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Experimental Study of the Effect of Temperature and Time on Injection Moulding Plastic Manufacturing Process Technologies

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Abstract

The injection moulding technique, it is evident that injection moulding has become a crucial process in manufacturing, widely utilized across various sectors, bringing significant enhancements to production. This technique involves heating polymer materials, injecting the material into a mould, allowing it to cool, and finally yielding a finished product ready for use. The experiment highlights that injection moulding relies on three key variables: temperature, time, and cooling rate. The experiment demonstrates the actual effects of these factors on the final product This versatile technique finds applications ranging from milk cartons and bottles to aerospace components. Injection moulding has improved product quality and reduced production time and costs.

Keywords: Injectionmoulding, Temperature, Cooling rate

1. Introduction

Plastic injection moulding is a transformative manufacturing process widely utilized for the production of plastic parts and components across various industries. This method stands out due to its ability to create complex geometries with high precision and repeatability, making it a preferred choice in sectors such as automotive, electronics, consumer goods, and medical devices.

The process of injection moulding involves several key steps: first, thermoplastic or thermosetting polymers are heated until they reach a molten state. This molten plastic is then injected into a specially designed mould under high pressure. Once theplasticcools and solidifies, the mould is opened, and the finished part is ejected. The efficiency of this process allows manufacturers to produce large quantities of identical parts rapidly, significantly reducing the cost per unit. According to a study by K. K. Choudhury and R. K. Ghosh (2011), the injection moulding process can achieve cycle times as short as 10 to 30 seconds, depending on the complexity and thickness of the parts being produced.

The versatility of injection moulding is further enhanced by the wide variety of polymers available. Materials such as polycarbonate, polypropylene, and polystyrene can be used, each offering unique properties that cater to specific application needs. For instance, polycarbonate is known for its impact resistance and clarity, making it ideal for safety glasses and electronic components, while polypropylene is favoured for its chemical resistance and lightweight characteristics, often used in automotive parts [2, 3, 4]

In addition to traditional thermoplastics, advancements in material science have introduced new polymer blends and composites that enhance the mechanical properties of injection-moulded products. These innovations allow for the production of lighter and stronger components, addressing the growing demand for high-performance materials in industries such as aerospace and automotive [5, 6]

The design of the mould itself is a critical factor in the injection moulding process. Effective mould design can minimize cycle times and improve the quality of the finished product. Modern mould-making techniques, including computer-aided design (CAD) and computer-aided manufacturing (CAM), allow for intricate designs that were once challenging to achieve. Moreover, the integration of automation and robotics in the moulding process has streamlined production, reducing human error and enhancing consistency [7].

Despite its many advantages, injection moulding does come with challenges. The initial costs associated with mould design and fabrication can be high, which may deter small-scale manufacturers. Furthermore, the need for precise control of temperature and pressure during the process requires skilled operators and sophisticated machinery [8].

In conclusion, plastic injection moulding is a vital manufacturing process that has revolutionized the way plastic products are fabricated. Its ability to produce high-quality, complex parts efficiently makes it indispensable in modern manufacturing. As technology continues to advance, the potential for innovation in injection moulding remains vast, promising to meet the evolving needs of various industries.

2. Experimental Method of Injection Moulding

In general, the injection moulding process proceeds as follows:

1. The mould is prepared for the moulding operation, which typically consists of two parts that are securely fastened together.
2. A screw plunger is loaded with powdered plastic material, which is then heated as it travels through the screw. This heating causes the plastic to melt, allowing different plastic materials to blend homogeneously.
3. The plunger forces the molten plastic through a nozzle and into the mould via designated gates.
4. The plastic remains in the mould to cool and solidify. Cooling can occur naturally through air or be expedited using water or other cooling fluids.
5. Finally, the mould is opened, and the finished part is ejected using ejector pins.

The following Figure 1 illustrates the main parts of the machine used in the experiment. The following steps were followed to analyze the effect of temperature and time on the samples.

Fig. 1 The Machine Utilized in the Experiment

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3. Results and Discussion

The initial phase of the experiment will involve maintaining a constant temperature of 250°C in the third chamber, with varying time intervals.

Initially, the time was set to 15 seconds, and upon activating the machine, the resulting sample exhibited shrinkage due to a rapid cooling rate.

Fig 2: The Mould and Shrank Sample

To study the effect of time and temperature on the shape of the sample. The time was set at 15 seconds, and the temperature in the third chamber was fixed at 250°C. Upon activating the machine, the sample did not conform to the mould shape as expected; this discrepancy arose from insufficient material feed, leading to a deficient outcome as shown in figure 3.

Fig 3: Sample of Scanty Feeding

To study the effect of the period of process on the final shape, the temperature was set at 250°C, and the time was extended to 30 seconds. Upon starting the machine, the outcome was a well-formed sample, exemplified in the following illustration.

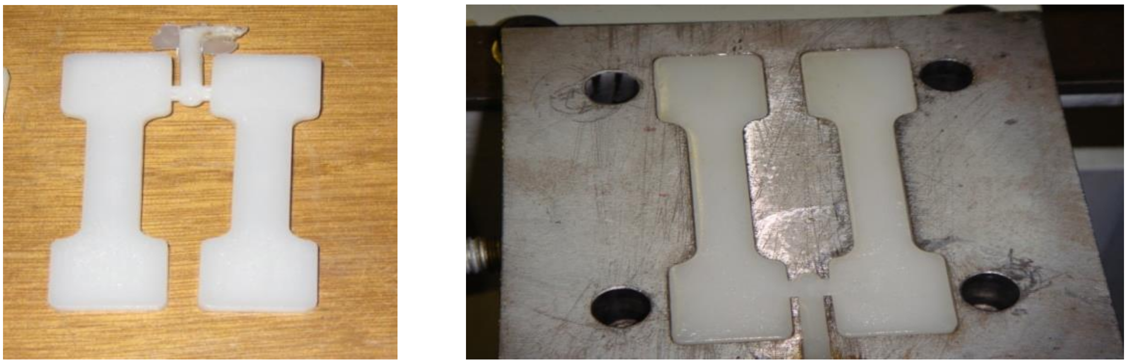

Fig 4: The Best Shape

To study the impact of temperature and time on the length of the sample, the mould were heated in an oven to a temperature of 65°C before being placed in the machine. In the first sample, the temperature was then setto 250C and the timeto 5 seconds, the length of the tested sample in these conditions is 78.4mm.

The experiment studied the effect of time on the length of the sample, the ambient conditions for the sample were set at a temperature of 250 degrees Celsius, with an increase in filling time by five seconds.

Fig 5: The Mould Form in the Furnace

Fig 6: The Samples Which Were Produced

The results of the time's effect on the length of the sample are demonstrated in Table 1.

Table 1: Effect of Filling Time on the Light

Time (Sec)	Distance (mm)	Temperature (^{o}C)

5	78.4	250
10	74.6	
15	74.3	
20	69.5	
25	67.5	
30	67	

Finaly the effect of variable temperature in length the sample is studied study the effect of temperature on the length of the sample, the time was set at 20 seconds while varying the temperature.

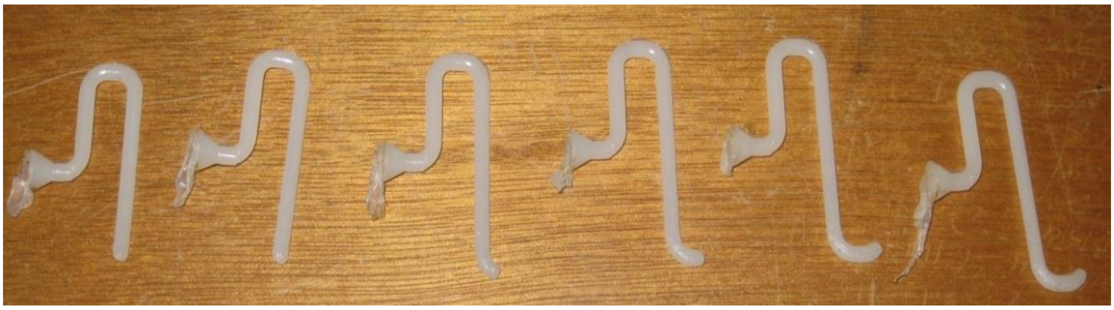

Fig 7: The samples which were produced

The following table illustrates the change in sample length based on temperature.

Table 2. Effect of the Temperature on the Length

Temperature (^{o}C)	Distance (mm)	Time (Sec)
270	84.0	20
260	83.5	
250	81.5	
240	76.0	
230	71.5	
220	69.0	

4. Conclusion

From the preceding experiment, it is evident that the key factors in the injection moulding process are temperature, time, and cooling rate. In the initial phase, the sample exhibited shrinkage due to a rapid cooling rate.

In the subsequent phase, where the mould was heated to 60°C with varying time intervals and a fixed temperature, it was noted that the distance of the resulting shape reduced. This reduction was attributed to the decreased temperature of the mould, impacting the polymer flow distance.

Moving on to the third phase, where the temperature varied while the time remained constant, and a similar observation was made regarding the decreased distance of the produced shape. This was a result of the diminishing temperature of the heated polymer, influencing the length of the produced shape, causing it to be shorter.

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