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SILTING PROBLEMS IN HYDROPOWER PLANTS

Engineering

KEYWORDS: Erosion, Turbine, Silt Size, Silt Concentration.

Sourabh Khurana

Associate Professor, Mechanical Engineering Department, Gurukul Vidyapeeth, Rajpura-140401

ABSTRACT

Silt Particle laden flow through hydro turbine components causes erosion to the surface which comes in contact with it. Silt size, silt concentration, velocity of flow, and properties of silt materials and operating hours of turbine play a vital role in damaging the turbine components. Efficiency of turbine decreases with increase in erosive wear. In the present paper effect of silt on erosion and performance of turbine and case studies conducted by the Author in Himachal Pradesh have been discussed.

I. INTRODUCTION

In India the Ministry of power has been entrusted to develop large hydropower resources and the Ministry on Non-conventional Energy Resources has been promoting small and mini hydro projects [1, 2]. Therefore, hydro turbines must have high efficiency, but due to silt erosion turbines show declining performance. Therefore, hydro turbines must have high efficiency, but due to silt erosion turbines show declining performance. Silt erosion is a mechanical wear of components due to silt flowing with water. Erosive wear of hydro turbine components is a complex phenomenon and a large number of factors influence silt erosion in hydro turbines. Silt erosion depends upon several factors like silt size, silt concentration, shape, hardness, impingement angle, velocity of flow, properties of materials, and diameter of jets [3, 4]. It can be readily observed that quartz is the main component of silt with a very high value of hardness (7.0 on Mohs scale). Damage to turbine and other components due to silt carried by the Himalayan Rivers results in a frequent shutdown of hydropower stations, causing huge economic losses in developing country like India [5]. In the present paper effect of silt on erosion and performance of turbine and case studies have been discussed.

II. LITERATURE REVIEW

Khurana and Varun [6] have developed a correlation for estimating percentage efficiency loss of rated efficiency for Turgo Impulse turbine runner as:

$$\eta_{\%} = 2.93 \times 10^{-8}\, S^{0.212}\, C^{01.113}\, V^{1.409}\, t^{0.737}$$

Khurana et al. [7] have developed a correlation for estimating erosive wear rate as a function of system and operating parameters for Turgo Impulse turbine runner as:

$$W = 1.976 \times 10^{-10}\, S^{0.118}\, C^{0.967}\, V^{1.368}\, t^{1.117}$$

Khurana and Varun [8] conducted experimental study on small scale Turgo impulse turbine to study the effect of jet diameter, silt size, silt concentration, jet velocity and operating time. They develop correlation for the estimation of normalized wear of a Turgo impulse turbine runner.

Padhy and Saini [9] conducted experimental study to investigate the mechanism of erosion on small scale Pelton turbine under actual flow conditions. Silt parameters were considered to investigate the mechanism of silt erosion in Pelton turbine buckets. They found that silt size is strong parameter to produce erosion and the material removal from the surface.

Takgi et al. [10] performed performance tests on Francis turbine model with silt laden flow and observed that maximum efficiency decreases in direct proportion to increase in solid concentration. The efficiency reduction was given by:

$$\eta_m = (1 - 0.085\, C_w)\eta_w$$

Krause and Grein [11] stated that erosion of conventional steel Pelton runner made of X5CrNi 13/4 can be predicted as:)

$$\delta = P\,Q\,C\,V^{3.4}\, f(D_{50})$$

Padhy and Saini [3] experimentally investigated the effect of silt size, silt concentration, jet velocity and operating hours of turbine on efficiency loss in Pelton turbine buckets. They developed a correlation for estimating percentage efficiency loss of rated efficiency for Pelton runner as:

$$\eta_{\%} = 2.43 \times 10^{-10}\, (S)^{0.099}\, (C)^{0.93}\, (V)^{3.40}\, (t)^{0.75}$$

Mathur et al. [12] reported the case study of Salal (6 ×115 MW) and Baira Siul (3 ×60 MW). In the water silt present was very high indicated the presence of 75–98% quartz bearing hardness 7–8 on Moh's scale and about 98% silt particles are of size 0.25mm and less. After 4000 h of operation at Baira Siul guide vanes made of 13Cr4Ni stainless steel, the loss was about 10–15% whereas at Salal this loss was approximately 10–12% of design weight.

From the literature review it can be concluded that silt parameters leads to erosion in hydro turbines and due to erosion performance of turbine also decreases.

III. TYPES OF HYDRO POWER PLANT

- High Head
- Medium Head
- Low HeadSmall Hydro Power (1 -15MW)
- Mini Hydro power (100KW-1MW)
- Micro hydro power (5KW-100KW)
- Pico hydro power (up to 5 KW)

IV. CURRENT STATUS OF HYDROPOWER IN HIMACHAL PRADESH

- The potential of power generation of Himachal Pradesh has been assessed at 23,000 Megawatt, which is about 25 percent of the total hydropower potential of the country.
- Approx. 750 MW under Small Hydro Sector.
- In Himachal Pradesh 547 sites are identified for small hydropower projects.

V. CASE STUDIES

Kothi Mini Hydro Project (Manali)

- Capacity (2×100 KW)
- Set up year 2001
- Turgo Impulse turbine used
- Efficiency 85%
- Head 87.08 m
- Due to silt chocking in Penstock and in needle occur.

Lower Baijnath KUHL Mini Hydro

- Capacity (2 × 500kw)
- Set up year 2005
- Horizontal Francis turbine
- Efficiency 88%
- Net Head 60m

- Penstock Diameter 3m
- Rated Discharge 1.015cubic meter per sec.
- Due to silt erosion in blade occurs.

Figure 1: Francis Turbine

Aleo Small Hydro Manali

- Capacity (2 × 1.5MW)
- Set up year 2005
- Pelton turbine
- Efficiency 83%
- Net Head 297m
- Due to presence of silt runner has been replaced after 2 years
- Eroded blade is shown in Figure 2

In this hydro project during monsoon season concentration of silt particles was around 3000 ppm. Due to presence of quartz which is having hardness 7 on Moh's scale. Due to quartz runner was replaced after two years of operation. We can observed that how material removes after striking of silt water to buckets of turbine.

Figure 2: Eroded Blade

Based on investigation it was observed that material removal was due to plastic deformation and ploughing of surface.

Marhi Hydro Project Manali

- Capacity (2 × 2.5MW)
- Set up year 2007
- Pelton wheel Turbine
- Efficiency 85%
- Net Head 350 m
- Due to presence of silt Buckets and runner effected and coating is used(Stellite)
- Desilting chamber used to remove silt

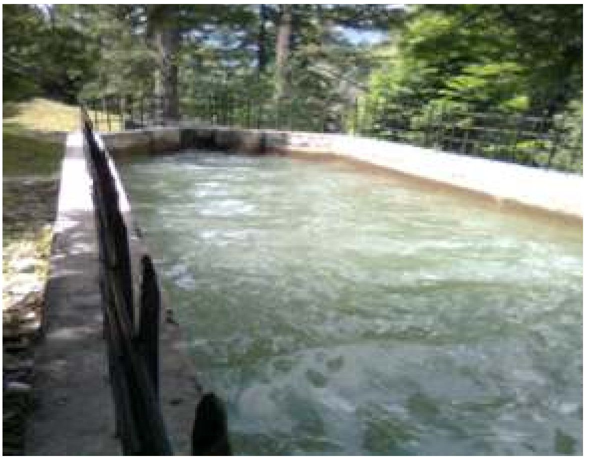

Figure 3: Desilting Chamber

VI. CONCLUSION

Silt erosion in hydro turbines is a complex phenomenon and it cannot be avoided completely. For this Stellite coating can be used after erosion. Many investigators have studied the process of erosion and due to erosion declined performance of hydro turbines through analytical and experimental studies. One case study also reported in the text. Various case studies conducted by Author and from these it was concluded that due to silt even runner can be replaced.

VII SCOPE FOR FUTURE WORK

The present work can be performed by experimental study and then this work can be compared to software.

Different type of materials of buckets/ blades can be considered.

REFERENCE

[1] M. K. Padhy and R. P. Saini, A review on silt erosion in hydro turbines, Renewable and Sustainable Energy Reviews, 12 (2008) 1974-1987. | [2] S. Derakhshan and A. Nourbakhsh, Experimental study of characteristics curves of centrifugal pump working as turbines in different specific speeds, Experimental Thermal and Fluid Science, 32 (2008) 800-807. | [3] M. K. Padhy and R. P. Saini, Study of silt erosion on performance of a Pelton turbine, Energy, 36 (2011) 141-7. | [4] H. P. Neopane, O. G. Dahlhaug and M. J. Cervantes, The effect of sediment characteristics for predicting erosion on Francis turbines blades, Hydropower & Dams, 19 (2012) 79-83. | [5] B. S. K. Naidu, Addressing the Problems of Silt Erosion at Hydro Plants. International Journal of Hydropower and Dams, 3 (1997) 72–77. | [6] Sourabh Khurana, Varun and Anoop Kumar Silt erosion study on the performance of an Impulse turbine in small Hydropower, International Journal of AmbientEnergy http://dx.doi.org/10.1080/01430750.2015.1023831 | [7] Sourabh Khurana, Varun and Anoop Kumar, Effect of silt particles on erosion of Turgo impulse Turbine blades, International Journal of Ambient Energy, 35 (2014) 155-162. | [8] Sourabh Khurana and Varun, Effect of jet diameter on erosion of Turgo impulse turbine runner, International Journal of Mechanical Sciences and Technology, 28(11) 2014 4539-4546. | [9] M.K. Padhy and R.P. Saini, Study of silt erosion mechanism in Pelton turbine buckets, International Journal of Energy, 39 (2012) 286-293. | [10] Takgi, T., T. Okamura, and J. Sato. 1988.Hydraulic Performance of Francis Turbine for Sediment-laden Flow. Hitachi Review No-2.| [11] M. Krause, and H. Grein. Abrasion Research and Prevention. International Journal of Hydropower and Dams 4 (1996) 17–20.