Development of Non-contact 3D Measurement System for Parts of Accelerator Cavities

K.Enami[1], T.Kume[1], Y.Higashi[1], K.Ueno[1]
[1]*High Energy Accelerator Research Organization, Japan*

enami@post.kek.jp

Abstract

The purpose of this study is to measure 3D profiles of parts of accelerator cavities rapidly with no contact. An accelerator cavity is main parts to accelerate electron and positron used in ILC project. Its measurement and inspection is very important.
We developed a measurement machine and conducted the measurement experiment.

1 Introduction

At present day, the ILC (International Linear Collider) project is progressing through international collaboration (Fig.1 left). The major goal of ILC is to produce and investigate Higgs bosons. ILC consists of two linear accelerators facing each other, and will hurl some 10 billion electrons and positrons toward each other at nearly the speed of light. Accelerator cavities are important components to accelerate particles to near light speed. A cavity consists of 9 cells and processed by welding main 18 half cells and another additional parts (Fig.1 right). Material of a cavity is niobium. The shape of a half cell is similar to oblate hemispheroid which have a hall at the pole. The diameter of equator is about 210 mm and the diameter of hole (iris) is about 70 mm. The height is about 60 mm. The shape of each cell and positional relation between cells determine the accelerating performance of a cavity. However, shape of half cells and positional relation are deformed by pressing forming and effect of welding (Fig.2). Thus it is needed to measure 3D profile of half-cells and welded ones. Two half cells welded at the iris part are called “A dumbbell”. At present, CMM is used to measure and evaluate them. However, A touch probe scratches the inner surface of a half cell. The dents causes electric discharge in running and spoils accelerating performance. In addition, 3D profile measurement by CMM takes long time and requires fixation and alignment of a target. It is not realistic to measure and inspect all half cells by CMM in mass production. For these reasons, we are now developing novel measuring system for accelerator cavity parts. The dumbbell is chemically polished. It has semi mirror surface.

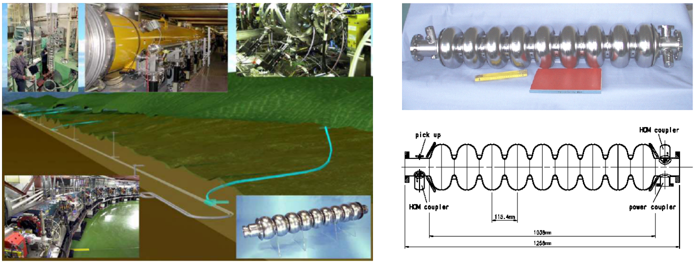


Figure 1: Left: International Linear Collider Right: An accelerating cavity .

Figure 2: A half cell and a dumbbell

2 Principles

We propose ring laser rotating system to measure profiles of half cells rapidly and easily. This system consists of a rotating unit which has a ring laser unit and cameras(Fig.3). The laser line scans all inner surface of a half cell while rotating. The cross-section shape of the half cell is measured using triangulation. The system is able to measure half cells and dumbbells. Additionally, It is not necessary to fix and align the target because the system doesn't contact a target. Thus this system is able to measure and inspect all half cells.

To improve accuracy of measurement, we enhanced image processing and error cancelling and reduction system. These methods are developed to use with another measuring machine. [1] We used two cameras, and aligned one right of the laser unit and the other left of the laser unit. The position errors caused by texture or irregularity of the laser spots occur on the opposite side. Therefore, the errors are cancelled by summing these outputs.

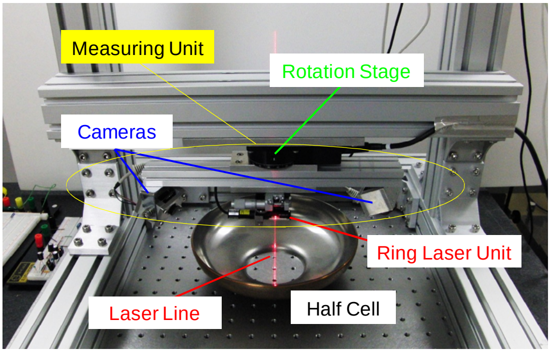


Figure 3: Half cell measuring machine.

3 Calibration

We calibrate system using a cylindrical artefact. It calibrates relationship between cameras and rotation axis. Figure 4 shows coordinate system. 2D-coordinate created by camera and laser plane. 3D coordinate is made by rotating 2D-plane. Some parameters are to be calibrated(Fig.5). We get 2 lines data –top and inside by measuring 1 profile of an artefact. The parameters are derived from data of some profiles.

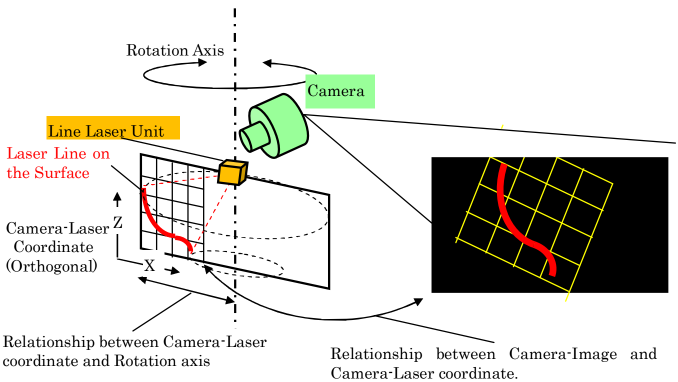
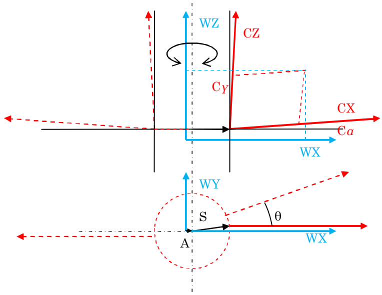


Figure 4: Coordinate system.



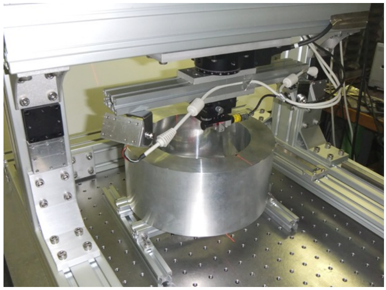


Figure 5: Parameters to be considered by measuring a cylindrical artefact.

4 Measurement

We carried out measurement experiment. Figure 6 shows the result of measurement. 64 profiles. Colors indicates height. The shape of a half cell is correctly reconstructed.

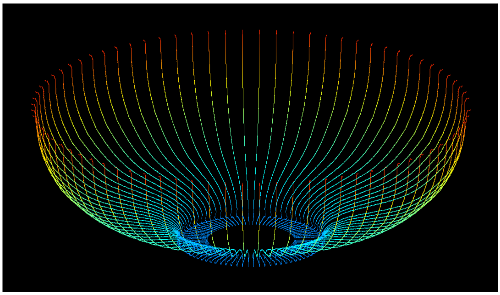


Figure 6: Result of measurement

5 Conclusions

We developed 3D measurement machine for half cells. We constructed a half cell measuring machine, and confirmed that this system is capable of measuring the 3D shape with no contact. We will evaluate accuracy by comparing with CMM data

References:

[1] K.Enami, T.Kume, Y.igashi, K.Ueno, “Development of inner 3D Shape non-contact measurement system for bellows pipe 3rd report”, 2007 JSPE autumn conference, pp. 1153-1154, Kanagawa, Japan, March. 2007