

CONTRIBUTIONS TO THE DIVERSIFICATION OF PREFABRICATED FOOTWEAR SOLES USING INJECTION MOULDS WITH INTERCHANGEABLE MODULAR COMPONENTS

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Abstract—Currently, prefabricated shoe soles are made using sets of injection moulds with unique cavities which are custom made for each sole model. This paper presents design solutions of different injection moulds with interchangeable cavities. This types of moulds allow rapid construction of new cavities, corresponding to new soles designs, by modifying only those parts that are fitted into the cavities, not by replacing the entire mould. Experiments have shown that soles obtained using injection moulds with interchangeable parts have the same appearance and properties as soles obtained using classic moulds. Introducing in manufacturing processes of such moulds opens new perspectives for design diversification of soles, taking less time and with lower manufacturing costs, contributing to a better viability and profitability of moulds parks.

Keywords—footwear, shoe soles, injection moulds

I. INTRODUCTION

FOR manufacturing prefabricated footwear soles, individual sets of moulds are used, which have at least one mould for each size number. Given the fact that soles have become increasingly more a criterion for footwear diversification, it is necessary to manufacture a wide variety of sets of injection moulds.

A mould in which footwear are made wears out physically after about 200000 pairs of soles. Large soles manufacturers have the capacity to use moulds up to their physical wear. In the case of medium or small manufacturers, injection moulds wear out morally before they wear out physically. Therefore, many manufacturers use moulds a number of cycles, depending on orders, and then they have to store them or to melt them for new moulds. Due to high manufacturing costs of moulds, their usage is not profitable below their designed

production capacity.

Therefore, the question arises if it is possible to structure moulds in a different and a new way, so the transition from one sole model to another to be made reusing some parts of an existing mould [1], [2], [3]. On this basis, this paper will present the solutions [4], [5]. For this problem, namely, the development of “injection moulds with interchangeable modular cavities”.

For the development of this solutions, a number of objectives were established: the possibility to diversify the shape and size of soles; the moulds to have similar functional characteristics with those of moulds with single cavities, assembling on to injection machines, operating mode of the mechanisms for opening and closing the moulds, adjusting the technological parameters of soles injection processes, feeding cavities process, and removing soles from the moulds. The purpose of these objectives is to be able to operate this moulds on the existing machinery without any adjustments.

II. DESIGN SOLUTIONS OF MOULDS WITH INTERCHANGEABLE MODULAR CAVITIES

A. Solution number 1

Currently, moulds for prefabricated soles, have single cavities which result from closing two parts, a base plate and a shutter plate. These moulds permit the manufacture of a single model of the sole. For a different sole design, it is necessary to manufacture a new set of moulds.

Figure 1 shows a new design solution for injection moulds [6], [7] by interchanging a number of modules, it is possible to diversify the design of soles, using at the same time the same basic mould. The drawings from Fig. 1., represent two different models of soles, from two viewing modes.

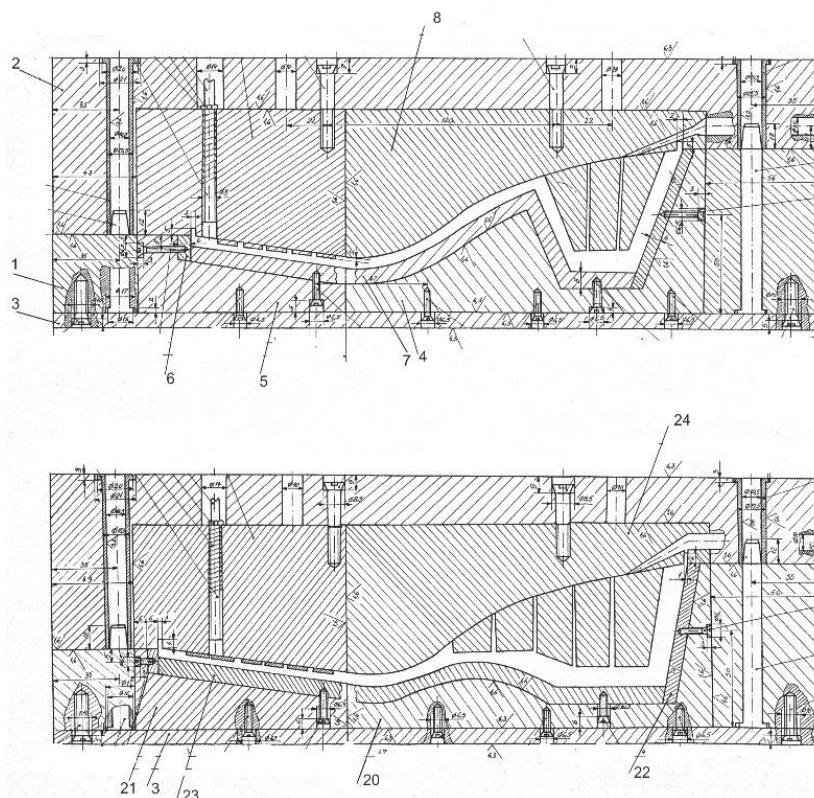


Fig. 1. Injection moulds with an interchangeable modular cavity for prefabricated soles. Solution 1.

1-base plate; 2-shutter plate; 3- bearing plate; 4- module 1, sole cavity model 1; 5- module 2, sole cavity model 1; 6- sole lateral surface module for model 1; 7- antiskid embossment module, model 1; 8- weight reduction cavities module, model 1; 20- sole cavity module 1, model 2; 21-sole cavity module 2, model 2; 22- sole lateral surface module for model 2; 23- antiskid embossment module, model 2; 24- weight reduction cavities module, model 2.

This mode of representation, highlights multiple ways for diversifying the design of soles, like variation of heel shape, sole thickness, antiskid embossment design, lateral surface design and feather line shape. These type of injection moulds do not allow changes in heel height whereas the diversification of models are produced for the same model of last.

The injection moulds proposed in solution number 1 are composed of: a base plate 1, a shutter plate 2, a mould bearing plate 3 and a series of interchangeable modules. First three components are the main parts of a mould and are used until they wear physical. For manufacturing new moulds, corresponding to different designs of soles, supply cavities and crossing components are also reused.

The main components and the interchangeable components of the moulds are designed and manufactured for each shoe last design and for the entire size range.

The overall dimensions of the moulds were adapted for the entire set, corresponding to the maximum size of the range.

This solution is driven by the need to simplify the design of moulds and hence their manufacture. Dimensional differences from one size number to the next one are correlated with the dimensions of cavities in

which soles are modelled, in our case, the cavities are represented by the interchangeable modules.

The diversification of heel shape is possible through the cavity forming module 1. When changing the heel design, is necessary to restore the corresponding module 20 and also the modules responsible for the lateral sole surface design and for the antiskid embossment design, respective modules marked 22 and 23.

Endless possibilities for diversification of shoe soles design can be performed by changing the antiskid embossment design.

In the case of keeping the original shapes of the soles it is necessary to change only the antiskid embossment module, reference numeral 7 in the figure.

Changing the sole thickness is another mean to diversify soles design. Also, the modules which determine the weight reduction cavities, number 8 and 24 from Fig. 1., may be a mean of diversification.

These types of moulds can be fitted on the same machines on which classical moulds are fitted, separately from, or together.

B. Solution number 2

The drawings from Fig. 2., represent another solution for designing an injection mould [6], [7]. using this injection moulds, different soles designs can be made by

interchanging various modules. This solution enables the same design diversification of soles as in the case of solution number 1. To change the sole design, for the new injection mould, most of the components from a classical mould are used, namely: main plate, shutter

plate and mould bearing plate (until they are worn out) and most of the mounting and crossing parts and the injection material supply systems.

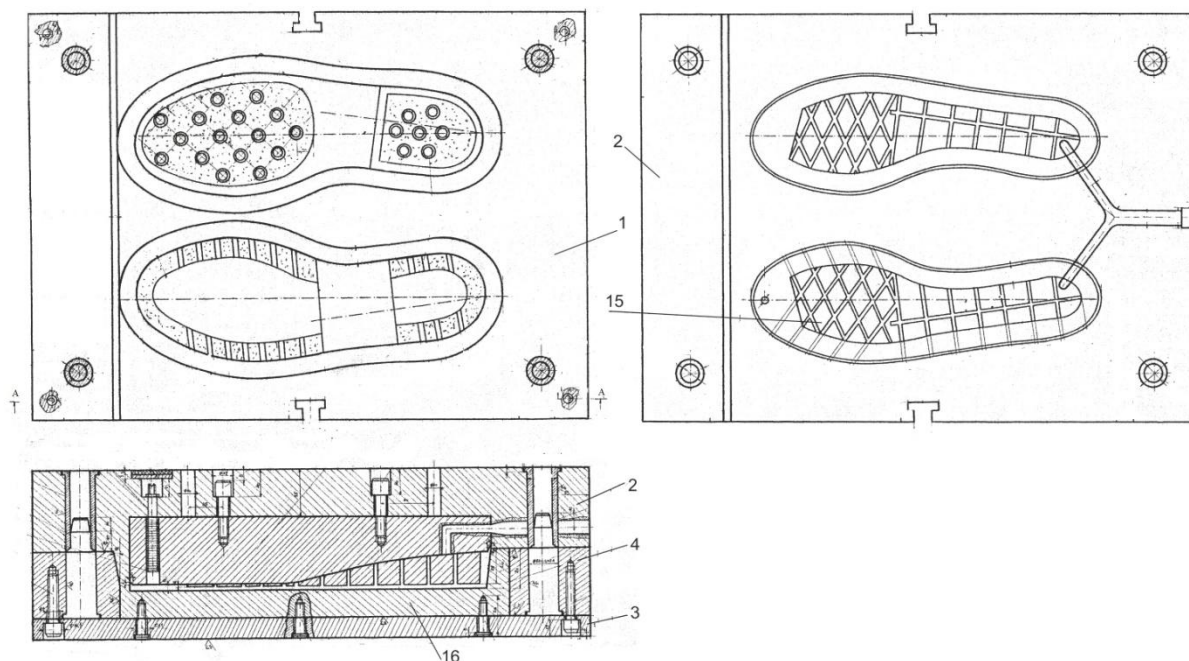


Fig. 2. Injection moulds with an interchangeable modular cavity for prefabricated soles. Solution 2.

1- main plate; 2-shutter plate; 3- bearing plate; 4- sole cavity module, model 1; 16- sole cavity module, model 2; 15- weight reduction cavities and feather line module.

The solution presented in Fig. 2., led to different soles designs, by shape, volume and antiskid embossment pattern. This solution leads to a different sole design, compared to the previous one, by restoring modules which determine the weight relief cavities 4 and the feather line outline 15.

In cases where the shape and volume of soles remain unchanged and only the antiskid design or the lateral surface design are changed, cavity modules will be designed to allow attachment of removable parts corresponding to this areas.

Moulds presented in can be fitted on the same machines on which classical moulds are fitted, separately from, or together

As in the case of the moulds from solution number 1, moulds from solution number 2 can also be fitted on the same machines on which classical moulds are fitted, separately from, or together.

III. EXPERIMENTS

Based on the developed solutions, prototypes of the moulds were manufactured.

A. Experimental mould for Solution 1

The first version of injection mould [4], [5], referred to as the solution 1a, is presented in Fig. 3. This mould

is composed of different parts and modules that are reused for new moulds, each corresponding to new soles designs, until physical wear. Reusable parts are shown in Fig. 3a. are the following: one main plate with openings for fitting modules which will determine final soles design, one shutter plate with openings for fitting modules responsible for weight relief cavities and the feather line outline of soles and one mould bearing plate which will allow the installation of the mould in the injection machine [6], [7].

Fig. 3b. presents a series of modules which were used for obtaining new injection moulds used for manufacturing soles with different designs. Modules that have determined the shape and volume of the soles were fitted into openings from the main plate. The joining lines between the two modules are concealed by the module which determines the side surface design of soles and the module that determines the antiskid embossment design [6], [7].

The whole mould together with the reusable parts and the modules responsible soles designs are showed in Fig. 3c. Experimental moulds were fitted on an injection machine, the same one used for classic moulds with unique cavities [6], [7].

The soles manufactured using the experimental moulds have physical and aesthetic properties

comparable to those of the soles manufactured using injection moulds with unique cavities.



Fig. 3. Experimental injection moulds with an interchangeable modular cavity for prefabricated soles. Solution 1a.



Fig. 4. Experimental injection mould with the interchangeable modular cavity and the soles manufactured using it. Solution 1a.

The obtained soles designs [6], [7] from polymer blends of PVC and TR rubber, are presented in Fig. 4. The soles are obtained by interchanging different components manufactured by applying solution number 1.

The soles manufactured by injection according to the proposed solution have similar properties to soles manufactured using injection moulds with unique cavities.

Fig. 5. represents a solution for a different modular mould, obtained following the design from Fig. 1, solution 1b. This mould is made from the same reusable parts, as previously: main plate, shutter plate whit

cavities for mounting different modules as for solution 1a and a bearing plate to install the mould in the injection machine. The injection mould from solution 1 differs by the design of interchangeable modules which are fitted on the main plate. By solution 1a, the shape and volume of soles are determined by two different modules in comparison with solution 1b, where the same soles are obtained by using only one module. Using this solution, endless diversifications of sole designs can be performed by changing the antiskid embossment using different modules. Also, on the shutter plate, as for solution 1, different modules can be fitted in order to obtain various

designs for the weight reduction cavities and/or for the feathering.

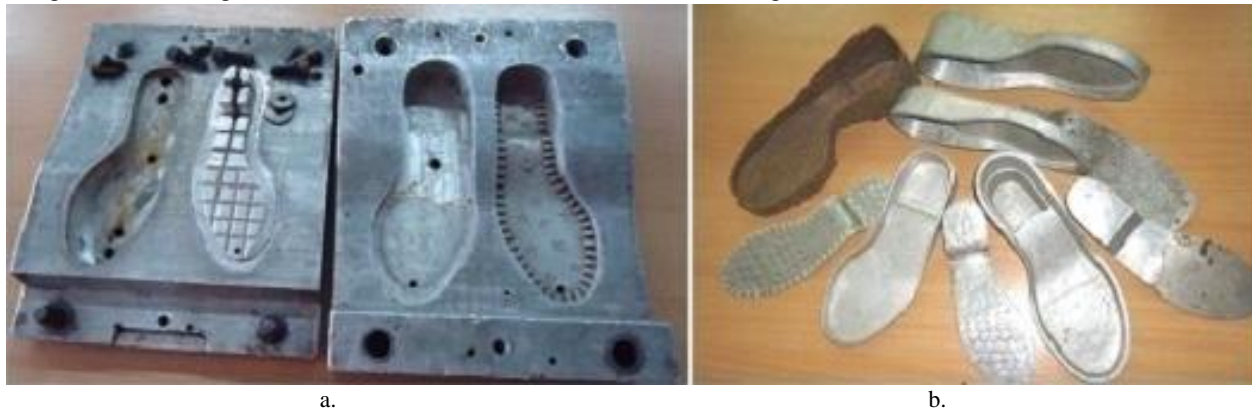


Fig. 5. Experimental injection moulds with an interchangeable modular cavity for prefabricated soles. Solution 1b.



Fig. 6. Experimental injection mould with the interchangeable modular cavity and the soles manufactured using it. Solution 1b.

By the experiments carried out using solution 1b, using the proposed injection mould and interchanging different modules, different soles designs have been obtained by, which are presented in Fig. 6.

No differences between the soles injected using solution 1 and the ones obtained using classic moulds have been observed.

B. Experimental mould for Solution 2

The main plate, the shutter plate and the bearing plate, reused for each sole design, are presented in Fig. 7.

The experimental mould [6], composed of the mentioned reusable parts and the interchangeable modules, that was used to obtain soles with various designs is presented in Fig. 8. The soles obtained by injection using the experimental mould can be observed in Fig. 9.

This solution, like the previous ones, allows the diversification of the heel shape, sole thickness, antiskid embossment, lateral sole surface design and the feather line design. For this proposed solution, only the module that forms the mould cavity it is necessary to be recovered. This module is fitted on the main plate.

Experiments have shown that using this moulds, the obtained soles have the same quality as soles obtained by using single cavity moulds.



Fig. 7. Reusable parts of modular injection mould. Solution 2.



Fig. 8. Experimental injection moulds with an interchangeable modular cavity for prefabricated soles. Solution 2.



Fig. 9. Experimental injection mould with the interchangeable modular cavity and the soles manufactured using it. Solution 2.

IV. CONCLUSIONS

- 1) *The proposed design solutions for injection moulds allow faster and cheaper construction of new sets of moulds with modular cavities for manufacturing various soles designs. The way these new injection moulds are composed represent their main advantage, because it is possible to reuse some of their parts from one sole design to another.*
- 2) *The shape and design of soles are determined by various modules, fitted in the main cavity of the mould, which, depending on changes to the sole design, are reused fully or partially. Using this interchangeable module, various soles designs can be made, by varying heel shape, sole thickness, antiskid embossment, lateral sole surface design and weight reduction cavities.*
- 3) *Various soles designs can be obtained in all cases, fast and with reduced costs, resorting to partially diversification of different modules. In these cases, the shape and volume of soles remain the same but the antiskid embossment and/or the lateral sole surface design can be modified, by replacing corresponding modules.*
- 4) *By manufacturing a few moulds with interchangeable modular cavities various soles designs can be obtained in a short time for market research purposes. Therefore, such type of injection mould facilitates soles design and prototyping processes.*
- 5) *Because of low operating costs, injection moulds with modular cavities are suitable for research activities regarding new polymer mixtures recipes for soles.*

- 6) *The use of proposed injection moulds is profitable for small enterprises, which for classic injection moulds, with single unique cavities, are expensive.*
- 7) *Injection moulds with interchangeable modular cavities can be operated without any adaptations on the same injection machines on which moulds with unique single cavities are used.*

REFERENCES

- [1] R. McNeel, "Shoe Design and Visualization", Institute of Biomechanics of Valencia, Rhinoceros Advanced Training Series, Available: https://anna.nscad.ns.ca/help/pdfs/rhino_shoe.pdf, Accessed:20/February/2016.
- [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, "Modelling of Planar and Spatial Forms of Footwear", in *Romanian, Pim Press Iași*, 2008, pp.109-134.
- [4] E. Chirilă, "Solutions on aspects of mathematical modelling of the optimum number of the nests that a cast must have", in *Bulletin I.P.Iași, Tome LIV (LVIII), Fasc. 1-3 Mechanical Engineering Department*, Romania, 2008, pp.125-129.
- [5] A. Dragomir, "Emplacement possibilities of the cavities and some positioning possibilities of the injection channels in the moulds used footwear manufacturing", in *Proceedings "The X International Conference on the Theory of Machines and Mechanism"*, Technical University of Liberec, sept. 2-4, Czech Republic, 2008, pp. 189-193.
- [6] C. Ionescu, R. Mocanu, I. Cioară, "Diversification the prefabricated soles footwear in modular moulds" in *Proceedings Autex 2015, 15th World Textile Conference*, Bucharest, Romania, ID 161.
- [7] M. Costea, "Footwear and rapid prototyping modelling components prophylactic", *Publisher Performantica*, 2015, ISBN 978-606-685-328-6, pp. 80-97.