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COORDINATION OF 3-D DIGITAIZER AND NC MILLING MACHINE

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Abtsract

In this paper we present one modeling system, which is composed of a 3-dimensional proile measurement unit, a CAD system and a NC milling macnine. This system is compactly combined so that measurement, desining and manufacturning can be performed efficiently. This system was actually applied to make a plaster model of the pottery.

1. Introduction

Nowadays mass production systems are highly developed. Automatic mass production systems can be found in many industries, like automobile industries and home electric industries. In the factory where the number of the products of one kind are no less than hundreds or thousands, automation of the production systems has eminent benefits. However, if the number of the products are small, automation of the production system is not necesarily preferable. In such cases, manual task are often most preferable, since conventional NC machine and Robot systems are not so flexible to cope with a variety of kinds of production. In addition, programming of automatic machine and preparation of new production procedures often spend so mauch time. In Nagasaki, Japan, we are producing potteries and house-wares, where almost all of the tasks are performed manually. Once we examined to introduce a fully automatic production system in this area. The conclusion was that automatic machines developed in the mass production fields could not be applicable here. The main reason was that the number of each pottery to be produced was so samll and also that automatic machines developed were not so flexibe. More flexible production system and machines are desirable in this fields.

We propose one simple CAD/CAM system, which produce models of potteries. Three main components of our CAD/CAM systems are a 3-dimensional profile measuring system, a CAD computer and a desktop NC milling machine. One distinctive feature of our system is that these three components are compactly organized. Furthermore, our system is effective to the modeling tasks and also low-priced.

Generally the model of potteries are fabricated as follows. Firstlly, designers make a clay model. And the clay model is measured to obtain numerical data. Once the numerical data are obtained, the data are transfered to NC machine. The NC machine gives us the plastic or plaster model. The model are used to examine the shapes and operability. Using our system the above procedures can be executed easily.

2. CAD/CAM System

2.1 System Setup

Configuration of our CAD/CAM system is shown in Fig.1. A desktop NC milling machine is driven with three pulse motors. These three pulsc motors are controlled with a personal computer. Milling cutter on the milling machine can be readily exchanged with a 3-dimensional profile measurement sensor unit. By excahnging with this sensor unit, the miiling machine is endowed with a function to measure the 3-dimensional profile of the target product.

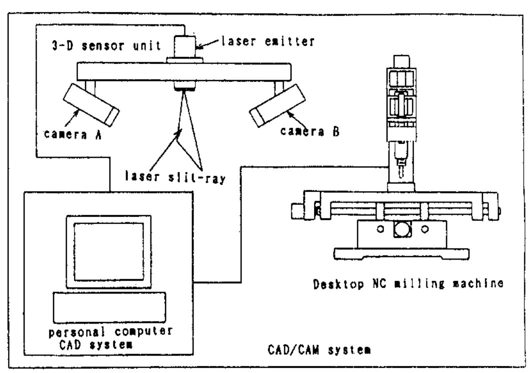

Fig.1 System configuration

Since a CAD system (Auto CAD) works on this computer, 3-dimensional profile data obtained through the measurment are easily modified or edited to obtain desired profile data.

Furhtermore, CAD data are translated to NC data considering the shape of the cutting tool on this personal computer. Therefore, measuring, designing and manufactuing of the model can be executed using this system.

2.2 Desktop NC milling machine

The desktop NC milling machine has three degrees of freedom as shown in Fig.2. All the movements are controlled with three pulse motors. The milling cutter can be moved with 0.025 mm resolution. Also the bench where the target work is settled can be moved in the x and y directions with 0.025 mm resolution. The profile is shows in Photo.1.

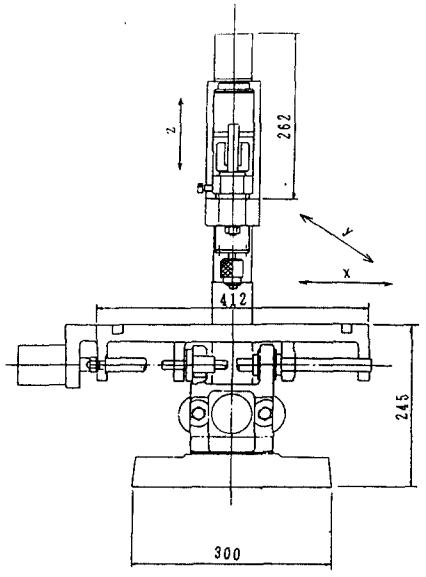

Fig.2 Desktop NC milling machine

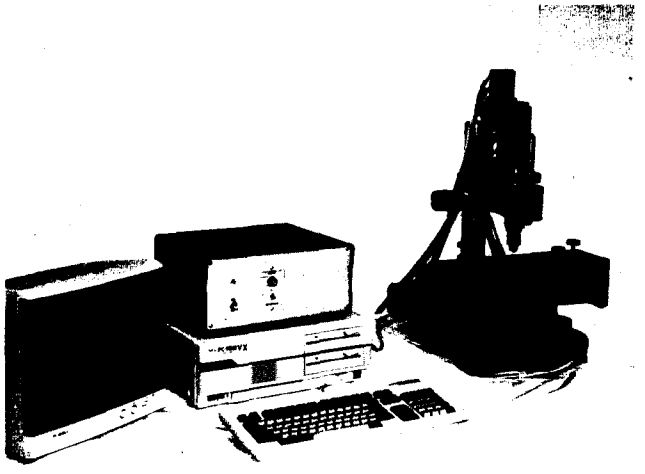

Photo.1 Profile of NC milling machine

2.3 3-dimensional measuring system

By mounting 3-dimensional profile measuring unit on the NC milling machin , 3-dimensional profile measurment can be performed.

The principle of the measurment is based on the slit-ray projection method . Details of the measuring unit are shown in Fig.4. And the view of the unit mounted on the NC milling machine is shown in Photo.2.

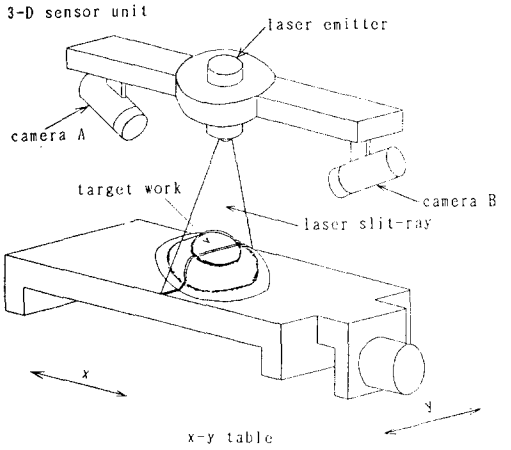

Fig.3 3-D mesuring unit

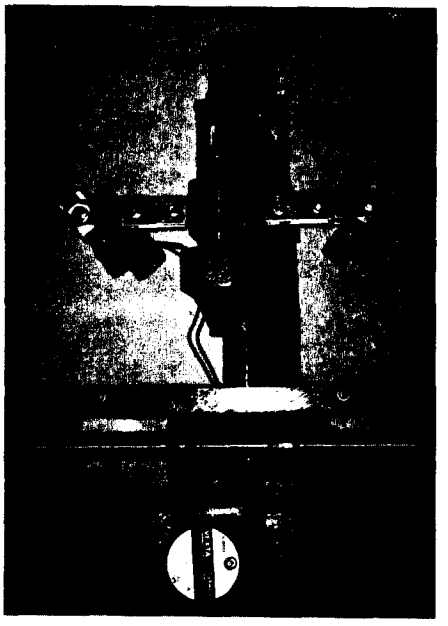

Photo.2 Veiw of 3-D measuring system

A target work is settled on the bench. When the 3-dimensional measurement is started, the bench is moved so that the laser-slit scans all the surface of the target work. The laser slit-ray is emitted from a semi-conductor laser with 770 nm wave length. The reflected lights are measured with CCD TV cameras. Two CCD cameras are employed since unmeasurable potion which is inevitable to slit-ray projection method could be eliminated as much as possible.

We suppose that the coordiates x, y and z are fixed on the bench and the origin are also on the bench as is show in Fig. 4. We adjust the laser slit-ray projector to compose a surface pararell to the y-z surface. Then, the relation between the raster coordinates (u, v) of the slit-ray images and the 3-dimensional coordinates (x, y, z) becomes

$$y = f1(u, v),$$
$$z = f2(u, v)$$

where f1 and f2 are determined by the geometrical setting of cameras and slit-ray and also lens deformation.[1)2)3)] As everyone notice, x coordinate coresponds to the displacement in thex-direction of the bench.

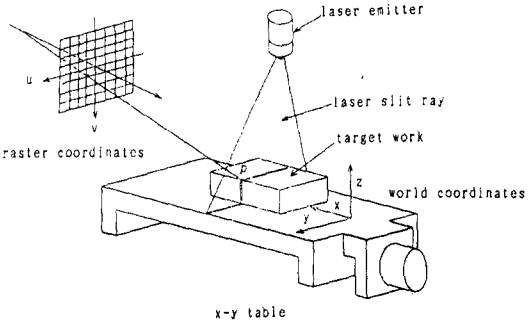

Fig. 4 Coordinate of system

In order to obtain the definte function f1 and f2, the following calibration is performed:

We marked one point on the bench and also in the laser slit-ray. We reapeated to move the bed in the y and z direction and also measuerd the raster coordinate of the marked points. These measurements were performed ten times in the y direction and ten times in the z direction. As results, a table that correlates world coordinates y, z and raster coordinates u, v are generated. Since this table is not prepared for all possible y, z values, we prepared one prgram that has two-dimensional interporlatin function on this table. Therefore, it is quite easy to obtain y, z coordinates from the u, v coordinates using this table.

2.4 CAD sytem

Once the three dimensional profile data are obtained with the above system, the designer can display, edit, deformate correct the data on the computers. One popular CAD system (Auto CAD) is employed and optoinally the function of correction is increased on the personal computer.

2.5 CAM system

CAD data are automatically conveted into the macnining data of our NC milling machine considering the tool shape.[4)] In order to check the machining data the milling process can be simulated in advance.

3. Experimant

In order to check the applicability of our system in the industries, a pottery is measured 3-dimensionally and a model was fabricated.

On the right in Photo. 3, a target pottery is shown. Also the model fabricated is shown on the left side. Computer display of the pottery is shown in Fig. 5. All measurement was perforformed in two minutes. All the manchining spent two hours. Accuracy of the 3-dimensional measurment wasabout 0.3 mm.

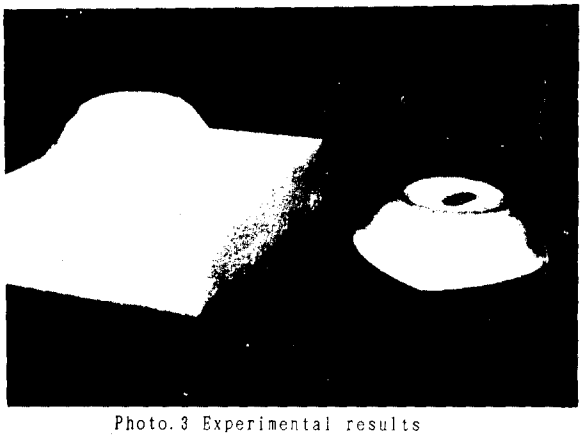

Photo. 3 Experimental results

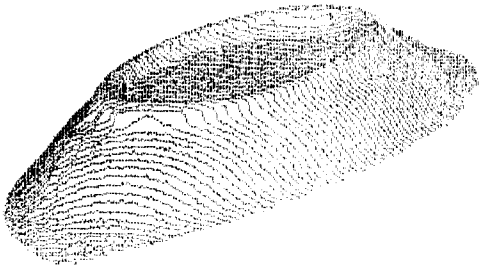

Fig. 5 Computer display of pottery

4. Conclusion

3-dimenaional modeling system which is used to make a pootery model is developed. One feature of our system is that 3-dimensional profile measurement and machining can be executed using one milling machine.

References

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