

Modification of Injection Moulding Process with Servomechanism

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Abstract: The injection moulding process is widely used to manufacture the products made from thermoset and thermoplastic materials. The advancements in the manufacturing process is the main focus of many researchers. The main aim is to make the products with accuracy and increase the production rate. In this paper we have worked on to make the system automated using microcontroller and made the vertical moulding machine to use the earth's gravity to fill the cavity of the mould in short time and to increase the production rate.

Keywords: Injection Moulding, Servomechanism, Microcontroller.

Introduction

To manufacture the parts made from plastic material, injection moulding process is widely used in industries. The products manufactured by this process can be small like bottle caps, toys and can be big as well like milk crates and bins. The only thing to be taken care that how precisely these products are made. If there is a small error during the manufacturing it will lead to a big loss to the manufacturing industry because no one is going to buy the product. In the contemporary world, the research is being done to manufacture the product with minimum human intervention. The computer-controlled production leads to good precision and better quality [1], [2].

Injection moulding process is used to produce parts made from both thermoset and thermoplastic materials. In the injection moulding process, the material is heated in the barrel and then is fed to the injection moulding machine and is filled in the cavity where it cools down and take the desired shape of the cavity. The small granular thermoplastic materials are used to shape into the desired product [3]. A typical moulding machine consist of injection, hydraulic, mould, clamping and control system which is shown in Figure 1.

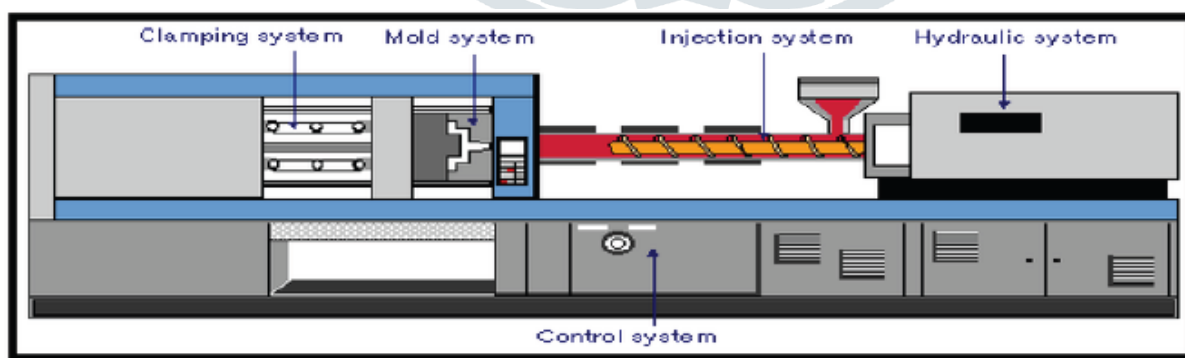


Figure 1. Injection Moulding Machine [4].

Jain *et al.* [4] analysed the effects of process parameters They used Taguchi Approach to optimise these parameters by using two level factorial design. Their investigation was related to shrinkage and warpage in the products prepared using injection moulding process. Guo *et al.* [5] proposed a mathematical model which is used to optimise the parameters like melt, coolant and mould temperature, injection time and switch over. They used fractional factorial design approach to optimise these parameters. Moon and Choi

[6] used the modelling approach in Computer aided engineering software to validate the various parameters and their effects on dimensional stability. In this paper the main objective is to modify the injection moulding process by using servomechanism process. The acrylic material is melted with the help of heater and with the help of servomotor is injected inside the mould. This system will overcome the limitation of traditional method in which the raw material is melted separately and then injected to the mould cavity. The automation of the manual feeding system of injection molding with servomechanism will do the casting in less time. The main benefit is to reduce the time of human effort in which the material is melted separately and then allowed to inject it to the system. The modified system will increase the production rate and quality of the products manufactured.

Injection Moulding System

Injection moulding systems consists, an injection system and heating unit (the injection ram or the screw mechanism has been modified by using a servo injection mechanism therefore automating the process) and presses hold the whole mechanism. The nozzle heater and the spring coil has been integrated so they work as a combined unit with the help of microcontroller which is supervising the servomotor which further feeding the solid acrylic material into the nozzle which is getting heated by the heater to liquefy the material there by passing it further to the mould cavity.

The equipment used in the process are: Servomotor, Heater, Nozzle, Split Pattern and Microcontroller. To make the mould for the process Aluminium material is used. The servomotor injects the acrylic material to the mould cavity. The acrylic material is heated by the heater which then comes to the molten state before injecting it into the cavity. The work of nozzle is to flow the molten material into the mould cavity. The nozzle ensures the flow of liquid material into the mould cavity with integration with a heater which heats up to 150 degrees. The nozzle also manages the speed and turbulence of flow of the molten or melted solid acrylic material in transit from clamp to die or mould.

The microcontroller is the important part of the mechanism. It controls the feeding of acrylic material through the servomotor and the heater which is attached to the nozzle which melts the material and through servomotor feeding it further enhance to the mould cavity. The micro controller is preprogramed so as to attain a required servo motor speed and uniform feeding in to the mould. The coding for the microcontroller is:

```

#include <avr/io.h>
#include<util/delay.h>
int main(void)
{
    DDRD |= 0xFF;
    TCCR1A |= 1<<WGM11 | 1<<COM1A1 | 1<<COM1A0 | 1<<COM1B1 | 1<<COM1B0;
    TCCR1B |= 1<<WGM13 | 1<<WGM12 | 1<<CS11;
    ICR1 = 39999;

    //OCR1A = ICR1 - 3000; //18000
    while (1)
    {
        OCR1A = ICR1 -900;
        _delay_ms(2000);
        OCR1A = ICR1 -5000;
        delay_ms(2000);
    }
}

```

Methodology

The methodologies used in the process are in accordance with the mould strength, heat required, pattern required and material used. The whole system of metal solidification is lubricated by oiling and various other methods. It is kept in observation that the molten metal completely reaches the mould and the mould is opened only when the solidification process is completed. The modification made by replacing the screw injection process by the servo system process eases the use of the whole apparatus of servo injection moulding. As mentioned above the difference created by reassigning the conventional moulding method using an automated has added up to the user ease and the time securing.

The injection moulding process is a very common method to create plastic or acrylic material moulds in a large number. Numerous products of daily usage are prepared by injection moulding like toys, grinder masks, plastic components and other household products. In a rather conventional way, the plastic products are made in way so that the process followed is easy, economical and secure.

Steps for the mechanism

- 1 Firstly the acrylic material (ethylene vinyl acetate) is being fitted into the nozzle having diameter of 12 mm.
- 2 Then the whole acrylic material has been connected to the feeding mechanism which contains lever which push the material to the mould box through the servomotor which is connected and controlled by the microcontroller.
- 3 Nozzle has heater connected to it which melts the material into liquid form and thus pouring it into the mould cavity which again has heater to prevent the material to get solidify before filling the whole cavity by the thrust force (through servomotor) and under the action of gravity force.
- 4 When the mould box filled to the optimal amount the power source is switched off manually there by switching off the heater and the servomotor which is connected to microcontroller.

Figure 2 shows the flow chart which explains the working of the mechanism.

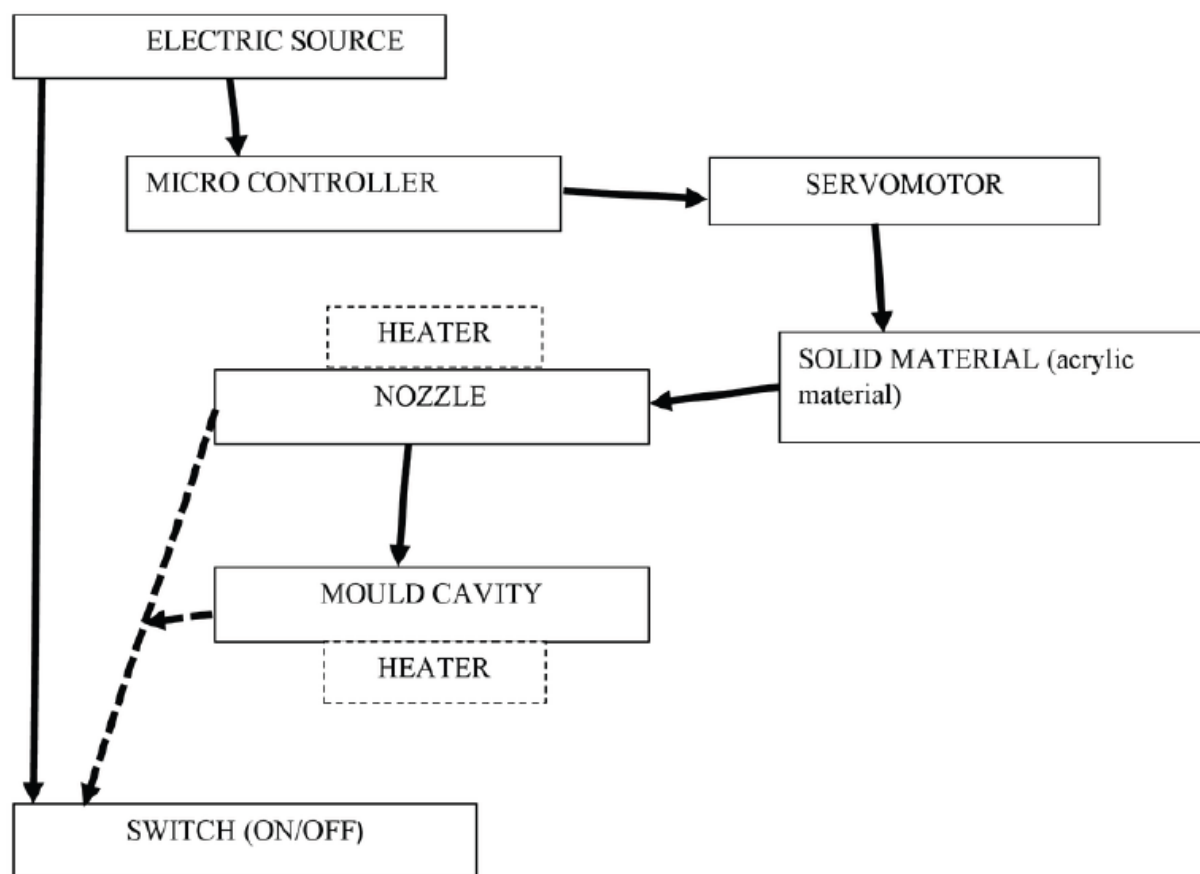


Figure 2. Working of Injection Moulding Mechanism.

Discussion

The automation of the injection moulding through the servo mechanism is possible and the pattern can be made for various casting process:

Time taken	Minutes
Heater to melt the material	2 - 2.5
Fill the mould cavity	4 - 4.5
Solidification	5 - 5.5

During the processing we have found many difficulties to accomplish the mechanism, firstly the injection of solid acrylic material was difficult as the cycle time is hard to adjust secondly the mould cavity has been done by the wooden material because of which several difficulties like misran and cold shutting is occurring simultaneously because of heat getting continuously absorbed by the wood as it has very low thermal conductivity. Secondly the flow of molten material through the nozzle is getting difficult as the cycle time and feeding of material through servomotor is getting difficult. Thirdly heating problem has arisen as the material was not getting properly heated with the required number of heaters. Fourthly the flow rate of the molten material has been compromised because of the horizontal arrangement of mechanism. All these problems have been overcome by following steps:

1. Programming of microcontroller has been revised to control the feeding of the servomotor and heater.
2. Aluminium has been used instead of wood as it has more thermal conductivity compared to wood.
3. Multiple heater has been used to heat the material properly.
4. Whole horizontal arrangement has been changed to vertical arrangement in order to increase the flow rate.

Conclusion

The injection moulding process in which the acrylic material is used and is fed into the mould which run by the use of the servomotor and heater is placed within the injection process and it heats the material and injects through the nozzle into the mould cavity. The material gets melted and another heater is placed in the base of the cavity which prevents the material from getting solidified before the cavity is filled completely. The micro controller holds the system to control the timing and speed of the molten material to get fed into the nozzle. This will help to inculcate the old manual process in which the molten metal is heated and is fed to the system manually through led and screw mechanism but here we can say that with the help of servo mechanism we can decrease the time and human effort in the process of injection moulding process where servo meter helps to automate the process and to inject the material to the system and can solidify and is used to make the pattern and thus increase the production rate.

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