Customized 3D-printed Seat Cushion for Wheelchair Users

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Building and fitting customized wheelchair seat cushions for paralyzed people today is still a 100% analog hand craft process trying to find the best seating cushion solution and with it preventing pressure ulcers. CSEM knowledge on developing flexible 3D-printed parts and medical validation models has now been used to build a customized anatomically shaped seat cushion for wheelchair users, with open celled multi-softness zones, to provide an efficient pressure relief and improve air circulation at the body interface.

As paralyzed people are compelled to be seated in their wheelchair for many hours, an optimal seat interface is essential. By individually shaping seat cushions, wheelchair specialists try to build the best possible seat interface, to provide good comfort and avoid decubitus skin defects caused by pressure overload on prominent anatomical spots (ischial tuberosity/ sitting bone and coccyx). In addition, skin temperature and transpiration have a big impact on the healthy skin condition. Therefore, air circulation at the body interface, which is the key to control skin temperature and skin moisture, is an essential requirement, which however is not met by today's standard cushions.

Approach

A proof of concept model of a 3D printed open celled flexible seat cushion with multiple softness zones was created for the Swiss Paraplegic Centre in Nottwil based on their requirements.

As a starting point, a precise 3D scan of a conventional customized seat cushion made of Alveolux (low density polyethylene foam) covered by an elastic honeycomb structure was realized (Figure 1).

Softness information were gathered from the existing cushion and directly from the user, leading to the definition of four softness zones of varying dimensions and softness (Figure 2). As the entire seat cushion was printed with the same material (TPU thermoplastic polyurethane of shore hardness A85), to achieve the desired softness zones design variations of the inner structures and its dimensions where applied.

The surface of the entire seat cushion device holds hundreds of small holes letting air or water flowing through the open celled inner structure (Figure 3).

For stability reasons the seat cushion was reinforced, at the bottom, by a lightweight plywood base plate building an interface to the wheel chair.

Result

The benchmarking of the 3D-printed multi zone softness seat cushion gave very promising results, as all requirements could be achieved and the user test on daily comfort were very satisfying. According to the user, a big improvement was achieved by significantly reducing the isolation factor, by allowing air to circulate at the body interface. Even after an extensive full-day usage no skin irritation was observed. Finally, washing the seat cushion is now simple and the drying time of the seat cushion is shorter.

The benefit of digital workflow integration

Today fitting and shaping a customized seat cushion is still a 100% analog hand craft process. No data on the current design is available. It is not possible to make an exact copy of an existing device due to the variation of carving the surface by hand. With a complete digital workflow each design and all its variations will be available as data sets. Rebuilding an exact device, applying changes based on existing data will help improve developing better seat cushions. When this is achieved any technician will be able to apply the required design changes to the latest data set, always having a history track, and not having to start from scratch as currently the case.

Figure 1: 3D printed seat cushion (red) and existing Alveolux seat cushion with a top layer of honeycomb structure.

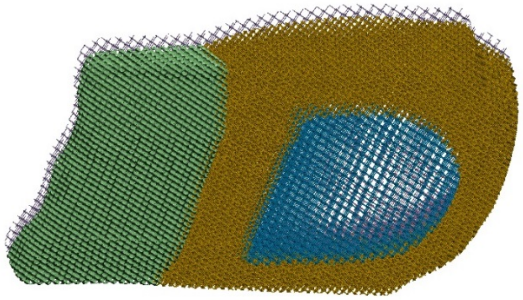

Figure 2: The four sections of different softness are marked with different colors.

Figure 3: 3D printed open-celled customized multi soft zone seat cushion.

Next steps

- Standardizing the soft zone structures for seat cushion building blocks.
- Development of entire digital process flow.
- Integration of sensors (pressure, temperature, humidity).

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