Design of Portable Cavitation Detection Software for Hydraulic Turbines

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Abstract

This system is a set of LabVIEW-based portable turbine cavitation monitoring system developed by using the notebook's own sound card. The monitoring and alarm system is established. The characteristic signals that can reflect the cavitation cavitation are found in the field, and the characteristic signals are analyzed. The law of change in the degree of cavitation changes by monitoring this characteristic signal to achieve real-time monitoring of the degree of cavitation. Once the selected parameters reach the criteria set by the system, it is considered that the turbine has cavitation, and the alarm is notified to the staff to modify the working parameters of the turbine in time to adjust the working conditions in time. First, optimize the working efficiency of the turbine. Minimize the loss caused by cavitation. It also extends its service life. This is the design idea of this system.

Keywords

Labview; Cavitation; Data; Detection

I. Introduction

Introduction Cavitation is an unavoidable damage that occurs during the operation of a turbine. It seriously affects the working efficiency and life of the turbine. It has been found that all fluid dynamics related machines, equipment and components are subject to cavitation damage. Uncontrolled cavitation can have serious and even catastrophic consequences. From low specific speed mixed flow to high specific speed uranium flow and impact type water wheel in the turbine are subject to cavitation erosion. Valves and their fittings in piping systems are subject to cavitation erosion due to frequent changes in flow rate during operation. It can be seen that cavitation cannot be underestimated. The previous turbines were all after-the-fact inspections. Obviously, this maintenance cost is very high. Therefore, it is very necessary to establish a system to monitor the cavitation of turbines in real time.

II. Introduction to LabVIEW

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a program development environment [1]. Similar to C and BASIC, the core concept of LabVIEW is "software is the instrument", which is the concept of virtual instrument. The interactive user interface of the virtual instrument is called the front panel because it mimics the panel of the actual instrument. The front panel contains knobs, buttons, graphics, and other control and display objects. You can view the results on your computer screen by entering data and control buttons through the mouse and keyboard. Because the terms, icons, and concepts used by LabVIEW are familiar to technicians, scientists, and engineers, LabVIEW can be used to develop your own applications even if the user does not have much programming experience.

III. Cavitation and cavitation

Cavitation is an unavoidable phenomenon in the operation of a turbine. Usually, the phenomenon that the water is heated and vaporized under a certain pressure is called boiling; while the ambient temperature is constant, the vaporization caused by the pressure is called cavitation [2]. The cavitation generated by cavitation collapses on the surface of the solid material, causing the material to be ablated, which is cavitation and also emits cavitation noise.

The initial state of the turbine is that there is no cavitation, that is, the turbine is working properly and there are no air bubbles inside. As the internal pressure of the turbine decreases or the flow velocity increases, the cavitation coefficient begins to decrease, and the critical region of the tiny holes in the very small area of the flow field occasionally appears, which is called cavitation nascent. In the initial stage of cavitation, the radiation noise is relatively small, so it is difficult to monitor. When the number of cavitation is further reduced, that is, cavitation continues to develop, more and more air bubbles are generated. When a large number of cavitation collapses, the energy of the radiation also increases. Compared to the initial phase, the noise pressure during the bubble collapse phase is much higher. However, it is worth noting that there is no uniquely determined dependence between cavitation noise and cavitation number [3]. The strength of cavitation noise depends on the number of cavitation generation and the speed of collapse. When the water velocity is not When the pressure is changed, the number of vacuoles increases, but as the pressure drops, the collapse rate of the vacuoles also decreases accordingly. Therefore, there is an extreme value of cavitation noise, that is, when these two factors are properly matched.

IV. Turbine cavitation detection software design

In order to obtain the relationship between cavitation noise and blade cavitation, the cavitation noise data acquisition experiment was carried out on the turbine simulation test bench.

A. Experimental principle block diagram

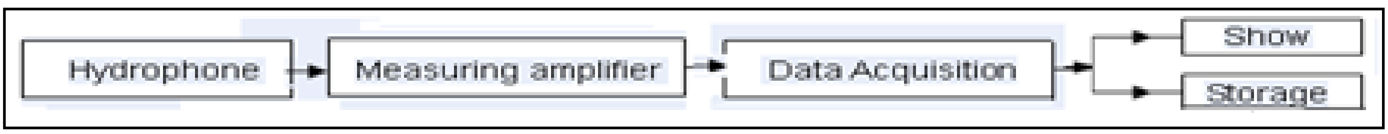

Fig. 1 : Schemetic experimental turbine data acquisition

According to the experimental schematic diagram, as shown in Figure 1, connect the instrument, open the data acquisition interface of LabVIEW software, and start collecting and saving data. A LabVIEW data processing program is programmed to process the collected data in the time domain and the frequency domain. In the time domain, the acquired data sequence is the abscissa, and the voltage of the cavitation noise is the ordinate; in the frequency domain, the power spectral density analysis is performed on the read data, the abscissa is the frequency, and the ordinate is empty. The power spectral density of the noise is used to establish a two-dimensional graph. The specific processing results are as follows:

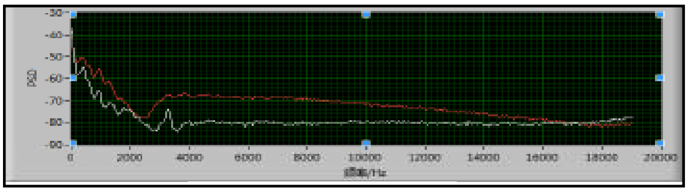

Fig. 2 :The first data processing PSD graph

From the data processing results of the above experiments (Fig. 2), when cavitation occurs, the voltage value of cavitation noise increases in the time domain as a whole, which can be set as monitoring cavitation. A criterion that has occurred. In the frequency domain (PSD diagram), there are two aspects. First, look at the low frequency band 0-3.5 kHz and do a curve fitting. It is easy to see that the slope of this segment is larger than that when it is not cavitation. This can also be set to monitor the criteria for cavitation. Then look at the latter frequency band, the slope of this slope is smaller than that when it is not cavitation, and the power spectral density of cavitation noise is significantly increased. At the same time, on the PSD diagram, the area enclosed by each curve and the x and y axes represents the total power of this condition, and can also be regarded as the total energy of cavitation noise under this condition, so it can also be seen when cavitation This change in energy is also used as a criterion for monitoring cavitation, rather than the increase in the total energy of the cavitation noise. It is worth noting that if the cavitation is severe, the total energy may decrease. This is because the cavitation volume is very large, and the sound of the empty gun bursting radiation is easily absorbed by other cavities (sound absorption); in addition, due to the vacuole The number is large and the volume is large, which leads to an increase in the probability of bubbles between the bubbles. This phenomenon can be slightly reflected from the third experiment. But this does not affect the increase of energy as a criterion, because from the cavitation state to the cavitation state, the energy is increased first, and will reach an extreme value.

B. Software Implementation

1. Software design process

This thesis is to use LabVIEW to build a sound card-based online monitoring system for turbine cavitation noise. According to the requirements of the system, the software flow chart of online detection is shown in Figure 3:

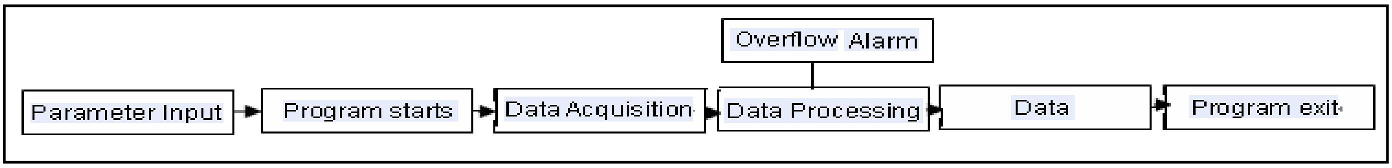

Fig. 3 : Cavitation Monitoring System Software Flow

2. Data collection

In data acquisition, we can use LabVIEW's own set of sound card-related functions written using Windows' underlying functions [4].

3. Data Processing

The continuous signal from the sensor is first filtered by a Butterworth low-pass filter with a minimum frequency of 5 Hz and a maximum cutoff frequency of 100 Hz. This is the corresponding control button on the front panel of LabVIEW. For each data point collected, the burr is removed by 2.5 times the variance, and the maximum and minimum values of the remaining points are obtained, and the difference between the subtraction is the time domain peak-to-peak value. When the monitoring system considers that the cavitation is sufficiently severe, an alarm is initiated to remind the staff to modify the corresponding parameters. When an alarm occurs, the alarm module will continue to sound until the worker comes over and presses the stop button. When designing this system, four thresholds were used to determine whether to alarm. The two slopes of total energy, peak-to-peak value, and power spectral density, depending on the design of the software system, can also select some of these four thresholds as the judgment criteria. Of course, one of them crosses the border and does not indicate that cavitation has occurred. Obviously this is also very inaccurate. Therefore, it is necessary to count the number of their crossings at a fixed time. When the crossed-out number set by us is exceeded for a fixed period of time, the alarm is selected.

4. Integrated Software System

In order to integrate the software system, it is necessary to call the previously programmed program, that is to say, the various functional modules compiled in the previous section are to be called as subroutines. To do this, you need to create icons for these VI programs, that is, the graphical representation of the VI programs, so that they become sub-instruments SubVI, the created program icons can be placed in the code window (flow chart) of other programs, and the interface board Is the input port and output port of the subroutine defined. Right-click the program icon in the upper right corner of the instrument module's front panel or flowchart window, and select EditIcon[5] in the shortcut menu to open the program icon editing window. The original default icons of each module are re-edited separately and changed to easily distinguishable icons. This can greatly improve the readability of the program. In terms of user interaction, users can interact with the program in a variety of ways, including buttons, play sounds, dialogs, menus, and keyboard input. Each function module has corresponding control buttons and parameters on the front panel.

V. Summary

This paper is designed to monitor the turbine cavitation. Different departments at home and abroad have proposed a lot of monitoring methods for cavitation, but because the turbine is working in a closed volute water flow environment, in many cases, the signal occurs. It is difficult to fix and install the transmission and receiving devices. Therefore, it is relatively feasible to monitor the cavitation cavitation by monitoring the cavitation noise. The system can monitor the working state of the turbine in real time, but because the design of the system is based on the data acquisition experiment of the turbine simulation test bench, and under actual conditions, the cavitation is related to many factors, therefore, the turbine online control system is considered. It is also necessary to do a lot of work to quickly and accurately determine the cavitation when applied to the water wheel real machine.

References

[1] *Sun Zhongwei. Analysis of turbine vibration signal based on LabVIEW [D].Shijiazhuang: Hebei University of Engineering, 2017*

[2] *Wang Yong, Yan Jun, Wang Jian, et al. Unsteady cavitation formation mechanism of rotor-stator centrifugal hydrodynamic cavitation generator[J].Journal of Harbin Engineering University,2018,39(12) : 1887 - 1893.*

[3] *Zhao Shuangjie. Cavitation Mechanism and Measures of Hydraulic Turbines [J]. Value Engineering. 2016, 6(18): 94-96*

[4] *Wu Chengdong, Sun Qiuye, Sheng Ke et al. LabVIEW virtual instrument program design and application [M]. Beijing: People's Posts and Telecommunications Press, 2008*

[5] *Su Peihua. Research on virtual experiment application based instru*ment[J].2015,7(13),172-174