Analysis of the operating conditions of a hydraulic turbine of the bulb-type

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Abstract

In the last decades we have witnessed a technological advance and the search for 4.0 technologies, in this scenario, one of the most important topics to promote a good performance in the production of equipment is the monitoring of operation through preventive maintenance, especially for large industrial enterprises. In this article we present a dynamic test and an analysis of the operating conditions of a hydraulic turbine of the bulb-type operating with a production level of 70 MW. The results demonstrate the vibrations at different points of the equipment and the frequency of turning of the blades. Through these results it was possible to demonstrate the operating condition of the device.

Keywords: Preventive maintenance; dynamic test; bulb-type.

1. Introduction

In recent decades, one of the most evident points in the growing technological development is to improve production efficiency and cost reduction integrated with a safety in production processes. Mainly the industrial sector has demanded that the levels of availability of its equipment remain as long as possible in its full use and, one of the pillars for this operation to be possible consists of a rigorous preventive conditional maintenance (MARTIN, 1995), so that investments in preventive maintenance equipment and techniques have multiplied. In this sense, one of the techniques that have been highlighted in this area is vibration analysis. For, the results of this procedure may indicate a malfunction of equipment in an initial stage, so the repair becomes easier and at a lower cost (SANTOS, 2019).

The first step is to understand from a technical point of view what a vibration consists of in an operating system of equipment. According to Yamamoto (2016) the machine vibrates at various frequencies and these vibrations propagate throughout the machine and nearby structures, and severe vibrations induce wear and fatigue, and are certainly responsible for definitive equipment breaks. When the structures of the machines were excited by the dynamic efforts resulting from their operation, they respond with vibratory signals whose frequency is identical to that of efforts that provoke them (BARILLI, 2013). The vibration signal, taken at some point in the equipment, will be the sum of the vibratory responses of the structure to the different frequencies of the driver efforts. According to Fonseca Junior (2018), taking into account that the deterioration of the equipment is demonstrated by a change in the distribution of vibratory energy, and that its most common consequence is the increase in the vibration level, it is possible, from the taking of the vibratory signal at certain points of the equipment to monitor the evolution of vibration signals, as well as the identification of the appearance of new dynamic efforts or the sudden increase in the amplitude of the response, which in this case are indicators of the appearance of defects or degradation of operation. Ainda neste sentido, de acordo com Inman (2001) a vibração é o ramo da engenharia que lida com o movimento repetitivo de sistemas mecânicos de peças de máquinas para grandes estruturas. De acordo com Silva (1999) o estudo das vibrações mecânicas se mostra de fundamental interesse para a engenharia moderna, especialmente quando aplicado durante as fases de projeto e manutenção. Having as north, the importance of vibration analysis and its levels of action in the operation of industrial equipment, we present in this article a case study of prevention of physical deterioration through the application of the technique of vibration analysis (MITCHELL, 1993). With this in mind, the relevance of this work is justified by its various applications, such as: reduction of maintenance cost, demonstrate the effectiveness of condition-based maintenance and demonstrate through cause effect the increase in plant production with the use of vibration analysis (TANDON, 1999).

2. Results and discussions

The experimental measurements were performed in a bulb-type turbine of approximately 71MW, in which the rotating part is anchored by two slip housings appointed by Turbine Guide Housing - MGT and Combined Generator Housing – MCG (MELO, 2020). The fixation of the entire turbine assembly is made by the central column, called the support column, in addition to the central column we have the lateral support rods of the bulb (VASCONCELLOS, 2007), and figure 1 illustrates the model of the turbine mentioned above.

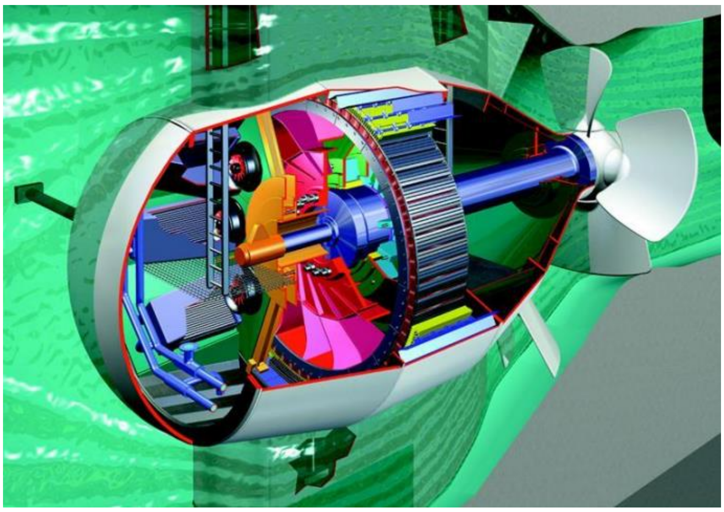

Figure 1. Illustration of the bulb turbine. Source: https://www.cgti.org.br/publicacoes/wp-ontent/uploads.

For decomposition of failure frequencies, knowledge about the technical characteristics of the equipment is necessary, such as electrical frequency, rotation, number of blades, guidelines and poles vanes. Table 1 presents the technical information of the analysed turbine.

Table 1. Description of the technical information of analysed turbine

Components	**Nominal data**
Rotation	100 RPM
Numbers of paddles	5
Number of guidelines reeds	16
Number Of Poles	72
Frequency	60 Hz
Weight	900 Tons
Diameter	8 meters
Length	15 meters

Process the vibration history was taken into account. The initial data (mirror) were compared with the current data, which made it possible to determine the variation that is from the entry into operation of the equipment to the current date, besides using the method of analysis by comparison between similar equipment. Then the dynamic assay was performed at various load levels, in this process the vibration levels for each operating condition of the equipment were evaluated, this procedure was performed to correlate the behaviour of the equipment with the failure of structural fatigue. Figure 2 shows the result for the production potentials of 70 MW of production potential of the generating unit. Before the measurement, 20 minutes were waited for hydraulic stabilization.

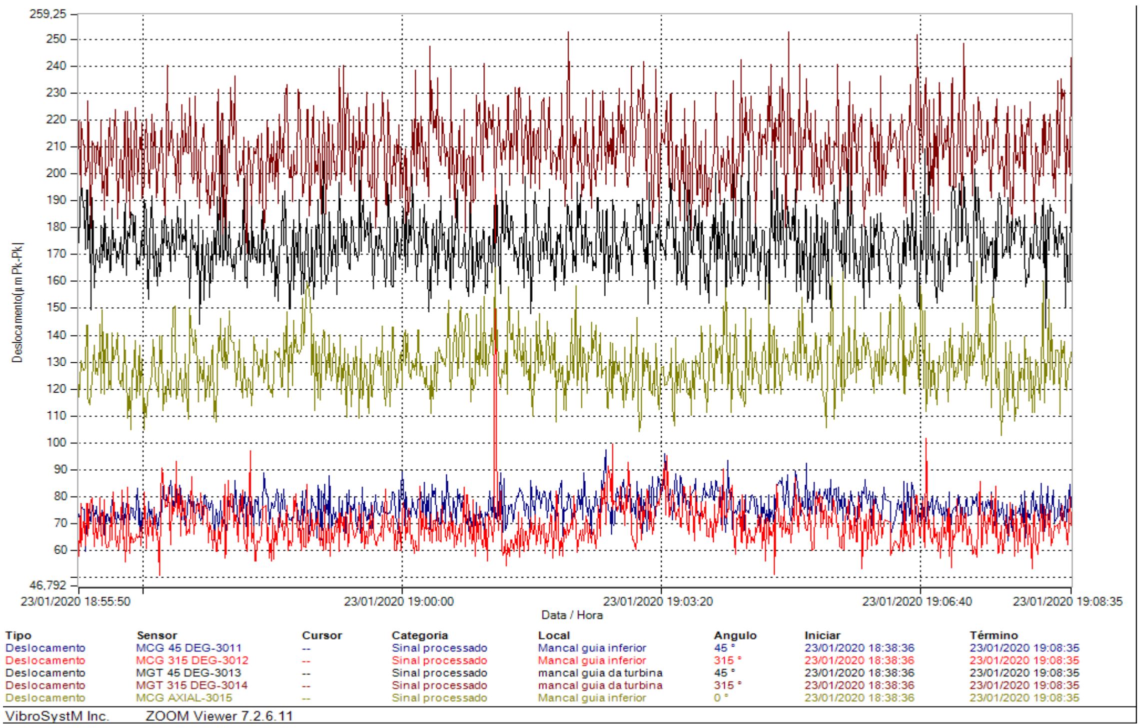

Figure 2. Absolute vibration measured at 70 MW of production. Sensor 315 degrees lower (red line), sensor 45 degrees lower (blue line), axial sensor (green line) sensor 45 degrees top (black line) and sensor 315 degrees higher (wine line).

For the relative vibration a stable behaviour was observed, with maximum oscillation peaks of approximately 250 µm (with 70MW), unexpected behaviour due to the high absolute vibrations captured around the collector ring. Figure 3 shows the relative vibrations for the same conditions measured as absolute vibrations at 70 MW.

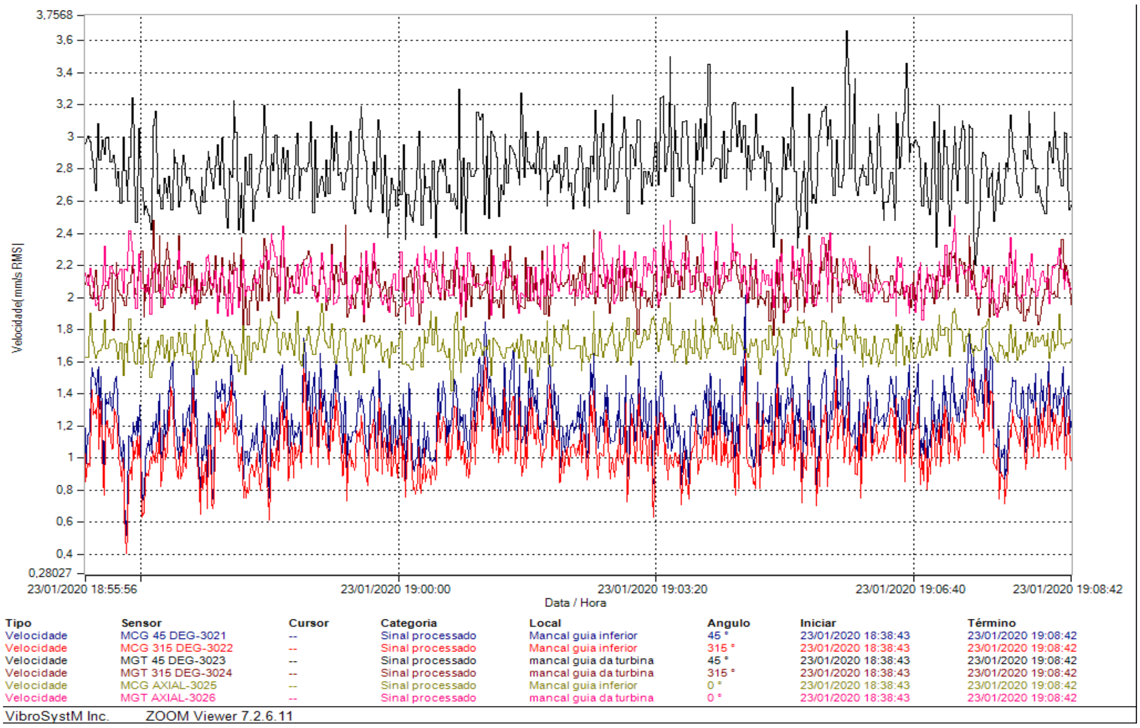

Figure 3. Vibration measured at 70 MW of production. Sensor 315 degrees lower (red line), sensor 45 degrees lower (blue line), axial sensor (green line) sensor 45 degrees top (black line) and sensor 315 degrees higher (wine line).

Figure 4 shows the frequencies of absolute vibration signals of the nose bulb.

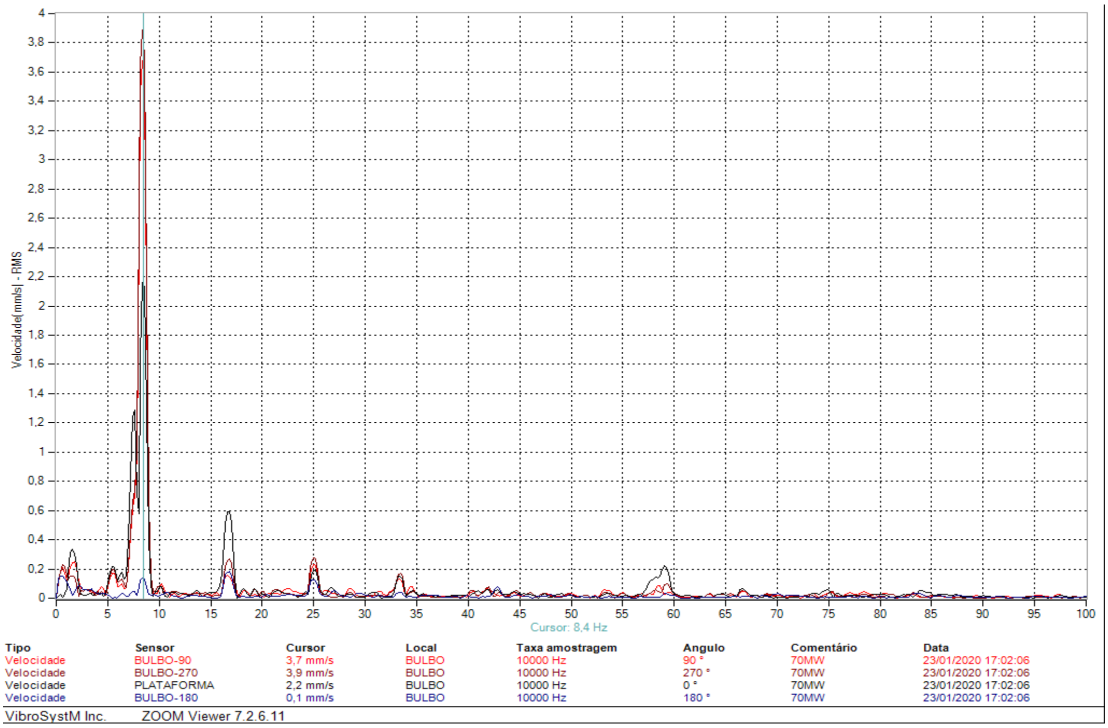

Figure 4. Frequency of turbine blades operating at 70 MW.

In the graph it is possible to observe that the peak of the filtered signal was 8.4 Hz with approximately 3.9 mm/s RMS. Based on the results obtained, it is observed that the operation is within the expected considering the margin of tolerance and safety of operation.

3. Conclusion

In this article, the results of the 70 MW operating test of a bulb turbine were presented. The research aimed to demonstrate through preventive analysis a vibration diagnosis of a hydraulic turbine. The proposed objective was met, because effectively the work was able to demonstrate that through vibration analysis it was possible to map the state of operation of the equipment. Therefore, it was possible to demonstrate the effectiveness of maintenance based on preliminary vibration analysis this analysis can contribute to the increase in the performance of rotating equipment, as it demonstrates whether the device is operating under ideal production conditions.

4. Acknowledgement

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