The Application of 3D Laser Scanning Method in Monitoring the Quality of Pressure Vessel

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***Abstract*—Pressure vessel is widely used in the industrial engineering and will deform when working in the long time. Large deformation will do great harm to people and property. 3D laser scanning method uses non-contact measuring method and can directly obtain the point cloud data of the mass surface which can be used to obtain displacements. According to the advantages of 3D laser scanning method, in this paper, it is introduced to monitor the quality of pressure vessel.**

Keywords-3D laser scanning method; pressure vessel; quality; deformation

I. INTRODUCTION

With the rapid development of our economics, in the past ten years, the ability and level of design and product of pressure vessel have been improved greatly, which make it possible that pressure vessel can be in work in the long time[1-2]. The work of pressure vessel in the long time will make it deform and large deformation will effect the safety of pressure vessel. Therefore, it is important to monitor the deformation of pressure vessel.

3D laser scanning method can easily obtain 3D coordinate information of surface points and is a kind of 3D measuring techniques[3-5]. Comparing to the common 3D techniques, it can finish the measurement of complex objects and has the characteristics of non-contact, high precision and rapid measurement, which can improve the efficiency of measurement and save time and cost.

Therefore, according to the advantages of 3D laser scanning method, in this paper, it is introduced to monitor the quality of pressure vessel.

II. THE PRINCIPLE OF 3D LASER SCANNING METHOD

The system of 3D scanning method is based on the principle of time measurement. The scanning lengths of scanning points *r* can be obtained by 3D laser scanning beams and then according to the horizontal and vertical angles of the laser scanner, the relative coordinates of object points in 3D space can be calculated out. The local coordinate in the 3D laser scanner can be regarded as *oxyz* as is shown in Figure I and the 3D coordinates of any object point can be expressed as

$$\begin{cases} x = r\cos\varphi\cos\theta \\ y = r\sin\varphi\cos\theta \\ z = r\sin\theta \end{cases} \quad (1)$$

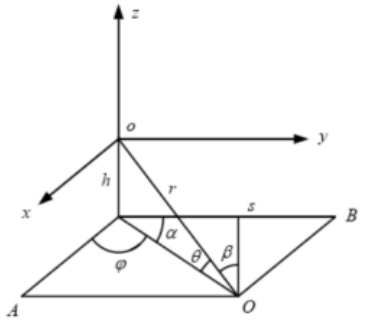

FIGURE I. 3D SCANNING COORDINATE

The direct data obtained by the 3D laser scanning is the set of single point, named as point cloud. The information of single point includes 3D coordinate *(x,y,z)* and reflection strength i. And then the data of point cloud are be operated using the special software. The process of operation is shown as follows:

(1) Noise reduction: deleting the object points which are not located in the scanning range and don't belong to the research object.

(2) Target position: using the ability of recognizing target to finish target position for the registration of point cloud.

(3) Registration of point cloud: transferring the data of point cloud in the scanning coordinate to the same coordinate

(4) Simplification of point cloud: simplifying the data of point cloud and using the lest points to obtain the best effect

(5) Deformation measurement: the common methods for deformation measurement include point cloud superposition, point cloud comparison, gravity model method and fit method.

3D surfaces, displacements and deformations of measured objects can be obtained using 3D laser scanning method.

III. EXPERIMENT

Before In order to verify the application of 3D laser scanning method in monitor the quality of pressure vessel, a

pressure vessel produced in Hebei province is elected as the experimental specimen. And then using the actual dimension of the specimen in CAD design drawing, the deformation of pressure vessel can be obtained.

The device used in the experiment is Faro Focus 120 3D laser scanner. The precision of distance measurement in 25m is 5mm and the resolution in 10m is up to 0.9mm. The view-angle coverage is 360*320 and the largest scanning rate is 97600p/s.

Because the specimen is large, five laser scanners are used to finish the experiment. The measuring system is shown in Figure II.

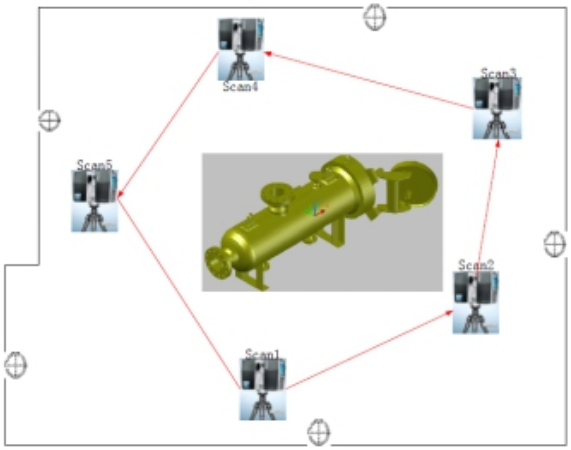

FIGURE II. THE MEASURING SYSTEM CONSISTING OF FIVE SANNERS

IV. EXPERIMENTAL RESULTS

The surface data of the specimen obtained by five scanners is input to Faro Scene and the center points of five scanners is fitted. According to the fitted coordinates of five scanners, the data of point clouds are transferred into the same coordinate system and then spliced. The 3D surface of the specimen is shown in Figure III.

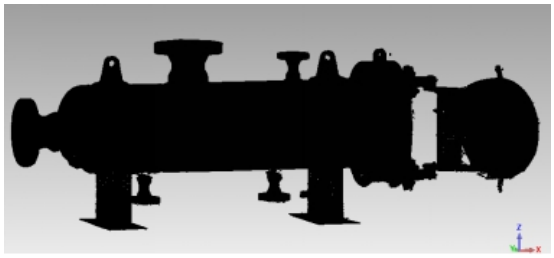

FIGURE III. 3D SURGACE OF THE SPECIMEN

In order to obtain the deformations of the specimen, the initial dimension of the specimen is compared with the experimental results. The initial dimension is shown in Figure. IV, which is provided by the designer of pressure vessel.

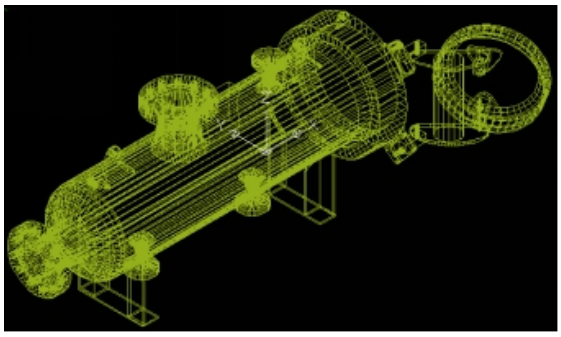

FIGURE IV. THE INITIAL DIMENSION OF PRESSURE VESSEL

After obtaining the surface information of the specimen, we can analyze its deformation. The deformation can be calculated out by comparing the coordinates of the same points, which is shown in Figure V. The different displacements are marked with different color. The azure blue is 0~4mm, the blue 4~8mm, the yellow 8~12mm, the orange 12~16mm, the pink 16~20mm and the red larger than 20mm.

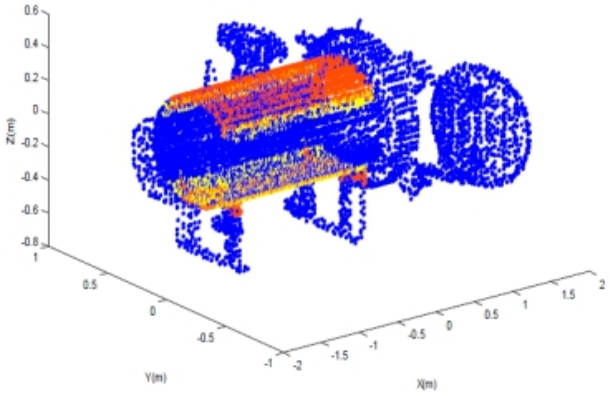

FIGURE V. THE DEFORMATION OF THE SPECIMEN

According to the deformation of the specimen, the deformation is enough little compared with the actual dimensions of the specimen and we can conclude that this pressure vessel working in the long time remains safe, which certify that 3D laser scanning method can be used to monitor the quality of pressure vessel.

V. CONCLUSION

Pressure vessel is widely used in the industrial engineering and will deform when working in the long time. If the deformation is too large, great harm will be done to the lives and properties of people. Therefore, in this paper, according to the advantages of 3D laser scanning method, it is introduced to monitor the quality of pressure vessel. According to the experimental results, the deformation is enough little and the pressure vessel working in the long time remains safe, which certify that 3D laser scanning method can be used to monitor the quality of pressure vessel.

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