**DYNAMIC CRACK PROPAGATION IN WOOD FIBRE COMPOSITES**

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**Introduction**

Dynamic crack propagation has, partly due to the complexity of the field, primarily been studied on relatively homogenous materials such as steel, glass and amorphous polymers. There is a need to understand also the dynamic failure process in heterogeneous and anisotropic materials. This presentation aims to provide a link between dynamic crack propagation in homogenous materials and that in heterogeneous. This is done by comparing crack propagation in strip specimens [1] in a short fiber composite, to that of its pure matrix material. The work has been focused on wood pulp based bio-composites with a degradable PLA matrix. As both PLA and wood fibers are hydrophilic, experiments are performed for both wet and dry material. The experiments are compared to numerical results obtained using a dynamic phase field model [2] where a crack is represented by a diffuse fracture phase field. The phase field method is based on the principle of energy minimization, and the governing equations are obtained from variation of the Lagrangian,

\[
L = \int_{\Omega} \psi_k \, d\Omega - \int_{\Omega} \{ \{(1 - d)^2 \psi_\ell^{<} + \psi_\ell^{>} \} \, d\Omega - \int_{\partial \Omega} G_c \left( \frac{d^2}{2l} + \frac{l}{2} \frac{\nabla d \cdot \nabla d}{d^2} \right) \, d\Omega. \tag{1}
\]

**Results and Discussion**

Crack tip velocities up to 0.5–0.7 times the Rayleigh velocity \(c_R\) are measured from image analysis of high-speed camera footage. The different materials have slightly different limiting crack tip velocities, specifically wet PLA had the lowest limiting velocity \((0.5c_R)\), while wet wood fiber PLA composite had the highest \((0.7c_R)\). A decrease in critical fracture toughness occurs for the wet samples of both materials, compared to the dry samples. The analytical solution, obtained from the phase field model correlates satisfactory with both wet and dry PLA and wood fiber PLA composite with respect to fracture energy and crack tip velocity, Fig. 1.

In the PLA material, branching occurs, to some extent, in all samples. The branching pattern correlates reasonably well with respect to simulations (Figs. 2-3). The dry wood fiber PLA composite shows some branching, but the wet wood fiber PLA composites show no apparent branching.

**Figure 2: Branching pattern in dry PLA.**

**Figure 3: Branching pattern predicted for dry wood fiber PLA composite using a dynamic phase field finite element model.**

Comparison of experimental and simulation results show interesting differences. Firstly, the wet wood fiber PLA composite samples do not branch. Secondly, although there was no significant change in stiffness between dry and wet PLA, the limiting velocity was lower for the wet samples. These differences are possibly due to the microstructure of the material. A wet material could also be more ductile, indicating that plasticity behavior may have to be included in the models. Thus, there is a need for further development of fracture models to better capture the behavior of heterogeneous and/or anisotropic materials.

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**References**
