SORPTION, SHRINKAGE, AND FIBER SATURATION POINT OF KEMPAS (*KOOMPASSIA MALACCENSIS*)

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ABSTRACT

Sorption isotherms and radial and tangential shrinkages were determined for kempas (*Koompassia malaccensis*). Radial shrinkage and swelling were found to be 10.0 and 9.2 percent, respectively. Tangential shrinkage and swelling were found to be 11.5 and 9.2 percent, respectively. The mean fiber saturation point was determined to be 23 percent.

The main objective of this study was to investigate the dimensional stability of kempas (*Koompassia malaccensis*) wood by determining radial and tangential shrinkage and swelling at several relative humidity (RH) conditions. We also wanted to determine the apparent fiber saturation point (FSP). Equilibrium moisture content (EMC) values from 20 to 95 percent RH were extrapolated to derive the apparent FSP.

The vast forest resources of Southeast Asia will receive increased attention as the forest products industry searches for suitable raw material for processing. One of the species that requires additional research is kempas. Kempas is a commercially important species found throughout Malaysia and Indonesia in swampy lowland forests and upland hillsides. The tree can reach a height of 180 feet with a clear and straight bole up to 80 to 90 feet and a diameter at breast height of 6 feet with heavy buttresses (2).

If kempas is to gain acceptance as a favorable species for structural and nonstructural applications, it is imperative that its dimensional stability be studied in order for the wood to be efficiently processed to ensure satisfactory in-service performance. Previous research has found that the timber usually dries well with some tendency for warping and checking. Included phloem tends to allow splits to develop. The wood has a specific gravity (SG) (ovendry weight and green volume) of 0.72 (2). However, specific information pertaining to dimensional stability is lacking.

Research on the FSP of kempas is critical but is also absent from the literature. The FSP of wood is the moisture content (MC) reached when all the fibers are completely swollen, but no liquid or free water exists in the coarser capillary structure. This point is often erroneously defined as the MC in equilibrium with 100 percent RH (3). According to Thomson's law, all capillaries depress the vapor pressure (although the effect may be minor), so the real FSP can only be determined by extrapolation (6). This point is critical for efficient processing because wood properties are altered below this point. Below this point, bound water is removed from the cell wall and appreciable shrinkage will occur. Wood will swell as water is added to the cell walls until the FSP is reached.

MATERIALS AND METHODS

Flat-sawn lumber, representative of three trees, was cut into 162 specimens measuring 2 by 2 by .125 inches. These specimens were then used for determining EMC and the shrinkage and swelling in the radial and tangential directions. The specimens were initially divided into two groups (A and B) before being placed in the proper desiccator. The A group was water-soaked with 30 minutes of vacuum at 20 inches of Hg and 30 minutes of pressure at 150 psi (wet condition) and the B group was dried over calcium chloride (dry condition) in a desiccator to completely remove moisture in the specimens.

Nine different concentration levels of aqueous sulfuric acid were formulated to create nine levels of RH conditions (**Table 1**). One desiccator for each RH level was maintained. The levels were: 20, 30, 40, 50, 60, 70, 80, 90, and 95 percent RH. Nine specimens from each group (A and B) were placed in each desiccator.

It is generally recognized that the FSP at 100 percent RH cannot be defined as the EMC at 100 percent RH. Therefore, it must be recognized that values given on a sorption isotherm plot above 95 percent

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TABLE 1. — Equilibrium relative humidity values for sulfuric acid-water solutions.[a]

Relative humidity (%)	Weight (%) H2SO4
20	57.5
30	52.5
40	47.5
50	43.5
60	38.5
70	32.5
80	26.0
90	19.0
95	16.0

[a] Source: American Society for Testing and Materials (1).

RH are generally incorrect and only represent the extrapolation of values measured at 95 percent.

From the difference in weight of the A group specimens after conditioning in the dessicators at the different RHs and the finally determined ovendry (OD) weight, the EMCs at the release of moisture were calculated. Also, from the difference in weight of the B group specimens after conditioning and the OD weight, the EMCs at the absorption of moisture were calculated. The EMC values expressed are a percentage of the OD weight. The difference in the EMC of the A and B groups is due to the hysteresis effect. All specimens were weighed at room temperature until constant weights were obtained. Linear dimensions were measured at room temperature with a vernier caliper to the nearest 0.0001 inch.

Second order polynomial regression lines were determined using a least squares regression technique (7) in conjunction with SAS programming (5) to predict 1) radial and tangential swelling; 2) radial and tangential shrinkage; and 3) adsorption and desorption. A higher order regression model was found to give optimal fit because of the traditional nonlinear behavior of the isotherms.

RESULTS AND DISCUSSION

The sorption and desorption isotherms are plotted collectively on **Figure 1**. As expected, the hysteresis loop is readily apparent. The hysteresis effect is comparatively small and is indicative of the dimensional stability of the species. When we extrapolate the isotherm curve to 100 percent RH, the real FSP is 23. Rijsdijk and Laming (4) found the FSP of kempas to be 22 percent.

The radial and tangential shrinkage and swelling at each EMC condition are shown in **Figure 2** and **Figure 3**, respec-

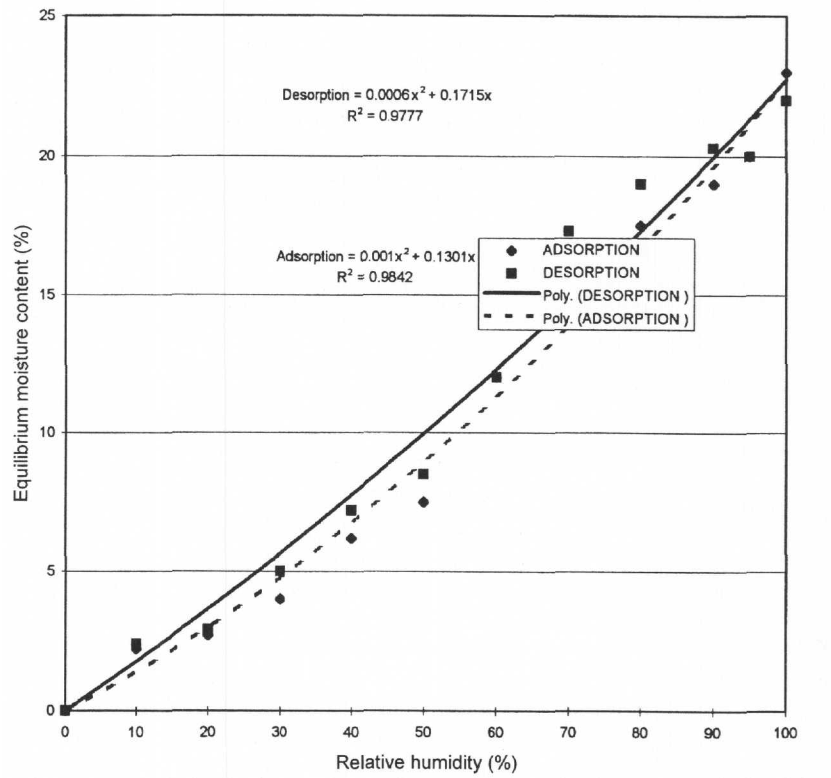

Figure 1. — Sorption curves and second order polynomial regression lines of kempas wood. Each mean value represents nine samples.

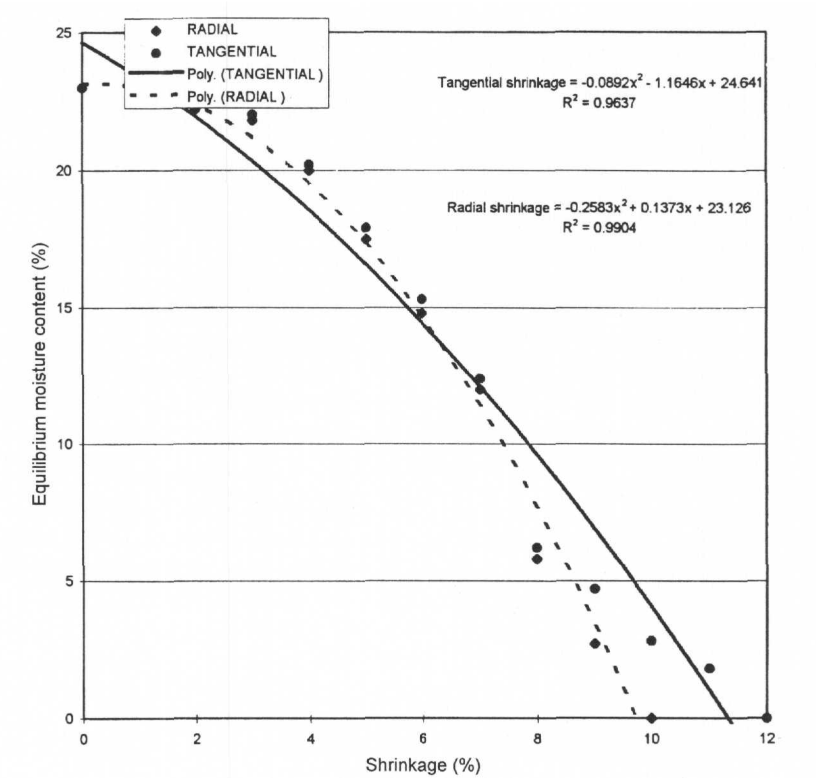

Figure 2. — Radial and tangential shrinkage and second order polynomial regression lines of kempas wood. Shrinkage was measured in percent of green dimensions.

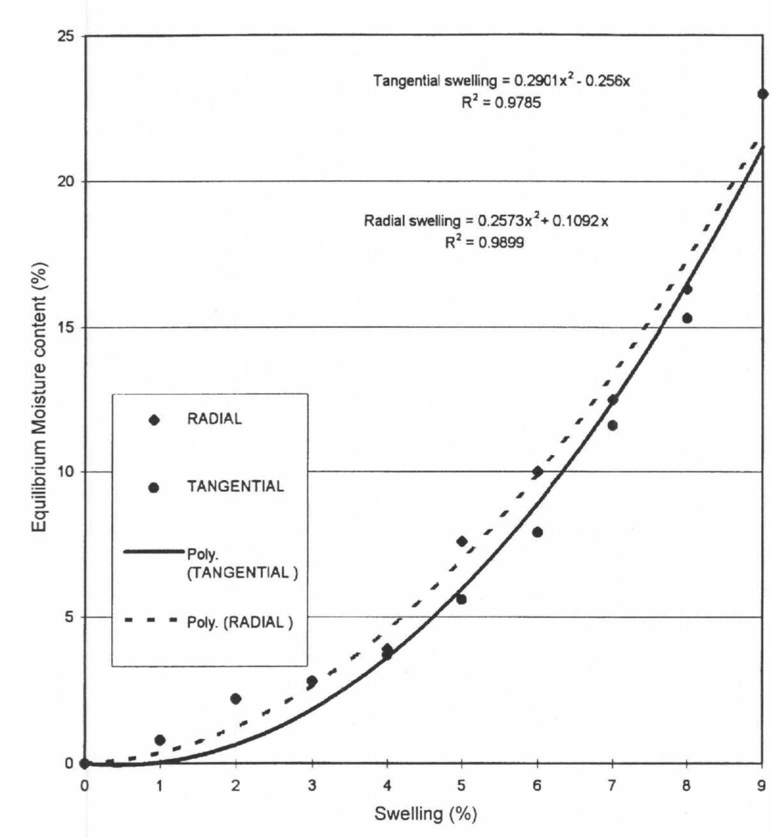

Figure 3. — Radial and tangential swelling and second order polynomial regression lines of kempas wood. Shrinkage was measured in percent of green dimensions.

tively. The total swelling is 9.2 percent in both the radial and tangential directions. The total shrinkage was found to be 10.0 percent radially and 11.5 percent tangentially. Chudnoff (2) reported shrinkage from green to ovendry to be 6.0 percent radially and 7.4 percent tangentially, and 14.5 percent volumetrically. Rijsdijk and Laming (4) found shrinkage and swelling to be near 6 percent radially and 8 percent tangentially. Our findings are slightly higher but reinforce the theory that kempas has fairly similar dimensional change properties in the radial and tangential direction.

The shrinkage and swelling values are rather high, but are not surprising given the high density of the species (SG at OD weight and green volume = 0.72) (2). Volumetric shrinkage is often correlated to specific gravity, and Stamm (6) has shown that total volumetric shrinkage is a product of FSP and SG on a swollen volume basis.

Conclusions

Based upon this research, kempas appears to have fairly similar shrinkage and swelling properties in both the radial and tangential directions. Kempas appears to have a drying property that should allow it to perform favorably in service for many applications. Also, radial and tangential dimensional movements and sorption and desorption can be accurately predicted using a second order polynomial regression line.

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