

How Forward AM Makes Sports Safer

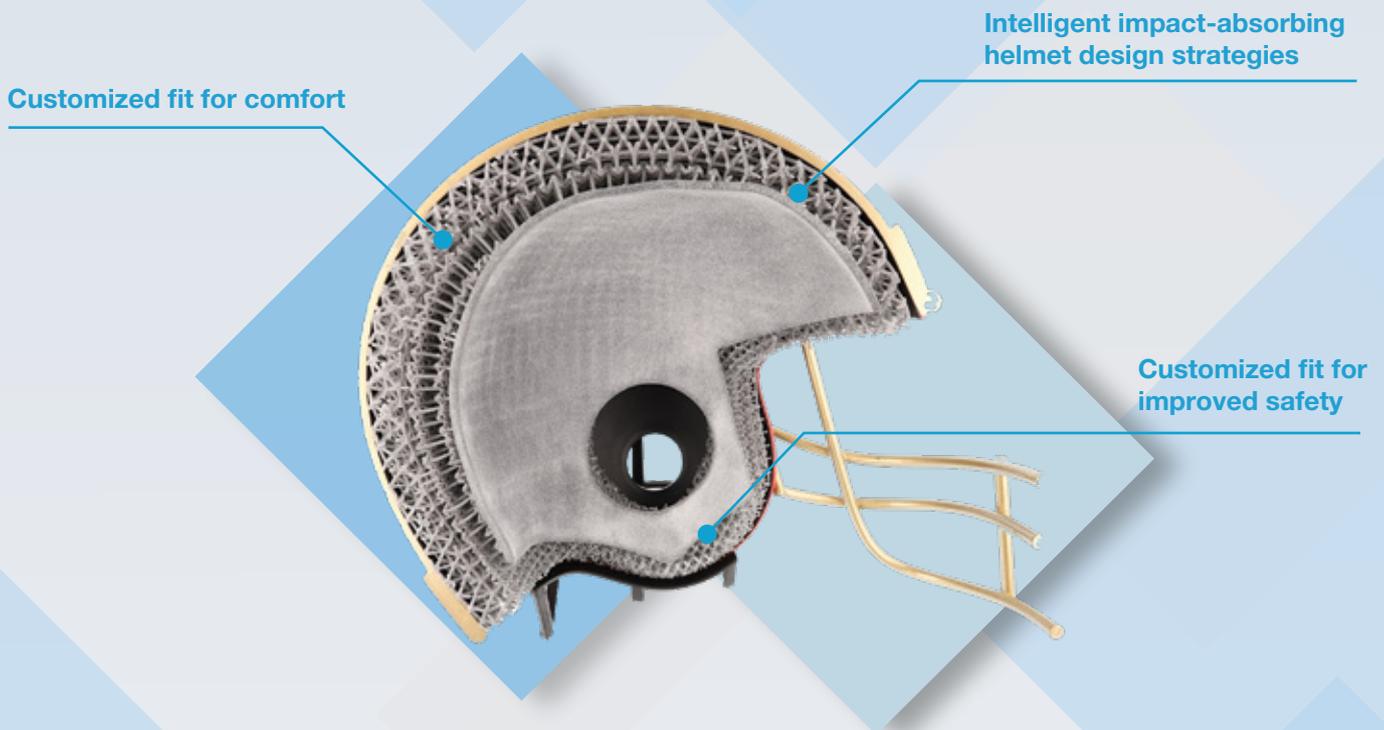


Figure 1: Excellent shock absorption by a lattice structure printed with TPU powders from Forward AM.

Yes to sports – no to head trauma!

In baseball, hockey, football and all other sports, head trauma through collision is an omnipresent risk for all athletes. And it doesn't stop with sporting activities: All of us who ride motorcycles, go skydiving or skiing also face this risk. Improving the performance of protective gear is therefore crucial in preventing injuries and increasing safety. Forward AM is strongly committed to safety and improving the performance of helmets and other protective gear.

The primary purpose of helmets is of course to reduce the transfer of collision energy to the head. An essential element of protective helmet design is therefore highly efficient energy-dissipating components. However, today's protective helmets are still largely based on closed-cell foams and injection molded plastics designed seventy years ago.

Next level of head protection – Forward AM takes the lead

After seven decades with minimal design development, Additive Manufacturing – “AM” – now creates the opportunity not only to distribute differentiated impact strategies intelligently throughout the helmet but also for individualized helmet fit. The result is hugely improved safety.

Perfect synergy of material, technology and design

Forward AM’s advanced engineering and design expertise makes it possible to identify the optimum combination of materials, technology and processes in the most cost and time efficient way.

Our high performance range of thermoplastic polyurethane (TPU) powders now enables the industrial-scale 3D printing of flexible parts with class-leading shock absorption. This TPU range is ideally suited to manufacturing complex lattice structures: Its high processing stability and accuracy make extremely detailed designs possible. These benefits are mainly thanks to the outstanding mechanical properties of TPU powders:

	Typical Values* X-direction	Typical Values* Z-direction
Hardness Shore A	88-90	88-90
Tensile Strength / MPa	9	7
Young’s Modulus / MPa	75	75
Elongation at Break / %	280	150
Charpy Impact notched	no break	no break
Rebound Resilience/ %	140	100

Table 1: Ultrasint® TPU01_Technical Data

Hardness Shore A	88-90
Tensile Strength / MPa	8
Young’s Modulus / MPa	75
Elongation at Break / %	270
Charpy impact notched	no break
Rebound Resilience / %	63

Table 2: Ultrasint® TPU 88A_Technical Data



Ultrasim® by Forward AM – accelerating application development with Virtual Engineering

Forward AM’s unique Virtual Engineering design service for 3D printed components is based on Ultrasim®. This **Finite Element Modelling** capability was originally developed in our Engineering Plastics division over the last 25 years to optimize our materials’ performance in traditional injection molding. Modelling elastomers is extremely challenging because of the complex viscoelastic behavior that TPUs exhibit, as well as the Mullins effect.

- Viscoelasticity
- Mullins effect/cyclic behavior (irreversible softening of stress/strain curve)
- Buckling
- Contact
- Rebound
- ...

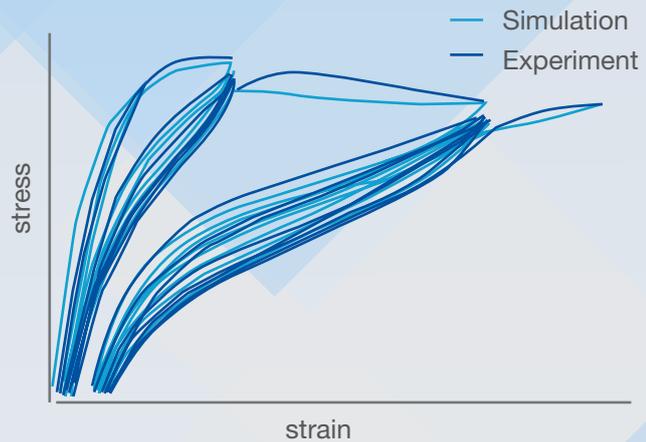


Figure 2: Major challenges in elastomer simulation.

Figure 3 demonstrates we have succeeded in achieving accurate material models for our TPU through testing confirmation. This enables the design adaptation of printed structures through precise simulation to achieve a specific force-deflection response – in the case of helmets, optimized impact absorption. By combining this Virtual Engineering capability with rigorous confirmation testing to create intelligent designs, we can accelerate application development rather than rely on time-intensive “print, test, repeat” which in fact may never achieve the desired mechanical performance.

Forward AM has harnessed this approach to develop highly innovative structures that optimally balance outstanding impact performance with weight management, a further key performance criterion.



Figure 3: Optimized AM structure designed with Ultrasim®

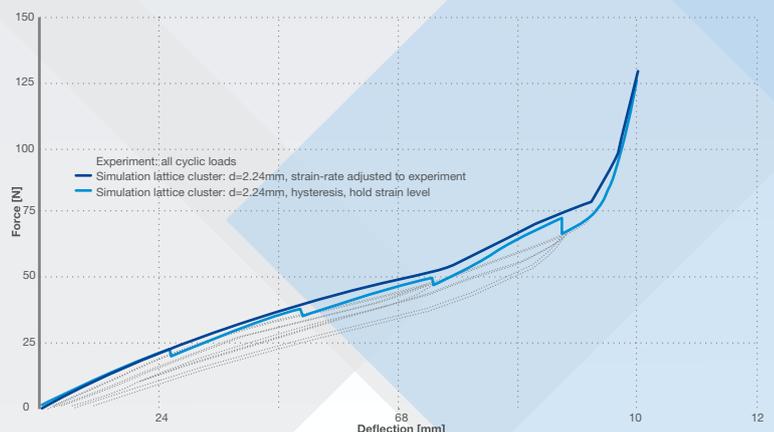


Figure 4: Force-deflection curve – experiment vs. simulation

We can apply this not only to helmets but to other applications such as footwear, where the desired mechanical response instead requires maximum rebound. Depending on the specific characteristics of individual applications, the variety of potential structures is enormous: Lattice designs with optimized configuration and strut size, solid structures, or even other innovative geometric configurations are all possible. The key is that all these structures are developed most efficiently and effectively to fulfil their performance goal with the aid of Virtual Engineering.

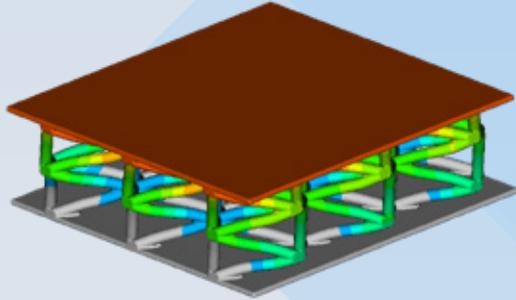


Figure 5: Finite Element Model for mathematical optimization



Figure 6: Lattice structure for footwear

Ultracur3D® flexible coatings create real eye catchers

Forward AM has developed industry-leading finishing strategies for parts 3D printed with our TPU powders. Through post-processing such as dry-ice blasting, chemical etching, or dyeing, an already high quality surface can be modified to deliver the desired effect. For instance, Ultracur3D® flexible coatings enable an aesthetically enamel-like surface that not only ensures an attractively colored part but also provides functionalities such as moisture impermeability plus highly effective dirt and oil sloughing.

The result: A major advance in helmet safety through optimized AM design and smart material choice.

At Forward AM we provide our customers with end-to-end solutions to enable them to shape the AM industrial revolution. Our market leading service spectrum comprises:

- Virtual Engineering design service
- Rigorous in-house testing and analytics
- Engineering-grade AM materials
- Expertise in the latest finishing solutions to complement our AM materials.

**We're ready to
support your project in
Additive Manufacturing**

Simply get in touch!

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