A COMPARISON AND CONVERSION GUIDE

UPGRADING METAL TO PLASTIC THERMOFORMING

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“Metal versus plastic is an old argument and it’s likely that you or your company have already compared them for utilization in past projects. However, innovations in plastic materials, composites, and process capabilities, coupled with changes in industry demands have closed many of the physical and cost performance gaps that once existed between metal and plastic. Now companies are taking advantage of the clear benefits of thermoplastic for many industry applications by upgrading their metal components to plastic thermoforming.”

Evan Gilham
Chief Operating Officer
Productive Plastics
PROCESS OVERVIEW

Sheet Metal Fabrication Process

Sheet metal fabrication is a manufacturing processes that shapes a piece of sheet metal into a desired part shape with techniques such as material removal and/or material deformation. Various machinery is used to cut, bend, or stretch the sheet metal to design specifications. Multiple part assembly is accomplished by welding, adhesive bonding, riveting, fastening, or a crimped seam.

Depending on the surface finish desired, additional operations such as weld cleaning, sand blasting, paint preparation (priming), polishing, or surface painting may be required.

Most sheet metal applications start with a raw material sheet thickness, or gauge, of between 0.006 and .250 inches thick. The size of sheet metal parts can range from a small die cut component, midsize enclosure, or large aircraft wings.

Other metal processes include metal stamping, metal spinning, and metal casting manufacturing.

Process Quick Reference

1. Fixture/die construction
2. Machinery programing
3. Cutting, bending, stretching of material
4. Welding, fastening, or other assembly
5. Cleaning welds, sand blasting, surface preparation
6. Surface finishing or painting

Common metal fabrication materials include:

- Aluminum
- Magnesium
- Tin
- Brass
- Nickel
- Titanium
- Bronze
- Stainless steel
- Zinc
- Copper
- Steel
- Titanium

KEY POINTS

- Low-cost parts for designs with simple geometry
- Any design complexity requires additional assembly steps, machinery production time, and cost
- Multiple processing steps required even for simple shapes
- Limited design freedom
- Painting required to avoid rust or oxidation
PLASTIC THERMOFORMING Process (Heavy Gauge)

Plastic thermoforming is a manufacturing process used to create formed plastic parts. There are multiple techniques within thermoforming. The two most common are vacuum forming and pressure forming.

The process begins by applying heat to a sheet of formulated thermoplastic. The now pliable thermoplastic is then stretched onto a temperature controlled mold to conform to a desired three-dimensional shape or part. This is accomplished through the application of either vacuum or positive pressure (vacuum forming or pressure forming).

The selection of vacuum forming or pressure forming techniques depends on the requirements and characteristics of each application.

Once the part has been formed in the mold, it is then removed and any excess material is CNC trimmed to exact design specifications.

Secondary operations, if required, such as painting, silk screening, additional assembly, or attachment point bonding are accomplished to complete a finished part.

KEY POINTS

- Fast part processing times
- Process largely automated
- Tight tolerances and consistent part dimensions
- Complex part shape and geometry capable with little impact on lead time and cost
- Ideal for part runs from 250 – 10,000 EAU (estimated annual usage)
- Environmentally safe
- Wide range of materials and properties available
**Process Quick Reference - Vacuum Forming**

1. Thermoplastic sheet is secured & heated to forming temperature
2. Heated plastic sheet is placed over the mold face
3. Air is evacuated from the mold, pulling the plastic onto mold surface
4. Part removed and CNC trimmed to specification

**Process Quick Reference - Pressure Forming**

1. Thermoplastic sheet is secured & heated to forming temperature
2. Heated plastic sheet is placed over the mold face & covered
3. Air is applied above the mold and vented below to form shape
4. Part removed and CNC trimmed to specification

*Click on the image for 1 min video demo of the heavy gauge vacuum thermoforming process*
METAL VS PLASTIC THERMOFORMING

Weight Considerations

Heavy weight is high cost

This has been a tenet in the aviation industry for a long time and is slowly being adopted by rest of the transportation and other industries as a factor affecting operating costs and environmental impacts are examined. Lighter weight offers savings in both fuel and energy consumption, and decreases carbon footprint and operating costs. For example, a reduction of 800 lbs (~360 kg) to an average city transit bus can equate to a 2-3% savings in fuel consumption, according to a 2010 study conducted by the U.S. National Highway Traffic Safety Administration. Additional benefits are a tangible increase in the life of vehicle components, such as brakes and propulsion systems.

PLASTIC THERMOFORMING

Plastic thermoformed parts are 6 times lighter than steel and half the weight of aluminum.

A lower specific gravity translates to a relatively lower finished part weight. See some specific gravity data below for common metal and thermoplastic materials. For more specific information, you can reference material product data sheets that are available on most material provider’s websites. You can also reference other online sources on metal and thermoplastic for generalized material data.
PROCESS AND MATERIAL PERFORMANCE COMPARISONS

Production/Lead Time

METAL

Metal is an inherently difficult material to manipulate from a component manufacturing perspective. This is a trade off from one of its greatest qualities, its strength and rigidity.

To achieve a desired part design, metal often requires multiple manufacturing techniques be applied to a single part such as bending, stamping, welding, forming, and assembly. Each of these techniques typically utilize a specific type of machinery which equates to a single part being cycled through multiple processing machines to complete a single component. Combined with the added labor of transitioning between machines and processes, the result is an increase in production and lead times, plus additional costs associated with complex processing. Automation technology and advanced machinery can be utilized to somewhat reduce production time.

PLASTIC THERMOFORMING

In the plastic thermoforming process, most of the design features, part geometry, surface texturing, branding, and even some attachment fixtures are incorporated into a component’s tooling and it is a rare case in which more than one tool is required for a single part or production run. Average cycle times are less than 15 minutes per part. In many cases, integral colored plastic material can also eliminate the need for the additional process of surface painting.

This allows the plastic thermoforming process to produce high quality parts at consistent tolerances very quickly at a very competitive cost.

Order fulfillment and time to market can be affected by single component completion often requiring multiple processes and machinery which results in increased production and lead time

Single Component Production Cycle
1. Material cutting (independent machine – if req.)
2. Material bending (independent machine - if req.)
3. Material forming (independent machine - if req.)
4. Assembly or mating point hole drilling (independent machine - if req.)
5. Assembly (welding, fastening, bonding - if req.)
6. Surface preparation (sand blasting, cleaning - if req.)
7. Surface finishing (painting - if req.)
8. Single part completion (packing and shipping)

Most applications require only one tool, one process, and one machine to produce one part (if trimming is required, a second CNC machine is often utilized)

Single Component Production Cycle
1. Plastic material thermoforming (single machine)
2. Formed part robotic trimming (CNC machine - if req.)
3. Surface finishing (painting - if req.) (integral colored plastic can eliminate this process)
4. Single part completion (packing and shipping)

Temperature controlled aluminum tool used in plastic thermoforming
PROCESS AND MATERIAL PERFORMANCE COMPARISONS

Design Capability and the Effect on Cost

PLASTIC THERMOFORMING
Increasing part design complexity has a relatively minimal impact on the cost of a part manufactured with the plastic thermoforming process. This is because complex designs, shapes, branding, and surface textures can be incorporated directly into a part’s tooling. While this may add a slight increase in the upfront tooling cost, it will not add any additional secondary or shaping labor operations that would affect part cost or production time. Thermoforming also offers a much larger scope of design complexity capabilities and options that are unavailable to metal manufactured parts.

METAL
As mentioned in previous pages, shaping a metal part can require a number of separate processing techniques and equipment resulting in a greater potential for quality defects and a greater cost. So, as part design complexity increases, part cost and lead time also increase at a rapid rate. Even with today’s technology, metal’s characteristics can prohibit complex part designs or shapes, such as compound curves or fluid designs from either a material capability or cost limitation.
PROCESS AND MATERIAL PERFORMANCE COMPARISONS

Strength-to-Weight Ratio

**PLASTIC THERMOFORMING**
Advances in plastic composites and the addition of carbon fiber or other glass fibers to plastic material formulations have enabled specialized thermoplastic materials to have strength characteristics that can compete with metal at a fraction of the weight.

**METAL**
Metal and its alloys typically have very high strength properties. However, as with most material characteristics, a exceedingly high performance in one category comes with a negative impact in another. In this case, metal’s strength comes at the expense of increased weight.

**Strength to Weight Ratio**, also known as Specific Strength, is a material's strength (force per unit area at failure) divided by its density.

When referencing the chart below note that examples of thermoplastic reside in the composite and polymer categories and that this data may not include all thermoplastic material products, many of which are specially formulated to compete with metal and alloys in strength and stiffness. Data for these materials can be found on thermoplastic material manufacture websites.

*Source - By Nicoguaro - Own work, CC BY 4.0*
**PROCESS AND MATERIAL PERFORMANCE COMPARISONS**

**Strength to Stiffness Ratio**

**PLASTIC THERMOFORMING**

Just as with strength to weight properties, plastic composites and the addition of carbon fiber or other glass fibers to plastic material formulations allow thermoplastic material manufacturers to create materials with stiffness characteristics that can compete with metal at a fraction of the weight.

**METAL**

Similar to its high strength properties, metal and its alloys typically are very resistant to material deformation, also called stiffness. Again, this performance comes at the cost of increased weight. However, while metal may have greater stiffness than plastic it can dent upon impact where many thermoplastics absorb impact, typically without deformation.

**Stiffness to Weight Ratio**, also called **Specific Modulus or Specific Stiffness**, is a material’s property consisting of the elastic modulus per mass density of a material. This is a material’s ability to resist deformation in relation to its weight.
# Metal vs Plastic Thermoforming

## Material and Other Considerations

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<thead>
<tr>
<th></th>
<th>Thermoforming</th>
<th>Metal</th>
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<tbody>
<tr>
<td><strong>Industry Standards</strong></td>
<td>Material variants exist that meet industry standards for national and international Rail, Mass Transit, Aviation, Medical, and FST requirements (see individual material provider data sheets for compliance)</td>
<td>ASTM International has been the standards development for the metals industry for over 100 years. Thousands of ASTM standards cover both ferrous and non ferrous. These standards contribute to infrastructure construction projects as well as to the development and production of industrial and consumer items</td>
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<td><strong>Dent Resistance</strong></td>
<td>●●●●●</td>
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<td><strong>Sound Absorption</strong></td>
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<td><strong>Structural Strength</strong></td>
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<tr>
<td><strong>Design / Styling Freedom</strong></td>
<td>●●●●●</td>
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| **Surface Finish Capabilities** | • Painted  
• High or low gloss material caps  
• In-mold textured or patterned  
• Silk screened  
• Distortion printed  
• Plastic material pre-colored  
• High quality unfinished surface  
• Plastic material pre-textured | • May be painted or plated  
• Can be silk screened  
• Surface textures can be developed with grit blasting |
| **Process Volume Cost Feasibility** | Small – multiple thousand part runs (250—10,000) | Fabricating - as few as one up to 500 part runs may be produced. Automation may be involved, however, manual grinding and finishing will be needed. Stamping is an option with high tooling cost. |
| **Lead Times**         | Tooling and first part **6-8 weeks**               | Fabrication - fixtures and first part 4-6 weeks  
Stamping - tooling and first part 12-16 weeks |
| **Heat Resistance**    | ●●●○○                                              | ●●●●●                             |
| **Lightweight Material** | ●●●●●                                          | ●○○○○                              |

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**WWW.PRODUCTVEPLASTICS.COM**
Transitioning your product manufacturing process from metal to plastic thermoforming can allow you to capitalize on some major upgrades, benefits, and cost savings for your project.

However, the process of transitioning from one manufacturing material and process to another, and doing it correctly, may be more complex than simply handing over the existing design and tooling. Below are the basic steps and considerations for the transition process that Productive Plastics has found to help ensure you get the best results from the conversion.

1. Choosing the right plastic thermoforming manufacturer and process

Plastic thermoforming can be accomplished with either vacuum forming or pressure forming techniques. Consult with your thermoformer to aid in selecting the ideal process for your application. Visit our thermoforming process pages for more information on each process.

- Select a thermoforming contract manufacturer experienced in processing a wide variety of material options with a strong understanding of those material properties.
- Choose a manufacturer with experience in converting applications from metal to plastic thermoforming to avoid common pitfalls that can delay or increase the cost of the transition.
- Strong consideration should be given to a manufacturer with in-house design engineers. The onsite expertise will help to ensure a smooth technical transition from metal to plastic thermoforming.
- Select a manufacturer that is up to date with best practices such as ISO, Lean Manufacturing, Six Sigma, etc.

2. Adapting your existing product design to the plastic thermoforming process

Manufacturing techniques, process capabilities, and material properties differ from metal to plastic thermoforming. This is a good thing. The differences are what motivated you to consider converting your product in the first place. These differences will, more than likely, necessitate modifications to your existing design and tooling to meet your product’s needs and to maximize the advantages available with the thermoforming process.

A design engineer, with plastic thermoforming experience, can adapt your product’s design to harness the benefits of the thermoforming process. Productive Plastics utilizes its experienced in-house design engineers to help customers with process conversions.
PROCESS OF UPGRADING TO PLASTIC THERMOFORMING

3. Material selection
An important consideration when manufacturing a thermoformed plastic part is the selection of appropriate material. There are a multitude of different types of plastic materials, each with their own specific characteristics, properties, strengths, and weaknesses. Communicating your product’s requirements and industry material standards early in the conversion process will allow your thermoformer to assist in selecting the ideal material for the application.

Learn more about thermoplastic material properties and selection

4. Tooling
Properly designed and constructed tooling sets the foundation for tight tolerances and a high quality part. This becomes increasingly more important for complex and multi-part designs. Having your existing tooling evaluated by your thermoforming contract manufacturer as early in the transition process as possible can have a large impact on the lead time of your first part run.

Choose a thermoforming contract manufacturer experienced with tooling materials options and processes to assure the right tool choice for your application and product life.

Learn more about tooling for plastic thermoforming

5. Prototype testing
Prototype development should be considered with a testing plan that includes dimensional as well as properties evaluation. Engaging in early involvement, support, and collaboration with a thermoforming manufacturer, like Productive Plastics, can aid in creating a successful verification plan.
The team at Productive Plastics hopes that you have found the information in this comparison and conversion guide on upgrading metal components to plastic thermoforming helpful and useful in addressing your project’s manufacturing and performance needs.

We invite you to contact us at Productive Plastics for any additional information on the advantages of converting from metal to plastic thermoforming or to discuss solutions for your project’s design, development, or production challenges.

Our team of experienced engineers and manufacturing professionals are focused on providing you with design expertise, lean manufacturing processes, and excellent customer service to deliver you high quality plastic thermoformed parts that meet your time to market schedules and bottom line requirements.

Over 55 years of thermoforming, design, and manufacturing expertise

ISO 9001:2008 certified

On site painting facility

Secondary assembly capabilities

Lean manufacturing enterprise

READY TO GET STARTED?

Submit a Contact Request or call us and we will reach out to you ASAP to start providing solutions for your next project.

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For more technical information on designing and manufacturing with heavy gauge plastic thermoforming download our design guide.