



A NEW DESIGN METHOD FOR FLAT FOOTWEAR SOLES

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Abstract: Carried research regarding footwear soles revealed that by moulding footwear details can be obtained in a wide variety of models. Shoe soles are complex three dimensional objects and for attaching them with the uppers, the interior contour of the soles has to correspond to the featherline contour of the last. That's why, is necessary that soles design to be done with high accuracy and in strict accordance to the last. Nowadays, there are specialized software applications which can perform various computer aided design processes for footwear. Among the high performance systems used for the design of footwear soles and injection moulds for shoe soles, we may mention: Delcam Shoe Solution, Delcam PowerSHAPE-e, Padsy II and Padsy III, Shoe Master System, Lectra System, Parmel System and ATOS II System. This paper presents a 3D design method, developed by the authors, for footwear flat soles using PowerSHAPE-e software program from of Delcam Crispin. The computer-aided design technique used in this paper highlights several important advantages that include: increased design quality; three dimensional viewing of soles, which can lead to immediate decisions, regarding the acceptance of newly developed models; it can be appreciated the complexity of mould cavities execution, without the need of making prototypes; the outlines of construction templates are accurately obtained for the mould cavities and for all size numbers; calculations can easily be done for determining the soles volume for the entire size number, with implications on estimating polymer blend consumption and so on.

Key words: footwear, shoes soles, shoes soles design, soles injection mould

1. INTRODUCTION

The CAD/CAM design systems have been largely developed including for the domain of footwear uppers and footwear soles. Among the high performance systems used in the design of footwear soles and moulds for shoe soles, we may mention: Delcam Shoe Solution (3D), Delcam PowerSHAPE-e (2D and 3D) [1], [2] Padsy II (2D) and Padsy III (3D), Shoe Master System (2D and 3D), Lectra System (2D and 3D), Parmel System (2D) and ATOS II System (3D). These systems are equipped with colour graphical displays, plotters, digitizers, terminals and other peripheral equipments needed for computer assisted activities.

The footwear soles are produced as flat footwear soles, as partially spatial zed footwear soles and as spatial zed footwear soles [3]. The complexity of footwear soles design and mould cavities increases with the degree of spatialization. The Delcam Shoe Solutions and Delcam PowerSHAPE-e applications provide to the user the necessary tools to design the most complex footwear soles and footwear moulds.

In this paper is presented a method [4] developed by the authors, for the 3D design of the footwear flat soles which are formed in injection moulds, using the PowerSHAPE-e application.

2. FLAT SOLES FOOTWEAR DESIGN in PowerSHAPE-e. CASE STUDY

The flat sole is the easiest kind of sole to design from a geometrical point of view. A set of steps are followed to design the flat footwear soles [4].

Step 1. Copying the shoe last

The bottom contour of the shoe last is copied as a patten using one of the known methods. This pattern represents the shoe last insole (Fig.1).

Step 2. Inputting the insole outline, drawing the main axis and positioning the basic foot anatomical points

These operations are shown in Fig. 1. The insole outline is drawn as a Bezier curve using the *Create a Bezier Curve* tool under the *Curve* function.

After inputting the insole outline, the two axes are drawn: the insole axis and the shankpiece axis. These axes are drawn using the *Create a single line* tool in the *Line* function as simple lines, by specifying the coordinates.

The main anatomical points are positioned on the insole axis represented by the segment 1-7 in the Fig. 1b. Their coordinates are calculated according to the foot length L_p . The value of the foot length is equal with the footwear last size number, in centimetres. The reference points used for the footwear sole design are the following: 0 – rear foot curvature amplitude; 2 – heel centre; 3 – middle of the foot arch; 4 – centre of metatarso-phalangeal articulations I-V and 5 – extremity of toe V. The position of these points, respectively the length of the segments relative to the point 1, are calculated with the following relations: $0-1=0.025*L_p$; $0-2=0.18*L_p$; $0-3=0.48*L_p$; $0-4=0.66*L_p$; $0-5=0.81*L_p$; $0-6=L_p$. The length of the segment 6-7, represents the length of the footwear last tip whose size is variable and depends on the tip shape.

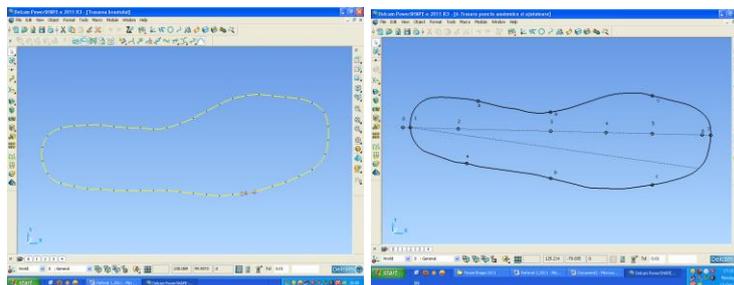


Fig. 1: Step 1 and Step 2

The posterior extreme point 0 is obtained by extending the insole axis in the rear zone. In order to accomplish this, a work-plane is positioned with its origin in point 1 and its ox axis overlapping the insole axis. To create this work-plane follow this procedure: select the *Workplane* function and then the *Create a single workplane* tool and position the new work-plane with its origin in the point 1; reposition this plane's ox axis along the insole axis; open de insole axis parameters

editor; select the newly created work-plane as the value of the *Workspace* field; fill the 1-0 segment inverted length in the X field of the start point.

To position the points 2, 3, 4, 5 on the insole axis follow this procedure: select the circle drawing tool; open the position dialog box; select the *Along* option; select the insole axis by clicking next to the start point; fill in the *Proportion* field with the corresponding proportion (e.g.: 0.18 for the point 2); click on *Apply* and then on *OK*.

The position of the point 6 will be determined using the *Line* function and drawing an added line whose length will be equal with the foot length. After positioning the point 6 the added line should be erased using the option *Delete*. The *Horizontal text* tool in the *Annotation* function is used in order to label the points. The position of the points will be marked by circles which are drawn using the *Create a full arc* tool in the *Arc* function. The radius value will be filled in the *Radius* field. The *Name* field is filled automatically with a number generated in the order of creation. However, each circle name can be manually set.

Step 3. Drawing the footwear sole interior contour

The sole interior contour is presented in Fig. 2.

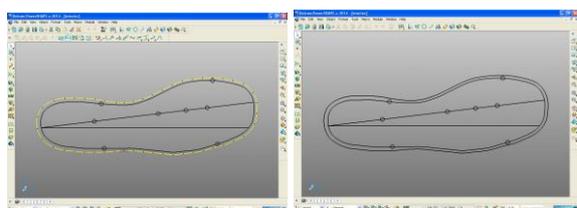


Fig. 2: Step 3

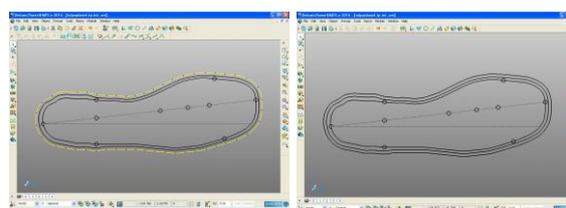


Fig. 3: Step 4

The sole interior contour is obtained by adding the thickness of the upper parts to the insole contour. This thickness varies along the insole perimeter depending on the number and the thickness of the layers. From the thickness variation point of view, the zones a-1-a, a-b, b-c and c-7-c are distinguished on the insole contour, represented in Fig. 1. The positioning of the points that separates these zones is accomplished by constructing a set of added lines as Bezier curves. The curves will be drawn in the outside direction using the point 1 as start point

The distance at which the sole interior contour will be positioned in relation with the insole contour is variable. To draw this contour, the *Variable offset* tool in *General edit options* is used. In the *Offset* window associated with this tool, the set of points for each zone is selected individually. If the transition from one zone to the other is not smooth, the curve should be fine-tuned to obtain a smooth curve.

Step 4. Drawing the footwear sole exterior contour

The sole exterior contour, presented in Fig. 3, is drawn at a constant distance in relation with the interior contour. This distance varies depending on the footwear sole model, between 0 and 8 mm. The *Offset items* tool from the *General edit options* is used to draw this curve. Select the sole interior contour and then select the *Offset items* tool. The offset value is specified in the associated window. The *Keep original* button must be activated in order to keep the sole interior contour.

Step 5. Defining the footwear sole gluing surface

The gluing surface, represented in Fig. 4, is the area where the upper and sole are assembled by gluing. This surface is continuous, without weight removal cavities and its width is of 14-15 mm. The exterior of the gluing surface is delimited by the sole interior contour. The interior limit of the gluing surface is obtained by drawing a contour parallel to the sole interior contour, at a distance equal with the gluing surface width. The tool used is *Offset items* in the *General edit options*. After

selecting the sole interior contour click the *Offset items* tool and then specify the offset distance and activate the keep original.

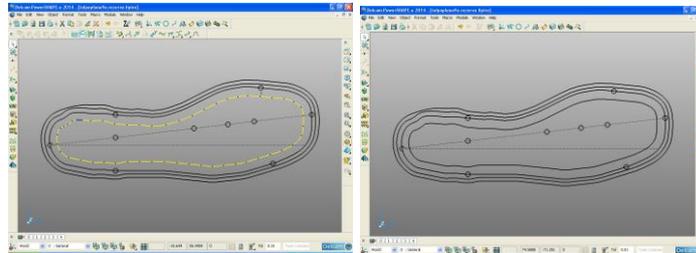


Fig. 4: Step 5

Step 6. Creating the solid that defines the volume occupied by the upper in the sole volume

In order to assemble the footwear upper by gluing with the sole a cavity in the sole volume is needed. This cavity represents the volume occupied by the lasted upper in the sole volume.

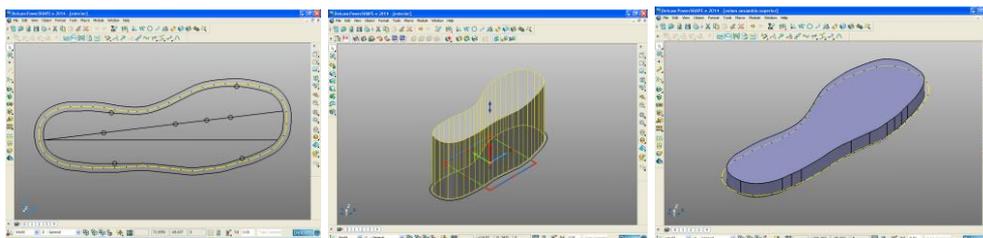


Fig. 5: Step 6

To accomplish this, an extrusion solid is created starting from the interior contour of the sole. This solid enters in the sole volume on a distance equal with the cavity height. This volume will be removed from the sole volume. Select the sole interior contour and using the *Create one or more solid extrusions* tool from the *Solid* function the solid is created. The solid extrusion height will be specified in the parameter editor for this solid in the *Negative Length* field. The *Length* occupied by the solid above the sole will be established big enough to allow an easy selection of the solid. In Figure 5 there are shown stages of the step [5], [6].

Step 7. Creating the solid that defines the sole volume. Obtaining the sole cavity

The thickness of the sole is obtained by summing the heel height, the sole cavity height and the sole thickness in the front sole zone.

Initially, the sole will be defined as a monolith solid, obtained by extruding in negative direction the exterior contour on a distance equal with the sole thickness. In order to accomplish this, the sole exterior contour is selected, the solid is created using the *Create one or more solid extrusions* tool in the *Solid* function and the value of the sole thickness is filled in the *Negative Length* field. The field *Length* is filled with the zero value because the sole will be delimited above by the XOY plane of the coordinate system associated to the work-plane. The sole cavity height is obtained by eliminating the solid that defines the cavity from the solid that defines the total sole volume. To operate on the solid that defines the sole, this solid must be activated by checking the option *Active*.

The tool used for solid removal is *Remove the selected solid, surface or symbol from the active solid* in the function *Feature*. Several operations are in Fig. 6.

Step 8. Defining the heel volume

The heel volume is obtained by removing an auxiliary solid from the solid that defines total volume of the sole. The auxiliary solid contour is obtained by drawing a set of straight line segments and/or curves which will be converted in a composite curve. After selecting the contour as a composite curve, the auxiliary solid is created using the *Create one or more solid extrusions* tool in the *Solid* function. The dimensioning of the auxiliary solid is done using the parameters editor: in the *Workspace* section is specified the vertical position of the auxiliary solid in relation with the bottom limit of the sole; in the *Dimensions* section is specified the *Negative Length* so that the auxiliary solid will pass the bottom limit of the sole; the *Length* is set to zero because the top limit is the vertical position of the contour set in the *Workspace* section. The removal of the auxiliary solid is obtained using the *Remove the selected solid, surface or symbol from the active solid* tool in the *Feature* function. The sequence of operations that led to the definition of the heel shape and volume is presented in Fig. 7.

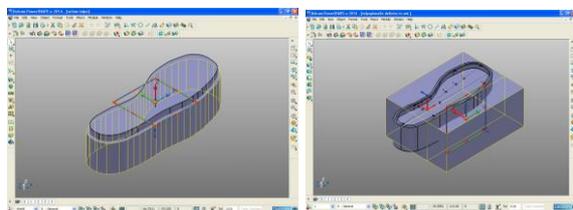


Fig. 6: Step 7

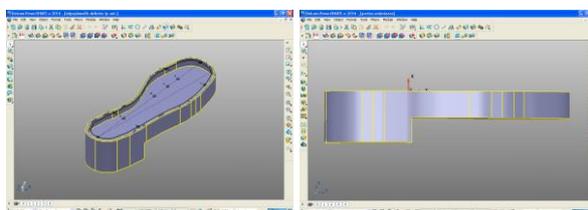


Fig. 7: Step 8

Step 9. Obtaining the sole weight removal cavities

A fast and precise method of drawing the weight removal cavities consists in using an auxiliary construction. Using the compound curve tool, each individual weight removal cavity contour is drawn. The auxiliary solids are created by extrusion using this contours solids which will be removed from the sole solid. The extrusion is done in negative direction on a length equal with the depth of the weight removal cavities. The weight removal cavities were obtained by removing the auxiliary solids from the sole volume using the *Remove the selected solid, surface or symbol from the active solid* tool in the *Feature* function. Several operations are in Fig. 8.

Step 10. Obtaining the anti-skid relief. Obtaining the sole templates, designing the mould cavities manufacturing templates

The work method is similar to that used to obtain the weight removal cavities. On the surface of the solid on which the anti-skid relief will be made, an auxiliary network is drawn which will be used to obtain the contours of the auxiliary solids that will be removed from the sole volume. Because the surface of the heel and the surface of the sole are situated on different levels an auxiliary network will be drawn for each of this two zones. For each of the two surfaces a work-plane will be associated. The tool used for the creation of the work-planes is *Create a single workplane*. In order to draw the anti-skid embossment design, the *Create a single line* tool from the *Line* function and *Curve* function will be used.

Finally, the drawings are used to obtain the composite curves using the *Create a Composite Curve by tracing* tool. The composite curves are used to obtain the auxiliary solids using the *Create one or more solid extrusion* tool in the *Solid* function.

The anti-skid relief will be obtained by removing or adding the auxiliary solids volume to the sole volume using the *Remove/Add the selected solid, surface or symbol to the active solid* tool in the *Feature* function. Steps the anti-skid relief drawing are shown in Fig. 9.

By designing the sole, the following templates are obtained: sole interior contour, sole exterior contour, sole contour with antiskid relief and longitudinal cross-section through the sole

axis. To design the mould cavity, these templates will be increased by one of the available methods, using the contraction coefficient value of the polymeric blends used for the sole.

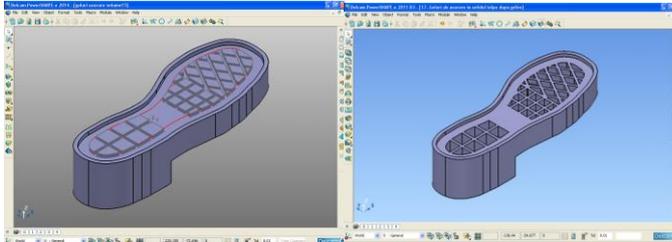


Fig. 8: Step 9

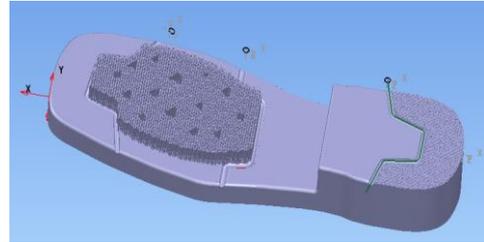


Fig. 9: Step 10

3. CONCLUSIONS

- The Delcam PowerSHAPE-e application provides a complete and intuitive computer aided design solution. Unlike other CAD solutions, using PowerSHAPE-e, the surfaces and 3D solids are created with a minimum effort. The method presented in this paper is approachable to any category of designers with basic skills in CAD systems.
- Hybrid modelling from PowerSHAPE-e, combines perfectly solutions for solid and surface modelling, providing the necessary flexibility to develop complex shapes like the footwear soles and mould cavities.
- The developed method allows the input of the 3D last contour, the 3D sole design, endless diversification possibilities of the soles designs, the three-dimensional visualization of the sole models, obtaining the patterns or casts needed for the execution of the mould nests, determining the polymer blends volume needed to obtain the soles, etc.

REFERENCES

- [1] M. Stein, E. Bowman, G. Pierce, "Direct 3D. Professional Reference," in New Riders Publishing, 2008, pp. 30-55.
- [2] L. Mărcuș, "Regarding the Lasting of Footwear Uppers Using Different Technological Variants", in Annals of the Oradea University, Fascicle of Textile Leatherwork, 2008, pg. 331-336.
- [3] M. Drișcu, "Modeling of Planar and Spatial Forms of Footwear", in Romania, Pim Publishing Iași, 2008, pp.109-134.
- [4] C. Ionescu, R.Mocanu, "Geometrical Design Algorithms for Moulds Shoe Soles" in Annals of the Oradea University, Fascicle Mechanical Engineering Department, 2011, pp.4.19-4.25.
- [5] C. Ionescu, R. Mocanu, in "Design Molds for Shoes", in Romania, Pim Publishing Iași, 2010, pp. 60-82.
- [6] M. Costea, in "Modeling and rapid prototyping footwear components prophylactic", in Romania, Performantica Publishing Iași, 2015, pp.120-126.