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Thin Hardboard Manufacture from Waste Lignocellulosic Papers as Overlay Substitutes in Low Grade Plywood and Particle Board Panels(I)*1

Byung-Guen Lee · Sang-Yeob Lee*2

고지로부터 저급합판 및 파아티클보오드 표면단판으로 사용될 수 있는 박판 하아드보오드의 제조(I)*1

이병근 · 이상엽*2

要 約

이 연구는 저급합판이나 파아티클보오드의 표면단판 대용으로 얇은 하아드 보오드가 사용될 수 있는지의 여부를 측정하는데 그 목적이 있다.

이 하아드보오드의 제조를 위하여 사용되는 공시재료는 여러 형태의 폐지류를 여러 혼합조건으로, 접착제로서 합성수지와 함께 또는 합성수지를 첨가하지 않은 상태에서, 실험실적 장치로 하아드보오드를 제조하였다. 이들 폐지류는 상당의 리그닌을 함유한 폐골판지, 우유 및 씨리얼 포장지, 그리고 폐잡지를 포함하였다.

실험결과는 0.32cm 두께의 상업용 하아드보오드에 필적할 수 있는 0.21~0.16cm 두께의 하아드보오드를 이들 폐지류로부터 얻을 수 있었다.

이들 폐지류의 혼합효과는 영계수(MOE)와 Taber-마모성 실험을 비롯한 하아드보오드의 제 물리적 성질 즉 두께 팽윤율, 수분 흡수율 및 길이 팽창율에 현저히 나타남을 확인하였다. 이들 폐지류의 혼합과 사용한 합성수지는 하아드보오드의 비중, 영계수(MOE)와 제 물리적 성질에 민감하게 영향을 미쳤다. 이 하아드보오드의 이러한 제 물리적 성질은 저급합판이나 파아티클보오드의 표면단판 대용으로 사용할 수 있음을 보여 주었다.

ABSTRACT

The purpose of this study was to determine the technical feasibility of making 3-dimensional thin hardboard panels for overlay substitutes of low grade particleboard and plywood panels.

Experimental studies were directed at assembling bench-top apparatus, learning the characteristics of different types of lignocellulosic waste papers, for making thin hardboard with several combinations of them with and without resin addition. The raw materials used are waste corrugated cartons, cereal boxes, and old magazines which contain substantial amount of lignin in it.

The experimental results showed that satisfactory thin(0.21~0.16cm) hardboard could be made

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*2 嶺南大學校 農畜産大學 College of Agriculture & Animal Science, Yeungnam University, Kyongsan 712-749, Korea.

from the residential mixed waste papers that have selected properties comparable to commercial 0.32cm hardboard. The significant mixing ratio effect of the waste papers was present on the thickness swelling, water absorption, linear expansion, and modulus of elasticity including Taber abrasion tests of the thin hardboard made.

The mixing ratio of waste papers and resin in the thin hardboard prominently affected the specific gravity of it, which led to affect modulus of elasticity and those physical properties sensitively. And it was shown that the hardboard containing those physical properties can be used for overlay substitutes of low grade plywood and particleboard panels.

Keywords : Thin hardboard, waste papers, Taber abrasion test, overlay substitutes, low grade plywood and particleboard panels

1. INTRODUCTION

The demend on wood and wood fiber by the forest products industries has increased very rapidly and the natural resources of those material is becoming more and more scarce. To cope with this situation, the wasted fiber products such as the old corrugated cartons (OCC), white office paper, old news print (ONP) and old magazine (OMG) etc. are very abundunt and easily colleted for recycling from our surroundings. As a well known method to recycle those wasted wood fibers, hardboard manufacture is the most simple and feasible utilization. Bryant(1994) has proposed replacing pulpwood and solid wood residues with waste paper for veneer and fiberboard panels. Franque(1978) also suggested that some worthless lignocellulogic fibers was used as raw material for hardboard manufacture. Vidaurre(1982), Larsen(1964), Lee and Biblis (1976) also devoted themselves to manufacture hardboard from miscellaneous lignocellulogic fibers.

However most of them except Bryant(1994) devoted themselves to manufacture hardboard only as a final products. They did not apply this products as an intermediate to increase additional value on the final products. As a similar study of Bryant's(1994) it is proposed that thin hardboard manufacturing from wasted papers as overlay substitutes in low grade particleboard and plywood panels.

2. MATERIALS AND METHODS

2. 1 Preparation of Waste Paper Fiber

150grams of waste paper for repulping were added to 19 to 20 liters of water in the hydropulper which produced pulp slurry with a consistency of 0.75 to 0.8 percent. The initial pulping time was three and half minutes after which one to three percents of resin was added, when it was required. Also mineral wool and various kinds of paper were added to make a variety of fiber mat types. When resin was added, sulfuric acid was added after two more minutes of mixing to precipitate the resin. The acidity of the mixtures was adjusted to 4.5. The mixing ratios were reached from 20:80, 50:50, 80:20 and 100 percents. The resin contents in hardboard made were 0, 1, 2 and 3 percents respectively.

2. 2 Mat Formation

The prepared pulp fibers were poured into the 30×30 cm decklebox with screen in the bottom level of the box. Before the pulp was added to the decklebox, the vaccum in the vaccum tank connected to the discharge opening below the screen in the decklebox was set at 51cm of mercury with the vaccum pump running. Then the valve in the line was opened slowly and a timer was started as the water level in the dacklebox began to recede. Vaccum continued to be applied to the mat until the vaccum gauge showed 12.7cm of mercury. The dacklebox was then opened and the formed mat produced.

2. 3 Hot Pressing of Fiber Mat

Hot pressing was accomplished in several ways, depending on the experimental designs. Some of the mats were pressed wet without drying, and some were dried at room temperature and rewetted on the surfaces with a water spray before pressing. The pressing temperature was set at 165℃. The pressing time and pressure were 5 minutes and 14kg/cm² respectively.

2. 4 Testing Procedures

Mechanical and physical property tests of the hardboard specimens included the specific gravity based on the dry weight of the boards, modulus of elasticity determined on 14 × 14 cm squre specimens by measuring center load deflection in both directions, thickness swelling of percent thickness increase, water absorption of percent weight increase, and linear expansion of percent increase in length and width. Those were tested after 24 hours soak in water. ASTM D 1037 method was adapted for these testing procedures.

Taber abrasion tests were also done. That indicated weight and thickness losses after 500 revolutions with 1,000 gram weight shown in Fig. 1.

3. RESULTS AND DISCUSSION

Table 1 showed resin content and fiber type effects on modulus of elasticity and various physical properties of the thin hardboard made. Generally the modulus of elasticity of the hardboard in the Table 1 increased with increasing resin content in it, and decreased physical properties such as thickness swelling, linear expansion and water absorption percentage. When fiber type was compared for modulus of elasticity(MOE) and the physical properties, the hardboard made with old corrugated carton(OCC) showed apparent higher MOE and lower percentage of the physical properties, even though it is admitted that specific gravity of the hardboard has a sensitive effect on MOE and physical properties and they were compared at almost same specific gravities.

Fig. 1. Taber abraser tester equipped with 1,000gram weight.
Note : thin hardboard sample under test in top center(Bryant, 1994).

Table 1. Resin content and fiber type effects on modulus of elasticity and physical properties of thin hardboard made.

Resin Content	The Kind of Test	Fiber Type		
		OCC *2	ONP *3	HdF *4
0 %	MOE*1 (kg/cm² × 10³)	48.9(0.89 *5)		22.1(0.74)
	Thickness Swelling(%)	87.0		153.0
	Linear Expansion(%)	0.83		0.93
	Water Absorption(%)	139.0		269.0
1 %	MOE(kg/cm² × 10³)	52.0(0.90)	39.8(0.96)	29.7(0.79)
	Thickness Swelling(%)	28.5	19.0	52.0
	Linear Expansion(%)	0.39	0.39	0.27
	Water Absorption(%)	39.5	54.0	98.5
2 %	MOE(kg/cm² × 10³)	60.3(1.00)	42.3(0.99)	35.9(0.83)
	Thickness Swelling(%)	32.5	11.5	47.0
	Linear Expansion(%)	0.42	0.40	0.24
	Water Absorption(%)	33.0	37.0	94.5
3 %	MOE(kg/cm² × 10³)	61.4(1.05)	48.1(1.04)	36.0(0.83)
	Thickness Swelling(%)	25.5	8.4	44.0
	Linear Expansion(%)	0.34	0.38	0.26
	Water Absorption(%)	28.0	31.5	85.5

*1 Modulus of Elasticity, *2 Old Corrugated Carton, *3 Old News Print, *4 Hardboard Fiber,
*5 Specific Gravity of the thin Hardboard.

Table 2. The fiber mix ratio and resin content(0% & 1%) effects on modulus of elasticity and physical properties of thin hardboard made.

Fiber Types	Fiber Mix Ratio(%)	Modulus of Elasticity(psi × 10³)		Thickness Swelling(%)		Linear Expansion(%)		Water Absorption(%)	
		0%	1%	0%	1%	0%	1%	0%	1%
OCC/ONP	80/20	46.1(0.95*2)	59.9(0.95)	85.0	41.5	0.74	0.37	113	78.0
	50/50	48.2(0.97)	38.6(0.97)	89.0	38.5	0.65	0.36	119	74.0
OCC/HdF*1	80/20	39.0(0.91)	50.6(0.94)	90.0	41.0	0.90	0.35	129	73.5
	50/50	33.0(0.82)	44.2(0.97)	125	34.0	0.88	0.32	201	63.5
OCC/Mineral Wool	80/20	26.6(0.77)	47.4(0.98)	72.0	28.0	0.70	0.29	112	58.5
	50/50	15.8(0.72)	43.6(0.98)	62.0	27.5	0.69	0.25	90	58.0
ONP/HdF	80/20	36.3(0.87)	39.7(0.89)	80	31.5	0.66	0.27	129	72.5
	50/50	31.2(0.80)	27.0(0.84)	101	20.5	0.60	0.24	164	38.5
ONP/Mineral Wool	80/20	26.9(0.77)	37.1(0.89)	66.0	20.5	0.58	0.21	102	61.5
	50/50	17.8(0.74)	27.4(0.89)	49.0	16.0	0.66	0.15	88	30.5

*1 HdF : Hardboard Fiber, *2 Specific Gravity of the thin hardboard.

Table 2 showed resin contents and fiber types effects on modulus of elasticity and physical properties of thickness swelling, linear expansion and water absorption of the hardboard. The effect of resin content on physical properties was significant. The hydrophobic nature of phenolic resin reduced the percentage of thickness swelling, linear expansion and water absorption very significantly, which was experienced by Lee(1982). The adhesive characteristic of phenolic resin also increased MOE of the hardboard, regardless of fiber types.

The fiber type including mineral wool(MW) in fiber mixtures saw significant lower thickness swelling, linear expansion and water absorption. It seemed to be the hydrophobic nature of mineral wool in the hardboard (Bryant, 1994). This Table showed that fiber type and fiber mixing ratio had a very important role to determine MOE of the hardboard. Generally OCC-ONP and their combination produced higher MOE than the others. Microscopic investigation revealed more close contact between this two different fibers(Bryant, 1994).

Fig. 2 showed MOE versus specific gravity of the hardboard which was made by three different fiber types with various mixing ratio. In the Figure, pure OCC showed superior quality for MOE of the hardboard, even though increasing ONP ratio in the OCC of fiber type showed increasing MOE values at certain level of mixture. This results seemed to be unique and contrary to the results in Table 1, because the MOE of the hardboard made with pure ONP showed significant lower value than that of the hardboard made with pure OCC. This phenomena might be explained by close fiber contact between this two different fibers which are long and short fibers, due to the void volume created by long fiber of OCC and eventually occupied by short fiber of ONP in the hardboard.

Fig. 3 showed the specific gravities of hardboard made versus fiber mixing ratios in it. The specific gravities were increased along with increasing fiber mixing ratio of ONP, and decreased with incresing hardboard fiber (HdF)ratio in the mixture. As seen in Fig. 3, the close fiber contact between long fiber of OCC and short fiber of ONP created slow drainage time to make fiber mat in the decklebox, which led to the hardboard with selective and higher specific gravity. On the contrary, the hardboard made with OCC and HdF mixtures indicated lower specific gravity. This might be due to the poor fiber contact of HdF with OCC fiber, which created very fast

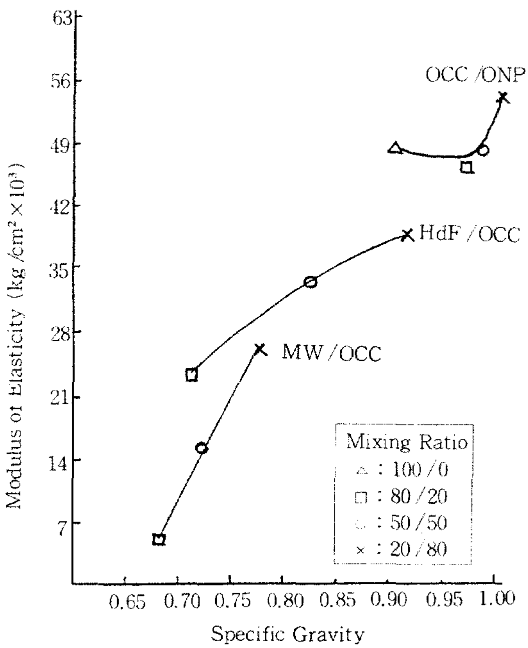

Fig. 2. The interaction of specific gravity of fiber mat and mixing ratio on modulus of elasticity.

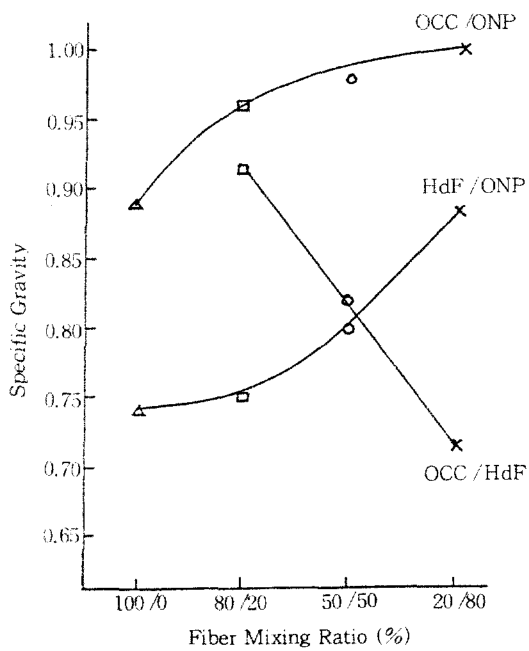

Fig. 3. The interaction of fiber mixing ratio on specific gravity of the thin hardboard.

drainage time(Bryant, 1994).

Fig. 4 showed MOE versus resin contents, and fiber mixing ratio. In this Figure, the MOEs of the hardboards treated with phenol formaldehyde resin generally showed apparent higher values than those of the hardboards without resin treated in both combi- nations of OCC-ONP and OCC-MW fiber types.

Fig. 5 showed thickness and weight losses related with resin content in the hardboard made in the Taber abrasion test. OCC and ONP combination of fiber type in this Figure showed less thickness and weight losses than those made with other combinations. This

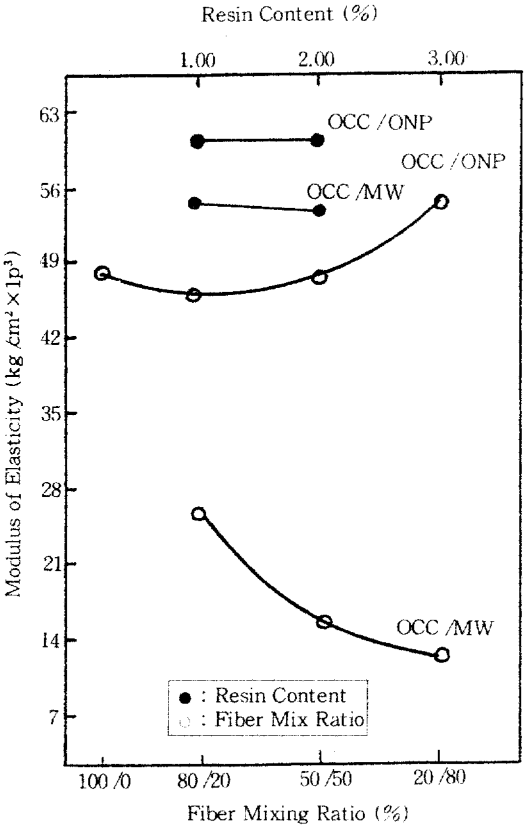

Fig. 4. The Interaction of fiber mixing ratio and resin content on modulus of elasticity of the thin hardboard.

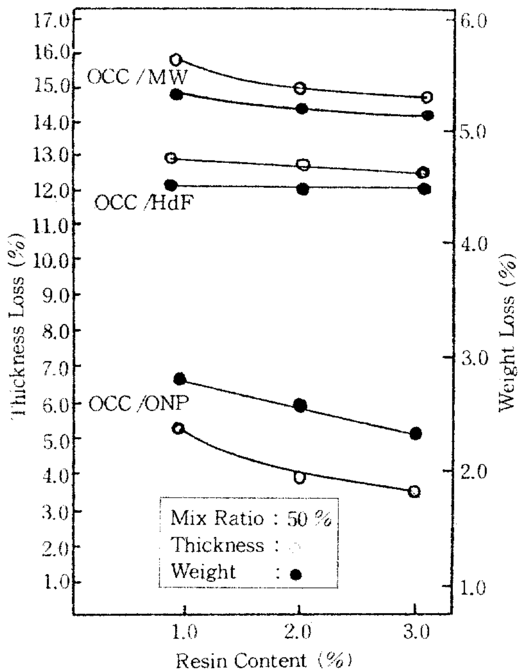

Fig. 5. The resin addition effects on thickness and weight losses of the thin hardboard in Taber abrasion test.

Table 3. The comparisons between commercial hardboard and thin hardboard made.

Pulp Types	Pulp Mix Ratio	Resin Content (%)	Static-Bonding Test		Water-Resistance Tests		
			Specific Gravity	MOE (kg /cm² × 10³)	Specific Gravity	Thickness Swelling(%)	Water Absorption(%)
OCC /ONP	20 /80	0	1.00	53.4	1.00	84	111
OCC /HdF	80 /20	1	0.94	50.6	0.94	41	73.5
OCC /HdF	80 /20	2	0.99	58.5	0.99	31	40
OCC /HdF	80 /20	3	1.01	72.2	1.10	32	49.5
Commercial Board(Oil Tempered)			0.922	43.7	0.908	2.4	7.1
Commercial Board(Untempered)			0.87	31.2	0.89	6.6	21.8

results explained that the hardboard having higher specific gravity had higher MOE and had more strong fiber contact characteristic among fibers learned by Stordalen(1950). This characteristic prevented weight and thickness losses of hardboard in Taber abrasion test.

Table 3 showed clearly that high quality hardboard can be made with low quality, low cost residential mixed waste paper, when commercial hardboard and the thin hardboard made were compared.

4. CONCLUSIONS

Thin hardboard made from residential, mixed waste papers revealed both physical and mechanical properties equal to or better than commercial hardboards, even if they have oil tempering treatments.

The physical and mechanical properties of the hardboard made were significantly improved by the addition of 1.0~3.0 percent phenolic resin solid(based on fiber weight). Most of physical and all mechanical properties were improved by 20 to 60 percent, regardless of fiber types used, however the physical properties of thickness swelling and water absorption of the hardboard made showed quite lower values than those of commercial boards.

Waste paper mixtures to make the thin hardboard created drainage rate problem. When old news prints which are the slowest draining component were replaced by MW, drainage rate have been improved, even though there remained a number of factors to be studied for other physical and mechanical properties.

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