Enhancing Efficiency of Kaplan Turbine by Implementing Advance Features: A Review

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Abstract—The sharp increase in the cost of energy in recent years has led to a strong demand for more efficient electric generation and the evaluation of 1% of efficiency has become higher than of the price of generating equipment. Efficiency can be gained by replacing or modification one or several turbines components as well as improvement in hydraulic structures. In this paper Efficiency enhancement is currently in the centre of interesting of many researchers and several studies and experiment have already been made.

Keywords—Kaplan turbine, bearing bush, fatigue life, cavitations, efficiency.

I. INTRODUCTION

Hydropower is a renewable, non-polluting and environment friendly source of energy for conversion of mechanical energy into electrical energy. The Kaplan's blades are adjustable for pitch and will handle a great variation of flow very efficiently. They are 90% or better in efficiency and are used in place some of the old (but great) Francis types in a good many of installations. Hence failure of a Kaplan turbine operation result efficiency loss of production supply.[11]

However, operating life of a Kaplan turbine can be drastically curtailed by improper start up and shut down practices. So properly planed executed maintenance schedule is in dispensable for very power plant having hydraulic turbine on their main equipment in their process plant.

The case study deals with the failure analysis of failure and design is checked and then proper solutions are given to improve the effectiveness of turbine.

II. ABOUT GANGREL HYDRO ELECTRIC POWER PLANT

The Gangrel Hydro Electric Power Station (R.S.SAGAR DAM) is situated at Gangrel in left bank of “Mahanadi” which is about 13 km away from Dhamtari district [c.g.] and 90 km from Raipur.

The Gangrel Hydro Electric Power Station is designed and developed for “Incidental Power Generation” by irrigation release from Mahanadi Reservoir.

The total capacity of the plant is 10 MW, which consists of 4 units, each of 2.5 MW Capacity. The Turbine is M/s Alstom make vertical Full Kaplan with automatically adjustable guide vanes & runner blades with parameters. [1]

<table>
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<tr>
<th>TABLE 1 KAPLAN TURBINE SPECIFICATION</th>
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<tr>
<td>Rated output</td>
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<td>Rated speed</td>
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<td>Rated discharge</td>
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<td>Rated head</td>
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<td>Full reservoir level</td>
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<td>Minimum draw down level</td>
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III. COMPONENTS OF KAPLAN TURBINE

1. Spiral casing
2. Distributor assly
3. Shaft and coupling
4. Runner and Blade regulating system
5. Guide Bearing
6. Shaft Gland
7. Draft tube
8. Mechanical over speed Switch Assly.
9. Electronic over speed relay assly

Figure I Kaplan Turbine
IV. LITERATURE SURVEY
A. According to Loza,D.M , “Investigation of The Potential For Improving The Efficiency of The Turbines Of Hydro Electric Power Generation Station”.

In order to obtain accurate results of possible efficiency improvement the replacement of particular component can be done by measuring efficiency before and after replacement using CFD analysis.


The author has focused his work on one type of Kaplan turbine runner cavitations – tip vortex cavitations. On the basis of CFD analysis he has estimated the intensity of caviating vortex core, danger of possible blade surface and runner chamber cavitations pitting.

In order to prevent the Blade surface against pitting, the following possibilities as the change of geometry of the runner blade, dimension of tip clearance and finally the installation of the anti cavitations lips are discussed.


The author has performed static analysis and designed of Micro Hydro Kaplan Turbine Blade which is based on calculation of main characteristics i.e. Discharge through runner, Power that can be generated, Hub diameter on which the design of the runner is based.

From comparision of tables the author has concluded that by increasing the diameter of stress relieves grooves the amount of stress generated is less.


The author has performed experimental analysis of the Optimal Cam Characteristics for a Kaplan Turbine for a unit of 22 MW with 12.5 m designed net head and 185 m³/s rated discharge , in a run of river power plant.

The efficiency has obtained at different runner blades and guide vanes opening combination across a range of heads. The optimum three dimensional combination between the runner blades opening and the guide vanes opening , for different head values has determined, which concluded that the efficiency in the conditions of new Cam characteristics increased up to 2% with a smaller opening of the guide vanes , which decreased from 6% to 9 % of the total opening.

E. According to Campian, C., Et Al, “A Dynamic Analysis of Inner Bearing Bush from Blade Adjustment Mechanism of Kaplan Turbines”.

The author has presented the analysis using the finite element method of an inner bearing bush from a Kaplan turbine. Analysis of Kaplan turbine was made in order to determine stresses distribution and displacements.

V. PROBLEM IDENTIFICATION

The tendency of higher power concentration in hydraulic turbines, bring as a consequence an increase in both the load and hydraulic forces in the machine. These conditions produce major stresses in bearing and possible vibration problems that could cause fatigue and fracture the bearing. White metal is used as bearing bush material of thickness2mm to prevent wear of bearing and shaft the filling of white metal bush is done for a regular interval of 6 month and hence the plant have to be closed down for at least 15-20 days on each failure. The failure causes lose of generation of electricity.

<table>
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<th>SR. NO.</th>
<th>TROUBLE</th>
<th>CAUSES</th>
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| 1       | Less output   | a) Reduction in efficiency due to worn runner.  
|         |               | b) Head available is less than net head required.  
|         |               | c) Low water flow at the intake.  
|         |               | d) Debris in turbine.  
|         |               | e) Tail race obstruction  
|         |               | f) Leakage  
|         |               | g) Electrical  |
| 2       | Vibrations    | a) Alignment and levels disturbed.  
|         |               | b) Foundation bolts loose.  
|         |               | c) Bearing damaged  
|         |               | d) Uneven wearing of runner causing unbalance. |
|         |               | e) Weak foundation.  |
| 3       | Components wear off quickly | a) Runner wears out soon due to high silt content in water.  
|         |               | b) Bearings, bushes etc. wear out due to misalignment and improper leveling.  |
| 4       | Over heating of bearings | a) Dirty water used.  
|         |               | b) Lack of lubrication  
|         |               | c) Inadequate or no water flow to bearing.  
|         |               | d) Misalignment of shaft and it is brushing with bearing housing.  |

Table 2 Causes Of Failure
VI. REMEDY FOR FAILURE

1. Replace The Seals With Self Lubricating Seals

Replace the seals using self lubricating seals the chance failure is less ,with the increase of lifetime of the bearing, cost are eliminated related to machining of worn parts, grease and oil used in the distributor mechanism.

Self lubricating material has an advantage of longer lifetime and its higher load capacity when compared with PTFE foils.[16]

II. Design Of Blades

In order to decrease the maximal stress value it is necessary to reduce the hydrodynamic loads on the blade which is possible by increase in number of blades. The efficiency is obtained at different runner blades and guide vanes opening, for the different head values.[8]

III. Fatigue Analysis Of Bearing Bush

The fatigue analysis can be made which validates the bearing bush for usage in turbine which can bear high load capacity and can sustains high temperature so that the lifetime of bearing is increased.[7]

VII. CONCLUSION

A plant survey has been done to Gangrel Hydroelectric Power Plant and investigation has been done to enhance efficiency of vertical full Kaplan turbine of Hydro Power Plant. Based on analysis of available information from problem identification and research studies, scientific publication that has carried out for other Kaplan turbine, the methodology of enhancement of turbines efficiency gain is possible.

To sum up everything, it is worth to incur some important conclusions:

1. Investigation of the problems associated with the operation of Kaplan Turbine has been identified; the losses and cause for such losses has been described. The remedy to such problem has been compared with the Current technology introduced.
2. To facilitate the task of enhancing efficiency, Methodology is prepared which follows through all the important losses which occur in turbine. Approximation of possible increase in efficiency is included for each separate part.
3. To speed up the estimation and improvement of efficiencies the Optimum area of project has been discussed.

4. Among the suggested area for project, the bearing bush has been found to be feasible which can be done by fatigue analysis with other material and suggesting the optimum bearing bush.

REFERENCES


