Application of the “S-MAC” System; Eye Rim Forming Machine

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1. Introduction

Sanyo Denki declared the “Open Architecture”, making its FA technology open to meet the needs of the times, and has been introducing the concept of our network controller “S-MAC” into the market. In addition, we have developed the products that accommodate those open networks, such as SERCOS and DeviceNet as a motion network, and Ethernet as a upper level network. This document introduces an application example of our open network controller “SMS-10” vs. the conventional NC (computer numerical control) for the application of an eye rim forming machine.

2. Outline of the Solution of Eye Rim Forming Machine

Fig.1 shows the eye rim forming machine of the developed system. This device is an integrated system of the three-dimensional eye rim forming and the lens shape tracer that traces the lens-shaped die and measures numeric data from it.

In the three-dimensional eye rim forming portion , the processing materials are fed by the wire-delivery shaft, and the three-dimensional bend processing is done with a bending shaft and a R shaft that form the lens shape and lens curve. When the processing ends, cutting is done with an air pressure cutter, and the product is completed.

The lens shape tracer measures numeric data from the lens-shaped die with a digital gauge while rotating the die set on the device using a trace shaft, and transfers the numeric data to a management personal computer (hereafter, “management PC”).

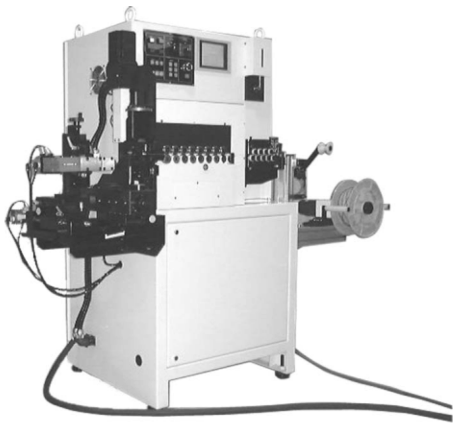

Fig.1 Eye Rim Forming Machine

2.1 Outline of Solution

The system created was developed to find the solutions to the under mentioned problems.

① Prevention of outflow of customers' know-how due to the use of PC-base controller
② Reduction in development cycle
③ Drastic reduction in costs
④ Pursuit of higher functionality and process speed

2.2 Bending Operation

Fig.2 shows the outline of the bending operation. At the bending operation, there is synchronization of the position of the material advanced by the wire-delivery shaft (X axis), the R bending operation is done towards a set depth by a R shaft (Y axis) that controls the rotation working, and the bending operation is done by a bending shaft (A axis) that works vertically.

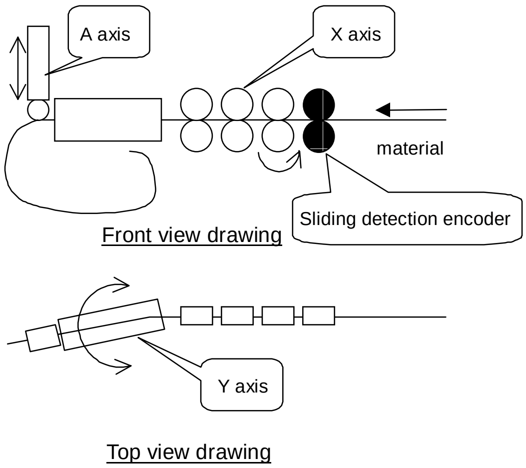

Fig.2 Outline of Bending Operation

2.3 Tracing Operation

Fig.3 shows the outline of the tracing operation. The lens-shaped die of eye rims is rotated with the trace rotation shaft (Tr axis), and the machine measures the distance from the center of each angle of the die with the digital gauge installed in a vertical direction. 800 points are measured in this process for one oval. Data for the bending processing is created based on this measured data.

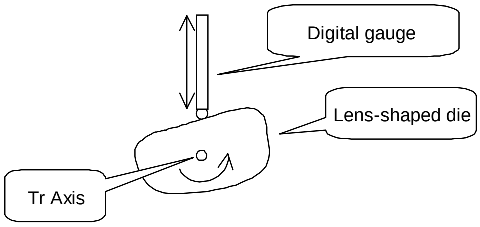

Fig.3 Outline of Tracing Operation

2.4 Process Data Creating Work

The bending process data is created by a management PC (external). The management PC takes into account various conditions based on the traced data to create process data. Corrections not obtained during the measurements can be reflected directly in the process data as well.

The various conditions are as follows.

1) Type of the material
2) Amount of material backlash
3) Shape of the material
4) Thickness of the material
5) Lot of the material
6) Others

2.5 Machine Specification

Table 1.1 shows the specification of the three-dimensional eye rim forming machine, table 1.2 shows the specification of the lens shape tracer, table 2 shows the system configuration of the control unit, and table 3 shows the specification of the control software.

Table 1.1 Machine Specification (three-dimensional forming machine)

Item	Contents
Purpose	Eye rim forming
Production efficiency	10～20 pieces/min.
Details of process	Bending, Curving
Allowable tolerance （incl. Transient response）	Feeding tolerance：1.5mm Bending tolerance：±2° R tolerance：±0.5mm

Table 1.2 Machine Specification (eye shape tracer)

Item	Contents
Purpose	Measurement of eye-shaped die value
Measuring time	30sec／piece(high-speed) 60sec／piece(low-speed)
Details of process	Measurement of value, data transfer
Resolution	10μm

Table 2 System Configuration

Item	Contents
Controller	“S－MAC” SMS10A016S005 AML
Control axes	4axes
Servo driver	PQRAS3331166100
AC Servo Motor Wire-delivery shaft	P50B08050DXS00
AC Servo Motor Bending shaft	P50B08040DXV00
AC Servo Motor R bending shaft	P50B07040DXV00
AC Servo Motor Tracer shaft	P50B05020DXS00
HMI	Liquid crystal touch panel
Communication with host	Ethernet
Motion bus	SERCOS
Communication with HMI devices	RS-232C

Table 3 Software Specification

Item	Contents
OS	VxWorks
Motion language	AML 6.14 Runtime
Others	AML application program HMI painting data Mapped position conversion program

3. Outline of Control System

The outline of the control system is explained below.

3.1 System Configuration of Control Unit

Fig.4 shows the system configuration of the control unit. Target PC in the block chart is “SMS-10” as a “S-MAC” controller. “SMS-10” installs the SERCOS I/F card, and communicates with the servo driver.

The servo driver used in this system is “PQ” Type R supporting SERCOS communication. “SMS-10” and the servo driver are connected by optical fiber. It is connected to a host system including the development environment over the network via Ethernet, and communicates with the liquid crystal touch panel by RS-232C.

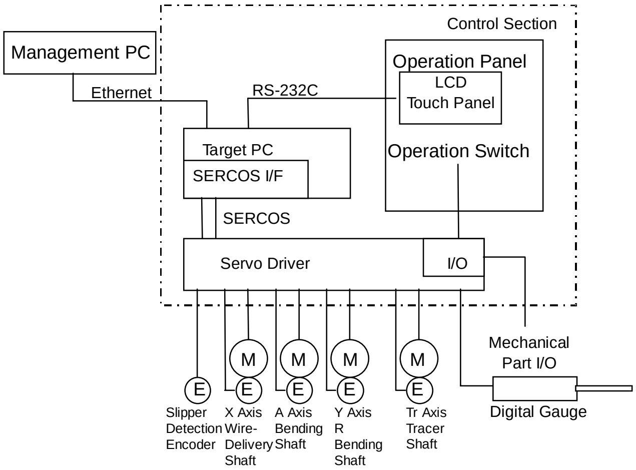

Fig.4 System Configuration in the Control Part

3.2 Outline of Servo Control

Four servo motors are used in this system; X axis, A axis, Y axis, and Tr axis.

1) Control of X axis
X-axis, which is the only wire-delivery shaft to feed the material of eye rims, rotates the material-feeding roller and executes a full close control using the slipping detection encoder that maintains contact with the material. Therefore, the amount of slipping is automatically corrected and then an optimum amount of feeding will be added or decreased if slipping occurs between the positions of the roller and the material. When this amount of slipping exceeds the specified amount, the error would be detected as a slipping.

2) Control of Y axis
Y-axis is used as a R bending shaft to make depth of an eye rim along the thickness of the lens. In the operation of making the depth of eye rims, the servo's fast response is necessary to carry out the change in a steep bending direction when forming each corner of an eye rim.

3) Control of A axis
A axis is used as a bending shaft to implement bending process. Since the bending roller has a certain diameter, the surface that comes in contact with the material is changed depending on the descent position. Therefore, the control of A axis positioning considers various conditions like backlash of the material and also the diameter of the bending roller used.

4) Control of Tr axis
Tr axis is used as a rotating shaft for performing the rotation of a lens-shaped die placed in the lens shape tracer to measure its numeric data. In the measuring operation, this axis rotates the die at a constant speed and 800 points of the die are measured per rotation with a digital gauge.

3.3 Outline of Management PC

The management PC carries out the calculations to convert the traced data into the data for processing, which is later used by the AML program. This PC is shared with two or more eye rim forming machines since it is not used while processing. The switching between the machines is done with TCP/IP and the node name.

1) Operation of Processing Data Conversion
This operation considers various conditions of the material and the diameter of the bending roller, but also manages other factors such as the manual numeric correction and the tolerancing between the confirmation of the processed item and the design data. In addition, operation speed can be corrected to optimize the processing time.

2) Creation of Map file
"AML" is used to create the control software of the machine, and a AML map file is for the creation of the actual processing data. Management PC creates the map files for each 4msec of X axis, Y axis, and A axis from data for processing. When converting into map data, s-curve acceleration/deceleration variables and the path point movement are also included for the shock reduction (noise prevention) of the machine.

3) Storage of Traced Data
With traced data storage function, the management PC processes the data received from the controller first, and then stores them. The tracing process is carried out with a spherical glass ball of about 5mm in diameter, which is attached to the head of the measuring instrument. The measured data always contains deviation of this glass ball to the real data because the contact angle of the ball to the die changes according to the contact surface of the die. Through the data storage process, therefore, the management PC carries out calculations to correct the measured data for the deviation of the glass ball.

4. Features

1) Slipping Detection of Material Feeding and its Correction
The design was done taking into consideration the possibility of slipping between the material and the feeding roller because any flaws on the material caused by the tightening of the roller should be prevented. The control system is structured to be able to correct slippage as it happens. In other words, it is a full-closed control system using an encoder to monitor the deviation between the amount of rotation of the wire-delivery axis and the amount of material actually fed. Thus, this is a system that can carry out the correction to the feeding for the slipping when slipping happens.

2) Noise Reduction Measures

One of the indexes that show the quality of the machine may be its quietness. Even the sound out of servo motors sometimes can sound noisy for some user. At the first of this development, there was a large noise problem from the sound of the acceleration/deceleration and reversing of each shaft. To remove this noise, we redefinded parameters, such as s-curve acceleration/deceleration and path point movement, to be imported into the map data for each 4msec point during the map data creation to achieve an acceptable quietness level.

5. Conclusion

The eye rim forming machine that used "S-MAC" has been presented here. A 40% reduction in costs of the control has been realized as compared to the conventional machine used NC. In addition, we have succeeded in the improvement of HMI operability by changing the conventional NC screen to the direct image screen of user definition, as well as prevention of the customer know-how outflow by using PC base controller and AML. The characteristics of the bending machine for eye rim now clarified can guide the further performance of these processes. We expect that the application of these solutions can be developed to other forming machines in the future.

＊DeviceNet is the trademark of ODVA（Open DeviceNet Vendor Association, Inc.）
＊SERCOS is the abbreviation of SErial Realtime COmmunications System

Reference

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