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Review

Sources of vibration and their treatment in hydro power stations-A review

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ABSTRACT

Vibration condition monitoring (VCM) enhances the performance of Hydro Generating Equipment (HGE) by minimizing the damage and break down chances, so that equipment stay available for a longer time. The execution of VCM and diagnosing the system of an HPS includes theoretical and experimental exploitation. Various studies have made their contribution to find out the vibration failure mechanism and incipient failures in HPS. This paper gives a review on VCM of electrical and mechanical equipment used in the HPS along with a brief explanation of vibration related faults considering past literature of around 30 years. Causes of the vibrations on rotating and non-rotating equipment of HPS have been discussed along with the standards for vibration measurements. Future prospectus of VCM is also discussed.

Contents

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1. Introduction

Vibration of equipment has been a severe problem in Hydro Power Stations (HPS) from the very beginning of power generation. Failure of the equipment due to vibration causes shut down, or sometimes, even a disaster in hydro power station (HPS) [1,2]. VCM has to be done to examine the performance of such equipment online automatically and to know the status of complex systems in hydropower generation. In HPS, online vibration monitoring is provided in various parts of hydrogenating equipments including relative shaft vibration, bearings absolute vibration, turbine cover vibration, thrust bearing axial vibration, stator core vibrations, stator bar vibrations, stator end winding vibrations. Non-contact capacitive proximity probes are usually provided to dynamically monitor the motion of the generator/turbine shaft relative to the bearings. The probes need to be insensitive to electrical run-out, magnetic field and shaft mechanical surface imperfections. Low-frequency accelerometers is usually provided to monitor the absolute vibration of the bearings and of the turbine cover. A multi-channel, multi-tasking, online programmable digital processing unit is provided for system configuration for processing vibration data from vibration probes. Going for VCM is very important as it provides early indication of impending failure. By doing this, any technical person can easily detect the fault or abnormal condition before it causes tripping of the unit. Thus, unnecessary maintenance can be avoided and the resources can be saved. This paper discusses various sources of vibrations and the methods for their treatment. There are a significant number of previous studies on this topic, but there is a need for a review of all those studies to understand the vibration related issues in a better way. This paper presents the information from various existing literatures to give a brief knowledge about the VCM.

The condition of a machine can be estimated by measuring the vibration levels. Fault detection techniques and vibration signal processing are the other techniques which have more scope to study. The HGE vibrate with the influence of different factors i.e. electrical, mechanical and hydraulic factors [3]. The causes for these vibrations are very complicated and mostly unavoidable. Inspection of these causes and handling them at an earlier stage are the necessary steps to be taken for safe and stable operation. Vibrations are most dangerous stresses of an HPS, which occur during the sudden opening or closing of wicket gates. Analysis of vibration transients of an existing HPS prevents harmful resonances those occurred at a plant and hence reliability/availability of the equipment is increased. The VCM can be inferred in a least time and gives details regarding the incipient failure. This paper provides a comprehensive review on the said topic with the support of experimental studies. The distribution of publication of research articles covered in this review is shown in Fig. 1. However, there are also a number of standards, professional bodies/group related to this area, i.e. IEEE Guide for the rehabilitation of hydroelectric power plants, International Energy Agency (IEA), IEEE Standard 492™-1999, Task Committee ASCE, BIS Standard IS-12800 (Parts I, II, III), 1991 etc., and their contributions are absolutely significant in the condition monitoring area of HPSs.

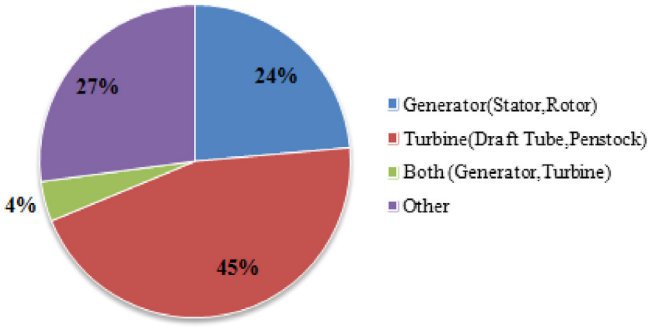

Fig. 1. Pie chart showing the distribution of papers covered in this review.

Different sources of imbalance, bearing problems, wicket gate problems and shear pin failure can be determined by monitoring of vibration at turbine guide bearings and the generator. VCM is the most effective technique to find machine faults [4,5] by selecting input and output with data acquisition and signal processing. High frequency phenomena can be monitored using data acquisition and sensors which are attached to the required equipment [6]. Excess vibrations cause wear & tear along with fatigue failure of guide vanes, runner blades, rim, bearing, shaft seal, shaft, runner labyrinth, Loose or shear nuts, wedges, stampings, bolts, pole wedges etc. at affected locations. These rapid wear & tear and fatigue failure need frequent replacement of equipment [7]. Excess vibrations can also cause excess noise.VCM provides root causes of fault sequence [8] in failure mode. Finite element analysis plays a significant role on vibration studies [9,10].

2. Sources of vibration

Different components of HPS have been shown in Fig. 2. Here, turbine, generator, and power transformer are cost intensive and most important electro-mechanical equipment [11]. The rotating elements generate specific vibration frequencies. Quality and

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