SHOT VOLUME AND CUSHION POINT CONTROL FOR INJECTION MOLDING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to plastic molding machinery, and more particularly to apparatus for controlling the activity of injection molding apparatus.

Although the injection molding principle has long been known and apparatus for practicing injection molding widely used, it has been only recently that sophisticated controls have been developed for automatically monitoring and correcting the activity of injection molding apparatus. Previously the adjustment and control of an injection molding machine was a tedious, artful process which relied to a great extent upon trial and error and upon the skill and experience of the individual operating the machinery. While there are several reasons which may be advanced to explain this situation, perhaps the most salient reason is the multiplicity of variables which are involved in the operation of an injection molding device.

The basic operation of a typical injection molding apparatus is straightforward. A ram having a spiral thread formed thereon is disposed within a barrel having an elongate cavity, at the end of which is a mold to be filled by the injection process. A quantity of plastic material, which may be in pelletized or granulated form, is introduced at the rearward end of the ram and the ram rotated to masticate and thus plasticize the particulate material, forcing it forwardly upon the spiral ram flights and compressing it in the forward end of the barrel. The working and compression of the plastic material, along with heat which is ordinarily applied to the external surface of the barrel, serves to heat the plastic material to a fluid state. As more material is forced into the area ahead of the ram, the ram is necessarily pushed backward until enough plasticized material is accumulated ahead of the ram to fill the mold. At this time rotation of the ram ceases, and the ram may be pulled back further to relieve the pressure upon the accumulated plastic material or "shot". To effect injection molding the ram is forced forward, commonly through the mechanism of a hydraulic piston. The shot is then injected under great pressure into the mold, the ram continuing to advance until the mold is filled. At this point, advancement of the ram ceases and after solidification the finished part is withdrawn from the mold. At this time the ram may again commence rotation in order to introduce another shot of plasticized material into the barrel.

While the foregoing operation is straightfoward and conceptually simple, control of the process is more of an art than a science due to the many variables involved. The fluidity of the plasticized material may be varied by changing the temperature of the injection mold barrel. It may also be operated upon by changing the pressure applied to the ram during the plasticization process, and/or the speed or rotation of the ram. Besides this, the velocity at which the ram is advanced during the injection process must be carefully controlled, and it may be even desirable to vary the ram velocity during the injection stroke. The total length of the stroke, the amount of retreat achieved through rotation (screwback) and translation (pullback), and the point of stroke termination within the barrel are also variables which may be adjusted either independently or in concert with one another. In addition to the foregoing, the pressure applied to the ram must be varied at different stages of the process.

With increasing attention being given to controls for injection molding machines, many approaches have been devised for monitoring and controlling various combinations of the above-noted variables. For example, in U.S. patent application Ser. No. 194,129—Wheeler, filed Nov. 1, 1971 and assigned to the assignee of the present invention, there is set forth a sophisticated process control system which controls several of the afore-noted variables as a function of the viscosity of the plasticized material.

One important criterion used in several modern-day controls relates to the filling or packing of the mold. It will be appreciated that as the ram advances and the mold fills, the pressure of the plasticized material will undergo a sudden rise. At the same time, due to the relative incompressibility of the plasticized material, there is a corresponding decrease in ram velocity. If injection pressure is thereafter maintained upon the ram the mold will be overfilled with the result that the mold will "flash," a phenomenon which results from plasticized material being forced into interstices between the segments of a mold. In order to avoid this problem, several solutions have been suggested. For example, with one approach mold pressure is monitored and when it exceeds a predetermined peak value it is assumed that the mold is filled; the pressure on the ram is then reduced to a lower holding pressure. Another approach is to monitor the rate of change of shot pressure, and when the rate of change of pressure rises it is assumed that mold filling or packing has taken place. These two approaches may be implemented by monitoring the pressure of the plasticized material in the mold, the pressure of the shot within the barrel of the injection apparatus, or the pressure of the hydraulic fluid forcing the ram ahead. While each approach has its adherents, to date no one version is demonstrably superior and the merit of any given approach is open to debate.

Still another approach has been taken in which the velocity of the ram is monitored and either the velocity, or the rate of change of velocity, utilized to indicating the packing point. As before, when the packing point is achieved pressure is reduced to a suitable holding value to allow curing of the part in the mold without flashing. Another, more prevalent method of control implements the change from injection to holding pressure after a predetermined period of time has elapsed, irrespective of ram position.

It will be seen that most of the foregoing approaches to injection molding control rely upon closely monitoring a suddenly-changing variable. Further, to provide the requisite signals representing the rate of change of pressure or velocity it is usually necessary to process the signals by a differentiation circuit. It will therefore be appreciated that it would be useful to provide an improved control system for an injection molding machine which relies upon only a single, easily measured variable.

It is therefore an object of the present invention to provide an improved, simplified control for an injection molding apparatus.

It is another object of this invention to provide self-correction control circuitry for an injection molding apparatus, which does not rely upon the sensing of time-related mold packing characteristics.