“PLASTI-GARAGE,” AN EXTRUSION BLOW MOLDED GARAGE DOOR PANEL

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Abstract

A garage door is a door commonly composed of a composite wood, aluminum, and other materials. This door is generally composed of four panels that stack on top of one another and open and close in a vertical fashion. This design project demonstrates a garage door panel that can be extrusion blow molded to save assembly time, and material.

Introduction

In the early 1900’s as cars became popular, the need for a place to store vehicles became a necessity. The idea of a garage came about around 1910. The first garage door was a barn door; a double door, attached to the exterior wall of the garage with strap hinges. The doors opened outwards. Screws and hinges became fatigued, and snow blocked the path of the doors, creating huge problems [1].

The solution to this problem became a garage door that slide across a track. The door moved sideways and slid across the front of the garage. The main issue with this design was width of the garage had to be double the width of the door [1].

Eventually, in 1921, C.G. Johnson invented the overhead folding garage door. The garage door saved space and made opening and closing more convenient with an automatic garage door opener [1].

As time went on, garage door materials progressed with technology. Originally, garage doors were composed of wood. Wood weathers easily and requires scraping and painting every couple of years[1].

The next material, in the 1970’s, was galvanized steel. Galvanized steel is steel that has gone through a chemical process to keep it from corroding [2]. The steel was not a great insulator, but two pieces of steel could be put together and filled with polystyrene for insulation [1].

Today, garage doors are composed of composite filled wood covered by aluminum sheeting. Aluminum sheeting was chosen due to the use of aluminum siding on houses for good resistance [1].

A garage door that is extrusion blow molded out of rigid PVC will eliminate the use of various materials, cut back on production costs, and decrease the amount of time it takes to assemble a section of a garage door section. The sections of this garage door would fit together with an open tongue and groove, much like the tongue and groove that is used on the existing aluminum garage doors. The sections of the garage door would be connected with the same steel hinges. The inlays and texture that are typically on the garage doors will be included in the design of the mold. Once the material is extrusion blow molded, a foam material will need to be injected to add stability and for insulation purposes. Ribs can be incorporated in the rear of the door to act as the aluminum supports that are there to prevent the sections from buckling. The garage door will require less workers, time, and material to be made. The secondary operations of this product will consist of trimming flash, and injecting foam into the finished section. Installing this type of garage will be the same as the installation of aluminum garage doors. Figure 1 shows an isometric view of the garage door panel.

Figure 1 – Isometric View of a Plastic-Garage Door Section

Statement of Theory and Definitions

Extrusion Blow Molding Machine and Mold

Extrusion blow molding is a high volume production process and is generally the most economical process for making plastic bottles. This method of blow molding is the oldest method of producing plastic bottles. It is also
the most common process used today to make plastic bottles [3]. The most common bottle made by this process is the milk container. Extrusion blow molding is a process done with materials that have high melt strength, such as HDPE. Melt strength is defined as the measurement of strength a plastic material has in its molten state [4].

There are generally two stations on an extrusion blow molding machine. In the first station the parison, a hollow tube of plastic, is extruded and cut. The second station is the blowing station, where air is injected into the mold to push the parison against the mold walls.

Material starts out by being put into a hopper that leads the material to a screw. A hopper is a funnel like object that directs the material in pellet form to the barrel of the machine. In the barrel the material is melted, mixed and conveyed by the screw. The screw reciprocates continuously to convey material to the front of the barrel, or to the die and mandrel.

Extrusion blow molding is a method where a material is extruded as a parison. The parison, which is formed by the die and mandrel, is extruded vertically downward. The die forms the outside of the parison where the mandrel creates the inside of the parison. There are two types of dies, a converging die and a diverging die. Figure 2 shows a cross section view of a diverging and converging die.

Figure 2 - Diverging and Converging Die (From The Blow Molding Process Guide)

When the mold closes over the parison, flash is created at the top and bottom of the part, and in some cases, on the sides. Flash is the excess material that is pushed out of the mold where the two halves come together or in this case the extra material from the parison that the mold clamps up on. This section of the mold is known as the pinch off point. This part of the mold seals the parison so it can be blown into its final shape.

Once the parison is extruded, the mold closes over the parison. A blow pin or a needle is inserted into the mold and blows air into the center of the parison to push the material against the mold walls. The mold opens and then the blow pin moves upward out of the way. This also allows for the part to be stripped off of the blow pin.

Figure 3 shows the steps of an extrusion blow molding process.

Blow pins are used on parts with large diameter openings, such as bottles. Usually, a blow pin will create the inside of the neck of a bottle. When this happens, cold air needs to be blown through the pin in order to allow the neck to cool. When the neck is formed by a blow pin, threads are generally created by compression with the mold and the blow pin.

Blow pins are more commonly used with wheel type machines. Blow pins leave very tiny diameter openings in a part to blow it up. Figure 3 shows the steps of an extrusion blow molding process.

Figure 3 – Steps of an Extrusion Blow Molding Process (From Custompart.net)

A mold for extrusion blow molding is generally much cheaper than an injection mold or a compression mold. An injection mold usually sees much higher pressures than that of an extrusion blow mold. This means that an extrusion blow mold can be made out of a cheaper material, or even just be thinner to save money. Also, an extrusion blow mold does not need to have an ejection system to push a part out of mold.

Advantages and Disadvantages of Extrusion Blow Molding

The first and most important advantage of extrusion blow molding is the ability to make complex hollow parts or bottles at a relatively cheap cost. Extrusion blow molding has the ability to produce a bottle with a handle and/or an offset neck.

The difficult ability to create a perfect uniform wall around a bottle or complex part is another disadvantage in extrusion blow molding. Parison sag and blow ratio are the two main factors that make this task difficult. Parison
sag is the effect on the parison due to gravity. The longer the parison, the heavier it is, the more will sag, creating the section of the parison closest to the die and mandrel to be the thinnest. The blow ratio is the length the parison has to be stretched to reach the wall of the mold. The greater the difference in diameter of the part, the greater the blow ratio it creates. If the part is not symmetric, wall variation will differ significantly. The use of the parison programmer can account for these issues. The parison programmer moves either the die or mandrel to adjust the thickness of the parison wall. In some cases ovalized head tooling is used to correct for a varying uniform wall thickness. There are two types of ovalized head tooling. The first type is uniform thickness, where both the die and mandrel are ovalized. Non uniform thickness tool is when only the die or mandrel is ovalized and the other is circular. In this experiment a non uniform tool was used.

Back Round and Product Specification

The overall goal of this design project is to successfully design a garage completely out of plastic. This garage door panel will be extrusion blow molded. This product will also cut down on the costs and materials of garage door assembly.

This product will be expected to withstand weathering, wind and applied forces, and various temperatures.

Plasiti-Garage will be a huge competitor with the existing garage door assemblies. This project is a redesign of existing composite and aluminum garage doors to a garage door comprised of only plastic.

Design Details

Design Requirements

The critical dimensions for the “Plasti-Garage,” are the overall dimensions such as the height, width, depth, and the thickness. The critical dimensions are shown below in Figure 4.

Figure 4 - Overall Dimensions of Plasti-Garage

The overall width of panel raises concerns about the varying thicknesses from one end of the panel to the other. The panel will be extruded so that the panel will be oriented in a vertical fashion, shown in Figure 5. The main concern with this orientation is parison sag. As the parison is extruded it becomes heavier and the effects of gravity create a thinner parison closest to the extruder. This will cause a variation in the wall thickness of the panel.

Figure 5 – Orientation That Plasti-Garage will be Extruded

Structural Design Factors

Ribs are commonly added to a part to add rigidity to a product. However, in extrusion blow molding it is difficult to get ribs to pull out of the mold. To add rigidity to a part that is extrusion blow molded corrugation must be incorporated into the design. Corrugation is incorporated into the rear of the panel, or what would be the inside face of the garage door.

A tack off point is another feature that was added to the design of this project to add rigidity. The tack off points are points on the part where each side is pushed together to add rigidity. In this case, the tack off points is incorporated on the inlays of the panel. Figure 6 shows where the Plasti-Garage incorporates the rib and tack off points in a sectioned view.

The tongue and groove like sections located on the top and bottom of the panel are used for a locking mechanism when the completed four sections are stacked on top of one another. This tongue and groove is designed so there is play when the two panels are locked together. This allows the panels to move when or bend upon opening and closing of the assembled garage door.
The Material

When choosing a material for this product the key properties that were examined were mechanical, weather ability, color ability, and cost. After analyzing several materials PVC (polyvinyl chloride) is the desired material for this product. This amorphous material is the third most produced material. This material is commonly used in outdoor housing application such as, siding, decking, and soffit and fascia. PVC is a relatively cheap material that is roughly $1.05 per pound. This material’s mechanical properties and weather resistance will make it good choice for a garage door.

Secondary Operations

Removing flash from the sides of the panel will be the first operation that will need to be performed. Flash will be on sides of the panel due to the orientation of the panel when it is extruded. The flash is created by the pinch points in the mold. These pinch points seal the parison to allow parison to blow up and take the shape of the mold.

Once the flash is trimmed from the panel, the Plasti-Garage will be filled with expandable polyurethane foam. The foam will help insulate the garage from out door weathering. The foam will also add rigidity to the panel.

Surface Finish

Extrusion blow molding is typically known to have a poor surface finish. However, this will not affect the quality of the exterior finish. A wood surface finish will be put in the mold to create a wood texture on the exterior surface of the panel. This will also give the panel the effect that the door is painted wood.

Presentation of Design

The first step to test the Plati-Garage under ideal conditions was to find the average wind speed. Research shows 15 Mph to be the highest wind speed in most cities. Calculations were performed to turn 15 Mph into force acting on the garage door panel. 15 Mph is calculated to be .09135 psi on the garage door. Calculations are shown below [5].

Use to find area:
Area=Height * Width
Area=(7ft)(1.67ft)=11.6ft²

Use to find Pressure:
Pressure=0.00256*Wind speed²
Pressure=0.00256*(15Mph)²=0.576

Use 2 for a drag coefficient for a flat plate.

Use to find the Force:
Force=Area * Wind Pressure * Drag Coefficient
Force=(11.6ft²)(0.567)(2)=13.1544Psf

Conversion:
13.1544 Psf*1/144psi=0.09135 psi

The model was then imported into Ansys Workbench to run an analysis. The material used in the analysis is PVC, and common material properties have been properly added to Ansys Workbench. Plasti-Garage is being tested assuming a hollow part. However, once tested with the foam filled polyurethane the panel will be more rigid. Fixed supports have been inserted to the top, bottom, left, and right side of the panel. The 0.09135 psi force has been applied to the front of the panel. Figure 7 shows the boundary conditions.
After running the analysis the maximum stress on the panel is about 50 psi. This stress is located along the bottom of the panel just below the inlays. Figure 8 shows the stress concentrations.

The maximum deformation on the panel is 0.0018 inches. This deformation occurs across the panel where the inlays are shown. Figure 9 shows the total deformation on the panel.

Figure 10 shows an isometric view of a Plasti-Garage Assembly.

Blow molding a garage door panel out of PVC will decrease assembly time and save money and materials. This product will weigh less and meet the strength requirements necessary. This product will also allow for less maintenance for a home owner. Unlike a wooden or steel door, this door will not rot or corrode making up keep nonexistent.

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References


