

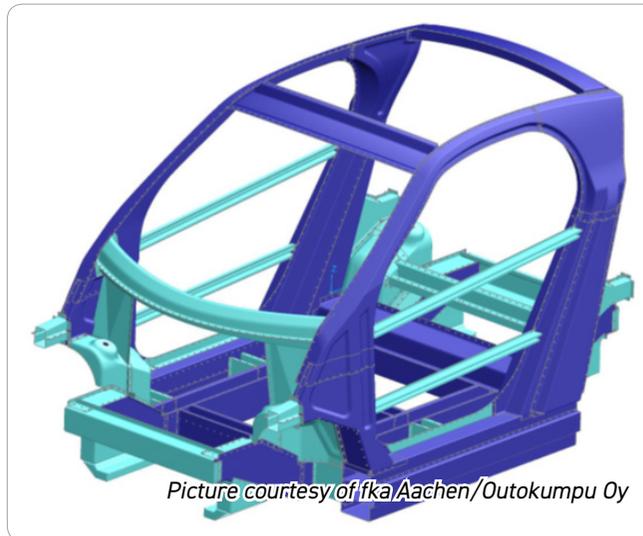
## Folded stainless steels create a new concept in bend-formed body structures for small electrified urban vehicles

**Name of member:** Outokumpu Oy  
**Developer:** Fka Aachen  
**Field:** automotive  
**Location:** Aachen, Germany  
**Environment:** urban  
**Grade and surface:** Temper-rolled austenitic stainless steel  
**Competing materials:** Hot-formed ultra-high strength carbon steels and aluminium extrusion profiles

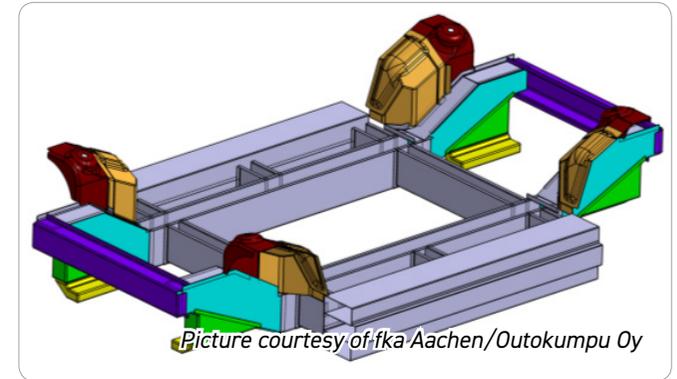
### Advantage point of using stainless steel:

- Temper-rolled ultra-high strength austenitic stainless steels have been used in an innovative approach to the design of bend and welded body structures for small electrified urban vehicles inspired by folded packing cases.
- The number of individual components and welds in a body-in-white has been halved.
- This approach eliminates the traditional high investment in forming tools as well as providing excellent intrusion withstand and energy absorption behaviour during vehicle crash situations
- Combined with innovative manufacturing processes, stainless steel significantly reduces the CO<sub>2</sub>-footprint of L7e category vehicles and enables local manufacturing on a worldwide basis

Stainless steels are well-known for their excellent formability. But currently, this advantage is used rarely in automotive manufacturing. Now Outokumpu is demonstrating the suitability of temper-rolled austenitic stainless steel with Rp0.2 > 800 MPa for the manufacturing of body structures for the fast-growing sector of small urban electrified vehicles



Picture 1: Primarily bend-formed vehicle structure (< 180kg) developed only with austenitic temper-rolled stainless steel in two strength levels (dark blue for base material yield strength level of 800 MPa, lighter blue for yield strength level 500MPa. ©fka Aachen/Outokumpu Oy

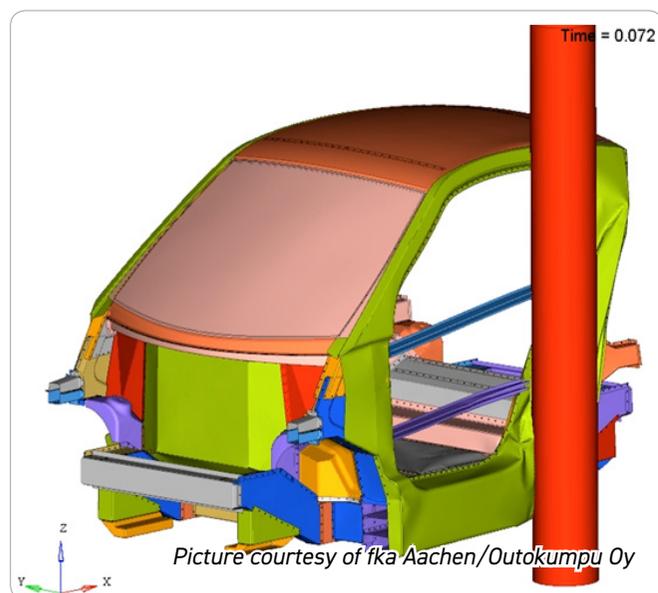


Picture 2: Bend-formed stainless floor structure for safety integration of battery modules, designed as a cost-effective common part strategy ©fka Aachen/Outokumpu Oy

classified by the EU as L7e-vehicles (total vehicle weight < 450 kg without batteries). In this sector, many start-ups and local manufacturers do not have the established manufacturing lines, investment-intensive deep-drawing tools and cost-intensive coating lines that would enable them to compete with the major OEMs. For example, the current state-of-the-art for a body-in-white construction is a steel-intensive design with 600 parts and up to 6,000 spot welds, while forming tools and presses require an investment of up to €2 million per tool. L7e-vehicles are not only a significant challenge for lightweight design but also for crash safety.

Currently, there are no vehicles in this category that meet the official crash requirements of M1-category vehicles like Smart or VW Golf.

To eliminate the drawbacks of the traditional



Picture 3: Successful withstand during crash simulation of the primarily bend-formed stainless vehicle according to EuroNCAP lateral side impact. ©fka Aachen/Outokumpu Oy

approach, the advantages of temper-rolled ultra-high strength austenitic stainless steels have been utilized with a new design methodology for vehicle structures inspired by folded packing cases. The manufacturing steps for the floor structure and parts of the pillars require only tool-less bend-forming and one welding procedure to create a folded and therefore stiff lower vehicle structure. The material properties combine with the folding principle to halve the number of individual components and welds. This results in a much lighter structure (less than 180 kg) with increased crash safety that is constructed by more simple, cost-effective manufacturing processes with shorter cycle times as well as lower CO<sub>2</sub>-emissions over the whole vehicle lifetime.

Advantages:

- Compared with other high-strength but less ductile materials, ultra-high strength austenitic temper-rolled stainless steels enable cost-effective manufacturing of a stiff vehicle structure with tool-less bend-forming and no need for coating processes
- The designed safety cell has enabled the construction of a L7e-vehicle to meet the pole side impact requirements of M1-category vehicles such as Smart and VW Golf
- The number of body-in-white components and spot welds has been halved against current state-of-the-art vehicles yielding significant cost-reductions and faster manufacturing
- Minor intrusions into battery compartment during pole side impact
- Torsional stiffness at the same level as series vehicles
- Leveraging the benefits of additive manufacturing and aluminum profiles, this concept demonstrate that folded stainless steels can play a key role in reducing weight as well as enhancing safety and stiffness