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METHOD FOR DETERMINING THE MAXIMUM ARRANGEMENT FACTOR OF FOOTWEAR PARTS

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Abstract: *By classic methodology, designing footwear is a very complex and laborious activity. That is because classic methodology requires many graphic executions using manual means, which consume a lot of the producer's time. Moreover, the results of this classical methodology may contain many inaccuracies with the most unpleasant consequences for the footwear producer. Thus, the costumer that buys a footwear product by taking into consideration the characteristics written on the product (size, width) can notice after a period that the product has flaws because of the inadequate design. In order to avoid this kind of situations, the strictest scientific criteria must be followed when one designs a footwear product. The decisive step in this way has been made some time ago, when, as a result of powerful technical development and massive implementation of electronical calculus systems and informatics, This paper presents a product software for determining all possible arrangements of a footwear product's reference points, in order to automatically acquire the maximum arrangement factor. The user multiplies the pattern in order to find the economic arrangement for the reference points. In this purpose, the user must probe few arrangement variants, in the translation and rotate-translation system. The same process is used in establishing the arrangement factor for the two points of reference of the designed footwear product. After probing several variants of arrangement in the translation and rotation and translation systems, the maximum arrangement factors are chosen. This allows the user to estimate the material wastes.*

Key words: *pattern, arrangement factor, discretion, simulating*

1. THE OPPORTUNITY OF THE TOPIC

One of the main objectives in any production process is to spend as less material as possible. In the footwear industry, saving material comes in question immediately after the design table: the patterns are theoretically evaluated and arranged in several positions, to determine the most economic combination on the material. The aim is to find the arrangement that leads to minimum waste. Usually, the best combination is chosen by looking at a certain value, the so-called "arrangement factor". Most of the times, the optimal factor is determined manually, after several try-outs of the pattern combination.

This paper presents a methodology that can be used to automatically determine the best arrangement factor. The only task of the user is to introduce data in the computer, representing the coordinates of the points defining the pattern.

2. SIMULATING THE GRAPHICAL PROCEDURE USED IN OBTAINING THE BEST ARRANGEMENT. PRACTICAL STEPS

The core of this procedure is an algorithm based on mathematical modelling of the graphical manual procedure of obtaining the maximum value of the arrangement factor. The main parts of the algorithm are:

***Sequence 1**: Modelling the shape on the computer screen, calculating the geometrical parameters and digitizing the geometrical shape into a finite number of steps*

This sequence comprises the following steps:

- first, the pattern is numerically approximated (digitized) either manually or automatically;
- the pattern is modelled in the computer so that we can visualize on-screen its graphical shape;
- we divide the pattern into a discrete, finite number of points, situated at equal distances, using a certain pace, depending on the performances of the computer (see fig. 1).

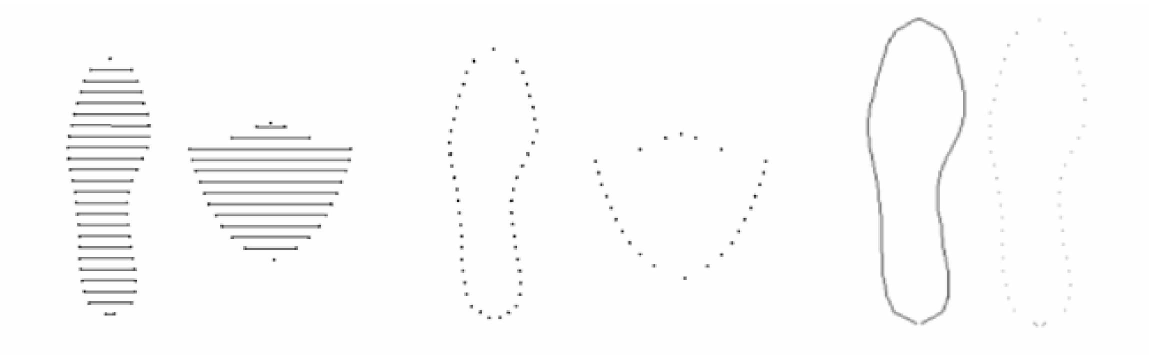

***Fig. 1:** Discretization of the geometrical shape into a finite number of steps*

***Sequence 2:** Multiplying the shape and obtaining tangent contours*

The mathematically discrete pattern can be multiplied and translated left or right to the initial one. In order to do that, we must first calculate the distance with which the pattern should be translated to obtain a new position, tangent to the initial one.

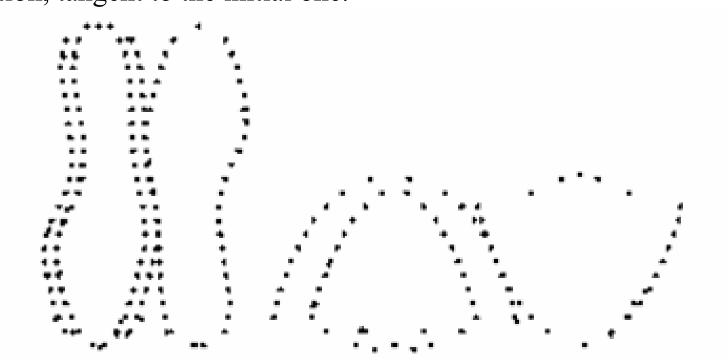

***Fig. 2:** Multiply and move the discrete pattern for creating tangent contours*

***Sequence 3:** Making a matricial graphical shape in a translation and roto-translation system*

When arranging the patterns, we must take into consideration the fact that they should be combined on the production material. In order for this sequence to be automatically determined, we must first create a matrix variant of the pattern, formed by three lines and three columns, by translating them (in a translation system – see picture 3) or rotating them (in a roto-translation system – see picture 4).

This will allow the simulation of the graphical manual procedure used in determining the maximum arrangement factor in the two systems.

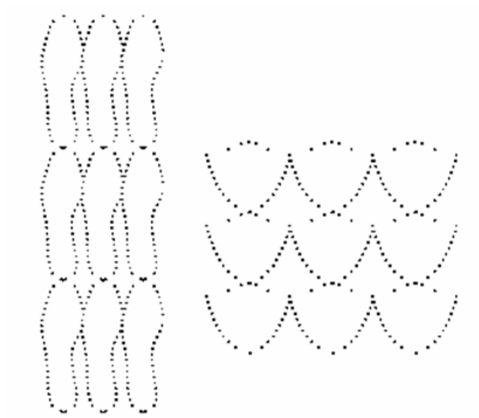

Fig. 3: *Making a matricial graphical shape in translation system*

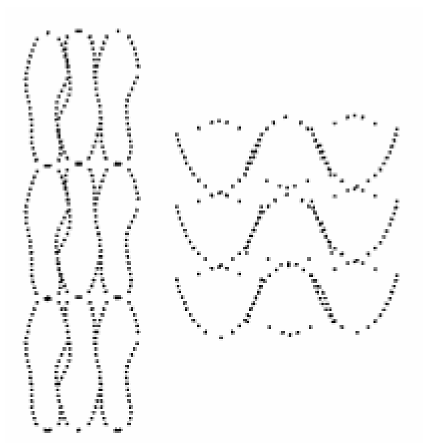

Fig. 4: *Making a matricial graphical shape in roto- translation system*

Sequence 4: *Determining the area of the pattern*

To determine the area of an irregular shape, such as the pattern of a footwear product, we use the tools of modern mathematics. It follows that a definite integral of the function f(x) for the interval [x_1 , x_2] represents the area between the graph of the function and the x_1, x_2 abscises, as described by the relation:

$$\int_{x_1}^{x_2} f(x)dx = \sum_{i=1}^{n} (x_{i+1} - x_i) f(\xi_i) \quad \textbf{(1)}$$

This calls for the division of the x_1, x_2 interval in some other n sub-intervals, $\{x_i , x_{i+1}\}$ and, ξ_i being one point of the elementary subdomain (fig. 5).

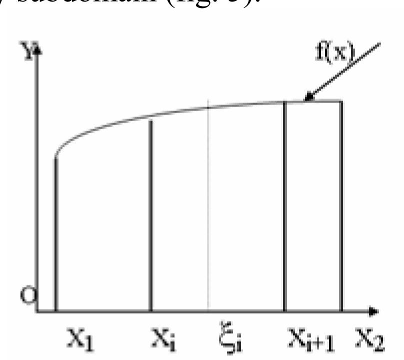

Fig. 5: *The integral of the function f(x)*

The relation suggests the following algorithm: ‘

- if $=\sum(x_{i+1}-x_i)f(\xi_i)$ represents the area of an interval between the axes $x= x_1$, $x= x_2$, axis Ox and the graphic of the function f(x), then the area between the two functions will be the difference between the two sums, as shown by the equation:

$$A=\sum_{i=1}^{n} f_1(x_i)(x_{i+1}-x_i)-\sum_{i=1}^{n} f_2(x_i)(x_{i+1}-x_i) \quad \textbf{(2)}$$

- if the function represents the ordinates of a set of points $\{x_i , y_i\}$, then the area defined by this set of points will be given by the equation:

$$A=\sum_{i=1}^{n-1} y_i(x_{i+1}-x_i) \quad \textbf{(3)}$$

This relation will be further used to determine the area of an irregular shape, corresponding to the digitized pattern of a footwear product.

Sequence 5: *Determining the arrangement factor*

For determining the arrangement factor, we use the following equation for each position:

$$F_a=\frac{nA_{pattern}}{A_{par}} \quad \textbf{(4)}$$

Where:

- n – is the number of the patterns in the parallelogram
- $A_{pattern}$ – the area of the pattern
- A_{par} – the area of the parallelogram

The method allows the graphic visualisation of each outline position and the corresponding value of the arrangement factor. Picture 6 presents all arrangement variants for a pattern of a footwear product.

Sequence 6: *Simulating the manual graphical procedure with the purpose of obtaining the best arrangement variant*

This sequence is done in a number of iterations equal to the number of points that define the shapes situated on one line or one column. For each of the iteration, all the following steps are executed:

- moving the patterns placed on the columns or the extreme lines of the matricial graphical shape with a distance equal to the discretization pace of the contours (established in sequence 1), all along a coordination axis (longitudinal or transversal direction);
- translating them on the other axis (direction), so that, in the end, the contours have the highest possible number of tangent points;
- determining the area of the arrangement parallelogram, a parallelogram containing a mathematically natural number of patterns;
- determining the arrangement factor, using the following equation for each position:

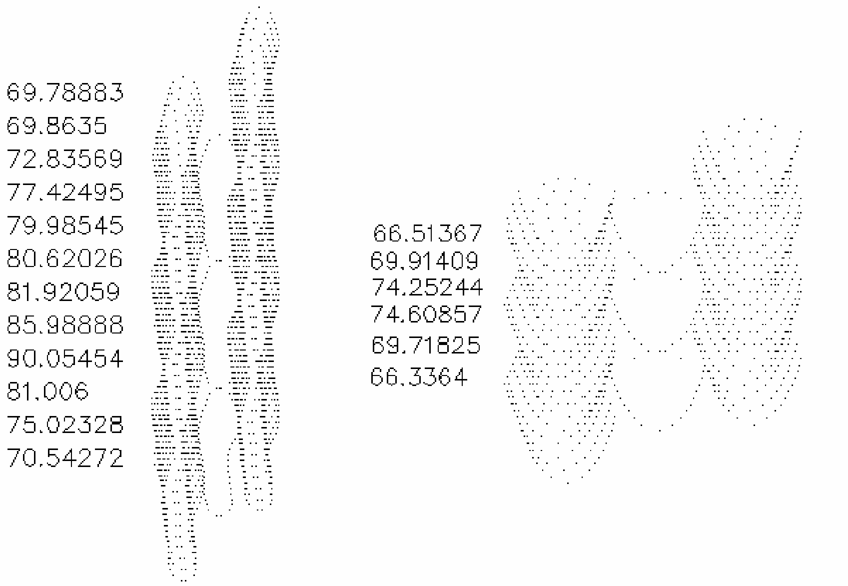

Fig. 6: *All arrangement variants for a part width*

Sequence 7: *Determining the optimal position of arrangement of the patterns corresponding to the matricial form*

The numerical data obtained in the previous sequence are memorised and organized in data bases, allowing the determination of the optimal arrangement variant, according to the following steps:

- we determine the maximum arrangement factor out of all the values;
- we create the optimal arrangement position of the patterns, using the information in the datasheet related to the position corresponding to the maximum arrangement factor;
- we insert the maximum arrangement factor
- we compare the maximum arrangement factor obtained in the two arrangement systems (translation and roto-translation) and we select the highest one. This will be the optimal arrangement factor.

Picture 7 presents the final position of the patterns in the two matricial shapes, displaying both the maximum arrangement factors and the framing parallelogram.

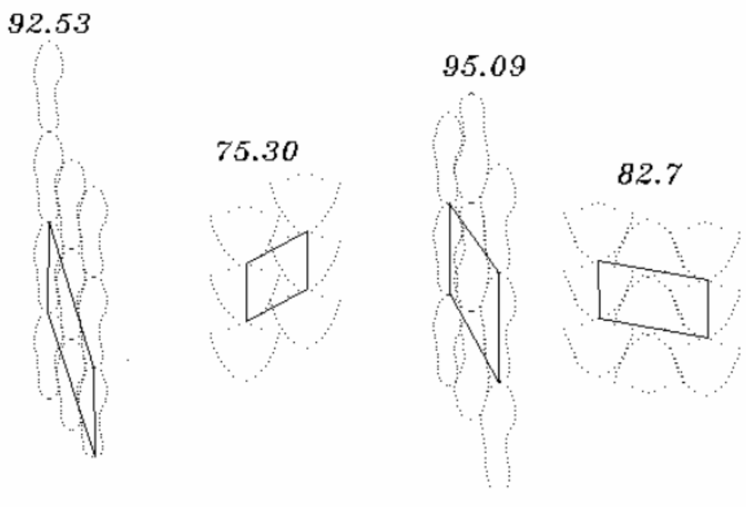

Fig. 7: *The optimal arrangement of the patterns*

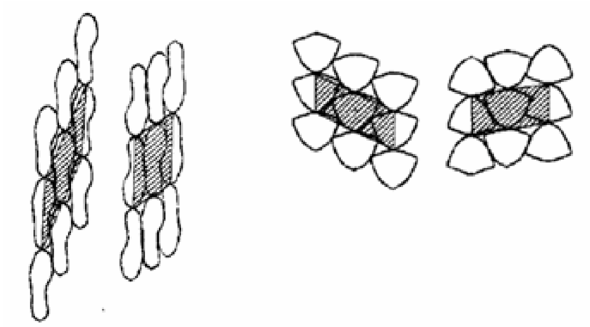

Fig. 8: *The final form of patterns' arrangement*

We repeat the graphical matrix, according to the dimensions of the material and create the optimal combination on the material that can be used in CAM sessions to obtain the patterns (see picture 9).

3. CONCLUSION

Using the common calculus technique in designing footwear products leads to a precise and correct design of each pattern. The stage in which the user estimates the costs, allows him to establish how economically profitable the product is and also allows the manager to take a decision in weather or not to diversify the pattern, in order to obtain even a better output of saving primary materials.

This software makes possible automatic determination of the theoretical arrangement for footwear patterns. The program can easily be used by any company, because it only requires a computer equipped with a digitizer and an output device (plotter or cutting devices) and it can be implemented in any domain dealing with material arrangement.

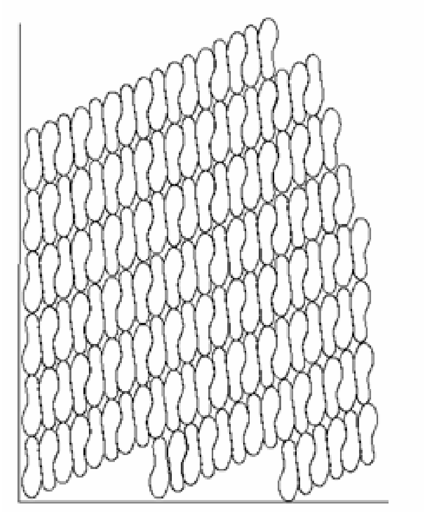

Fig. 9: *The optimal combination on the material that can be used in CAM sessions*

REFERENCES

[1] M. Costea, M. Drişcu, *Crispin Dynamics 3D –New solution for shoemakers creating and modification of the shoe last*, Leather and Footwear Journal 11 (2011), pg 109-120, ISSN 1583-4433

[2] M. Drişcu, *Reconstruction and flattening of the surface shoe last*, Proceedings of The 14th Internaţional Conference, Iaşi&Chişinău ModTech2010, May, 2010, Romania, ISSN:2006-391

[3] A. Mihai, M Costea ş.a., *Customized footwear insers for high arched foot – one case study*, Proceedings of the 3nd International Conference on Advanced Materials and Systems 2010- ICAMS 2010 Bucuresti

[4] G. Mălureanu, A. Mihai, *Bazele proiectării încălţămintei*, Ed. "Gh. Asachi", Iaşi, 2003

[5] R. Burden, J. D., Faires *Numerical Analysis*, PWS-KENT Publishing Comp., Boston, 1985