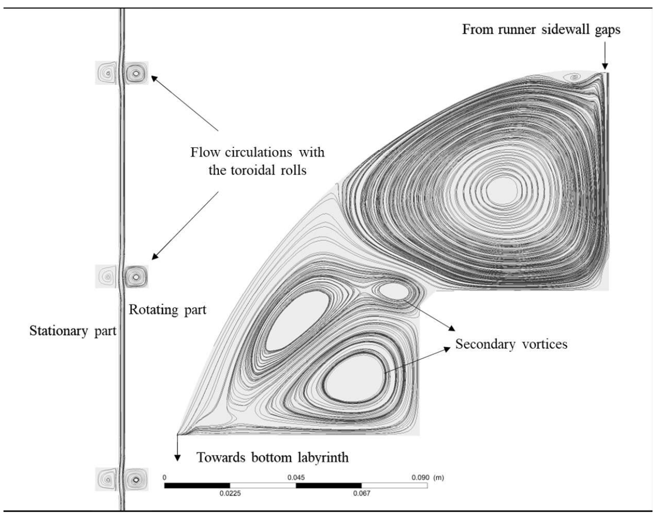


Fig. 2 Vortices regions in bottom labyrinths

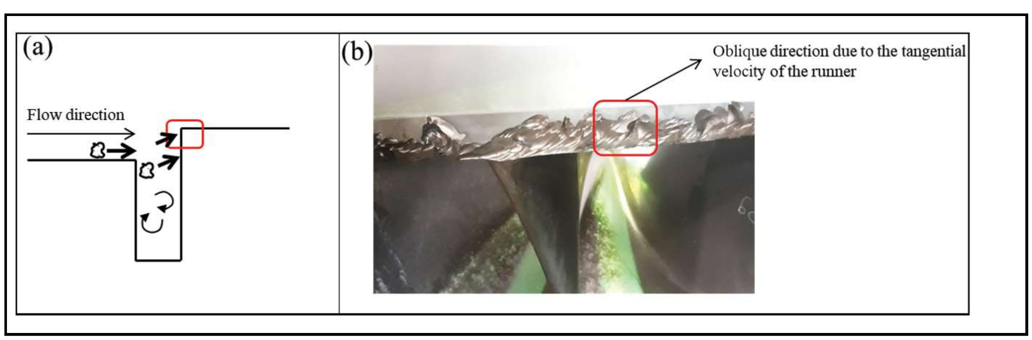


Fig. 3 Effect of sediment contained flow on the turbine material (a) Nature of sediment contained flow and (b) Erosion effects towards runner band

The numerical model is validated with the numerical uncertainty measurement and with the experimental results. Different locations of the turbine with the complex secondary flows and consequent sediment erosion effects are examined separately. Erosion effects at guide vanes are due to the development of leakage flow inside the guide vane clearance gaps. At the runner inlet, erosion is mainly due to leakage vortex from clearance gap and leakage flow from rotor-stator gaps. Towards the upper and bottom labyrinth region, erosion is mainly due to the formation of secondary vortical rolls. The simultaneous effects of secondary flows and sediment erosion at all these locations are found to affect the overall performance of the turbine.

A novel technique, high-velocity clean water injection, is being studied to minimize the sediment erosion at labyrinth regions and rotor-stator gaps of Francis turbines. This method is achieved by cleaning the sand-laden water through penstock with the use of a hydro-cyclone separator. Clean water from the outlet of the hydro-cyclone separator is supplied to the labyrinth region with high velocity and is circulated through the seal. The cleaned water is led under sufficiently high pressure to the pressure side of the seal so that the cleaned water forces the water flowing through the turbine away from the seal. Thus is the supply of cleaned water to the seal assured.

In parallel to the research works under sediment erosion in turbines, experiments are being carried at KU to investigate the effect of sediment erosion in the rotor-stator gap of Francis turbines. A simplified model based on the concept of Rotating Disc Apparatus (RDA) is conceptualized to make the analogy with the gap available between runner and guide vanes. Fillet gaps are introduced in the model to emulate the gaps available between runner blade and GV for real case scenarios. Four samples with 90° separation of each are mounted on the disc rotating at variable rotational speeds. A sediment size of 150 μm diameter with particle mass flow rate based on the maximum amount of sediment passing through the reference turbine is used. This study aims to propose an erosion model based on the width of rotor-stationary gaps and height differences between these components.

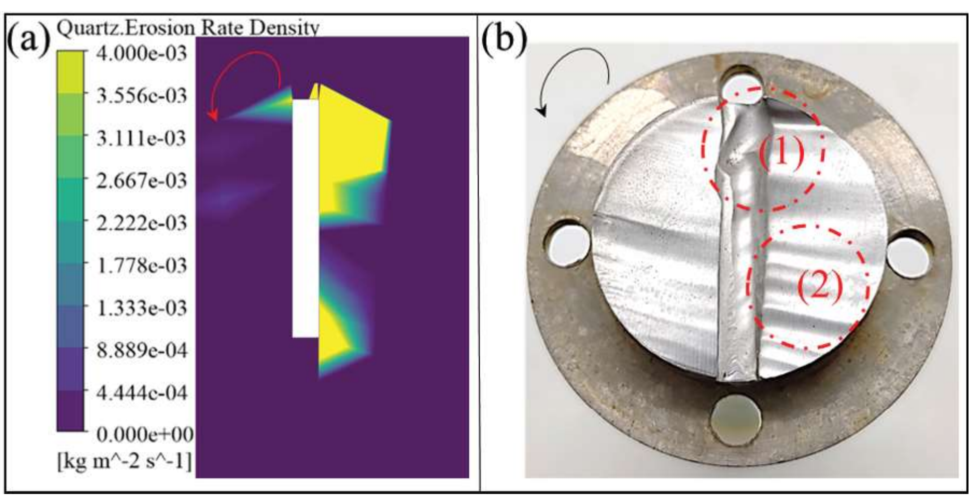


Fig. 4 Result from numerical study and experiment (a) Sediment erosion predicted by numerical study and (b) Erosion predicted by the experiment for same case

CMHydro

"Condition Monitoring of Hydropower Plants in Nepal owned by NEA."

Objectives:

- Identification of general and specific problems in hydropower plants in Nepal along with investiga-tion, determination and finalization of the possible parameters for condition monitoring.
- Determine respective instrumentation & data acquisition system and develop reference data set for condition monitoring.
- Develop a monitoring program and perform fault detection in real time.
- Development of procedure/standards for conducting condition monitoring in Nepalese hydropow-er plants

Principal Investigator	Dr. Hari Prasad Neopane	KU
Co-principal Investigator	Dr. Sailesh Chitrakar	KU
Activity Leader	Dr. Ram Lama	KU
Researchers	Mr. Prajwal Sapkota; Mr. Amul Ghimire	KU
Project Date	September 2020 to August 2023	
Funding Agency	Nepal Electricity Authority (NEA)	

Summary

Condition monitoring as name itself is a part of predictive maintenance process to detect faults in machine components. This project (CM Hydro) is joint collaboration between Turbine Testing lab and Nepal Electricity Authority (NEA) which aims for general and specific problem identification of NEA owned power plants for the study and implementing condition monitoring process in Nepalese power plants. Six power plants have been selected for the study process which includes power plant ranging from one

hundred & forty-four megawatts to one megawatt projects. Similarly, it includes power plants with all types of turbine available in Nepal i.e., pelton, francis and bulb turbine types. The power plants are Devighat Hydropower Station, Seti-Phewa Hydropower

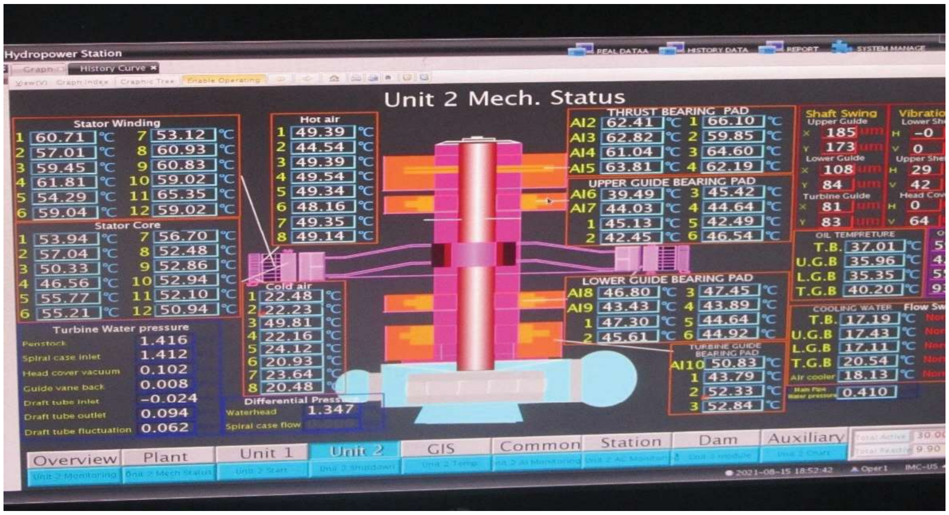


Fig. 1 Monitoring system of Trishuli 3A

Station, Puwakhola Hydropower Station, Chatara Hydropower Station, Gandak Hydro-power Station and Kaligandaki Hydropower station. The project aims for further analysis of condition moni-toring parameters to predict developing faults in the hydro-power plants.

Fig. 2 Sediment erosion of runner at Kaligandaki hydropower plant

Similalry, a separate study is being carried out to which expects to reduce erosion by using optimization techniques for the runner of Kaligandaki Hydro power station at variable speed operation.

UGC Project

"Experimental investigation of sediment erosion in hydraulic turbine."

Objectives:

- Design and develop the non- re-circulating type (NRC) of erosion setup to perform erosion tests and quantify the results.
- Performance testing and evaluation of discrete sediment injection and separation system employed in the erosion set-up.
- Compare the experimental results obtained with other experimentally and numerically obtained results from literature for validation.

Principal Investigator	Dr. Hari Prasad Neopane	KU
Co-principal Investigator	Dr. Biraj Singh Thapa	KU
Researcher	Mr. Aman Kapali	KU
Project Date	2018 to 2021	
Funding Agency	University Grants Commission, Nepal	

Summary

Most of the erosion testing developed so far, especially for studying the sediment erosion problem in hydro turbines is re-circulating –type test rigs with the rotating type of test specimens. Erosion studies were conducted using RC-type test rigs because of the complex design and operating system involved in NRC –type. However, an attempt has been made to design and develop an NRC-type test rig that can be reproduced and can maintain repeatability of the test. The operational limits include a flow rate up to 67 l/s and/or a pressure head up to 33 m. The sediment injection capacity of the injection system ranges between 2.6-26 l/min for different rpm of the peristaltic pump.

The tests are conducted on an aluminum test blade of a Cross-flow runner by accelerating the sediment concentration to evaluate the amount of erosion and erosion rate in a short period of time of operation. The validation of the results obtained using this rig is done for erosion patterns observed in the painted specimen of Cross-flow runner blades with that of numerical studies. The erosion curves plotted at different values of concentration for test duration of 12 hours are compared with findings from the literature that were carried out using RC-type test rigs. The discrete sediment injection system and sediment separation system are evaluated based on the injection efficiency and separation efficiency, and found to be within 10% and above 95% respectively.

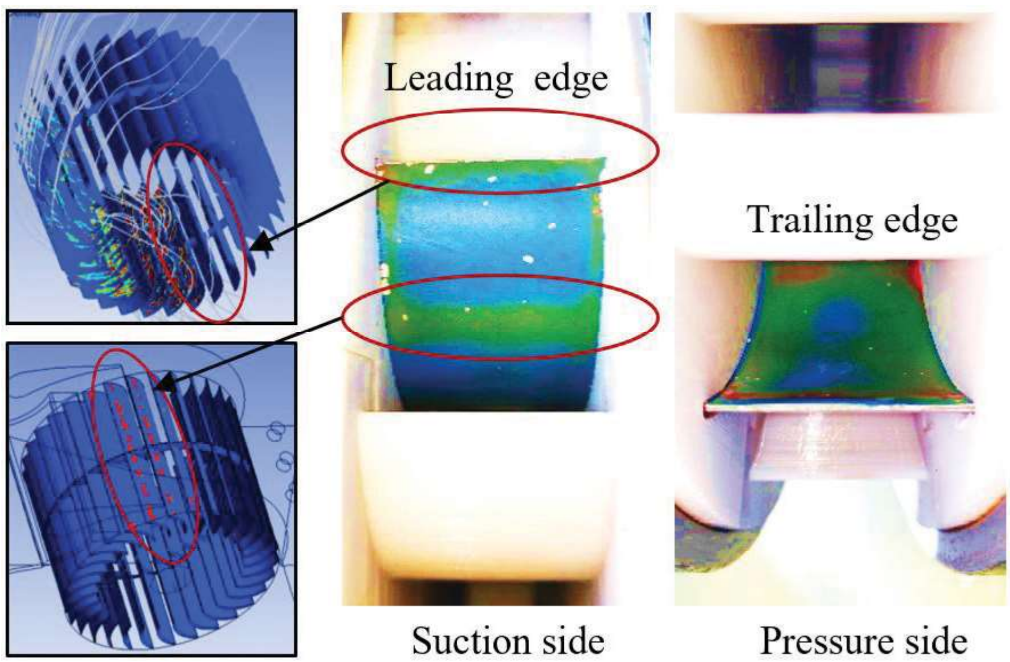


Fig 1. Comparative study of erosion pattern

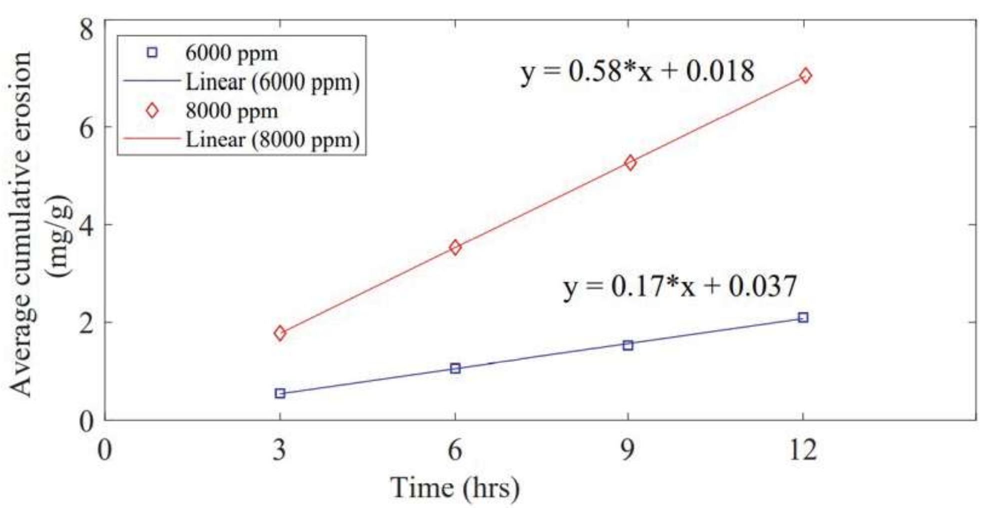


Fig 2. Effect of slurry aging in erosion curve

Doctor of Philosophy (Ph.D.)

"Development of Sediment Friendly Cross Flow Turbine."

Candidate	Mr. Oblique Shrestha	Kathmandu University
Advisor/ Supervisor	Dr. Bhola Thapa	Professor, Kathmandu University
	Dr. Hari Prasad Neopane	Professor, Kathmandu University
	Dr. Young Ho LEE	Professor, Korea Maritime and Ocean University
Start Date		2015
Status		In Progress

Objectives:

- To design sediment resistive turbine blade using numerical approach (CFD studies).
- To develop a CFT erosion test rig (ERT)
- To validate the optimized blades obtained from numerical studies using ERT.

Summary

This research work is based on both numerical and experimental analysis. It can be divided broadly into three sections: Rotating Disc Apparatus (Numerical and experimental analysis), Numerical Studies on KMOU design and Experimental works to validate it. In the first part of this study, a close investigation of the previous research and development on RDA was carried out to develop an RDA and conduct the experiment to evaluate the sediment erosion on the crossflow blade of different designs. A series of experiments on a different design of T-15 blades were performed using RDA at KU and KMOU to investigate the sediment erosion effect on the alternative design of CFT blades. The KMOU design was the optimized design of the T-15 model to obtain maximum efficiency. The experiment was done on the optimized blade using five different materials and tungsten carbide coating. The second part of this study focuses on numerical studies on KMOU design by varying the β-angle distribution. Five different cases of different β-angle distribution were formulated and a numerical study was carried out to minimize the effect of sediment on a runner without significant loss on the efficiency

of the CFT.

Finally, the sediment erosion test setup was designed and developed at TTL to experiment on CFT turbine to study its performance along with the sediment erosion patterns on blades which can be compared with the numerical analysis results to validate them.

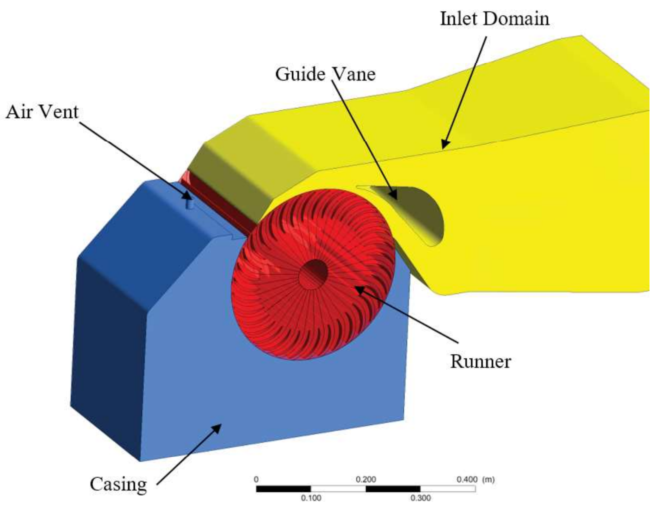


Fig. 1 Domain for CFD analysis

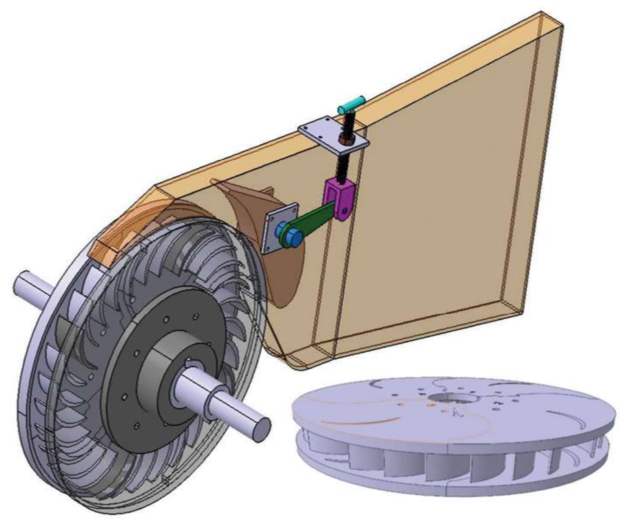


Fig. 2 3D CAD model of experimental CFT

Fig. 3 3D CAD model of the experimental setup

Doctor of Philosophy (Ph.D.)

"Optimization of Francis Turbine Runner and Guide Vane for Minimizing Sediment Erosion"

Candidate	Dr. Ram Lama	Kathmandu University
Advisor/ Supervisor	Dr. Hari Prasad Neopane	Professor, Kathmandu University
	Dr. Biraj Singh Thapa	Assistant Professor, Kathmandu University
Start Date		May 2017
Status		Completed September 2021

Objectives

- To optimize the design of Francis runner and guide vane for minimizing sediment erosion
- To compare the numerical and experimental results of existing design of model Francis turbine
- To develop a Francis turbine's testing facilities at Turbine Testing Lab

Summary

Sediment erosion in hydraulic turbine is the major problem from the perspective of operation and maintenance in power plants of Himalayan and Andes region. The conventional design criteria for high head Francis turbine i.e., the highest possible efficiency avoiding cavitation with smallest possible dimension is not appropriate for projects under these regions, where sediment flow is severe. The prevention of sedimentation in the catchment areas, tapping sediments at intakes, and applying preventive coatings on turbine components exposed to high velocity water are not only complete solution for reducing the sediment erosion. The sedimentation problem in this region leads to create a new design philosophy for turbine design by incorporating this problem in hydraulic design itself thereby ensuring minimum sediment erosion effects on the runner. In this study, the proper selection of guide vane profile and optimization of the runner blade geometry is carried out to ensure the better performance of the turbines for sediment laden water. Each hydraulic design parameters having highest effects on sediment erosion of Francis runner are varied in pre-defined ranges and changes in erosion relative

to the reference design are evaluated. Area averaged sediment erosion rate density has been defined as a means for the relative change in sediment erosion due to variation of the runner design.

The data from Jhimruk hydropower plant with severe sediment erosion problem is chosen as reference case for this study. Numerical method has been used for evaluating the hydraulic performance of the turbine. For the experimental investigations on the performance of the turbine, the Francis turbine testing facility was designed and developed at TTL. The complete Francis turbine test rig consists of turbine unit with the setup of 92 kW model turbine, generator, pressure tanks (High and Low), compressor unit, pipelines, valves, pumps, torque transducer, flow meter and pressure sensors installed at different locations of turbine components. With the test set up the validation of the numerical model was carried for the validation of the efficiency measurement. It was found that, at all the rotational speed of the turbine the numerical model gives good agreement with the experiment with highest deviation 1.62%.

Fig. 1 Experimental set up for 92 kW Francis turbine

For selection of guide vane profile with smoothest acceleration and minimum leakage flow, the numerical analysis on Francis turbine of Jhimruk Hydropower Plant was carried out with three different guide vane profiles with sediments. Out of three guide vanes profiles NACA 4412 exhibited optimum performance and minimum sediment erosion on runner blades for all operating conditions. Therefore, implementation of NACA 4412 in real power plant can be done to have minimum

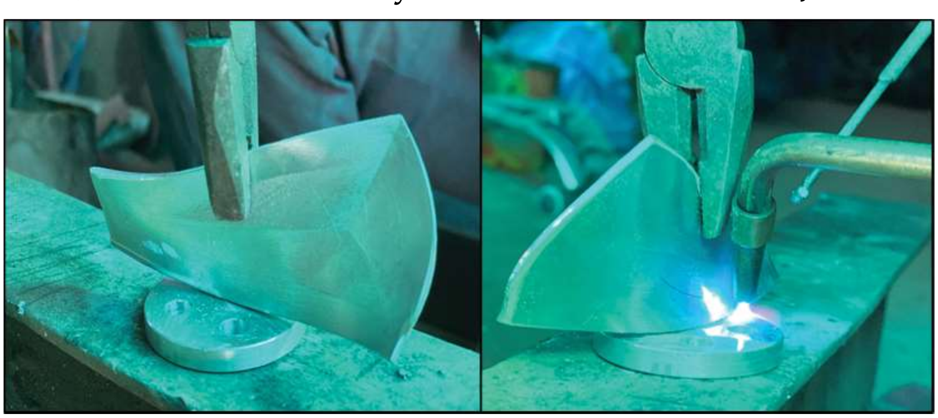


Fig. 3 Development of scaled down runner blade to investigate the sediment erosion by experiment

sediment erosion on runner blades and optimum performance at all operating conditions. Finally, optimization of the runner and guide vane was carried out to improve the performance of the runner with an aim to minimize the sediment erosion by considering basic design parameters. The optimization process combines with basic design settings, numerical analysis, and optimization in an iterative loop. The design methodology is parameterized in a MATLAB algorithm. Parameterized runner designs are implemented in the Design of Experiment (DoE) to get sample runners. These sample runners are investigated using a CFD tool to obtain efficiency and sediment erosion data. Response Surface Model (RSM) is used to predict the output parameters by changing the input parameters using second order polynomial function. The generated sample runners are used in the optimization based on Multi-Objective Genetic Algorithm to generate final optimal runner.

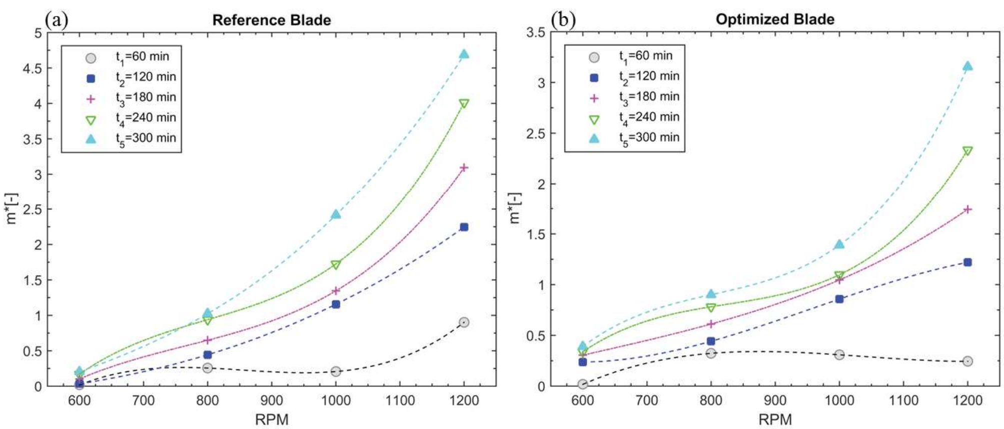


Fig. 3 Effect of erosion at different time and different RPM, (a) Reference blade and (b) Optimized blade

From the series of optimization for the runner, the erosion rate was improved by 14.78% with negative improvement in efficiency by 2.36% for preferred blade. These opposite trends of efficiency and sediment erosion gives choice of selecting the turbine based upon its operation for clean water or sediment laden water. On the other hand, for combined NACA 4412 guide vane profile and preferred blade, the improvement in erosion and efficiency were 32.73% and 0.01% respectively. To validate the optimized blade from erosion perspective an experiment was conducted in Rotating Disc Apparatus (RDA) for evaluating the erosion wear pattern and sediment handling capacity for scale down model of reference and optimized blade. From the experiment it was observed that erosion rate is significantly reduced for the optimized blade as compared to the reference blade at high rotational speeds and several hours of operation thereby confirming better sediment handling. Therefore, all these results give choice for the turbine designer to evaluate the need of turbine to be operated of sediment laden water or clean water whether efficiency is the critical parameter to be considered or sediment erosion. For hydropower plants operated in sediment laden water, sediment erosion improvement by 32.73% could be wise selection for the turbine that minimizes the overall operation and maintenance cost of the power plant.

Doctor of Philosophy (Ph.D.)

"Condition Monitoring of Hydraulic Turbines Exposed to Sediment Erosion."

Candidate	Mr. Prajwal Sapkota	Kathmandu University
Advisor/ Supervisor	Dr. Bhola Thapa	Professor, Kathmandu University
	Dr. Hari Prasad Neopane	Professor, Kathmandu University
	Dr. Sailesh Chitrakar	Assistant Professor, Kathmandu University
Start Date		2019
Status		In Progress

Primary Objective:

- To conduct the condition monitoring of turbines exposed to sediment erosion.

Secondary Objectives:

- To investigate, determine and finalize the possible parameters for condition monitoring of turbines exposed to sediment erosion.
- To develop reference data set and a monitoring program to detect the fault on the basis of developed data set.
- To develop a standard procedure for condition monitoring in the context of sediment eroded turbines.

Summary

Condition monitoring is a part of predictive maintenance process for detecting faults in a machine components with the help of pre identified measuring parameters to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. The use of condition monitoring allows maintenance to be scheduled, or other actions to be taken to prevent consequential damages and avoid its consequences. Condition monitoring has a unique benefit in that conditions that would shorten normal lifespan can be addressed before they develop into a major failure.

Some hydropower plants have been chosen for the identification of problems in Nep-

alese power plants. The basis of choosing power plants is size of power plant and type of turbines used in the power plant. The problem identification processed followed a questionnaire survey to respective plant managers and field visit to the respective site. The major problem identified were leakage, sediment erosion at different turbine components along with head covers, leakage, vibration, cavitation and heating.

Similarly, the measurement process has been studied in the respective sites during the time of questionnaire survey and field visit. With the advancement in technology, newer power plants are being equipped with newer system and sophisticated technology for measurement and data acquisition of different parameters at hydropower plants. But in case of older power plants, there is no such measuring system and they rely on the analog or in worst cases very minimal measuring devices. The older power plants have analog measuring devices for measuring pressure, speed, current, voltage, power factors, frequency while the newer power plants have new sensors for measuring pressure at different locations including heat exchangers and oil pressures, temperature of bearings and oils, power output, vibration at different positions, speed, reservoir levels, oil levels, temperature of generators, position of guide vanes & spare needles.

Fig. 1 Leakage of water from shaft seal during the operating condition.

Fig. 2 Monitoring and control system in one of the hydro power plant.

Master by Research (M.S.)

"Performance Evaluation of Pump in Nepal with Application in Turbine Mode for Hydropower Projects."

Candidate	Mr. Nischal Pokharel	Kathmandu University
Advisor/ Supervisor	Dr. Bhola Thapa	Professor, Kathmandu University
	Dr. Biraj Singh Thapa	Assistant Professor, Kathmandu University
Start Date		March 2019
Status		In Progress

Objectives:

Primary Objective:

- Performance evaluation of a pump in turbine mode and design modification for efficiency improvement

Secondary Objectives:

- Identify a suitable pump for laboratory testing in Turbine mode.
- Numerical and experimental analysis of pump in Turbine mode and its design modification for better efficiency.
- Modification and laboratory testing of pump impeller in Turbine mode

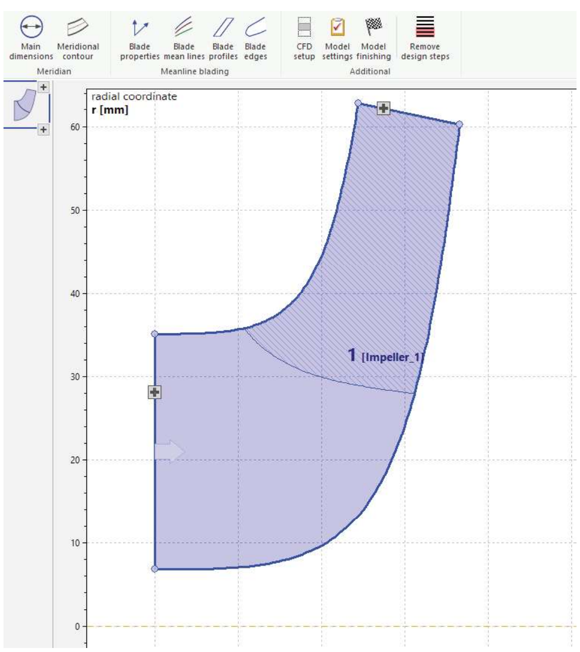
Summary:

Designing and manufacturing site-specific turbines for small hydropower is not economical. Using abundantly available Pump, from the market, as Turbine (PAT) instead of designing a completely different turbine can be much more economical for small-scale hydropower. Lot of research have been going throughout the world on this and has already proven its effectiveness. In Nepalese hydropower, including the ones already developed and the ones that will be developed in the future, Francis turbines are supposedly the suitable turbine of choice. However, designing and manufacturing Francis turbine is a tedious task and the local manufacturers, who are expert in manufacturing Cross-flow turbines; do not have the technology and competence to manufacture the modern Francis turbines. Sediment in Himalayan rivers are the major hurdles of operation as they reduce the lifetime of the turbine by a very large factor, shooting up the

Fig. 1 Erosion Pattern in pump impeller

maintenance cost of the hydropower. The operational region of Francis turbine and PAT overlaps quite a lot, thus indicating that PAT can be used in many of the hydropower in Nepal. The Chinese and Indian pump manufacturers are already renowned in developing a wide range of pumps and supplying them in Nepal. Despite having such great opportunity, pumps have never been used in turbine mode in Nepalese hydropower. In addition to that, no research has been done, in Nepal, regarding the effects of sediment on pumps being operated as pump or turbine.

Therefore, this study mainly started with motive of uplifting pump technology in Nepal utilizing the existing market and resources in the country. This study started with some literature review about the status of pump technology used in Nepal. The study revealed that there are large volumes of pump imported in Nepal. However, no manufacturers are in the country for its production.



Fig, 2 Meridonial view of impeller in CFturbo

Fig. 3 3D printed impeller

Master by Research (M.S.)

"Variable Speed Francis Turbines for Sediment Laden Hydropower Projects."

Candidate	Mr. Amul Ghimire	Kathmandu University
Advisor/ Supervisor	Dr. Hari Prasad Neopane	Professor, Kathmandu University
	Dr. Sailesh Chitrakar	Assistant Professor, Kathmandu University
Start Date		July 2020
Status		In Progress

Objectives

Primary Objective:

- To optimize variable speed Francis to minimize sediment erosion

Secondary Objectives:

- Development of the reference scenario, including the design parameters, factors affecting erosion and possibility of the variable speed operation for a chosen site.
- Perform design optimization of the turbine to minimize sediment erosion in variable speed conditions using numerical techniques.
- Experimental validation of the optimum design.

Summary:

Electricity market of the whole world is developing such that the fluctuations in demand, even in a single day cannot be controlled. In order to meet the fluctuating demand, hydro turbines have to be operated at off design conditions. Operating turbines at off design conditions causes substantial damage to the turbine components. The situation is much worse when sediment comes into the picture as the turbines run by sediment laden waters, at off design conditions are found to have much shorter life.

Variable speed Francis turbines have been recommended to be the solution to the problem caused by its frequent operation at off design conditions. This study is going to analyze the effectiveness of variable speed of Francis turbine in sediment laden hydropower. In contrast to the previously performed studies in variable speed Francis turbines, this study will optimize the turbine, taking into consideration that sediment erosion is the primary optimization parameter.

Kaligandaki-A hydropower project, which is one of most affected project due to sediment erosion, is selected as the reference site for the study. The reference design of the project has been prepared based on the drawings available from previous studies. Numerical analysis of the design was performed to predict the sediment erosion on the runner and it was found that locations near trailing edge, towards the shroud on low pressure side and the shroud are of the runner are most affected region in the runner, which is very . In order to design a variable speed Francis turbine to be operated in sediment laden hydropower project, optimization is being carried out taking meridional shape, blade angles at inlet and outlet, blade angle distribution, lean, etc as the key design parameters. Multi Objective Genetic Algorithm is being used for the optimization of the design.

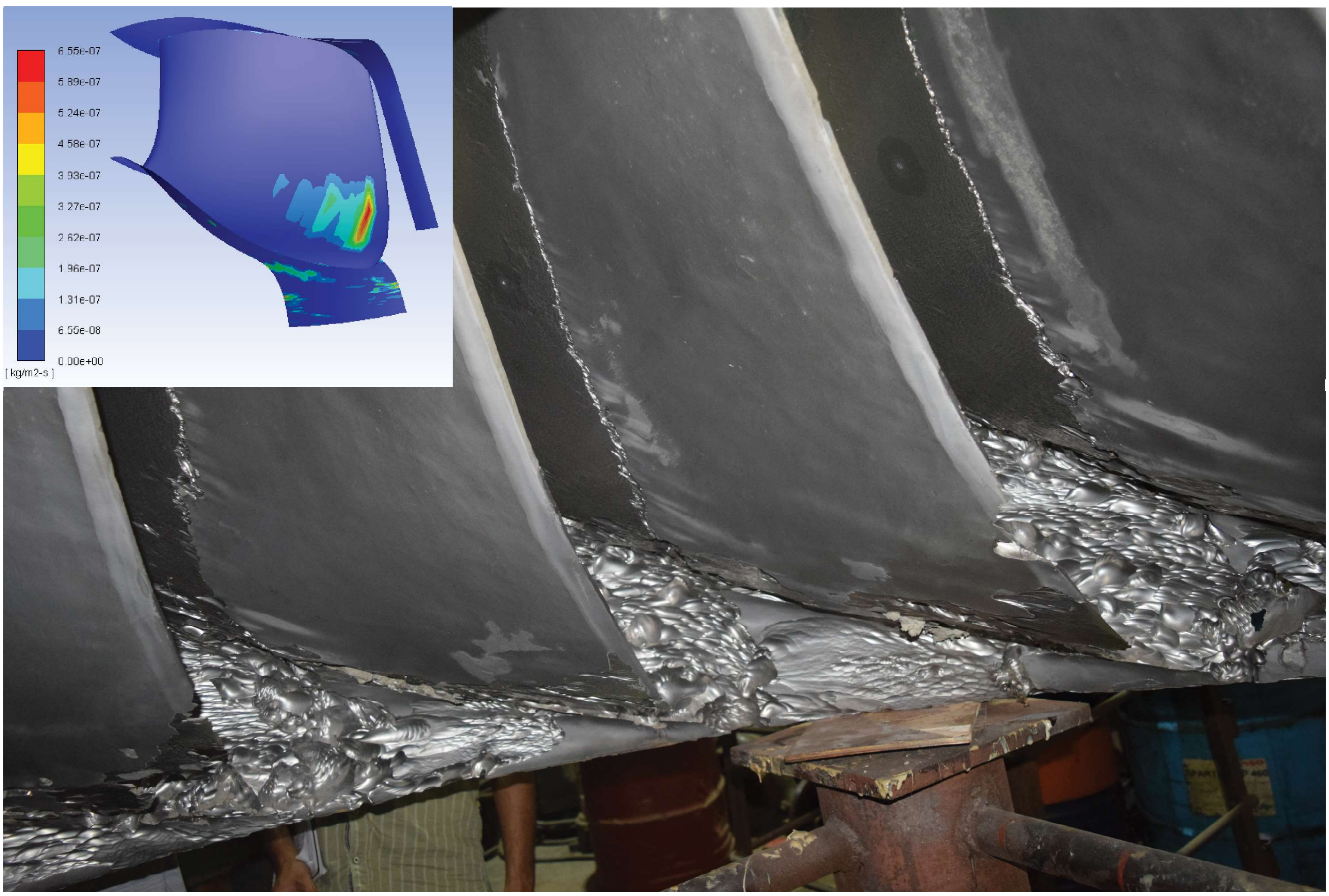


Fig. 1 Comparision of sediment erosion at site and as predicted using Numerical Analysis

Laboratory Test with Full Scale Erosion Test Rig

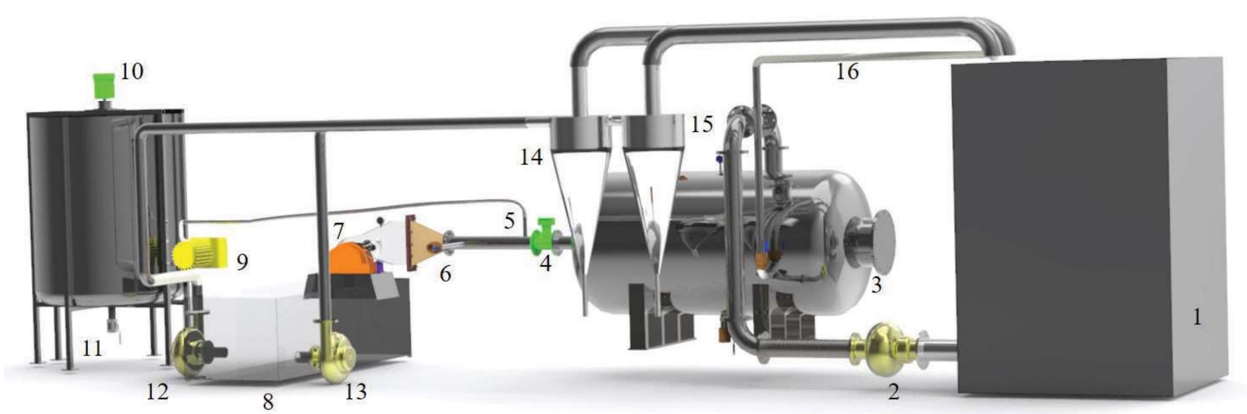
The problem of slurry erosion is serious in the hydro power plants operating in sediment laden-water. These sediment particles comprise various constituents like quartz, feldspar, and garnet that are even harder than turbine materials. A continuous interaction between these sediment particles and hydraulic components like spiral casing, stay vanes, guide vanes, nozzles, seals etc. of hydropower plants causes material loss over the period of operation. The loss of material from components over a period of time leads to geometrical changes in hydraulic profiles and an increase in surface roughness. Erosion in turbine parts support cavitations, vibration, and failure and associated frequent shutdowns. Ultimately, this results in huge financial loss every year due to increased maintenance costs, losses in electricity generation during the shutdown or overhaul periods.

Evaluation and quantification of the erosion can be achieved by laboratory testing. Laboratory testing using erosion testing apparatus has proven to be useful in the prediction, evaluation, and quantification of erosion; selection of the materials based on their erosion resistivity, and design optimization to minimize its effect. These tests are conducted to study basic wear mechanisms and to investigate the effect of various erosion influencing factors on the erosion rate of different materials and coatings, particularly caused by the impact of sediment particles. These types of laboratory tests are purposely designed to accelerate the wear rate of test specimens in order to obtain results in a short period of time within a controlled and monitored environment. In case of erosion testing by solid particle impingement, normally the velocity of impact particles or concentration of the abrasives, density of the abrasives is amplified to obtain rapid erosion results. It should be kept in mind that the result of accelerated tests should be expressed in terms of erosion rate, corrosion, efficiency, life etc. with respect to the level of impact applied over time. However, these testing facilities are limited by their ability to test the erosion in turbines by simulating actual operating conditions.

This article describes the non-recirculating type of erosion test rig, developed and installed in TTL. This experimental test set up consists of all the components that are required to perform sediment erosion test and can closely replicate an operation conditions as in hydro power plants as shown in Figure below. It consists of two discrete independent systems that are (a) sediment injection system and (b) sediment rejection system. In the former type, the sediment particles are injected into the turbine inlet by the peristaltic pump that pumps the pre-mixed slurry contained inside the mixing tank. The provision of a concentration measurement port at the turbine inlet allows the determination of sediment concentration using the sand flow method. The latter system includes the hydro cyclone, which separates the sediment particles from the slurry mixture after passing through turbine. A double suction split type centrifugal pump, driven by VFD is used to supply the required flow into the high pressure tank that further pressurized the fluid to obtain the required head. The electromagnetic flow meter is mounted between the turbine and pressure tank to measure the discharge. A turbine's inlet pressure is measured by placing two pressures tapping, connected to the pressure transducer, at the turbine's inlet pipe. The efficiency measurement is calculated by the data obtained from the torque transducer mounted in between the generator and the runner. A data logging system is used to collect and store all the data from the sensors using LabVIEW.

The most distinctive features of the test rig are given in the Table below.

Distinctive Features	
Variable flow rate	13.24 - 67.32 Liters per second
Variable pressure head via. pressure tank	Up to 60 meters
Variable sediment injection system	2.6-26 Liters per second
Non-Recirculation type	Hydro cyclone designed for d_{50} =19 microns

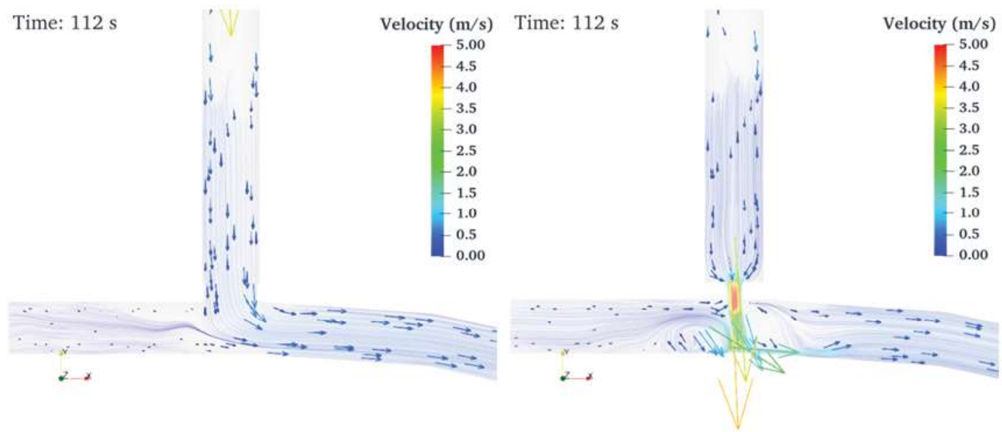


1.Sump tank, 2.Main pump, 3.Pressure tank, 4.Flow meter, 5.Sediment injection port, 6.Sediment concentration monitoring port, 7.Cross-flow turbine, 8.Turbine outlet collection tank, 9.Peristaltic pump, 10.Stirrer motor, 11.Mixing tank, 12&13.Secondary pumps, 14&15.Hydro cyclone, 16.Bypass line

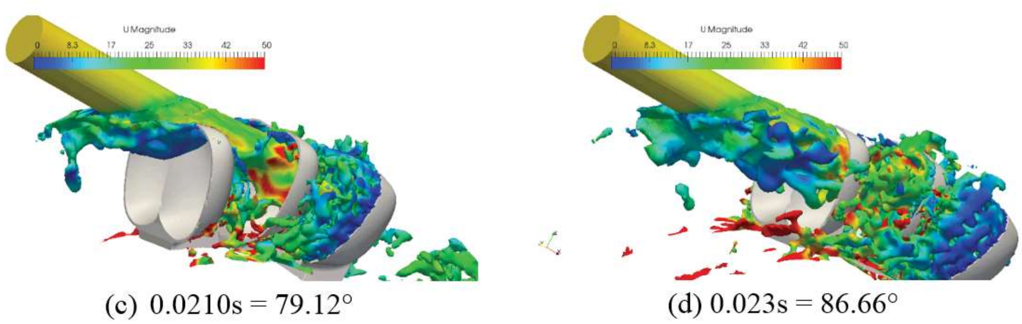
Aman Kapali
Research Associate
Turbine Testing Lab

Openfoam for Hydropower Applications and Cooperation with KU-HPC

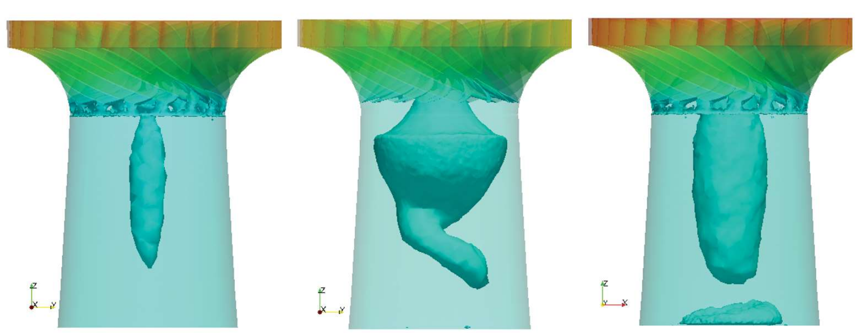
Turbine Testing Lab has recently started several cooperations with KU-Supercomputer Center for carrying out CFD on turbines and other components related to hydropower. Apart from that, several workshops have also been conducted for the interested students related to the use of supercomputer for Openfoam.



Flow visualization in the surge shaft during startup (above) and shutoff (below) conditions for surge shafts with and without orifice (Prabin Timilsina et. al., 2021)



Interaction of jet with bucket at different degree of rotation (Pawan Bijukchhe et. al., 2021)



Visualization of vortex draft tube vortices at different operating conditions (Saroj Basnet et. al., 2021)

GHL: Research Excellence

As the rest of the word is making a transition towards the hydrogen-based economy, the developing country like Nepal cannot alone remain behind. There has been a need to initiate scientific exploration and research on green hydrogen technologies at the Nepalese academic institutions. Since the technology has achieved a much higher development stage at a global level, for Nepal the start would be knowledge transfer and local adaptation. To make the transition period of the technology transfer shorter for Nepal, the Green Hydrogen Lab (GHLab) was established on 2nd August 2020 under Department of Mechanical Engineering (DoME), Kathmandu University with the vision to specialize Nepalese industries to produce, store, transport, and use green hydrogen at a commercial level. Green Hydrogen Lab aims to transfer technology, innovations and local adaptation of green hydrogen energy systems in Nepal through continuous research and development activities.

With the continuous efforts, GHLab was successful to sign a MoU between KU and Nepal Oil Corporation (NOC) to foster the mutual interest and development in the field of field of fuel and energy sector on 8 January, 2021, leading to an agreement for the research grant support of 50 million NPR. To promote and facilitate the research within the GHLab, a MoU was signed in between Department of Mechanical Engineering, KU and Jade Consult Pvt. Ltd on 25 January, 2021. On 28 April, 2021 Kathmandu University and Alternative Energy Promotion Centre (AEPC), Nepal signed a MoU to setup the demonstrative facility for the production, storage and use of Green Hydrogen.

On the occasion of World Environment Day, 5 June 2021, considering the significance of environmental impacts of green fuel, GHLab set forth for National Hydrogen Initiatives. The National Hydrogen Initiative (now Nepal Hydrogen Initiative) is being incubated as a consolidated program of the Nepal Government with the mandate to establish the policy foundations, develop an implementation action plan, and incubate a value chain for the business development with Green Hydrogen. GHLab has been engaging with Ministry of Energy, Water Resources and Irrigation and Ministry of Education, Science and Technology, regarding the possible collaborations for Nepal Hydrogen Initiatives. Green Hydrogen Lab organized training on "Green Hydrogen for Nepal: Media Perspective" on 20 September 2021 to understand the viewpoint from the perspective of journalist and aware media sector regarding technological and environmental urgencies of green hydrogen.

As of now, GHLab has integrated a course Hydrogen Technologies in the fourth-year undergraduate course of Department of Mechanical Engineering, Kathmandu University. Green Hydrogen Lab has set up a 10W and 1kW hydrogen production and demonstration model in the laboratory. More than 50 technical/popular articles and few research papers have been published from the lab. At present, Green Hydrogen Lab has enrolled 1 Ph.D. and 3 Master by research candidates together with 3 full-time researchers, 6 interns and more than 15 undergraduate students involved in several projects.

Fig. 1 Timeline of major activites accomplished at Green Hydrogen Lab (GHL)

Asst. Prof. Dr. Biraj Singh Thapa
Team Leader
Green Hydrogen Lab
Kathmandu University

Academia-Industry Cooperation at TTL

One of the main objectives of Turbine Testing Lab of KU is to develop a bridge between academia and industry, such that the research activities of the academics are driven by the actual industrial problems. Within a decade of the establishment of the lab, TTL has been able to gain a momentum and create a remarkable achievement in uplifting this cooperation through joint projects, workshop/trainings, emphasizing on the local manufacturers for testing of turbines and conducting research works on the local problems of hydropower plants. Apart from the international collaboration and research focusing on the state-of-the-art technologies, there is a need for establishing a research culture in the hydropower industry of Nepal by focusing on the specific problems. The idea is to attract the industrial investment on the activities of TTL, such as to ensure the sustainability of the lab in a long run. Therefore, the objective of the present concept is to create a separate wing of TTL that focuses mainly on strengthening the linkage between the two sectors, University and Hydropower industries, by keeping in-tact the regular research activities of the lab.

Turbine Testing Lab is broadening its academic research scope in the field of hydropower with a vision to produce highly skilled human resource that can contribute on national as well as global hydropower industry. In present context, condition monitoring has not been prioritized in Nepal but globally condition monitoring is a widely applied science and a successful tool in predicting the failures of machine components. Hydropower plants no more differ from different failures & breakdowns and they need frequent maintenances. The industrial wing at TTL believes on the essence to start a collaboration of Nepalese Governmental Entities and Universities to work for the development of Nepalese hydropower industry for solving these problems. The wing aims for identifying major problems & its physical parameters in power plants which needs a serious investigation.

This co-operation has both academic and industrial benefits. It would be helpful in bridging the Nepalese knowledge with industries for solving a common goal. This kind of collaboration will be a milestone for the development of human resource and generation of academic knowledge in Nepal. Successful completion of this project has long term benefits in the field of O&M as well as reducing the unexpected breakdown of components in Nepalese power plants.

Major roles of the Academia-Industry Cooperation

- Facilitate the academia-industry collaboration in TTL
- Maintain bridge between TTL and relevant industries for applied research and knowledge transfer
- Facilitate collaboration between national and international industrial experts/organization for knowledge sharing through training/workshop etc.
- Provide basis for policy interventions related to laboratory model testing of the turbines through continuous discussions with national stakeholders.
- Make necessary arrangements for carrying out prototype testing of the turbines.
- Co-ordinate with local industrial sectors for the identification of the problems associated with hydropower and research for the solutions.

Dr. Ram Lama
Co-ordinator,
Academia-Industry Cooperation
Turbine Testing Lab

3rd IAHR-Asia Symposium on Hydraulic Machinery and Systems

This year, Turbine Testing Lab is hosting one of the most prestigious events in the field of Hydraulic Machineries and Hydropower, IAHR-Asia chaired by the Vice-Chancellor of Kathmandu University, Professor Bhola Thapa. The event is going to take place in a hybrid (physical and online) mode, with around 70 technical papers. The papers are planned to be published in IOP Conference Series: Earth and Environmental Science.

Conference Organizing Committee

Professor Bhola Thapa (Chair)

Professor Won-Gu Joo, Yonsei University (Co-Chair)

Professor Zhengwei Wang, Tsinghua University (Co-Chair)

Professor Chisachi Kato, Tokyo University (Co-Chair)

Local Organizing Committee

Dr. Biraj Singh Thapa (Co-Chair)

Dr. Sailesh Chitrakar (Secretary)

Prof. Dr. Manish Pokharel (Advisor)

Dr. Brijesh Adhikary (Advisor)

Prof. Hari Prasad Neopane (Advisor)

Prof. Triratna Bajracharya (Member)

Dr. Daniel Tuladhar (Member)

Mr. Kul-Man Ghising (Member)

Mr. Amul Ghimire (Member)

Mr. Ashim Joshi (Member)

Keynote Speakers

Professor François Avellan
Swiss Federal Institute of Technology Lausanne

Professor Young-Ho Lee
Korea Maritime and Ocean University

Professor Chisachi Kato
The University of Tokyo

Professor Wang Zhengwei
Tsinghua University

Technical Papers

Theme: Hydraulic Turbines

HT002 Comparative CFD analysis of Kali-gandaki "A" Francis runner with runner generated from Bovet method
Samundra Karki, Srijan Satyal, Krishna P Rijal, Neeraj Adhikari and Prasanna Koirala
Tribhuvan University, Nepal

HT004 Determination of Casting Parameters for Affirmative Directional Solidification in 750 KW Francis Runner
Abishek Kafle, Nishant Sapkota, Raman Silwal, Pratisthit Lal Shrestha, Nischal Sharma, Bhola Thapa
Kathmandu University, Nepal

HT005 Experimental and CFD simulation validation performance analysis of Francis turbine
Baig Mirza Umar, Jingwei Cao and Zhengwei Wang
Tsinghua University, China

HT006 Experimental and numerical modal analysis of a reduced scale Kaplan turbine model
R Roig, O De La Torre, E Jou, B Mulu, X Escaler
Universitat Politècnica de Catalunya, Spain

HT007 Experimental Investigations of a Simplified Francis turbine
Amul Ghimire, Prajwal Sapkota, Atmaram Kayastha, Biraj Singh Thapa, Young Do Choi, Young Ho Lee, Kathmandu University, Nepal

HT008 High flexibility in Francis turbine operation and design philosophy: A review
Johannes Opedal Kverno, Igor Iliev and Ole Gunnar Dahlhaug
Norwegian University of Science and Technology, Norway

HT011 Study on the characteristics of vortex motion and pressure pulsation in vaneless zone of Kaplan turbine
J Y Xue, C Z Meng, X F Fan, L J Zhou and Z W Wang
China Agricultural University, China

HT012 Use of 3D Printing technology for developing novel procedure to manufacture runner of Francis Turbine
Abishek Kafle, Pratisthit Lal Shrestha, Raman Silwal, Amul Ghimire, Sailesh Chitrakar, Bhola Thapa
Kathmandu University, Nepal

Theme: Pump and Pump-Turbines

PP003 Comparative analysis of flow characteristics of different blade inclination outlet schemes of long shaft pumps
J F Zhang, W J Zhang, S B Jin, Z J Yang, C M Jin, L H Fu, X H Yu and G D Li
Jiangsu University, China

PP005 Numerical Investigation of Hydraulic Performance and Recirculating Flow Characteristics at Low Flow Rates of a Mixed-flow Pump with Various Impeller Inlet Diameters
Yong-In Kim, Hyeon-Mo Yang, Kyoung-Yong Lee, and Young-Seok Choi
Korea University of Science and Technology, Korea

PP008 Static Characteristics Analysis of Shaft Rotor of Vertical Long-Shaft Fire Pump Under the Connection of Different Shaft Lengths
J F Zhang,X H Yu,S B Jin,Z J Yang,H Q Song, L H Fu and W J Zhang
Jiangsu University, China

PP009 Wear in centrifugal pumps: causes, effects and remedies: A Review
Nischal Pokharel, Amul Ghimire, Biraj Singh Thapa, Bhola Thapa
Kathmandu University, Nepal

PP010 Numerical investigation of the non-condensable gas effect on predicting the cavitation performance of a centrifugal pump
Lei Cao, Liu Mingming, Wang Zhengwei and Zhang Yiyang
CCCC National Engineering Research Center of Dredging Technology and Equipment Co. LTD., China

PT001 Influence factors of clearance leakage flowrate and clearance hydraulic axial force of pump-turbine
X X Hou, Y G Cheng, D L Hu, S Xue, B Wang, X X Zhang, X Wang and J H Ding
Wuhan University, China

PT002 Pressure pulsation analysis of runner and draft tube of pump turbine under different working conditions
Dong Wang, Zhenggui Li, Qing Zhao, Deyou Li, Wanquan Deng, Lei Ji◎Peng Shengyang
Xihua University, China

PT003 Research on Selection of Different Speed Units for Super High Water Head and Large Capicity Pumped Storage Power Station
Zhang Xin◎Li Haijun◎Shen Jianchu◎Zhou Jie
Huadong Engineering Coorporation, China

Theme: Small and Micro Hydropower

SM002 Tunnel support practice in small hydropower tunnels in Hindu Kush Himalaya region through observational approach
Sujan Karki, Bimal Chhushyabaga, Shyam Sundar Khadka
Kathmandu University, Nepal

SM004 Design of Structural components of a Power House Located in the Nepal Himalaya
Bimal Chhushyabaga
Kathmandu University, Nepal

SM006 Performance Analysis of Micro Francis Turbine Manufactured Locally in Nepal
Dadi Ram Dahal, Aatmaram Kayastha, Sailesh Chitrakar, Biraj Singh Thapa, Hari Prasad Neopane and Bhola Thapa
Kathmandu University, Nepal

SM001 Analysis and research on sluice gate flow of a hydropower station under different working conditions
Yang Xu, Zhenggui Li
Xihua University, China

SM003 Analysis of deformation characteristics of flood gates of runoff hydropower stations under different operating conditions in case of frequent floods
Shuang Shao, Zhenggui Li, Xuyong Kong, Jie Kang
Xihua University, China

SM009 To Enhance the Efficiency of a Micro Hydropower Plant by Optimizing Bucket Angle and Speed Ratio
Anupkumar Chaudhari, Gaurang C Chaudhari
Parul University, India

Theme: Computational and Experimental Techniques

CE001 Analysis of 3d printed model turbine with CNN algorithm as proof of concept for using Machine learning techniques as means of condition monitoring of runner in hydropower plant
Raman Silwal, Bhola Thapa
Kathmandu University, Nepal

CE003 Determination of Generator Efficiency on Performance Test of Prototype Turbine
Dengfeng Cao, Peng Zhang, Ye Zhou and Xiaocheng Zhang
China Institute of Water Resources and Hydropower Research, China

CE004 Dynamic Experimental Review of Hydraulic Turbine Stay Vane Strengthen for Baihetan Hydropower Station Left Bank
Fang Xiaohong, Li Haijun, Cao Chunjian, Fang Jie, Deng Jinjie
Power China Huadong Engineering Corporation, China

CE005 Experimental Studies of Jet Expansion on Different Nozzle Geometry
Vimal K Patel, Hemal N Lakdawala and Gaurang C Chaudhari
Sardar Vallabhbhai National Institute of Technology, India

CE006 Experimental and Numerical Analysis of the Impeller Backside Cavity in a Centrifugal Compressor for CAES
Zhihua Lin, Zhitao Zuo, Wei Li, Jianting Sun, Xin Zhou, Haisheng Chen, Xuezhi Zhou
Institute of Engineering Thermophysics, Chinese Academy of Sciences, China

CE007 Investigation on the Flow Characteristics of Complex Flow Channel System of Mixed-flow Pump with Impulse Operation
Mingkang Sun, Jin Xu2, Chuibing Huang, Xiaoping Zhang, and Zhenwei Huang
Tsinghua University, China

CE009 Numerical investigation of a Pelton turbine at several operating conditions
Saroj Gautam, Sailesh Chitrakar, Hari Prasad Neopane, Bjørn W Solemslie and Ole Gunnar Dahlhaug
Kathmandu University, Nepal

CE011 Numerical Investigation on Suitable Flow Guide for Performance Enhancement of Darrieus-type Hydraulic Turbine by 2-D Simulation
Y Mayuzumi, Y Katayama, S Watanabe and S Tsuda
Kyushu University, Japan

CE012 Numerical simulation of the runner blade channel vortex in Francis turbine
Huan Cheng, Lingjiu Zhou, Zhongjing Wu, Quanwei Liang, Demin Liu and Zhaoning Wang
Dongfang Electrical Machinery Co. Ltd., China

CE015 Pressure fluctuation measurement in pressure vessel
Aman Kapali, Hari Prasad Neopane, Sailesh Chitrakar, Prajwal Sapkota
Kathmandu University, Nepal

CE017 Research and Analysis on Model measurement and Prototype Operation of large-scale Kaplan turbine
ZHOU Jingming, LUO Hongyun and WU Yibin
Guangxi Datengxia Gorge Water Conservancy Development Co. Ltd., China

CE018 Study on Measurement of Penstock Head Loss for Hydropower Station with Multiple Units Per Penstock
Zhou Ye, Tuo Yu, Cao Dengfeng, Li Chenglong and Wu Dongjun
China Institute of Water Resources and Hydropower Research, China

CE019 Study of the phase resonance phenomenon in Francis turbine
Yue Lv, Zhengwei Wang and Lingjiu Zhou
China Agricultural University, China

CE021 Unsteady Simulation of the Internal Flow in a Tubular Pump Considering Tip-Leakage Flow
Puxi Li, Faye Jin, Ran Tao, Fangfang Zhang and Ruofu Xiao
China Agricultural University, China

Theme: Sediment Erosion

SE001 A Review on Erosion and their Induced Vibrations in Francis Turbine
Rakish Shrestha, Samman Singh Pradhan, Prithivi Gurung, Amul Ghimire and Sailesh Chitrakar
Kahtmandu University

SE002 Coating technology in hydro-turbines for sediment affected power plants: A Review
Shekhar Aryal, Sailesh Chitrakar, Rajendra Shrestha, Ajay kumar Jha
Tribhuvan University, Nepal

SE003 Credibility of Rotating Disc Apparatus for investigating sediment erosion in guide vanes of Francis turbines
Shekhar Aryal, Sailesh Chitrakar, Rajendra Shrestha, Ajay kumar Jha
Tribhuvan University, Nepal

SE004 Development of simplified numerical model for prediction of sediment induced erosion in runner sidewall gaps
Nirmal Acharya, Saroj Gautam, Sailesh Chitrakar, and Ole Gunnar Dahlhaug
Norwegian University of Science and Technology, Norway

SE005 Assessment of Hydro cyclone Separator in Sediment Laden Hydropower Plants
Atmaram Kayastha, Nashla Shakya, Biraj Singh Thapa, Bhola Thapa and Young Ho LEE
Kathmandu University, Nepal

SE007 Investigation of sediment erosion in low head Francis turbines and its effect on the structural integrity
Aasma Bhattarai, Prashant Kunwar, Gyatabya Singh, Pawan Lal Bijukche, Sailesh Chitrakar, Saroj Gautam

SE009 Numerical investigation of sediment erosion and cavitation in Francis Turbine

Ranjeet Twayna, Ram Manandhar, Bikash Singh, Dadiram Dahal, Atmaram Kayastha and Biraj Singh Thapa
Kathmandu University, Nepal

SE013 Sediment erosion in the labyrinths of Francis turbine
Saroj Gautam, Nirmal Acharya, Sailesh Chitrakar, Hari Prasad Neopane, Igor Iliev and Ole Gunnar Dahlhaug
Kathmandu University, Nepal

SE014 Experimental study of Crossflow turbine under different operation conditions
Oblique Shrestha, Aman Kapali, Bhola Thapa, Hari Prasad Neopane, Young Ho Lee
Kathmandu University, Nepal

Theme: Cavitation and Vibration
CT002 Measurements in Condition Monitoring of Hydropower plants: A Review
Prajwal Sapkota, Sailesh Chitrakar, Hari Prasad NeopaneBhola Thapa
Kathmandu University, Nepal

CT003 Effects of Inlet S-duct on Inducer Performance and Cavitation Instability
Youngkuk Yoon, Seung Jin Song
Seoul National University, South Korea
CT004 Evolution and influence of high-head pump-turbine cavitation during runaway transients
W D Wu, K Liu, L Li, X X Hou, P C Zhang, C Du, X Y Liu and Y G Cheng
State Grid Xinyuan Company Ltd. China

CT005 Influence of Rotor Geometry on Cavitation Characteristics of Rotational Hydrodynamic Cavitation Generator
X Wang, C Xie, W Zhang and G Q Q G Meng
Inner Mongolia Vocational College of Chemical Engineering, China

CT006 Numerical Analysis of the Effect of Slit Shape on the Performance and Cavitation Instability of Liquid Rocket Inducer
Asuka Kowata, Satoshi Kawasaki, and Yuka Iga
Tohoku University, Japan

CT007 Critical speed analysis of the shafting rotor of the vertical long shaft fire pump under the different positions of the impellers
L H Fu, Z J Yang,S B Jin, J F Zhang, H Q Song, X H Yu, W J Zhang and G D Li
National Research Center of Pumps Jiangsu University, China

CT009 Study on Setting Elevation of Double-Suction Centrifugal Pump Based on Cavitation Characteristics
Dunzhe Qi, Rao Yao, Haichen Zhang, Yubin Shen, Xijie Song and Zhengwei Wang
Ningxia Water Conservancy Engineering Construction Center, China

CT010 Clearance flow field characteristics of Kaplan turbine under different flange clearance
Y L Zhang, Y B Wu, J W Wei, L J Zhou and Z W Wang
China Agricultural University, China

CT012 Mass transfer rate effects on the cavitating vortex shedding flow around a circular cylinder at low Reynolds number
Jian Chen, Xavier Escaler
Universitat Politècnica de Catalunya, Spain

CT013 Influence of Rotor Dimple Geometry on Cavitation Characteristics of Rotational Cavitation Generator
Y F Jia, C Xie, W Zhang and G Q Q G Meng
Tsinghua University, China

VB002 Head-Cover vibration investigation of a Prototype Reversible Pump-Turbine Unit during Start-up in Pump mode. Part I: Fluid dynamic analysis
Haixia Yang, Qilian He, Huili Bi, Xingxing Huang, Mengqi Yang, Mingde Zou and Zhengwei Wang
Tsinghua University, China

Theme: Design Optimization
DO002 Effects of Slotted Impeller Configurations on the Hydraulic Performance of Double-Suction Pump

Jong-Woong Yoon, Hyun Su Kang and Youn-Jea Kim
Sungkyunkwan University, Korea

DO003 J-groove shape optimization to suppress the swirl flow in the Francis hydro turbine draft tube
Ujjwal Shrestha and Young-Do Choi
Mokpo National University, Korea

DO004 Modeling of the Blade Leading-Edge Pressure Drop of Centrifugal Impeller Based on Machine-Learning
Yanzhao W, Na Li, Ran Tao, Puxi Li and Ruofu Xiao
China Agricultural University, China

DO005 Numerical Optimization of Gravitational Water Vortex Turbine using Computational Flow Analysis
Dylan S. Edirisinghe, Ho-Seong Yang, Byung-Ha Kim, Chang-Goo Kim, S D G S P Gunawardane and Young-Ho Lee
Korea Maritime and Ocean University, Korea

DO006 Optimization of Unit Dispatching Operation Strategy Based on Improved Biogeography-Based Optimization-Dynamic Programming
Pan Hong, Luo ZhengLiang,Feng Fang, Zheng Yuan
Hohai University, China

DO009 Rapid Analysis of Cylindrical Bypass Flow Field Based on Deep Learning Model
Jian Liu, Zhenwei Huang, Jinsong Zhang, and Zanao Hu
Tsinghua University, China

DO010 Recent developments in the optimization Francis turbine components for minimizing sediment erosion
Ram Lama, Saroj Gautam, Sailesh Chitrakar, Hari Prasad Neopane, Biraj Singh Thapa and Ole Gunnar Dahlhaug
Kathmandu University, Nepal
DO012 Research on the Fine-grained Axis Locus of Hydropower Unit based on Convolution Neural Network
Pan hong, Luo zhengliang, Xu jingjun, Feng fang
Hohai University, China

Theme: Sustainable Energy, Integrated Systems and Green Hydrogen Technologies

SI001 Effect of fish swimming on the stability of flow fields inside the pipeline
Dehong Fang, Zhenwei Huang, Jinsong Zhang and Zanao Hu
Tsinghua University, China

SI004 Turbine blade strike tests for evaluation and optimization of fish-friendly turbine
L Meng, R Chen, C Y Zhang, W P Wang, C L Liao and X Wang
China Institute of Water Resources and Hydropower Research, China

GH002 Green Ammonia as a flexible hydro-electricity carrier for Nepal
Bishwash Neupane, Sushobhan Bhattarai, Aman Kumar Singh, Biraj Singh Thapa
Kathmandu University, Nepal

GH003 Parametric modeling of re-electrification by green hydrogen as an alternative to backup power
Abhishek Subedi and Biraj Singh Thapa
Kathmandu University, Nepal

GH004 Hydrogen as a fuel for Electrifying Transportation Sector in Nepal: Opportunities and Challenges
Nashla Shakya, Rizan Shrestha, Rajesh Saiju, and Biraj Singh Thapa
Kathmandu University, Nepal

List of Publications 2019 onwards

Nischal Pokharel, Amul Ghimire, Bhola Thapa1, Biraj Singh Thapa, Zhongdong Qian, Zhiwei Guo, “Numerical and experimental study of pump as turbine for sediment affected micro hydropower project in Nepal“, IOP Conference Series Earth and Environmental Science 774 (2020) 012062

Sailesh Chitrakar, Bjorn Solemslie, Hari Prasad Neopane, Ole Gunnar Dahlhaug (2020), “Review on numerical techniques applied in impulse hydro turbines“. Renewable energy, vol. 159

Ram Lama, Saroj Gautam, Sailesh Chitrakar, Hari Prasad Neopane, Biraj Singh Thapa, “Method of erosion prediction hill diagram to investigate the performance of Francis turbine operated in sediment laden water“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012017

Amul Ghimire, Dadiram Dahal, Atmaram Kayastha, Sailesh Chitrakar, Biraj Singh Thapa, Hari Prasad Neopane, “Design of Francis turbine for micro hydropower applications“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012019

Nischal Pokharel, Amul Ghimire, Biraj Singh Thapa, Bhola Thapa, “Opportunity for research and manufacturing of pump in Nepal“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012018

Biraj Singh Thapa, Bhola Thapa, “Green Hydrogen as a Future Multi-disciplinary Research at Kathmandu University“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012020

Saroj Gautam, Ram Lama, Sailesh Chitrakar, Hari Prasad Neopane, Biraj Singh Thapa, Baoshan Zhu, ” Numerical investigation on the effects of leakage flow from Guide vane-clearance gaps in low specific speed Francis turbines“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012016

Abishek Kafle, Pratisthit Lal Shrestha, Sailesh Chitrakar, Bhola Thapa, Biraj Singh Thapa, Nischal Sharma, “A review on casting technology with the prospects on its application for hydro turbines“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012015

Aman Kapali, Hari Prasad Neopane, Sailesh Chitrakar, Aatmaram Kayastha, Oblique Shrestha, “Experimental and CFD study of influence of sediment size on efficiency of hydrocyclone for use as sediment separation device“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012014

Sangit Kattel, Jeewan Prakash Bhatt, Rahul Subedi, Bhola Thapa, Surendra Sujakhu, Abishek Kafle, “Investigation of Mechanical Properties of Brass Francis Turbine Manufactured by Local Investment Casting Technique in Nepal“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012013

Ashish Sedai, Biraj Singh Thapa, Bhola Thapa, Aman Kapali, Zhongdong Qian, Zhiwei Guo, “Application of Reverse Engineering method to model eroded Francis runner”, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012012

Devendra Sharma, Bikalpa Khadka, Aashutosh Parajuli, Dadi Ram Dahal, Bhola Thapa, “Effect of welding pattern during repair and maintenance of Francis runner on sediment erosion: An experimental investigation using RDA“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012011

Prabin Dhakal, Manish Adhikari, Biraj Singh Thapa, Atmaram Kayastha, Prajwal Sapkota, Dadi Ram Dahal, “Uncertainty evaluation of efficiency measurement in laboratory conditions“, IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012007

Samita Rimal, Sanjay Pd. Sah, Nischal Pokharel, Biraj Singh Thapa, “An Experimental Investigation of

PAT in Direct and Reverse Mode at Turbine Testing Lab", IOP Conference Series: Journal of Physics: Conf. Series 1608 (2020) 012006

Atmaram Kayastha, Biraj Singh Thapa, Bhola Thapa, Young Ho Lee, "Experimental investigation for R&D in sediment laden pico hydraulic francis turbine", Renewable Energy, Vol. 155, 2020

Saroj Gautam, Hari Prasad Neopane, Nirmal Acharya, Sailesh Chitrakar, Biraj Singh Thapa, Baoshan Zhu, "Sediment erosion in low specific speed francis turbines: A case study on effects and causes", Wear, Vol. 442-443, 2020

Sailesh Chitrakar, Hari Prasad Neopane, Ole Gunnar Dahlhaug, "Development of a test rig for investigating the flow field around guide vanes of Francis turbines", Flow Measurement and Instrumentation, Vol. 70, 2019

Aman Kapali, Sailesh Chitrakar, Oblique Shrestha, Hari Prasad Neopane and Biraj Singh Thapa, "A Review on Experimental Study of Sediment Erosion in Hydraulic Turbines at Laboratory Conditions",

IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012016

Dadi Ram Dahal, Sailesh Chitrakar, Aman Kapali, Biraj Singh Thapa and Hari Prasad Neopane, "Design of Spiral Casing of Francis Turbine for Micro Hydro Applications", IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012013

Ram Lama, Saroj Gautam, Sailesh Chitrakar, Hari Pd. Neopane and Biraj Singh Thapa, "Comparative numerical analysis between two designs of Francis runner blades in sediment affected conditions",

IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012009

Amul Ghimire, Dadi Ram Dahal, Nischal Pokharel, Sailesh Chitrakar, Biraj Singh Thapa and Bhola Thapa, "Opportunities and Challenges of introducing Francis Turbine in Nepalese Micro Hydropower Projects", IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012007

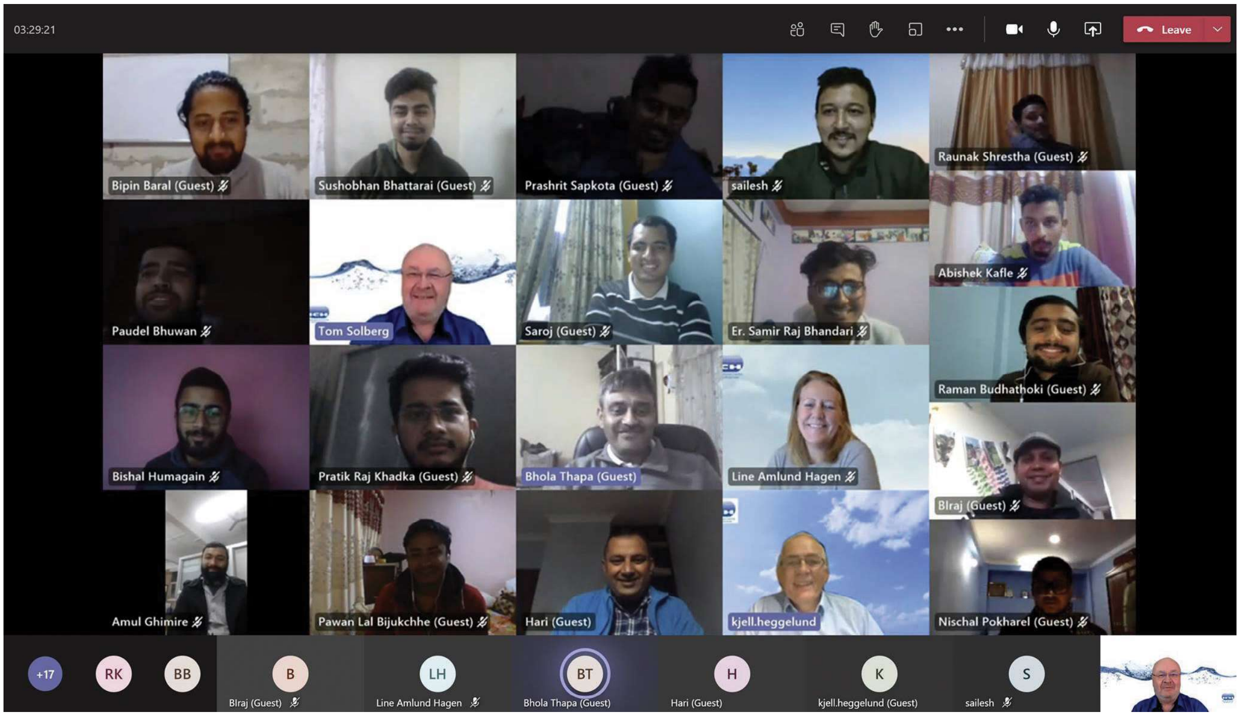
Rabina Awal, Prajwal Sapkota, Sailesh Chitrakar, Biraj Singh Thapa, Hari Prasad Neopane and Bhola Thapa, "A General Review on Methods of Sediment Sampling and Mineral Content Analysis", IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012005

Nirmal Acharya, Chirag Trivedi, N. M. Wahl, Saroj Gautam, Sailesh Chitrakar and Ole Gunnar Dahlhaug, "Numerical study of sediment erosion in guide vanes of a high head Francis turbine", IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012004

Saroj Gautam, Ram Lama, Sailesh Chitrakar, Hari Prasad Neopane, Biraj Singh Thapa and Baoshan Zhu, "Methodology to Predict Effects of Leakage Flow from Guide Vanes of Francis Turbine", IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012003

Animesh Bachan, Nirajan Ghimire, Johannes Eisner, Sailesh Chitrakar and Hari Prasad Neopane, "Numerical analysis of low-tech overshot water wheel for off grid purpose", IOP Conference Series: Journal of Physics: Conf. Series 1266 (2019) 012001

TTL: Glimpses of Major Activities



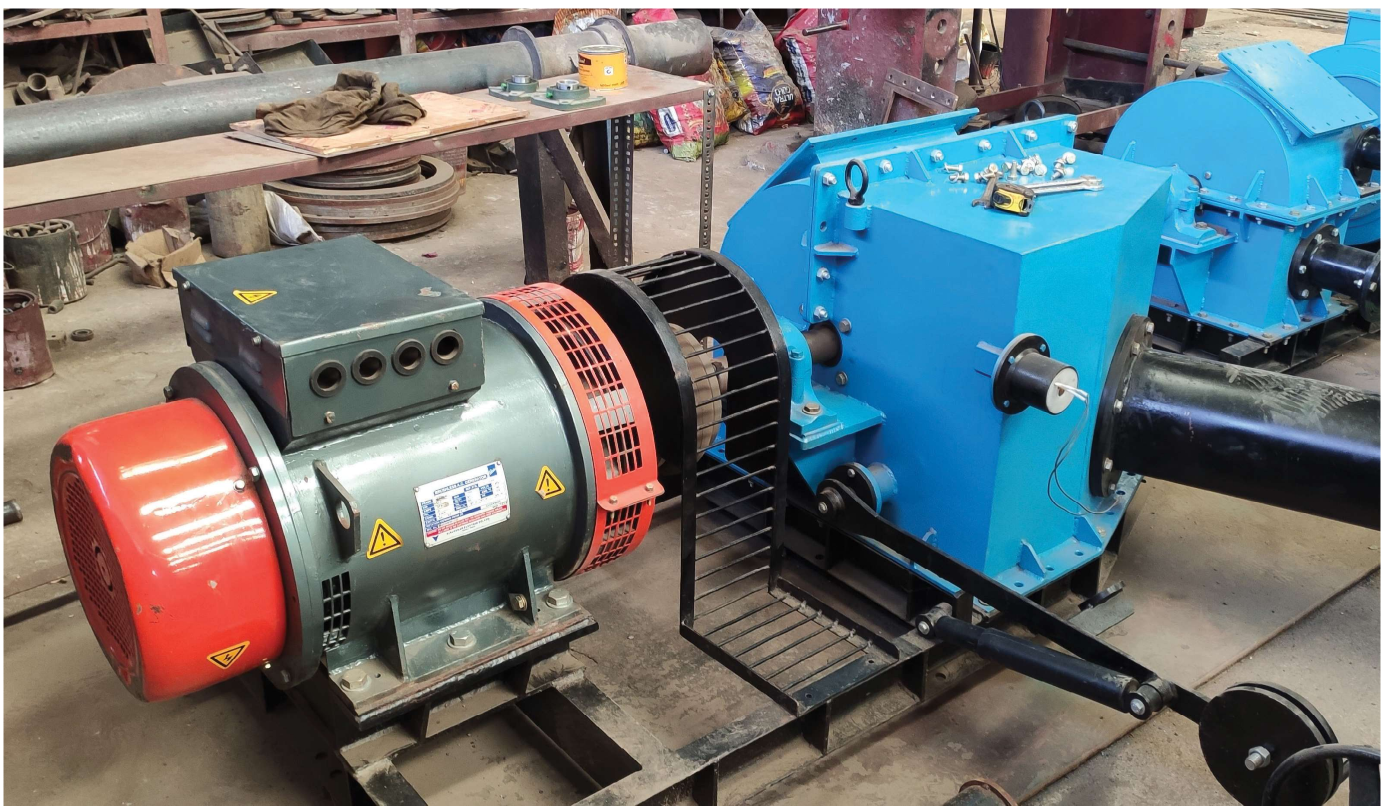
3rd edition of Advancement in Turbine and Hydropower Technology (ATHT III), one day training (online mode) on December 10, 2020 provided by Kjell Heggelhund in cooperation with International Center for Hydropower, Norway.

Power plant visits by the research team of CMHydro project funded by Nepal Electricity Authority

Power plant visit by the research team for studying the erosion challenges

Research team getting hands-on experience of 3D scanning tool at site


River water pump (coil pump) tested during the project TTL-IRDP. The project was funded by KOICA under KU IRDP program for the period of 2020-2021.



Visit ot Nepal Yantra Shala Energy (NYSE) for inspection of Micro Hydro Turgo turbine to be installed in site as a part of an upscaling project from RenewableNepal Phase II

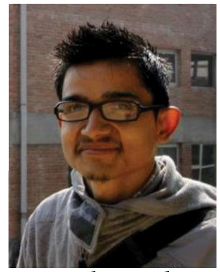
Visit by the Norwegian Ambassador at TTL in relation to the EnergizeNepal extension project on October 26, 2021

Group Photo of TTL members with O&M committee of Turbine Testing Lab

TTL Alumni


Supriya Koirala
Research Assistant
2010 to 2012


Sudip Adhikari
Research Assistant
2011 to 2013


Amod Panthee
Research Asst./Fellow
2011 to 2015


Neekhel Gurung
Research Assistant
2012 to 2014


Suren Sujakhu
Research Assistant
2012 to 2013


Mausam Shresth
Research Assistant
2012 to 2014


Niroj Maharjan
Research Assistant
2013 to 2014


Binaya Baidar
Research Fellow
2014 to 2016


Bidhan Rajkarnikar
Research Associate
2013 to 2016


Ravi Koirala
Research Asst./Fellow
2013 to 2017


Laxman Poudel
Ph. D. Candidate
2010 to 2013


Krishna P. Shrestha
Ph. D. Candidate
2012 to 2018


Balendra Chhetri
MS by Research
2014 to 2017


Nirmal Acharya
Research Associate
2014 to 2018


Rabina Awal
Research Assistant
2019

Remember us for:

- Performance Tests of Hydraulic Machines
- Development of New Turbines
- Applied Research to Solve Problems of Hydropower Industries
- Education and Training

Turbine Testing Lab
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Lab Specifications
Maximum Flow: 500 Lps
Natural Head: 30 m
Pump Head: 150 m
Lower Reservior: 300 m^3
Upper Reservior: 100 m^3
Maximum Testing Capacity: 300kW