Real-Scale Single Yarn Impact Modelling Through Discrete Element Method

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INTRODUCTION

Multifilament Models

Mesoscale* ← ? → **Microscale***

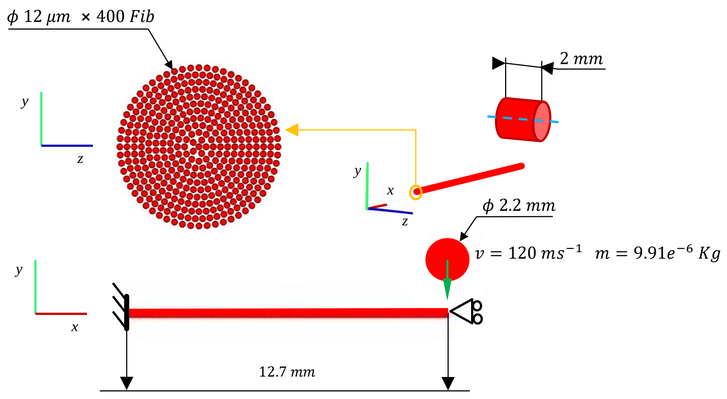
- Digital Element Method
- Max 30 eq. fibre per yarn
- Spring Element

- Finite Element Method
- Real scale yarn modelling
- 3D elements

OBJECTIVES

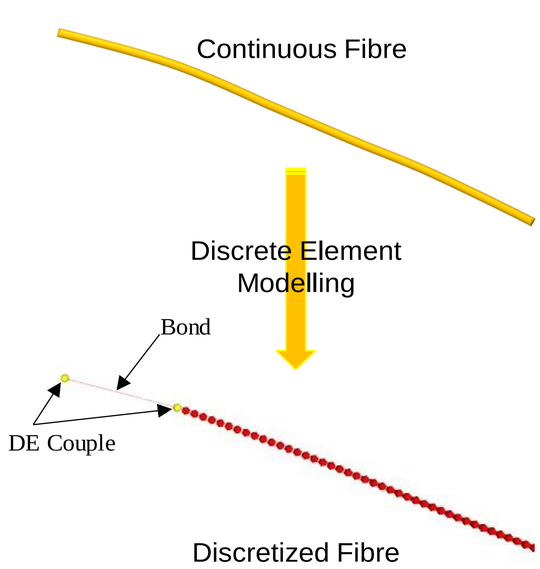
- *Validate the fibre pin-joined model at the microscale*
- *Quantify the information lost in pin-joined model*
- *Analyze the **scale transition** from full to reduced model*

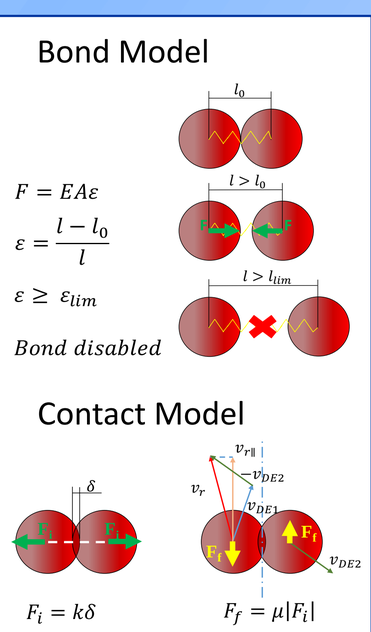
IMPACT TEST SET UP



The impact test consist in a single yarn of Kevlar KM2 600** impacted transversally in the centre by a cylindrical bullet.

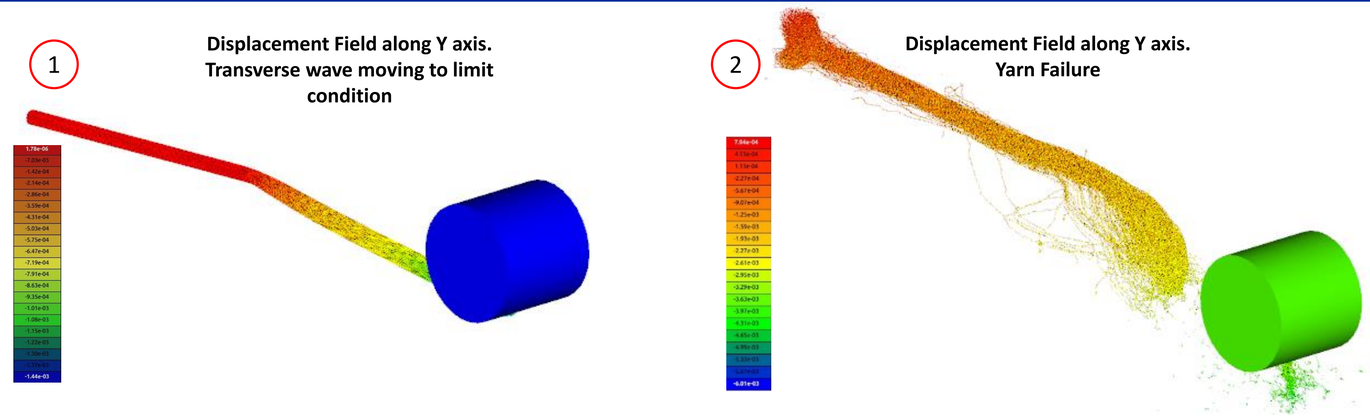
NUMERICAL MODEL

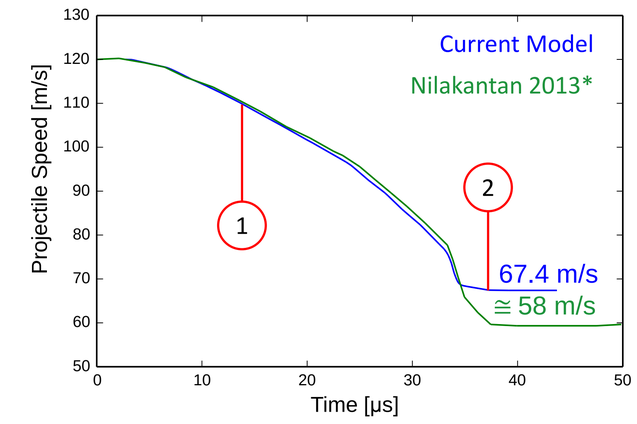


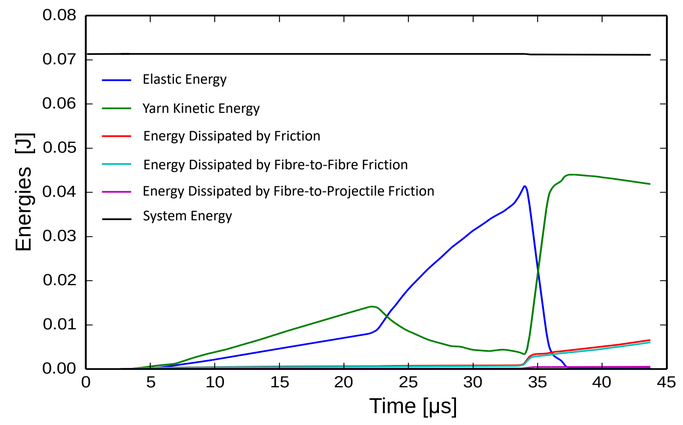


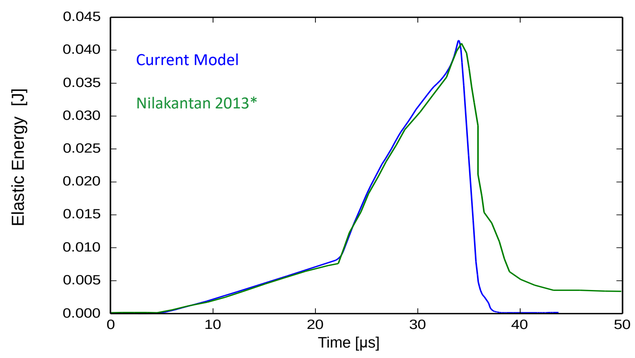
- Each fibre has been discretized by a sequence of Discrete Elements.
- Discrete Elements radius has been assumed equal to the fibre radius while yarn mass has been equally distributed within the model.
- Elastic behavior of the material** is provided by bonds which connect Discrete Elements Pair
- Contact Mechanic is managed by Discrete Element Method

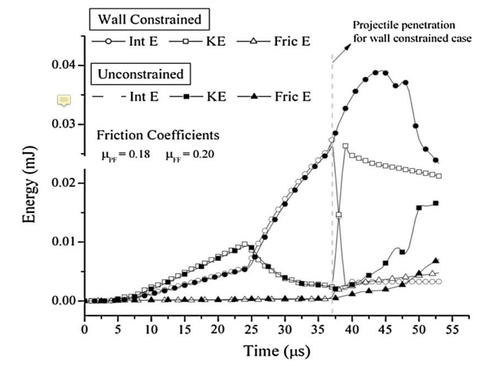
RESULTS







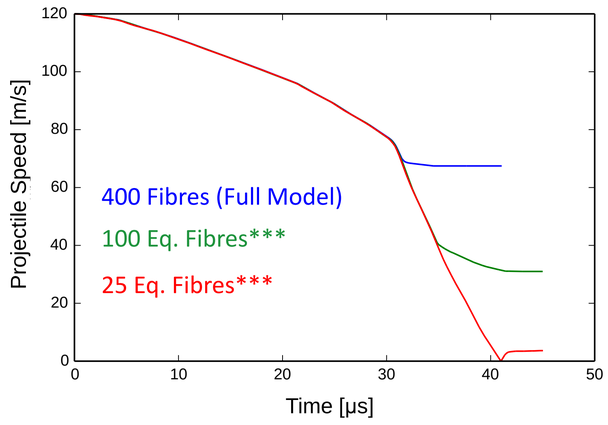


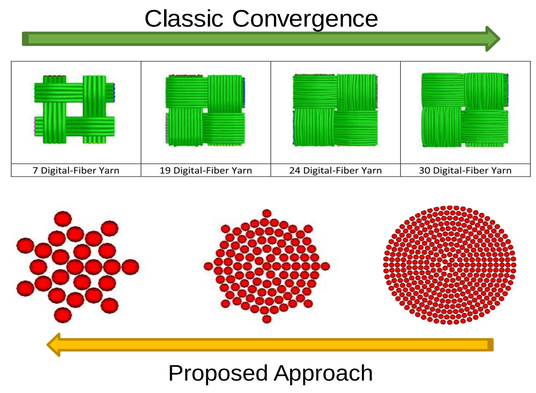


Elastic, Kinetic and Friction Dissipated Energy for other impact cases by the reference*

- **Good agreement** up to failure on residual speed and elastic energy
- **Discrepancies** could be attributed to the **lack of bending stiffness**
- **Friction dissipation** is **negligible before failure**
- **Fibre-Fibre Dissipation >> Fibre-Projectile Dissipation**

A multiscale transition has been initiated and compared with classical approach***





- **Classical approach** has an **effect on failure initialization**
- **Reduced models** are **not equivalent** at the microscale

CONCLUSION

- **A multifilament yarn model for impact simulation has been validated**
- **Failure mechanisms have to be analyzed in order to improve model results**
- **Friction effect have been decoupled to understand the role of projectile-yarn interaction**
- **Scale transition has been approached and the limits of classic method have been shown**

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