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Preliminary

Thermal Softening of Wet Wood in the Temperature Range of 0 to 200°C*[1]

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Introduction

Thermal softening of wet wood changes markedly with temperature and is a key factor in several wood processing operations, e.g. wood bending, mechanical pulping, board manufacturing and compression or surface hardening of softwoods for furniture and interior materials. Softening properties, however, seems to be different for different wood species since the difficulty of processing operations vary widely with species even if the operation is made at the same temperature. The objective of the present investigation is to study the influence of temperature of 0–200°C on the softening behavior of wet wood subjected to large radial compression, to understand how wood should be processed depending on species in high temperature application.

Materials and Methods

Wood specimens were compressed radially between 0 and 200°C at 25 mm/min. The compressions between 0 and 100°C were performed in a standard mechanical testing machine with the specimens placed in circulating water. Between 100 and 200°C, compressions were carried out in a hydraulic testing system equipped with an autoclave which was heated by saturated steam. In this system, a newly developed load cell[1)] was placed within the autoclave. The yield point is defined as the point at which first linear-elastic line and subsequent plateau line cross. The wood used were sugi (*Cryptomeria japan* D. DON.), hinoki (*Chamaecyparis obtusa* ENDL), Norway spruce *(Picea abies)*, kaede (*Asea* L.), keyaki (*Zerkkowa serrata* MAKINO), shirakashi (*Quercus Myrsinaefolis* BLUME), buna (*Fagus*

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crenata BLUME), mizunara (*Quersus crispula* BLUME), mizume (*Betula grossa* SIEBOLD et ZUCC.), and yurinoki (*Liriodendron tulipifera* L.). The specimen size was 10×10×10 mm (L.R.T) and was conditioned to the fiber saturation point FSP. In each compression between 0 and 100°C, one specimen only was compressed, but in each compression between 100 and 200°C, 3 to 12 specimens were compressed simultaneously to obtain a compressive force much larger than the variations in force due to steam pressure variations in the autoclave.

Results and Discussion

As for load-detecting problem, we observed that newly developed load cell could be used for detecting loads precisely under steam at temperatures from 100 to 200°C. We further observed that the non uniform specimen degradation occurring under steam could be minimized by minimizing time required for wood attaining thermal equilibrium state to 60 sec through specimens in the FSP state.

Fig. 1a and 1b show the normalized yield stress on the logarithmic scale versus temperature for the coniferous wood and hard wood, respectively. For both figure, the yield stresses measured in the two different intervals (0–100°C in water and 100–200°C in

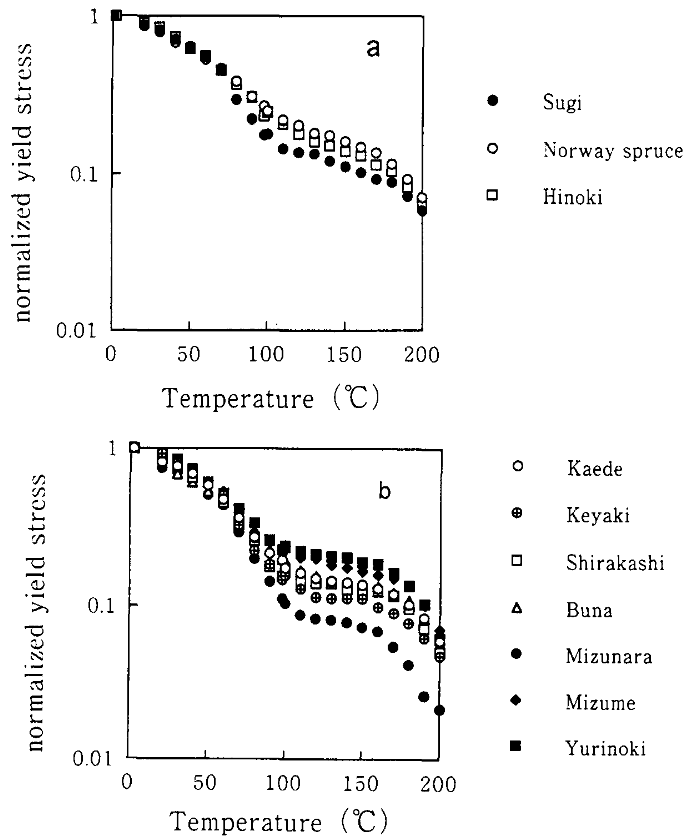

Fig. 1. Normalized yield stress in radial compression on a logarithmic scale versus temperature for coniferous wood (a) and hard wood (b).

steam) overlapped, and thus these figures are thought to reflect the softening behavior of wood between 0 and 200°C precisely. Both figures exhibit two well-defined softening regions. The first region at around 80°C is considered to be due to the glass transition of water-saturated lignin, which occurs at 83°C at forced sinusodial vibrations of 0.05 Hz as determined by the tan δ peak[2]. On the other hand, the second region at around 180°C seems to include hemicellulose decomposition, since only hemicellulose in cell wall polymers is hydrolized into low molecular substances by steaming at around 180°C for a few minutes[3]. It is to be noted that the flatness of the curves between 100–160°C recognized in Fig. 1b is contrasted with curves in Fig. 1a. This difference is thought to reflect the difference in the distribution of relaxation process due to lignin. This fact therefore suggests the difference in chemical structure of lignin between coniferous wood and hard wood.

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