DESIGN AND DEVELOPMENT OF LOW COST COORDINATE MEASURING EQUIPMENT

S. Dhayanidhi Ginagar[1], B. Dinesh[2]

[1] *S. Dhayanidhi Ginagar, Mechanical Engineering, Prince Shri Venkateshwara Padmavathy Engineering college, Tamil Nadu, India*
[2] *B. Dinesh, Mechanical Engineering, Prince Shri Venkateshwara Padmavathy Engineering college, Tamil Nadu, India*

ABSTRACT

The aim of our project is to design a low cost coordinate measuring equipment for the collection of coordinates to measure the geometric coordinates of solid model with the use of joystick to obtain point to point distance measurement and dedicated program to collect the 3D cloud points of the solid model for the purpose of inspection and reverse engineering which will be suitable for small model of about 300x300x450 mm dimensions with curved body using distance measuring sensor. In order to do this, a designed rotating table setup for holding the object to be measured and linear motion of distance measuring sensor is made and controlled by stepper motor using Arduino for making the work cost efficient and effective in measuring, inspection and reverse engineering applications.

Keyword : - Coordinate measuring , *3D scanning, Cloud data points, and distance measurement*

1. INTRODUCTION

3D scanning is the process of analyzing a real-world object or environment to collect data on its shape and possibly its appearance. The collected data can be used in construction of digital 3D model by extrapolation and it can be used in variety of applications. Contact type scanner is the Coordinate Measuring Machine used in highly precise inspection while Non-contact scanner uses light source such as ultrasound or x-ray for active type and stereoscopic or photometric system for passive type.

1.1 Existing Design Concept

The selection of coordinate measuring machine is based on measuring uncertainty, tolerances of the measurements and accuracy [1]. The precision of the CMM when measuring distances between planes does not depend on the position and in comparing the scanning probe (SP-25) and touch probe(TP-200), scanning probe has better performance with no significant differences of the measurement when three, four or five contact points used to define the plane of the object [2]. Also that Cylindrical surfaces can be easily constructed with minimum error between the surface and the point cloud because the cylinders was near 180° of angular extension and therefore high number of points was acquired both for contact and laser. For the fillets the surface only covers 0° to 90°, so a low number of points generates error in radii and in the center location. The multi-oriented strategy is recommended only when vertical surfaces are being digitized. This strategy not only does not provide a higher accuracy but also spends much more operation time. Comparing with the global strategy, the multi-oriented one requires more time for probe qualification, more time for point acquisition and more time for point cloud post-processing. [3].

1.2 Optimization of design

The ultimate aim in making of a coordinate measuring system from its conventional CMM is reducing the cost of CMM by the application of distance measuring sensor and electronic components in making the process continuous

over the measuring model. The design of 3D image capturing is made simply by linear motion of a stepper motor for the measurement of z coordinates and measurement of y coordinates and x coordinates by the value of r and θ through another stepper motor controlled by Arduino.

1.3 Objective

- To make the work efficient for multiple coordinate measurement by program feed.
- To simplify the point to point distance measurement using joystick.
- To provide the application in both inspection and reverse engineering.
- To reduce the cost of coordinate measuring equipment.
- To provide the precision and accuracy for coordinate measurement.
- To process the obtained cloud points for 3D model reconstruction.

2. METHODOLOGY

2.1 Working principle

The working principle is the collection of data points from the 3D model using an infrared distance sensor and this process of data cloud collection is made all over the 3D model using a rotating table for x axis and linear movement of sensor for z axis while the sensor measures the distance of y coordinates. The x, z axis motion is provided by NEMA 17 stepper motor controlled by the A4988 stepper motor drive through Arduino program.

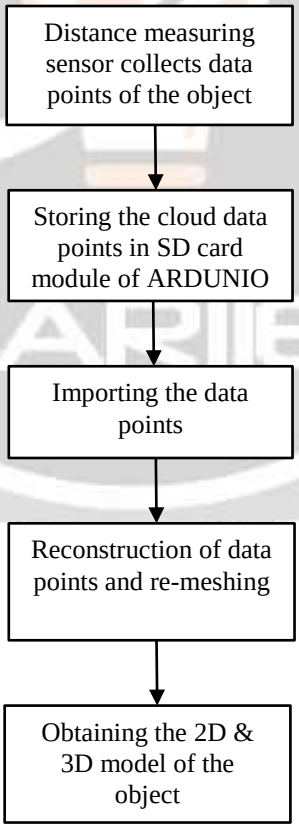

Fig -1: Working principle

The r measurement by the sensor at different locations of the rotating model on the turn table is collected and θ from the stepper motor is used to calculate the y and x coordinates through Arduino program. The collected data cloud is stored on a SD card module as text file containing coordinate points of x, y and z. This file is now imported into mesh lab and reconstructed for 3D image and by further processing, dimensions of the 3D image can be obtained for detailing in reverse engineering process. For single coordinate measurement the joystick is used to move the z axis coordinates and θ so that the distance moved between coordinates can be measured.

$x = D \times \sin\theta$

$y = D \times \cos\theta$

where, D is the known distance between distance sensor to the measurable point of the object

θ is the angle of rotation calculated from turntable stepper motor

z is calculated by the angle of rotation of carriage stepper motor.

2.2 Description of components used

Table -1: Description of components

Distance sensor	Sharp GP2Y0A710K0F
Stepper motor	NEMA 17
Arduino	Uno Rev3
Lead screw	4 star trapezoidal
Stepper motor driver	A4988
Deep Groove Ball Bearing	HCH 698
Linear Bearing	LM800

3. DESIGN AND DEVELOPMENT

The design structure of the coordinate measuring equipment consists of 'base' for the holding of stepper motor, 'carriage' for holding the distance sensor over the lead screw motion controlled by one of the stepper motor, 'collar for fixing the lead screw with guide rod and turn table to hold the work piece of measurement controlled by another stepper motor.

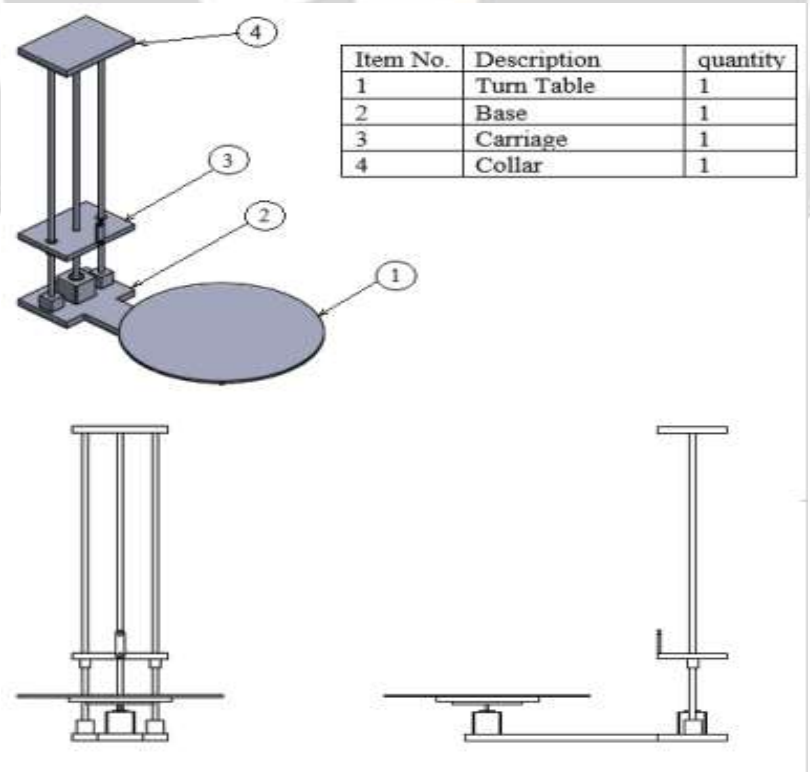

Fig -1: Design of Assembled view

The selection of material for the parts of the design are selected to be acrylic sheet for the turn table and PVC sheet for base, carriage and collar. This selection was based on the low density and weight requirement for the coordinate measuring equipment.

Fig -2: Assembled view of the Coordinate Measuring Equipment

The fabrication process involved in coordinate measuring equipment are cutting, drilling, milling and soldering of circuit connection.

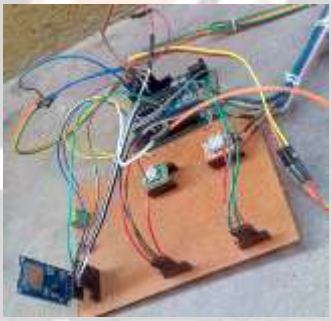

Fig -2: Detailed Circuit Connection

4. DATA COLLECTION AND PROCESSING

The measured distance from the sensor is calculate and the Adruino is programmed to calculate the x and y coordinates by calculating from the known distance between the distance sensor to the centre of table. Hence the obtained dimension are accurate from the centre of turntable.

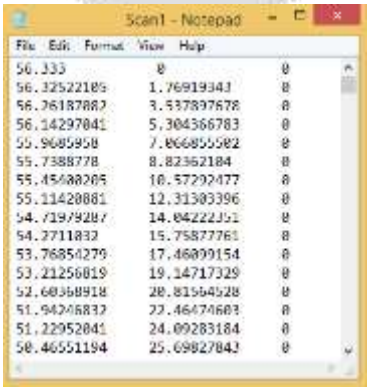

Fig -3: Collection of coordinates

The collection of data cloud points as text file from the Adruino is saved in SD card which is processed and the following 3D structure has been obtained. The time taken for the collection of cloud points is high because of the increased delay time in program for higher precision. The cloud points are meshed and reconstructed to obtain the dimension of the object.

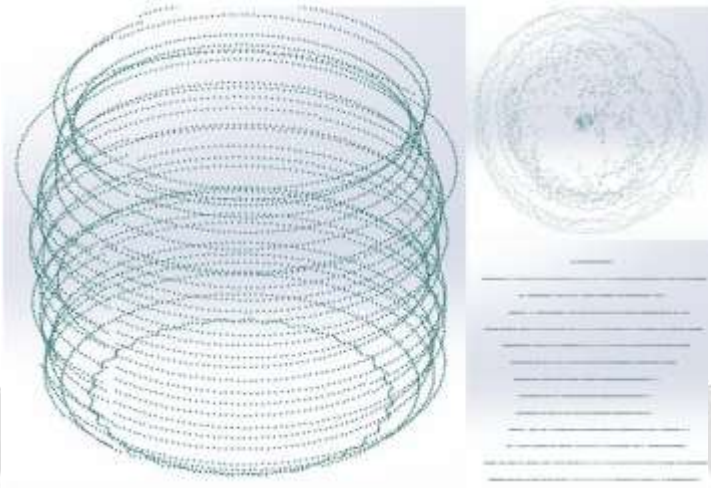

Fig -4: Importing as cloud points

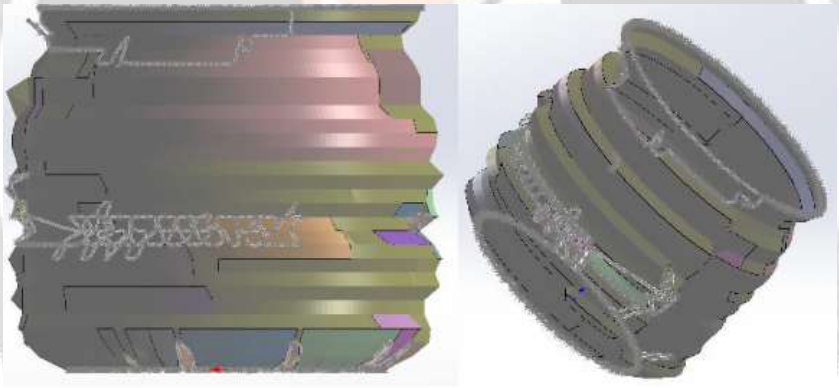

Fig -5: Meshing and reconstruction

5. CONCLUSION

In this way we finally conclude that the coordinate measurement equipment is applicable for point to point distance measurement using the joystick for instantaneous measurement and multiple coordinate measurement of a solid 3D model for reconstruction. After post processing process the cloud point reconstruction is of admissible accuracy.

6. REFERENCES

[1]. "Principles for Selection of Coordinate Measuring Machines" by Virgil TEODOR et al (2009)
[2]. "Precision study of a coordinate measuring machine using several contact probes" by Puertasa et al (2013)
[3]."Comparison between non-contact and contact scanning systems for dimensional control" by Susana Martinez et al (2008).