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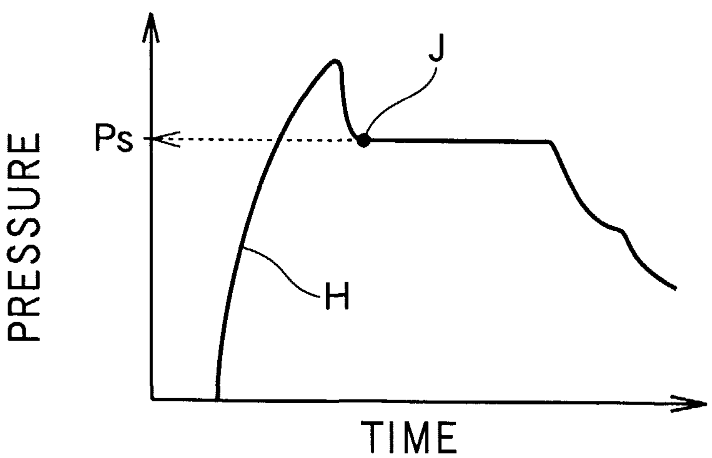
(54) Title: METHOD OF DETERMINING A HOLD PRESSURE CONTROL START PRESSURE FOR RESIN INJECTION MOLDING



(57) Abstract: A hold pressure control start pressure for resin injection molding is determined by finding a pressure (Ps) at which a pressure curve (H) representing the pressure on a resin melt inside the mold cavity forms a valley (J) occurring first after a peak of the pressure curve, and setting the thus found pressure (Ps) as a hold pressure control start pressure that is used for performing pressure control during a subsequent resin molding operation. Since the hold pressure control start pressure is determined on the basis of the pressure curve, it is essentially possible to obtain a setting pressure value for such hold pressure control start pressure through a single run of test injection molding process.

WO 03/080307 A2

DESCRIPTION

METHOD OF DETERMINING A HOLD PRESSURE CONTROL START PRESSURE FOR RESIN INJECTION MOLDING

Technical Field

The present invention relates to an improvement in a method of determining a hold pressure control start pressure for resin injection molding.

Background Art

Japanese Patent Publication No. (Hei) 4-48339 discloses an injection control device for an injection molding machine, which is designed to start hold pressure control when the pressure on a resin filled in a mold exceeds a preset pressure or when a predetermined time elapses after the start of the injection operation. The resin pressure inside the mold may be measured by a pressure sensor built in the mold.

According to an investigation conducted by the present inventors, it has been found that the technique disclosed in the above-mentioned Japanese publication is not fully satisfactory and still has two problems to be solved. One problem is that the preset pressure is not easily determined, and the other problem is that the resin pressure inside the mold is difficult to measure due to the occurrence of great pressure changes or fluctuations. These problems will be described below in greater details with reference to Figs. 6A and 6B and Fig. 7.

Figs. 6A and 6B are graphs illustrative of two different ways conventionally taken to determine the preset pressure. In the graphs shown in Figs. 6A and 6B, the horizontal axis represents the time elapsed after the start of the injection process and the vertical axis represents the pressure inside the mold.

In Fig. 6A, a pressure curve denoted by "a" indicates that a large peak occurs at the final stage of the injection process due to an excessively high injection speed. A pressure curve denoted by "b" in Fig. 6 shows that a peak occurring at the final stage of the injection process is smaller than that of the pressure curve "a" because of a reduced injection speed. A pressure curve indicated by the phantom line "A" represents an optimum pressure curve. Theoretically, the optimum pressure curve "A" can be determined by repeating a test injection process under the conditions that the peak occurring at the final stage of one injection process becomes smaller than that of the preceding injection process, as evidenced by the pressure curves "a" and "b" shown in 6A. This procedure is not preferable from the viewpoint of mold protection because the mold is subjected to excessively large pressure loads during the repeated test injection processes.

Fig. 6B shows a different procedure, in which for protection of the mold, the test injection process starts with an injection speed sufficiently reduced to prevent the occurrence of a peak pressure, as evidenced by pressure curve "c" shown in Fig. 6B. In the next run of the test injection process, the injection speed is slightly increased, so that a pressure curve denoted by "d" is obtained. Thus, the test injection process is repeated while increasing the injection speed gradually until the phantom-lined optimum pressure curve "A" is obtained. This procedure requires many nuns of test injection operation and hence the efficiency is low.

Fig. 7 shows a typical example of conventional pressure-sensor arrangements. As shown in this figure, a pressure sensor 104 is embedded in a movable mold 102 so as to face substantially the center of a cavity 103 defined between the movable mold 102 and a stationary mold 101. In an injection process, a resin melt issued from an injection nozzle 105 is injected through a hot runner 106 and an internal nozzle or gate 107 into the cavity 103. For some time after the start of injection, the resin melt undergoes turbulence (which may involve generation of swirls and collision of resin melt) and the cavity pressure (i.e., the resin pressure inside the cavity) fluctuates abruptly. The pressure fluctuations make the cavity pressure measurement difficult to achieve. Accordingly, consideration must be given to the location where the pressure sensor is to be mounted.

It is accordingly an object of the present invention to provide a method which is capable of determining a hold pressure control start pressure easily, speedily and highly efficiently.

Disclosure of the Invention

According to the present invention, there is provided a method of determining a hold pressure control start pressure for resin injection molding, comprising the steps of: while performing injection speed control, effecting a test injection process to obtain a pressure curve under conditions that the pressure curve includes a peak drawn due to a cavity pressure occurring at a final stage of the test injection process; finding a pressure at which the pressure curve forms a valley occurring first after the peak; and setting the thus found pressure as a hold pressure control start pressure that is used for performing pressure control during a subsequent resin molding operation.

Since the hold pressure control start pressure is determined on the basis of the pressure curve, it is essentially possible to obtain a setting pressure for the hold pressure control start pressure through a single run of test injection molding process. This procedure provides a great reduction in man-hour of the test injection processes.

It is preferable that the cavity pressure is measured at a position where a resin melt which has been injected from a gate into a cavity of a mould assembly is permitted to flow stably. That portion of the cavity which is located in the proximity to the gate is filled with a resin melt before the remaining portion of the cavity, and the cavity pressure (i.e., the pressure on the resin melt) at this cavity portion soon becomes stable. A pressure sensor used for the cavity pressure measurement is located in the cavity portion, and preferably at the center of the cavity portion.

In one preferred form of the invention, the cavity has a cavity portion located in proximity to the gate and having a larger space than the gate. The cavity portion has a first region located immediately downstream of the gate, a second region located far away from the gate and blending into a main portion of the cavity, and a third region disposed between the first and second regions. The position for measurement of the cavity pressure is located in the second region of the cavity portion, and preferably at the center of the second region of the cavity portion.

Brief Description of the Drawings

Fig. 1 is a vertical cross-sectional view of a mold assembly provided for carrying out a method of the present invention;

Fig. 2A is a horizontal cross-sectional view taken along line 2A of Fig. 1;

Fig. 2B is a graph showing a pressure distribution in a portion of the mold cavity located in the proximity to a gate of the mold;

Fig. 3 is a graph illustrative of the manner in which a hold pressure control start pressure is determined through a test injection process according to the present invention;

Fig. 4 is a flowchart showing a sequence of operations achieved in a service run of an injection molding machine according to the present invention;

Fig. 5 is a graph showing a pressure curve representing the cavity pressure during the service run of the injection molding operation;

Figs. 6A and 6B are graphs showing two different methods conventionally taken to determine a hold pressure control start pressure; and

Fig. 7 is a view showing a typical example of sensor arrangements conventionally taken to install a pressure sensor in a mold.

Best Mode for Carrying Out the Invention

One preferred embodiment of the present invention will be described in greater detail with reference to the accompanying sheets of drawings.

Fig. 1 shows in cross section a mold assembly used for carrying out a method of the present invention. The mold assembly 10 is composed of a movable mold 11 and a stationary mold 12. The stationary mold 12 has formed therein a hot runner 13 and an internal nozzle or gate 14. The movable mold 11 and the stationary mold 12 define therebetween a cavity 15 that communicates successively through the gate 14 and the hot runner 13 with an injection nozzle 18. The stationary mold 12 has a pressure sensor 17 embedded therein in such a manner that the pressure sensor 17 faces that portion 16 of the cavity 15 which is located in proximity to the gate 14.

As shown in Fig. 2A, the cavity portion 16 has a cross-sectional area sufficiently larger than that of the gate 14 so that the resin melt issued from the gate 14 can be smoothly introduced through the cavity portion 16 into a main portion of the cavity 15. The main cavity portion has a volumetric space excessively larger than that of the cavity portion 16. In the illustrated embodiment, the cavity portion 16 has a square shape in cross section. The pressure sensor 17 is preferably disposed at the center of the cavity portion 16, as will be understood from a description given below with reference to Figs. 2A and 2B.

Fig. 2B is a graph showing a pressure distribution inside the cavity portion 16 that is obtained through measurement using the pressure sensor 17 while changing the position of the pressure sensor 17 relative to the gate 14 (Fig. 2A). Figs. 2A and 2B are shown related with each other such that the origin of the coordinate axes of the table shown in Fig. 2B is coincident with the position of an outlet of the gate 14 shown in Fig. 2A.

In a first region E (Fig. 2B) of the cavity portion 16, which is located immediately downstream of the gate 14, the pressure on the resin melt undergoes fluctuations. This is because the pressure on the resin melt widely varies with locations due to turbulence, swirl or the like disturbing phenomenon occurring when the resin melt is allowed to suddenly blow off from the gate 14 into an excessively large space of the cavity portion 16.

In a second region G (Fig. 2B) of the cavity portion 16, which is located far away from the gate 14 and is blending into the main portion of the cavity 15, the pressure on the resin melt shows a steep drop. This is because the resin melt flows from the cavity portion 16 into the main cavity portion that has an excessively great space as compared to the cavity portion 16.

In a third region F (Fig. 2B) of the cavity portion 16, which is located substantially centrally between the first and second regions E and G, the pressure on the resin melt is free from fluctuations and falls gently at a substantially uniform rate as the distance from the gate 14 increases. It may be considered that once the resin melt fills in the cavity portion 16, the pressure on the resin melt inside the cavity portion 16 becomes stable. It appears clear from the pressure distribution shown in Fig. 2B that the pressure sensor 17 is preferably disposed in the third region F and, more particularly, at the center of the third region F that is far distant from both of the first region E and the second region G.

Fig. 3 shows a graph illustrative of the manner in which a hold pressure control start pressure is determined through a test injection process according to the present invention. While the test injection process is achieved, injection pressure control is not performed but injection speed control is done. The test injection process is conducted under conditions that a pressure curve H, representing the pressure on a resin melt, includes a peak occurring at a final stage of the test injection process. When the pressure curve H forms a valley J occurring first after the peak, a pressure Ps at this time point is found. The pressure Ps is then set to be a hold pressure control start pressure that is used for performing pressure control during a subsequent resin molding operation. Since the hold pressure control start pressure Ps is determined on the basis of the pressure curve H, it is essentially possible to obtain a setting pressure value for such hold pressure control start pressure through a single run of test injection molding process.

Fig. 4 is a flowchart showing a sequence of operations achieved during a service run of an injection molding machine according to the present invention.

At a first step ST01, an injection molding machine incorporating the mold assembly 10 (Fig. 1) is set to operate in an injection speed control mode. In the injection speed control mode, extrusion speed of a screw of an injection device is controlled in accordance with a predetermined program to thereby control the injection speed of the injection molding machine.

Then, a step ST02 starts an injection process while performing the injection speed control.

During the injection process, the pressure on a resin melt issued from the gate 14 into the cavity 15 is measured by the pressure sensor 17 (Fig. 1) as at a step ST03.

A step ST04 determines whether or not Pact is equal to or greater than Ps where Pac is an actually measured pressure obtained through the pressure sensor 17 (Fig. 1), and Ps is the hold pressure control start pressure determined in the manner previously described with reference to Fig. 3. When the determination is affirmative, the procedure goes on to a step ST05 where the injection speed control mode is switched to a hold pressure control mode. Subsequently, a hold pressure control process is performed.

When the determination at the step ST04 is negative, then the procedure returns to the step ST03, and the injection process continues further.

Fig. 5 is a graph showing a pressure curve representing the pressure on a resin melt within the cavity 15 that are observed during service runs of the injection molding machine. While performing injection speed control, an injection process is conducted. The injection process continues until the pressure on the resin melt obtained by actual measurement reaches the preset hold pressure control start pressure Ps, whereupon the injection speed control is switched to pressure control (hold pressure control). A pressure curve obtained through the operations described above is well matched with the optimum pressure curve A shown in Figs. 6A and 6B. This means that the hold pressure control start pressure Ps determined in accordance with the method of the present invention is practically useful.

As thus for described, a method of the present invention for determining a hold pressure control start pressure for resin injection molding comprises the steps of: while performing injection speed control, effecting a test injection process to obtain a pressure curve under conditions that the pressure curve includes a peak drawn due to a cavity pressure occurring at a final stage of the test injection process; finding a pressure at which the pressure curve forms a valley occurring first after the peak; and setting the thus found pressure as a hold pressure control start pressure that is used for performing pressure control during a subsequent resin molding operation. Since the hold pressure control start pressure is determined on the basis of a pressure curve, it is essentially possible to obtain a setting pressure value for such hold pressure control start pressure through a single run of test injection molding process. This procedure provides a great reduction in man-hour of the test injection processes.

Furthermore, according to the method of the present invention, it is possible to increase the injection speed and cut or lower a peak pressure during injection. Reduction of the peak pressure allows the use of a mold with reduced rigidity, leading to downsizing of the mold.

According to the method of the present invention, the cavity pressure is measured at a position where a resin melt which has been injected from a gate into a cavity of a mould assembly is permitted to flow stably. Especially, that portion of the cavity which is located in the proximity to the gate is filled with a resin melt before the remaining portion of the cavity, and the cavity pressure (i.e., the pressure on the resin melt) at this cavity portion soon becomes stable. A pressure sensor used for the cavity pressure measurement is located in the cavity portion, and preferably at the center of the cavity portion. This arrangement ensures stable injection molding operation.

Industrial Applicability

With the arrangements so far described, the present invention can be used advantageously as a method of determining a hold pressure control start pressure for resin injection molding with utmost ease and high efficiency.

CLAIMS

1. A method of determining a hold pressure control start pressure for resin injection molding, comprising the steps of:

(a) while performing injection speed control, effecting a test injection process to obtain a pressure curve under conditions that the pressure curve includes a peak drawn due to a cavity pressure occurring at a final stage of the test injection process;

(b) finding a pressure at which the pressure curve forms a valley occurring first after the peak; and

(c) setting the thus found pressure as a hold pressure control start pressure that is used for performing pressure control during a subsequent resin molding operation.

2. The method of claim 1, wherein said cavity pressure is measured at a position where a resin melt which has been injected from a gate into a cavity of a mould assembly is permitted to flow stably.

3. The method of claim 2, wherein said cavity has a cavity portion located in proximity to the gate and having a larger space than the gate, the cavity portion having a first region located immediately downstream of the gate, a second region located far away from the gate and blending into a main portion of the cavity, and a third region disposed between the first and second regions, and wherein said position for measurement of the cavity pressure is located in the second region of the cavity portion.

4. The method of claim 3, wherein said position for measurement of the cavity

pressure is located at the center of the second region of the cavity portion.

FIG.1

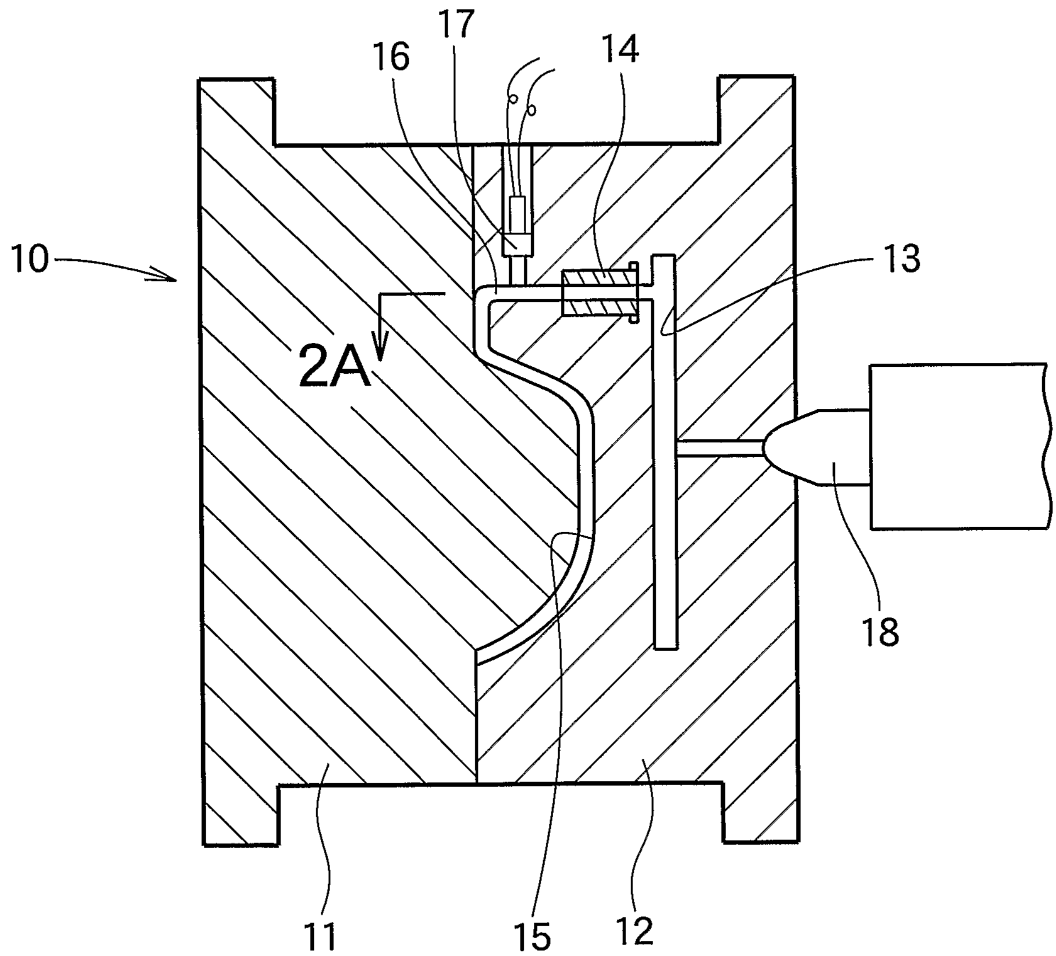


FIG.2A

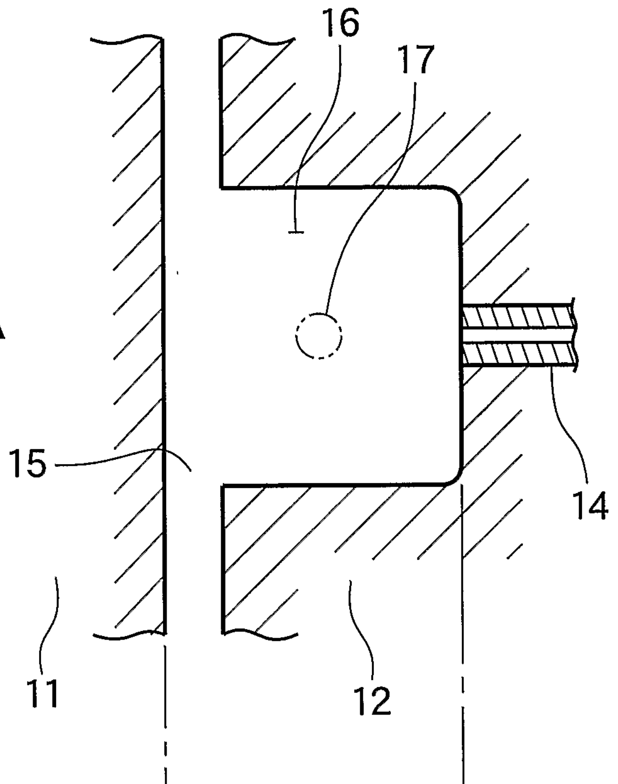


FIG.2B

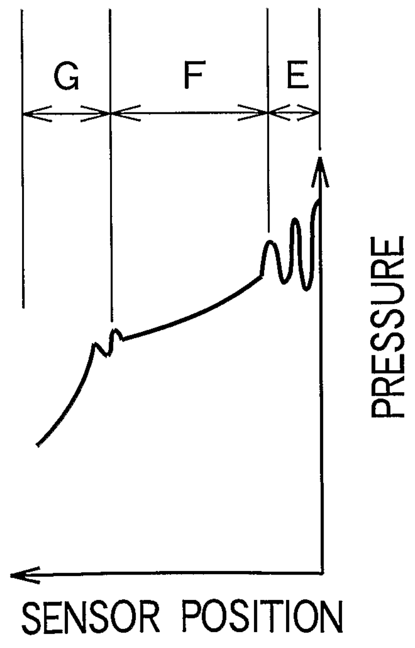


FIG.3

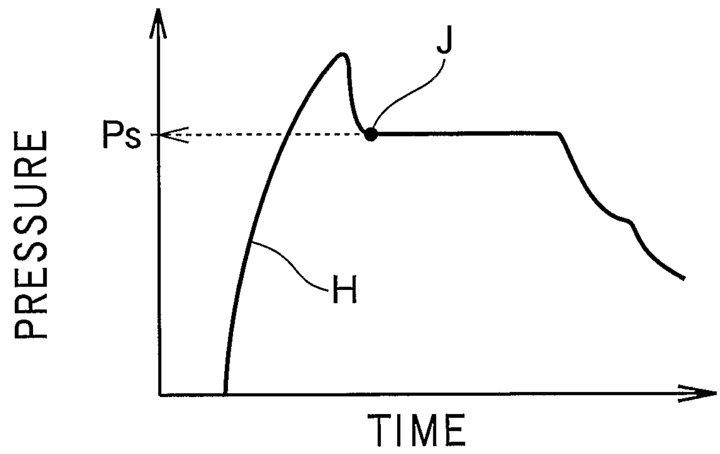

PRESSURE
Ps
J
H
TIME

FIG.4

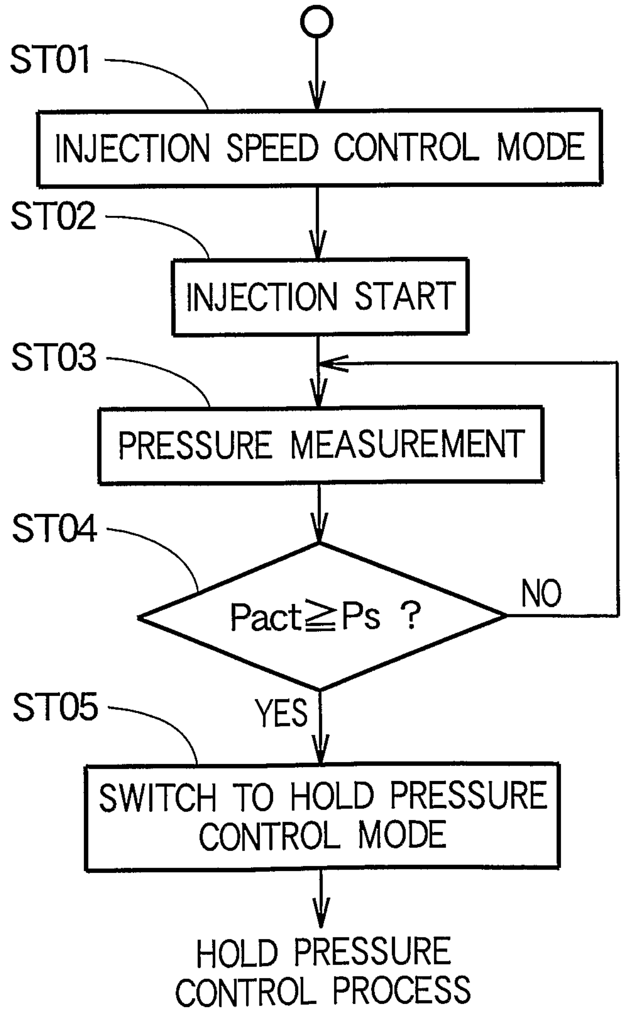

ST01
INJECTION SPEED CONTROL MODE
ST02
INJECTION START
ST03
PRESSURE MEASUREMENT
ST04
Pact≧Ps ?
NO
YES
ST05
SWITCH TO HOLD PRESSURE CONTROL MODE
HOLD PRESSURE CONTROL PROCESS

FIG.5

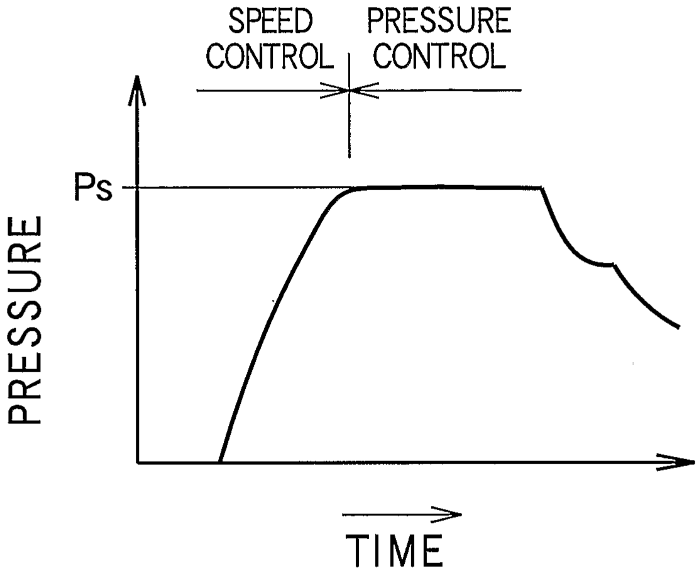


FIG.6A

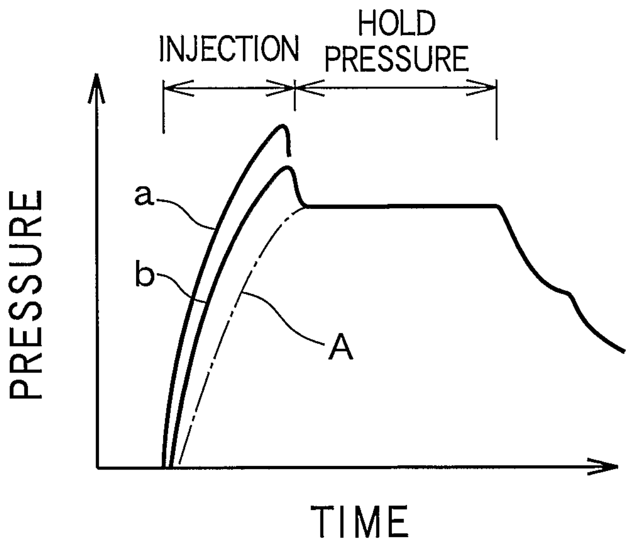

INJECTION
HOLD PRESSURE
PRESSURE
a
b
A
TIME

FIG.6B

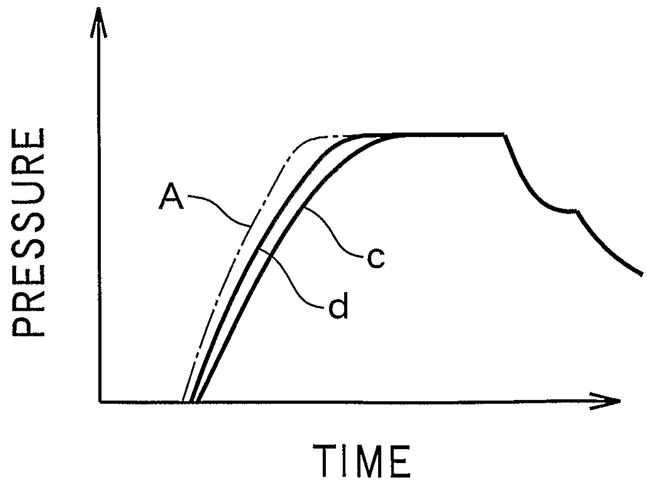

PRESSURE
A
c
d
TIME

FIG.7