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# CONTRIBUTIONS TO THE DETERMINATION OF A MOULDING MATERIALS OTHER THAN STIFFENERS AND SHOES INSOLES

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***Abstract:*** *The footwear insoles and heel counter stiffeners are made using fibrous structure materials. The spatial forming of these parts is made in moulds. After forming, the parts must have the same spatial dimensions with those of the shoe lasts used in the footwear manufacturing. During the forming process, the fibrous structure materials have an elastic-plastic behavior. So, for the moulds dimensioning, it is important to know the percentage of plastic deformation from the total deformation of the stressed material; this means to know the value of these materials forming subscript. The paper presents some theoretical and experimental contributions in finding of the forming subscript of the materials used in the footwear industry, for the footwear insoles and heel counter stiffeners manufacturing. Experiments were made on installations and experimental moulds sphere, cylinder and central angle. Experimental results shows that the forming subscript depends on the mould shape and the sample humidity when the stress is cancel. So, the deformations have a high rate, the sphere surfaces having the, highest forming subscript. In the case of sample forming which use cylinder moulds the value of the forming subscript on these surfaces is the lowest. In the case of the center angle occurs a a high level of plastic deformation. The results will be applied at the designing of the insoles and heel counter stiffeners moulds used for the pre-moulding.*

***Key words:*** *footwear, insoles mould, heel counter stiffeners mould*

## 1. INTRODUCTION

The footwear insoles and heel counter stiffeners are confectioned from the rigid leather for soles, artificial leather for soles, of the materials made from cellulose fibers, board, etc. manifest elastics-plastics deformations [1]. When the footwear parts made from the fibrous structure materials are manufactured, there are used moulds. So, after forming, the parts must have the same spatial dimensions with those of the shoe lasts used in the footwear manufacturing. This connecting parameter is the forming subscript which is a part of the plastic deformation from the total deformation. Wanting the dimensioning of the moulds used in spatial forming of the footwear insoles and heel counter stiffeners, it is imperious necessary to know the value of this subscript [2]. On the other side, the footwear shoe-lasts have complex designs. On their surfaces there are various curvatures which may be parts of cylinder, sphere and central angle surfaces. It is a problem to identify the designs which appear on different areas of the shoe-last and to follow the dependence between the shape of the shoe-last and the value of the forming subscript. The forming subscript depends, in the same time, on the proprieties of the material, but the technological conditions, too.

The manufacturers of the moulds used in pre-forming of the footwear insoles and heel counter stiffeners, provide moulds kits (which were conceived for each kind of material), to the manufacturers of the footwear.

In the real manufacturing processes, the researches are very useful for finding the technological conditions in using of moulds set for different materials. In an opposite case, the often renewing of the moulds set is expensive and non-productive.

As follows, there are presented an operative calculation method of the forming subscript and technological solutions for the using of the same moulds kits for different kind of materials.

## 2. EXPOSITION

When the footwear parts made from the fibrous structure materials are manufactured, there are used moulds with stresses in unlimited space and moulds with stresses in limited space. In the moulds with unlimited forming space, the parts are compressed between two concave-convex surfaces without lateral limits. As a result of the compression and bending stresses, the parts dimensions are modified on tangential directions at the mould curved surfaces, both on the longitudinal and on the cross directions [3]. These moulds are used in leather insoles and soles forming. In the moulds with limited forming space, the parts are compressed in a certain space. These moulds are used in heel counter stiffeners forming. The effect is forming and fixing of the heel counter stiffener structure at a precise form.

After the forming, the part must have the dimensions of the curved spatial surface of the shoe-last used for fitting. So, in the forming process, the part must compress between two concave-convex surfaces which must be dimensioned so that, after the canceling of the elastic deformations, the part must have the shoe-last [4] dimensions.

Whether: $D_c$ – spatial dimension of the shoe-last; $D_m$ – spatial dimension of the mould and, respectively of the concave-convex surfaces; $D_r$ – dimension of the part. Considering $D_c=D_r$ and the canceling of the elastic deformations: $D_m<D_c$. For the connecting of these two dimensions, it will consider the cylinder surface having a radius R, Fig.1 (representing only the convex surface) [3, 4]. On this surface, a plane part is generated by compression. After the elastic deformations are canceled, the radius R of the plane part becomes the radius R'.

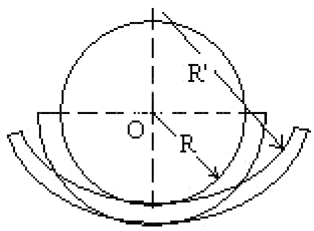


***Fig. 1:*** *Rays of curvature of the cylindrical mould*

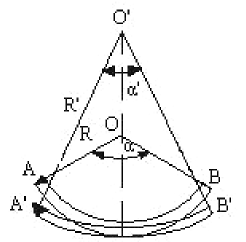


***Fig.2:*** *The angles to the center of cylindrical mold*

Considering R-dimension of the mould and R'-dimension of the part after the elastic deformation canceling, it results the following two relations: R'>R, $D_r>D_m$. But the part dimension must be equal with the shoe-last one, so, $D_c>D_m$. Knowing that, in any forming process, the two kind of deformations (the elastic one, $\varepsilon_e$ and the plastic one, $\varepsilon_p$) take place and knowing that the elastic deformation is canceled when the load is removed, it results that, between the spatial dimensions of the shoe-last and those of the mould, it must exist a bonding factor depending on the plastic deformation of the material which is formed, [3, 5]. Considering: $D_m/D_c=I_f$, where $I_f$ is the forming subscript, the mould dimensions will be calculated using the relation (1).

$$D_m = D_c \cdot I_f \text{, [m]} \tag{1}$$

Considering that the material is only plastic deformed, the forming subscript will be equal to 1, so, $D_m=D_c$. But, as the relation (2) shows, the material is elastic deformed, too; this aspect must be considered when the material dimensions in plane will be changed with the shoe-last dimensions in space.

$$\varepsilon = \varepsilon_e + \varepsilon_p \text{ , [N]} \tag{2}$$

$\varepsilon$ -total deformation; $\varepsilon_e$ – elastic deformation;
$\varepsilon_p$ -plastic deformation.

Considering relation (2) and the total deformation equal to 1, the plastic deformation is calculated using relation (3).

$$\varepsilon_p = 1 - \varepsilon_e \text{ , [N]} \tag{3}$$

Alter the elastic deformation cancels, the part dimensions will increase in comparison with the mould once, being equal with those of the shoe-last. This aspect is possible if the mould dimensions and the shoe-last once may be connected in a relation as relation (4).

$$D_m = D_r(1-\varepsilon_e),\ [\text{m}] \tag{4}$$

Replacing this value in relation (1), it will obtain relation (5).

$$I_f = \frac{D_c(1-\varepsilon_e)}{D_c} = 1-\varepsilon_e = \varepsilon_p \tag{5}$$

So, it results that the forming subscript has a value equal to the plastic deformation one, when the deformations sum is equal to 1. In figure 1, there were represented only the radius of the curvature of the mould and of the part which must be obtained using a forming process. Considering, for the same situation, the lengths of the circular arcs of the part before the forming (l), respectively, after the forming (l'), and the central angles before the forming (α) and after the forming ($\alpha^{'}$), Fig.2, between all these parameters is a relation as the relation (6) is:

$$l = R\cdot\alpha,\ [\text{m}] \tag{6}$$

α is expressed in radians.

The change from R radius spatial form to $R^{'}$ radius spatial form takes place without the change of the circular arc length, so, $l^{'}=l$. In these conditions, $R^{'}\alpha=R\ \alpha$. So, the value of $\alpha^{'}$ angle may be calculated using the relation (7).

$$\alpha^{'} = \frac{R\alpha}{R^{'}} = \frac{R\alpha}{RI_f} = \frac{\alpha}{I_f},[\text{rad}] \tag{7}$$

It results that the value of the central angle through the passing from the mould to the part may be obtained using the form subscript. The passing from the shoe-last dimensions to the mould dimensions is possible, in this case, using a theoretical method by calculation, considering the main parameter as the forming subscript.

It is a problem to identify the designs which appear on different areas of the shoe-last in the three planes, considering that the passing from the shoe-last to the mould is not possible using only one forming subscript.

In the longitudinal section of the shoe-last, there are some curve designs, which are components of the cylinder, having respectively $R_1$, $R_2$,...,$R_k$ radius. Cylinder components, having respectively $R_{k+1}$, $R_{k+2}$,..,$R_n$ radius, are in the cross sections, too. The using of a forming subscript appropriate to the insole material would lead to some other cylinder components having $R_1^{'}$, $R_2^{'}$,..,$R_k^{'}$ radius for the longitudinal sections of the shoe-last and, respectively, $R^{'}_{k+1}$, $R^{'}_{k+2}$,…,$R^{'}_n$ radius for the cross sections.

In the case of the passing from the shoe-last to the mould used in heel counter stiffener forming, Fig. 3, there are observed cylinder components having $R_1$, $R_2$,..,$R_n$, radius and the central angles α and β.

Inside of the posterior area, there are a cylinder having a $R_5$ radius, Fig. 3, in projection on vertical plane, the cylinder components having $R_6$ and $R_7$ radius in projections on horizontal plane and the central angle γ. It results that, in the projections on the three directional planes, there are observed circular arcs generated from some cylinders crossing and central angles generated by tangential planes to the line between the lateral area and the inferior area of the shoe-last. On the posterior area of the shoe-last, the curvature is very pregnant, having a revolution ellipsoid design which, on limits, may be considered as a globe calotte.

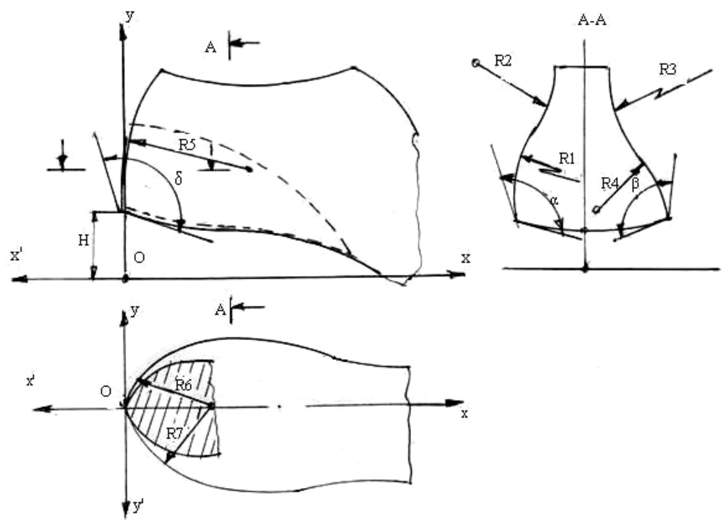


***Fig. 3:*** *Circular arcs and central angles as components of the shoe-last used in heel counter stiffener manufacturing*

In conclusion, when the passing from the shoe-last design and dimensions to the mould design and dimensions takes place, it must use forming subscript respectively for the three kinds of shapes: cylinder, central angle and sphere.

## 3. EXPERIMENTAL

The values of the forming subscript were calculated for some materials used in footwear manufacturing For the experimental research [5], there were realized three kinds of moulds with the following shapes: cylinder, central angle and sphere; these shapes are on the shoe-last, as in Fig. 4.

For each kind of shape, there were realized moulds having more dimensions: hemispheric moulds having the diameters of the circle 49 mm and 66,4mm, cylinder moulds having the diameters of the circle 29mm, 38 mm and 48 mm and central angle moulds having angles $90^0$, $100^0$ and $110^0$. This kind of dimensions has average values often used in the shoe-last manufacturing. The distance between the two surfaces concave-convex is, in all cases, 2mm which is the distance equal to the average thickness of the insoles and of the heel counter stiffeners.

The study has analyzed the behavior of the stiff leathers used for insoles, of the materials made from leather fibers and of the materials made from cellulose fibers, in the forming process.

The forming subscript depends on the proprieties of the material, but the technological conditions, too. This is the reason because, when the forming subscript was calculated, it counted the material humidity, the forming pressure, the time of pressure action and the rest time of the part.

The humidity of the material is an important technological parameter. Knowing the technological moisture ways, the conditioning regimes are: samples storage in air with humidity Φ= 65%, at temperature t=20-25$^0$C and time τ=24 hours; immersing in water with temperature t=25-30$^0$C and time τ=2 minutes; storage in saturate atmosphere with humidity Φ= 100%, at temperature t=20-25$^0$C and time τ=24 hours; immersing in water with temperature t=25-30$^0$C and time τ=2 hours; storage in saturate atmosphere with humidity Φ= 100%, at temperature t=20-25$^0$C and time τ=24 hours.

In forming process, the samples were compressed at 100daN/cm$^2$- the working pressure of the equipments used for insoles and heel counter stiffeners forming.

The adopted pressure time was 30 seconds; this time results knowing that the output of the equipments used in insoles and heel counter and stiffeners compressing is 800 pears/8 hours.

The researches was made using the three kinds of moulds in three conditioning regimes anterior mentioned.

After the forming process, when the samples are extracted out from the moulds, they are still wet. Depending on the conditioning regime, for the leather fibrous materials, the parameters values were: U=11,2% for regime Φ= 65%, t=20-25$^0$C and τ=24 hours; U=21,4% for regime 2 minutes moisture, Φ= 100%, t=20-25$^0$C and τ=24 hours and U=40,1% for regime 2 hours immersing and Φ= 100%, t=20-25$^0$C and τ=24 hours. The high humidity allows the cancel of the elastic mechanical work which was stored during the stress. After a 24 hours rest time, it were measured the radius of the samples which were formed using moulds with hemisphere and cylinder shape, respectively, moulds with central angles shape.

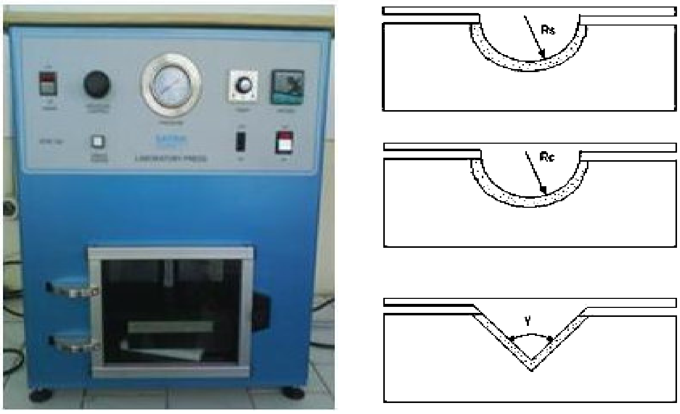


***Fig. 4:*** *Installation and experimental moulds: sphere, cylinder and central angle*

## 4. RESULTS AND DISCUSSIONS

The statistics shows that the forming subscript depends on the mould shape and the sample humidity when the stress is cancel. Table 1 presents experimental results [5] obtained using an artificial sole (a kind of leather fibrous material).

***Table 1:*** *$I_f$ values of the artificial sole*

| U, % | Mould shape | Average | Mean square deviation | Confidence interval |
|---|---|---|---|---|
| 11,2 | Sphere | 0,930 | 0,0126 | 0,900-0,951 |
| | Cylinder | 0,600 | 0,0096 | 0,437-0,783 |
| | Angle | 0,797 | 0,0043 | 0,724-0,870 |
| 21,4 | Sphere | 0,980 | 0,0100 | 0,963-0,997 |
| | Cylinder | 0,800 | 0,0631 | 0,602-0,908 |
| | Angle | 0,870 | 0,0393 | 0,803-0,937 |
| 40,1 | Sphere | 0,966 | 0,0193 | 0,931-1,001 |
| | Cylinder | 0,672 | 0,0530 | 0,578-0,771 |
| | Angle | 0,818 | 0,0340 | 0,753-893 |

Table 1 goes to the next conclusions[5]:

- Average of the forming subscript for the three kinds of spatial shapes is the highest for intermediate regime of humidity 20 and 25%.
- For the 20-25% humidity, average has maximum value: when it used a sphere mould (0,980), next one being the center angle mould (0,870), the smallest being for the cylinder one (0,800).
- Confidence interval in the sphere case is over 1; when it is adopted this kind of forming subscript, the material would be over-forming stress, so, in real conditions, it will adopt an average subscript having the value 0,980.

The final conclusion is that, for the leather fibrous materials (known as artificial sole), the values of the forming subscript to be chosen for the mould dimensioning will be: the forming subscript for sphere: $I_{fs}$=0,95 in comparison with an average value 0,98; the forming subscript for cylinder: $I_{fc}$=0,80 in comparison with an average value 0,80 and the forming subscript for central angle:$I_{fu}$=0,85 in comparison with an average value 0,87. The differences between the three calculated subscript is because of different plastic deformation of the material structure when it stresses on different shape surfaces.

## 5. CONCLUSIONS

In the case of sample forming which use sphere moulds, the bend deformations don't take place in only one direction, but in infinite directions radial concentric of the hemisphere pole. In the same time, on the parallel concentric circles take place elongations. On these, the deformations because of the compression between the two concave-convex surfaces superpose. The release after deformation takes place in all directions including the tangential direction of the parallel circles. So, the deformations have a high rate, the sphere surfaces having the highest forming subscript.

In the case of sample forming which use cylinder moulds, after the cancel of the stress and after the drying, the sample will have a cylinder shape with R radius. The value of the forming subscript on these surfaces is the lowest. In the same time, the researches show that, the variation of the cylinder diameter does not increase the rate of plastic deformation in the total one.

In the case of the center angle, a bending stress is only in the peak. In the areas of the center angle, the single stress is compression. The bending nearby the peak of the center angle may be considered similarly with a stress applied on a cylinder having a curvature radius tending to zero. This aspect determines an increasing to infinite of the stress and a high level of plastic deformation.

## REFERENCES

[1] C.Ionescu Luca „*Technological Aspects Viewing the Footwar's Spatial Designing*, Acta Universitatis Cibiniensis Technical series, vol. LVIII, "Lucian Blaga" University of Sibiu, ISSN 1583-7149, pp.89-94, 2009.

[2] Cociu V., Volocariu R.S. and Ionescu C., *„Matrite si dispositive de formare",* Rotaprint Universitatea Tehnicã "Gh. Asachi" Iaşi, România, 1994.

[3] Schwartz, Mel. (2005). *New Materials, Processes and Methods Technology*, Ed. Taylor&Francis Group, ISBN 978-0849-320-538.

[4] Secan M., C., "*Contribuţii la optimizarea utilizării înlocuitorilor din piele în procesul de fabricare a încălţămintei",* tezã de doctorat, Universitatea Tehnicã"Gh. Asachi" Iaşi, 2009.

[5] C.Luca Ionescu and Chirilã E., **„***Subscripting in the design of the some footwear moulds",* Proceedings of The International Conference –New face of TMCR, Modern Technologies, Quality and Innovation –New Face of TMCR, 20-22 May 2010, Slãnic Moldova, Romania, ISSN:2066-3919,p.339-343 , 2010.

[6] C.Luca Ionescu and E.Chirilã, „*Algorithms used for the designing of the heel counter stiffeners moulds",* Proceedings of The International Conference –New face of TMCR, Modern Technologies, Quality and Innovation –New Face of TMCR, 20-22 May 2010,Slãnic Moldova, Romania, ISSN:2066-3919, p.343-347, 2010.