



UNIVERSITI
TEKNOLOGI
MARA

THE DOCTORAL RESEARCH ABSTRACTS

Volume: 4, Issue 4 Nov 2013

**FOURTH
ISSUE**

INSTITUTE of GRADUATE STUDIES

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IPSiS Biannual Publication

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Title

Finite Element Analysis Of The Tensile Strength And Puncture Resistance Of Woven Fabrics

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The tensile, ballistic and puncture impact behavior of woven fabric have been subject of interests for many researchers. The tensile behavior of woven fabric can be analyzed from the experimental and analytical methodologies. While experiment provides accurate information about woven fabric's mechanical properties than the analytical approach, it also generates sample wastage. Finite element analysis (FEA) method is used to model uniaxial tensile, impact and puncture response of woven fabrics in two and three dimensional geometrical model shapes. Woven fabrics models sizes are based on either unit cell or meso-scale (large scale) approach. Nevertheless, limited publications address woven fabric models in terms of weave repeat sizes. Finite element analysis has the ability to represent fabric geometrical properties and their symmetries, with weave mesh structures able to be made as close as possible, with minimal assumptions. Other than ballistic impact performance, limited work is done to model tensile performance of aramid based woven fabrics. In addition to that, many publications neglect the weaves structures influences such as float and yarn crimp to tensile and puncture impact behavior. Hence, in the study, an alternative simulation procedure was proposed to develop the understanding and prediction of float and yarn crimp relationship in uniaxial tensile and puncture

impact behavior of isotropic weave repeat unit. Woven fabric geometrical models were developed with TexGen and Abaqus CAD pre-processor module. The study was divided into three critical stages. Initially, FEA models were established on plain 1/1, 2/2 twill and 8 ends satin. Woven fabrics were configured as a balanced weave thereby allowing systematic investigation of the effect of uniaxial tensile stress on the weave. Woven fabrics were designed to have equivalent densities 8 yarns cm⁻¹ for all three weaves. Equivalent woven fabric specifications were manufactured and tested. Stress-strain validation between experimental and simulation results were made. Next, puncture impact models were developed based on the validated uniaxial tensile simulation models framework and its selected assumptions. Woven fabric for puncture simulation was expanded to consider larger model size than the previous uniaxial tensile model. Here, puncture model analysis was developed with 7 ends and picks cm⁻¹ with a total of 112 yarns in both directions. Similar in uniaxial tensile approach, validation analysis was made between puncture model and experimental stress-strain result. Parameters studies were executed on the validated puncture models. The effects of yarn frictions and impactor shapes to puncture models stress-strain, post-impact kinetic energy and damage evolution were analyzed. The stress-strain behavior of woven fabrics was found to be related to woven fabric structures. In uniaxial tensile validation, the presence of float in woven fabrics had contributed to stronger square woven fabrics in both warp and weft directions. The apparent gap was more pronounced in puncture model validation than uniaxial tensile model validation. The parameters studies results had shown that flat impactor shape and tightest yarn to yarn frictions contributed to highest stress-strain, post-impact kinetic energy and damage evolution results. Both uniaxial tensile strength and puncture impact present analogous non-linearity behavior in stress-strain result, which indicated the crimp interchange and yarn extension presence in the analysis.