UTILIZATION OF POLYCOMPONENT COMPOSITES IN AUTOMOBILE TRANSPORT

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Polycomponent composite materials for automobile transport are used in interior of automobiles and namely for tyre manufacturing. The tyres are essential elements into interactions between vehicles and roads which secured of force transmission with ability of damping of road irregularity etc. Therefore it expect from these materials with theirs excellent material parameters that will be able to good securing of observance of right function with respect to working requirements of automobile and high tyre life.

The contribution deals with complex composite – tyre for its characteristic specific deformation properties. These properties are determined of construction – geometry and placement of reinforcements and also tyre materials.

The computational modelling of strain-stress states of selected composite assisting to solution of right selection of optimum geometry and placing reinforcing long-filaments – cords. The authors used for computational modelling the Finite Element Method program ANSYS. The orientation is namely on materials parameters of rubber matrix and steel-cord reinforcement, which are applied into tyre casing for passenger vehicles. It is necessary to deal with materials for tyre manufacturing and also materials upon degradation action with respect to transport safety.

Key words: polycomponent, composite, tyre, composite

1 Tyre as polycomponent composite in automobile transport

Tyres as polycomponent composites are subject to combined loading superimposed by effects of the environment in which the tyre operates. This is why exceptional emphasis is laid on the security of tyres.

The automobile tyres as long-fibre composite consist of composite structure parts (Figure 1) with textile cords (especially PA 6.6 and PES textile fibers are used) and steel-cords into tyre tread as reinforcements which are:

- textile tyre carcass single or two-plies,
- overlap textile belt,
- steel-cord multi plies belt.

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These structure parts of tyre have got:

- different cord-angle (e.g. for steel belt applied angle 21-27°),
- material of cords (steel, textile, Kevlar, combine),
- shape and construction of cord (wire, wire strand),
- numbers of layer (single-layer or multi-layer).

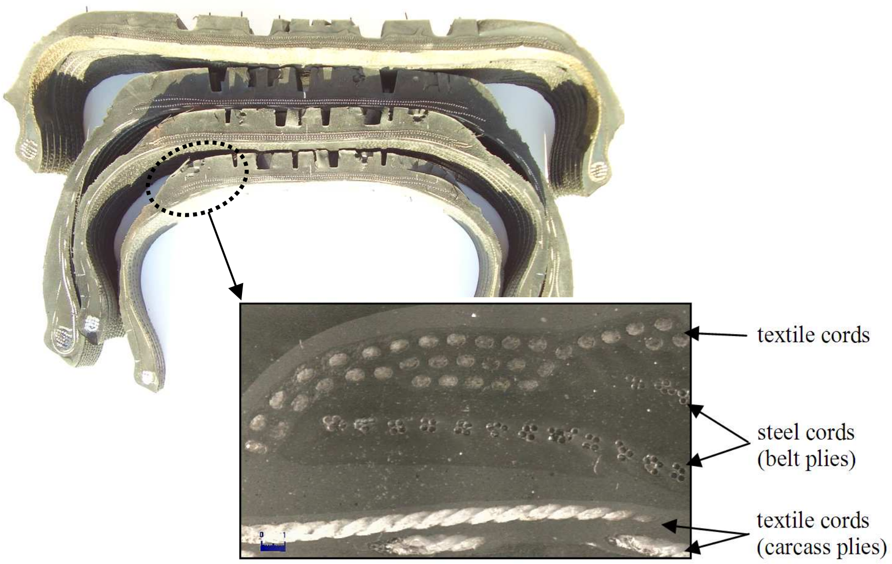

Figure 1 Tyre cross section and microstructure of reinforcing plies

So tyre has got characteristic specific deformation properties. Tyres are developed namely considering their design and material. The design and production of tyres as polycomponent composite applies computer modelling and uses various models.

The tyre must satisfy basic requirements on Figure 2. Therefore high-strength steels are used exclusively for steel-cord production and good adhesive bond between rubber and cords required. Reinforcing steel-cords can be in form of thin wire or wire strand with different constructions (e.g. wire with diameter 0.94 mm and wire strand 2x0.30 mm or 2+2x0.28 mm used for passenger radial tyres).

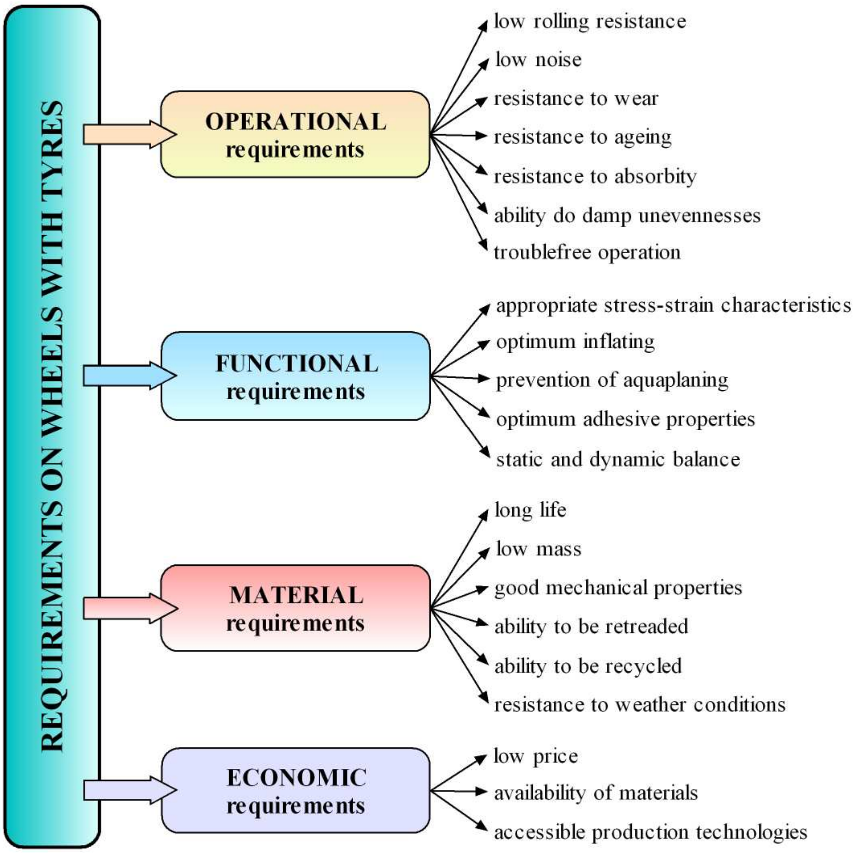

Figure 2 Basic requirements of wheels with tyres

In the case of steel-cord surfaces are modified by chemical-thermal treatment (braze or copperier) to achieve the best adhesive bond of a steel cord and elastomer.

For creations computational models of composites structures of tyre it is necessary to have a good knowledge about:

- structure of tyre-casing as whole,
- steel-belt which used into radial tyres,
- adhesive bonds metal-elastomer, which obtained by metallography observation of reinforcements-matrix transit,
- material parameters of matrixes and reinforcements;
- influence of degradation processes – corrosion effect on composite materials from micro and macrostructure point of view.

Therefore will be important engaged in not only adhesive bond between reinforcement-elastomer into microlocality but also macrostructure experiments e.g. static test of tyre for computational modelling.

2 Static tests of tyre for computational modelling

Knowledge of the extent of resistance of tyres to various modes of loading and effects of the environment is gained from tests of strength and life – in other words from destructive tests. Also basic statically deformation characteristics of tyres can be obtained from a device called statical adhesor (Figure 3).

Figure 3 Statical adhesor with contact area detail

It is possible to obtain outputs from experiments on statical adhesor:

- radial deformation characteristic (by vertical tyre force loading),
- torsion deformation characteristic (slip curve by twist moment),
- size and shape of contact area and distribution of contact pressure.

The statical adhesor also enables measurement of data from the contact surface under defined condition:

- shape of obstacles,
- vertical loading,
- inflation pressure,
- size of radial deformation etc.

3 Computational modelling of tyre as polycomponent composite

Creation of a computer model of a tyre based on the Finite Element Method (FEM) requires a comprehensive and systematic approach [1-5]. It is necessary to have knowledge of the function of wheels with tyres, their design, structure, material spectrum, operating parameters, characteristic behaviour for the given type of loading and further data. All such information can be considered as "inputs" into computer modelling without which a contemporary computer engineer can hardly manage. 3D FEM models incorporating combinations of hyperelastic and orthotropous material models which would be sufficiently "finely" discreted have hitherto not been published.

The example of compiled computational models for determining the deformation states of the tyre 165/70 R13 is shown on Figure 4. For computational modelling was applied the program system ANSYS. Reinforcing parts of the tyre are made up of the areas which are described as orthotropic models of material behaving such so-called rebar features [1].

Material factors for their description were obtained based on the computational modelling of on-purpose splitted the tyre parts so based on detail models of e.g. steel-cord belt. It’s due to non-possibility of detail incorporation of reinforcement cords into the computational models of whole tyre so it’s necessary to alternate the composite parts of tyre.

Presented computational model shows good results at interaction of the tyre with the chosen road surface bumps. The outputs from computational modelling presented Figure 5 as example.

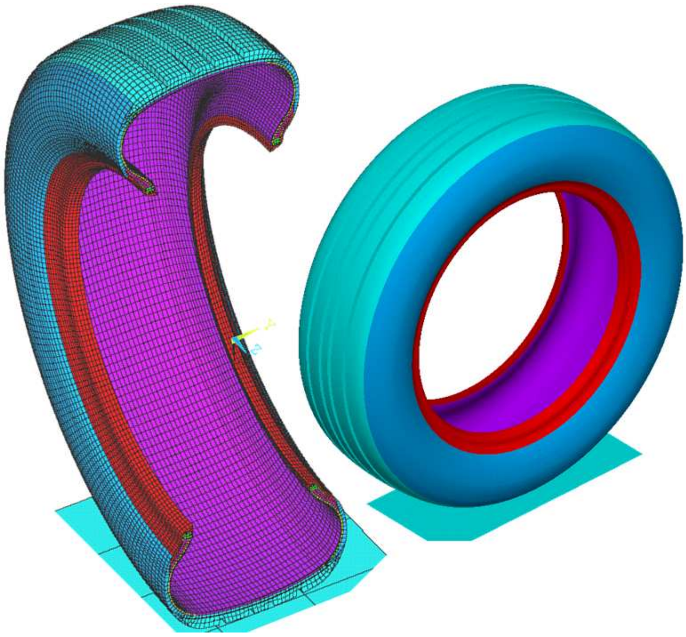

Figure 4 FEM model of tyre for static stress-strain analyses

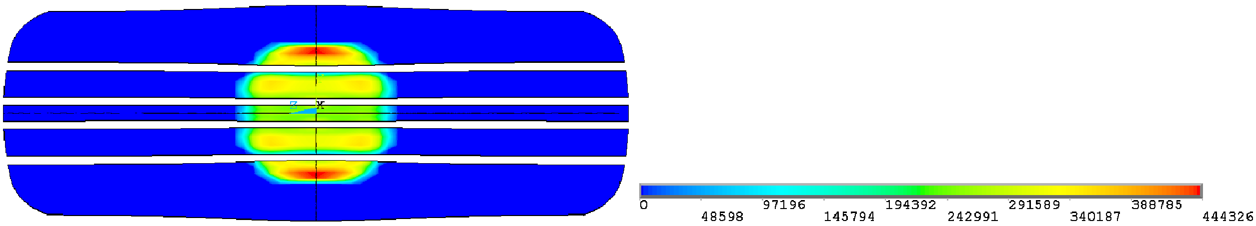

Figure 5 Distribution of contact pressure in contact surface on smooth roadway

According to static computations of the tyres and individual composite elements the design modifications can be proposed consisting e.g. in change of inclination angle of the cord fibres in the area of the tyre crown (Figure 6), which will lead to achieving of more proper deformation tyre characteristics.

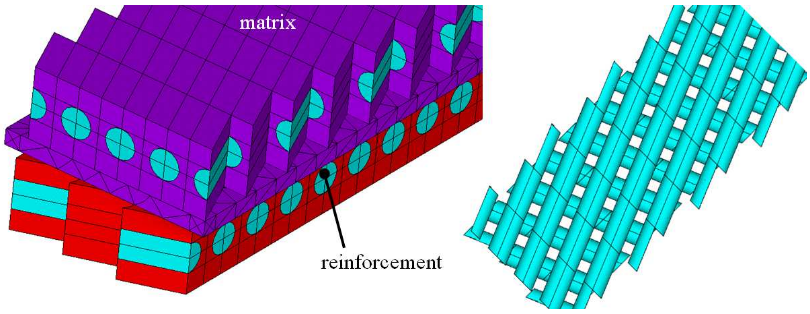

Figure 6 Arrangement of cord of a long-fibre belt in a tyre

4 Conclusion

This contribution deals only with a specific field which the computing engineer has to be well acquainted.

Data from operation and experiments are important for computational modelling, since account must be taken of the fact that a tyre as polycomponent composite is subject to combined loading both mechanical (static and dynamic) and thermal (local heating in microspots, overall heating of the tread propagating into the tyre during braking).

Calculations require accurate material characteristics of the reinforcement, matrices and above all of the combined composite elements including the purposely separated components of the tyre casing gained by experimental modelling.

Approach to the compiling of the computational models of the tyre shown in [1] can be applied also to the other construction types of the tyres and different sizes.

It is necessary to deal with computational and experimental modelling of macrostructure and microstructure of tyre upon degradation action with respect to transport safety.

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