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Sand Size impact on Hydraulic Turbine Material:A Case Study of Sunkoshi River in Nepal

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Abstract

Sand size impact on hydraulic turbine is one of the major problems and is very difficult & complex in nature. Sediment characteristics are important parameters to be considered while measuring its impact on Hydraulic turbine material. Sediment problem in Nepal is one of the major and challenging in hydropower development. It degrades the reservoir capacity, hydraulic turbines efficiency and life of the turbine. There are no of researches have been carried out in this field and have proven that sand as major substance that erodes the turbine material, but only few researches have accounted every parameters of sand on degradation of hydraulic turbines. This paper accounts impact of sand size which is one of the important parameter that has direct impact on turbine material. Sediment size impact has been studied firstly by characterizing size into four different layered using sieve analyzer and testing its impact by using high velocity test rig at Kathmandu University. Sand samples from 05 different stations of Sunkoshi River were collected and tested on turbine material 16Cr4Ni. It was found that greater the sizes of sediments have greater the impact values than relatively smaller ones. It is depicted that 300-400 micron size sediment, have highest impact with weight loss of 0.013 milligram and averagely 0.0115 milligram, 212-300 micron size has 0.008 and averagely 0.005 milligram weight loss, 90-212 micron size has 0.0025 and averagely 0.0018 milligram and below 90 micron sizes have 0.0012 and averagely 0.0010 milligram of weight loss.

Key words: High velocity test rig, Sand impact, sand size, sieve size

Introduction

Hard particles as Quartz and Feldspar are present in large amount in most of the rivers across in the Himalayan basins. In run-off-river hydro power plants these particles find way to turbine and cause its components to erode. Loss of turbine material due to the sand erosion and subsequent change in flow pattern induce in overall efficiency, vibrations and reduced life of turbine components are the major effects of sand erosion of hydraulic turbines. Hydraulic turbines are more prone to damage by means of sand size impact. Sand has different eroding characteristics and varies according to its mineral content, size and shape too. Many researches though have been explored, not have yet been able to totally subsidize turbine material that best fits. So sand being the most eroding and responsible particle, a detail understanding of it is must. Nepal is rich in hydropower resource, more than six thousand small and large streams and rivers flows from high hill to low landfill Terai region [19]. Among them Sunkoshi River is, one of the major streams that originates from Himalayan region and have great potential for power production. This study is done to detail understanding of sand particles size characteristics and its impact on turbine material. Its knowledge is essential while exploring turbine material. Different kinds of sands are abundant in nature and have different nature of impact properties. Considering these factors, this research was carried out. Sunkoshi River sand particles were chosen and tested. From the result it was evident that different sediment particles have different characterizing properties and impact values on turbine material. Examining size of sand particles can well benefit investors by choosing efficient material.

Material and Methods

Sand is the major sample to be collected in this research work. Major run off the rivers of Nepal are sediment laden type, so sand is the major constituents available in those rivers and has high erosive properties that directly have effect on turbine material. A complete study is done to build a database and profile of sand particles effect of different rivers according to size, Sunkoshi is the river from where sediment samples were collected. This river flow draining north central region of the country and is one of the main rivers of this region. Five different strategic locations were traced out

along the river sections and sediments were sampled from the stations. Two hydro projects are running from this river. Different strategic locations of river have been selected according to tributaries joining point, human interference zone and channels from where water is used for drinking and irrigation purpose and from intake, settling basin, reservoir and downstream of build hydropower plant. Samples of Sand particles collected were used to identify the sand erosion impact on turbine materials on the basis of size, this study will help investor, researchers, engineers, geologists to know the impact of sediment of this river. This study helps to make a rational decision for policy makers to identify the places for different sustainable development activities like building hydropower plant, irrigation, drinking water, waste water treatment area etc. and can identify the socio-economic activities of the people near by the stations, upstream and downstream of the river. Sampling of sediments

(5kg) of sand from each 05 different locations was sieved to categorize the particles into 4 different sizes. The sieve analyzer was vibrated for 10 minutes to separate each sample size, in their respective sieve plate. Among these different sieve categories, particle of of sizes 90 to 425 microns are more prone to cause effect on turbine material. Other big particles were filtered to enter into turbine section. The study was done on those 4 different sieve categories only. Table 1 below shows different size categories of sieve analyzer.

Table 1. Sieve analyzer size

Sieve No	1	2	3	4
Size(μm)	300-425	212-300	90-212	<90

These different sieve sizes from 05 different sections of Sunkoshi River were then tested. To find out the impact of different sediment sizes, a high velocity test rig was utilized. It determines the sand erosion rate of particles by impinging the water mixed with sand samples. It consists of a nozzle that strikes on turbine material in a fixed and varying velocity. A hooper is fabricated in between the nozzle and valve from where sand samples are drawn and mixed with water that strikes the test material. The flow condition, sand size and time were recorded. The schematic diagram (Figure 1) below represents the test rig. The circuit has 5.5 kW mono block centrifugal pumps with 45 m head, 6 litre/sec discharge rate with 5.1 kg/cm^2 pressure Valves were used to control the flow of water and sand particles. The sand was weighed and filled into 1.5 m height hopper 100mm ahead of a nozzle. Once the pump was started and the water circulated through the nozzle, the valve of sand hopper was opened. The water created turbulences inside the hopper and sand fell down in the horizontal pipe because of gravity. The increased velocity of water helps the sand particles to flow continuously through the nozzle. The test was continued until all the sand particles passed through the nozzle. For one test 1.5 kg of sand were used which it took about 20 min to pass all the sand particles from the nozzle.

was done by collecting sand from river banks, bed and mid section of river. This river is one that flows draining the west central region of the country. Five different strategic locations along the river path of Sunkoshi River were chosen for sand sampling. This river sediment is utilized to find out the erosion impact on turbine test specimen and its erosion rate is determined to understand the sand erosion of this river. Sand was sampled from 05 different strategic locations from the tip of origin to the end of Sunkoshi River, considering human interference zone, tributaries joining points and industries. Samples from river bed, bank and fluvial were collected by using different sampling equipment. From each location 10kg of samples were collected and brought to the lab oratory at Kathmandu University. One of the most important parameters is the sand size, which has great impact on turbine material. To distinguish particle size, four-layered sieve analyzer was used. Five kilogram

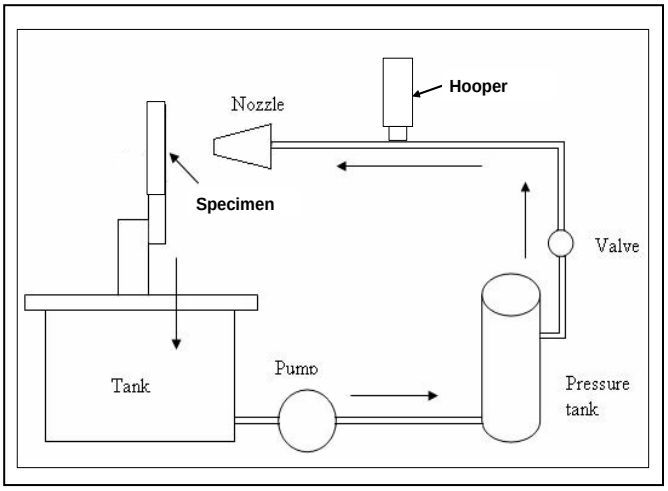

Fig 1: Schematic High Velocity test rig for sand erosion

Result and Discussion

Sunkoshi River is the one that also drains the north central region of central development region of Nepal. It lies east of Indrawati and is considered to be bigger than Indrawati with big river as its tributaries. Five different strategic locations were chosen and its sediments were collected to study its impact value on turbine specimen. Experiment was carried out at Kathmandu University erosion testing laboratory set up. The below figure 2a, 2b shows the impact of five different river spots sediments by different sizes sediment. The figure below 2b is shown that the impact trend line of different locations sediment by different sediment size group. Similar kind of trend line is depicted by all sediment sizes. The figure below 2a shows the trend line of Indrawati River. average plot at 5 different stations. The bar chart shows that the effect of sediment size in turbine material increases with increase in sediment size.

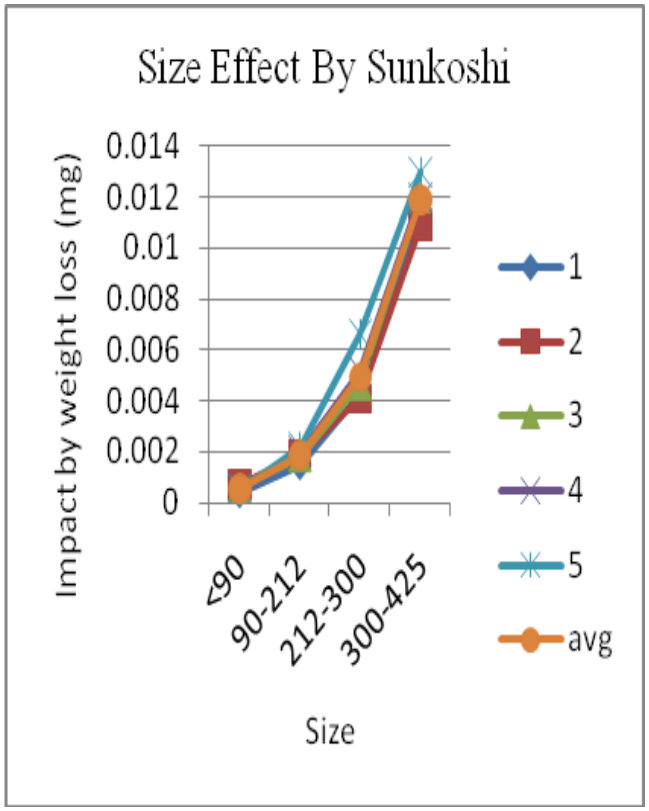

Figure 2a

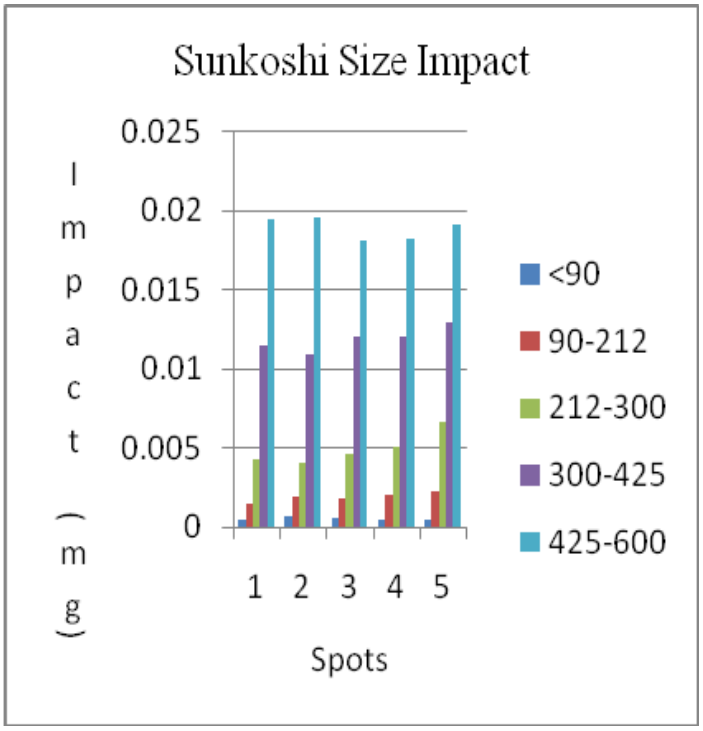

Figure 2b

Figure 2 (a,b): Impact by size of different seive sizes in different sections of Sunkoshi River

Its sizes effect is shown in the above figure 2a, 2b where the vertical axis shows the impact measured in the basis of weight loss in milligram and horizontal axis with locations from where sediments were sampled to find out the impact. The seive sizes have a unit in microns and effect is in milligram. It is figured out that the size of sediment range 300-425 micron has high impact comparatively with other but in location 5, it has lower impact that the sediment size of 212-300 micron. It is found that the higher the size higher is the impact value. Considering the spot and impact value all there is a huge difference of impact likewise in Roshi river value. The value is in the range of double extending from one size group to another. So it can be assured that this is also one peculiar kind of trend followed in impact.

Conclusion

It is evident from the above result that the lines of impact value of different sizes of sediment at different spots have similar and significant values. The big dashed between line shows the average value of all spots impact. All the lines follows similar trend and have same average impact value. Figure 2 (a) shows the impact at different spot by different size ranges sediments. It is depicted that 300-400 micron size sediment, have highest impact with weight loss of 0.013 milligram and averagely 0.0115 milligram, 212-300 micron size has 0.008 and averagely 0.005 milligram weight loss, 90-212 micron size has 0.0025 and averagely 0.0018 milligram and below 90 micron sizes have 0.0012 and averagely 0.0010 milligram of weight loss. It is also depicted that the impact value is higher as higher sediment grain sizes range. It is resulted from the entire chart that higher is the sediment size higher is its impact value and its value ranges in somewhat double on the turbine specimen. It clearly indicates that sand particles in upstream and downstream part has also different impact properties. It may be affected by minerals content and shape of sand. Turbine being one of the most important components to produce energy in hydropower plant needs great attention. Most of the power plant often shut down due to early detritions of turbine material, so it is necessary to consider all the parameters that Detroit. This research idealizes sand as one of the most eroding element and its characteristics and impact value were studied. According to research results, it shows that sand particles with greater size have high erosion rate than smaller particles flowing with water. The size is one of the major one, but it could be as per shape, mineral content etc too. These results are the basic parameter of sand, which can help policy makers, designers and investors to choose the efficient material and site location for hydropower generation.

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Biography

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Received BE degree in Mechanical Engineering from the Institution of Engineers, India in 1992, the MBA degree in Management from Tribhuwan University in 2000, the M.E. degree in Mechanical Engineering from the Kathmandu University, Nepal, in 2007, and is going to complete the Ph.D. degree in Mechanical (Hydropower) Engineering from Kathmandu University within 2013, respectively. Currently, he is an Associate Professor of Mechanical Engineering at Tribhuwan University, Institute of Engineering, Pulchowk Campus, Nepal. His teaching and research areas include ***Sand Erosion on Hydraulic Turbine Materials and Sediment Characterization***. He has published more than thirteen Articles in Journal and Proceedings so far.

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