Methods for Improving Alignment Coordinate System of Accelerator Tunnel at KOMAC

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1. Introduction

100-MeV proton linear accelerator at KOMAC (KOrea Multi-purpose Accelerator Complex) has been operating since 2013 [1]. The alignment status of the accelerator in the proton accelerator is measured twice a year through maintenance in winter and summer. In order to measure the alignment of the accelerator, it is important to set the coordinate axis of the accelerator tunnel. The coordinate axis of the accelerator tunnel is established through a survey of the AN (Alignment Network) installed in the accelerator tunnel using a laser tracker [2]. After installing HLS (Hydrostatic Leveling System), it was found that the variation in accelerator position information by the constructed coordinate axis is larger than the variation in the vertical direction of HLS [3]. In order to improve the coordinate axis setting of the accelerator tunnel, there were processes such as repetitive measurement of AN and expansion of the number of ANs [4]. In this paper, the improvement of the coordinate axis setting method of the accelerator tunnel and the method of improving the measurement errors included in the set coordinate axis are presented.

2. Methods and Results

2.1 Alignment Network Survey

Fig. 1 is a plan view showing the coordinate system of the accelerator tunnel. The survey of AN is carried out by repeating the process of measuring and moving the ANs installed on the wall of the accelerator tunnel (row 135 m * column 38 m) using a laser tracker.

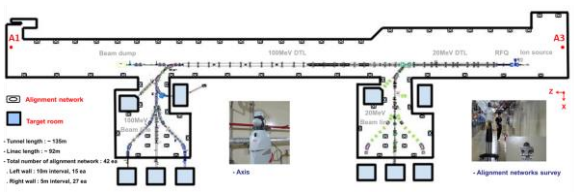

Fig. 1. Coordinate system of the accelerator tunnel

The AN survey starts with the first set-up of the laser tracker near point A3 in the figure. The building of the laser tracker is called a station. In the 1st station, set the Y-axis using the axis of the gravity direction, which is a function of the laser tracker. It measures the AN around the A3 point and moves to the next station. From the 2nd station, three or more points overlap with the AN measured at the previous station. Currently, at least 6 or more points are overlapped and moved. In this way, stations are built 27 times in the Linac (Linear accelerator) section, move to the 100MeV beamline section, and build a station by overlapping three or more points of the AN of the Linac section again from a place close to the Linac section. In the 100MeV beamline section, six stations are built. The 20 MeV beamline section also conducts the AN survey in the same way as the 100MeV beamline section. When this AN survey process is finished, the coordinate axis is completed by setting the Z-axis connecting the A3 and A1 points and forming the Y-axis in the previous gravity direction.

2.2 Nominal value of alignment network

In KOMAC, the coordinate axis of the accelerator tunnel was established every time AN survey of accelerator tunnel was conducted, and the alignment status of the accelerator was monitored. Fig. 2 shows the alignment status (center of Y direction) of the Linac section accelerator from 2019 to 2023 by constructing the coordinate axis each time. Differences between periods were up to ~17 mm.

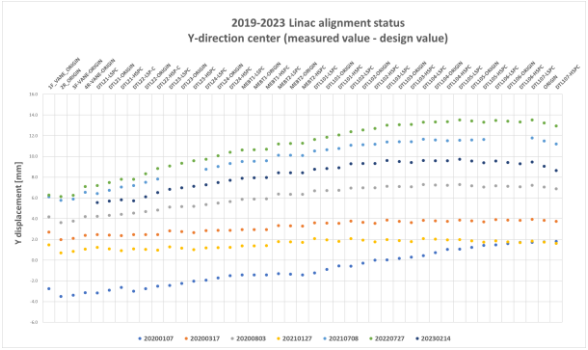

Fig. 2. Linac alignment status from 2019 to 2023 using previous method

By determining the nominal value of the AN, the coordinate axis set after each AN survey of accelerator tunnel is intended to use the coordinate axis of the nominal value. Because of the accelerator alignment work during the winter maintenance period in 2019, it was determined as the nominal value of AN. Fig. 3 shows the status of Fig. 2 based on nominal value. Compared to Fig. 2, the variation was reduced by about

8 mm. The X direction also decreased from about 9 mm to about 4 mm. However, it still has measurement errors in the X and Y directions.

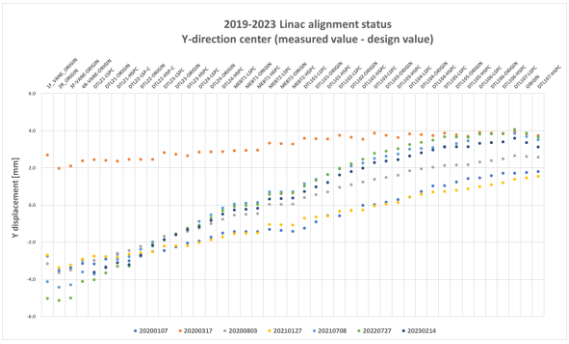

Fig. 3. Linac alignment status from 2019 to 2023 using

2.3 Measurement tolerance improvement method in X direction

The measurement error in the X direction can be confirmed by comparing the results of two AN surveys in the winter of 2020, as shown in Fig. 4. The first is the result of the AN survey of the entire section of the accelerator tunnel, and the second is the result of the AN survey of only the Linac section.

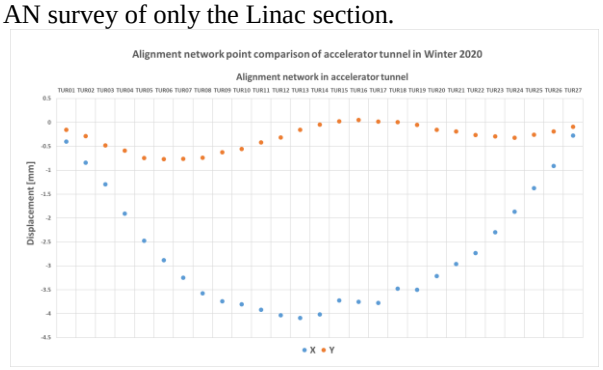

Fig. 4. Alignment network point comparison of accelerator tunnel in winter 2020
: Comparison of overall accelerator tunnel section and Linac section in AN survey.

The maximum difference in the Y direction is ~400 um, and the difference in the X direction is ~4 mm.

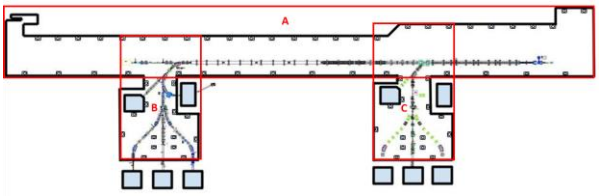

Fig. 5. Coordinate system setting section of the accelerator tunnel;
A: Linac section, B: 100-MeV beamline section, C: 20-MeV beamline section

In order to improve the measurement error in the X direction, as shown in Fig. 4, the coordinate axis is divided into three sections during the AN survey of the acceleration tunnel. AN survey of Section A precedes, followed by Sections B and C. In order to combine the entire coordinate system, sections B and C are set to share a part of the alignment network of section A.

2.4 Measurement tolerance improvement method in Y direction

As a method to reduce the measurement error in the Y direction of the AN survey of accelerator tunnel, a digital level is used as shown in Fig. 6. The height of each components is measured using a digital level. The results combine the AN survey data of the laser tracker using the USMN (Unified Spatial Metrology Network) of the SA (Spatial Analyzer) program.

Fig. 6. Measurement of standard invar staff using the digital level (Leica, LS-15)

3. Conclusions

There were several measurement errors in the AN survey process of the accelerator tunnel, and improvement methods were presented. In the future, it is necessary to maintain a consistent coordinate axis of the accelerator tunnel through verification of the improvement method and establishment of a detailed AN survey procedure after verification.

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