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EFFECT OF PET PARISON SIZE ON INJECTION MOULDING MOULD DESIGN

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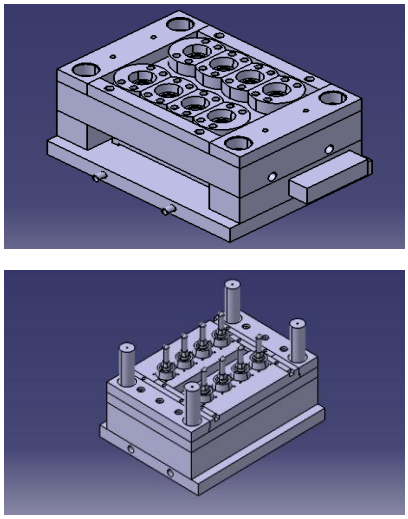
Graphical abstract



Abstract

Injection molding is one of the most popular manufacturing processes for producing good finishing plastic products with low cost and high volume production, especially for the production of plastic bottles. In order to produce high quality plastic bottle with specific size, the injection moulding mould need to be properly designed. This study is aimed to design injection moulding mould for producing three different sizes of Polyethylene Terephthalate (PET) parison. The actual dimensions of a commercial bottle preform of parisan of 25g weight were measured. PET was used as thermoplastic material because it has good strength and light weight properties. The designing process involved two primary components; (1) Female section consists of cavity plate as the main component and (2) male section consists of core plate as the main component. The effect of parisan size on the mould design was evaluated. Three different designs of female and male sections were constructed using CATIA software based on 15g, 20g and 30g parisan weight. The designs were also compared to the existing mould system of 25g PET parisan. It was shown that the design of insert cavity of female section and core cavity of male section were highly influenced by the size of the preform.

Keywords: Mould design, injection moulding, parison, thermoplastic

1.0 INTRODUCTION

Injection moulding is one of the manufacturing processes to produce parts using injection technique of a material into a mould. Thermoplastics are the most frequent materials used for injection moulding. In injection moulding, the material chosen is fed into a heated barrel for mixing process before forced into a mould cavity to let it cools and hardens according the part configuration [1-3]. The product is produced by injecting thermoplastic materials into a mould. This process is greatly preferred in producing plastic components because it can convert thermoplastic into simple or complex shapes of hollow parts with high dimensional accuracy at very short cycle times. Injection molding process involves melting plastic pellets and injecting it through a core pin forming a round hollow tube called a parisan. The parisan is then transferred to a blow molding station where compressed air is injected into the tube forcing the plastic to the interior walls of the mold forming the plastic bottle. In order to facilitate the moulding process, the parts to be injected must be carefully designed. All these aspects need to be taken into consideration during the design process; the material used for the part, the desired final shape, the features of the part, the material of the mould, and also the capacity of the moulding machine [2, 4].

Due to its capability, the technology on injection moulding has been improved continuously. This is also

corresponded to many factors which influenced the quality of injection molded parts, such as the property of plastics, mould structure and manufacturing accuracy, injection machine, and injection parameters [5-7]. The material which is Polyethylene Terephthalate (PET) is reviewed to understand its properties and behavior. Polyethylene terephthalate (PET) exists both as a semi-crystalline (opaque and white) thermoplastic and an amorphous (transparent). Usually, it has good resistance to solvents, acids and mineral oils, but not to bases. The semi-crystalline PET has good ductility, strength, hardness and stiffness while the amorphous PET has better ductility [8]. It also can be recycled for other applications and has good process ability. In this study, semi-crystalline PET was used to produce plastic bottles.

There are several components in injection moulding machine which are hopper, barrel, screw, nozzle, mould and others. Mould is one of the most crucial parts which consist of tie bars, stationary and moving platens, as well as molding plates that house the cavity, sprue and runner systems, ejector pins, and cooling channels. Mould system is an assembly of platens and molding plates typically made of tool steel. The mould system shapes the plastics inside the mould cavity (or matrix of cavities) and ejects the moulded part(s). The stationary platen is attached to the barrel side of the machine and is connected to the moving platen by the tie bars. The cavity plate is generally mounted on the stationary platen and houses the injection nozzle. The core plate moves with the moving platen guided by the tie bars. Occasionally, the cavity plate is mounted to the moving platen and the core plate and a hydraulic knock-out (ejector) system is mounted to the stationary platen [9, 10]. There are two types of mould which two plate mould and three plate mould. The vast majority of moulds consist essentially of two halves. This kind of mould is used for parts that are typically gated on or around their edge, with the runner in the same mold plate as the cavity. Three plate moulds is typically used for parts that are gated away from their edge. The runner is in two plates, separate from the cavity and core [10].

PET has a good clarity and not leaving any taste in the water where these properties are important for plastic bottle application. PET has good barrier properties against carbon dioxide and oxygen. Its physical properties and chemical inertness made it suitable in food packaging applications especially in drinking water. Many researchers have studied the technology or parameters to enhance the quality of products produced by injection moulding. This study is aimed to design the injection moulding mould with three different sizes of PET parisan and analyze the results

2.0 EXPERIMENTAL

2.1 Disassemble Process

This is a reverse engineering technique where the first step is to disassemble the existing mould in order to obtain the actual mould design for commercial use. The mould was disassembled into several parts because there are many components in this mould and in order to measure each and every dimension of the components. The disassemble process was carried out by two primary components which are disassemble of female part and male part. The tools needed to carry out this process are chain lock, allen key, hammer, vernier caliper, HDI advance 3D scanner and measurement tape and other measurement apparatus.

2.2 Dimensionaling Process

The dimensions of each component need to be measured. All the data or dimensions were needed to create an accurate design in CAD/CAM software. This dimension can be divided into two part; critical part dimension and normal part dimension.

Normal part dimension is the part that quite simple and can easily be measured. Thus, the tools needed to be used were only vernier caliper and meter tape. Meter tape was used to measure the straight part of mould, while vernier caliper was used to measure the part that contain complicated shape such as hole in order to get the depth and diameter of the hole.

As for the critical part of dimension, it focuses on PET preform part. It has complicated shape at the neck. The angle and length of the thread as well as the diameter inside the PET preform are hardly measured due to their uneven shape. A 3D scanner has to be used to get the accurate dimension of the PET preform. For the outer side of PET preform, the product was scanned and the dimension of the part was generated. For the inner part of PET preform, the product needed to be cut into half section in order to get the inner dimension. The hacksaw was used to cut the preform before the scanner generated the dimension in details.

2.3 Modeling Process

2.3.1 Existing Mould

A 3D Model of existing mould was created by using CAD/CAM software. In this study, CATIA was used as modeling software. Each component was created part by part using the dimension that has been measured before. The female section part was created first which consists of the top plate, runner plate, cavity plate, insert part, cavity insert lock, manifold/heater, and heater rod element. Then, the male part section which consists of the core plate, the spacer plate, the bottom plate, the core cavity,

the valve ejector, the packing/wedges, the slider insert, and slider block was created.

2.3.2 New Mould

A new model of mould was created based on the modifications of PET parisan dimension. The first parts that have been modified are the dimensions of insert and core cavity. The existing PET preform size of 25g was modified into the new preform size of 15g, followed by 20g and 30g.

3.0 RESULTS AND DISCUSSION

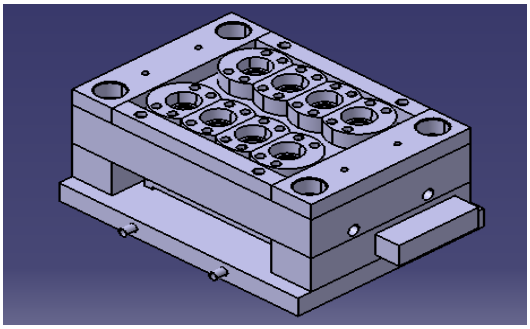


Figure 1 Overall assembly view of injection moulding which consists of female section consists of cavity plate.

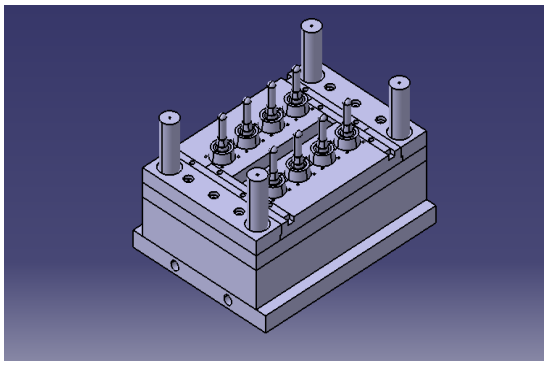
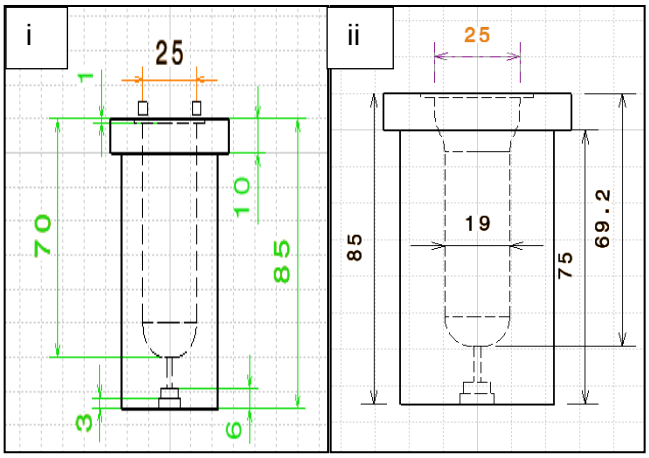


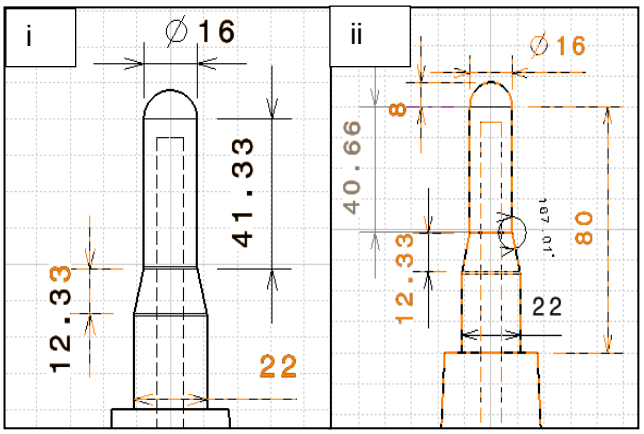
Figure 2 Overall assembly view of injection moulding which consists of male section consists of core plate.

Figure 1 shows the existing mould that was used to fabricate 25g PET preform (parisan). For the 15g PET preform, the outer dimension of insert is still the same as the existing insert (25g PET preform). The only dimension that has been changed was the size of mould diameter of the preform in the insert cavity. The diameters at the neck of preform were both 25mm, but the length of preform cavity was modified from 70mm to 69.2mm. It can be seen that when the size of preform was changed, the design of the mould was also changed as well as the shape of the preform cavity. The existing cavity has constant diameter from neck to bottom, however for 15g preform cavity, the diameter at the neck was 25mm, and it was reduced to 19mm at the core cavity which can be seen in Fig 2a. Another dimension that has been changed was the core cavity. The total length of existing mould core cavity was 88.67mm and was modified to 88mm for 15g preform. This modification can be seen as in Fig 2b.



Insert dimension in cavity plate

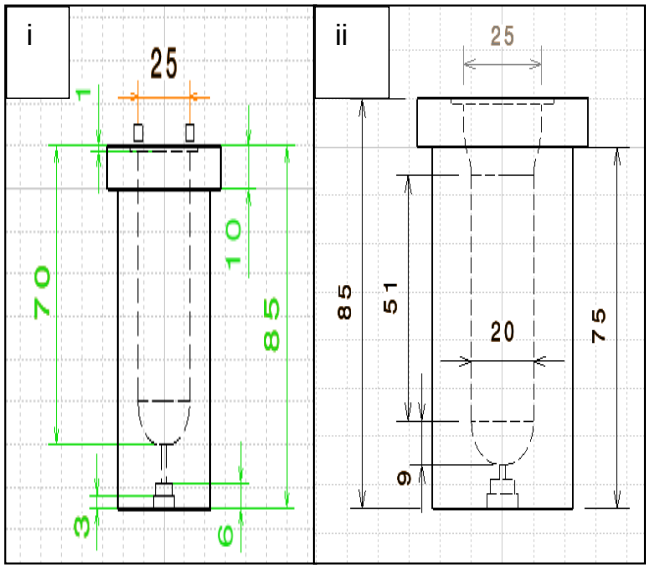
Figure 3 The dimension comparison on PET preform for insert of (i) the existing preform design (25g) and (ii) the modified preform design (15g)



Core dimension in core plate

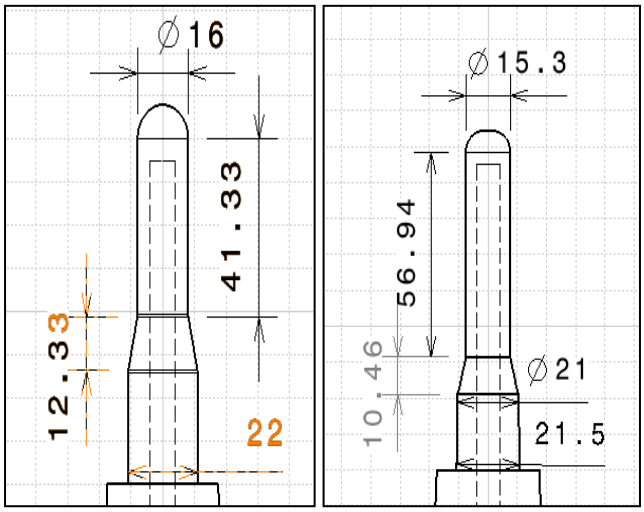
Figure 4 The dimension comparison on PET preform for core cavity of (i) the existing preform design (25g) and (ii) the modified preform design (15g)

Another size of PET preform that has been investigated was 20g preform. Similar as 15g preform, the insert dimension remain the same as the existing insert. However, the insert cavity has to be changed because of the different size of PET preform. The inner diameter of insert cavity for a new 20g PET preform was modified from 25mm to 20mm. The dimension of core cavity also needs to be changed according to the size of preform. The total length of core cavity for a new 20g PET preform was increased after the modification. Fig 3 shows the comparison on dimension for 20g preform.



Insert dimension in cavity plate

Figure 5 The dimension comparison on PET preform for insert of (i) the existing preform design (25g) and (ii) the modified preform design (20g)



(b) Core dimension in core plate

Figure 6 The dimension comparison on PET preform core cavity of (i) the existing preform design (25g) and (ii) the modified preform design (20g)

The third size of PET preform that has been studied was 30g preform. As for this case, several parts need to be changed in their dimension due to the fact that the size of cavity affects the thickness of the cavity plate. Components that need to be modified were insert size, cavity plate, and core cavity. The insert size was modified from 85mm to 113mm. This is due to the length of the insert cavity for 30g PET preform is 103mm, which is longer than the old insert length (85mm) as shown in Fig 4a. Cavity plate was also changed because of the modification made on the insert size. The cavity plate support and hold the insert in the female part. The size of cavity plate is affected by the size of the insert. Once it is larger, the cavity also needs to be modified to a larger size. Fig 4b shows the comparison between existing cavity plate dimension and the new cavity plate of 30g PET preform.

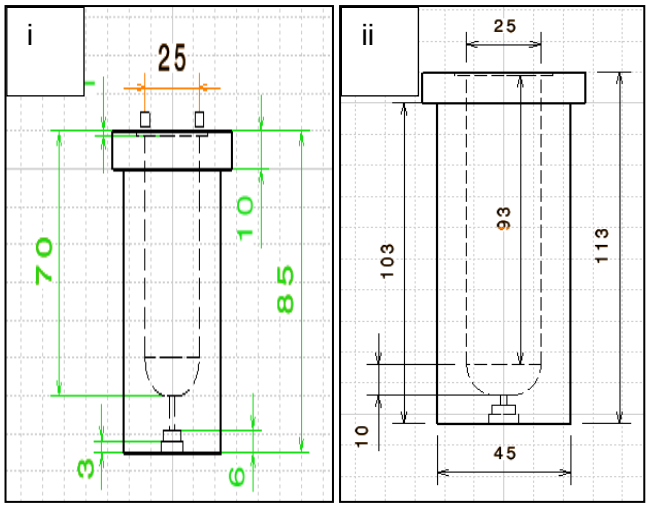


Figure 7 The dimension comparison on PET preform for insert of (i) the existing preform design (25g) and (ii) the modified preform design (30g)

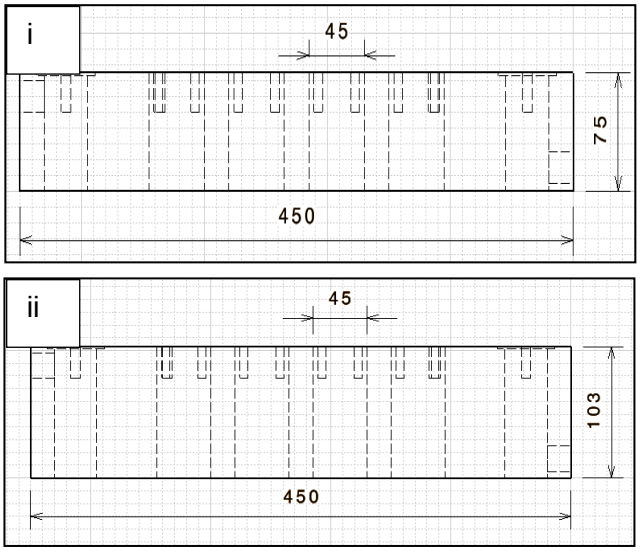


Figure 8 The dimension comparison on PET preform for cavity plate of (i) the existing preform design (25g) and (ii) the modified preform design (30g)

4.0 CONCLUSION

The effect of design on three different sizes of PET preform, which are 15g, 20g, and 30g, was investigated. The existing injection mould was disassembled to get the dimension of each component. The mould was divided into two primary parts, female and male section. The critical part, especially for neck and preform cavity was measured by using 3D scanner to give an accurate reading. The existing mould was created in CATIA using current measurement and the effect of design on three different sizes of preform was successfully evaluated. The size of preform shows a very significant influence on the insert and core cavity diameters.

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