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THE DATA ACQUISITION ON VIBRATION EVALUATION FOR ICE WATER PUMPS SYSTEMS IN TPS*

Yung-Hui Liu†, Yen-Ching Chung, Zong-Da Tsai, Chin-Shen Chen,
National Synchrotron Radiation Research Center, Hsinchu, Taiwan

Abstract

The vibration status is a critical problem for the utility system, especially for those continuously operate deionized and cooling water pumps used in synchrotron accelerator. The purpose of this paper is to evaluate the vibration level and spectrum condition for TPS water pump systems. In order to predictive maintenance before pump systems fail, the vibration monitoring system was constructed. After vibration test for several months, the alignment of some of the ice water pumps were found mismatched because of poor system positioning and operate continuously. Besides, the ice water pump were redundantly operated and switch over every Monday morning. The recorded data showed the system sometimes switch fail because of control status or system stability. Thus, the water pump systems were repaired and maintained base on vibration monitoring system. There is still some remain problems for ice water pump systems. The utility systems could prevent malfunction through regular vibration inspection and daily data acquisition.

INTRODUCTION

The utility systems in Taiwan Photon Source (TPS) operated continuously over years. The rotational machine includes motors, pumps, chillers and air handling unit (AHU) needed to operate sustained without any shutdown. In order to provide synchrotron accelerator operation requirement, the whole utility systems needed to be keep stable. The vibration inspection become one method to preventive maintenance [1]. In 2004, ANL [2] studied the mechanical vibration control systems and the specifications for all rotational facilities. In 2007, the investigation of Taiwan Light Source (TLS) on water induced vibration and vibration propagation by piping system also be studied [3]. The ISO 10816 established vibration standards on industrial machines with normal power above 15 kW and nominal speeds between 120 to 15000 rpm when measured in situ [4]. According to the experience from TLS, the vibration amplitude and spectrum for the TPS utility systems can also be applied the same criterion. After vibration measurement, some of the booster (BO) and copper (CU) deionized water (DIW) pump systems generate higher vibration amplitude and exceed ISO 10816 standards [5]. The rapidly increase vibration level in short time indicated the malfunction for CU DIW system. The broken inertial pad thus replace a new stronger one and the continuously vibration inspection provide over one month before the inertial pad broken [6].

* Work supported by National Synchrotron Radiation Research Center
† iris@nerrc.org.tw

INSTALLATION OF DATA ACQUISITION SYSTEM

The data acquisition system Pheonix GM3 for TPS ice water pump system was conducted by Prowave Engineering Corporation. The 32 channels signal capture system is supplied by PW 747 DAQ shown in Fig. 1. The bandwidth is 20 kHz and the sampling rate is 51.2 K/s for PW 747. The resolution is 24 bits and the data transmitted by Ethernet. The vibration sensors were mounted in the horizontal direction of the motor side and the vertical direction of the pump side also showed in Fig. 1. The whole 32 channel data were transmitted to the PC server and the original vibration acceleration waveforms were recorded in forms of raw data.

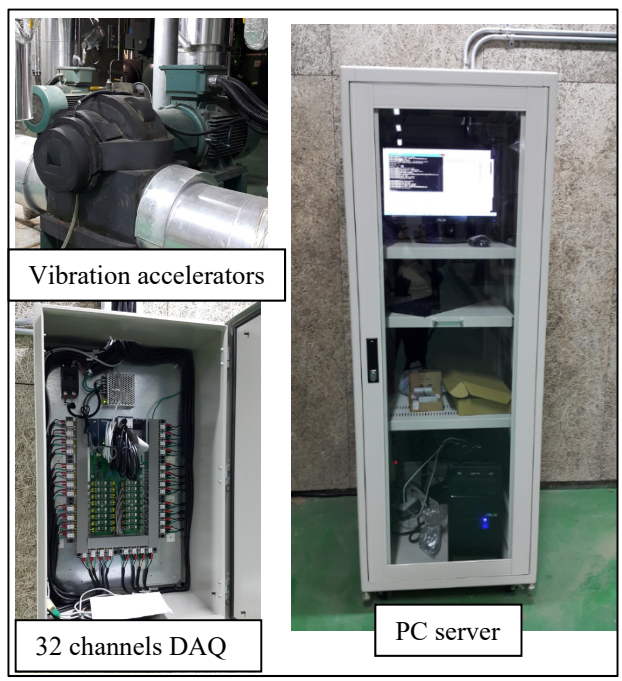

Figure 1: The Data Acquisition System - Pheonix GM3.

INTERNATIONAL VIBRATION STANDARDS - ISO 10816

The ISO 10816 vibration standard released in 1995 and amended in 2009. The standards describe vibration amplitude measured in situ for industrial machines with power above 15 kW and rotation speeds between 120 to 1500 rpm. The frequency range of vibration measurement is from 10~1000 Hz when the machine operates over 600 rpm. The power of TPS ice water pump systems is 37 to 110 kW for different ice water supply. The maximum rotation speed is 1750 rpm with 684 m^3/h flow rate. The

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lift head of motor is 45.72 m for ice water supplied to the administration building. The foundations are flexible type with damping spring support. According to vibration standards, the vibration amplitude tested in any location in irrotational point exceed 11.2 mm/s means system damage. The vibration from 10~1000 Hz between 7.1~11.2 mm/s had to restrict long-term operation.

VIBRATION MEASUREMENT RESULTS

The data acquisition system Pheonix GM3 was built in 2017. The system recorded vibration raw data for every single day and could analysis frequency spectrum. The system could show the trend and vibration change of the specific test point. The accelerator and velocity of vibration with different frequency band were recorded depends on specific requirement.

TPS ice water systems were divided into several subsystems, which the ice water produced by chiller and supplied to different subsystems. ZP1 ~ ZP3 pump systems supplied ice water to heat exchange for TPS deionized water cooling. ZP4 ~ ZP6 pump systems supplied ice water to air conditioning for TPS tunnel. And ZP7 ~ ZP9 pump systems supplied ice water to air conditioning for TPS experimental area and administration building. ZP10 and ZP11 pump systems supplied ice water to air conditioning for activity center.

ZP1 ~ ZP3 Ice Water Pump Systems

The three ice water pump systems ZP1, ZP2, and ZP3 operated for heat exchange to TPS deionized water cooling. Two of these three pumps ran continuously in order to supply ice water without interruption. Every Monday, the pump system exchange one pump to another remain system stable. The motors of these three pumps are 75 hp (55 kW) with 380 V-3 phase electrical drive. The maximum rotation speed is 1750 rpm with 2125 GPM (482.95 m^3/h) flow rate. The lift head of motor is 90 ft (27.43 m). The vibration sensors were mounted in the horizontal direction of the motor side and the vertical direction of the pump side.

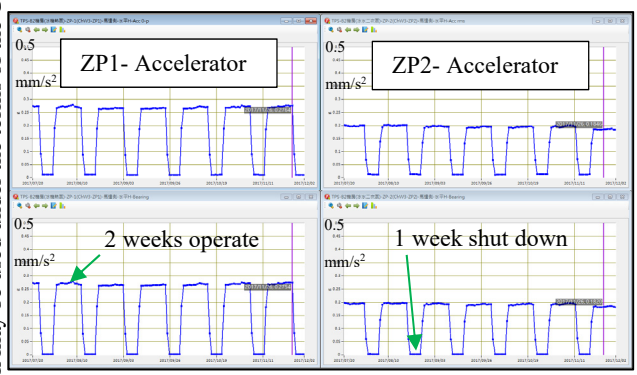

Figure 2: Daily record of vibration amplitude (accelerator mm/s^2) for ZP1 and ZP2 during 7/20~12/2 2017. (Hori-zontal direction for drive-end of motor side).

The ZP1 and ZP2 ice water pump systems daily record of accelerator vibration amplitude during Jun. 20 to Dec. 2, 2017, was shown in Fig. 2. The Pheonix GM3 system record one raw data for every vibration test point. The test results showed the ZP1 operated for two weeks and shut down for one week, same as ZP2 and ZP3. The same vibration level indicated the system is stable.

ZP7 ~ ZP9 Ice Water Pump Systems

The three ice water pump systems ZP7, ZP8, and ZP9 supplied ice water to AHU for TPS experimental area and administration building. Every Monday, the pump system exchange one pump to another remain two of these three pumps keep running. The motors of these three pumps are 150 hp (110 kW) with 380 V-3 phase electrical drive. The maximum rotation speed is 1750 rpm with 3010 GPM (684 m^3/h) flow rate. The lift head of motor is 150 ft (45.72 m).

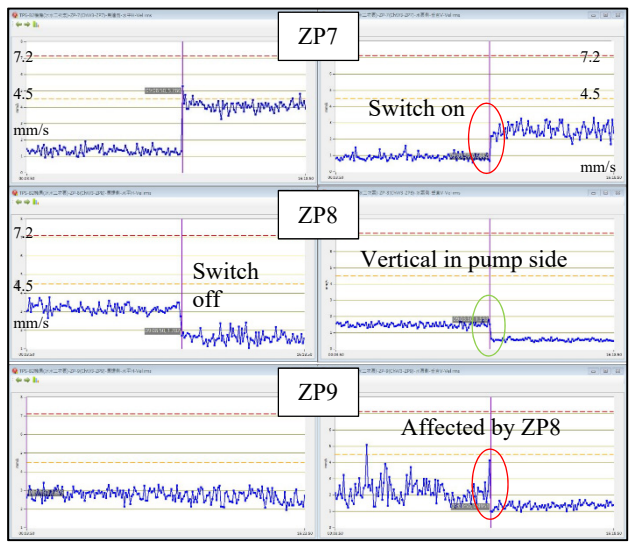

Figure 3: Vibration test for ZP7, ZP8, and ZP9 on Jan. 15 2018. (Data recorded in every 300 sec.)

Figure 3 showed the vibration velocity of ice water pump system ZP7, ZP8, and ZP9 switching on Jan. 15 2018. The RMS velocity amplitude in 10 to 1000 Hz frequency band of vibration was recorded in every 5 min. The ice pump system switch one to another at 9:00 every Monday morning. ZP7 switch on about 9:00 and the either motor side and pump side showed the vibration jump up after motor turn to start. After ZP7 turn on, the velocity vibration increasing over 4.5 mm/s at some time, it needs to be noticed.

ZP8 switch off also about 9:00 and both motor side and pump side showed the vibration jump down after motor turn to stop. Even though ZP8 remain slightly velocity vibration both motor and pump side, the vibration status still showed the status of system operation. There is an interesting finding, ZP9 also had apparently vibration change about 9:00. Not showed in motor side, but showed in pump side. That is because of the pump side connected by pimping, and ZP8 and ZP9 are close together.

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ZP4 ~ ZP6 ICE WATER PUMP SYSTEMS

The three ice water pump systems ZP4, ZP5, and ZP6 supplied ice water to AHU for TPS tunnel. The motors of these three pumps are 125 hp (90 kW) with 380 V-3 phase electrical drive. The maximum rotation speed is 1750 rpm with 2200 GPM (500 m^3/h) flow rate. The lift head of motor is 150 ft (45.72 m).

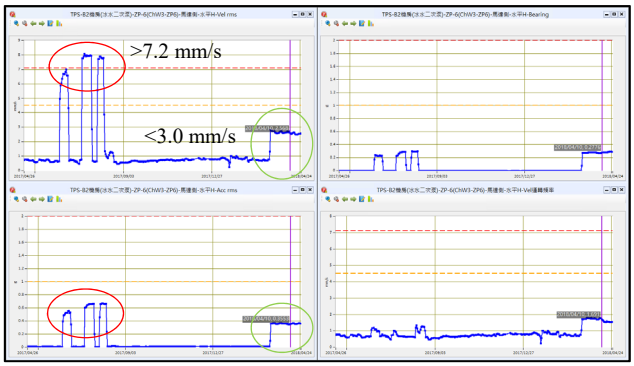

Figure 4: Daily record of vibration amplitude for ZP6 during 4/26 2017 ~4/24 2018. (Horizontal direction for drive-end of motor side).

Figure 4 showed the status of ZP6 ice water pump over one year. The Pheonix GM3 established in the beginning in 2017. After data acquisition system adjusted and monitored, the velocity vibration of ZP6 found was exceed 7.2 mm/s during Jun. to Aug. 2017. According to ISO 10816 standards, the pump system had to restrict long-term operation. After that, ZP6 shutdown for maintenance and adjustment.

After the long shutdown for TPS during Feb. 2018, ZP6 was maintained. The motor re-alignment and the pump was disassembling for replacing a new bearing and cleaning the cover of pump shown in Fig. 5. After that, ZP6 started to restart Mar. 2018 and operate continuously until now. The velocity os vibration reduced apparently from over 8.0 mm/s to 2.5 mm/s. Although the vibration was not found in acceleration part, the maintenance indicated the good performance for system stable and the monitoring system provide an efficient way to evaluate the motor system status.

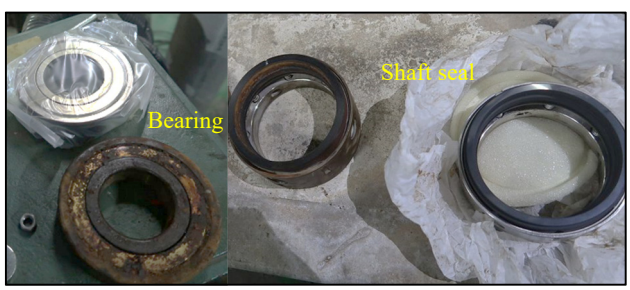

Figure 5: The original bearing and shaft seal and new ones for ZP6 pump system.

CONCLUSIONS AND DISCUSSIONS

The vibration inspection system for ice water pump systems was established and operated over one year. The measurement results give all kinds of message about the system status. It could give us whether the system is in good condition or not. In the case of bearing abrasion, the daily vibration record supplied many information from vibration amplitude and frequency change. Is also provide sufficient time for operators to maintain the system in advance.

There is still some remain problems for ice water and other deionized and cooling water pump systems. The utility systems could prevent malfunction through regular vibration inspection and daily data acquisition.

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