Secondary Flow and Sediment Erosion in Francis Turbines

Sailesh Chitrakar

NVKS
NORWEGIAN HYDROPOWER CENTRE

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Details

PhD Period	: 2015-2018
Supervisors	: Ole Gunnar Dahlhaug
Co-Supervisor	: Hari Pd. Neopane
Degree awarded by	: Norwegian University of Science and Technology Kathmandu University
Project	: SEDIPASS

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What is SEDIPASS?

Sustainable Design and Operation of Hydropower Plants Exposed to High Sediment Yield

WP I – Multi-Frequency aDcp measurements of bed and suspended load

WP II – Using lightweight material in physical model

WP III – Sediment erosion in turbines

WP IV – Identify environmental impact of different flushing strategies

NINA Norwegian Institute for Nature Research

Statkraft

NTNU Norwegian University of Science and Technology

Hydro Lab

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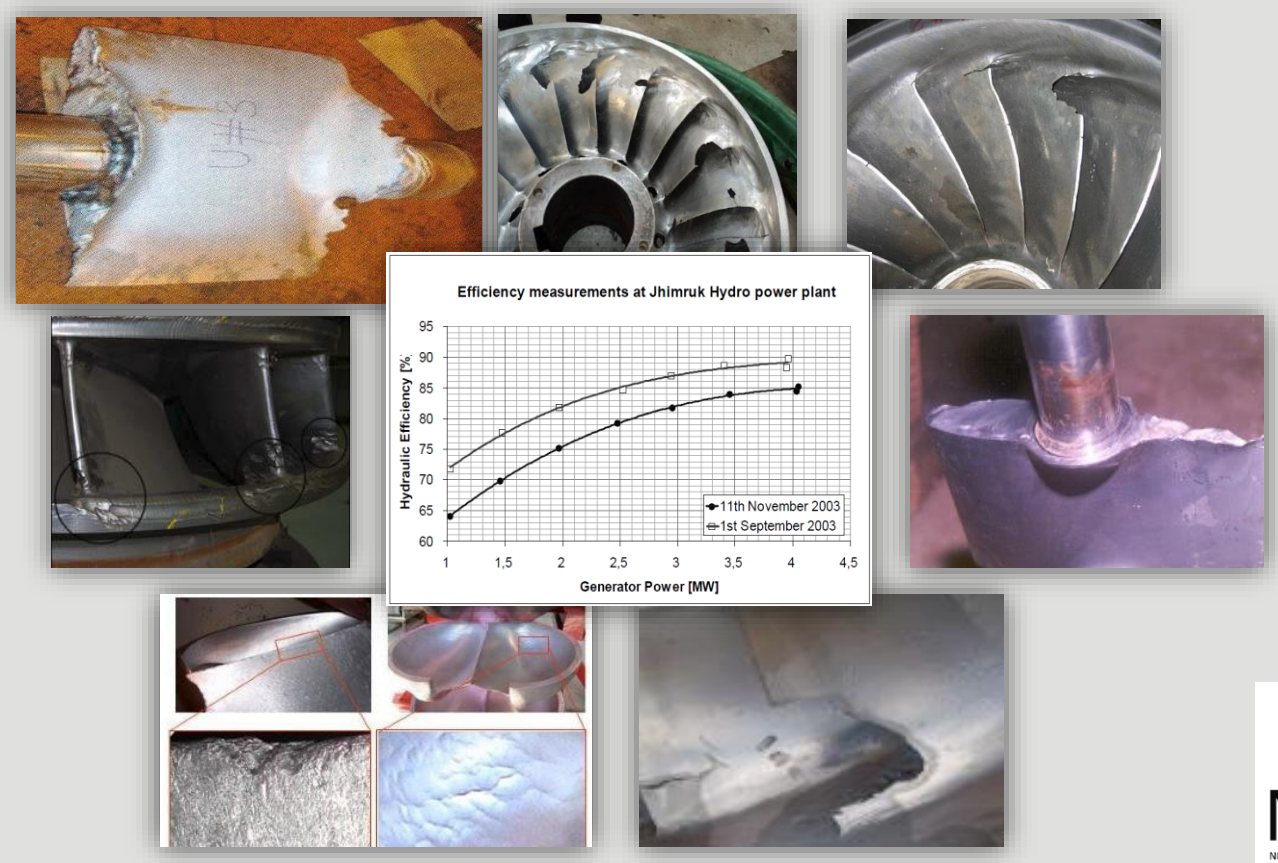
Background of the problem

The problems of **Sediment erosion** is inevitable from operation and maintenance perspective in Nepal



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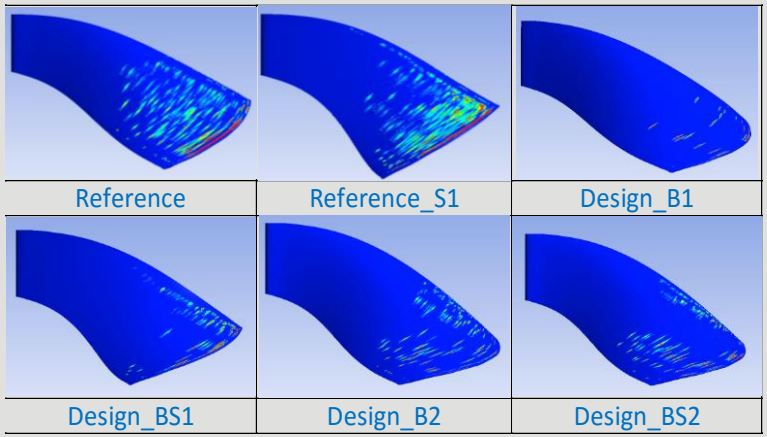
Background of the problem

Previous research works have shown some possibilities of how the erosion can be reduced



Using CFD to predict erosion on different blade profiles

Rotating Disc apparatus to test erosion on blades

Validation of the numerical results ?

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Motivation

Secondary flow
responsible for efficiency drop, noise and vibrations in the turbine

Responsible for erosion in turbine components

Eroded profiles
increases the intensity of secondary flow and consequently the erosion

Eroded profiles

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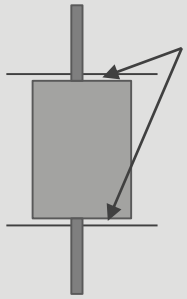
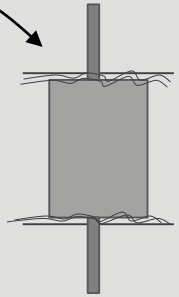
Motivation

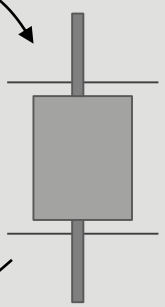
In the case of Guide Vanes of Francis turbines



A small clearance gap is present for changing the angle according to operating conditions

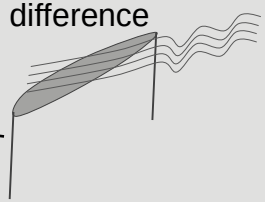


Flow containing sediment particles passes through this gap causing erosion



Increases the size of the gap

The gap enforces leakage flow due to pressure difference



Disturbances in the main flow

Reduction in efficiency

Increase in erosion

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Background of this PhD

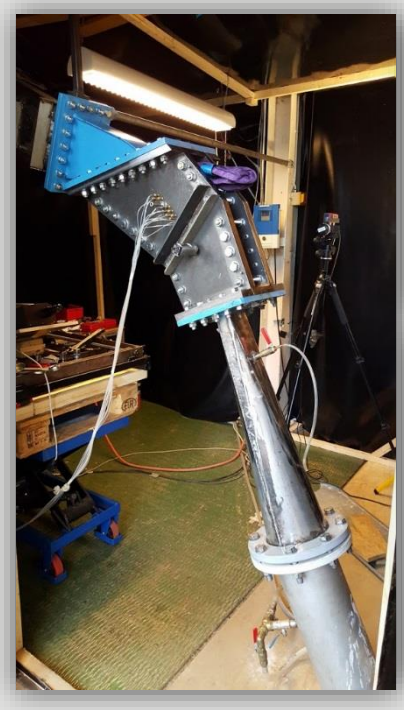
A one-GV cascade rig has been built in Waterpower Laboratory (from PhD of Biraj S. Thapa)

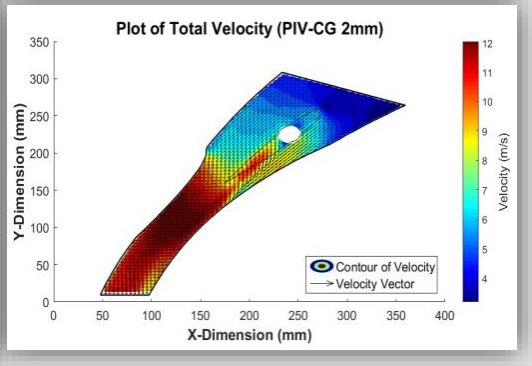
The rig is aimed and being used for:

- Using the PIV technique to study the flow at different clearance gaps of the reference turbine

- Validating the numerical results so that an in-depth study of the flow physics is possible

- Testing the optimized guide vanes





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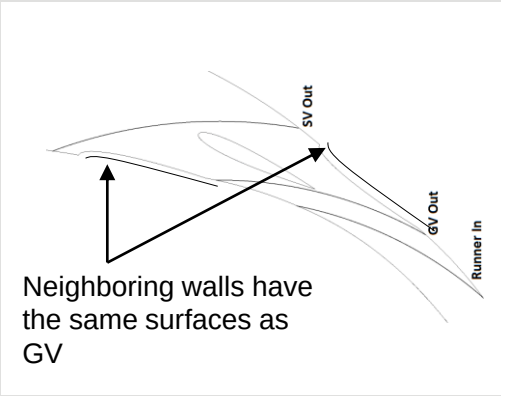
Background of this PhD

Limitations of one GV cascade rig

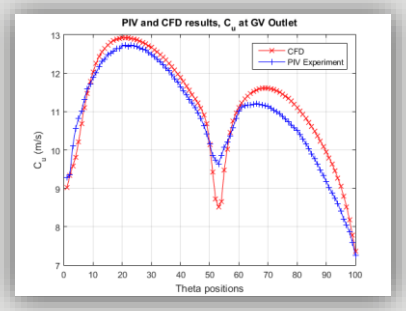
- Testing in off-design conditions, where the flow separation is more, is not possible in this rig

- The walls of the rig influence the testing of different GV profiles in the rig

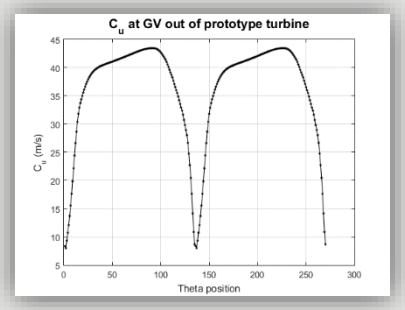
- The wall also influences the results compared to the real turbine



Neighboring walls have the same surfaces as GV



Results from current test rig



GV outlet flow in real scenario (BEP)

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Objectives of this PhD

- Numerical and experimental investigation of the leakage flow through clearance gap of guide vanes in high head Francis turbines

- Design and development of 3 GV cascade rig to overcome the limitations of 1 GV rig

- Guide vane design optimization to reduce the secondary flow and its consequent effects on turbine erosion in sediment laden hydropower projects

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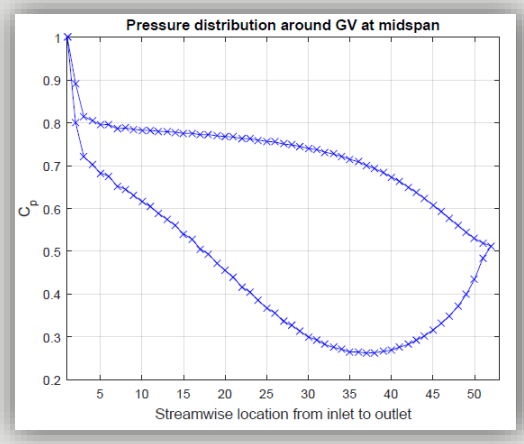
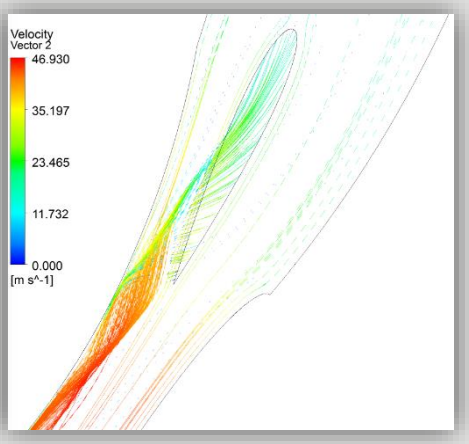
Findings and Progresses

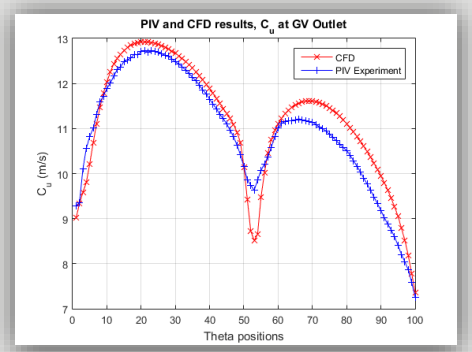
The results of CFD is comparable with PIV

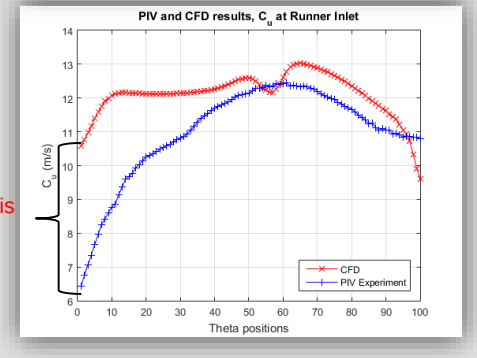
The leakage flow is related with the pressure difference over guide vane surfaces





Reason of this difference ?





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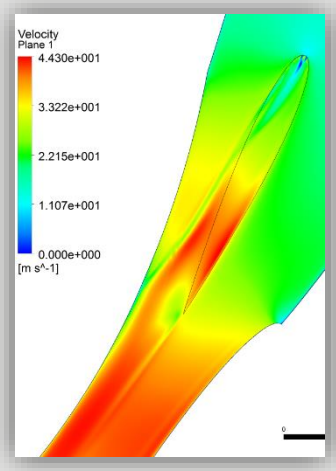
Findings and Progresses



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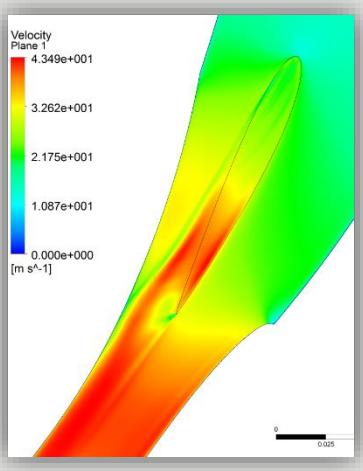

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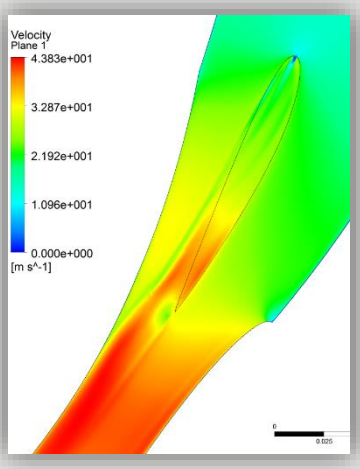

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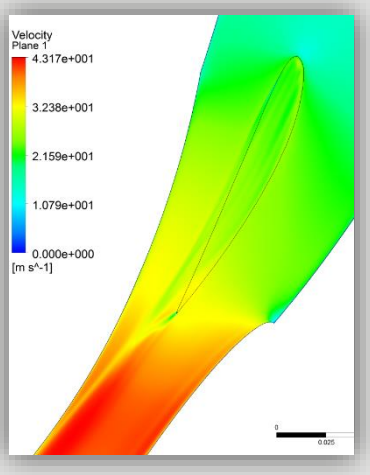

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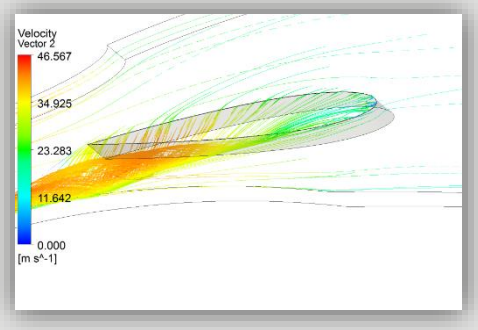
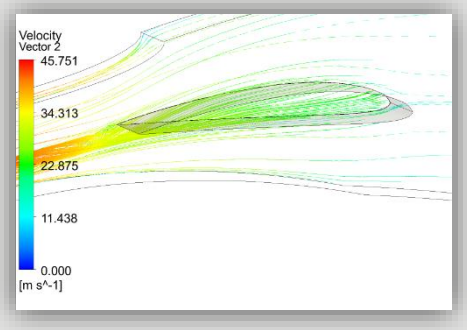


Symmetrical GV



Asymmetrical GV

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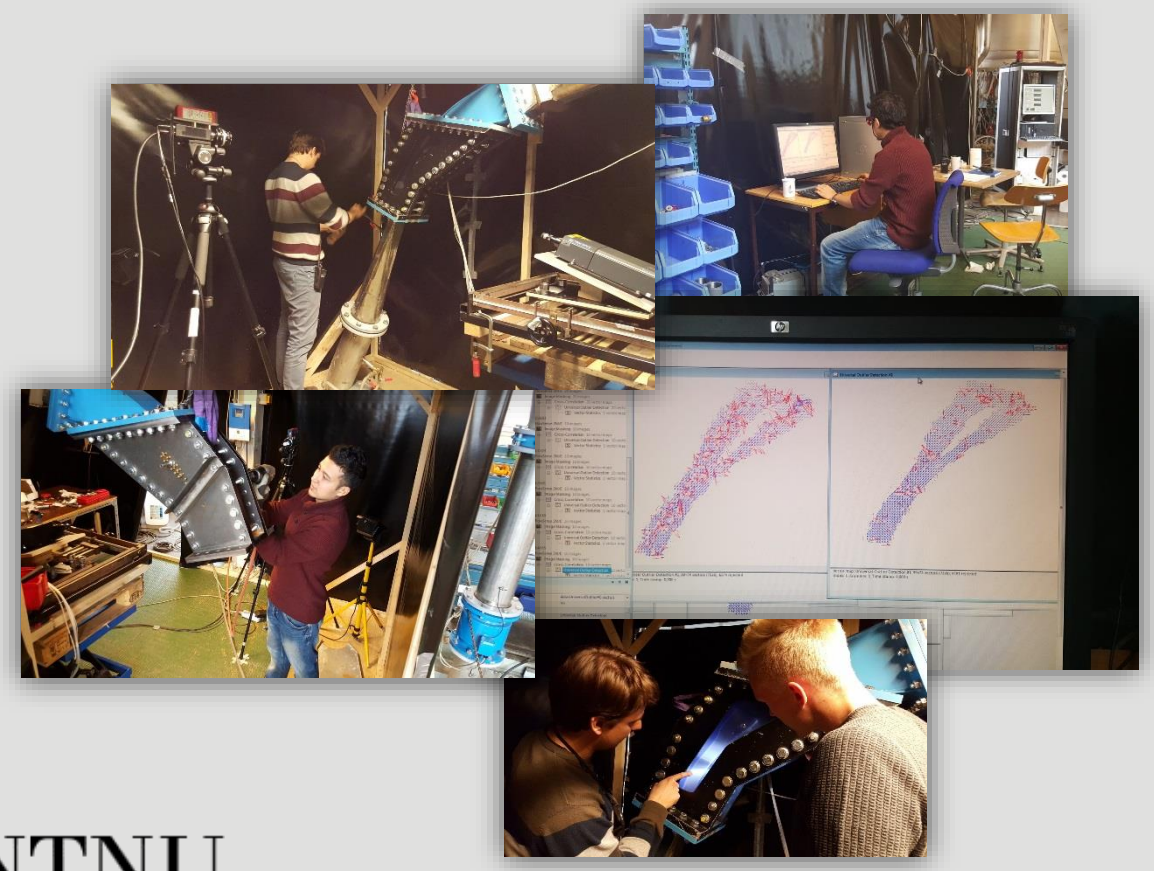
Findings and Progresses

Experimental validation of CFD in progress



Further works:
- Analysis of PIV
- 3 GV rig design and development
- Testing in off design conditions
- GV optimization

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Thank you!

Contact:
Sailesh Chitrakar
sailesh.chitrakar@ntnu.no
sailesh@ku.edu.np
Phone: +4746431989
+9779843386214

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