International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 01,January-2015

Estimation of Silt Erosion in Hydro Turbine

Sandeep Kumar
Mechanical Engg. Department
Kanpur Institute Of Technology
Kanpur [U.P.]

Dr. Brajesh Varshney
Mechanical Engg. Department
Kanpur Institute Of Technology
Kanpur [U.P.]

***Abstract*—Hydro turbine is considered as the main component of a hydro power plant and unfortunately, hydro turbines encounter problems like silt erosion which reduces the efficiency over a period of their operation and decrease their operating life. A large number of hydro power plants in India are confronting silting problem .Data was collected from power plant facing silt erosion problem such as Tiloth Hydro Power .This power plant facing regular damage due to excessive silt in water and facing number of operation. An attempt has been made to develop relation between rates of material eroded from turbine runner and silt load and a comparison is made between the original data and the estimated data.**

Keywords—silt concentration ,silt size ,material eroded,Microsoft office Excel 2007.

I. Introduction

Silt erosion of hydro turbine is major problem for the efficient operation of hydropower plants .The high content of unsettled silt particles pass through the turbines during rainy seasons resulting in erosion of turbine components These problems are more prominent in power stations which are of run-of-river types The problem is aggravated if the silt contains more percentage of quartz, which is extremely hard (hardness 7 in Moh's scale) and freshly broken sharp particles, causing severe damage to the turbine components [1-3]. It is generally considered that erosion damage is the gradual removal of material caused by repeated deformation and cutting actions [4]. When particles strike the surface at small impingement angle the material is removed by cutting mechanism. The abrasive grits roll or slide when they strike on the surface at small impingement angle and cause erosion by abrasion or cutting mechanism [5,6].The process of erosion damage is influenced by a number of factors, namely: average velocity of particles, the mass of particles, the concentration of abrasive particles in fluid, size distribution of particles and their average grain size, shape of the particles, angle of impingement, time interval of the attack, the erosion resistance of structurall material [7].

The shape of the particles is one of the important factors which control erosion rate.

Under the study Naidu [8] reported that about 22 large hydropower stations in India are facing silting problem. These power stations have been classified into three categories based

on quantum of damage as; (i) category A – indicates intensive damage and needs renovation every year, (ii) category B – indicates substantially high damage and needs renovation in every 3 years and (iii) category C – indicates considerable damage and needs special efforts and resources after 15–20 years. In another study Naidu [8] has stated that Baira Siul project (3×66 MW) in Himachal Pradesh in India, handles nearly 10,000 tons of silt per day, per machine during critical monsoon days and more than 90% of the silt passing through these machines is quartz. Nepal is also facing severe silting problem in hydropower plants with specific sediment yield of about 4240 tonnes/km2/year. Marshyangdi river is one of the sediment-laden rivers in Nepal [9]. The sediment logical study performed in 1981 has revealed an average annual load of 26.7 million tonnes and bed load of 2.9 million tonnes. Out of this total load, 90% of the sediments are transported in the river during the monsoon season from May to October. Similar conditions also prevail in rest of the rivers [10].

The erodent shape is an important property, but its effect is difficult to quantify for natural particles. For impact of spherical particles on ductile materials.

Silt erosion is designated as abrasive wear. This type of wear will break down the oxide layer on the flow guiding surfaces and partly make the surfaces uneven which may also be the origin for cavitation erosion [11]. Sand erosion therefore may be both releasing and contributing cause for damages that are observed in power plants with a large transport of wearing contaminants in the water flow.

we have done study on the silt erosion of hydro turbines and develop a relation of erosion rate of turbine with respect to operating condition and effecting parameters of the silt.

This paper is organized as follows. In section II, factors affecting silt erosion are described. In section III, methodology, in section IV, analytical results, In section V, conclusion.

II. FACTORS EFFECTING SILT EROSION IN HYDRO TURBINE

The sediment erosion damage is due to the dynamic action of sediment against a solid surface. Characteristics of the sediment, fluids (carrying sediments) and base material are jointly responsible for sediment erosion. The erosion intensity depends on followings.

A. The Sediment Type and Its Characteristics

The intensity of the erosion is also directly proportional to the hardness of particles (irrespective of sizes) [12]. The intensity of erosion is directly proportional to the size of the particles. Particle sizes above 0.2 to 0.25 mm are extremely harmful [13]. The fine sediment can also be dangerous, if the turbine is operating under high head.

Generally, particle shapes are described qualitatively such as round, angular and semi-round based on visual observation. Sharp and angular particles cause more erosion in comparison to rounded ones. Round shape of silt particle have been considered in the analysis.

Erosive wear rate is proportional to the concentration up to a certain limiting value of the wear [14].

B. Velocity of Water Carrying Sediment

Material damage due to plastic deformation and cutting occur simultaneously and the ratio of these damage mechanisms depends on the velocity of particle and the impingement angle together with other parameters [15].

C. Impingement Angle

The angle between the eroded surface and the trajectory of the particle just before impacting a solid surface [16].

D. Effect of Temperature on Erosive Wear

The primary effect of temperature in wear is to soften the eroded material and increase wear rates [14].

III. METHODOLOGY

Under the present study, the effect of silt parameters on hydro turbine is to be studied. This has been done on the basis of silt data available in the field For the study different data such as silt concentration ,material eroded, silt size, velocity of striking water ,power channel discharge ,river discharge have been collected from the above mentioned power plant. Silt particles size of 150 micron was arbitrarily chosen for the study and the velocity of striking water of 4.65 m/s was chosen.

The material eroded from the turbine components is the function of silt load, silt attacking velocity, silt size.

The most often quoted expression is wear ∝ (Silt load, Velocity, Silt Size)^{a}

or $$W \propto (C, V, D)^{a}$$

or $$W=k(C,V,D)^{a} \quad (1)$$

here a and k are constants

Where, index may vary upon the factors [17]. The simplest way of writing equation for erosion is:

Erosion = f (operating condition, properties of particles, properties of base material)

Now we can write the above equation as:

$$W=k(C)^{a} \quad (2)$$

by keeping the other factors constant.

The final expression which comes after study is as follows:

$$W=8.52\ C^{0.384} \quad (3)$$

Using above equation, we have find the estimated value of material eroded.

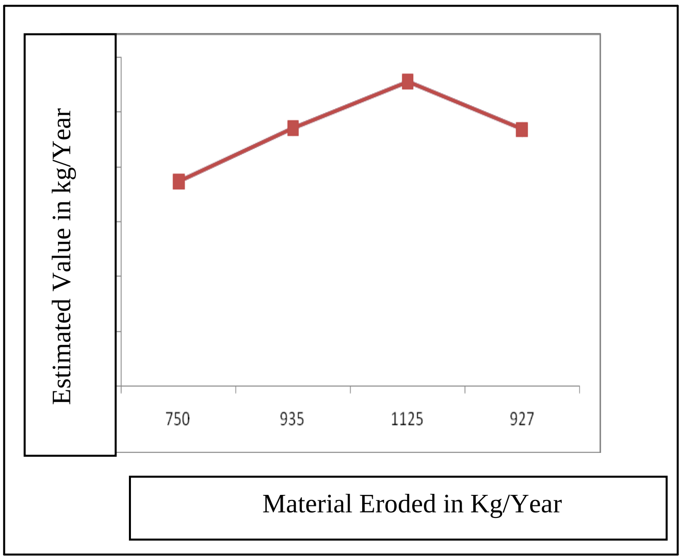

Figure 3.1: Comparison of material eroded kg/year vs. estimated value in kg/year

IV. Analytical Results

The equation (3) has been used for calculation of eroded material of turbine which is compared with the original value of eroded material as dwawn from the plant.

The parameters required for calculation of weight of silt eroded material are given in the table:

Table 4.1: Operating Parameters

Installed Capacity	3x30 MW
Design Discharge	71.4 m³/s
Design Head	147.5 m
Turbine Type	Francis
Turbine Output	30 MW
Generator Output	30 MW
Water velocity	4.65 m/s
Silt Size	150 micron

In the study we have observe that the rate of turbine eroded increases as the rate of silt passed through the turbine increases. The value of turbine eroded varied from 750 kg to 1125 kg corresponding to the silt passed through the turbine from 114321 to 323041 tons and estimated value of turbine eroded which is get from the relation varied from 746 kg to 1111 kg and obtain the Absolute Percentage Error varied from 0.52 to 1.2.

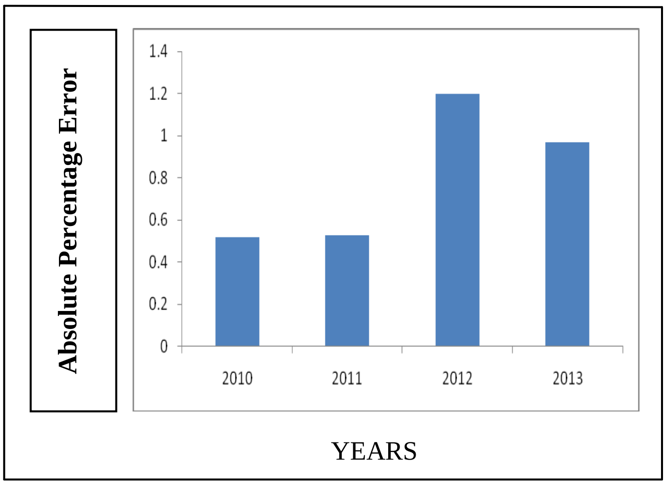

Figure 4.1 Percentage error based on estimated value and eroded value in kg per year

V. Conclusion

Based on the above study we have find that the silt concentration, material eroded, particle size and velocity of water are the important factors. It is observed that the rate of turbine eroded increases as the rate of silt passed through the turbine increases. Based on the collected data, a relation is developed between the silt load and eroded material. Hence, on the basis of the relation we can conclude that if silt load is known then we can estimate the eroded material easily by keeping the other factors constant. We have also compare the estimated eroded material value from the original value of eroded material drawn from the plant and evaluate the absolute percentage error.

Acknowledgment

I would like to express my gratitude to my supervisor Dr. Brajesh Varshney, Department of Mechanical Engineering Kanpur Institute of Technology Kanpur, UPTU Lucknow, for his exceptional patience, Thank you for providing me with valuable feedback in my research which made it stronger and more valuable. I am sincerely grateful for his priceless support and contribution toward my research.
Also, I would like thank Mr. A.S. Verma, Head of Mechanical Engineering Department, Kanpur Institute of Technology Kanpur, for providing me the opportunity to carry out the present study and thesis work.
I extend my sincere thanks to my friend Mr. Musheer Alam, Finally, I would like to thank my family for their help, encouragement, prayers and cooperation during my research work.

REFERENCES

[1] Tilly, G.P. (1973), "A Two Stage Mechanism of Ductile Erosion", Wear (23), 87. D.Tong, (1981) Cavitation and wear on hydraulic.

[2] V.K. Pande, (1987). Criteria for developing silt erosion model test.

[3] S.C. Singh, (1990) Operational problems and development of a new runner for silty water. International WP&DC; November

[4] Hutchings I. M. Tribology-friction and wear of engineering materials, 1992 (Arnold, Pans).

[5] Takgi T, Okamura T, Sato J. Hydraulic performance of Francis turbine for sediment-laden flow. Hitachi Review 1988;(No-2).

[6] Sundararajan G., comprehensive model for the solid particle erosion of ductile material. Wear 1991; 149:111e27.

[7] M. K. Padhy and R.P. Saini, (2008) A review on silt erosion in hydro turbines, Renewable and Sustainable Energy Reviews 12 1974-1987.

[8] Naidu BSK. Silting problem in hydro power plant & their possible solutions. India: NPTI; 2004.

[9] Chaudhary CS. Impact of high sediment on hydraulic equipment of Marsyangdi hydropower plant. In: Proceedings of the international seminar on sediment handling technique, NHA, Kathmandu; 1999.

[10] Bajracharya TR, Acharya B, Joshi CB, Saini RP, Dahlhaug OG. Sand erosion of Pelton turbine nozzles and buckets: a case study of Chilime hydropower plant Wear 2008; 264:177–84

[11] H. Brekke, Hydraulic design of turbines, in: C.G. Duan, V.Y. Karelin (Eds.), “Abrasive Erosion and Corrosion of Hydraulic Machinery”, ICP, London, 2003.

[12] Zu, J. B., Hutchings, I. M., and Burstcin, G. T., “Design of slurry erosion test rig”, Wear, 1990, 140, 331–344.

[13] J. Sato, K. Usami, T. Okamura, S. Tanaba, “Basic studies of coupled damage caused by silt abrasion and cavitation erosion”, ASME FED 136 (1992)

[14] Hari Prasad Neopane, “Sediment erosion in Hydro Turbines”, PhD thesis, Waterpower Laboratory, Department of Energy and Process Engineering, Norwegian University of Science and Technology (NTNU), Norway, February 2007 to March 2010.

[15] Mack, R., Drtina, P., and Lang, E. “Numerical prediction of erosion on guide vanes and in labyrinth seals in hydraulic turbines”, wear, 1999, 233–235, 685–691.

[16] G.P. Tilly, Treatise on Material Science and Technology, vol. 13, Academic Press Inc., 1977, pp. 287–319.

[17] Tsuguo N.,1999. “Estimation of repair cycle of turbine due to abrasion caused by suspended sand and determination of desilting basin capacity”, in: Proceedings of the International Seminar on Sediment Handling.