

Practical Guide to Injection Blow Molding



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Samuel L. Belcher

Practical Guide to

Injection Blow Molding

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Preface

High-density polyethylene is the most produced resin in the United States and the world, and its uses are growing at an ever-increasing rate. The blow molding industry is the largest user of high-density polyethylene. There are several distinct processes employed by the blow molding industry to produce blow molded products ranging from angioplasty balloons to containers holding over 1500 gallons.

Injection blow molding is one of the main processes used in the blow molding industry. The other processes are free extrusion blow molding, injection stretch blow molding, entrapment blow molding, and stretch blow molding. Each method has its advantages and disadvantages.

This book is written to reach members of the industry, from the novice to the experienced blow molder, and explain the injection blow molding industry from conception to design, costing, tooling, machinery, troubleshooting, and daily production.

Anyone in the plastics industry, including possible investors, will benefit from this book's straightforward approach, with its use of pictures, charts, figures, and supplements to show detailed tooling and container design. Basic costing procedures can be used to determine possible investment or expansion of the injection blow molding process. Costing should include resin costs, machine costs, tooling, labor, energy, floor space, overhead, sales and administration, and, of course, profit.

I do hope you will enjoy this short but detailed book and find it useful in your daily operation. There is very little published on injection blow molding, and the people that pioneered the process have mostly left the industry; thus, I have strived to bring to this book a discussion of the industry, the history of injection blow molding, and the daily ins and outs—or dos and don'ts—that we all face daily in production blow molding plants with product design, material selection, machine selection, tooling design, advantages and disadvantages, and efficiencies to be achieved. Each chapter is written to provide you with basic knowledge of the injection blow molding industry. Chapters are devoted to the history of the industry, container design, tooling design, machinery, resins, parison design, and the limitations of the process.

Whether you are in teaching, research, production, finance, tool design, or analyzing the market, this book could benefit you.

This book is dedicated to the many pioneers of this industry, including Frank Wheaton, Jr.; Ted Wheaton; Ernie Moslo; Joe Johnson, who started JOMAR; Dewey Rainville, who started Rainville Co.; Carl Andrews; John Raymonds, Sr. , who started Captive Plastics; James Dreps; Ralph Abramo; A. Piotrowsky; G.T. Schjeldahl; Angelo Guisconi; Adveple Matteo; Alfred Boked; Walter Panas; Denes Hunkar; Jack Farrell; Joe Flynn; Gottfried Mehnert; W.H. Kopetke; D. Farkus; Louis Germanio; Larry Barresi; Hataschi Aoki; and to the many people on the production floor who keep the injection blow molding machines running and the products going into the boxes every hour of the production day.

I also thank my devoted wife, Donna, who has supported me all these years and listened to my many stories of the plastic bottle industry.

Please enjoy the book and feel free to contact me at the following address:

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Sincerely,
Samuel L. Belcher

chapter one

History

Injection blow molding is, by definition, combining injection molding with blow molding. The parison or preform is injection molded at the first station. Once the outside skin of the parison is set up so that it will not fracture when the injection mold halves separate, the rotating table rises a set height, rotates either 120° or 90°, and then drops down to lay the core rod containing the injection-molded parison into the blow mold bottom half. Then the blow mold clamp closes, capturing the injection-molded parison, and the trigger bar inside the rotating table is activated to move forward a set distance. This trigger bar movement pushes the spring-loaded core rod body or tip to open, and air or another gas enters through the core rod and lifts the injection-molded parison from the core rod and, via the air or gas pressure, forms the hot injection-molded parison to the inside of the female cavity blow mold shape. The neck or finish (threaded or snap fit) of the injection-molded parison is formed in the injection mold station and is cooled or allowed to set up in the blow mold station. Once the blown shape is allowed to cool so that the blow mold shape is retained, the air or gas is exhausted. Once exhaust takes place, the blow mold clamp opens, and the rotating table carrying the core rod and the blow-molded product lifts to its set height and again rotates either 90° or 120° to the eject station.

From the earliest days of extrusion blow molding, it was obvious to the personnel striving to produce plastic blow molded products that small containers would be costly to produce, as there was as much off-fall or regrind as there was weight in the blown product. Thus, the early pioneers searched for a new method that would allow them to produce blow-molded plastic containers that were free of off-fall.

The blow molded plastic industry really started when Dr. Jules Montier created an underarm deodorant and sought a squeezable plastic container to hold the product. The container needed to be able to be squeezed to spray the product onto the consumer's skin. Plax Corporation produced the container, and over five million units were sold the first year. Thus the plastic blow molding industry became a reality. The "Stopette" underarm deodorant

squeeze bottle molded by the Plax Corporation was the first high-volume LDPE commercial blow molded container in 1946.

Interestingly enough, Emhart Corporation, the big glass machinery producer, actually owned the Plax Corporation. In the early 1950s, Owens-Illinois purchased a 50% interest in the Plax Corporation from Emhart. Later, Monsanto purchased the 50% of the Plax Corporation from Owens-Illinois in 1957 and the remaining 50% from the Emhart Corporation in 1962. The Plax name was soon dropped, and the company became part of Monsanto. Thus, Monsanto was one of the early blow molding container producers as well as a plastic resin supplier in the 1960s. Other resin companies followed this lead, such as Dow Chemical, Union Carbide, Phillips, and Owens-Illinois (then a half owner of the former USI high-density polyethylene producer).

The earliest injection blow molding process is credited to Mr. W. H. Kopetke, who had patents issued in 1943 while he was employed by the Fernplas Company. The early injection blow molding systems were actually modified injection molding machines with specialized tooling mounted between the platens of the injection molding machine. However, the earliest and most referenced process was the system developed by A. Piotrowski, depicted in panel 1 of Figure 1.1. Other developments followed, such as the Moslo (ERNIE) method (Figure 1.1, panel 2), the Farkus (D.) method (Figure 1.1, panel 3), and the Guissoni (Angelo) method (Figure 1.1, panel 4). The Piotrowski method used a center rotating plate with a vertical split parison mold and a vertical split blow mold. However, removal of the blown product, which was ejected downward during rotation, was a hindrance to the process. The Moslo method used split molds with a mold shuttle plate that moved vertically in two directions. In this method, though, the plate shutting and ejection of blow product from the blow mold were hindrances. The Farkus method employed not only a vertical shuttle plate but also a horizontal movement to allow for the blown product to be ejected. For this method, long cycle times and the presence of several plate movements were hindrances to the process. The Guissoni method was adopted and is the basis of the injection blow molding industry today. This method employs a rotating horizontal table with three main stations for injection, blowing, and ejection. Each step takes place at the same time the other step is taking place. The JOMAR, Rainville, Wheaton, Farrell, Nissei, and Bekum early machines all adopted the Guissoni method, involving the rotating horizontal table to which the core rods were attached, with the parison injection mold, the blow mold, and the ejection tooling being stationary.

Wheaton (ALCAN), Bekum, and a newcomer, Novapax station, designed the rotating table to include four stations, for safety when checking the core rods before they transfer to the injection station. The addition of a fourth station also provided for the safety station to be used to condition the core rods to producing injection blow molding containers from polyethylene terephthalate and polyethylene naphthalate. The fourth station allowed for faster cycles because the rotating horizontal table only rotated 90° instead

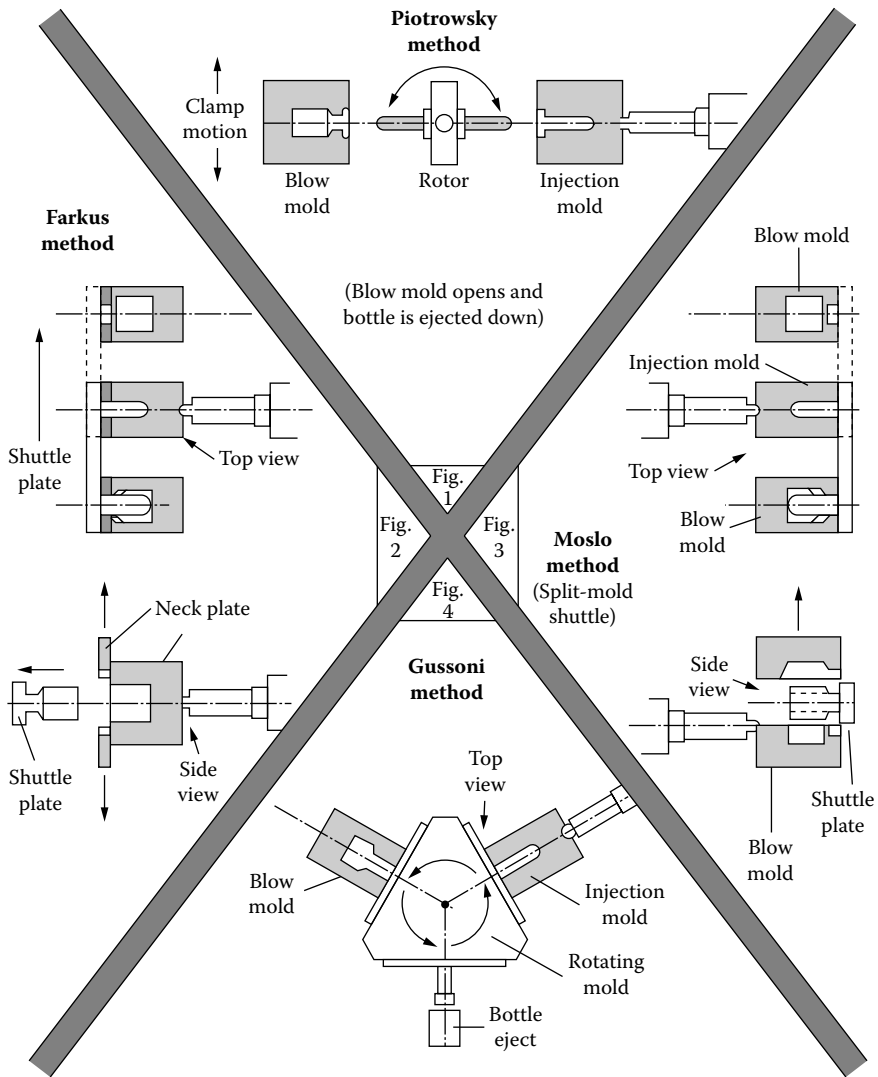


Figure 1.1 The four methods.

of the regular 120° , as found on the regular three-station rotating table machines. The fourth station did add to the tooling cost, as you had to have core rods and face bars for four stations versus for three stations. The fact that the four stations can open, index, and close on a faster cycle, however, should lead all machinery producers to produce only the four-station machines. In addition, the extra station adds safety against tool damage, and the conditioning station for polyethylene terephthalate and polyethylene naphthalate is another reason to produce four-station machines.

chapter two

The process: injection blow molding

Injection blow molding combines injection molding with blow molding, thus resulting in injection blow molding. The injection phase uses either a vertical plastifier or a horizontal plastifier to take the thermoplastic resin from the plastifier's hopper and convey it into the heated barrel containing a screw for mixing and melting the thermoplastic material into a homogeneous melt, ready to be injected into a heated manifold. The heated manifold maintains the homogeneous melt and distributes it to the injection cavities of the parison injection molds. The parison injection molds contain the parison shape and are closed onto a metal core rod, which is centered in the parison injection mold. The metal core rods are mounted onto the rotating horizontal rotating table by retainers and a face bar. Once the homogeneous melted thermoplastic material is injected into the injection parison mold, the injected material is cooled so that the outside skin of the injected parison will not fracture on the opening of the injection parison mold.

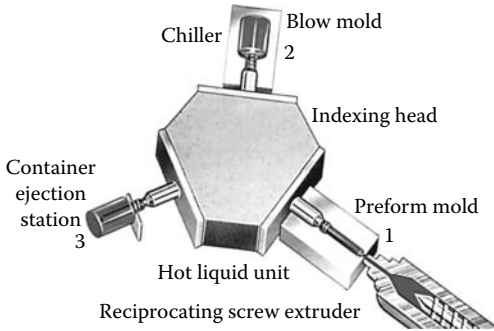
The injection parison mold is split evenly into halves and one half is mounted to a stationary die plate and one is mounted to a movable die plate. The bottom half of the injection parison mold is mounted stationary in relation to the injection parison mold die plate. The heated manifold is also mounted stationary in relation to the injection parison die plate. The injection parison die stationary plate is mounted to the flat horizontal table by use of die clamps and bolts, and the blow mold die set is similarly mounted at the blow mold station. The top half or upper half of the injection parison mold is mounted to the upper injection parison die set via holding screws and key ways, and the upper half of the injection parison die plate is bolted to the movable clamp, which travels upward for opening and downward for clamping. This system is employed at the injection station and at the blow mold station. On some of the injection blow molding machines, there is a separate injection clamp and a separate blow molding clamp station. Other machines employ only one horizontal moving platen, not separate clamps for the injection station and the blow mold station. In this situation both the

upper one half of the parison injection mold which is mounted to the upper die plate and the upper one half of the blow mold which is mounted to the upper die plate are both mounted to this one movable platen.

Once the injection parison mold and the blow mold have opened to their set opening, the horizontal rotating table containing the core rods that hold the injection molded parison or parisons raises and rotates either 90° (for a four-station machine) or 120° (for a three-station machine). Once rotation is complete, the rotating table drops into its set height position, and the injection parison clamp and the blow mold clamps close. This movement captures the heated parison, which is then blown off the metal core rod while a new parison is injection molded. Air or some other gas enters through the rotating horizontal table through the metal core rods, lifts the heated thermoplastic parison off the metal core rod, and forms the heated parison to the inside design of the closed blow mold cavity. The finish, or threaded area formed on the parison at the injection parison station is not blown in the blow mold but is held in the blow mold tooling to maintain its proper designed dimensions. Thus, only the body of the injection molded parison is blown or lifted off the metal core rod by the blow air pressure. The blow mold cools the now-formed product so that it retains the desired shape and dimensions. Following proper cooling of the blown product and the completion of the injection molding of the parison in the injection parison position, the clamps open vertically. The horizontal rotating table then rises to its predetermined set position, rotates either 90° or 120° , and carries the new injection molded parison to the blow mold station, the blown product to the strip or eject station, and the core rods free of product to the parison inject station. The horizontal rotating table then drops vertically downward to its predetermined position. This allows for the parison inject clamp to close, the blow mold clamp to close, and the stripper to strip the formed product from the metal core rods either for packaging or into position for secondary operations such as decorating, assembly, or treatment. The process is now complete.

This procedure continually repeats on a three-station injection blow molding machine. On a four-station injection blow molding machine, in contrast, the fourth station either allows for safety checking of the core rods to ensure that they are clean and free of any product, or there may be a vertical clamp station present, which allows for the core rod(s) to be conditioned via air chambers. This is particularly true on four-station injection blow molding machines used to produce polyethylene terephthalate or polyethylene naphthalate blown containers. The fourth station may also be used to flame heat and decorate the blown containers. Conditioning and decorating at this station will be discussed further in the chapter on processing.

This simplified explanation of the injection blow molding process as described above (pictorially explained in Figure 2.1 for a three-station machine) is just the beginning of the real injection blow molding process. The injection blow molding process begins when any plastic item to be produced begins.



The process

Stage 1—Injection

Resin is injected by the horizontal reciprocating screw into the preform cavity. The parison is formed and temperature conditioned. This is where the precise neck finish is produced.

Stage 2—Blowing

After indexing 120° counter-clockwise to the blow mold, the preform is positioned there and the mold closes. The neck finish is held while the parison is blown to the final container shape and cooled.

Stage 3—Ejection

Now the core rod, carrying the completely finished container, again indexes 120° where a stripper bar removes the finished container.

All three stages take place simultaneously with the cycle time being determined by the injection molding preform production stage.

Figure 2.1

The item to be injection blow molded is first designed, whether by the customer or by a product designer, in the mold building facilities. Normally, containers holding under 8 ounces are blow molded, whereas larger containers are normally designed for free extrusion blow molding. The container design is critical with regard to the finish or top of the container and to what the critical function for this area is (e.g., to hold a closure or fitment, etc.). With the advent of childproof closures, this area became more critical to the product designs as well as to the filling and packing customer. Proper product design can save valuable grams of resin with good management of the wall thickness of the finish, the height of the finish, and the use of a flat surface area so that a top-seal membrane (such as aluminum, coated paper, or coated plastic) will adhere. Proper design of the container can save 15%–20% of the final container weight and of the cost of production. The design of the push-up in the base of the container, with regard to depth and to decorating locators, also has an effect on tool costs and cycle time. The push-up or recess in the bottom of a container serves several purposes. By recessing the bottom of a container, the designer strives to provide the container with a flat surface that will allow the filled container to set flat on a flat surface. This recess can also have an indent to allow for labeling machines to use this indent to accent the container to have the container aligned so it can be labeled as desired by the company filling the container with product. If you look at the recess or push-up you may also see the recycling code for the resin used in producing the container. These may also be the trade mark of the company injection blow molding the container and

a date code may also be found in this area as well as a cavity number. The cavity number indicates what blow mold cavity was used to produce the container in question. These are limits as to how deep you may recess the push-up set by the government in the area of misleading the consumer. If you designed a deep push-up that could produce an ounce of volume from the containers volume. This is false packaging. The consumer would feel they are receiving a larger container of product versus a competitor's product due to the larger size of container.

Choosing the proper resin for a project is usually done by the company that is going to fill the container. The choice of plastic resin used is the major variable encountered in injection blow molding. In this process, the annual volume of the product and whether the user orders it on a regular basis or has a cyclical demand usually determines how many cavities will be planned for production. Naturally, the injection blow molder has to figure out what machine or machines he or she has available to produce the product.

There are several items that are of utmost consideration in choosing the injection blow molding machine to use for production. The annual volume required, the resin to be used, and the willingness of the user to pay the cost for the injection blow mold tooling all have to be considered up front so that the needed product volume can be met, proper tooling designed, and appropriate injection blow molding machine be made available.

The injection blow molding machine chosen has to be able to have an adequate injection unit for the number of grams per hour required. The machine also has to have enough injection mold clamp tonnage to allow for the chosen number of cavities and for the injection pressure that is required to fill the injection parison tooling. This measurement should include a 20% safety factor to ensure that the parison injection does not flash. Flash is excess plastic that is somewhere on the injection blow molded container, that is not specified on the container product design. It may be in the threaded area of the container, on the top surface of the container or in the recess or push-up area, and possibly on the side wall of the container at the parting line where the upper and lower injection parison mold or the upper and lower blow mold are to come to meet to form the desired injection molded parison or the desired blow molded container. Most injection blow molding machines have greater injection clamp tonnage than blow mold clamp tonnage. The injection pressure required to fill the parison mold can be approximately 3000 psi for the olefins and as high as 6000–8000 psi for engineering materials such as polyethylene terephthalate, polybutylene (PBT), polyethylene naphthalate, polycarbonate, and resin blends. The blow mold gas (normally air) is used from 80 psi up to 220 psi; thus, high blow clamp tonnage is not required. For instance, a 55-ton injection blow molding machine may have 38-ton injection clamp tonnage and only 17-ton blow clamp tonnage. Each injection blow molding machine manufacturer has its own specifications as to the injection unit, the injection clamp tonnage, the blow clamp tonnage, the