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Erosion in Francis turbines due to geometrical positioning of runner and guide vanes

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Objective

The major objective of this work is to understand the sediment erosion phenomenon in Francis turbines with the focus on the flow pattern around the gap between GV blade width and runner blade height.
Following are the specific objectives of this work:
1) Analysis of spatial temporal progression of leakage vortex through GV's clearance gap.
2) Investigate the flow pattern inside top and bottom sidewall gap in Francis turbine.
3) Investigate the effects of hydro-abrasive erosion due to geometrical positioning of Francis turbine's rotor- stator components.

Background

This research work was intended on the investigation of flow pattern in sidewall gaps in Francis turbines. It refers to the clearance region between the stationary and rotary components as shown in figure 1. For hydro turbines operating in sediment laden water, sediment will pass through these gaps and erode the parent material. Due to continuous effects of abrasion and erosion, these side wall clearance region increases and consequently the leakages through these gaps. Although research has been done on clearance region between guide vanes and cover plates, this sidewall gaps has still been unexplored.

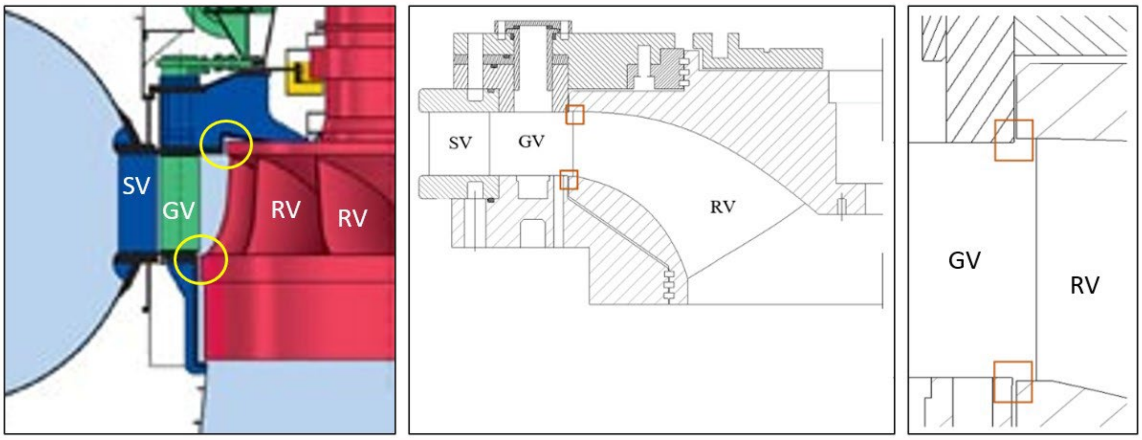

Figure 1. Cross section of Francis turbine with the enlarged view of sidewall gap

Experimental test set up was designed to study the flow behavior in those regions. The test set up as shown in figure 1 utilizes the method of rotating test specimen in a mixture of calculated amount of sand and water. Test specimens are mounted on the disc with the help of counter sunk screw. Rotor assembly comprises of rotating disc with test specimens mounted that are attached to the shaft connected to the motor. Rotational speed of motor is adjusted by Variable Frequency Drive (VFD) connected to the setup. Housing of rotating disc apparatus (RDA) consisted of two chambers viz; inner chamber which is the cooling chamber and outer chamber which encloses the base plate with specimens and sand-water mixture. It consists of 4 test specimens fitted in 90-degree periodic positions inside the disc.

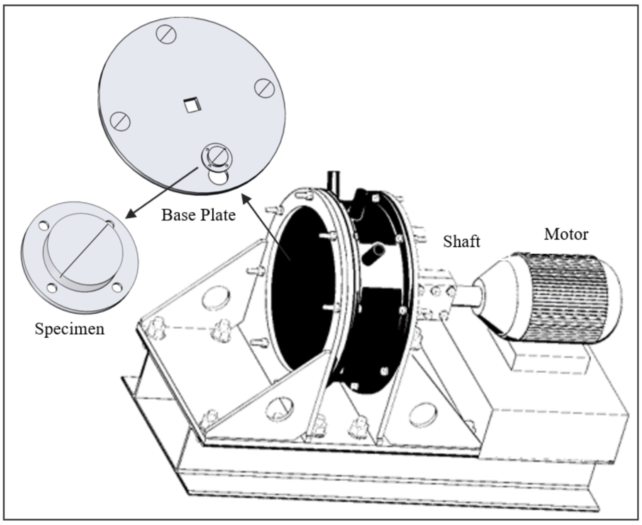

Figure 2. 3D representation of RDA along with base plate and test specimens

Results/Findings

The results of the experiments showed that with increasing rotation speed, the wear on the metal increased. The position of the rotating and the stationary part in relation to each other had a lot to say. If the rotating part of the turbine was located higher than the stationary part, this would cause significantly more wear than if they were at the same height, or if the rotating part was lower than the stationary part.

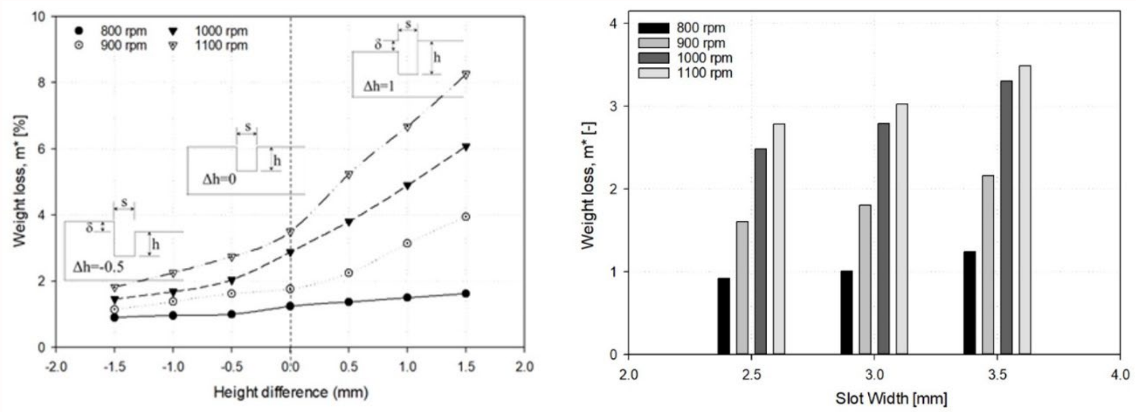

Figure 3. The figure on the left shows an increasing weight loss (due to increasing erosion) with an increasing height difference between the stationary and the rotating part of the turbine. The figure on the right shows how there is a correlation between the width of the tracks and the number of rotations.

Relevance/utilization

It is quite obvious that presence of sidewall gaps and flow in such regions is inevitable in hydraulic machineries. Hence the design process should ensure sidewall gaps flow as well for efficient machine design. Flow phenomenon associated with sidewall gaps should be well considered and alanyze them during the preliminary phase of machine design.
Based on the results of the experiments carried out, the general erosion model has become more specific, so that it becomes more accurate for the operation of Francis turbines in water with sediments. The "new" model also includes the width and height differences between the rotating and the stationary part of the turbine.

Refrences and links to publications and thesis

Thesis: **NTNU Open: Erosion in Francis turbines due to geometrical positioning of runner and guide vanes**