A NEW 3D DESIGN METHOD FOR FOOTWEAR SOLES USING DELCAM PowerSHAPE-e SYSTEM

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Abstract: Design methods of soles and soles injection moulds must be accurate, timely and at the same time, accessible to a wide category of soles and injection moulds designers and manufacturers. For designing soles and injection moulds for soles, various dedicated CAD/CAM systems have been developed, such as: Delcam Shoe Solution (3D), Delcam PowerSHAPE-e (2D and 3D), Padsy II (2D) and Padsy III (3D), Shoemaster System (2D and 3D), Lectra System (2D and 3D), Parmel System (2D) and ATOS II System (3D). These systems are equipped with colour displays, plotters, digitizers, terminals and other equipment dedicated for computer aided design activities. Designing 3D soles models using computer systems enables the prevention of ambiguities inherited from 2D drawings, thus reducing errors and remanufacturing. Depending on the design complexity of soles, the technical means available for copying shoe soles and the technologies at the disposal of the soles manufacturers, soles and injection moulds designers adopt various design methods. Not all CAD/CAM systems are accessible for all users, because often their purchasing costs are high. Design method developed and presented in this paper, uses Delcam PowerSHAPE software program, which has the advantage that it can be accessed free of charge from the manufacturer's website. At the same time, this software program provides the user with all the necessary tools and instruments needed to design the most complex injection moulds and footwear sole.

Key words: footwear, shoes soles, design shoes soles, mould's soles

1. INTRODUCTION

Design methods for shoe soles and injection moulds for soles must be regularly updated in order to respond to the latest market demands and to new manufacturing methods and systems of moulds. CAM systems have largely replaced conventional machines from injection moulds manufacturing facilities and this imposed the adoption of CAD systems for the designing process of shoe soles and injection moulds [1]. Apart from the necessity to design shoe soles using CAD systems, the following advantages can be mentioned [2]: 3D visualization of designed soles, design corrections without the need to redesign from scratch, fast and easy grading for all shoe sizes, the

possibility to validate soles design using rapid prototyping [3], the possibility to reuse previous designs for new soles designs thus eliminating several steps, estimating the required volume of polymer mixture for manufacturing soles and estimating production costs. Conventional design methods find their applicability in CAD systems, from the simplest to the most complex soles designs, but CAD systems offer new design possibilities, particular for these systems [4]. This paper presents a new 3D design method, developed by the authors, for footwear soles, using Delcam PowerSHAPE-e software program.

2. DEVELOPED DESIGN METHOD FOR FOOTWEAR SOLES. CASE STUDY

Step 1. Importing the shoe last
To design a shoe sole, it is necessary to digitize or to 3D scan the shoe last into an electronic format recognized by PowerSHAPE-e, IGES is recommended. The shoe last in IGES format is imported in to the workplace. After import, the last is defined by a series of surfaces. For use in design, it is converted into solid. From *File* menu select the *Import / Export* option. Selecting this option opens the *Select file to import* window, that allows to select the file containing the shoe last. After importing the last, it can be visualized in the workplace [5], [6].

Step 2. Converting the shoe last into a solid
The last imported into PowerShape-e software is defined by a series of surfaces. To convert it from *surfaces* to *solid*, select all surfaces of the shape of the last and from *Solid* menu select *Create solid from selected surfaces* tool.

Step 3. Defining the solid from which the sole will be modelled
After positioning the shape of the last in the axis system, orientated correctly in relation to the bearing plane and with heel height set correctly, the primary solid is constructed, so that it encompasses the sole, as shown in Fig. 1. This is the only restriction to create the solid; to facilitate the modelling of the solid it is recommended that it's limits should not be much bigger than the limits of the sole. For modelling the sole, a cuboid will be activated as a solid, which will cover the lower area of the last in all three directions (length, width and height). The cuboid has to exceed the limits of the shoe last (lateral, posterior, anterior and inferior). To create the cuboid, *Create solid block* tool will be enabled, and associated tools will be used to positioning and resizing it.
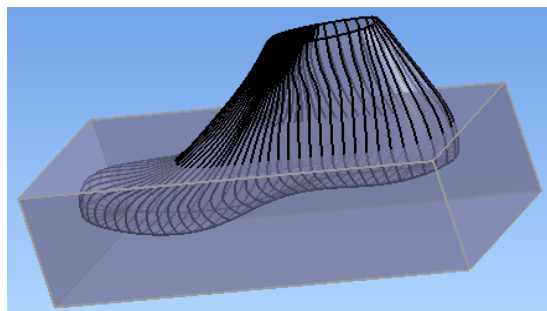

Fig. 1: *Defining the solid from which the sole will be modeled*

For the lateral contour of the sole and for the perimeter contour, slicing method with surfaces will be used [7], [8]. Slicing surfaces will be defined by a curved profile, linear, combined, opened or closed. In this case study, the upper lateral profile will be defined by an open type Bezier curve. Based on this curve, slicing surface will be created. The upper outline of the sole is defined by the adhesion limit between the sole and the footwear uppers, Fig. 2a. Depending of the destination of

the footwear product and the specific functions that must be ensured by the sole, the shape of the contour may be different from interior to exterior. Therefore, the interior upper contour limit can be higher to provide increased support for the arch of the foot, as shown in Fig. 2b. The difference between the lower contour of the last and the upper sole contour forms the lateral profile of the sole.
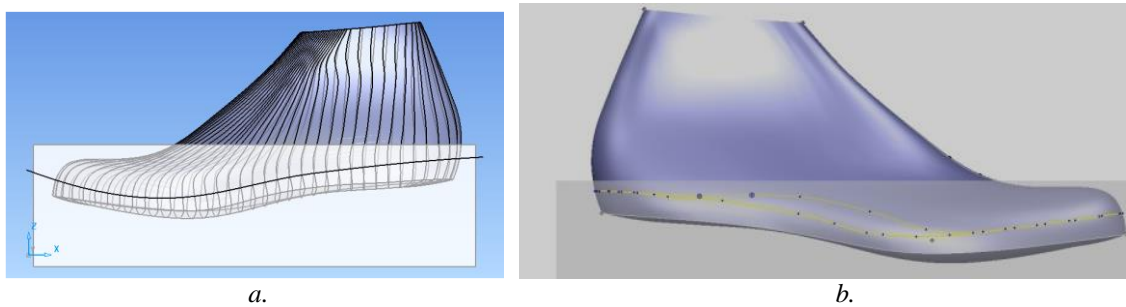
a.   *b.*
Fig 2: *Defining the upper lateral profile of the sole*
a. upper outline of the sole; b. highlighting the difference between inner and outer contour

Step 4. Defining the surface for sectioning

After sectioning the solid and removing the excess from the top region, the sole profile in this area is obtained. The interface surface has to exceed the cuboid solid in all lateral direction. The tool used for slicing the contour by surface is *Split the active solid using the selected solid, surface or symbol.* Therefore, after deleting the upper section of the solid, the upper profile of the sole is visible. These steps are presented in Fig. 3.
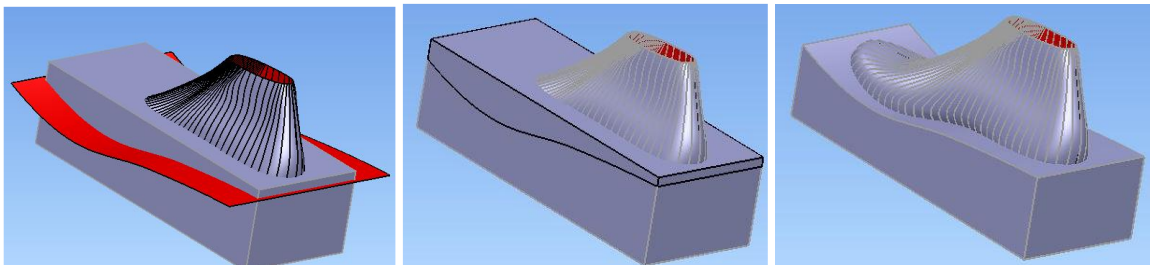

Fig. 3: *Defining the surface for sectioning*

Step 5. Defining the outer perimeter of the sole

The shape of the outer contour of the sole can be defined in several ways. The inner contour is defined by the intersection of the last with the solid. The resulting inner contour is represented by the curve of the yellow colour in Fig. 4. The outer contour is created by using *Offset object* tool, represented in the same Fig. 4a, by the green curve. To *offset* the contour to the exterior of the lasts, negative values were used. The outer contour (green colour) defines the sectioning surface profile. in this case, the outline is closed, and the area will be tubular.

If a contour that does not follow the shape of the last is desired, or which has a more complex shape, it can be traced by using line and/or curved segments. To define this contour, it is necessary to define an intermediary contour, resulted from the intersection between the last and the volume defining the sole, as shown in Fig. 4b. After that, the outer contour is traced by shifting the intermediary contour. the sectioning is carried out in the same way as in the case of the upper profile, equidistant from the inner contour. After sectioning the solid, the exterior is deleted, remaining the solid presented in Fig. 4c.
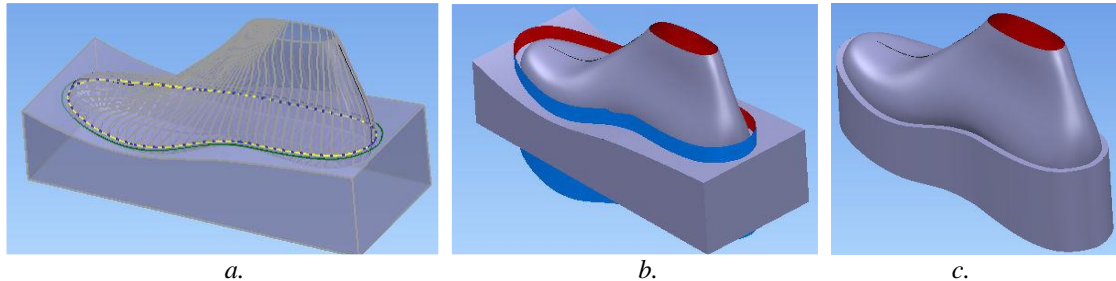
a.   *b.*   *c.*

Fig. 4: *Defining the outer perimeter of the sole*
a. defining the inner contour; b. defining the intermediary contour; c. sole exterior perimeter

Step 6. Defining the bottom lateral profile of the sole

Designing the bottom profile of the sole is done as in the case of the upper profile. First, the profile of the sole is drawn, which can be composed of straight and/or curved sections. Based on the created profile, the sectioning surface is created. After the solid is sectioned, the bottom excess solid is removed and the bottom lateral profile of the sole is obtained, as shown in Fig. 5a.

Step 7. Defining the sole concavity on the upper surface

The sole concavity represents the area that will be in direct contact with footwear uppers. The actual volume of the sole, as shown in Fig. 5b, is defined by removing from the volume of the solid, defined in the previous phases, the part that intersects the volume of the last. Thi is done by using the logical operator.

Step 8. Adjustments to the shape of the sole

Depending on the design requirements, it make take a number of adjustments to the shape of the sole. For example, rounding the outer edge of the sole. This operation, presented in Fig. 5c, is obtained by connecting the upper surface to the lateral surface. In order to obtain different designs, the upper edge of the sole can be processed in several ways.
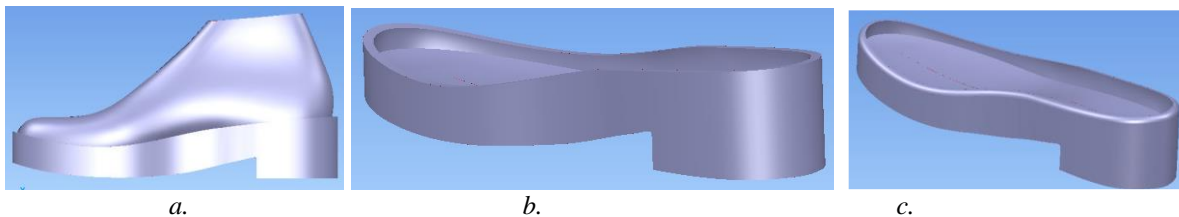

a.   *b.*   *c.*

Fig. 5: *Designing the 3D shape of the sole*
a. defining the bottom lateral profile; b. defining the sole concavity; c. finishing the 3D shape of the sole

Step 9. Designing the antiskid embossment design

In order to design various elements on the bottom surface of the sole, a network of construction lines is build, as shown in Fig. 6a. This network complies with the 3D shape of the plantar surface. The antiskid design is drawn on the defined network, using a series of segments composed of straight and/or curved lines. By projecting this network of lines on the plantar surface of the sole, a spatial network of lines is obtained. As long we comply with the spatial shape of the plantar surface, relief elements, defined as solids, can be defined by any available methods (primitive solid, generated or built). Based on this method, the whole assembly of components is designed in order to be catted, as shown in Fig. 6b. Depending on the designed model, the trajectories for generating various antiskid relief will have various shapes. By viewing the designed

solid and the trajectories, it can be verified the ownership of the trajectories on the surface of the sole. All curves are extended beyond the margins of the sole in order to ensure proper edge sectioning, as showed in Fig. 6c.
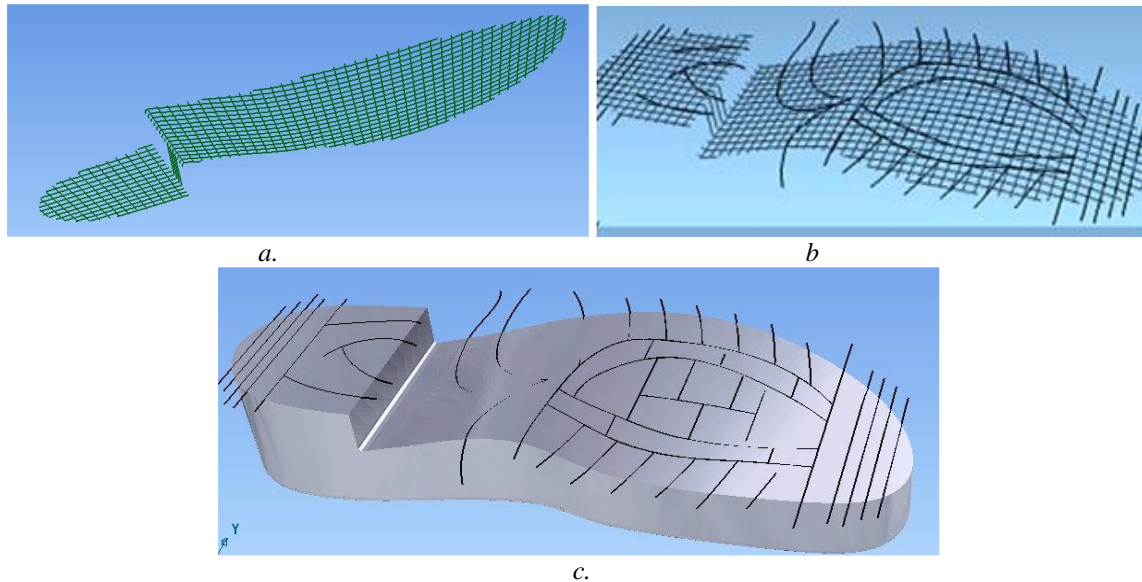

a.   *b*

c.

Fig. 6: *Defining the antiskid design*
a. network of construction lines; b. drawing the antiskid lines; c. projecting the antiskid design lines on the bottom surface of the sole

For each trajectory individually, the base outline (section) is traced. Based on defined sections and associated trajectories, solids that define the antiskid relief are designed. Created solids are placed on the bottom surface of the sole, as shown in Fig. 7a. The final shape of the sole s smoothed using software specific tools, Fig. 7b. [5] , [9].
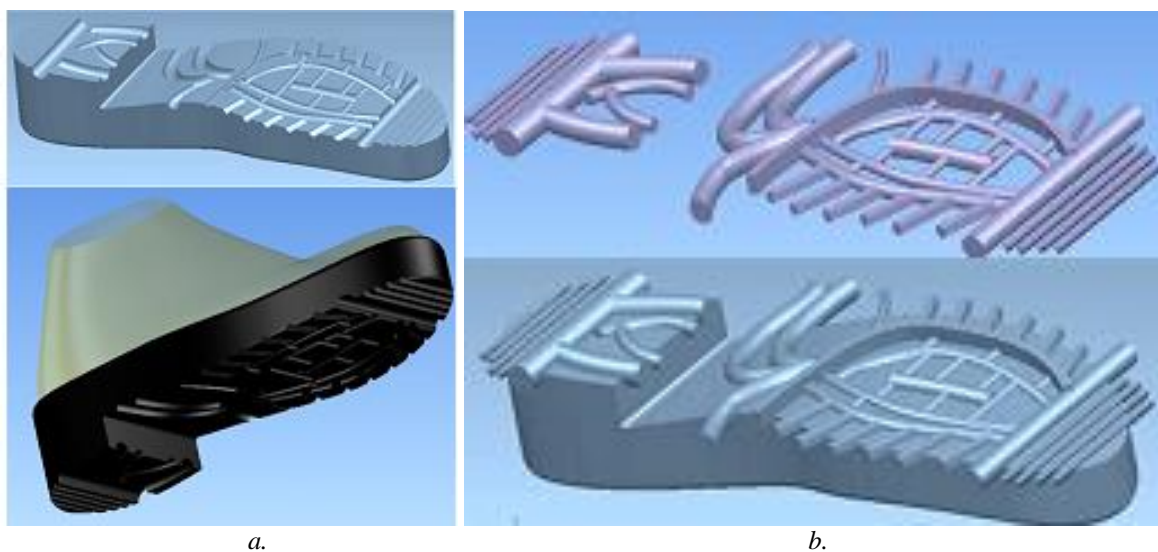

a.   *b.*

Fig. 7: *Designing the antiskid relief*
a. defining solid shapes; b. defining smoothing the antiskid relief

5. CONCLUSIONS

Design methods of shoe soles and by default of soles injection moulds must be accurate, fast and accessible to a wide category of designers and manufacturers. Manufacturers adopt various design methods depending on the design complexity of soles, the technical means available for copying shoe soles and the available manufacturing technologies. In the field of footwear soles and injection moulds design, advanced CAD/CAM systems have been developed. Most of these systems are not accessible to all users because of their high price. Delcam PowerSHAPE-e software program used in the development of the design method presented in this paper, has the advantage that it can be accessed for free from the manufacturer website. On the other hand, PowerSHAPE allows a mixture of design instruments, combining solid shapes modelling with surfaces modelling and has the flexibility needed for designing complex shapes, such as footwear soles. The soles designed using PowerSHAPE can be easily modified to obtain various 3D soles designs with multiple layers and colours. Unlike other CAD environments, using PowerSHAPE, 3D solid shapes and surfaces can be designed with minimum effort. The developed design method can be approached in advanced design of footwear soles and injection moulds for sole.

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