Traffic Light

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Introduction

The traffic light has been keeping moving vehicles organized, on the road, for over hundreds of years. Without them, traveling would be nothing like it is today. Traffic lights can be found in just about every town, city, and state. Almost all traffic lights seen on the road today are made of corrosion resistant aluminum and can consist of three components. The electrical controller, support arm, and traffic light housing.

The product that was evaluated and discussed in the following sections is traffic light housing. By replacing the aluminum housing with a PP the overall weight and cost of the traffic light can be reduced. These reductions can be found by evaluating the design, tooling, and manufacturing details.

The creation of the plastic housing will be produced my extrusion blow molding, rather than the previous aluminum die casting. Also secondary operations will be reduced because of the smaller amount of assembly operations. In the end, the goal is that this plastic housing will be better when compared to the aluminum housing.

Statement of Theory and Definition

The first traffic light was installed in London, England, in 1868. It was manually operated and consisted of two gas lamps that were red and green, which signaled drivers to stop or go. Shortly after installing it, the lamp actually blew up and killed a policeman. Because of this, improvements were quickly made. [1]

The first electric traffic light was created in Cleveland, Ohio, in 1914. This traffic light still only consisted of a green and a red light and a buzzer would go off to indicate the light was about to change. Shortly after this, in 1918, the traffic light we are all familiar with today was created in New York City. It consisted of green, yellow, and red lights and was manually operated with observation posts in the middle of the street. [1]

With today’s technology and resources traffic lights have a good chance at becoming more sophisticated and advanced. This is why by creating an extrusion blow molded housing will be easy and more efficient than the previous designs.

Extrusion blow molding allows for the creation of hollow thin walled parts such as a variety of different shaped bottles, containers, and drums. These types of parts would be nearly impossible to create by injection molding because of their hollow nature. Extrusion blow molding is especially popular in packaging to provide storage and protection to many everyday items.

The extrusion blow molding process begins with the material being loaded into a hopper. From the hopper throat, the material is filtered into an extruder screw channel, and begins the feed phase of the process. Once on the screw and within the barrel of the machine, the plastic material is heated to a molten liquid state, which is done during the metering phase. A well designed screw will lead to a better mixing and melting of the material. The screw, driven by a variable speed, rotates to force the molten plastic material forward through a die head and mandrel. Two die heads that are used can be seen in Figure 1, which illustrates a diverging (left) and a converging (right) die head. [2] Typically diverging die heads are used when the products diameter is greater than 152.3 mm (6 in) and a converging die head is used when the diameter is less than 127 mm (5 in).

![Figure 1- Courtesy of Michael Thielen](image)

Once the material is forced over the mandrel it exits over a ring-shaped section at the end of the die that is known as the die land. This is the area of the die where the area is kept constant. A longer die land will increase back pressure on the melt in the extruder head and improve the mixing of the material. [3]

After this the material is extruded into a hollow tube known as a parison, which hangs in the air. This tube should have uniform wall thickness, in most cases, depending on the final symmetry of the part. For example, if the part has an offset neck, the parison might be thicker on the side where the mold wall is furthest away to compensate for the extra stretching so that the final part has wall thickness uniformity. The parison is influenced by gravity, which can lead to sagging or a parison with a thicker bottom and thinner top. The final part may have a thicker base and thinner top. [3] If this occurs, it can
greatly impact wall thickness and quality of the final product.

Once the parison is extruded to the desired length, a dual cavity mold closes on the parison, which is illustrated in Figure 2, Step 2. The parison must be extruded just passed the depth of the mold so that when the bottle is pinched off it will create a seal for the blowing phase. A blow pin then blows the parison to shape, like a balloon. The material then extends to the mold walls, where is it cooled to maintain its rigid shape. Like injection molding, the mold is cooled by water lines to help solidify the plastic material and lock in its orientation.

![Figure 2](Courtesy of Michael Thielen)

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![Figure 3](Courtesy of Norman C. Lee)

Intermittent extrusion blow molding is achieved by extruding the parison one at a time rather than continuously. This can be done by either using an accumulator or a reciprocating screw. The advantage to this process is that you can extrude the parisons faster, which does not allow the parison to sag as much as it would in a continuous process.

One major advantage of the extrusion blow molding process is that the overall tooling cost is lower because it does not require high pressures like injection blow molding. Also the process only calls for a mold to be made for the blowing stage rather than two molds for both the blowing and preform creation stages like with injection blow molding. This leads to a lower overall part cost.

Another major advantage of extrusion blow molding process compared to other blowing processes is that the part size is virtually unlimited. This is partially because of the low tooling cost and the parison is extruded rather than separately molded like in injection blow molding.

A third advantage is that products can be made in high volumes because of the continuous nature of the process. This is why extrusion blow molding is so sufficient and beneficial for the packaging industry.

A major disadvantage of the extrusion blow molding process is that variations in wall thickness can be present if the part geometry contains deep draws. This is because the plastic will be stretched more to reach the deep draws. The more the parison is stretched the thinner the wall thickness will be in those areas. The parison will need to be thicker to accommodate these types of geometries.

Another disadvantage of the extrusion blow molding process is that the surface finishes of the products is limited and does not have as great of quality like the products from injection blow molding. Also the geometry...
of the products is rather limited, due to the fact that small features can not be created with extrusion blow molding.

A major disadvantage is that there is much more scrap created with extrusion blow molding because of the need to trimming of the sprue, head, and tail flash. [5]

Another disadvantage is that the parison in extrusion blow molding can experience sag, which is caused by the weight of the parison and gravity. This can cause major problems with the uniformity of parts wall thickness.

The material that will be used for the traffic light will be polypropylene (PP). PP is a great material for this specific application because it provides good weather ability, which is very important since the traffic light will spend almost its part life outdoors.

PP is semi-crystalline material, which means that naturally by its chemical structure, it is chemically resistant. The crystals act like a barrier and make it harder for damaging chemicals to break up the polymer chains.

Another advantage of PP is that it is easily processed and is highly available, which are both very important in order when creating a successful product. PP is also a low density material, which means it is light weight and is relatively cheap compared to other plastics. This light weight is an advantage because the material is bought by weight and sold by volume.

Also PP can be easily printed on and machined. This is good for the traffic light because the holes where there lights will be need to be drilled out before the electronics can be put into place.

A big disadvantage to HDPE is its ability to easily creep. In other words, if a load is placed on top of the box part it is susceptible to sagging under the load over time. However, additives or fillers can be added to the material to give it more rigidity and stiffness.

Another disadvantage is that it can be degraded by ultraviolet (UV) rays. This can cause weakened mechanical properties and a discoloration of the material. However, a UV coating can be applied to the part, which will help prevent this problem.

**Design Validation**

The plastic traffic light will first be judged successful if the part meets all design goals and specifications. If the part does not meet these goals and specifications the design will initially be deemed a failure. Should the design goals not be met the part design and qualifications will need to be redefined.

The new design should meet a weight reduction goal of 10% compared to the aluminum traffic light currently seen on the streets. This weight reduction will be verified by evaluating the 3D models’ volume in Pro Engineer Wildfire 5.0 and calculating the mass using the materials’ density. These calculations will be cross referenced with Ansys 13.0 mass calculations for accuracy.

**Design Procedure**

The design procedure started with brainstorming the basic design and functionality of the traffic light and its components. The most important step was to decide how to make the traffic light unique compared to its current industry counterpart that is made out of aluminum. The wall thickness of the part is 3.175mm (0.125in). A unique quality incorporated into the design was the smooth rounded edges, which give the part more rigidity and places where stress concentration can occur. (Figure 4).

Also 2° of draft was also applied to the short flat sides of the raised surfaces so that the part can be easily ejected without sticking in the mold. The holes for the tinted glass or plastic lenses will have to done with a drill as a secondary operation. The dimensions for these holes can be seen in Figure 5.

Also the hole on the top of the traffic light represents the parison diameter. It was decided that an appropriate parison diameter is 127mm (5in). The outside diameter of the traffic light is 381mm (15in). This makes the blow
ratio 3:1, which is a typical blow ratio used in extrusion blow molding.

The final step in the design procedure was the testing of the plastic paint can in Ansys 13.0. The mesh for the three dimensional (3D) Ansys model had an element size of 10mm (Figure5). The relevance center was Course as not to exceed the required number of nodes and elements (Figure 6).

**Presentation of Design**

The final part design surpassed all the goals and specifications outlined before the design process was started. The weight of an aluminum stop light housing is usually around 10 lbs. The weight of the plastic stop light was calculated to be 7 lbs. The final part weight was reduced by 30% due to the lower density of the PP. The reduction of weight can lead to lower fuel emissions from transportation trucks which can aid in the ongoing campaign to create a “greener” environment.

Since traffic lights can be exposed to outside forces it was necessary to evaluate the stress that can occur in a severe situation. For example, the severe situation that was evaluated was winds blowing up to 100 mph. This would apply around 103.3 kpa (15 psi) of force on one side of the traffic light. The analysis run in Ansys can be found in Figure 7.

![Figure 6- Mesh statistics & Meshed Part](image)

![Figure 7- Equivalent Stress & Total Deformation](image)

In Figure 7, assuming the top will be fixed on the post overhanging the intersection, it can be seen that only 2289 kpa (332 psi) of stress is present with a 103.3 kpa (15 psi) force being applied. Also the deformation chart shows that the traffic light will deform about 1.78mm (0.07in).

**Conclusion**

The new modernized traffic light can provide all the same functions as an aluminum traffic light. Also the traffic light produced an acceptable amount of stress and deformation when analyzed in Ansys. The weight was reduced by a total of 30%. The improved PP traffic light also is easier to process and assemble than the current aluminum traffic light. The process extrusion blow molding process is much faster and efficient that the current aluminum die casting and can save time and money.

**Appendix**

An additional drawing file with overall dimensions of the traffic light appear on the following page.

**References**

Overall Dimensions of Traffic Light