

 **SOLVARO**

WHITEPAPER

DEEP DRAWING TO PERFECTION

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# FOREWORD

*Modern commercial vehicles have increasingly high requirements for the functionality, performance, lifespan and appearance of components. These increased requirements have created a conundrum for the designers of perforated metal components, in particular – because, in practice, forming perforated metal into engine hoods, ventilation grilles or bumper grates is a delicate balancing act between cost and quality.*

*When forming perforated metal components, the challenge lies in selecting the correct forming process. When it comes to achieving the required air permeability, stability, air filtration and design, deep drawing is considered the gold standard by industry connoisseurs. However, getting started with the process is not easy, due to the cost and effort involved in developing the tools.*

# ON THE ART OF SHAPING PERFORATED METAL

Modern solutions approach the deep drawing of perforated metal components as a team effort for OEMs and suppliers. Experience has shown that when vehicle manufacturers and grille suppliers work together from the outset, deep drawing offers extensive advantages over other processes. With finesse, experience and expertise based on many years of practical experience, it is possible to develop fully fledged, high-performing deep drawing tools for serial production. This allows all the technical specifications to be fulfilled, while reducing the cost per unit.

## 'Challenges of deep drawing' – what can go wrong in the forming of metal

When deep drawing metal components, the flow behaviour of the material is critical. It determines which drawing parameters should be applied for the precise forming of the component into the desired shape. Influencing factors include the material, the drawing radius and the drawing speed. For solid sheets, these parameters can be used to run modern simulations that predict the forming process with pinpoint precision.

When forming perforated metal components, however, simulation-supported processes quickly exhaust their potential. For example, a single hexagonal perforated component with a hole width of 2 mm and a hole pitch of 2.5 mm (Hv 2–2.5) has an incredible 184,000 holes per square metre. With a thickness of 0.5 mm, the bridges between the holes are so thin that it is simply not possible to calculate the forming behaviour mathematically.

As a consequence, even the smallest error in setting the drawing parameters can lead to cracks or deformation in the sheet. While cracks in the perforated sheet only slightly reduce the stability of the ventilation grille on the vehicle front, the deformation of the bridges becomes problematic during the coating process. When applying corrosion protection, the delicate holes quickly fill up with coating, which not only impacts their appearance but also impedes air flow.



WHEN VEHICLE MANUFACTURERS AND COMPONENT SUPPLIERS WORK TOGETHER FROM THE OUTSET, DEEP DRAWING OFFERS EXTENSIVE ADVANTAGES OVER OTHER PROCESSES.



Working on the deep drawing press requires a lot of finesse and specialist knowledge.

# 200,000

deep-drawn parts per year speak for the high quality of the technology.

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SUCCESS THROUGH TEAMWORK:  
TOGETHER WITH OUR  
CUSTOMERS, WE HAVE DEVELOPED  
AROUND 500 DIFFERENT  
DEEP-DRAWN PRODUCTS.



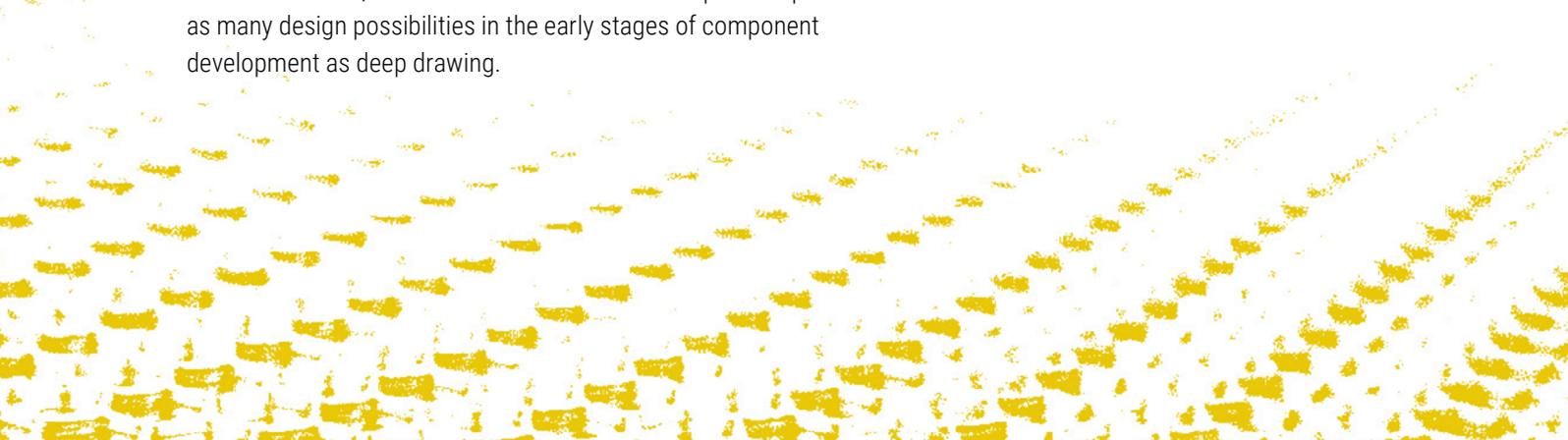
Yet another challenge in the deep drawing of perforated metal components is that the springback behaviour after reshaping differs considerably from that of solid sheets and must be taken into account accordingly.

The lack of calculability in the flow behaviour and the high cost of deep drawing tools have led many companies in the industry to fall back on alternative reshaping methods. On the one hand, these processes are easier to master. On the other hand, they are inevitably associated with significantly reduced design possibilities. For example, complex 3D components typically cannot be reshaped in the desired depth, making these processes insufficient for achieving the pronounced design specifications of modern commercial vehicles.

Experts agree that the deep drawing of perforated metal components is a science in itself and, alongside specialised deep drawing tools, requires experience, practical knowledge and finesse. At the same time, it has been shown that no other process permits as many design possibilities in the early stages of component development as deep drawing.

Different products that can be produced  
with deep drawing tools at Solvaro:

500



With engineering skill, expert knowledge and a whole lot of practical experience, it is possible to fulfil all the various requirements for function, design, weight and air permeability at once. Those who take on the 'challenge of deep drawing' and work with the grille manufacturer from the outset are generally rewarded with outstanding results. Four steps are key to achieving this.



There are various factors that can influence the result of the deep drawing process.

## A STEP-BY-STEP APPROACH TO DEEP-DRAWN METAL COMPONENTS

Through many years of working with customers, Solvaro has managed to optimise the deep drawing process for perforated metal components. In doing so, it has become clear that early collaboration of the development teams on both sides and a step-by-step approach are key to success. Solvaro's engineering expertise in figures:

in just one year, the company reshaped almost 200,000 parts into complex 3D components using its deep drawing process.

At this juncture, the experts at Solvaro are happy to lend their extensive practical experience and describe the deep drawing development process in four crucial steps:

### STEP 1

#### Selection of the raw material

The engineering process begins with the selection of the raw material, as this influences the deep drawing behaviour of the component significantly. The deep drawing quality of the material is crucial: this determines which drawing depths and radii can be realised with the material, and whether the material is suitable for multi-step deep drawing processes.

In **5,000**  
operating hours

Cold-rolled steels of varying qualities are available.

These are suitable for different components:

- DC01: Drawing quality
- DC03: Deep drawing quality
- DC04, DC05: Special deep drawing quality
- DC06: High-grade deep drawing quality
- DC07: Super deep drawing quality

Depending on the desired contour of the component, cold-rolled steels between grades DC04 and DC06 are used in the deep drawing of perforated metal components. As a general rule, the choice of material influences the deep drawing properties during the reshaping process, meaning it is also instrumental in the occurrence of rejects. When selecting the raw material, the cost factor should be carefully considered: a material with a higher deep drawing quality may be more expensive to purchase, but often pays for itself with more precise flow behaviour in the production process. It is especially important that a well-founded decision is made in consultation with the customer.

## STEP 2

### Perforation quality

To meet the product-specific requirements for design, stability, corrosion protection and air permeability, the perforation of the perforated component must be precisely defined.

For air permeability, the shape of the holes is critical; in deep drawing, hexagonal or round holes are typical. With hexagonal holes, it is possible to realise exceptionally large free cross-sections. That is why this variant is often preferred for complex deep-drawn components. However, round holes also have their benefits – depending on the application – and can be easier to manage in certain projects. We therefore recommend always selecting the hole shape on a case-by-case basis and not to make a decision without careful consideration.

The look, stability and corrosion protection of a perforated metal component also depend heavily on the relevant hole parameters. These include hole pitch, hole width and bridge width. The selection of these parameters is of critical importance to the deep drawing process and has far-reaching consequences. The thin bridges of perforated metal components are extremely sensitive to tiny changes. That is why getting it right is a matter of practical experience and finesse. Solvaro produces around 500 different deep-drawn components and is therefore familiar with the optimal product-specific hole parameters.

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A HEXAGONAL PERFORATED SHEET,  
I.E. A METAL COMPONENT  
WITH HEXAGONAL HOLES,  
HAS 184,000 OPENINGS PER  
SQUARE METRE.

## STEP 3

### Tool expertise

Many companies decide against deep drawing for cost reasons: after all, developing deep drawing tools is laborious, time-consuming and extremely expensive. Solvaro has impressively demonstrated that with experience, expertise and ingenuity, it is more than possible to develop fully fledged deep drawing tools and gain considerable cost advantages in the production process. The approach taken during the development process makes all the difference: by using high-quality hammer-formed models as prototypes, it is possible to conduct preliminary tests of air permeability and installation on the vehicle. For prototype construction, cost-effective materials such as steel or aluminum are milled into a negative mold, then a perforated sheet is hammered into the desired shape. With the necessary craftsmanship and solid experience, a hammer-formed model is created that comes very close to the end product.

By using a hammer-formed model, the customer gains valuable insights into the technical feasibility of the vehicle. This eliminates the need to develop cost-intensive deep drawing tools to start with. It also allows design changes to be incorporated during the tool development stage and results in a tool with greater readiness for serial production.



Thanks to experience, expertise and ingenuity, Solvaro has been able to optimally execute even complex designs.



OUR DREAM IS IN FUTURE  
TO BE ABLE TO SIMULATE  
THE DEEP DRAWING OF  
PERFORATED MATERIAL.

## STEP 4

### Setting the drawing parameters

Due to the constructive properties of perforated metal components, the deep drawing process cannot be mastered with computer-aided processes and sophisticated production processes alone. Rather, it requires a degree of finesse and extensive experience with the deep drawing process. That is what makes it possible to control the active forces and achieve reproducible results in accordance with the technical specifications.

Thanks to many years of experience, the engineering team at Solvaro is able to accurately define the right parameters for the deep drawing process. These include the drawing radius and drawing speed, in particular. These are individually adapted to customer requirements based on extensive tests. Here, too, it is essential to incorporate empirical knowledge early on in the planning phase.

This allows the development team to ensure the required quality standards early on, and keep costs as low as possible.

## ARE THERE VIABLE ALTERNATIVES TO DEEP DRAWING?

Experts consider deep drawing to be the forming process that optimally fulfils the highest standards in the design, function and stability of perforated metal components. However, the development of deep drawing tools is extremely expensive and complex – and only pays off in serial production starting from certain batch sizes.

In practice, there are viable alternatives that can be used, depending on the forming process and quantity. The three most important alternatives to deep drawing are:

- **Bead rolling:** Bead rolling is suitable for a series of reshaping tasks, but quickly reaches its limits in reshaping that exceeds a certain size and depth. Complex 3D components with high design requirements cannot be produced via bead rolling.
- **Bending:** Bending of components lends itself when perforated metal components are shaped at a defined angle, without complex 3D contours. A typical application example is the construction of server cabinet doors.
- **Rolling:** Rolling is an incredibly popular reshaping process for components that only need to be rounded with a defined radius, without the need for deep drawing. Exhaust pipes are a classic example of rolled metal components.



A MODERN, COMPELLING DESIGN  
IS AT LEAST AS IMPORTANT  
AS ENGINE POWER IN COMMERCIAL  
VEHICLES TODAY.

When considering the different forming processes from an economic perspective, a decision can be made relatively quickly: deep drawing tools can cost well over EUR 100,000, meaning they are simply not economical for projects with a low batch size. For example, when producing a ventilation grille for a special vehicle of which only 100 will be produced, alternative reshaping processes are a practical and cost-effective solution. However, the greater the quantity and the more complex the 3D contour of the component, the more the advantages of deep drawing apply.

### **A practical example – strong perforated sheets for strong engine hoods**

The large tractors of today are real powerhouses. This is not only evident under the hood, but is also expressed with distinctive vehicle designs. High standards in function and design pose challenges for ventilation grille suppliers.

Solvaro impressively demonstrated the advantages of deep drawing on the engine hood that was developed together with the customer for the award-winning large tractor from the T250 series by Valtra. The challenge lay in supplying the tractor engine with sufficient cooling air, while preventing dirt from entering the engine compartment. In response, the Solvaro engineering team decided in close consultation with the customer to use a deep-drawn perforated sheet with 2–2.5 hexagonal perforation.



An example of a successful collaboration with Solvaro: the large tractor of Valtra Brazil.

This perforation offers a free cross-section of 64% with reliable filter performance. The hole pattern and hexagonal geometry prevent bridge breakages, despite the large free cross-section. The results are clear: the engine hood meets the highest standards in design and has impressively high stability and rigidity at a low weight, thanks to its honeycomb structure.

## Early teamwork ensures project success

Through many years of experience in the production of deep-drawn perforated sheets, we have become intensely familiar with the critical factors of engineering and development work. We have learned that highly complex development tasks can only be accomplished through early and close collaboration between the customer and supplier. In these times of modern simulation software and increasingly high-precision tools, the human factor still has a critical impact on the success of a project. Only with finesse, expertise and many years of experience is it possible to accurately predict the forces of the deep drawing process and account for them in the process parameters.

That is why we see ourselves as a sparring partner, who supports customers from the engineering stage to serial production, allowing us to offer practical, cost-effective solutions. Almost 200,000 deep-drawn components in one year and around 500 different deep-drawn products speak for themselves.



The Solvaro team is available to answer all your questions.

## CONTACT US!

### **Martin Schneider**

Head of Application Engineering

+49 7021 8048-110

[martin.schneider@solvaro.com](mailto:martin.schneider@solvaro.com)

