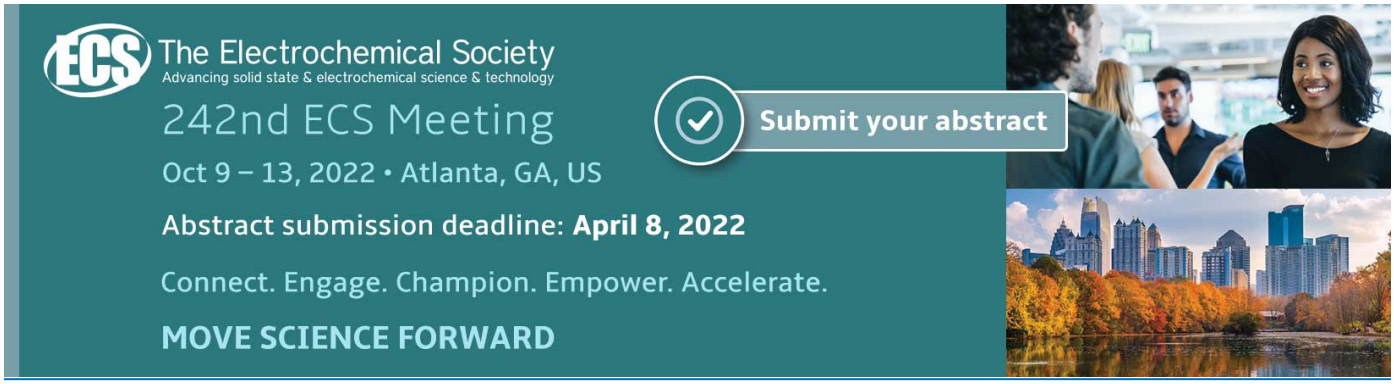
Current research in hydraulic turbines against sediment erosion: International partnership and collaborations



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Current research in hydraulic turbines against sediment erosion: International partnership and collaborations

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Abstract. The problem of material erosion in hydraulic machineries has been under the investigation since a century ago. However, the proper solutions to the erosion of hydro turbine due to sediment-laden flows has not been found yet. The new and future hydropower development is shifting towards Asia region, which holds the highest capacity of undeveloped hydropower potential worldwide, and is also the largest contributor of the sediment intake to the ocean through its river systems. At present the various academic and research institutions are making advancements in R&D of hydraulic turbines against sediment erosion. This article highlights some major achievements made by Kathmandu University and its consortium partner intuitions in the advancement of the turbine technology for the future market.

1. Introduction

Asia region contributes to the highest growth in energy demand, accounting for 70% of the growth in global energy consumption since 2000 [1]. This region also holds the highest capacities of the both, developed and undeveloped hydropower potential worldwide [2]. Asia region also suffers from soil erosion due to the weak geological formation and heavy precipitation in short time interval causing floods (Figure 1). In the central Himalaya and Ganges plain, more than 80% of annual rainfall occurs during the Indian summer monsoon season (May–October) [3] causing the sharp rise in sediment concentration in the rivers in this period.

Run off the river hydro power projects across the Himalaya region suffers several operational and maintenance challenges, which are often associated with financial losses. The concentration of sediments in the rivers during extreme conditions can reach up 57000 ppm and the amount of hard minerals in sediments is as high as 80% [4]. Loss of turbine efficiency in a power plant in Nepal, due to sediment erosion damage, has been measured to be 4% and 8% respectively in full load and part load conditions, within the short operational period of 01 September to 11 November in 2003 [4]. Sediment monitoring in the same period have indicated that approximately 6900 tons of sediment had passed through this unit during the test period.

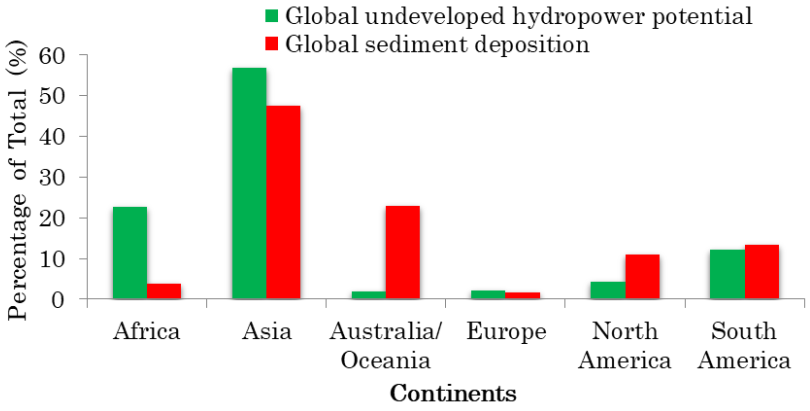

Figure 1. Proportion of undeveloped hydropower potential and sediment deposition worldwide [2, 3]

Similar cases of sediment erosion of turbine components and associated losses have been reported from power plants from China [5], India [6], Bhutan [7] and also from South American continents [8]. This has created a need and the possibilities of design optimization of the components for better performance of hydro power plants in the sediment-laden flows [6, 9, 10].

2. R&D Activities at Kathmandu University against sediment erosion

Since its establishment in 1991, Kathmandu University (KU) has been putting its effort in development of hydro turbines for the Nepalese context. Until 2010 R&D at KU was being done in the miniature laboratories in smaller scale [11]. With the limited resources some fundamental research were carried out to understand the basis phenomenon of sediment erosion in hydro turbine components and its relations with hydraulic design [10, 12]. With the major financial support from Norway and technical support from Norwegian University of science and technology (NTNU) a new Turbine Testing Tab (TTL) was established at KU in 2011. The aim has been to contribute to hydro turbine technology for sediment-laden projects, in the collaboration with industries and other academic institutions [13]. There are several projects at TTL contributing to the capacity and in fracture development in turbine technology [14]. At present TTL is conducting several R&D activities with the international partnerships.

3. International partnership and collaboration

With the common interest on the finding solution to the sediment erosion in hydraulic machines, the cooperation and collaboration of KU expanded from NTNU to several others universities in Asia. At present an unofficial consortium of following research centers is being formed for the joint research on sediment erosion in hydraulic machineries.

i. Turbine Testing Laboratory, Kathmandu University, Nepal, (KU)
ii. The Waterpower Laboratory, Norwegian University of Science and Technology, Norway, (NTNU)
iii. Flow Informatics Lab, Korea Maritime & Ocean University, Korea (KMOU)
iv. Institute of New and Renewable Energy Technology Research, Mokpo National University, Korea (MNU)
v. State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, China (WHU)
vi. State Key Laboratory of Hydroscience and Engineering, Tsinghua University, China (TSU)
vii. Alternate Hydro Energy Centre, Indian Institute of Technology (Roorkee), India, (IITR)

At present TTL has been in collaboration with each of these institutes with one or more R&D projects. Some of the major projects within this consortium are as presented in the Table 1.

Table 1. List of international projects at TTL, KU for sediment erosion in hydraulic turbines

Project ID	Aim	Partners	Period
EnergizeNepal	Developing IEC standard test rig at TTL	KU-NTNU	2016-2021
SediPass	Erosion measurement in guide vane cascade	KU-NTNU	2015-2019
FranSed	Research on variable speed turbine	KU-IITR-NTNU	2018-2022
RenewableNepal	Research on micro-hydro Francis turbine	KU-KMOU-MNU	2018-2020
Visiting Scholar	Mechanism of sediment erosion phenomenon	KU-WHU; KU-TSU	2019-2020

4. Future directions

There is a need of an international research center to address the research and innovation needs specific to the Himalaya region. Issues and challenges induced by sediment-laden flows to be in the main focus. This includes the design, manufacturing, operation of the major components of hydropower systems. A new facility is being planned to be established as the "Hydropower Research Center for Himalaya Region" (HRCHR). The main focus of this center will be to establish an excellence within sediment erosion of hydro turbines. KU, in collaboration with the consortium partner intuitions, is taking the initiations to co-build, co-manage and co-own this facility. HRCHR aims to build an open platform for international cooperation, scientific research and personal training. It is conceived to have the Academic, Research, and Professional service units to bring the universities, government agencies and industries under the common vision to develop hydropower sector in the Himalaya region by a proper acknowledgment of the local challenges by research and innovations.

5. Conclusion

The problem of sediment erosion has been a major factor for causing the operation and maintenance challenges of hydropower plants in the Himalaya region. There is a need of research and innovation in existing turbine technology to minimize the problems induced by sediment-laden flows, specific to this region. Joint effort from the different specialized research groups and labs working this subject, and the industries driving the business in this part of the world is necessary to find the optimum solution of this problem. Turbine testing lab at Kathmandu University is conceiving a 'Hydropower Research Center for Himalaya Region', which can be a common platform for different stake holders to contribute to the hydropower development in this region. It can be expected that a significant contribution can be made through this research center. Hence all the relevant stake holders should make good effort and contribute to establish this facility and initiate a sustainable cooperation in production of clean and affordable energy for all.

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