Road Sign
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**Abstract**

The study verified the feasibility and capability of a blow molded road sign made of PP to replace the traditional aluminium road signs. The study utilized Pro/Engineer for the design of the sign and production mold. The computer software ANSYS proved that the plastic sign met each necessary structural requirement for road signs.

The final sign resembles a traditional sign, but due to the nature of blow molding the letters/images of the sign are able to protrude of the surface of the sign. The final sign is lighter, cheaper and easier to produce.

**Introduction**

A superior design for a blow molded road sign was created and tested in this study. The new road sign design is target to replace the current 60.96cm x 91.44cm road signs that are found on American roads currently. The driving forces behind the redesign of the standard 2 mm thick aluminium signs are cost, weight, and converting a metal product to plastic. Currently metal 60.96cm x 91.44cm road signs cost upwards of $65 and weigh nearly 3.18kg. This leaves much room for improvement to be made.

The purposed design will save on cost from material, transportation, and production. The material cost will be substantially reduced when the switch from 2 mm thick aluminium sheet to polypropylene. This is a very substantial competitive edge for the blow molded road sign over the traditional design. Also the density of polypropylene is roughly .9g/cm³ to 1g/cm³ which is another significant reduction from aluminium’s density of 2.70g/cm³. This allows for the additional volume of material in the purposed road sign design to be used while maintaining a favourable weight difference. Furthermore the part design inherently lends itself to decoration due to the raised letter/images that can be produced with blow molding. With all of these purposes in mind the selected material for this design is Vylene Ext Pt-bm-015 made available by Lavergne Group.

The design was created in Pro/Engineer, and from that design a mold was fabricated for production of the road sign. Also the part design was tested in ANSYS for structural integrity based on deflections under specified loading conditions. Being that no prototypes were produced for this study ANSYS was the best means for structural analysis available.

**Statement of Theory and Definitions**

Road signs are used to inform drivers of hazards, speed limits, and other traffic laws. Today road signs are produced from aluminium. Certain specifications for these road signs are created by the Manual on Uniform Traffic Control Devices (MUTCD). This makes sure road signs are recognizable all over the country by motorist.

Design goals for this product include weight reduction, cost saving, load to withstand, chemical exposure, heat exposure, and life expectancy. The blow molded sign made out of polypropylene will weigh 2.270 kilograms compared to the 3.178 kilogram aluminium sign. This weight reduction cuts material and shipping costs. By saving material the cost for the blow molded product is cheaper than the aluminium sign. The cost for an aluminium road sign is 64 dollars compared to the 13 dollar blow molded sign. This can cut down costs for contractors and other departments of transportation. The load chosen for this blow molded sign was based on 88 kilometers per hour (kph) winds which equates to 344 Newton’s per square meter (Pa). The polypropylene sign only deflected 0.415 centimeters. This deflection equates to .54 percent strain onto the blow molded sign. This does not exceed the suggested strain limits of .72 percent for PP.

Some chemicals that potentially could be exposed to the blow molded sign would be precipitation, oils, and gases. Acid rain has a pH level around five which makes it a slightly acidic liquid. As said by Ashenden, “Sulphur dioxide and nitrogen oxides are the main pollutant gases responsible for increasing acidity of rainfall” [1]. The guide to the effect of chemical environments on plastics states that polypropylene will see no affect from this slightly acidic liquid. If a motor vehicle would happen to somehow splatter a sign with oil or gases this will not be a problem. This is due to polypropylene’s good chemical resistance against oils and gases [2]. Due to signs being used all around the world the temperature range for the blow molded sign varies considerably. Temperatures range from -40°C to 75°C where chosen to induce the most stress on the blow molded sign. The only disadvantage compared to the aluminium sign is the life expectancy. Aluminium signs are rated for a ten year life expectancy while the polypropylene sign’s life expectancy is only two to three years. The life expectancy is only two to three years due to ultraviolet rays (UV) from the sun will eventually degrade the material. The material degrades the sign will fade and lose reflective
properties. Reflective properties are needed to pass government and department of transportation regulations. This degrading can be slowed by adding UV stabilizers and paint to the polypropylene sign.

Competitors for the polypropylene blow molded sign include the original aluminium sign. Gaining acceptance into new market venues usually is difficult, and will be the greatest obstacle to overcome in order to sell the new sign. Also electronic roadside message boards are an alternative product to the new blow molded road sign, but they are very expensive. Usually message boards are only necessary when instructions to drivers are very lengthy. This subtle difference makes the blow molded road sign only a slight competitor with the message boards.

Extrusion blow molding will be the process used to create the blow molded sign. Extrusion blow molding uses an extruder to melt pellets which are feed to a die and mandrel. The die and mandrel create a hollow tube of plastic called a parison. As this parison descends it is clamped onto by two mold halves. As the mold halves close the material is pinched off so air can be introduced into the parison. Blow pins and blow needles are used to introduce the air into the parison. The air pressure allows the parison to come in contact and take shape of the mold. The cold mold walls cool the part for ejection [3].

Today road signs are produced from 2 mm aluminium. A film sheet for silt screening is cut to the specifications of the government to create the signs logo. The aluminium sheets are cut to the proper dimensions using a computer aided drafted (CAD) plasma cutter. A punch press rounds the corners and a drill creates the bolt holes. A chemical bath removes oils and grease from the aluminium sheet. Also the aluminium sheet undergoes an acid bath to reinforce weathering properties. Silt screening paints a reflective coat onto the aluminium sign for the final product [4].

The blow molded sign will use Vylene ext pt-bm-015 a blow molded polypropylene copolymer with talc filler. Also a UV stabilizer is used for prolonged exposure to the outdoors. Some key advantages obtained with this material are as follows. Good dimensional stability, good impact resistance, good processing characteristics, good stiffness, and good UV resistance [5].

Design Validation

The blow molded road sign has to meet substantial requirements in order to be worth pursuing. It will not be feasible to replace the traditional metal signs if these specifications are not met; withstand 88kph winds without deflecting 1 cm, endure impacts of 50N without failure, maintain government requirements for optical properties, weigh less than or equal to 2.270 kg, cost less than what is used today, resist all the chemicals fore mentioned (acid rain, oils, and gases) for 3 years, withstand temperatures from -40°C to 75°C, and have a life expectancy of 3 years.

It is possible prove all of the structural requirements with the use of ANSYS. Also a rough estimate of price can be obtained through material costs and standard mold prices. Many properties of PP fulfil the requirements of the sign. Things like chemical resistance and temperature come from the use of PP and will not pose an issue to the blow molded road sign. The optical properties of the sign will require a prototype to be made to accurately test the design. Furthermore accelerated weathering techniques can be utilized to simulate long term weather of the signs.

Design Procedure

Speed limit signs follow a simple design and a commonly used sign on the road today. The part is assumed to have uniform wall thickness, but note that during production certain areas will be thicker or thinner due to varying blow ratios. The lettering could be made having it either recessed into or protruding out of the part sign face. Having the lettering protruding out of the sign face provides an optical advantage over recessing letters. Also having the numbers protruding out of the sign face will help facilitate in the decoration of the letters/images of each sign. This will greatly reduce the amount of effort necessary to decorate two tone road signs.

The part surfaces have been drafted two degrees to ensure that ejection of the part will not be an issue. Another aspect that could pose an issue if not addressed is the blow ratio of the part. If an ovalized die and diverging mandrel were used which resembled the sketch found in Figure 1 it would be possible to reduce the blow ratio to 2:1. A 2:1 blow ratio is well within suggest blow ratios for parts made with extrusion blow molding and would provide for repeatable part quality.

Figure 1

If interchangeable inserts were used to make the letters/images, it would be possible to produce the same overall size sign with different messages. Having the interchangeable inserts will reduce the amount of molds needed for producing the gamut of road signs found on today’s roads.

When the part was finished a few different iterations where done in ANSYS. Test settings
where based off of 88 kph winds and a 344 Pa force that would be seen by a bird. The first iteration was done with no lettering. This was done to understand how the lettering affected the results of the part performance. The first iteration was with no rounds at the intersection of the letters and numbers to the walls. The test showed large stress concentrations at the intersections where the numbers and letters met the wall. When the rounds were added in the next iteration it decreased the stress concentration in those areas. The last iteration was done with different lettering to see how it influenced the results. Changing the lettering and numbers did affect the results, but not enough to cause a concern in part’s structural performance.

Presentation of Design

The speed limit sign that is to be extrusion blow molded has the same overall dimensions as the current signs except for it is 2.54 centimeters thick. The color of the signs can be matched to what they currently are, and due to the letters/ images being raised they will be far easier to decorate. The mounting of the sign to the pole would be the same as what is currently used and would not be a problem structurally for the sign. The only problem that could be foreseen is the use of reflective vinyl graphics. To obtain the necessary reflective properties in the new road sign design it might be insufficient to use paint. An alternative to paint would be the use of a vinyl decal, but this would cause an increase in production cost. Also this would negate most of the benefit of raising the letters off of the sign face.

The loads considered for the structural analysis of the road sign were 344.7 Pa as well as the 50N impact. These loads could be experienced from 88kph winds and the impact of a bird, respectively. If the part was to be produced results may vary from the ANSYS simulation results, and this is only a useful tool for estimating performance. To achieve accurate results from ANSYS a fine mesh needed to be generated which can be seen in Figure 1. The mesh had 100263 elements and 214003 nodes. These statistics where generated using a .00635 m element size and proved to be detailed enough to provide accurate results for this study.

Extrusion blow molding has many assumptions made such as the materials viscosity down the parison as well as its thickness down the parison. This assumption that the viscosity and wall thickness down the parison is uniform can cause both an over and under prediction of the parts strength. This is due to wall thickness playing a large role in the parts strength. If the parts wall thickness is thinner than what is assumed part failure will occur early than predicted and vice versa.

Many iterations where made on the parts design and each iteration sought after improved results or part attributes. The weight of a current road sign is 3.178 kg and the final design weighed 2.270 kg. This weight loss will help save money in assembly of the road sign since it will be easier to handle. Also a thinner post can be used to erect the sign. The first iteration was done with a blank design to help estimate the wall thickness needed to achieve the desired weight. The boundary conditions and total deformation results can be seen in Figure 1 and Figure 2. The results seen from this iteration showed a likely hood that this process of producing road signs using extrusion blow molding could possibly be done.
The next iteration was done with lettering and assumed wall thickness of 0.318 cm. Decreasing the wall thickness by a quarter of what it was in the first iteration gave the part a similar weight of what is used now. The results that were provided by ANSYS showed that the sign would pass 88kph winds with a deformation of 2.25 cm. The results and boundary conditions can be seen in Figure 4 and Figure 5. The weight however was not at the desired point so an additional iteration was made to achieve the weight desired.

The last iteration achieved the target weight of 2.270 kg and passed with a 50N force and winds of 88kph. The total deformation due to wind forces was 0.0041m and from the 50N force 0.0081m. The wall thickness needed to achieve the weight and have these results was assumed to be at 0.254cm. The results and boundary conditions of both of these tests can be seen in Figure 6, Figure 7, Figure 8, and Figure 9.

Conclusion
The plastics industry has become an ever expanding and popular way to improve existing designs and save money. Metal products are continuously being changed to plastic to save money on material and the added benefit of weight reduction. The aluminium road sign weighing 3.178 kilograms is nearly an entire kilogram more than the blow molded polypropylene sign weighing 2.270 kilograms. This reduced weight will provide a
significant advantage when it comes to shipping, handling, and installation of the product. The greatest and most significant advantage to switching from aluminium to polypropylene is material cost. Aluminium road signs normally cost around 64 dollars whereas the predicted cost for a polypropylene sign is nearly five times less at 13 dollars. This price reduction potentially can have a huge impact across the board for the Department of Transportation letting them use this money for the increasingly deteriorating roads in America. The results shown from the ANSYS work shows that using this lighter, cheaper and environmentally friendly design can maintain the integrity of the road sign as well as inform the driver of what lies ahead. The money saved from using this road sign can be used in many more places in which it is needed.

**Future Work**

Prototyping this product would be fairly simple and could be made through wooden twin sheet thermoforming. This would help in determining how the product will be fastened to the pole and anchored into the ground. Before production begins further iterations of the design should be done to optimize the structural performance and amount of material used in this sign. Special attention should be used to ensure that the sign can meet reflective and optical requirements for road signs.

More research into the government requirements of road signs should be done and the design should be altered to set a new standard and become a market leader. As state previously once production of this product is able to start ovalized diverging tooling can be created and an aluminium mold that has steel inserts around the pinch off area can be created.

**Acknowledgements**

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**References**


Die and Mandrel (square is part reference)
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Speed Limit Sign

Bradley Korash

Material: Plastic
Date: 30-Mar-11
Rev: C-XXX-XXX-XX
PDF compression, OCR, web optimization using a watermarked evaluation copy of CVISION PDFCompressor
PDF compression, OCR, web optimization using a watermarked evaluation copy of CVISION PDFCompressor
Product Description
Vylene EXT PT-BM-015, blow molding grade, 15% talc filled, 260 Kpsi flexural modulus polypropylene copolymer, UV stabilized for long outdoor exposure has an excellent balance of dimensional stability, stiffness, and impact resistance.

General
Material Status: Commercial, Active
Availability: North America
Filler / Reinforcement: Talc Filler, 15% Filler by Weight
Additive: UV Stabilizer
Features: Copolymer, Good Dimensional Stability, Good Impact Resistance, Good Processability, Good Stiffness, Good UV Resistance
Uses: Outdoor Applications, Structural Parts, Swimming Pools
Forms: Pellets
Processing Method: Blow Molding

Physical
Specific Gravity
Nominal Value: 1.01
Unit: g/cm³
Test Method: ASTM D792

Melt Mass-Flow Rate (MFR) (230°C/2.16 kg)
Nominal Value: 0.80 g/10 min
Unit: g/10 min
Test Method: ASTM D1238

Ash Content
Nominal Value: 15%
Unit: %

Mechanical
Tensile Strength (Yield)
Nominal Value: 3630 psi
Unit: psi
Test Method: ASTM D638

Flexural Modulus
Nominal Value: 260000 psi
Unit: psi
Test Method: ASTM D790

Impact
Notched Izod Impact
Nominal Value: 15 ft-lb/in
Unit: ft-lb/in
Test Method: ASTM D256

Gardner Impact (-22°F)
Nominal Value: 40.0 in-lb
Unit: in-lb
Test Method: ASTM D5420

Revision History
Added to Prospector: June, 2002
Last Updated: 12/22/2008

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