ANALYSIS OF FILLING STAGE FOR INJECTION MOLDING

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ABSTRACT

The injection or filling stage is the most important stage in injection molding process cycle. Injection or filling stage consists of the forward stroke of the screw injection unit to facilitate flow of molten material from the barrel through the nozzle and into the mold. As the first stage in the molding process in injection molding, the filling stage should give influences to the next stage. To investigate the filling stage mechanism and parameter for two plate mold, two methods have been used. The methods are machinery experimental and mold flow software analysis. The material will be used is ABS Starex SD0150 manufactured by Cheil Industries and the injection molding machine that used in machinery experimental is Arburg 520C Allrounder 800 – 2000. By doing the analysis of filling stage, the determinations of the fundamental necessary to improve the production rate without neglect the quality performance of the product that was produced. Injection pressure, injection speed and melt temperature are identified as the influences parameter in the filling stage. Finally, the analysis of filling stage in injection molding is should be considerate to achieve the good quantity rate of production without increasing the product defect.

ABSTRAK

Peringkat penyuntikan atau pengisian merupakan di antara peringkat terpenting di dalam kitaran proses penyuntikan acuan. Peringkat penyuntikan atau pengisian terdiri dari pergerakan kehadapan unit skru penyuntik untuk memudahkan pengaliran bahan cecair dari laras melalui nozel ke acuan. Sebagai proses pertama di dalam penyuntikan acuan, peringkat pengisian seharusnya memberi kesan kepada peringkat-peringkat yang seterusnya. Untuk menyiasat mekanisma dan parameter peringkat pengisian untuk acuan dua plat, dua kaedah telah digunakan. Kaedah-kaedah itu adalah eksperimen mesin dan analisa perisian mold flow. Bahan yang digunakan adalah ABS Starex SD0150 yang dibuat oleh Cheil Industries dan mesin penyuntikan acuan adalah Arburg 520C Allrounder 800 – 2000. Dengan menjalankan analisa mengenai peringkat pengisian, penentuan keperluan asas dalam meningkatkan pengeluaran tanpa mengabaikan kualiti produk dapat ditentukan. Tekanan suntikan, kelajuan suntikan dan suhu pencairan dikenalpasti sebagai parameter yang memberi kesan terhadap peringkat pengisian. Akhir sekali, analisa peringkat pengisian harus dipertimbangkan dalam mempertingkatkan kuantiti produk tanpa meningkatkan kecacatan produk

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LIST OF SYMBOLS

ABS	-	Acrylonitrile butadiene styrene
CAE	-	Computer aided engineering
D	-	Diameter
L	-	Length
l/t	-	Length over thickness ratio
MO	-	Mold open
PE	-	Polyethylene
PP	-	Polypropylene
PS	-	Polystyrene
PVC	-	Poly Vinyl Chloride
t	-	Thickness
Δp	-	Pressure differential

CHAPTER 1

INTRODUCTION

1.1 Project Title:

Analysis of filling stage for injection molding.

1.2 Project Objective:

Using mold flow analysis to investigate the filling stage mechanism and parameter for two plate mold.

1.3 Project Scopes:

a. Injection mold die is from standard die.
b. Only the filling stage will analyzed.
c. The analysis should be injection molding material, molding cycle, injection molding system and molding cycle time.
d. The molding cycle is including injection or filling stage, cooling or freezing stage and ejection and resetting stage.

1.4 Project Background:

Filling stage is an important stage in injection molding cycle. Starting to the pellet as a material in the hopper conveyed by screw in the chamber until the melt thermoplastics injecting into the cavity, filling stage is one of the major factors in plastic production field. In the industry nowadays, the high production rate is important. To be a good vendor of plastic equipment these industrial should have the ability to fulfill the demand from the customer and the plastic market.

A short shot is a molded part that is incomplete because insufficient material was injected into the mold. It can be caused by entrapped air, insufficient machine injection pressure (resulting from high melt resistance and a restricted flow path), pre-mature solidification of the polymer melt, and machine defects.

By doing the analysis of filling stage, the determinations of the fundamental necessary to improve the production rate without neglect the quality performance of the product that was produced. This element can give the benefit to the industry to achieve the profitable and survive in this challenging plastic industry. For reason that many element should be consider such as the cost, machinery condition, the material chosen and the consideration of another parameters that influence the production and quality rate of the product. The parameters that should to be consider such as the temperature that was used to heat the pallet, the pressure to force the melt and the cycle time to guide the process in this stage.

As the first stage of the molding process in injection molding, the filling stage should give the influence to the next stage. The authority of this stage is big to control the good running process in cooling stage and ejection stage. The review of cooling stage and ejection stage becomes importance for continues of this analysis.

Finally, the analysis of filling stage in injection molding is should be considerate to achieve the good quality rate of production without increasing the cost.

1.4.1 Problem Statement

- To identify the failure usually happened in production that related to the injection molding process especially in filling stage. And what should happen in filling stage to avoid this problem.
- To determine the absolute cycle time needed to process the product completely without cause any serious failure to the product.
- To identify how much filling stage process can effect the whole cycle and the factors that contribute to the injection process terminology.
- Cost of production is one of the big consideration in any industries, and the another problem that should be take is what the relation between filling stage process with the cost of production.

1.5 Flow Chart

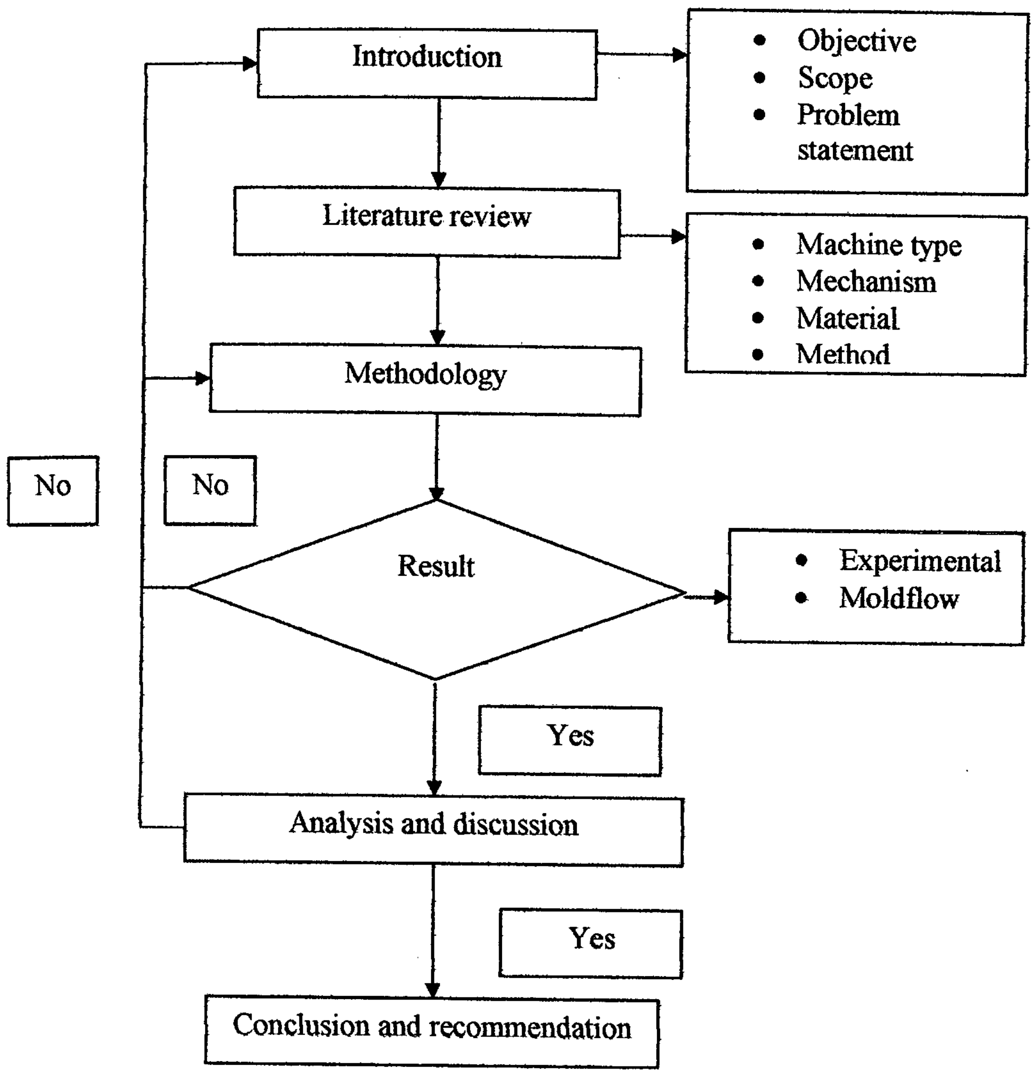

Figure 1.1: Project flow chart.

CHAPTER 2

LITERATURE REVIEW

2.1 Injection Molding

Injection molding is a manufacturing technique for making parts from thermoplastic material. Molten plastic that heated in barrel section is injected at high pressure into a mould, which is the inverse of the product's shape. The mold is made by a mold maker from metal, usually either steel or aluminum, and precision-machined to form the features of the desired part. And the mold are preferred in various type depend to product to be produced and should have matching connection to the machine.

Injection molding is widely used for manufacturing a variety of parts, from the smallest component to entire body panels of cars. Injection molding is the most common method of production, with some commonly made items including bottle caps and outdoor furniture. (Various author, www.wikipedia.com)

Injection molding is the most widely used polymeric fabrication process. It evolved from metal die casting, however, unlike molten metals; polymer melts have a high viscosity and can not simply be poured into a mold. Instead a large force must be used to inject the polymer into the hollow mold cavity. More melt must also be packed into the mold during solidification to avoid shrinkage in the mold. Identical parts are produced through a cyclic process involving the melting of a pellet or powder resin followed by the injection of the polymer melt into the hollow mold cavity under high pressure. (Various author, www.plasticsdome.com).

2.2 Reciprocating Screw

Reciprocating screw is a combination melting, softening, and injection unit in an injection molding machine. Reciprocating screws are capable of turning as they move back and forth. The reciprocating screw is used to compress, melt, and convey the material. The reciprocating screw consists of three zones (Figure 2.1.). The reciprocating screw is divided to feeding zone, the compression zone and metering zone.

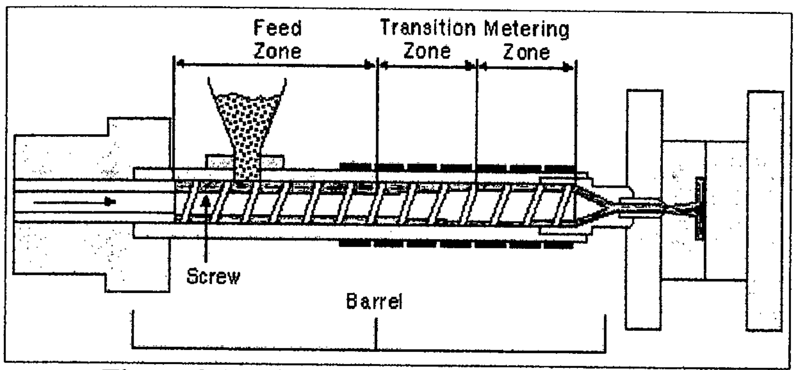

Figure 2.1: Injection molding machine. (Source: www.wikipedia_.injection_moulding.com).

While the outside diameter of the screw remains constant, the depth of the flights on the reciprocating screw decreases from the feed zone to the beginning of the metering zone. These flights compress the material against the inside diameter of the barrel, which creates viscous (shear) heat. This shear heat is mainly responsible for melting the material. The heater bands outside the barrel help maintain the material in the molten state. Typically, a molding machine can have three or more heater bands or zones with different temperature settings. (Various author, www.wikipedia.com)

2.2.1 Advantages and Disadvantages of Reciprocating Screw Machinery

The advantage of reciprocating screw is very efficient production process, with fast cycle times. Machines are mechanically simple and easy to operate the clamps do not shuttle, and the flow heads do not require bobbing and moderate initial capital investment also the advantage of reciprocating screw.

Limited to monolayer production 'and inability to utilize a screen changer (This limitation is overcome in the specific equipment in the machinery variation), make reciprocating can be more improved.

2.3 The Cold Runner Two-Plate Mold.

. The mold is essentially a heat exchanger in which the molten thermoplastic solidifies to the desired shape and dimensional details defined by the cavity. The vast majority of molds consist essentially of two halves, as shown Figure 2.2. This kind of mold is used for parts that are typically gated on or around their edge, with the runner in the same mold plate as the cavity.

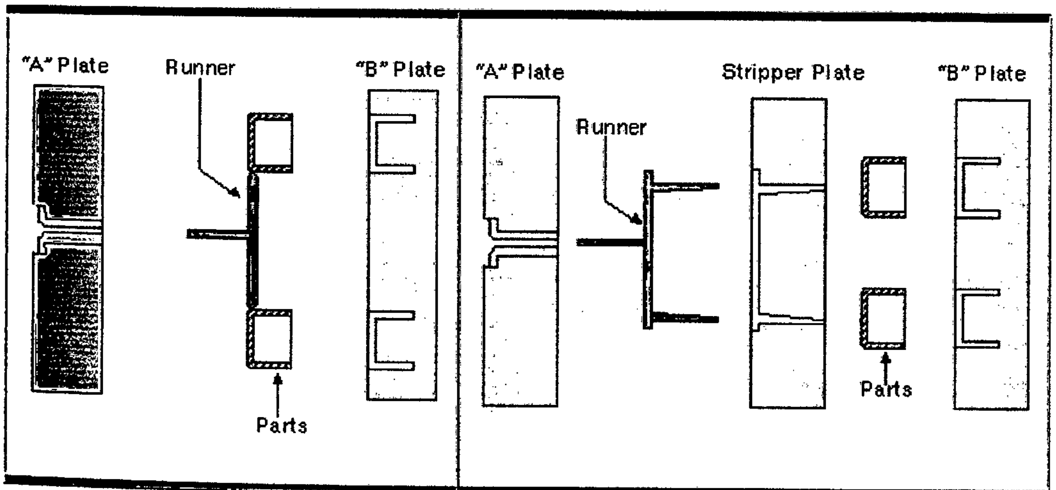

Figure 2.2: Two plate mold. (Source: www.sucd_injection_molding.com)

2.3.1 Advantages of Two-Plate Mold

The advantage of two plate mold are ddecrease weight and economical depend on mold design, easier for employees to setup and less wear on mold plate drive system.

2.4 The Injection Molding Cycle

The process sequences during the injection molding of a plastic part, as shown in Figure 2.3., is called the injection molding cycle. The cycle begins when the mold closes, followed by the injection of the polymer into the mold cavity.

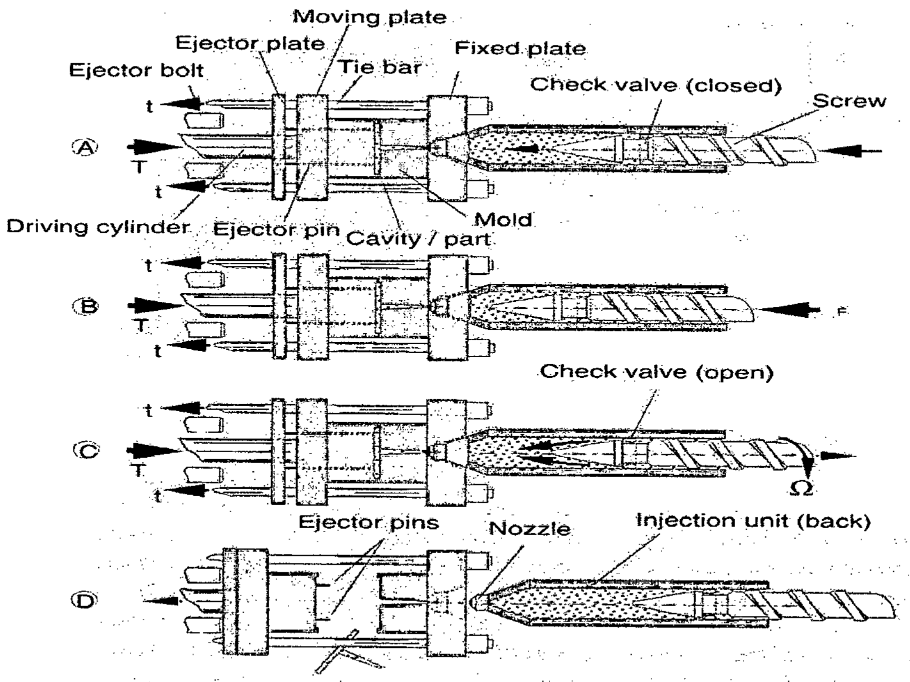

Figure 2.3: Injection molding process sequences. (Source: Herbert R, 2002).

Injections molding process start with injection of the polymer into the mold cavity. A holding pressure is maintained to compensate for material shrinkage. After that, screw turns, feeding the next shot to the front of the screw. The next shot is prepared. Then part is sufficiently cool, the mold opens and the part is ejected.

The injection molding process cycle consists of three major stages. The three major stages are injection or filling, cooling, and ejection or resetting.

2.4.1 Injection or Filling Stage

The injection or filling stage consists of the forward stroke of the screw injection unit to facilitate flow of molten material from the barrel through the nozzle and into the mold. The amount of material to be transferred into the mold is referred as the shot. The filling stage is proportional by a gradual increase in pressure.

To decrease the time to fill the cavity, the pressure should be increased rapidly, and packing occurs. During the packing part of the injection stage, flow of material continues; at a slower rate, to account for any loss in volume of the material due to partial solidification and associated shrinkage. The packing time depends on the properties of the materials being molded. After packing, the injection plunger is withdrawn or the screw is retracted and the pressure in the mold cavity begins to drop. At this stage, the next charge of material is fed into the heating cylinder in preparation for the next shot. (Boothroyd, G., Dewhurst, P. And Winston K, 1994)

2.4.2 Cooling or Freezing Stage

Cooling starts from the first rapid filling of the cavity and continues 1 packing and then following the withdrawal of the plunger or screw A resulting removal of pressure from the mold and nozzle area, At the point of pressure removal, the restriction between the mold cavity and the channel conveying material to the cavity, referred to as the gate of the mold, may i relatively fluid, especially on thick parts with large gates. Because of pressure drop, there is a chance for reverse flow of the material from the mold until the material adjacent to the gate solidifies and the sealing point is reached. Reverse flow is minimized by proper design of the gates such that quicker sealing action takes place upon plunger withdrawal.

Following the sealing point, there is a continuous drop in pressure as the material in the cavity continues to cool and solidifies in readiness for ejection. The length of the sealed cooling stage is a function of the wall thickness of the part, the material used and the mold temperature. Because of the low thermal conductivity of polymers, the cooling time is usually the longest period in the molding cycle (E.I. du Pont, 1986).

2.4.3 Ejection and Resetting Stage

During this stage, the mold is opened, the part is ejected, and the mold is then closed again in readiness for the next cycle to begin. Considerable amounts of power are required to move the often massively built molds, and mold opening and part ejection are usually executed by hydraulic or mechanical devices. Although it is economical to have quick opening and closing of the mold, rapid movements may cause undue strain on the equipment, and if the mold faces come into contact at speed, this can damage the edges of the cavities. Also, adequate time must be allowed for the mold ejection. This time depends on the part dimensions which determine the time taken for the part to fall free of moving parts between the machine platens. For parts to be molded with metal Inserts, resetting involves the reloading of inserts into the mold. After resetting, the mold is closed and locked thus compacting one cycle (Farrel R.E.,1985-86).

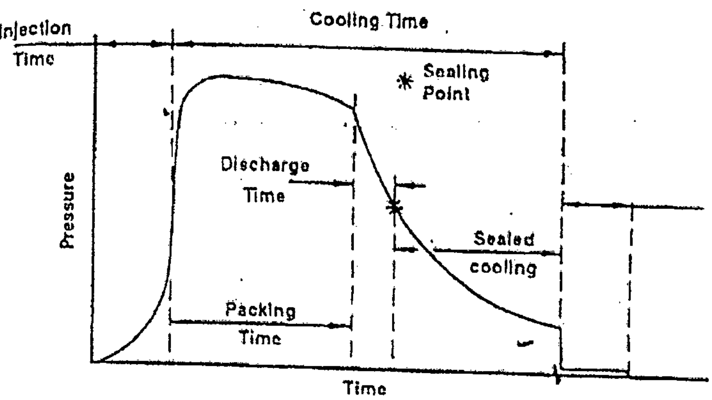

Figure 2.4: Injection molding cycle. (Source: Boothroyd, G., Dewhurst, P. And Winston K, 1994).

2.5 Mold Timing and Terminology

Dry-cycle: The total time required for the (machine) clamp to close and open, or the sum of the mold opening and the mold closing time. Today's fast machines have dry-cycles in the order of 1-3 seconds. A short dry-cycle is of particular importance with fast-cycling molds. The dry-cycle also depends on the length of the clamp stroke. (Herbert R, 2002)

Opening time: Usually quite fast. The ejection preferably should take place during this time, to reduce (or to omit completely) any mold open time. Occasionally, mold opening speed may need to be slowed down to suit the ejection method. (Herbert R, 2002)

Closing time: Usually quite fast, except for the final approach before the mold is fully clamped up, to avoid serious damage is caused to the mold. (Herbert R, 2002)

Mold protection: A system which senses (at the moment of final closing the mold) whether there is foreign material (dirt, plastic pieces, products which failed to eject, etc.) between the mold halves which could cause damage to the mold. A signal from the mold protection system will cause the mold closing to stop before damage occurs and sound an alarm. It usually automatically reopens the clamp so the foreign material can be removed.

There are many types of mold protection systems, such as electric, optical, or pressure activated. Some are more sensitive than others and may not always save a mold from damage. (Herbert R, 2002)

Mold open (MO) time: This is lost time. This time should be as little as possible. It can be zero. (Herbert R, 2002)

Mold closed time: Time from the moment the mold has closed until it reopens. It is the sum of the following times. Injection time is the time to fill the mold with plastic. Hold time is the plastic in the cavities is held under pressure usually lower than the injection pressure to add plastic volume as the plastic shrinks within the cavity. Cooling time are defined the time from the moment the injection (or hold) pressure is off until the mold starts opening. (This term is actually a misnomer, since the cooling is always on and starts to remove heat from the plastic as soon as the plastic enters the mold.). Ejection time is the time required to eject the products from the molding area so that the mold can re-close without catching an ejected piece. Preferably, this should take place during the opening time so as to eliminate the need for additional MO time. In some molds, it is not possible or practical to eject during the mold opening, and the ejection takes place partly or solely during the MO time.

The above-defined terms can be shown on a graph describing a complete molding cycle. Figure 2.5 is a very simple graph. All motions in a mold can and should be described in such a graph. This is particularly useful where there are several motions or timed air functions within the mold and wherever there are auxiliary mechanisms, such as product removal systems (robots, chutes, guide rails, etc.).

Following are detailed explanations of the times shown in the above schematic, for better understanding of the operation of a mold and of the various features influencing the times.

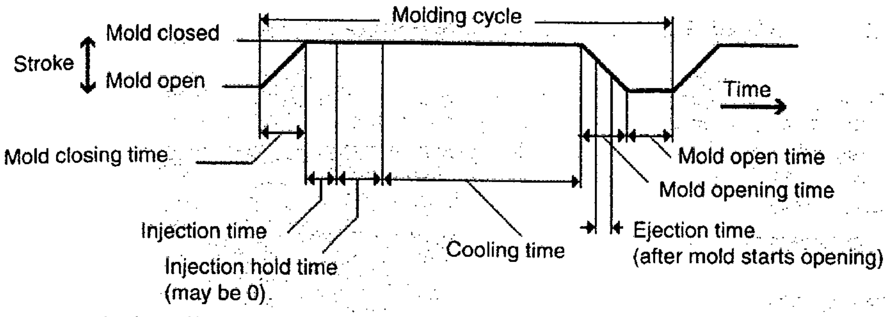

Figure 2.5 Timing diagram showing complete molding cycle. (Source: Herbert R, 2002)

2.5.1 Mold Closing and Opening Times (Dry-Cycle)

Some times are machine related. Some machines are faster than others, and speeds can be varied by settings of the machine. It is very important to understand that both the closing and opening times are more or less "wasted" times; that is, the longer they are, the smaller the productivity. Note, however, that during the mold opening stroke, the ejection can take place. The shorter the stroke, the less time is required, both for opening and for closing.

In Figure 2.5, the entire ejection takes place during mold opening, and there should be no need for the additional MO time shown. If, however, the ejection time becomes larger and is not finished by the time the mold arrives in the mold open position, some MO time will be required.

In some cases, it may be unavoidable to delay the ejection until the mold is fully open; for example, when unloading the mold with a robot or other mechanism which is not driven and interlocked (synchronized) mechanically with the clamp motion. But as a rule, the mold should be designed to eject during the opening stroke without the need for MO time.

Elimination of MO time is of particular importance with thin-walled products and any other type of product which can run at very short molding cycles.