

OPERATING EXPERIENCE OF WATER COOLING SYSTEM IN THE J-PARC LINAC AND RCS

K. Suganuma, K. Fujirai, M. Kinsho, P. K. Saha, Y. Yamazaki
 Japan Atomic Energy Agency, Tokai, Naka, Ibaraki 319-1195, Japan

Abstract

We carried out using the vibration measurement value of the cooling water pump and the measured value was calculated for the abnormal value for each cooling water pump by statistical processing. Similarly, the result evaluation by the vibration diagnostician and the statistical processing result were compared. Although there was a difference between the evaluation of the ISO 18436 vibration diagnostician and the statistical processing result, it was found that it is possible to detect abnormality of the circulation pump using statistical processing.

INTRODUCTION

The LINAC and RCS cooling systems have cooling capacities of 6MW and 26MW respectively. The LINAC and RCS are composed of 10 and 3 independent circulation loops. In February 2017, from experience the breakage of the circulation pumps due to the flow operations at the LINAC, we began to develop detection systems focused on abnormal vibration measurement for circulation pumps. In addition, in January 2018, we experienced shutdown of the systems due to wear of the circulation pumps bearings. From the experiences, in February 2018, the pumps of the LINAC and RCS, the total number is 25, were evaluated by vibration diagnosticians. In addition, we performed multivariate analysis using the figures obtained by the vibration measurement at that time and compared values by vibration diagnosticians with the figures showing the degree of abnormally outputted by statistical processing.

In this report, we will mention the results of measurement of measurement for circulation pumps and states of the development the systems for abnormally vibration from statistical processing.

WATER COOLING SYSTEM

The main specification of the water cooling system is indicated in Table 1. The cooling equipment of LINAC is composed of 10 parts, cooler exchanger, refrigerator, cooling water tank, temperature regulator, cooling jellyfish tube and something. They are built in LINAC. The cooling equipment of RCS is composed of 3 parts and cool down electromagnet, RF cavity and electromagnet power supply.

VIBRATION MEASUREMENT

Vibration Measurement 1

In January 2018, when we get perform patrol check, we found abnormal sounds from nearby bearing. We show

Figure 1, it is a condition of circulation pump (P2202) when it's bearing get abnormal. Also, we show regular specification of circulation pump in Table 2. We have exchanged bearing every 2 years since 2006. From experience of LINAC circulation pumps breakage, we installed portable detection systems two days later we check abnormal sounds. The detection systems we used is made by RION Co.,Ltd. The system's format is VA-12. Measurement positions are 2. We set up it in axial direction close to the impeller bearing. The measurement item is RMS, Peak, velocity and time. 6 days later we found abnormal sounds and 4 days later we start to detect, we stopped LINAC's bearing because if we keep the bearing running impeller and casing are conflicted and pumps are broken as displacement is over maximum. We show you to time series changes of acceleration, velocity and displacement in Figures 2, 3 and 4.

Table 1: The Main Specification of the Water Cooling Systems

Name	Object	Operating Temperature (deg-C)	Flaw Rate (l/min)
Li_RI1	RFQ	22±0.1	300
Li_RI2	Ion Source	27±2.0	100
Li_RI3	DTL,SDTL	27±0.2	3,800
Li_RI4	DTL,SDTL	27±0.2	5,800
Li_RI5	ACS,L3BT	27±0.2	8,300
Li_RI6	ACS,L3BT	27±2.0	800
Li_non_RI1	Ion Source, Klystron	27±1.0	2,200
Li_non_RI3	Klystron, DTQ	27±7.0	6,000
Li_non_RI6	Klystron, ACS	27±1.0	1,700
Li_non_RI8	Klystron, ACS	27±7.0	7,600
RCS_RI1	magnet	27±1.0	16,800
RCS_RI2	RF Core	27±1.0	4,170
RCS_non_RI	Power Supply	27±1.0	8,170

Table 2: Specification of Circulation Pump

Name	Specification
Type	End-Suction Volute Pump
Casing	SCS13
Impeller	SCS13
Grand Packing	Carbonized Fiber
Capacity	6393 L/min
Total Head	70 m
Efficiency	77.0 %
Electric Motor	110kW / 400V / 3 Phase
Number of Electric poles	4 pole
Number of Rotations	1470 / min

Vibration Measurement 2

In recent years, we measured vibration of the LINAC and the Circulation pumps of the total 25 units because breakage of the Circulation pumps occur like every year and the vibration consultant based on ISO18436 evaluated them. As a result, the vibration consultant decide 1 unit of RCS of the Circulation pumps (3105-P7012) of 25 units need to be repaired and exchanged as soon as possible. Figure 5 is the graph which show relationship between acceleration before and after replacement which we measured near the bearing of the Circulation pumps and time. We think the cause of abnormal vibration of the Circulation pumps is spring washer which maintain the bearing of the electric motor change flat washer.



Figure 1: Circulation pump P2202.

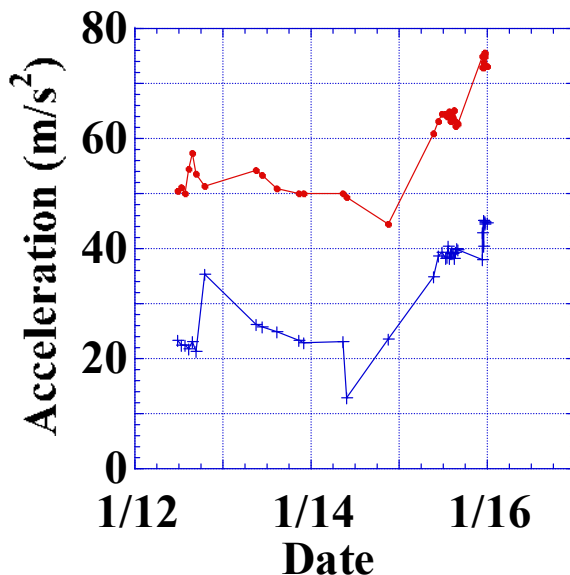


Figure 2: Record of acceleration measurement.

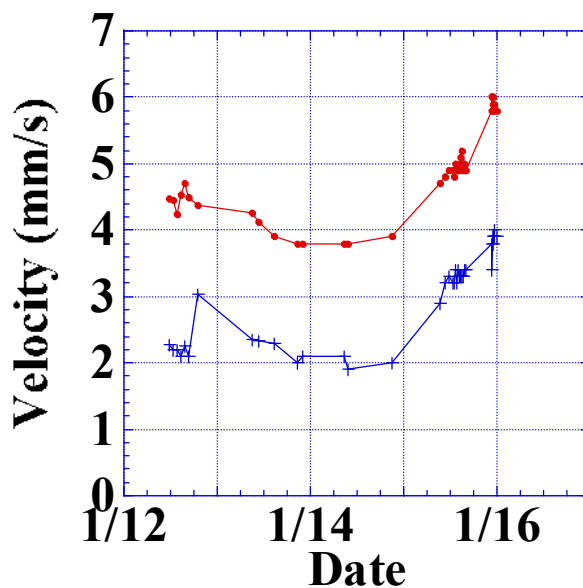


Figure 3: Record of velocity measurement.

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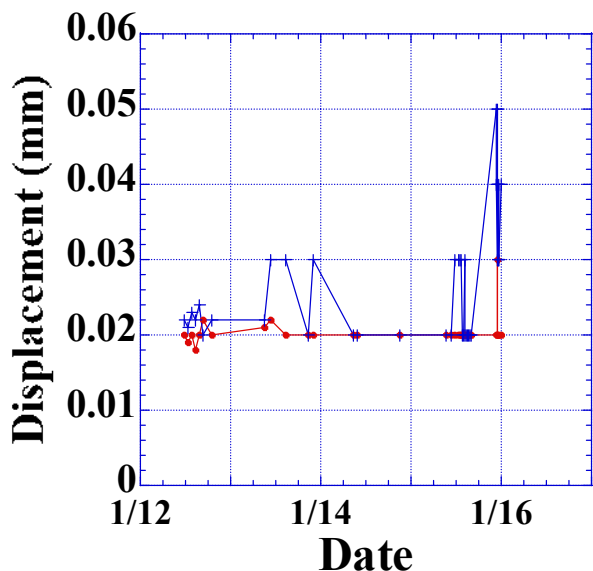


Figure 4: Record of displacement measurement.

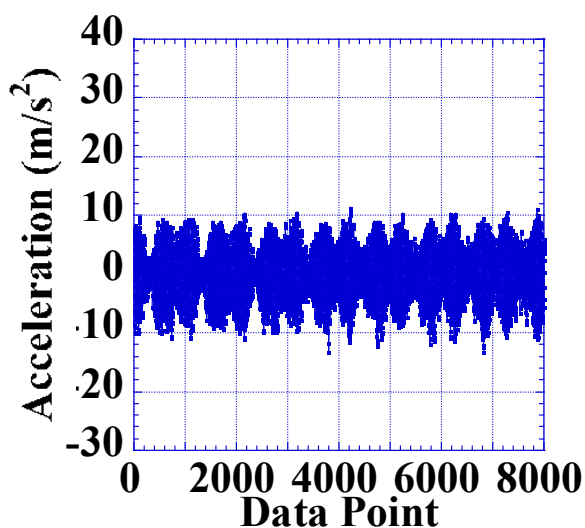


Figure 5: Record of acceleration waveform.

MULTIVARIATE ANALYSIS

We statistically processed the result of vibration diagnosticians of all circulation pumps. The data we use statistical processing is the same as the preceding paragraph. It regards power spectrum of FFT of acceleration which we obtained from using vibration measuring instrument (VA-12) as text data. We used “RStudio” to do statistical processing. We selected main components with numerical value of all Circulation pumps of about 1600 lines and 100 rows and with elbow raw. Next, we calculated outliers from the main components and selected the Circulation pumps in descending order in outlier. Table 3 shows results of statistical application with the vibration consultant and “RStudio”.

Table 3: Specification of Circulation Pump

Number of Pump	Zone of ISO 10816-1	Overall Judgment	Anomaly Rate of Statistical Processing with RStudio
3105-P2001	B	A	7.59
P7012	B	A	6.65
P6304	B	A	6.47
P6302	C	A	5.79
3105-P7012	B	C	5.73
P7303	B	A	5.69
P6303	C	A	5.66
P7302	B	A	5.21
P2201	B	A	NA
P2202	B	A	NA

SUMMARY

We think the LINAC and the RCS of cooling water equipments of the Circulation pumps increased the frequency of breakage because of aging. In 2017 Feb, from experience of the breakage of LINAC of the Circulation pumps we started detecting abnormality of the Circulation pumps. We started statistical processing with RStudio. We compared the breakage assessment by vibration measurement of vibration consultant based on ISO18436 and analytic value which we obtained from the statistical processing with RStudio. From now on, we are going to detect the abnormality, monitor the status, and estimate breakage.

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