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New Products Introduction

Application of "S-MAC" Type C
(Development of a Controller for Rolling Machines with Round Dies)

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1. Introduction

Sanyo Denki's "S-MAC" Type C does not use a motion control card. It is a full-software controller based on the combination of a controller with an object-oriented motion control language AML.

This paper outlines a typical application of an "S-MAC" Type C as a controller for rolling machine with round dies.

The rolling machine with round die is used for plastic forming which is promising as an eco-friendly method of working without producing chips.

2. Background of development

The following is a description of the features of an "S-MAC" Type C, in terms of its applications.

2.1 Controller for plastic forming

NC(Numerical Controller) has long been popular as a controller for processing-machine. In this controller, numerical data is extracted from the CAD data of the workpiece and converted to a G code to activate the target machine. NC is the result of development and evolution with its purpose limited to work cutting. A close relationship exists between machine tools, cutting, and the NC.

During work cutting, the superfluous portion is cut off from a material larger than the workpiece. The position and track of the work cutting tool correlates with the shape and dimensions of the workpiece, so that it is relatively easy to automatically generate a machining program from the dimensional data. During actual machining, parameters, offset and other data peculiar to the machine tool can be made to override the machining data, which results in the generation of an actual machining program. The NC is therefore called the override method.

On the other hand, plastic forming is the act of machiningperforms machining by deforming the material. Since the shape of the workpiece depends on the shape of the machining tool, there is no correlation with the machining program. There is an optimal machining program for each combination of workpiece and tool. This machining program must find the optimal type of action by repeating trial machining attempts. The machining program thus obtained is used as the database, from which one can select the appropriate settings to conduct optimal machining. Machining is performed according to the machining program containing the "knack"(recipe) of machining. This system is therefore called the recipe method.

A controller for plastic forming should be capable of changing the operation pattern in any way. Traditional controllers for plastic forming included those based on an NC for work cutting with enhanced operation commands and with the ability to change the operation pattern and those based on a PLC with motion control capability. These are based on different concepts and although they do function to some degree as a controller for plastic forming, they cannot be called the most suitable controllers.

2.2 Language for plastic forming

One popular language used for work cutting controllers is the G code. The G code is basically a structure that describes an X,Y,Z coordinates of the motor directly and is used for work cutting.

The "S-MAC" Type C employs a full-software motion control language called "AML"(Advanced Motion Language). A motion language that runs on a motion card functions quite differently from language that does not require any motion card. The language that runs on a motion card cannot do anything beyond the functions of that motion card. However, the full-software controller that does not require a motion card has no motion card constraints, so that it can basically use all functions of the servo amplifier.

AML is a language originally designed for controllers for packaging and wrapping machines. This language which was born to implement functions required for packaging machines while taking advantage of the features of the full-software feature is AML. It is SERCOS Runtime eXecutive (SRX), which is the controller firmware.

Thus, this system achieves electronic gear, electronic cam and other functions required for packaging machines on a structure with no constraints induced by the motion card, so that fine control is possible.

Packaging machines are designed to bag mainly food stuffs. The targets do not have constant shapes and film used for packaging is vulnerable to expansion and shrinkage. The system is therefore designed based on the recipe method, where trial runs are repeated several times and the optimal operation pattern is specified.

Each of the factors (such as the feed of articles to be packed, the feed of packaging film, and the feed shaft after packaging) must synchronize and run in a desired pattern. The system should be capable of running in a desired pattern with regard to time and of operation and in a desired pattern with regard to a particular shaft or virtual shaft. AML, which has these capabilities, is truly a language for plastic forming.

2.3 Requirements for rolling machines with round dies, which are the target of development

The requirements raised by the machine manufacturer, who is Sanyo Denki's co-developer of the system, are as follows:

(1)Machining system

Machines for plastic forming are available in two types: one based on reciprocating motion (such as presses), and one based on rotary motion. Yet another type available is that of rolling, where rotary motion of the right and left dies is used to machine a bar-shaped material. There are two types of rolling: flat die rolling (where two flat tools (dies) are involved) and round die rolling (where a cylindrical tool (die) is involved).

Round die rolling is available in the following types: one based on two round dies, one based on three round dies, and "planetary rolling"(a combination of round dies and segmented dies). Planetary rolling is intended for mass-production with a short tact time, while triple round die rolling is capable of machining hollow workpieces. Dual die rolling (which uses two round dies) has a simple structure, enabling it to perform various types of machining operations by varying the shape of the dies and the machining speed. The dual rolling machine with round die can be controlled in its operation pattern by the "S-MAC" Type C to meet the various types of operations as described below.

(a)Approach rolling

This is a normal rolling method. While turning, the dies moves inwards and performs rolling.

(b)Through feed rolling

This operation can roll workpieces longer than the die width. The right and left dies can be inclined upwards and downwards to allow the workpiece to move axially and perform rolling. A typical through feed rolling operation is illustrated in Fig.1.

(2)Configuration and requirements for the control shaft

The shaft configuration of the dual rolling machine with round die is illustrated in Fig. 2.

1. Single driving of the right and left dies
   While turning in the same direction, the right and left cylindrical dies move inwards and come into contact with the workpiece between the two dies, thus causing the workpiece to turn. The surface of the dies then deforms the workpiece, allowing it to be machined. Various types of machining operations can be performed depending on the shape of the dies used. Dies with an oblique groove can be used to machine screws, while dies with a radial groove can be used to machine splines and serrations.

   Thus, the dual rolling machine with round die is capable of various machining operations. The optimal die rotation speeds and the speeds at which the dies move inwards vary with the type of screw or spline, and must be changed depending on the type of workpiece involved. The faster the dies approach, the shorter the machining time. The tact time per product is much shorter, enabling mass-production. However, this also entails faster wear of the dies, resulting in a shorter service life. The machining time and service life of the dies must be examined to determine the optimal speed.

2. Control of the rotation speed and approach speed
   Many of the traditional dual rolling machine with round dies are controlled by a PLC. Although they allow the rotary speed and approach speed of the dies to be specified, these parameters cannot be changed while on the fly. Machine functions are therefore limited. For this reason, to prevent peeling and other product surface damage and to ensure a long service life of the dies, a long tact time was inevitable, which was a disadvantage. Peeling and other damage were unavoidable in some cases depending on the shape of the product.

   The above circumstances revealed that the use of a motion controller instead of the PLC (used in conventional practice) allows rolling speed to be controlled to a desired level. The authors were therefore able to shorten the tact time, ensure a long service life of the dies, and enable products of hitherto-unmachinable shapes to be rolled.

3. Overview of the rolling system

The dual rolling machine with round dies system is basically divided into a rolling machine (the machine proper) and a control system. This section gives an overview of the control system. Fig. 3 gives an overview of the system, while Fig. 4 shows a typical workpiece sample machined with this system.

3.1 Overview of the control system

Fig. 5 is a block diagram of the control system.

The "S-MAC" Type C is a motion-card-less, full-software controller. It is based on a PC-based controller compatible with a general PC. The controller, servo amplifier, and I/O are connected by a SERCOS network based on an optical fiber. The CPU in the control unit controls the motion and I/O, while the operation display connected via the Ethernet gives screen displays.

3.2 Details of the control unit

(1)Hardware configuration

The component called AML target in the block diagram shown in Fig. 5 is the controller for the control unit. It is a PC-based controller and incorporates a SERCOS interface board (which interfaces with the servo amplifier and I/O) and an encoder interface (designed to enter encoder signals). In this system a four-axis servo amplifier is used for the main axis(die rotation) and up-and-down inclining axes of main axis. It consists of four-axis worth of servo controls and a power supply integrated for each of them, and it achieves high cost performance per axis. The system can accommodate another single-axis amplifier as an option.

(2)Software configuration

The control unit uses AML to perform both motion and DI/DO control.

AML is a motion control language that runs on a real-time operating system. It is particularly versatile in electronic gear, electronic cam and other synchronizing control.

The control method used is that of synchronizing control, which synchronizes the right and left dies and synchronizes the approach positions of the dies and other factors.

There are two operation patterns, and selects the appropriate one depending on the type of rolling it is performing.

1. Normal operation mode
   The first operation pattern is based on PTP operation. Some points during rolling are specified to determine an operation pattern. This mode is used for general rolling.
2. Operation mode of the recipe method The other operation pattern is a recipe method based on map data. Map data is a database of points specified at specific intervals. The data points can be used to specify a desired operation pattern.
3. I/O control
4. DI/DO performs control according to events stemming from changes in input and other factors. It is called event-driven control.
5. Maintenance tool and other tools
6. The control language AML has various development tools. These are a Configuration Tool (which can easily set the servo motor), a Log Viewer (which records errors, alarms and other information that occurs while on the fly), and SERCOSCOPE (which monitors the operation of the servo motor). This language is therefore useful in developing and analyzing systems.
7. The development environment for AML runs on Windows. Data can therefore be analyzed with software on Windows. One can analyze data while developing an AML application on the same PC.

4. Operation display (HMI)

4.1 Hardware configuration of the HMI

A system designed only for rolling can be run with an operation switch consisting of minimal equipment. On the other hand, this system has an operation display with the functions of a programming station designed to create an optimal operation pattern (by trial machining).

The operation display (HMI) is another PC-based controller. The display incorporates a 12.1" TFT liquid crystal display. The display is covered with a touch screen and can be operated by touching the screen. Operation by the touch screen allows one to change screen displays and perform various operations simply by exchanging the software. Even if one wishes to add an optional function to the system, one does not need to add an operation switch or other hardware. It is therefore easy to customize the system to meet the requirements of a particular user.

The auxiliary storage accommodates floppy disks to store rolling patterns and other recipe data. The use of floppy disks allows recipe data created on the master machine to be brought easily to the processing machine, so that the system can run in the same operation pattern as that of the master machine.

The operation display and the control unit are connected by an Ethernet. They exchange operation patterns and other data, along with data with which to inform the other party of the operation status of the control unit.

The system incorporates an uninterruptible power supply (UPS) in preparations for power failures and other contingencies in order to protect the operation patterns, parameters and other data in the operation display.

4.2 Software configuration of the HMI

Creating an operation pattern for rolling requires the entry of many parameters and data. The system therefore consists of software based on Windows NT.

The screen display has been written in Visual Basic so that users can operate this system as if using a personal computer in their office

The screen mode is of 800 x 600 dot resolution, allowing many parameters and data can be displayed. If many parameters and data are involved and if the screen contains little information, the system switches screens, thus resulting occasionally in very poor operability. One can then increase the amount of information and check data on fewer screens, and can reduce errors in creating data.

4.3 Operation overview

System operations are divided into three modes: auto, manual, and setup.

The auto mode performs continuous rolling automatically while working with the center machine for carrying workpieces which is one of the accessory units. The manual mode performs rolling singly, such as trial machining of workpieces. The setup mode adjusts the machine by means of entering data and parameters for rolling patterns.

In normal runs, one can load rolling patterns and parameters from a floppy disk into the system and start the system in auto mode. Rolling can then be performed continuously.

5. Conclusion

Compared with work cutting, which has been developing in linkage with CAD data, the computerization of plastic forming still has much potential. The "S-MAC" Type C is another controller with much potential: i.e. for networking and an open architecture. The authors are confident that the combination of plastic forming, networking, and an open architecture will open up new applications. The authors are optimstic that this system will be of help in such developments.

This system has been jointly developed with Nissei Co., Ltd. Nissei has provided the authors with sample workpieces and information. The authors wish to express their

heartfelt thanks to the company.

*The names of the companies and products mentioned in this paper are trademarks and registered trademarks of the respective companies.

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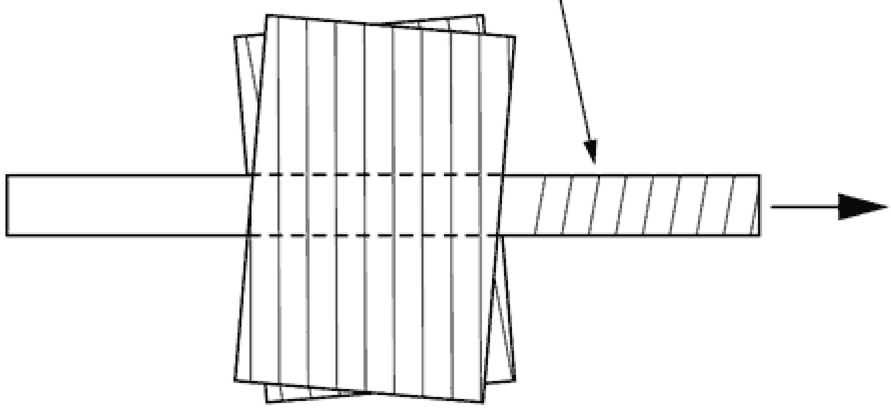

fig.1 Through feed rolling

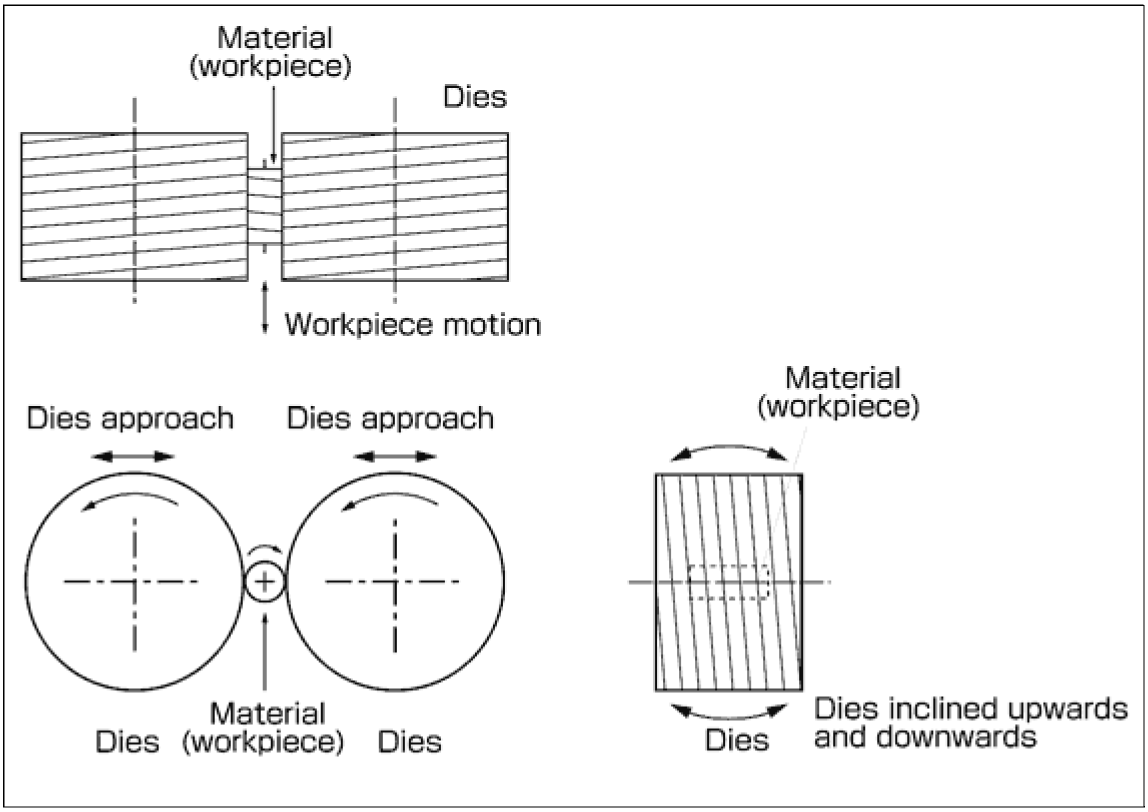

fig.2 Shaft configuration of the rolling machine

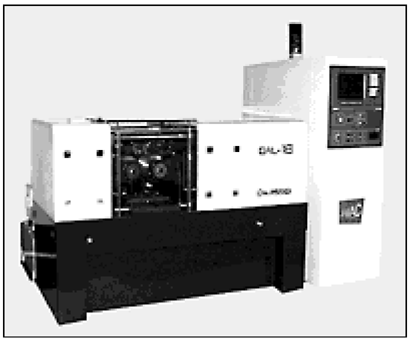

fig.3 Overview of the rolling system

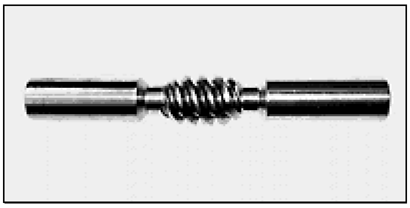

fig.4 Workpiece sample (worm gear)

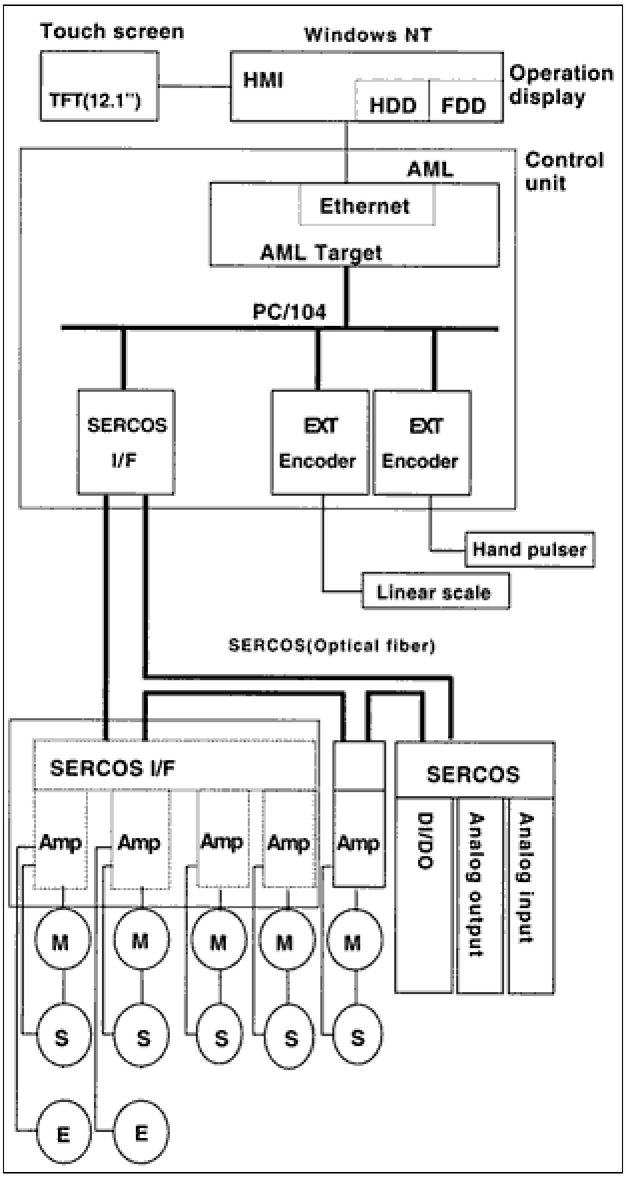

fig.5 Block diagram of the control system