Minutes of the 2nd WG 2 meeting in Stockholm (05/11/2009)
Discussion around single fibre testing

Around 20 persons intend this meeting. The goal was to do some kind of virtual fibre testing and listing all the critical points at each step.

1 – Fibre sampling

Depends on final goal(s):

– Pulp and paper industry has a "need for speed". Fibres are always damaged and this is necessary for a good bonding. A good statistic is required but what are the criteria for choosing (on line?) the fibres to be tested in a batch? Need for a database linked with the process used and the most important parameters are fibre length, cell wall thickness, elastic properties both in longitudinal and transversal directions, strength, etc. Is the single fibre test the good one in that case (*e.g.*, test on paper sheet with DIC and µCT)?

– Researches in wood micromechanics focus more on measuring the cell wall properties (*e.g.*, bottom-up modelling) that required as less damage as possible fibres. Is the single fibre test the good one for that purpose (*e.g.*, nanoindentation-like test)?

In all cases, it is necessary to well qualify the initial state of each fibre (L. Salmén strategy, see hi presentation) and its history:

– chemically or mechanically isolated (processing),

– length (with a minimum aspect ratio to avoid boundary condition effect), shape and cross-section variation along the fibre,

– mean microfibrils angle and its evolution during the test,

– defects type (kink, dislocations, MFA variations see P. Navi presentation, etc.) and distribution along the fibre.

2 – Gripping

Different kinds of gripping are used but they are more or less all based on gluing the fibber to a frame:

– ball and sockets gripping (S.M. Shaler) allows for some rotation at the beginning of the test (fibre straightening and alignment) but not really free to twist or rotate after,

– glued on plastic sheet with pinning to allow fibre alignment (M. Eder),

– glued on plastic sheets that are gripped in classical tension grips.

Note the possible used of micromanipulator (see poster from P. Saketi). Everybody agree that there is no real satisfactory solution up to now and that it's worth in wet conditions. The major keys are stress concentration (important if the ultimate tensile strength is required), glue penetration and stability with time and humidity and the possibility for the fibre to rotate/twist. K. Gamstedt showed in his talk the effect of the end boundary condition (free rotation along the fibre axis or not, no buckling occurrence) on the load or mean modulus measured (around 20%? lower if rotation is possible). Its' hardly possible to control this during the test (possibility of a real free rotation by using magnetic joint, L. Salmén) but perhaps it could be measured or completely avoided and the induce torque measured (how high could be this torque?). Collaboration with modelling is of course highly recommended and required.

Is a standard for doing the test (like for other materials qualification) required? The use of a fibre made of a synthetic well controlled material (glass, Kevlar, etc.), having a stiffness similar to that of wood

fibre, as a reference to qualify the uncertainty of the testing device (far lower than variation due to fibre parameters variability) and for control is necessary.

3 – Testing

Other types of loading are available like bending (poster P. Saketi), free vibration resonance in bending, cell wall sampling by FIB for micro-compression test, etc. Perhaps it could be a great improvement to be able to do torsion/tension test or to use torsion system to untwist the fibre before the tension test (does it induce more damage?). The use of nanoindentation for measuring cell wall properties is progressing too. The need for cell wall or fibre transverse properties is important but there are no real convincing methods nowadays (except the double cell wall test with DIC tried by L. Salmén but it needs more development).

No major problem with the measurement of the load is reported (could sometime drifts). The major point is the strain measurement to avoid error due to the grips or frame stiffness and stress concentration. The most promising system nowadays seems to be Digital Image Correlation (in 2 or 3D) but it hardly works under variable humidity conditions. The problem is to have a stable pattern. Perhaps this problem can be overcome by using (under SEM deposited) grid techniques or particles (eventually magnetic ones).Development of µ and nano-tomography (see poster from V. Koivu) and ESPI can create a new ways of investigations as well as in situ confocal Raman spectroscopy to measure cross-section variations during loading (too long acquisition time if creep occurs?). No report for the use of Speckle interferometry. The damage due to the beam in a (E)SEM is mentioned and needs be assessed.

4 – Data evaluation

More or less straightforward but could be far improved by using modelling of the real fibre shape and boundary conditions (with rotation measurements) for example. The major problem remains the fibre sampling and initial state.

5 – Homework: a common action is planned with a set of fibres to be tested with the different testing devices available in the laboratories involved in this action.

Only one person should prepare and select samples to reduce the effect of sample preparation. M. Eder will prepare 20 mechanically and 20 chemically fibres (40 for P. Mäkelä!) from the same latewood in the same ring of pine (?) normal wood with optical selection in the end (*e.g.*, similar length). Reference non-natural sample: 5 untreated E-glass fibres having similar stiffness as wood fibre sample (*i.e.*, diameter less than 15 µm?) Problem with adhesion of glass fibre with cyanocrylate resin must be checked and if so switch to epoxy resin. Each involved people should report precisely how test has been done (see listed parameters at point 1) and how data has been processed.

Laboratory participating to this action: L. Salmén (SW), P. Mäkelä (SW), B. Madsen (DK), P. Saketi (FI), A.-M. Olsson, M. Eder (GE).

The WG meeting is closed with a reminder on the Experimental Database Excel sheet to be filled on Google Docs. Any interested person should send an e-mail to Olivier Arnould: arnould@lmgc.univ-montp2.fr

Michaela Eder and Olivier Arnould