CRACK SIMULATION IN PNEUMATIC TIRES USING FINITE ELEMENT METHOD

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One of the important factors that determine the durability of pneumatic tires is the growth of defects. The belt edge is a critical region for the initiation of defects since the intersection of stiff cords and soft rubber matrix results in rise of local stress and strain values. We develop a finite element model of a tire containing an initial crack at the belt edge and analyze the growth of crack for the steady state rolling conditions.

We use the finite element package ABAQUS and employ global-local approach. The computational procedure starts with the three-dimensional analysis of the full tire geometry free of defects. The stress distribution corresponding to the free rolling of the tire is determined and used to select critical regions for crack initiation. The mesh is refined in critical regions and the resulting submodels are analyzed in order to obtain more detailed stress-strain information. This refinement is repeated until sufficient accuracy is achieved and appropriate region for crack inclusion is determined.

In order to study the behavior of crack we combine fracture mechanics calculations and the finite element method. A rectangular crack is placed in rubber region between two belts, close to the edge. The tearing energy, also known as the energy release rate, as the material property governing the growth of cracks is calculated for various crack sizes. In order to determine the variation of tearing energy for a rolling tire two circumferential positions of the crack are considered: the contact zone between the tire and the road, and the top region of the tire. A sequence of crack configurations representing circumferential and meridional growth is analyzed. The results indicate lower tearing energy values at the top as expected, and that modes II and III are dominant at the contact region, while mode I is also significant at the top.

The ultimate goal of the computational model described in this paper is to predict the total life of the tire as determined by the fatigue crack growth. The relation between the rate of crack growth and the change in the value of tearing energy is a material property. If this data is available, combining the finite element calculations with fatigue crack growth law of the material it is possible to calculate the history of the crack growth, therefore predict the total life in number of cycles.