Constitutive Modelling of Woven Textile Reinforcements and its Application to High-Pressure Hydraulic Hoses

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ABSTRACT

High-pressure hydraulic hoses with woven textile reinforcements are widely used in industry, e.g. for power transmission and for fluid transport. Such hydraulic hoses are composite structures where the fabric reinforcement consisting of textile materials like polyester lead to a highly flexible hose behaviour as well as to a high resistance against inside pressure. Rubber as base material guarantees the tightness of such hydraulic hoses.
The mechanical characteristics of multi-layered high-pressure hydraulic hoses are mainly determined by the properties of the single materials used and by the interaction between rubber and the woven textile reinforcement layers.

For the description of the hyperelastic behaviour of rubber the Ogden model [1], a well-known material model based on a potential function, is used. Concerning rubber, the main objective of this contribution is to provide reliable material data for realistic loading conditions. For that reason biaxial membrane tests in addition to the uniaxial tests normally used are suggested for identification of material parameters.

The main topic is the mathematical description of the mechanical behaviour of the textile braid. Its stiffness and strength has a significant influence on global hose behaviour. The concept is based on a trapezoidally-shaped fabric lattice model where the single fibres are represented by a spatial structure of rods [2]. In addition to material and geometrical nonlinearities this constitutive model also takes into account the increase of the fabric stiffness because of the mutual obstruction of crossing textile fibre bundles. For the latter, a concept based on the Hertzian theory is used. The determination of the stress state acting in the reinforcement layer including the lateral compression of the single fibres or fibre bundles as well as the calculation of the tangent stiffness according to this stress state is done by means of an incremental-iterative procedure within the framework of the finite element method.

The developed analysis model is calibrated and verified by means of collapse load analyses of regular sections of hydraulic hoses and of numerical simulations of the crimping of a hose fitting.

Keywords: fabric lattice model, finite element method, hydraulic hose

REFERENCES

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