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Technical Article

Thermoforming vs. Injection Molding:
Which One Is Right for Your Plastic Part?

	Thermoforming (Pressure Forming Specifically)	Injection Molding
1 Tooling Cost	($ $)	($ $ $ $ $)
2. Annual Volume	Ideal for low to medium volumes (hundreds to thousands) Also works well for parts with uncertain annual volumes, allowing you to gauge market interest without committing to expensive injection mold tooling right away (see also No. 10)	Ideal for high volumes (tens of thousands, hundreds of thousands, million+)
3. Cost (Direct) Per Part	($ $ $)	($ $)
4. Part Size	Although thermoforming can be well suited for smaller sized parts and volumes, the larger the part, the more economical thermoforming becomes	Larger parts can be cost-prohibitive; smaller, intricate parts at higher volumes become increasingly economical
5. Development Cycle Time	Time to market: possible in as few as four to six weeks (depending on part)	Time to market: possible in three to four months (depending on part)
6. Cosmetics	One side cosmetic detail. Molded-in custom color, features possible	Inherent cosmetic detail with molding imperfections: flow marks, gate marks
7. Geometry Changes (to tooling)	($)	($ $ $ $)
8. Part Trim Changes	($)	($ $ $)
9. Operations Required for Finished Part	Multi-step process: 1. Heated sheet applied to tooling using pressure, vacuum, or sometimes both 2. Part itself must then be trimmed to spec by CNC machine or hand-router 3. Possible glueing, subassembly, and kitting	Essentially a one-step process: Melted pellets injected in tooling become part using very high pressure; once it sets, the part is released
10. Initial Development and Prototyping	Risk related to factors like the following can be moderated by using this process initially: Product volume needs, Design of function (risk of changes), Required wall thicknesses for stiffness or load-bearing purposes, Projection of tolerance requirements	High risk/high expense process when volumes are unknown and/or other factors (see left) still require more certainty

Before we get to the 10 factors that will influence your decision, let's first cover the basics of each manufacturing method.

Thermoforming 101

Thermoforming can be divided into two main scenarios:

1) thin-gauge sheet thermoforming or roll-fed sheet thermoforming (primarily for packaging applications) and
2) heavy-gauge cut sheet thermoforming. Our discussion here is aimed specifically at heavy-gauge scenarios.

The process of thermoforming involves heating extruded thermoplastic sheet and then applying a force in the form of pressure, a vacuum, or, in some cases, both to form the sheet onto or over a custom 3D mold, often called the tooling (more on tooling below).

Note that this is a two-step (or more) manufacturing process. After the sheet is formed into a part, it needs to be trimmed using CNC equipment and a CNC trim program specifically developed to the part's requirements. Additional finishing steps may include painting, applying specialty coatings, and silk-screening.

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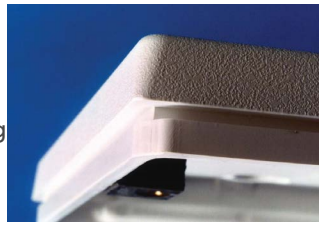
Three thermoforming methods

The specific type of thermoforming used depends largely on the requirements of the part's specifications. The three major types of thermoforming are:

Vacuum forming.

With this method, a vacuum pressure (14.7 psig) pulls the heated sheet onto a positive tool, negative tool, or a combination of both. Vacuum forming is especially effective for large, simple utility parts, such as covers, that have little detailing and no sharp corners or other extreme geometries.

Pressure forming.



Highly detailed cosmetic parts can be produced by pressure forming, which involves applying pressures typically around 40 to 60 PSI to force the heated thermoplastic sheet onto a negative tool. In fact, this method most closely rivals injection molding's ability to achieve high cosmetic molded detail (more on that below).

Twin-sheet forming.

Twin-sheet forming is the simultaneous heating of two thermoplastic sheets and forming them between two pressure-forming tools. First, a vacuum force is applied independently to pre-form each sheet. Next, the tools are quickly brought together, and compressed air is injected into the space to force the material to fuse together.

Injection Molding 101

Rather than heating thermoplastic sheet, injection molding involves heating thermoplastic pellets until they melt. The liquified plastic is then injected using very high pressure into a custom two-sided 3D mold.

Once the injected plastic cools, the part is ejected from the tool. Unlike thermoforming, which requires the secondary process of trimming, injection molding typically doesn't require subsequent manufacturing processes.

Like thermoforming, additional finishing steps may include painting, applying specialty coatings, and silk-screening.

10 Factors for Comparing Thermoforming and Injection Molding

Now that you have a background on thermoforming and injection molding, let's delve into the details on those 10 factors from the table above.

1. Tooling costs

Manufacturing a plastic part with either of these methods requires a mold, often called the tooling. But compared to injection molding, thermoforming generally has much lower tooling costs.

Why tooling for thermoforming is less expensive:

Pressure and volume. Thermoforming uses less pressure than injection molding and typically is made for low- to mid-volume production runs (more on volume below). Therefore, the tooling itself can be made from less expensive materials such as wood, light aluminum, polyurethane board, or epoxy board.

The injection molding process, on the other hand, demands tooling that can withstand high pressure and high volume production. Consequently, the tooling material itself needs to be made from more expensive materials like steel, heavy aluminum, or rugged copper alloys.

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Material amount. Thermoforming is a single-sided process, meaning only one side of the tooling controls the plastic sheet. That means less material is needed compared to injection molding.

Tooling for injection molding is two-sided. In essence, this process requires twice the tooling material as thermoforming.

Development time. For reasons like those above, tooling for thermoforming can be done much faster.

2. Annual volume

Low and medium annual volumes in the hundreds to thousands are much better suited for thermoforming largely because of the lower tooling costs (discussed above).

High annual volumes in the tens of thousands, hundreds of thousands, and beyond definitely favor injection molding. That high part volume is what justifies—and in essence pays for—the expensive tooling that injection molding requires.

3. Part cost

Primarily due to the production cycle time efficiencies of each process, part costs will typically be higher for thermoforming compared to injection molding. Remember that thermoforming is better suited to medium and low volumes, while injection molding is typically the method of choice for high volumes, which will drive the cost per part down.

Cost per part obviously needs to be considered in relation not only to volume but also other other major factors like tooling cost, part size, and lead time.

4. Development cycle time

It's an obvious and crucial project question: How much time do we have to produce this component?

Generally speaking, thermoforming lead times are shorter, largely because of the speed with which the tooling can be developed. In fact, depending on the part, the development cycle and time to market could be as few as four to six weeks with thermoforming.

Injection molding lead times will usually require several months. That's mainly because of the time it takes to develop the tooling.

5. Part size

Here at Profile Plastics, for example, we can produce parts up to 8' x 12'—at much lower tooling costs (discussed above) than injection molding. In fact, the larger the plastic part, the more cost-effective the thermoforming process is. That becomes especially apparent once part sizes exceed 2' x 2'.

But if you plan to manufacture smaller parts at high volumes, the economics of injection molding become much more compelling. The initially more expensive tooling and longer lead times can be worth it because of the high-volume production over a long period of time.

6. Cosmetics

Because of the extreme pressure used in injection molding, the process has long been considered a great option for producing intricate, highly detailed cosmetic parts.

However, continued improvements in thermoforming, pressure forming in particular, have made it a viable alternative to injection molding for achieving high detail.

In fact, injection molding can be subject to imperfections like flow marks, which can occur from different portions of the liquified plastic cooling at different rates.

Since pressure forming occurs simultaneously for the entire part, cosmetic problems like flow marks do not occur.

7. Geometry changes

No surprise here: Sometimes you may need to modify a part's design, whether while it's still in development, or even in the production stage. And that means the tooling has to be modified.

If you consider thermoforming's lower tooling costs (see above) compared to injection molding, it's not hard to understand why modifying the tooling is easier—i.e., much faster and cheaper—for the thermoforming process.

Tooling is a major expense in injection molding, making it imperative that you know exactly what you want when the tooling is made. (See No. 10 below on moderating risk.)

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8. Part trim changes

From a manufacturing standpoint, when a part comes out of an injection mold, it's usually considered finished. In thermoforming, after the part is removed from the tooling, it requires the secondary operation of trimming with a CNC machine and a dedicated CNC trim program.

We've already mentioned that modifying tooling is an easier process in thermoforming. In addition to that fact, you may be able to make tweaks to a thermoformed part at the CNC trimming change—no tooling modification needed.

Post-production tweaks in fit are much more difficult to do with an injection molded part. If the need to modify is dire, then it would likely require developing brand new tooling, which is extremely expensive

9. Operations required for finished part

In terms of the manufacturing process itself, injection molding is generally more efficient. Once the liquified thermoplastic pellets are poured into the mold, extreme pressure ensures all the tooling cavities and part features will be filled to form the part. Now it just needs to cool and the mold can release the finished part.

Thermoforming takes at least two steps, and sometimes more, to produce a finished part:

- Heating the thermoplastic sheet and using pressure, vacuum, or sometimes both forces to form the sheet into or over a custom 3D tool.
- Trimming the excess sheet with a CNC machine.
- Depending on the part, possible glueing, subassembly, and kitting.(Note that these services can be provided by the thermoformer as value-added services.)

Is having one step better than several steps? You could argue that the single-step process of injection molding is better by virtue of it being simpler and faster.

However, that doesn't take into account the tremendous upfront cost needed for injection molding tooling, not to mention the added expense required if that tooling has to be modified.

Also, in the end, the efficiency of the manufacturing process itself may still not be sufficient to shorten the overall lead time of the injection molding process compared to thermoforming.

10. Initial development and prototyping

Rather than opt for injection molding and the more expensive tooling it demands right out of the gate, your initial budget—and your risk tolerance—may be much more suitable for the thermoforming process. That's why thermoforming has a definite edge when it comes to initial part development and prototyping.

In fact, this is why a plastic part today that's traditionally injection molded may have started out as a thermoformed prototype. Then, over time, after initial part success and subsequent volume projections grew, it became feasible to switch to injection molding.

But beyond initial volume uncertainty, thermoforming can be ideal for the product development and prototyping stages for other reasons. For example, risk related to the part design and engineering can be moderated significantly by using the thermoforming process initially. Specific examples include:

- Design of function (risk of changes)
- Required wall thicknesses for stiffness or load-bearing purposes
- Projection of tolerance requirements

Your Next Move: Get Expert Insights to Start Moving Forward

Hopefully, you've now learned enough to see that your specific part and project needs should drive your decision regarding thermoforming vs. injection molding. So what should your next move be? Reach out to a trusted plastic supplier for a discussion—ideally as early as possible in your project.

Looking for more than just a supplier? Start with Profile Plastics. We've been providing heavy-gauge thermoforming and value-added engineering services for more than 60 years.

We'll be happy to discuss your needs and steer you to a solution that's right for you—even if it's injection molding.

65 Waukegan Road • Lake Bluff, IL 60044 • P: 847.604.5100 • www.Thermoform.com

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