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Electron Beam Damage During Testing of Wood in the SEM

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Technical note

ELECTRON BEAM DAMAGE DURING TESTING OF WOOD IN THE SEM

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SUMMARY: During the course of compression testing wood in the SEM a highly brittle failure is observed. Such behavior has earlier been ascribed to the high vacuum of the SEM and the resultant low moisture content of the wood (1,2,3). The results of the present investigation however, show that the brittleness is caused by electron beam damage. The failure morphology resembles that of gamma-irradiated wood (4). Although electron beam damage may be reduced, it can never be completely avoided. Caution is therefore to be exercised in the interpretation of results of such experiments.

MATERIAL AND METHODS: Specimens of spruce *(Picea abies)*, approximately 1x4x4mm with a necked down cross section of 1x1mm at the middle were conditioned. They were then taken to failure in compression parallel to grain at a constant rate of loading resulting in a time to failure of the order of 5-20 minutes depending on the ultimate strength. Four specimens were tested

Table 1 Conditions for mechanically tested specimens

Specimen number	Moisture cont.(%)	Mechanical test conditions
		normal wood
1	0	Tested in SEM. Beam exposure
2	0	Tested in SEM. No beam exposure
3	10	Tested outside SEM
4	19	Tested outside SEM
5	>30	Tested outside SEM
		compression wood
6	0	Tested in SEM. Beam exposure
7	0	Tested in SEM. No beam exposure
8	10	Tested outside SEM
9	>30	Tested outside SEM

in the SEM after having been exposed to a vacuum of 10^{-5} Torr for 24 hours. The remaining 5 specimens were tested outside the SEM at room temperature. Test conditions are given in Table 1. The backscattered electron imaging was used while mechanically testing specimens nos. 1 and 6. During loading, the electron beam was moved continously across the potential failure zone while using a magnification of 900 times. Consequently, each 0.1x0.1mm area of this zone was exposed to the electron beam for an average of 2 minutes. The secondary electron imaging was used after failure and coating of the specimens. Accelerating voltage was 20 kV.

RESULTS: Micrographs of failures showed a distinct difference in morphology of the failure depending on whether or not specimens had been exposed to the electron beam during the compression testing. Figures 1 and 2 show the glassy fracture of wood exposed to the electron beam as opposed to the ductile folding of the cell walls exposed to vacuum but not to the electron beam (Figure 3). The ductility of the latter is clearly illustrated in Figure 4, which shows the result of a gradual separation of an S2-wall, whereby bundles of microfibrils are bent and subsequently stretched with no signs of brittleness. An equally significant difference in failure morphology for exposed- and unexposed wood was found for the two dry specimens of compression wood. There was found no evidence of any significant brittleness for unexposed wood of different moisture content levels.

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(1)Kyanka, G. 1976: Proc. 2nd. Int'l Cong. Mechanical Behavior of Materials:1354-1357. (2)Aiuchi,T.; Ishida,S. 1978: Mokuzai Gakkaishi 24(7):507-510. (3)Bariska, M. 1985: Proc. CSIR Symposium, Vol.1. (4)Ifju, G. 1964: For. Prod. J. 14:366-372.

Fig. 1 Compression failure of spruce exposed to electron beam during testing

Fig. 2 Compression failure of spruce exposed to electron beam during testing.

Fig.3 Compression failure of spruce tested in vacuum but not exposed to electron beam during testing.

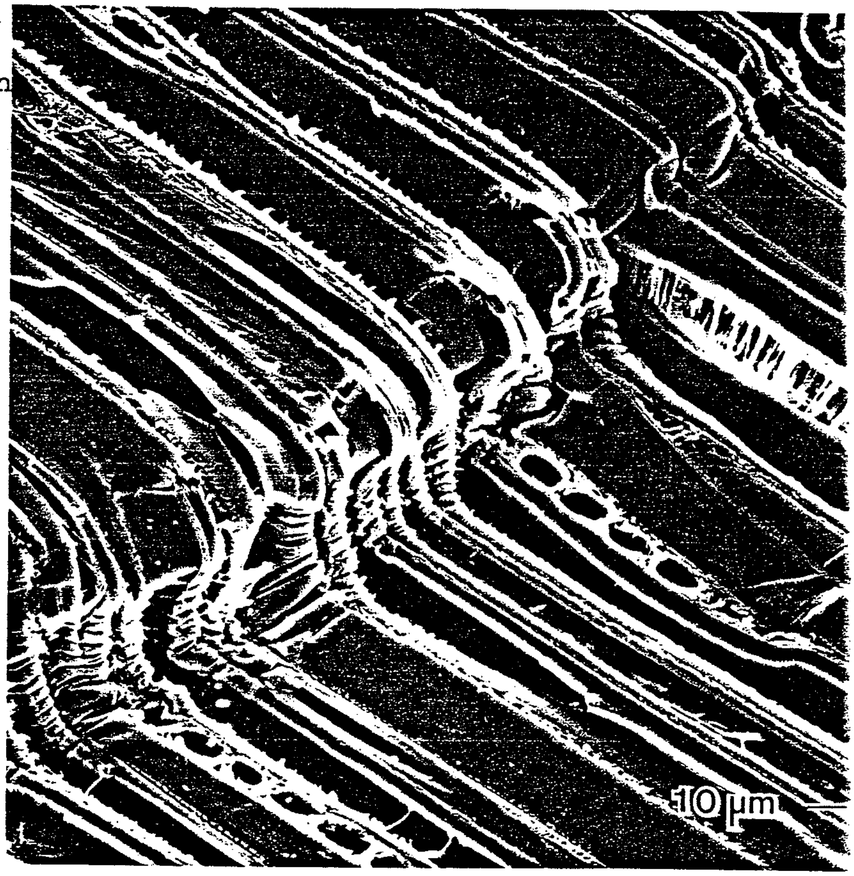

Fig. 4 Detail of Figure 3 showing the result of a gradual separation of cell wall elements.