# Optimization of Segmented Tire Mould

E. Hnátková [1,2,*], A. Uředníček [1], Z. Dvořák [1,2]

[1] *Department of Production Engineering, Faculty of Technology, Tomas Bata University in Zlin, nám. T. G. Masaryka 5555, 760 01 Zlín, Czech Republic*
[2] *Centre of Polymer Systems, University Institute, Tomas Bata University in Zlin, Tř. Tomáše Bati 5678, 760 01 Zlín, Czech Republic*
[*] *ehnatkova@ft.utb.cz*

**Abstract:** This paper deals with demoulding of the tire from segmented mould. The optimal number of segments will depend on a concrete tire tread. In case of small number of segments, the negative angles generate high stress on the material which can cause a damage of the final product, mainly due to lower strength when the rubber is hot. With negative angles rise also the difficulty to shift the segments into radial direction and increase wear of the moving plates due to the friction resistance. On the other hand a large number of segments provides construction and economic problems. That is why, it is necessary to perform calculation of stress acting on the tire tread surface during mould opening and optimize the number of segments in such a way that the solution will be economical. The obtained results showed that in this case study, without consideration the wear resistance, all the proposed solutions may be used. If we do not consider the economical part, the optimal segment angle is 23 ° and the number of segments is 11.

**Keywords:** Tire Mould; Segments; Groove Pattern; Demoulding; Simulation.

## 1 Introduction

Container and segmented mould is a special tire pressing tool intended for tires with a complex groove pattern. Design solution is technically and economically more demanding than the two-half moulds.

The principle is in utilization of the tool kinematics consisting of mutually linked movements scrolling mould segments. Schematic principle of tire demolding is shown in Fig. 1. In the first step, the mould is open by pulling the top part of the container and the segmented shoes are shifted into radial direction by driving mechanism until the segments reach the upper position. After this operation segments are moved into axial direction to the top of the part of the container without affecting the surface of the tire. In this way, the tire could be easy removed from the mould.

The problem occur, when the segment shoes are not shifted into radial direction due to adhesion caused by an excessive amount of negative angles in the tire grooves and moved directly to the top container plate or if the generated stress on the tire is too high. This may cause a disruption of tire grooves on the surface.

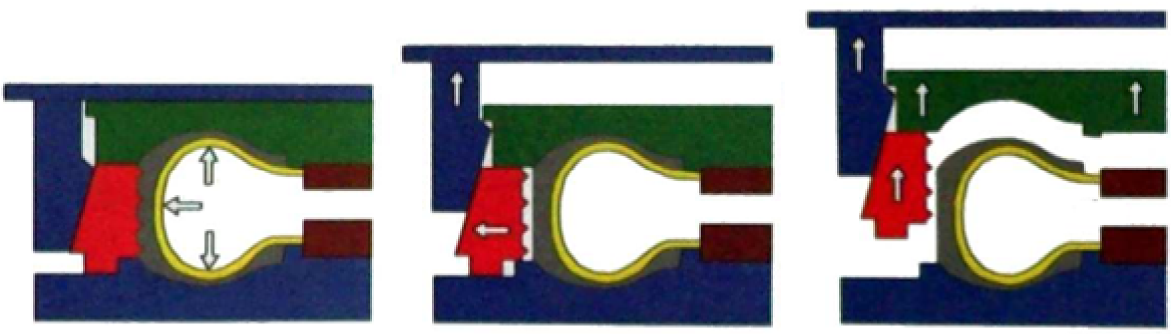

Fig. 1: Schematic principle of the tire demoulding from the segmented mould in the container.

The aim of this work is to carry out how the amount of segments in mould will influence the maximum generated stress and determine the optimal angles through which the segments will move.

## 2 Experimental Part

Design of tire tread and container mould with various number of segments was constructed in 3D CAD program Catia V5R19. To obtain the maximum generated stress on the tire tread surface during demoulding the mechanical simulation was performed by FEM analysis in the same program.

### 2.1 Design of the Tire Tread

Design of the tread pattern affects the overall performance of a tire, as well as its removal from the mould. The tire tread is moulded into a series of grooves and ribs demonstrated in Fig. 2.

Fig. 2: Tire tread.

### 2.2 Container Mould Design

Container mould is a tool where tires get their final shape. Tires with the complex groove pattern for which is insufficient mould with one separating line, should be manufactured in the multi-segmented mould. Fig. 3 shows a simplified cross-sectional view of container mould

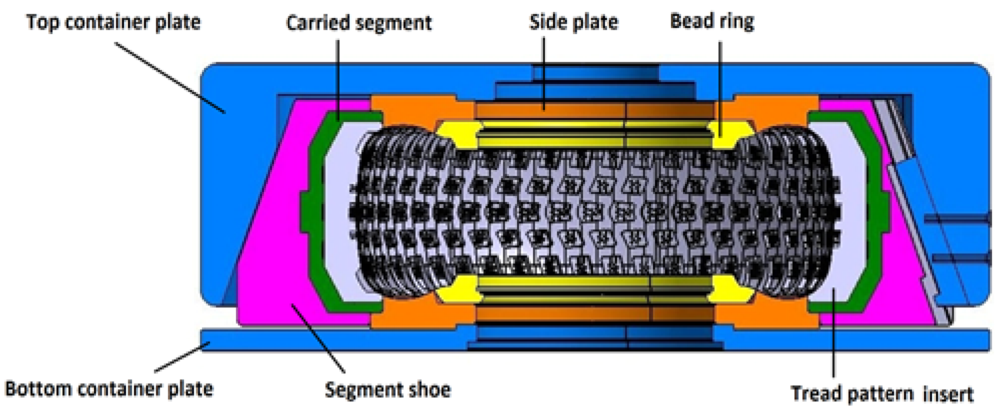


Fig. 3: Design of container mould intended for tire vulcanization.

The segment construction could be one-piece or multi-pieces. In our case, segments consist of three basic parts as can be seen in Fig. 4. The first part is the tread pattern insert ($a$) which is in direct contact with a tire and indicates the shape of the tread. This part is fixed in the carried segment ($b$) and the segment shoe ($c$) holds both previous parts together and contains the T-groove. This mechanism allows the motion in T-guide of the upper container part.

### 2.3 Numbers of Segments in the Mould

For design it was chosen the odd number of segments due to elimination of symmetric throwing of the tires in diagonal direction because of the mirror symmetry. The proposed numbers of segments (7, 9 and 11) in each mould is shown in Fig. 5.

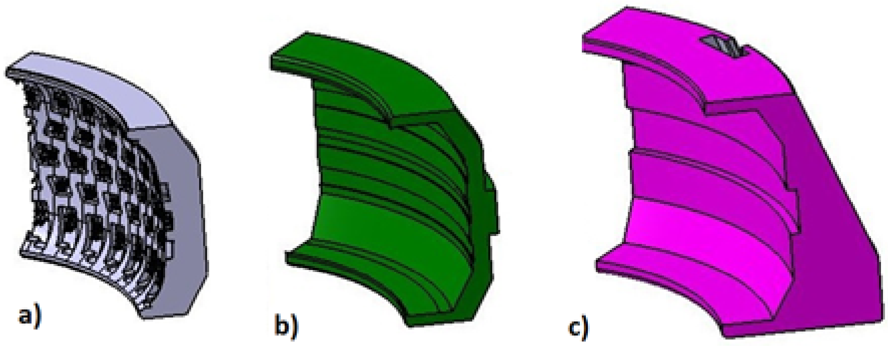


Fig. 4: Segment construction.

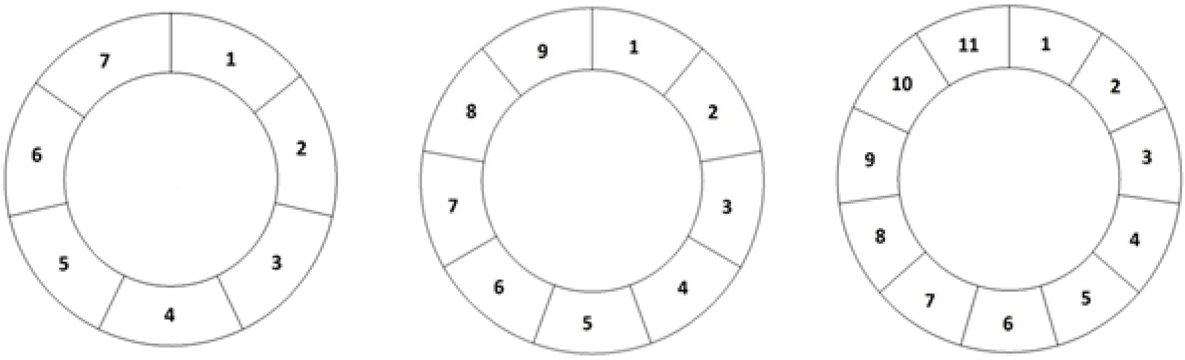


Fig. 5: Proposed Number of Segments.

## 3 Results

Fig. 6 shows the results from FEM analysis where von Mises stress is generated by negative angles on tire surface during demoulding. As can be seen, the mould construction with a higher number of segments will provide lower stress.

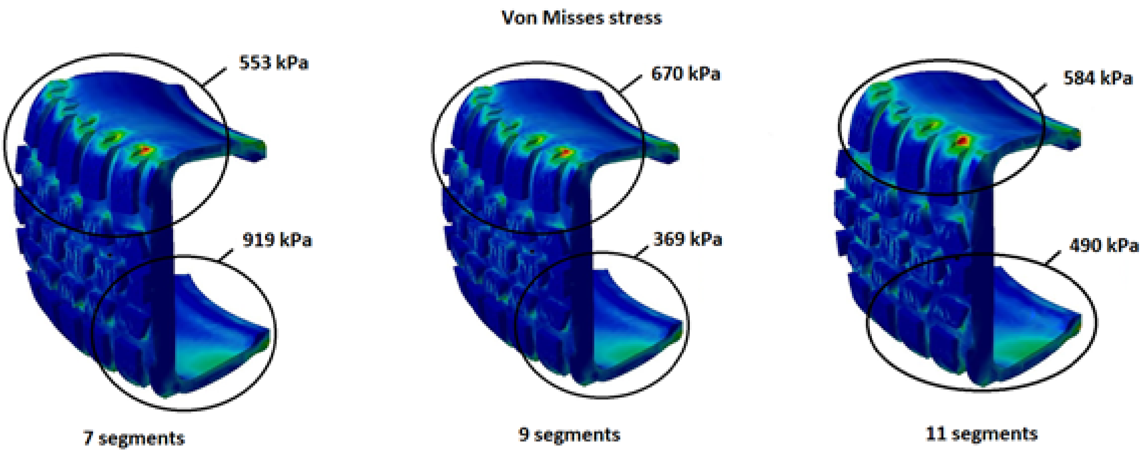


Fig. 6: FEM analysis.

In our case, the obtained von Misses stress for damage of tire surface is negligible, because common value of maximum allowed stress $\sigma_{max}$ on the hot rubber is between 12 to 14 MPa. However, the force $F_O$ which shifts the segments in radial direction should be higher than adhesive force $F_D$, according to Eq. (1):

$$F_O > F_D \tag{1}$$

Tab. 1: Calculated force based on segment angle.

| angle (°) | $F_{O,7segments}$ (N) | $F_{O,9segments}$ (N) | $F_{O,11segments}$ (N) | $F_D$ (N) |
|---|---|---|---|---|
| 18 | 246 | 188 | 152 | 130 |
| 21 | 290 | 222 | 179 | 114 |
| 23 | 321 | 246 | 198 | 108 |

Fig. 7 demonstrates a simplified schematic of acting forces without consideration the wear resistance. The force $F_G$ is gravitational force given by segment weight. Tab. 1 than indicates the force values for various number of segments and segment angles.

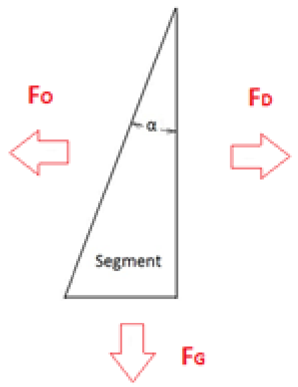


Fig. 7: Force acting.

## 4 Conclusion

The obtained results showed that in this case study all the proposed solutions may be used. If we do not consider the economical part, the optimal segment angle is 23 ° and the number of segments is 11.


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