ALIGNMENT ACTIVITIES FOR KOMAC 100-MEV PROTON LINEAR ACCELERATOR *

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Abstract

The KOMAC (Korea Multi-purpose Accelerator Complex) 100MeV proton linear accelerator has been providing high-quality proton beams to users in various fields since 2013. KOMAC's facility consists of a 100 MeV linear accelerator, one 20 MeV general purpose beamline and five 100 MeV beamlines: a beamline for RI production, low-flux, general purpose, prototype RI beam production, and a test beamline. At KOMAC, alignment-related work is divided into two parts: alignment of accelerating machines and monitoring for accelerator building ground displacement. First, for the alignment of accelerating machines, the overall alignment work such as axis setting, arrangement of accelerating machines and alignment of accelerating machines according to the construction of the accelerator was carried out in the 2012-2013 period. The maintenance of the accelerator is performed every year due to DTQ (Drift Tube Quadruple) failure of the DTL (Drift Tube Linac) tank, and alignment work is also performed according to improvement work such as adding an injector, expanding the beam lines, and installing the additional beam diagnosis devices. Second, HLS (Hydrostatic Levelling System) and WPS (Wire Positioning System), which are for monitoring the ground movement of the accelerator building, were installed as a follow-up measure to the earthquakes that occurred near KOMAC in 2016 and 2017. The sensors of HLS were installed in 10 locations throughout the accelerator tunnel where the accelerating machines are located, and the sensors of WPS were installed in 8 locations to monitor the movement of the basement surface according to the characteristics of the KOMAC accelerator building, in which one side of the building is a basement. In this paper, the overall contents related to the alignment of KOMAC are presented.

INTRODUCTION

The KOMAC proton accelerator has been providing more than 3000 hours of beam operation every year since 2013, and the number of users is increasing every year in various fields [1]. The KOMAC proton accelerator is located about 1.5 km south of the KTX (Korea Train eXpress) and about 100 meters north of the Gyeong-bu expressway. Due to this locational influence, the effect of the accelerator due to the surrounding vibrations was investigated at the beginning of the installation of the proton accelerator, and it was confirmed that there was no problem [2]. Figure 1 is the KOMAC areal-view.

Alignment in the proton accelerator is divided into measuring the position of accelerators using a laser tracker and monitoring the movement of real-time devices or buildings such as HLS and WPS. Figure 2 shows the positions of the alignment network and HLS and WPS in the accelerator tunnel of the proton accelerator.

SURVEY AND ALIGNMENT

The position measurement of the accelerator using the laser tracker is an alignment network survey for setting the coordinate axis of the accelerator, alignment work according to beamline extension, alignment work according to DT failure, etc after the start of the proton accelerator beam service.

Alignment Network Survey

KOMAC conducts periodic alignment network surveys twice a year. The alignment networks were installed on the wall of the accelerator tunnel. The distance between each alignment network is 5 m on the right and 10 m on the left along the beam direction in the accelerator tunnel. The total
number of tunnel networks is 42 and the height of the fixed location is 1.8m [3].

- Coordinate system.
  The tunnel coordinate system is set in the following order: The vertical axis (+Y) is set by NIVEL (Leica co.). As shown in Figure 3, two permanent references were used. The origin was determined by A3. And the Z axis is set as the X, Y coordinates of A1. These coordinates are linked to the construction coordinate system. The tunnel coordinate system is extended from the 1st floor to the 2nd floor using a see-through hole [3][4].

- Magnet alignment for beam-line
  The electromagnet of the beamline consists of 1T, 2T quadrupole magnet, bending magnet, AC magnet and steerer magnet. In the electromagnet alignment process, the identification of each electromagnet is checked in advance, and real-time alignment is performed within the precision ±150um with two laser trackers [6]. Figure 5 shows the beamline electromagnet alignment.

- Maintenance of drift tube quadruple
  Since the operation of the proton accelerator, DT failures have occurred at around 5 per year. It is a complicated process for DT replacement and is mostly performed during the maintenance period in the second half of the year when the maintenance period is more than 40 days. The replacement process is the same as for DT installation. Figure 6 summarizes the replacement and alignment by some DT breakages [5].

Linear Accelerator Alignment
Accelerator operations began in 2013 with a 100 MeV linear accelerator, one 20 MeV beamline, and one 100 MeV beamline. Four additional 100 MeV beamlines have been installed so far.

- DTL and DT alignment
  DTL consists of 4 tanks in the 20 MeV section and 7 tanks in the 100 MeV section. The 20 MeV DTL tank has 52 on the DTL21, 40 on the DTL22, 34 on the DTL23 and 30 on the DTL24, and the 100 MeV DTL tank has 35 on the DTL101, 29 on the DTL102, 26 on the DTL103, and 24 on the DTL104, 22 on the DTL105, 21 on the DTL106 and 20 on the DTL107.
  DT alignment performs the fiducial of each DT to determine the identification of DT. And, by performing fiducial of the DTL tank, the coordinate axis of the DTL tank is established. After that, each DT is aligned to ±50um precision after assembling the RF, vacuum and cooling related parts. All alignment process is carried out by building two laser trackers on both sides of the DTL tank. Figure 4 shows the arrangement of the DT by installing the DTL tank on the test bench. After DT alignment, it moves to the location of the DTL tank and aligns the DTL tank with ±150um precision [5].

HLS AND WPS
The proton accelerator operates HLS and WPS for real-time motion monitoring of accelerator buildings [8]. HLS and WPS were installed as a follow-up to earthquakes in 2016 and 2017. 10 HLSs are installed in the entire area of the accelerator tunnel floor to monitor the movement of the floor. The WPS is generally used to monitor the location of the device, but the proton accelerator is divided into two sections on the wall where one side is in contact with the basement, and a total of eight are installed to monitor the location. HLS and WPS were benchmarked installed on PAL-XFEL [7].
Hydrostatic Levelling System

According to the operation principle of HLS, each HLS is connected by one water pipe. As shown in Figure 2, 6 HLSs are operating in the linear accelerator section, 2 are in the 20MeV beamline, and 2 are in the 100MeV beamline. After the nearby earthquakes in 2016 and 2017, there were no specific findings regarding the effect of the accelerator by vibration. As shown in Figure 7, it is a pattern obtained from HLS, and tidal phenomena can be observed [8]. In addition, since the movement of the building floor is monitored for a long time, it is used as a measure to check the accuracy of the change in the height direction of the laser tracker during the alignment process of the accelerator.

Wire Positioning System

The WPS is installed in two sections on one side of the accelerator tunnel wall, three operating at 20 MeV sections and five operating at 100 MeV sections. Figure 8 shows WPS photos and data obtained from operation. In the early stage of operation, the fluctuation range due to insufficient fixation of the sensor support was affected. In addition, events such as fluctuations due to human contact and cutting of wires occurred to the corridor side of the accelerator tunnel, which is the installation location of the WPS.

NEW ALIGNMENT NETWORK

The data from the alignment network survey in the regular maintenance twice a year is being accumulated. In the data processing process, the position of each alignment network can be positioned with respect to the origin by setting the axis of the accelerator tunnel. Comparing the positions of each alignment network each year reveals a strange pattern [9]. At the beginning of the accelerator operation, this point was judged to be the actual movement of the building. After installing the HLS, it was confirmed that the movement of the floor was less than 100um, and an error in the data of the alignment network survey was found. To improve this, a total of 154 additional alignment networks were installed in the accelerator tunnel floor and walls. Figure 9 below shows an additional alignment network installed.

CONCLUSION

In the proton accelerator, alignment is performed using one or two laser trackers. Except for power outages and earthquakes, the alignment of the accelerator is carried out during the accelerator maintenance period. HLS and WPS are being used to monitor the movement of building floors and walls in real time. To reduce the measurement error of the laser tracker, additional network installation and network height measurement using a digital level were started. In the future, we should be try to improve the verification of the data measured using the laser tracker and the utilization method for the long-term accumulated data.

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REFERENCES


