Jour. Agri. Sci., Tokyo Univ. of Agric., 46 (3), 191–195 (2001)
東京農大農学集報, 46 (3), 191–195 (2001)

Production of Particleboard Utilizing Spiral Chips Processed from Urban Woody Residue

By

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(Received May 30, 2001/Accepted September 20, 2001)

Summary : Pruned branches harvested from parks were used as elements of particleboards. A chipping machine consisting of a helical cutter having twelve blades was developed. The helical cutter rotates while revolving around a branch, and cuts the branch into twisted chips (spiral chips). After undergoing accelerated cyclic aging treatment, particleboards made of spiral chips were found to exhibit dimensional change in thickness, modulus of elasticity, modulus of rupture, and internal bond strength. Particleboards produced from spiral chips, developed in this study, are found to be usable as construction panels and partition walls to be used, for example, in dry conditions and under light load.

Key Words : particleboard, spiral chip, helical cutter

1. Introduction

Environmental conservation and waste treatment are daunting tasks which mankind faces at present and in the coming century.

Large-scale urbanization brings a new problem : treatment of urban refuse. Pruned branches, which are produced periodically in the course of environmental management of trees in parks and along roadsides, are one type of wood residue to be considered for recycling. For example, in 83 parks managed by The Tokyo Metropolitan Government, about 35,000m^3 of pruned branches are produced annually, and at present these are incinerated, or processed into chips to be used as substitute matting for jogging tracks and pavement in parks.

Therefore, in the present study, we designed a process of producing reconstituted wooden boards, as particleboard, from pruned branches obtained from parks[1–3]. A chipping machine having helical cutters introduced in the present study is useful for obtaining uniform chips from branches of irregular size and of winding and forked shape. In the course of chipping, long, twisted chips are cut. Chips are believed to intertwine with each other, in the manner of wood fibers in paper production, to thereby assist binding of chips and reduce use of adhesive.

2. Materials and Method

2. 1 Preparation of elements

Pruned branches were harvested from parks in the Tokyo Metropolitan area. The branches measured about 50 mm in diameter and were of the species Japanese cypress, or SUGI (*Chamaecyparis obtusa* S. *et* Z.) and Japanese cedar, or HINOKI (*Cryptomeria japonica* D.Don). Each pruned branch with bark was soaked in water for 24 hours and processed into chips, in the manner of Fig. 1, by our chipping machine, which mainly consists of a helical cutter. The helical cutter is 13.6 mm in diameter and has 12 blades, and during cutting rotates while revolving around the branch to produce spiral chips. The helical cutter is rotated at 165.5 rpm and revolved at 72 rpm. As shown in Fig. 2, produced elements are of a new shape : the chips are in the form of a twisted spiral of 10～15 mm in length, 2 mm in width, and 0.1～0.2 mm in thickness. The spiral

A portion of this paper was presented at the 50th Annual Meeting of the Japan Wood Research Society, Kyoto, April 2000, as well as at the 1st International Symposium on Wood Machining, Vienna, Austria, September 2000.

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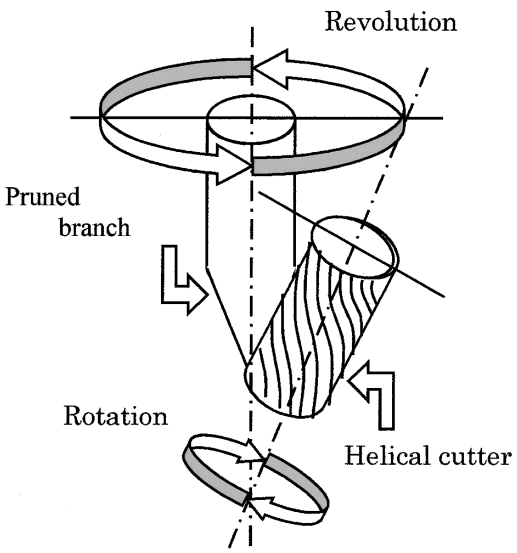

Fig. 1 Chipping helical cutter

Fig. 2 Spiral chips produced by our chipping Machine

chips were first air-dried, and then further dried in a laboratory oven set at 80℃ to assume a moisture content of 3 to 5%.

2. 2 Adhesive

Liquid phenol-formaldehyde resin was introduced as adhesive in an amount of 10% resin-solid content based on particle oven-dry weight.

2. 3 Board making

From the spiral chips blended with adhesive, single-layer random boards of 10 mm thickness were produced at target densities of 0.6, 0.7, and 0.8 g/cm^3. Mat size was 150 mm×150 mm. After mat forming was carried out for 15 minutes, pressing was carried out at 180℃ and a pressure of 30 to 40 kgf/cm^2 for 12 minutes to thereby produce particleboard ("Spiral chip board").

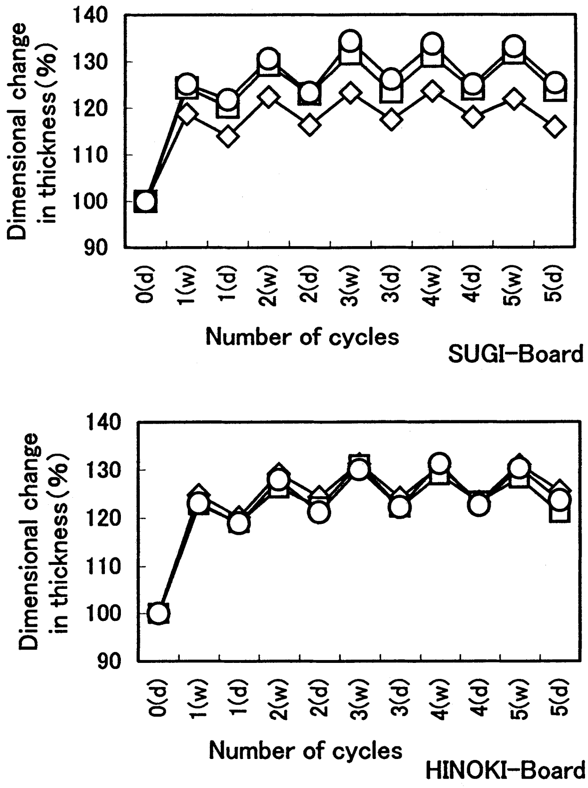

Fig. 3 Effects of the cyclic aging treatment on dimensional change in thickness of spiral chip boards
Specific gravity : ◇ 0.6, □ 0.7, ○ 0.8

2. 4 Board testing

Aging treatment was carried out for evaluation of the combined effect of aging and loading of particleboard. Treatment levels varied from 1 to 5 cycles. One cycle of aging-treatment of the specimens consists of (w) submersion in water for 24 hours, (d) conditioning in an oven for 24 hours at 80℃.

2. 4. 1 Dimensional change in thickness

Dimensional change was measured after Treatment (w) and after Treatment (d) ; specifically, board thickness was measured at three fixed points on each board.

2. 4. 2 Modulus of elasticity (MOE) and modulus of rupture (MOR) in bending

After Treatment (d), the boards were subjected to a bending test in accordance with Japan Industrial Standard (JIS) A5908-1983.

2. 4. 3 Internal bond (IB)

Internal bond strength (IB) was measured after Treatment (d), by application of a compressive force perpendicular to the plane of the board according to former JIS A5908-1961.

The following formula was employed to calculate the IB :

$$IB = P/A \,(\mathrm{kgf/cm^2})$$

Hence,

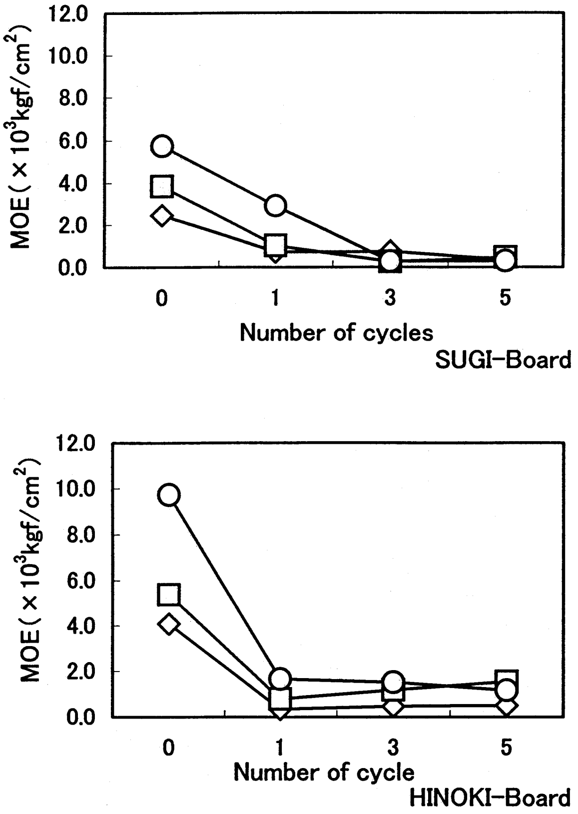

Fig. 4 Effects of the cyclic aging treatment on the modulus of elasticity (MOE) of spiral chip boards

Legend : ◇, □, ○ : Refer to Fig. 3.

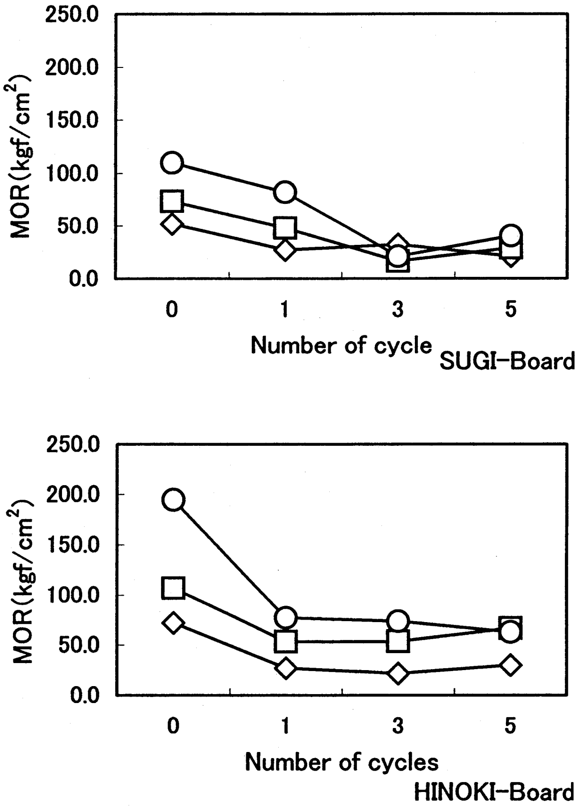

Fig. 5 Effects of the cyclic aging treatment on the Modulus of rupture (MOR) of spiral chip board

Legend : ◇, □, ○ : Refer to Fig. 3.

P : Compressive load

A : Shearing area

3. Results and Discussion

3. 1 Dimensional change in thickness

Figure 3 shows thickness changes caused by cyclic aging treatment for SUGI- and HINOKI-board. The upper values represent the thickness swelling of specimen after wetting, and the lower values represent the thickness after drying.

SUGI-board exhibits thickness changes slightly greater than those of HINOKI-board. Although in HINOKI-board specific gravity has no recognized influence on board thickness change, SUGI-board specimens of lower specific gravity (for example, r=0.6) show slightly smaller thickness change than do those of higher specific gravity. This is probably caused by insufficient blending of spiral chips and adhesive and insufficient heat transfer inside the board during heating.

3. 2 MOE and MOR

Figure 4 shows the effects of the cyclic aging treatment on MOE, and Fig. 5 shows the effects on MOR.

In both SUGI- and HINOKI boards, specimens of higher specific gravity exhibited higher values of initial MOE and MOR in dried condition before aging treatment. Moreover, for a given value of specific gravity, HINOKI-board showed higher values of MOE and MOR than did SUGI-board.

For both SUGI- and HINOKI-board, MOE and MOR decreased suddenly and obviously after the first cycle of aging treatment, and remained almost constant after subsequent cycles.

3. 3 IB

As shown in Fig. 6, in HINOKI-board IB strength increases with specific gravity, and decreases with the progress of aging treatment. However, in SUGI-board, specific gravity and aging treatment have no obviously recognized influence on IB strength.

3. 4 Strength retention

Figure 7 shows strength retention, or the ratio of strength after aging treatment to initial strength under the dried condition before aging treatment.

In general, in both HINOKI- and SUGI-board, strength retention of MOE and MOR decrease remark-

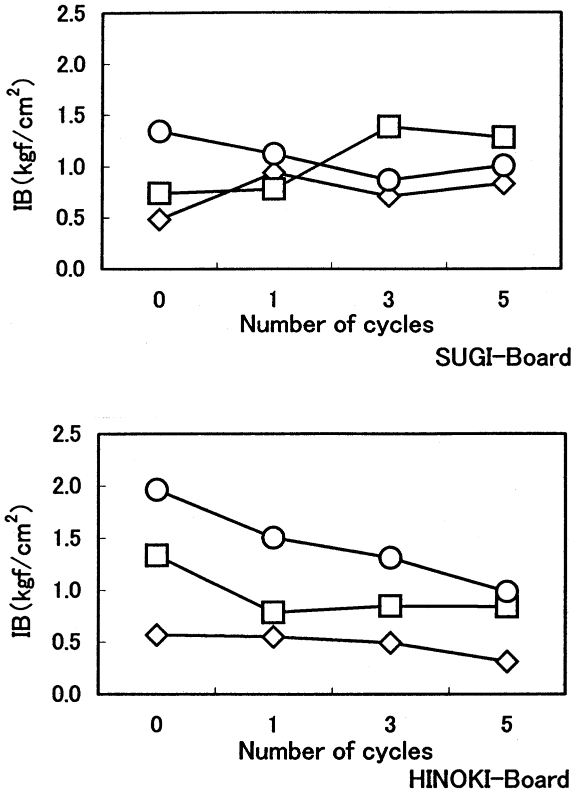

Fig. 6 Effects of the cyclic aging treatment on the internal bond strength (IB) of spiral chip boards
Legend : ◇, □, ○ : Refer to Fig. 3.

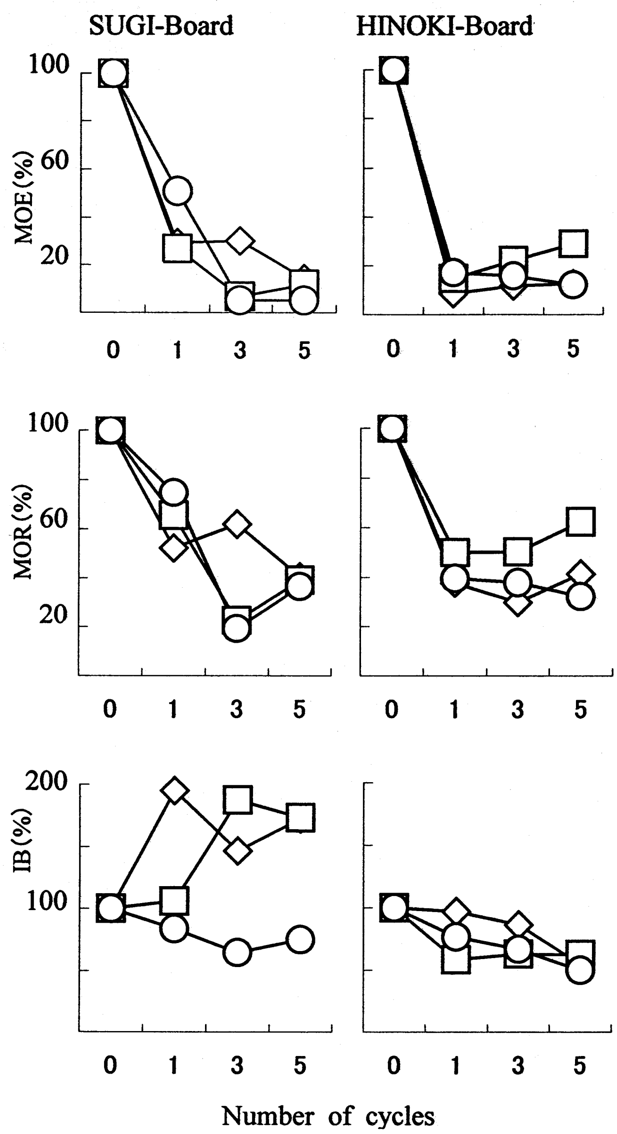

Fig. 7 Strength retention of spiral chip boards with the progress of the cyclic aging treatment
Legend : ◇, □, ○ : Refer to Fig. 3.

ably after the first cycle of aging treatment, due to high hydrophilicity of chips that results when no water-proof agent is mixed in particleboard. The contact angle of water on the surface of HINOKI solid wood is smaller than that in the case of SUGI[4]. Therefore, HINOKI absorbs much more water than does SUGI, and this obviously leads to a greater decrease in MOE and MOR after soaking in water.

Close entanglement of spiral chips in boards is assumed to be the reason why shearing strength (IB) of HINOKI-board was not influenced by aging treatment. However, study of the influence of aging treatment on IB retention of SUGI-board shows anomalous results, which may be due to experimental errors, such as insufficient blending of chips and adhesive, or usage of adhesive exhibiting low water resistance (phenol-formaldehyde resin).

We continue to seek effective uses of urban wood residue. Synthetic resin adhesive used in conventional processes to produce particleboard causes environmental and health hazards in dwellings ; particularly, emission of volatile organic compounds (VOC). In an effort to restrain VOC emission from particleboard, application of adhesive produced from natural products, i.e., use of dried granules of konjak (*Amorphopha konjac* K. Koch), instead of synthetic resin adhesive was considered[5]. Spiral chips have the advantage of wrapping around granular adhesive and distributing the adhesive uniformly throughout the board. Consequently, non-polluting particleboard can be produced without even a drop of water being used in the production process.

4. Conclusions

Since various types of particleboard are produced commercially, varying with the species and size of chips, type and resin-solid content of adhesive, specific gravity, orientation of chips in board, and processing conditions (pressing time and temperature), comparing particleboard produced from spiral chips and conventional particleboard in commercial production in terms of strength is difficult. However, for example, under Japan Industrial Standards (JIS), strength properties of particleboard (standard type -S20) are defined such that MOR is more than 200 kgf/cm^2 under the dried condition and absorption rate is less than 20% when specific gravity is more than 0.8 (MOE and IB are not defined by JIS)[6].

Because of insufficient treatment in the course of board preparation-blending of spiral chips and adhesive and cold pressing-particleboard that uses spiral chips as elements exhibits strength properties lower than those of conventional particleboard. However, specimens of high specific gravity exhibit bending strengths under the dried condition equivalent to that specified by JIS. Since the boards do not contain wax or other chemicals as waterproof additives, after soaking in water for twenty-four hours the boards exhibit insufficient dimensional stability and strength properties.

Strength properties of particleboard formed from spiral chips might be improved if sufficient board preparation were carried out. At the current stage of development, particleboards made from spiral chips are usable as construction panels and partition walls to be used in dry conditions under light load.

Acknowledgement : The authors would like to express their heartfelt appreciation for the contributions of Ms. Aki Misawa, former student of University of Tsukuba, throughout the experiments.

References

1) Tochigi, T., Tadokoro, C., Misawa, A., Kobayashi, J. and Onoda, R., 2000. Production of particleboard ffrom spiral chips obtained from pruned branches (in Japanese), *Proc. 50thhAnnual Meeting of Japan Wood Res. Soc.* (Kyoto, Japan), p. 275.
2) Kobayashi, J., Onoda, R., Tochigi, T., Tadokoro, C. and Misawa, A., 2000. Production of particleboard from spiral chips obtained from half-split chopsticks (in Japanese), *ibid*., p. 656.
3) Tochigi, T., Tadokoro, C., Kobayashi, J. and Onoda, R., 2000. Production of particleboard using spiral chips processed from pruned branches in parks, *Proc. 1 st Inter. Symp. Wood Machining* (Vienna, Austria), pp. 81–90.
4) Fushitani, Y. *et al*., 1985. "Wood Physics (in Japanese)", Bunkyo-Shuppan, p. 83.
5) Onoda. R., 2001. "Production of Wood-Based Material from Spiral Chips from Wood Residues," Master's Thesis for Tokyo University of Agriculture (in Japanese), pp. 1–36.
6) Suzuki, M. *et al*. 1993. "Wood-Based Materials (in Japanese)", Kaiseisha, p. 171.

都市型木質廃材から得たスパイラルチップによるパーティクルボードの製造

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（平成13年5月30日受付/平成13年9月20日受理）

要約：森林資源の枯渇が深刻な問題となっている今日，未利用のまま廃棄されている木材資源に付加価値を付与しうる利用方法が模索されている。そのひとつに公園樹木や街路樹をせん定する際に発生するせん定枝条がある。

本研究では，これら不定形円筒状の枝条の形状を考慮したうえで，自転・公転するヘリカルカッタを用い，それによって得られる新たな形状のエレメントを原料とするパ－ティクルボ－ドの製造を試みた。さらに，製造したボ－ドの物理的および機械的性能のうち厚さ膨潤，曲げ弾性係数，破壊強さおよび内部接着力について検討した。

キーワード：パ－ティクルボ－ド，螺旋状チップ，ヘリカルカッタ

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