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Recycled Organic Material "M-Wood2"

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Much ligneous refuse is simply thrown away or burnt. In particular, scraps, splinters and shavings that are generated by the log sawing process are not fully utilized. This paper reports on research into basic technologies for producing high quality building materials with wood texture that are fracture resistant and non-corroding through the application of technology to fine powder ligneous refuse as a timber raw material (usage of all ligneous refuse can be improved when fine powdered) and technology to compound it with plastics (comparatively simple materials to compound and mold with timber in order to improve productivity and performance). Key words: lumber flours, lumber, powdering, reducing, compounds

1. INTRODUCTION

Board-type building materials mainly consisting of lumber such as plywood, laminated lumber, fiberboard, and particleboard have been developed using technology that breaks down, powders, and reconstitutes lumber. Synthetic wood blend products combining various types of plastics with wood have also been developed. These materials have contributed to the effective utilization of a wide range of lumber as wood-texture materials. This has further led to a law regulating recycling from the standpoint of environmental protection and the effective use of resources. This law in particular mandates the effective utilization of building waste, which means ligneous refuse that used to be incinerated or buried must now be put to good use. However, lumber containing such used, dirty material cannot be utilized as raw material for conventional board-type building materials. Furthermore, even so-called synthetic wood blend products have a low wood content, and it would be difficult to say that they use a large quantity of wood.

2. OBJECTIVE

Technology for compounding plastic with wood flour includes a method that compounds PVC resin with fine wood flour to obtain high-grade synthetic lumber. Finely powdering lumber and removing fluff increases wood flour dispersal within the resins and makes it possible to obtain resin-molded products that have a texture that looks and feels very much like wood. However, energy is required to manufacture the wood flour for fine powdering. In addition, the type of lumber that can be used is limited due to color pattern reproducibility, thereby raising the problem of low usability when considering the use of ligneous refuse as raw material. The research presented in this paper focuses on technology for further reducing the energy used in manufacturing, increasing the types of lumber that can be utilized, and raising wood flour content.

3. EXPERIMENT 1

White lumber from certain types of conifers is processed into fine powder for use as wood flour that is compounded with resin-molded material. This maintains stable color in resin-molded products containing wood flour. In short, there is good color pattern reproducibility because there are no impurities except for the ligneous component. In addition, a process that reduces particle size and produces no fluff is used to improve flowability during molding, and this requires powdering and processing energy. It also leads to an increase in the number of manufacturing processes and a rise in processing costs. Furthermore, there are limits to the selection and use of a wider variety of ligneous waste materials. The crucial points of this experiment are cutting manufacturing costs and increasing the range of material that can be selected.

3.1. Materials

Spruce scraps and sawdust generated from processing at Misawa Home's Matsumoto panel plant were used for white, conventional wood flour. An intermediate processing company coarsely ground ligneous refuse from demolished homes and then processed it into chip-sized material. This was used for dark-colored, low-cost wood flour (see Table I).

Table I: Comparison of ligneous materials and applications

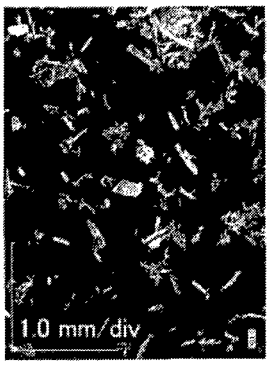
Material	Conventional Application	Color	Recycling Classification
Hemlock spruce only	Mosquito coils, etc.	White conventional type	Material recycling
White conifer lumber	Pulp White hardboard Particleboard		
Plywood	Dark-colored hardboard	Dark colored Low-cost type	Non-material recycling
Lumber including colored plywood	Fuel		
Lumber mixed with ceramic material	Industrial waste treatment		

Table II: Wood flour comparison results

Raw Material	Lumber Color	White, conventional type	Dark-colored, low-cost type		
	Processing method	(2) Fine powdering	(1) Grinding only	(2) Fine powdering	(3) 2-stage fine powering
Evaluation of Physical Properties	Visual observation	Lumber-only wood flour	Includes minute amounts of non-lumber color	Includes minute amounts of non-lumber color	Includes minute amounts of non-lumber color
	Average diameter (μ)	200	300	200	60
	Specific gravity	0.12	0.12	0.15	0.09
	Water content	9	12	9	6
	Dispersal	Few tangles	Particularly poor flowability	Poor flowability	Few tangles

Dark-colored (1)

Dark-colored (2)



Dark-colored (3)

3.2. Method

The experiment used wood flour processing methods (1) through (3) below to process two types of lumber raw material (white, conventional type and dark-colored, low-cost type) and then compared the resulting wood flour to evaluate its characteristics.

Three types of experimental processes were conducted as follows:

(1) Grinding, separation and removal of metal, and sieving
(2) Grinding, separation and removal of metal, fine powdering, and sieving
(3) Grinding, separation and removal of metal, fine powdering (2 stages), and sieving

The wood flour was then compared and evaluated by means of visual observation and for its flowability as a powder (see Table II).

List of machinery:

Grinding: Hammer-type powdering machine
Separation and removal of metal: Magnetic separators for iron, non-ferrous metals, and stainless steel
Powdering: Hosokawa ACM-60
Siever: Asano ST-52

The difference in external appearance between the conventional type and low-cost type of wood flour was visually determined to be extremely low. Therefore, we conducted a resin compounding experiment using the dark-colored, low-cost wood flour obtained from processes (1), (2), and (3).

4. EXPERIMENT 2

PVC resin and polypropylene resin extrusion molded products are frequently used as raw material for material that combines the texture of wood with the moldability of resin-molded products. Molded building materials containing wood flour that take into consideration not only physical strength, shock resistance, and moldability, but also the texture of wood and color reproducibility are being produced using these types of resins. However, it cannot necessarily be said that adequate consideration is being paid to price reductions and material recycling rates. We selected recyclable resin in consideration of price reduction and material recyclability factors. Through our experiment, we discovered an extrusion-moldable combination by compounding the dark-colored, low-cost wood flour manufacturing in experiment 1 with raw material resin.

4.1. Materials

Three types of wood flour obtained from experiment 1:	40%
Moldable extrusion-grade resin: (Polypropylene resin or PVC resin)	59%
Heat stabilizers and lubricants for resins:	1%
Material total:	100%

4.2. Method

The wood flours were mixed and compounded using a blender and then heated to around 150°C. Once the peak temperature was reached, the resin and additives were added. After the resin gelled, it was cooled to below 60°C

Table III: Evaluation of extruded compounds

Experiment No.		1	2	3	4	5	6
Compound %	Wood flour	(1) 40		(2) 40		(3) 40	
	PP resin	59	-	59	-	59	-
	PVC resin	-	59	-	59	-	59
	Lubricant and heat stabilizer	1	1	1	1	1	1
	No data for toughening agent						
Molding Evaluation	Molded shape	Poor	Poor	Good	Good	Good	Good
	Crack continuity	Moderate	Moderate	Moderate	Moderate	Good	Good
	Take-off state	Moderate	Moderate	Good	Good	Moderate	Moderate
	Overall moldability	Poor	Poor	Good	Good	Moderate	Moderate

using a cooling mixer. The finished compound was formed into 3-mm thick molded products by a conical 2-axis extruder, and then the shape during extrusion and extrusion properties were evaluated and compared (see Table III).

It is thought that moldability suffers due to tangling when wood flour particles are large. However, surface area increases when particles are too small. This causes extensive absorption of resin, which harms flowability during fusion. The end result is worsened moldability. A wood flour particle size of about 200 μ is generally thought to be appropriate. We evaluated and compared the optimum wood flour content within resin using this grain size.

5. EXPERIMENT 3

Examples of resin products used outdoors include rain gutters made of PVC resin and automobile bumpers made of polypropylene resin. Molded building materials containing wood flour can be produced by adding these types of resins, but in this experiment, we selected polypropylene recyclable resin because it is easy to obtain, low priced, and recyclable. We performed extrusion molding by combining the raw material resin with dark-colored, low-cost wood flour (2) that was selected in experiment 2. Through our experiment, we discovered the limit on wood flour content in molded products according to the rate of dimensional change and the rate of water absorption.

5.1. Materials

Dark-colored, low-cost wood flours from process (2):	55% to 65%
Recycled PP resin (extrusion grade):	44.5% to 34.5%
Dispersing agent:	0.5%
Total:	100%

5.2. Method

The wood flours were mixed and compounded using a blender and then heated to around 150°C. Once the peak temperature was reached, the resin and additives were added. After the resin gelled, it was cooled to below 60°C using a cooling mixer. The finished compound was formed into 3-mm thick molded products by a conical 2-axis extruder. The dimensions and weight of the molded products were measured, and then they were placed in room-temperature water (23°C). At appropriate intervals, the molded products were removed from the water to measure their dimensions and weight. The weight increase values and dimensions changes at multiple intervals were plotted on a graph, and then the rate of absorption and dimensional change were compared and evaluated using each sample (see Table IV).

Basis of durability evaluation: The durability evaluation is based on relative comparisons indicated by Superior, Good, Moderate and Poor in the following table.

Table IV: Durability evaluation when wood flour compound products absorb water

		PP Resin-Molded Product Compounded with Wood Flour		
		1	2	3
Compound Weight	Resin	44.5%	39.5%	34.5%
	Dark-colored, low-cost wood flour (2)	55%	60%	65%
	Dispersing agent	0.5%	0.5%	0.5%
Durability Evaluation	External appearance	Good	Good	Good
	Rate of water absorption	Superior	Moderate	Poor
	Rate of dimensional change	Good	Moderate	Poor
	Rate of thickness change due to water absorption	Good	Moderate	Poor
	Evaluation of physical properties	Good	Moderate	Poor

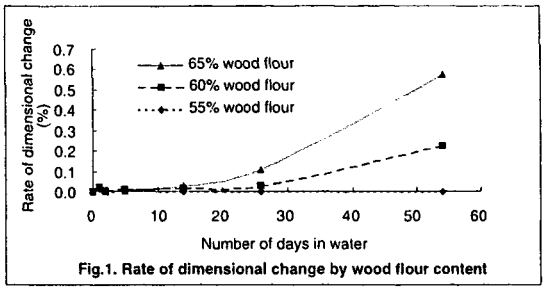


Fig.1. Rate of dimensional change by wood flour content

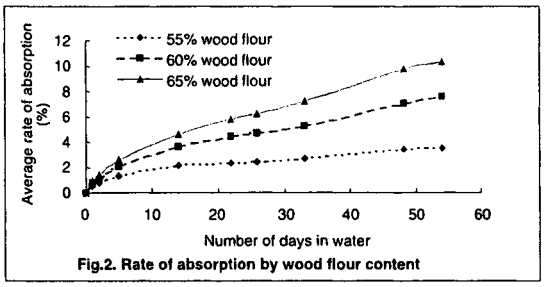


Fig.2. Rate of absorption by wood flour content

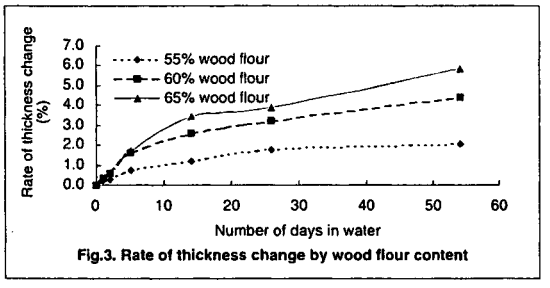


Fig.3. Rate of thickness change by wood flour content

6. RESULTS AND COMMENTS

Technology for compounding PVC plastic with 30% fine wood flour produces molded products that have a wood texture that is observable visually and tactilely. In addition, molded products that compound resin with mere wood flour or fibrous wood material are also being manufactured, but they do not have much of a wood texture. Building materials such as hardboard, particleboard, and MDF that are made of only wood flour have a different texture and appearance than wood, but they can be recycled as wood material.

The Construction Materials Recycling Act mandated the recycling of ligneous refuse from demolished houses. Technologies and applications for the mass reuse of this ligneous refuse must be developed. Furthermore, depending on how lumber was used, ligneous refuse from demolished houses is often contaminated or attached to other building materials.

The mass reuse of ligneous refuse from demolished houses requires a means of compounding powdered wood flour that is inexpensive and uses less energy in place of the conventional method for finely powdered wood flour. In addition, it requires a technology of compounding used lumber even with dirt. Through our experiments, we determined that it is possible to obtain molded products that have the water absorption properties required for building materials by increasing wood flour particle size, even when wood flour content is high.

Comments

(1) The wood flour must have a particle size of about 200 μ.

(2) The wood flour content must be 55% or less by compound weight. (50% or less by weight is desirable due to the relationship of water absorptions.)

In particular, we determined that building materials that effectively utilize the lumber from processes (1) and (2) using PP resin could be obtained. We also determined that building materials could be made by using lumber containing other mixtures (inorganic materials and colored plywood for example) that could not be used before.

This paper has shown that even wood flour containing other mixtures that previously could only be disposed of by incineration can be manufacturing into building materials through material recycling. This is considered a means to increase the effective utilization of lumber resources beyond previous levels. Building materials made in this manner have low water absorption properties and can be used as basic material that can withstand outdoor use.

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