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R for Progress

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Trend of Computer-Controlled Die Casting

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Introduction

Die casting machines have grown as high-productivity, shaped material producing machines by being supported mainly by the automobile industry.

Recently, a just-in-time production system increasingly has been employed in the automobile industry, which supports production of die cast products; and die casting machines are requested to exhibit flexibility. Thus, a need exists for computer-controlled die casting machines.

Under the above circumstances, this paper describes the trend and practice of computer control of die casting machines in Japan.

Integration of automated production systems as production form changes

As shown in Fig. 1, the amount of information for total preventative maintenance (TPM) increased as a wide variety of die-cast parts were required and the die casting form changed from large volume production of a few products to small volume production of a variety of products. In small volume production of a variety of products, high productivity can not be maintained with conventional mechanization. Therefore, it is desired to realize factory automation by integrating independently mechanized systems and controlling them with a computer.

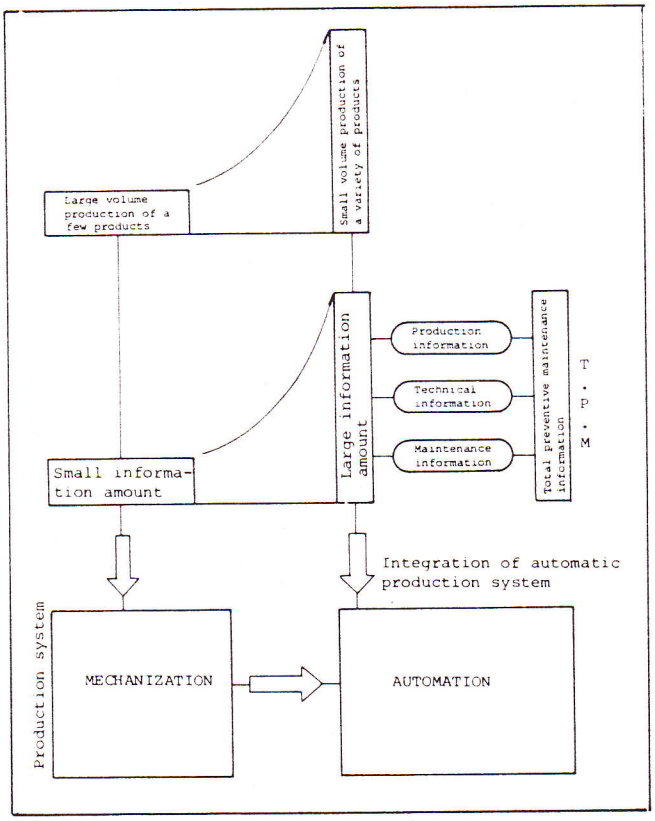


Fig. 1: Change in die casting production system

Die casting factory automation aims at improving the productivity with little manpower and freeing persons from troublesome casting work.

Action against upgraded die-cast products

Recently, die casting is increasingly employed for manufacturing functional parts and high-accuracy parts. "Functional parts" are those parts exhibiting high strength and airtightness, such as steering gear boxes and compressor bodies. "High-accuracy parts" are those parts exhibiting high shape and dimensional accuracy, such as floppy disk frames.

The die cast functional parts and high-accuracy parts are manufactured by use of high injection performance die casting machines. As the manufacturing conditions (called the casting conditions) for these parts, the injection speed and casting pressure rise time are adjusted on the basis of the solidification time with reference to the product thickness, as shown in Fig. 2.

Since the solidification time is very short (0.01 to 0.3 sec.), as shown in Fig. 2, the injection piston for injecting molten metal into dies is controlled within the solidification time.

In order to achieve high die casting yield, it is necessary to consistently maintain the injecting and die closing conditions. For this purpose, feedback control of injecting and die closing conditions will be effective.

For temporal reasons, it is impossible to activate feedback during machine operations by the conventional feedback control. Therefore, it has been proposed to systematically control the injecting conditions and die closing conditions using a computer.

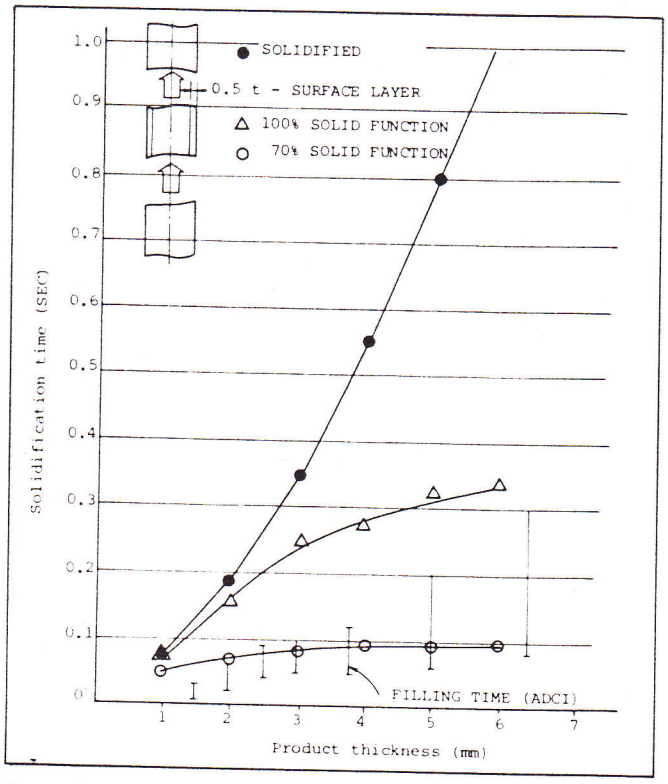


Fig. 2: Product thickness and solidification time

Practice of control with computer

The computer-controlled die casting machine will be described below in the order of development.

Computer-controlled die casting machine (CCD)

This machine, a cold chamber die casting machine having a die closing force of 350 tons (announced in 1982 as a Toshiba Machine's standard product) is controlled by a computer.

This machine is provided with actuators using proportional electromagnetic control valves, electrically-driven valves, pressure detectors, and position detectors necessary for computer control. The control devices are connected to the computer controller, "Castvisor", via the programmable controller, "Provisor", developed by Toshiba Machine. The controller of this machine has the appearance as shown at the center in Photo 1, and is provided with a keyboard for entering the operating conditions of the die casting machine, a CRT for displaying the setting conditions and operating status of the machine, a printer, and a cassette magnetic tape (CMT) for storing data.

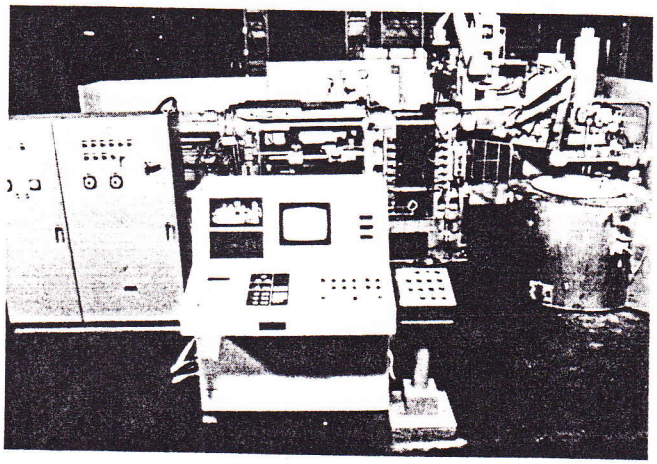


Photo 1: Appearance of computer-controlled die casting machine

The computer controller for the die casting machine has the following functions:

1) **Operation control function**

Machine operating conditions are input from the keyboard, and the machine is remote-controlled under the set conditions. The remote-controlled factors are shown in Table 1.

2) **Automatic control function**

The injection speed and the die closing force can be controlled at predetermined values. Therefore, in actual casting work, the computer always monitors the operations with reference to the conditions specified by the machine operator.

3) **Measurement monitor function**

Injection conditions and the die closing conditions always are monitored, and the results are displayed on the CRT. When the measurement results do not satisfy the set conditions, a buzzer is activated.

4) **Printer function**

Data displayed on the CRT of Castvisor is printed.

5) **CMT function**

Operating conditions of the die casting machine are stored in a cassette tape, or control signals are loaded from the tape into the unit. (One tape can store conditions for 255 dies.)

Table 1 Remote control factors

No.	Section	No.	Remote control factor
1	Die closing	1	Die closing speed
		2	Die closing speed change-over position
		3	Die opening speed
		4	Die opening speed change-over position
2	Ejection	1	Ejector forward speed
		2	Ejector return speed
		3	Ejector forward stroke
3	Core	1	Core forward speed
		2	Core return speed
4	Injection	1	Low injection speed
		2	High injection speed
		3	Injection speed change-over position
5	Die	1	Die thickness
		2	Die closing force

Table 1: Remote control factors No. Section No. Remote control factor

Die casting process adaptive control system (DACS)

This system, developed in 1984 after the above-mentioned CCD, also controls automatic units of the die casting machine, such as an automatic ladling unit, an automatic spray unit, an automatic lubricator, and an automatic unloader. This system controls a large machine having die closing force of 2,500 tons.

The system configuration and system layout of the DACS are shown in Figs. 3 and 4.

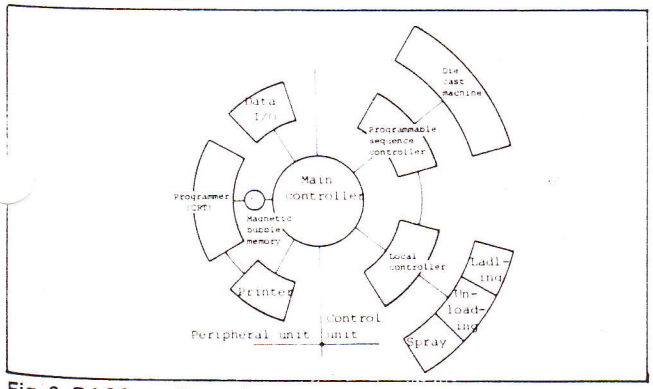


Fig. 3: DACS configuration

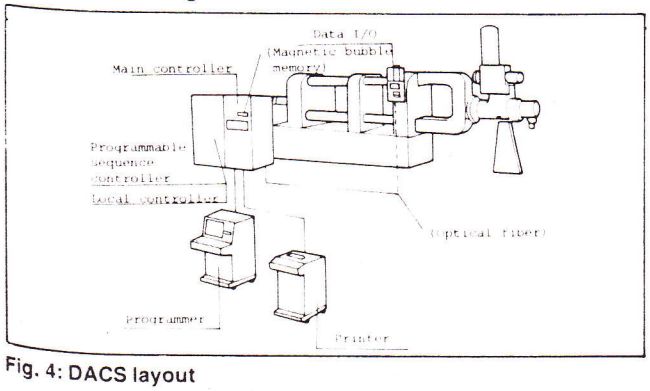


Fig. 4: DACS layout

The DACS is operated from the control box by use of the data I/O unit shown in Photo 2. Operating status also is displayed. This function makes operators of large die casting machines free from adjustment of injection speed and injection speed change positions. Instead of the CMT used as information medium in the CCD, a magnetic bubble memory is used in the DACS because it has no mechanically operating section. The magnetic bubble memory can store data on casting conditions for approx. 60 to 90 dies. The programmer shown in Fig. 4 can create casting condition programs in an offline mode that can, therefore, also be used as a casting condition simulator.

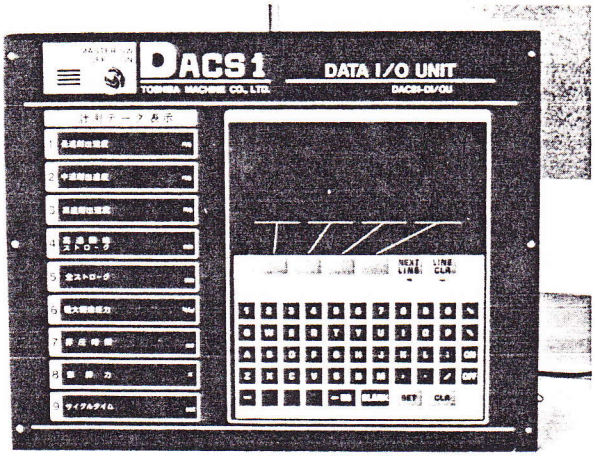


Photo 2: Data I/O

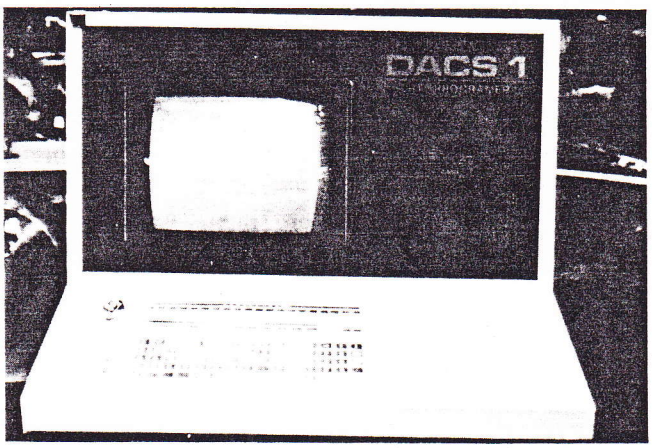
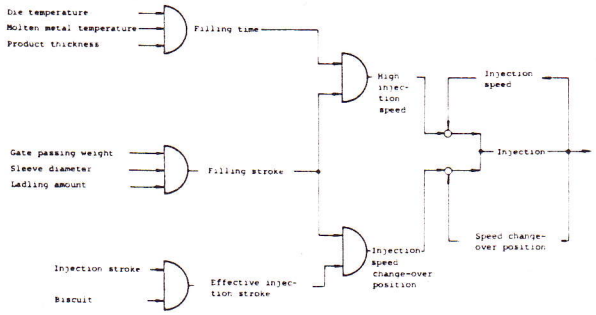


Photo 3: Operating and CRT sections of programmer

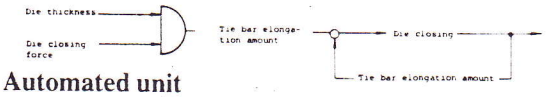
Major points of DACS control are described below.

Main body:

1) Automatic control of injection speed



2) Automatic control of pressure boosting time
3) Automatic control of die closing force



Automated unit

1) Automatic control of ladling amount
2) Automatic control of spray time based on die temperature
3) Automatic control of unloader position and speed

Computer-controlled die casting in the future

Control of die casting machines has begun to be upgraded from fixed value control to adaptive control, and the control objects include the molten metal temperature, die temperature, injecting conditions, die closing conditions, ejecting conditions, and core conditions.

Since some die casting techniques depend on the operator's experience, computer control of die casting machines lagged markedly behind computer control of machine tools and injection molding machines.

However, for some years ahead, sprue runner shapes and die temperatures have been analyzed with a computer. When new, relevant techniques are put into practice, the computer-controlled die casting machines will spread quickly.

As the microprocessor technique advances, control units will become smaller and more functional. Judging from the present technical level, it is considered that the control system will advance from the system using the programmable controller, as shown in Fig. 5, to a system using a regular control system, i.e. the intelligent controller, as shown in Fig. 6.

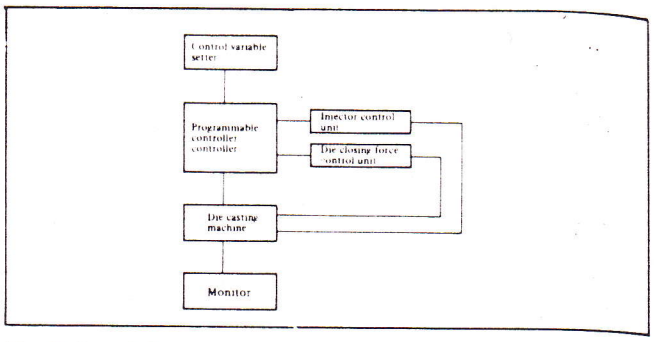


Fig. 5: Step I: System using programmable controller

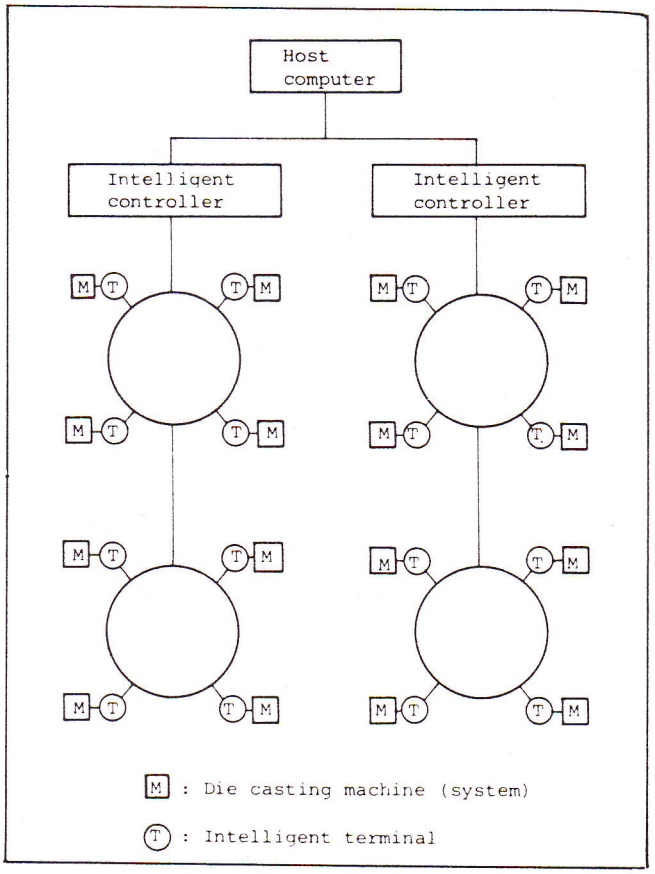
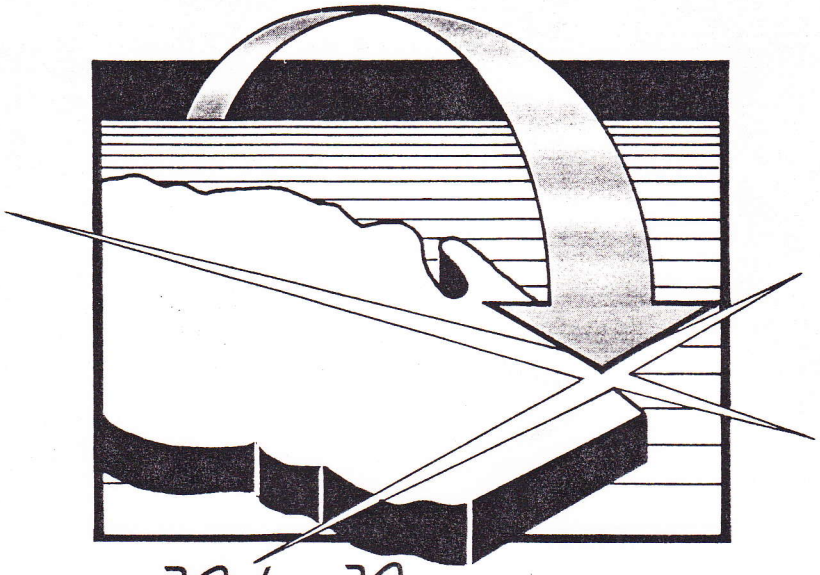


Fig. 6: Step II: System using intelligent controller

TRANSACTIONS



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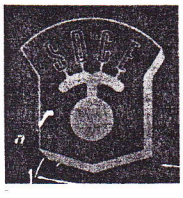

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