

Numerical Analysis of Kevlar KM2 Yarn Subjected to Transverse Impact in high speed range

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Mechanical behaviour of polymeric fibres and their fabrics under ballistic impacts has been largely studied and determined using different methods. Classical solutions include analytical [1], semi-empirical [2] and numerical approaches [3].

Within this group, numerical approaches are one of the most promising since they are usually more accurate than analytical ones but do not require large investments in materials and time as experimental campaigns.

Different numerical models have been proposed for fabrics under high velocity impact [3, 4, 5] while few attention has been dedicated to their basic constituents, i.e. fibres and yarns. In classical approaches, yarns are modelled as an homogeneous media with a linear elastic anisotropic behaviour. Their mechanical properties are usually obtained using physical assumptions and validated through analytical models which does not consider fibre-fibre interactions, inter-yarn friction, yarn section rearrangements or fibres three dimensional mechanical behaviour [3, 6, 7]. It has been proved by different studies that the previously mentioned elements have an influence on the global response of the fabric under ballistic impact [8, 9]. In order to determine a proper equivalent continuum model for yarns in highly dynamical applications, a mechanical study which goes further the analytical or experimental limitation is required.

Hereafter, a numerical study of a Kevlar KM2 600 yarn transversally impacted is presented, Fig.1. The single yarn is represented at its components level, i.e. fibres, allowing to take into account fibre-fibre interaction. A revisited version of Discrete Element Method inspired by multifilament models developed by other authors [5] is adopted in order to solve the problem in a friendly computational environment.

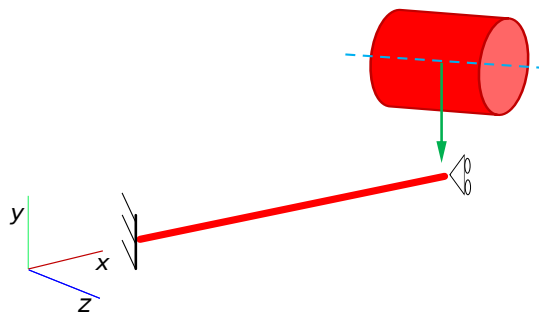


Fig. 1.: Transverse impact set up using symmetry conditions

Yarn impact response in the short ($0-3\mu s$) and long ($0-40\mu s$) time period has been analysed and compared to the analytical solution. Thanks to this approach all those phenomena which appear during the impact that are not visible using experimental/analytical techniques are carefully described, Fig.2. Moreover, thanks to numerical sensors, different physical quantities which are not available with classical approaches have been recorded.

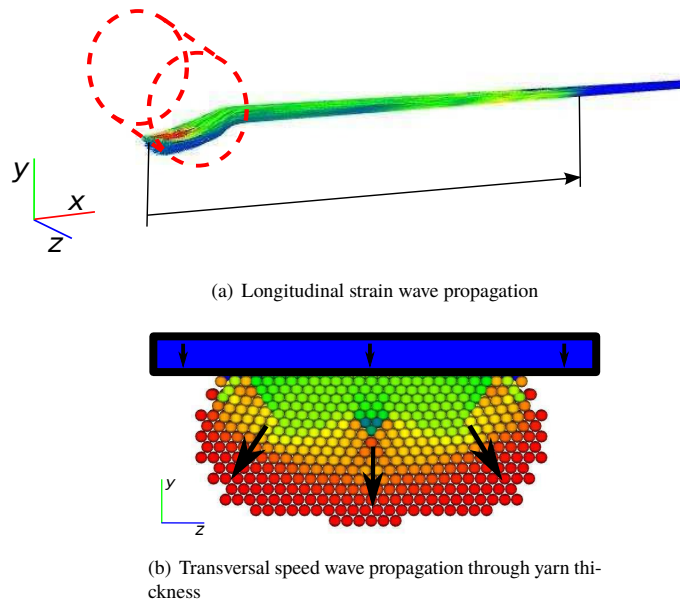


Fig. 2.: Wave propagations in yarn during transverse impact

This type of analysis will be successively used to get informations as energies trends, number of broken fibres and others in order to develop a material model for continuum yarn representation which is able to take into account even microscopic phenomena.

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