Preliminary

Permanent Fixation of Bending Deformation of Wood by Steam Treatment*[1]

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1. Introduction

Bent wood has been widely used as various curved parts and members required for wood-made products such as furniture, musical instruments, toys, barrels, sporting goods, and so on. To produce curved parts of wood, bending is the most economical of material and the most productive of members of high strength. However, the deformation is not stable and tends to recover through remoistening, so that both ends of the bent wood should be kept fixed to preserve the shape obtained after bending. The permanent fixation of bending deformation is essential to expand the utilization of bent wood. The present paper investigates the permanent fixation of bending deformation by steaming.

2. Materials and Methods

Hackberry *(Celtis occidentalis)* specimens, 35 cm in length (longitudinal) by 2 cm in width (tangential) by 1 cm in thickness (radial), were used. After they were conditioned for two weeks at 20°C and 65% RH, lines were drawn across the grain at 10 cm intervals from their central position to measure the strains along the grain on the convex and concave faces as well as the radius of curvature after bending, and then they were soaked in water until saturated. As soon as the specimens were irradiated with microwaves of 2.45 GHz and 500 W for 90 sec, they were bent around a semi-circular wooden form with a radius of 50 mm using a jig made of an iron strap (0.82 mm in thickness) with wood handles at both ends and held in restraint by using a metal piece. After cooling, the bent specimens were dried under restraint for 24 hr at 105°C *(D1)*, conditioned for two weeks at 20°C and 65% RH *(A1)*, and

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then subjected to the steam treatment in an autoclave for various lengths of time at 120°C to 220°C. The treated specimens were dried for 24 hr at 105°C *(D2)* and then metal pieces holding them to shape were removed. Then, they were conditioned for two weeks at 20°C and 65% RH *(A2)*, followed by water-soaking *(W1)* and oven-drying *(D3)*. After four drying-soaking cycles *(W5)*, the specimens were boiled in water for 60 min *(B)*, oven-dried *(D7)*, and finally conditioned for two weeks at 20°C and 65% RH *(A3)*. At each stage, the radius of curvature *(r)* and the strains of both the convex and concave faces were measured.

3. Results and Discussion

The strains on the convex and concave faces in the first drying *(D1)* were about 2% and 11%, respectively. This fact shows that the iron strap absorbed most of the tensile stress during the bending operation and most of the specimen was stressed in compression. Figure 1 shows the changes of r in the cyclic test for the untreated and steamed specimens. The value of r for the untreated specimen gradually increased during wetting-drying cycles and remarkably increased by boiling. On the other hand, the value of r for the steamed specimen rapidly decreased with increasing steam temperature and at last the bending deformation was completely fixed above 180°C. Figure 2 shows the relationship between temperature *(T)* and time *(t)* when the complete fixation was achieved after the final drying *(D7)*. The relationship was expressed by $T=207-35.8\log t$. From a practical viewpoint, however, the results after four soaking-drying cycles may be adoptable, because the bent wood is rarely exposed to such an extreme condition as boiling. The relationship was

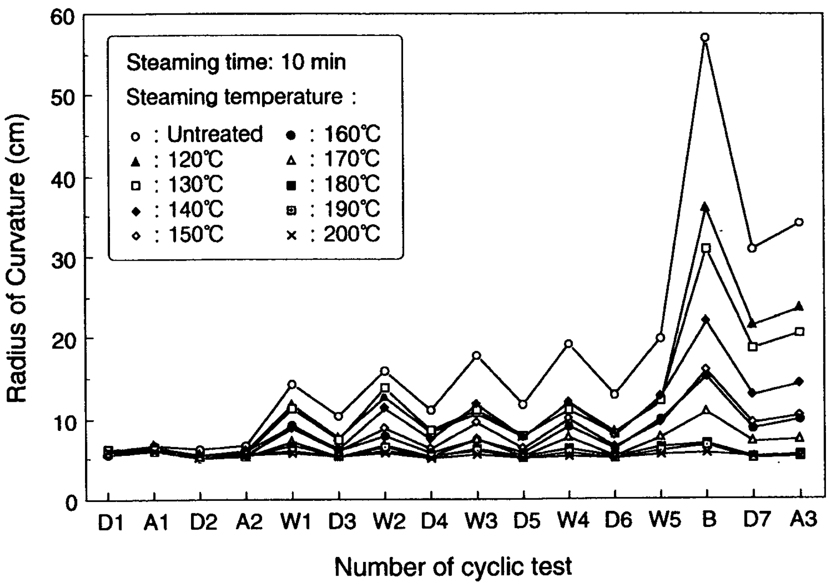

Fig. 1. The changes of the radius of curvature for the bent wood in the cyclic test. D: Oven-drying, A; Air-drying, W: Wetting, B: Boiling.

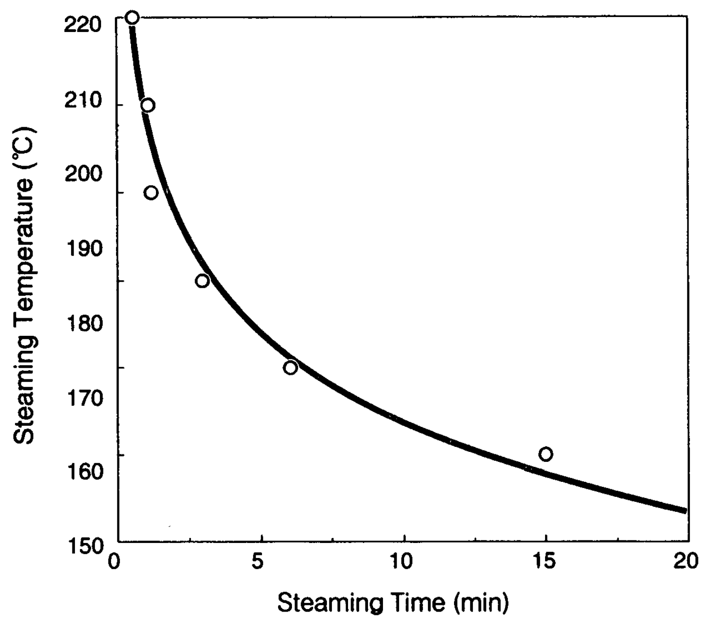

Fig. 2. The relationship between steaming temperature and time when the complete fixation of bending deformation was achieved.

represented by $T=203-41.7\ \log t$. These steaming conditions induced only a small change in the modulus of rupture and only a slight yellowing of the specimens. These results may be applicable even in larger specimens, because the maximum strain in bending occurs at the outermost convex or concave face.