3D Modelling and 3D Printing of Shoe Lasts' Fitting Components to Reduce Waste in Footwear Manufacturing

by TUIASI

In footwear manufacturing, the shoe last is the main tool used for lasting and assembling uppers with bottoms. Starting from the dimensional parameters the last, the parts of the footwear are designed, the working organs of some machines in the footwear industry are built, and the obtaining molds are built through injection or vulcanization processes of some prefabricated elements (soles, heels, counters, etc.).

It is very important for our society nowadays to identify where we can reduce waste. The footwear industry produces 23.5 Billion pairs of shoes annually for 7.6 Billion people in the world. [1]

Customized footwear differs from usual footwear both structurally and by the physical-mechanical and chemical characteristics of the materials that are part of it. It must offer great comfort through hygiene, interior volume, flexibility, and low weight, to ensure stability while walking:

- *prevents the development of an anomaly*
- *prevents the complication of the condition*

Usually, changing the shape of the last is done by manual techniques, which involve many tests and errors. [1]. There are lasts for custom footwear that allows the insertion of an adjacent component to ensure or compensate for the balance given by foot conditions. [2]. Also known are the lasts used in the production of footwear that fit different shapes of the feet or allow deformations of the foot. [3]. Some lasts have been adapted to build footwear with additional components such as steel-toe plates for protective footwear [4].

Various CAD and CAM design and manufacturing methods are known, and their development in recent years has been very rapid, making it possible to automate the processes of making the lasts [5]. Computerized methods of modeling and designing last use the basic principles of manual design, along with advanced functions specific to the field of computerized design and modeling.

The working mode in producing custom lasts is based on the following sequence: scanning, analysis, modeling, verification, and rapid prototyping [3]. The scanning step involves scanning the 3D shape of the initial last. The analysis step involves obtaining and interpreting the geometric dimensions of the previously scanned last and correlating them with the anthropometric dimensions [6]. The modeling step treats the changing of the dimensions of the selected last. The verification step implicates comparing and verifying the dimensions of the modeled last with the dimensions of the foot. The rapid prototyping step consists in producing, using a 3D printer or a cutting machine, the modeled last for a final check [7].

By overlapping the initial last with the modified one, figure 1 shows the difference in the upper area and thus the fitting element for that part is extracted. Figure 4 shows the differences in the area of the metatarsophalangeal joints I and V and thus, we can extract the load elements for those parts [8].

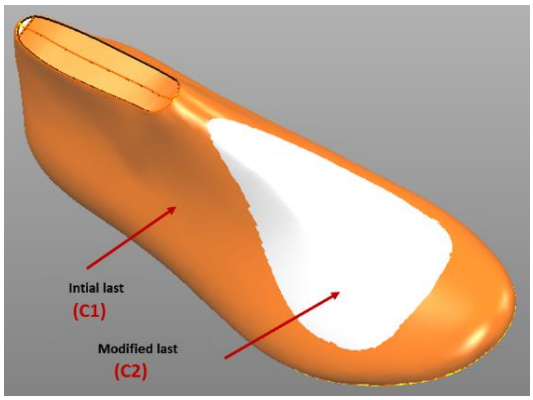

Figure 1. Last view after applying the top template

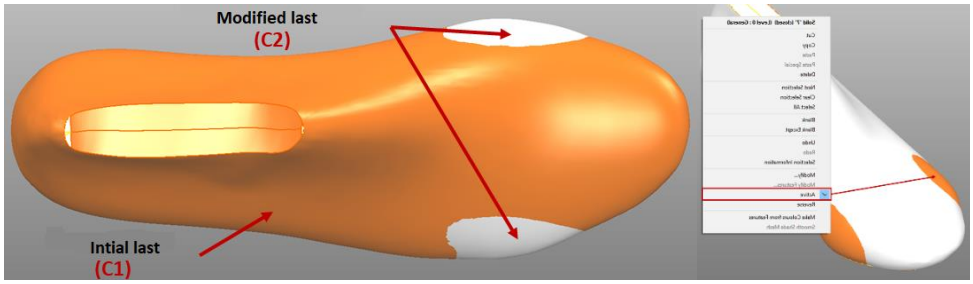

Figure 2. Side last view after applying loading areas

3D printers offer designers the ability to produce a prototype in a very short time (figure 3). Thus the prototype can be created, tested, and possibly redesigned quickly [9].

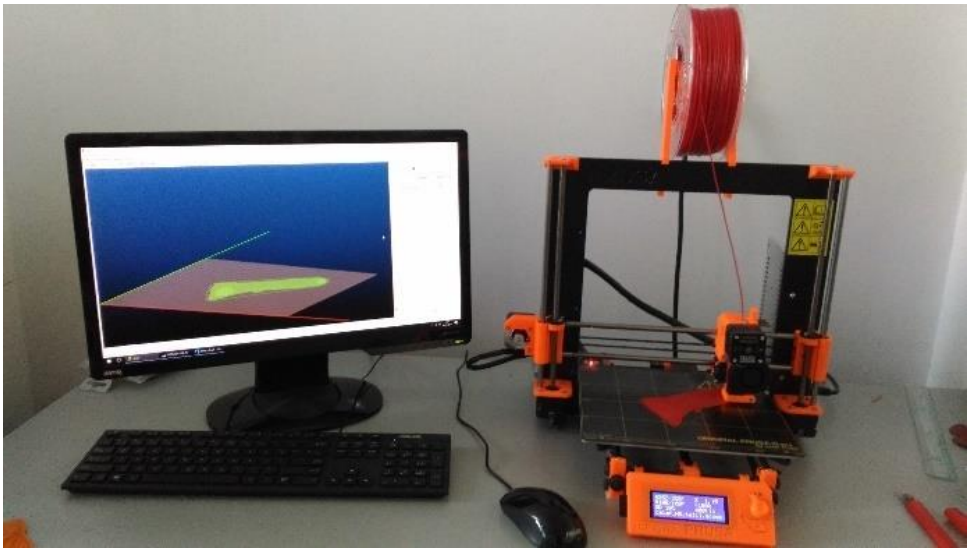

Figure 3. The 3D printing process using Prusa printer

TUIASI has tested this methodology using the Prusa 3D printer. In this specific case, the 3D file is sent to the printer's SD card, and the print command is given from the machine's internal menu. In the printing process, the head of the PLA plastic deposition nozzle heats up and melts the filament, and the movable arm moves on the three X, Y, and Z axes for deposition in layers.

The fitting elements resulting from the printer are attached to the last and continue with the creation of custom footwear. New fitting elements will be created at the next check of the patient's foot, depending on its changes.

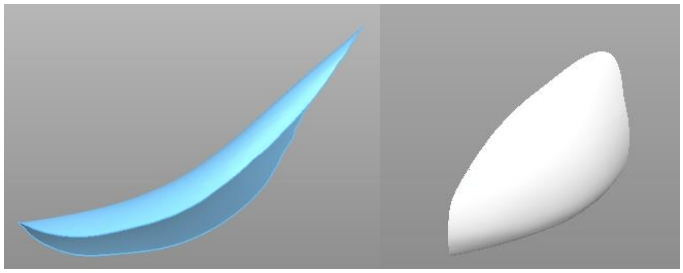

Figure 4. Custom last loading elements

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