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A MODELING APPROACH FOR FIBRE YARNS AND ITS APPLICATION IN AIR SPRING FE ANALYSES

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Twisted textile cords used as reinforcement in the elastomer matrix of air spring bellows typically incorporate two yarns consisting of multiple twisted fibres. In finite element analyses at component level, however, it is not feasible to discretely model single fibres. Hence, a material model is presented that describes a bundle of parallel fibres as transversally isotropic continuum. It exhibits high stiffness in fibre direction while providing low resistance to shear deformations attributed to the sliding of neighbouring fibres.

The material model is employed in the simulation of the textile cord's twisting process, which yields the deformed cross section of each yarn. A geometry model approximating this cross section is translated along and rotated about a spatial curve, which results in a three-dimensional shape destined to reproduce cord geometry inside air spring bellows. In reverse, the geometry model can also be utilized to decide if a certain point inside the bellows is located within any of the yarns. That allows for using a regular mesh of hexaeder elements, in which material properties are assigned at integration point level. In particular, if a point was identified to be part of the yarn, the aforementioned material model is assigned together with the determined local fibre orientation. Otherwise, the integration point belongs to the rubber matrix and receives hyperelastic constitutive behavior.

With this approach, both cord geometry and local fibre direction can already be resolved at component level. It provides the opportunity to analyze various design parameters of different scales, ranging from cord set up to global quantities like cord angle. As an example, the effect of varying twisting parameters was investigated in an air spring subjected to a suspension cycle. It was found that reducing yarn and cord twist positively affects the resulting elastomer stresses.

REFERENCES

[1] N. Heinrich, H. Donner and J. Ihlemann, J. Volumetric finite element models for textile reinforced rubber components. In: Proceedings of the 12th Fall Rubber Colloquium, Hannover, Germany (2016).

[2] H. Donner, FEM-basierte Modellierung stark anisotroper Hybridcord-Elastomer-Verbunde. PhD thesis, TU Chemnitz, 2017.