1 Importance of Foam Injection Molding for Industrial Lightweight Design

As already mentioned in the introduction, the actual breakthrough of foam injection molding did not take place until the 1990s, driven by the lightweight design trend in the automotive industry. Developments at that time, such as the lock housing already cited or headlight housings, are now standard technology. Not only that, but today all these components in automotive engineering are actually foamed. Foam injection molding has replaced compact injection molding as the standard process for many components in the automotive industry! The technology curve in Figure 1.1 clearly shows the “development history”.

The abscissa of the graph in Figure 1.1 depicts the technology life status of the components over time, starting from the development status to the state of the art. The ordinate shows the corresponding manufacturing process, partly named with the material component to be processed (MuCell® with TPU), partly as a combination technology, such as MuCell® with film back injection.

The superficial explanation for the definitive breakthrough of foam injection molding is that foaming the plastic reduces the weight of the material for the same part geometry. At the same time, the manufacturer saves on the material input of the polymer during the primary shaping process. A closer, more intensive look at the process steps, as we will explain in detail in Chapter 3 *“Definition and Characteristics of Physical Foam Injection Molding”*, also reveals a considerable range of additional advantages. In many cases, it is precisely these advantages that make it easy for the user to decide whether a component should be produced by compact injection molding or whether it is better to produce it as a foamed part.

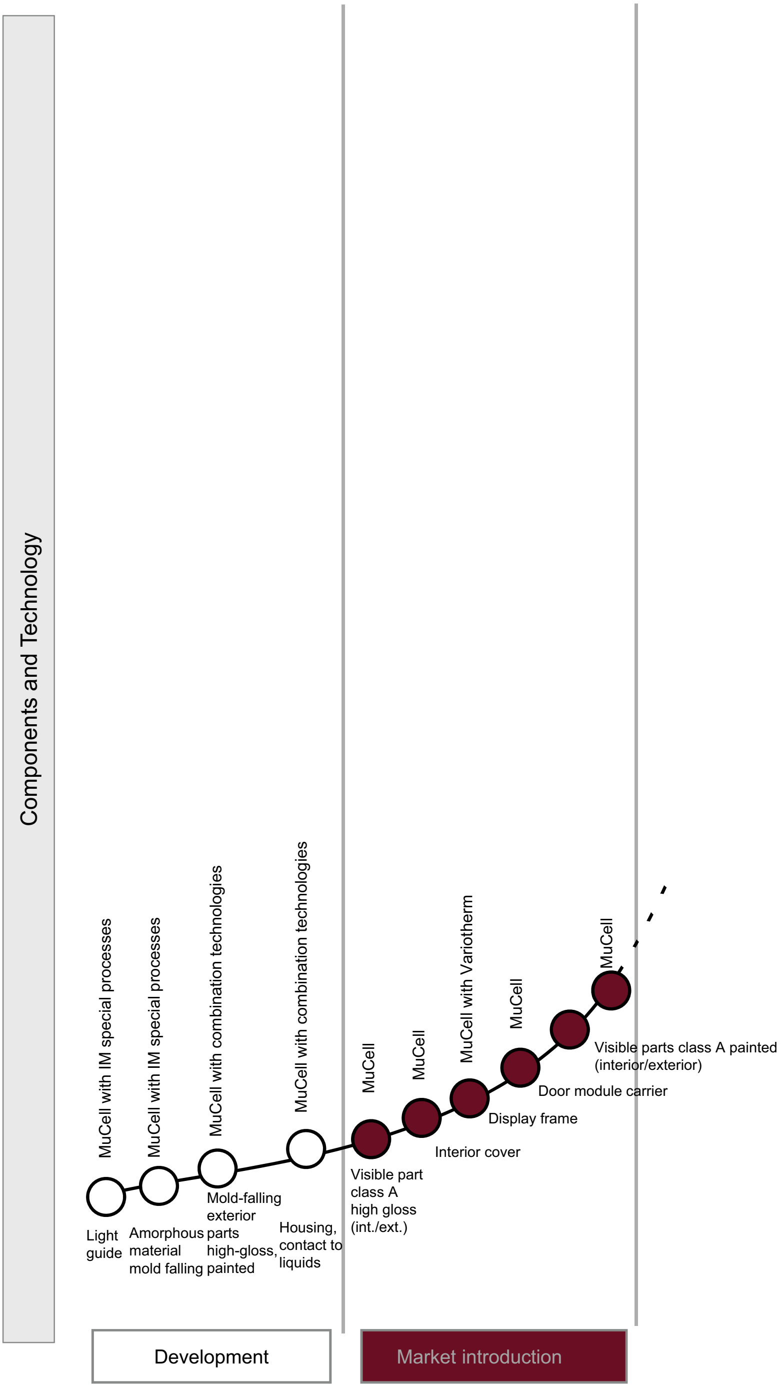
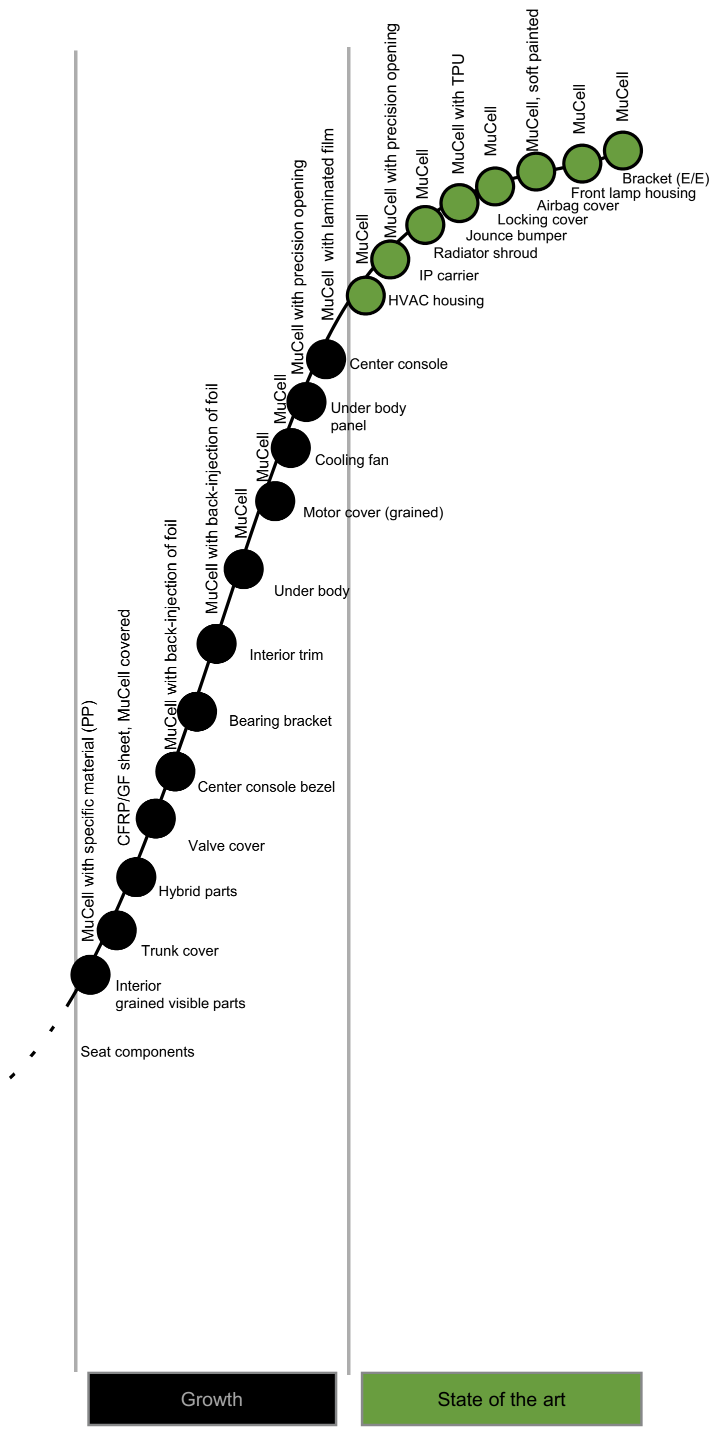


Figure 1.1 Development curve of MuCell® for automotive applications [Source: Trexel GmbH]


MuCell with specific material (PP)
CFRP/GF sheet, MuCell covered
MuCell with back-injection of foil
MuCell with back-injection of foil
MuCell
MuCell
MuCell
MuCell with precision opening
MuCell with laminated film
MuCell
MuCell with precision opening
MuCell
MuCell with TPU
MuCell
MuCell, soft painted
MuCell
MuCell
Bracket (E/E)
Front lamp housing
Airbag cover
Locking cover
Jounce bumper
Radiator shroud
IP carrier
HVAC housing
Center console
Under body panel
Cooling fan
Motor cover (grained)
Under body
Interior trim
Bearing bracket
Center console bezel
Valve cover
Hybrid parts
Trunk cover
Interior grained visible parts
Seat components
Growth
State of the art

These advantages of the TSG process are, in addition to the weight savings already mentioned:

- A reduction in sink marks (usually to zero).
- Hardly perceptible warpage of the components.
- Production increases due to cycle time reduction.
- Possibility of thin-walled lightweight design (see in detail Chapter 4 *"Design Guidelines for Foamed Components"*).

Figure 1.2 gives an exemplary overview of this, based on four reference parts from the automotive industry. To explain Figure 1.2, let us take the "oil pan" as seen in the third row: Here, the second column in the figure indicates the reference data in each case, i.e. the part weight, the equipment investment including tooling, the productivity, the resulting part costs, and the mechanical part properties required for the critical points. The reference is, of course, the classically compact injection molded part.

In the third column "Injection Molding with MuCell®", the first results can now be discussed comparatively:

- The component weight decreases, corresponding to the degree of foaming.
- The investment increases concerning the injection molding machine. A gas dosing station is also required.
- Productivity increases significantly, mainly due to faster production cycles.
- The costs related to the component decrease, since the reduced material input and the increased productivity offset the higher equipment investment.
- The necessary mechanical properties at the critical points of the component remain intact.

It becomes even more interesting for every user as soon as the component design has been carried out as a lightweight design in compliance with the TSG design guidelines (for details, see Chapter 4). For this purpose, we will now discuss the representation in the fourth column of Figure 1.2 “Injection Molding + MuCell® + Lightweight Design”:

- The component weight of the oil pan is further reduced by approx. –10%. This is due to the lightweight design suitable for the TSG process.
- The equipment investment increases slightly, also compared to the third column, because the tooling costs for such a component are slightly higher. Otherwise, there are no changes to what has already been stated.
- Productivity continues to increase! We achieve shorter cooling times due to thinner components as well as even faster cycles of the production line.
- The costs related to the component are reduced once again, now by a good 10% in total.
- There is no change in the mechanical properties of the critical areas of strength. The values are comparable with those of compact injection molding.

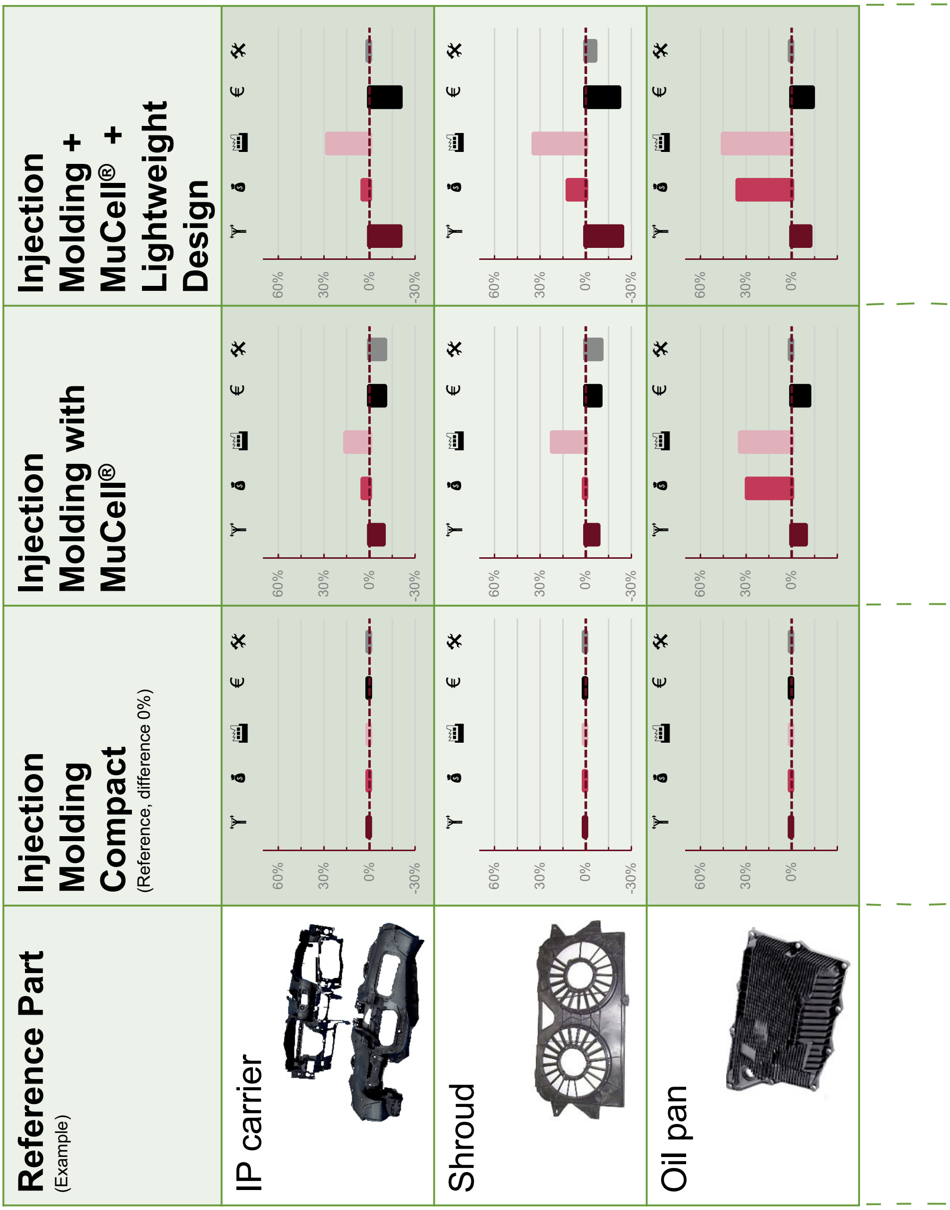
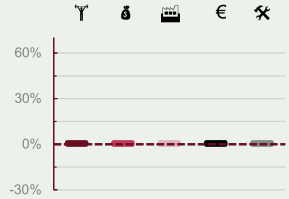
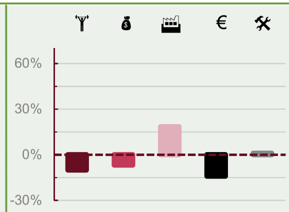
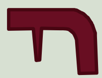
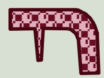
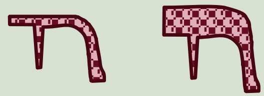


Figure 1.2 Advantages of exemplary TSG components [Source: Trexel GmbH]

Underbody (draft with mold opening stroke)			
			

Remark	Molded part in conventional design:
	- Rib / Wall ratio
	- Flow length
	- Injected from thick to thin
	
		Molded part in conventional design foamed with MuCell:
		- Less weight due to foamed structure
		- Production without holding pressure
		
			MuCell enables free part design adapted to topographic load :
			- Lightweight design
			  - Reduced wall thickness
			  - Thick parts with lower density
			- Increase in output
			

- = Weight
- = Investment
- = Productivity
- € = Part costs [1)]
- = Crucial mechanical property

[1)] Calculation based on a volume model with 300.000 cars per year

So much for the advantages of TSG components, which we experience every day in mass production. We do not wish to go into further detail here on another macroeconomic advantage that is repeatedly mentioned, namely the CO_2 footprint in production – we will discuss this issue in more detail using an example from the automotive sector in Section 9.1. However, it is clear to everyone that TSG offers considerable advantages here compared to traditional compact injection molding: Material costs decrease, production efficiency increases, and the lightweight part requires less kinetic energy in its “later life cycle”.

Let us return to Figure 1.1 in this chapter. In particular, the “Development” section should clearly show here that TSG by itself is a technology that today can be described as a standard process. In addition, however, every expert is aware that TSG in conjunction or in combination with another process offers an enormously large, yet unexploited potential for new processes.

Last but not least, we would like to point out that in most chapters of this book we list tips and suggestions in prominent type under the motto “Less is more”. In each case, the labeling begins with the symbol of a scale and points out advantages and interesting aspects of foam injection molding.

We hope that this will motivate as many readers as possible to take a closer look at this innovative process, so that further development and research will be carried out in this area in the future – because, as already mentioned above, this technology still holds some unrealized potential.

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