Wood Flour And Sawdust As A Filler

For

Plastic Materials

By

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INTRODUCTION

One of the most abundant and most wasted raw materials in the world is likewise the one with the widest range of potentialities. Wood products have been used for generations, but this use has been accompanied by much waste. Even with the lumber industries' modern methods, a great proportion of every tree cut goes to waste. Sawdust, bark, tops of trees and limbs are a few of the things that contribute to the waste of our forest's products. At the present time scientists have been working towards the utilization of wood waste by inventing new products. The production of wood flour and sawdust is one of the fields which shows promise of becoming a major use of our wood waste. One of the more important uses of wood flour today is as a filler for plastic materials. My thesis will be on the manufacture and use of wood flour as a filler for plastic materials.

The Importance Of Wood Flour As A Filler

In order to understand the use of wood flour as a filler for plastics we must examine the composition, preparation and uses of plastics. The various materials which enter into the production of plastics may be roughly grouped as binders, fillers, dyes, pigments, plasticizres, solvents, hardeners, lubricants, accelerators and catalysts. The boundaries in this grouping are not well defined, however, as the same substance, wood for instance, may be used for making the binder in one case and the filler in another. Also, as the different items are broken down, many of the component chemicals are found to function in different capacities and thus to have multiple appearance in the final plastics. The two most important items from the view point of quanity are the binder and the filler. The binder is the fundamental part of the plastic. It is a resin compoment which hardens after being in a liquid stage. As the name implies it binds the other materials(notably the filler).

The purpose of the filler varies with the different plastics. With a given resin it is often possible to produce plastics with a wide range of properties by varying the filler material. The more usual fillers are wood flour, asbestos, graphite, mica, cotton and paper, but many others are used and countless further materials are being tried. Fillers play a very important part in the manufacturing of plastics having a phenol base. While fillers are employed primarily as dilvents to reduce cost and to provide body, they serve other equally usefull purposes. All filler compounds will cure faster than unfilled compounds, some fillers producing mixtures that will mold more rapidly than others. Compounds with fillers will hold closer to established finished dimensions since there is a reduced variable in the resin shrinkage. A large variety of special purpose fillers is used to obtain special properties in the molded compound. Asbestos, for example, is widely used as a filler in compounds requiring high temperature resistance or more than average dimensional stability. There are two classes of fillers generally used, inorganic and organic. Inorganic fillers, such as asbestos and silica, have high heat resistance, high insulation, etc. Their disadvantage is their high specific weight. Organic fillers do not possess this disadvantage and are used on a much larger scale by the industry. Wood flour, cotton flock, rayon waste, powdered cellulose, etc., are on the market today.

The high strength phenolic molding compositions consists of two principal ingredients: the resin and a fibrous filler. The resin is important as the bonding agent for the filler, contributes to the water resistance, electrical properties, hardness and surface finish and, in part, determines the flow of the molding compound. Changes in the basic resin formulation are of comparatively minor importance in so far as strength is concerned. The nature of the filler largely determines the strength characteristics of the molded part, and contributes, to a considerable extent, to the moldability of the compound. Where impact strengths greater than can be obtained with wood flour-filled plastics are desired, special materials are used. Impact-type materials have been confined to what are known as macerated-fabric-filled or rag-filled types. These materials have proved adequate in the past for applications requiring good strength characteristics. Because of the demand for a moldable material possessing an impact strength 2 to 3 times that of the macerated-fabric-filled composition, a wide range of fillers have been investigated and their effect on physical and mechanical properties and molding characteristics evaluated.

In molding compounds utilizing individual fibers as the filler, as compared to macerated fabric, it was found that fibers of much greater weight and accompanying strength will flow with the resin under heat and pressure to give a satisfactory molded article. As a result, high impact strength were obtained in well-filled articles using string, cotton waste, sisal fiber, cord and similar fibrows fillers, and thus eliminating the principle drawback to high strength fabric-filled materials. They are now experimenting with wood flour where they will not grind it too fine, but have it more fibrous. This would give the fillers more strength in forming strônger plastics. The species of wood perhaps would be the big differents here. Douglas Fir might be the ideal wood for this.

Wood flour makes a satisfactory general purpose material filler, since it combines low cost and fair mechanical properties. Its moisture absorption is high as compared to other filler materiāls. Some importance is attached to the role that the fiber structure of these fibrous fillers plays in improving the strength of the molded product. The fact remains, however, that in wood flour the fiber structure is almost completely removed. Wood flour cannot be used for light-colored materials, but it takes dark colors very well. Selected grades of wood flour have minimum abrasive action on the molds and help produce a high gloss finish onthe molded part. Pieces molded from wood flour materials are resistant to oils and to some weak acids and alkalis. With certain special phenolic resins, and selected grades of wood flour, it is possible to produce molding compounds which are free from odor and which are also resistant to water and some solvent and chemicals. Wood flour and graphite are often in combination as a filler for molded bearings and castor wheels requiring fair strength and water resistance.

Sources Of Wood Flour

The grinding and preparation of wood flour for use as a filler requires very careful selection of the stock, coupled with rigid processing and inspection standards. The best wood flour comes from the soft woods, since they are low in resin content and light in color. The choice woods are fir, white pine, spruce, poplar, basswood and cottonwood. These raw materials must be free from knots and bark. Wood flour is ground in several types of grinding mills such as stone grinders, ball mills, roller mills and hammer mills. The most desirable wood flour is ground in attrition mills which tend to defibre the wood along the grain. This leaves the fibres with maximum strength since wood is strongest along the grain. Sawdust is ordinarily used at the start of the grinding operation. All wood flour materials are ground to the fineness of wheat flour. We shall now look into the different grinding methods they use today in the manufacture of wood flour. About 40% of the wood flour produced in this country, is ground in stone mills. They consist of two large millstones, one of which is stationary, while the other is connected to a vertical shaft and revolved. The material is deposited on the lower stone, which is flat. The stones grind firmly aganist each other except near the center, where the grinding surface of the upper stone is somewhat concave, forming a space for the coarser wood material when it first enters between the stones. The material is finally reduced to flour. Here it is drawn or blown off,,and after screening is put into sacks.

The double attrition mills consist of two opposing grinding disks which are mounted on separate shafts and are run in opposite directions. The one disk is solid while the other is made of heavy steel spokes. The solid disk is entirely covered with grinding plates of very hard steel which are furnished with radial V-shaped depressions, the edges of which produce sharp cutting surfaces. The spoked disk is also furnished with grinding plates, but they do not extend to the center of the disk. In both cases these plates are in sections and can be readily removed and replaced with new ones if needed. This entire mechanism is inclosed in a stout iron case and the material to be ground is fed into the center of the machine. The wood particles are rubbed against the opposite plate, and being constantly reduced they are finally forced through the outer grinding rings at the periphery of the plates and finally deposited on the bottom of the case which incloses the grinding disks. The finished product is drawn or blown-off and carefully screened.

The single-attrition mills are those equipped with only one revolving disk. The material is introduced into the machine through the spokes of the revolving wheel, in the same fashion as in the double mill, and the material is rubbed against the sides of the casing, which is equipped with a grinding surface and acts much like the second disk in a double mill, except that it is stationary. This type of machine features an air-separation device, which is to obivate sieving the finished product. A current of air is used to draw the material from the grinder. In the upper portion of the machine this current of air is allowed to expand into a somewhat larger chamber. Here the air on expanding loses part of its lifting power and the coaser particles, which were held in suspension, fall back into the grinding chamber. The dust-laden air is conducted to a large settling chamber where the wood flour is finally precipitated to the floor.

The hammer mills consists of a horrizontal cylindrical chamber through which a heavy steel driving shaft revolves. Keyed on to this driving shaft are heavy steel plates, which are about two-thirds the diameter of the cylinder in which they are inclosed. Attached to these steel plates there is a series of loosely swinging hammers which extend nearly to the walls of the case in which they are inclosed. A grinding surface is provided on the one side of the interior portion of the cylinder and the shavings or other wood substances are admitted to this surface and reduced by the impact of the rapidly swinging hammers. The material is conducted off through a screen at the bottom of the machine and may be drawn off by air current to bins or logging hoppers.

The roller mills consist of heavy steel rollers which are equipped with steel teeth of varying degrees of fineness. The rollers working in pairs are made to revolve in opposite direction and the material fed between them is crushed and cut by the protruding teeth. These mills are usually equipped with several series of rollers, each succeeding one with teeth of increasing fineness. The material having passed through one set falls to the next rollers, and perhaps to a third set, after which it is screened and bagged.

Properties Of Wood Flour

Increasing expansion of the plastics industry is creating a demand for fillers. The wood flour industry is relatively new, prior to 1930 it was increasing rapidly, then fell off greatly during the depression and only now is gaining again. The market, as it exists, is fairly stable, but potentially it may be considerably increased. The present uses for technical grades of wood flour are rather limited, its principal use being a filler for phenolic resin plastics. The technical grade has rather rigid specifications as to color, resin content, uniformity, compressibility, chemical reactions, dryness, and the presence of bark, excess resin, and foreign materials. The last one of the major factors limiting the economic use of sawdust is the quantity of sawdust avaible. In cases where the use of sawdust involves processing in specialized equipment as the manufacture of wood flour, there is a certain minimum quantity of raw material which must be had to justify the installation of the necessary equipment.

Preferably species must not be mixed, and light colored woods are used-mainly white pine, with some spruce, fir, cottonwood, yellow poplar, birch and willow. The non-technical grades are used mostly in linoleum and also in various molded articles wherein the wood flour is bound with some binder or resinous formulato make dolls, furniture, molded carvings, picture frames, etc. Light colored softwoods and hardwoods are used.

Wood flour is simply finely ground wood. As it comes from the mill, it resembles ordinary wheat flour in appearance; hence the name. The material is designated by "mesh" or number of bars per lineal inch of screen through which the product is sifted. The sizes of the wood flour most commonly used are 40, 60, and 80 mesh. The finest grade of wood flour marketed is about 140 mesh. Where a fine flour is required, 80 mesh stock will usually be satisfactory, and the bulk of the product is 80 mesh and finer. Sandings from plywood mills are now being used throughout the country today.

Production And Value Of Wood Flour

The manufacture of wood flour is centered in the East at plants located advantageously with reference to sources of raw material and the more important consuming imdustries. Statistics covering the output of wood flour in this country are not available, but figures from various sources indicate that in 1937 about 32,000 tons were imported in that year. Current domestic production of wood flour is probably considerably greater than in 1937 due largely to inability to procure foreign stocks. Also in the year 1937 there were 8,000 tons imported.

The prices of wood flour at points of consumption in 1937 ranged from about $18.00 to $20.00 per ton for the coarser grades to $50.00 per ton for the finer grades used in plastics. Scandanavian wood flour when last available sold at prices ranging from $20.00 to $28.00 per ton in New York. Present prices of wood flour in all grades have probably increased somewhat over 1937 figures.

About 75% of wood flour is from white pine and the remainder largely from poplar, spruce, hemlock, maple, birch, white fir and in a few cases Douglas Fir. The color of Douglas Fir usually lowers the grade and limits the use.

There are no mechanical reasons why wood flour cannot be made from many other woods. There are, however, both softwoods and hardwoods, that preclude their use for that product. Wood having excessive pitch, gum, oil, or resin are not satisfactory for wood flour.

Unless there is some specific use for wood flour of hardwoods species, there is not much point in making hardwood flour, except possibly light-colored, light weight woods, such as aspen, basswood, and similar species. The prefered raw materials, the soft pines and spruces, are still plentiful and cheap and the finished product is low priced. Wood flour of the harder species of hardwoods has no stable markets and currently is of little importance in the wood flour trade.

Types Of Wood Flour

Wood flour is employed in the manufacture of a wide variety of products. To accommodate the various uses more exactly three general types of wood flour are made: nontechnical, technical, and granulametric.

Nontechnical wood flour is a common grade in which the requirements are not very exacting. It may consist of one species, or of a mixture of closely related woods, and may be of various sizes. Nontechnical grades can be used to make certain plastics as well as the bulk of linoleum. The bulk of wood flour consumption is of the nontechnical grades.

Technical wood flour is made to specified standards. The requirements may relate to size or mesh, species, color, weight, resin content, character of fiber, absorptive properties, or some other property, or a combination including any of the above.

Granularmetric wood flour is really a special type of technical wood flour in which for any mesh the particles are uniform in size and character.

With the increasing developments of the

plastic industry, there should be some increase in wood flour demand. It should be pointed out that not all types of plastic use wood flour filler. The phenolic (Bakelite) are the principal user. Light colored types use none, or some use a pure, white, cut, sulphite pulp.

Wood Flour As A Component Of Plastics

Phenolic plastics are used more generally than any other type of plastics. Wood flour is used mostly with this type of plastic, because the phenolic plastics are dark. Filler and resins play an important part in the special properties of the materials available, and it is therefore advisable to consider carefully all the available molding materials. Users must select the compounds which is best suited for a particular application. The phenolic molding compounds are divided into several general classes for easy selection. I will limited my information to the phenolic plastics, since these are the ones we are most interested on our line of work.

The general purpose of the phenolic materials are designed to give the maximum economy for those broad fields of application which have no special physical or chemical requirements. The phenolic plastics are those plastics materials which are made from phenol or carbolic acid in combination with other chemicals. Since formaldehyde is commonly used in combination with phenol, these plastics are often called phenol-formaldehyde or phenol-aldehyde plastics.

The phenol-aldehyde plastics are the foundation of the plastics molding industry. They constitute a large percentage of the molded plastics manufactured today, and are used almost exclusively for the industrial (nonlighting) laminated plastics materials. Many raw materials can be used in the manufacture of the phenol-aldehyde resins. The phenol bodies, phenol or cresol, or a mixture of several phenolic bodies, are generally used because of their availability. In the aldehyde series, formaldehyde and furfuraldehyde are most frequently used. Formaldehyde is more often used because of its faster molding cycle and greater availability.

Important fillers used phenolic plastics besides wood flour are fabric fillers, asbestos fillers and cotton fillers. The fabric fillers have pieces of chopped cloth or canvas is used in making impact-or-shock-resisting phenolic molding compounds. These fabric-filled materials are difficult to mold; some of them cannot be molded at all in complex shapes. The asbestos fillers are widely used in phenolic compounds for many reasons. These minerals fibres offer the best heat resistance of any of the mineral fillers available. The cotton fillers are frequently used as a fuller for molded parts which require better than average impact resistance.

The wood flour is thoroughly mixed with the phenolic resin, coloring matter, etc., into a plastic mass. After drying, this material is then ready for molding. It is molded in presses that are capable of exerting a pressure of about 2,000 lbs. per square inch and the molds are heated to temperature of approximately 350 F.

Filler material is more important in relation to the resins than to other binders. Wood flour when mixed with cellulose nitrate and some other ingredients becomes the familiar plastic wood. A function of wood flour filler in phenolics is to minimize the inherent brittleness. Flour is usually ground fine enough to pass a 100 mesh sieve.

Among the more common phenol resins are Bakelite, Redmanol, Condensite, and Durez. These products mixed with wood flour and coloring materials are molded under heavy pressure and heat into various commodities, such as radio dials, knobs, telephone parts, kitchen ware novelties, etc. The amount of wood flour in these articles, comprises from 30 to 50 percent or more of the total weight of the finished product. Where high luster is required of an article only a small amount of wood flour is used. When luster is secondary to strength, the amount of wood flour is increased.

New Experimental Development In Wood Flour

A. Patching Defective Lumber

In Northwestern part of United States, a wood flour plastic has been developed for the use in filling worm holes and in the repairing and filling of small knots and pitch pockets in lumber that is otherwise high grade. This plastic, which becomes an integral part of the lumber, was developed in an attempt to salvage some of the fire-killed timber which is being attacked by the round headed wood borer.

The plastic is a mixture of cellulosic esters and ethers, in the presence of volatile solvents, suitably modified by various plasticizers and resins. The filler used is largely Douglas Fir wood flour. Machines and handling methods used in the plastic-plugging operation are relatively simple. After the lumber has been dried and blanked, the holes or defects to be filled are cleaned or routed out with tools. The lumber is then rolled toward the filling machine where the boles are centered under it and filled with the plastic under about 700 lbs. pressure per sq. inch. This process is fast and continuous, making it possible to handle large quantities of lumber each day. After the defects are plugged, the lumber is stocked and the plastic allowed to dry. When hardened, the wood is re-run to pattern, or if the lumber is already finished, the filler portions are sanded to remove the surplus plastic material.

The advantages of being able to repair lumber with a material are many. Timber which was formerly considered worthless can now be salvaged, thus creating an appreciable increase in our lumber supply.

Several test made prove the rot resistance of the plastic had very encouraging results, These test were conducted by G. M. Hansen in the forestry and pathological laboratories of Oregon State College. One of the test was of wetting and drying over a period of 6 days using Douglas Fir boards 5/8" thick with ½" and 5/8" in dia. The holes filled with the plastic was still intact and unaffect by the water, although the wood had

had undergone severe shrinkage and swelling.

Another test encompassing 73 days subjected the plastic to the attack of wood rotting fungi. The decay was measured by relative weight losser. For comparison, wood filled with plastics, both wet-dry treated and untreated, and cubes of solid Douglas Fir and solid plastics were tested in the same manner. This was the test procedure:

1. The wood and plastic were dried to a weight of equilibrium in a vacuum desiccator; 2. Weight were recorded; 3. The wood and plastic were placed in jars of previously prepared thriving fungal cultures. 4. The fungi were allowed to work on the wood and plastic for 73 days. 5. The wood and plastics were again dried to a weight of equilibrium. 6. Weights were recorded. 7. The previous weights, as of(2), were compared with those of (6). In comparing results of treated with untreated plugged wood, it was evident that the wet-dry treatment had no effect upon losses by decay. The Douglas Fir was thoroughly rotted with great loss of weight, while the plastic showed very little weight loss, thus indicating

great rot resistance. Only when the wood becomes very rotten and shrunken does the plastics show cracks around the edges.

The commercial activity of this process is, at present, confined to use in the plant which developed the plastic. Keen interest has been shown in the process by lumber manufacturers from places as distant as Sweden and Australia.

B. RESIN BOARD

This experiment was conducted at the Oregon State College Chemical Research Labortory. They are using 5 to 30% resins with the remainder Douglas Fir wood flour as a filler to make plastic boards. They are using three different types of resins. They are as follows: The phenolic resins which is the strongest of the three, but cost the most to make. The urea formaldehyde which is the second strongest and cost less than the phenolic resins to make. The third one is the polystyrene resin. It is as strong as urea formaldehyde, but costs the least of the three. They use 80 mesh wood flour and together with the resin, mold this mixture under an average of 3,000 lbs. per sq. inch pressure. The temperature used in the molding process varies 100 degrees to 200 degrees. The maximum strength in the early experiments was about 70% of the strength of wood, but with later development in the process, this plastic became as strong as wood.

It cannot be expected to replace wood in all cases, nevertheless it has some qualities which will make it more desirable than wood for certain uses.

C. WOOD FLOUR PLASTER

This experiment is also being conducted at the Oregon State College Research Laboratory. Its main purpose is to use Douglas Fir wood flour, general the low grade, as a plaster over plywood or other walls for interior finishings in the homes. This plastic wood flour dries faster than plaster. It dries within 24 hours, whereas plaster takes more than a month. The cost is considerably less than that of plaster, averaging 10¢ per sq. yard of material, where plaster is from 60¢ to 75¢ per sq. yard.

The material that makes up this wood flour plaster is ethyl (ether) cellulose, alcohol, and gasoline is used in the mixture, because it will prevent the material from sticking, thus making it easy to spread. This new wood flour plaster will have a lower heat conductivity. It will not have moisture content that will decay the walls and inner walls of the house like plaster.

One disadvantage is the need to perfect some machine to spread this mixture in a smooth surface. If this difficulty can be overcome, the future of this plastic will find wide spread use in home construction.

Economic Factors

The utilization of wood waste need not be confined to the use of sawdust since hogged material from slabs, edgings, and wood waste can be successfully utilized as long as it is bark and dirt-free, not need the waste wood be dried before processing. Although coniferous woods usually produce a material with lower strengths than the hardwoods, proper modifications of these processes may make them equally suitable for this purpose.

In view of the present shortages of resins for molding compounds, it is very interesting to note that savings of up to 50% in resins content can be made by substituting hydrolyzed wood for the ordinary wood flour filler. That is, molding powders consisting of 25 to 30% phenolic resin with hydrolyzed wood, produce molding compounds comparable to general purpose powders containing 45 to 50% resin, with ordinary wood flour filler in respect to flow and strenght (8,000 to 13,000 pounds per sq. inch) and even superior to water resistance (0.2 to 0.3% water absorption, 48 hours immersion). Hydrolyzed wood is treated with diluted acid. Thus a substitution of hydrolyzed wood for unhydrolyzed wood flour could be the means of increasing the amount of molding powder that could be produced from a given amount of phenolic resin by 60 to 100% with no sacrifice in quality or molding characteristics.

Sawdust and other waste products from the lumber industry contain all of the ingredient necessary for making a filled plastics material.

Plastics made from waste wood products could be produced more cheaply than any other types.

Fully 75% of the wood flour manufactured in the United States is made from white pine, and the success of the wood flour industry will depend upon having a combination of first, sufficient raw material of the proper kind and, second, an abundant supply of cheap electric power for reducing the raw material to flour.

Wood flour might properly be considered as a by-product of the lumber industry, because over 60% of that produced is made from wood shavings and sawdust, but the sawmill or planing mill owner who is a prospective manufacture of this material should not labor under the impression that all of his sawdust, chips, and mill ends can be led through any type of grinder and be made to yield handsome profits. The several concerns which have successfully engaged in wood flour production have done so only by diligent attention to manufacturing details, which has resulted in their ability to produce grades of wood flour in every way equal to the European product. The successful producer of wood flour should study the most approved and efficient grinding methods.

Status Of The Wood Flour Industry

While there is an abundance of raw material for wood flour production, the relatively small consumption of that material and a rather slow market are factors that limit new enterprises in the wood flour field. The principal producers of wood flour have been in the business a long time and have succeeded chiefly because of their intimate knowledge of the industry and the exacting requirements of consumers. Other factors important to successful wood flour production are a large and continuous supply of suitable raw material, nearness to markets, and, of course, a good demand for wood flour at fair prices.

The uses of wood flour may be expected to increase and absorb larger quantities of stock in the future. They can hardly be expected, however, to develop sufficiently to afford a profitable outlet for more than a fraction of the wood flour that could be produced from wood waste. The potential supply of wood flour is much greater than the potential demand, and the dangers of excessive overproduction must be considered by those who might contemplate its manufacture.

PHENOLIC RESINS

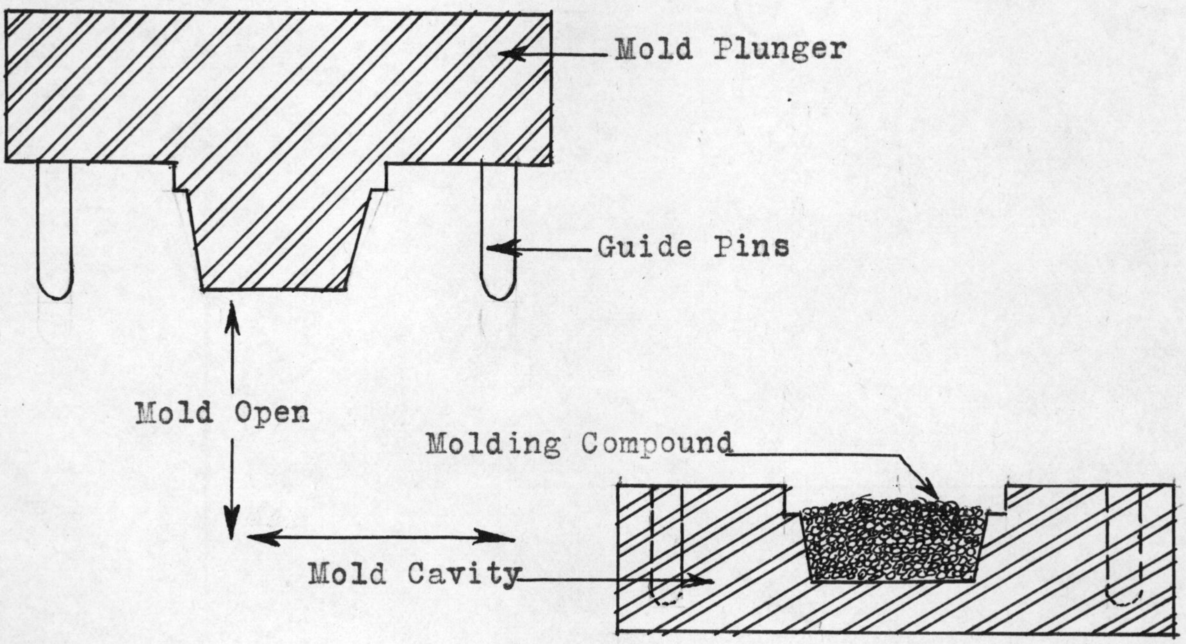
(Used With The Chart)

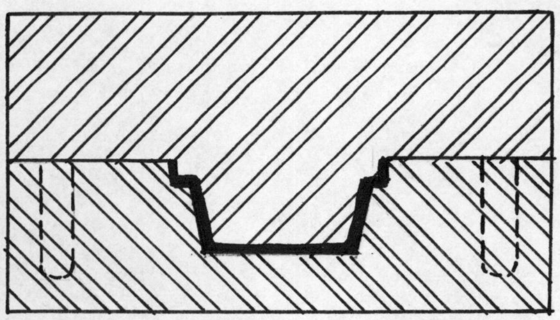
1. The basic raw materials for this resin are largely products of chemical synthesis.
2. Phenol, formaldehyde, and catalyst are weighed out in the desired proportion and are piped into the resins kettles or into the reservours above the kettles.
3. The phenol and formaldehyde combine in this kettle to form a still fusible resin, having about the consistency offmolasses. The agitator is mounted at the center of the vessel. Water formed during the reaction is removed under a vacuum.
4. On completion of the reaction, the liquid resin is drained into shallow containers for rapid cooling and hardening. The solidified resin is broken up into lumps and then ground to a powder.
5. Wood flour or other fillers and coloring materials are mixed with the resin on heated compounding rolls and the cure of the resin is advanced

to a stage at which it will harden rapidly in the mold.

6. The plastic mass is taken from the heated rolls and reground in huge grinding machines. The granular powder is passed over magnetic separators to remove any stray particles of metal. It is then shifted, blended with other batches to ensure a uniform product.
7. Phenolic resins are obtainable by the interaction of many different phenols, aldehydes, or ketones, and catalysts.

The Compression Molding Process



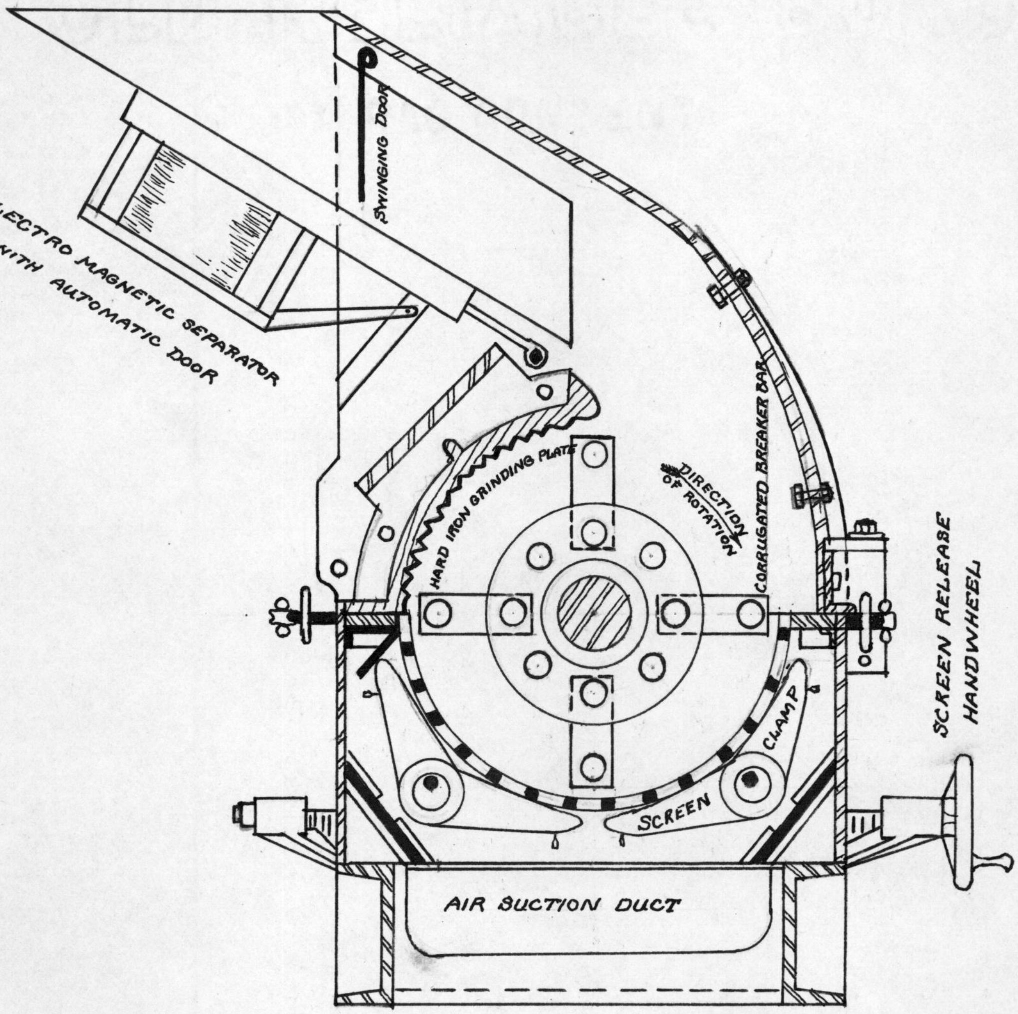


Mold Closed

When the mold is closed, the molding compound is compressed to the shape of the piece and held in this form until the material hardens.

HEAVY DUTY HAMMER MILL

The degree of finenessddesired for woodflour is more efficiently obtained through the use of this mill than with other types.



Showing The Effect Of Different Fillers On Phenolic Moldings

Property	Wood Flour (50%)	Asbestos (50%)	Mica (50%)	Wood Flour & Celite (Ea. 25%)
Specific gravity, Molded	135	175	210	149
Tensile strength, lb. per sq. inch.	8,000	5,000	7,000	7,000
	11,000	8,000	10,000	9,000
Compressive strength, lb. per sq. inch.	22,000	17,000	19,000	25,000
Flexural strength, lb. per sq. inch.	5,000	3,700	5,500	5,390
Impact strength, ft, lb.	2.00	1.49	1.35	1.65
Water absorption (In percent) 48hrs. immersion	0.82	0.24	0.055	0.55

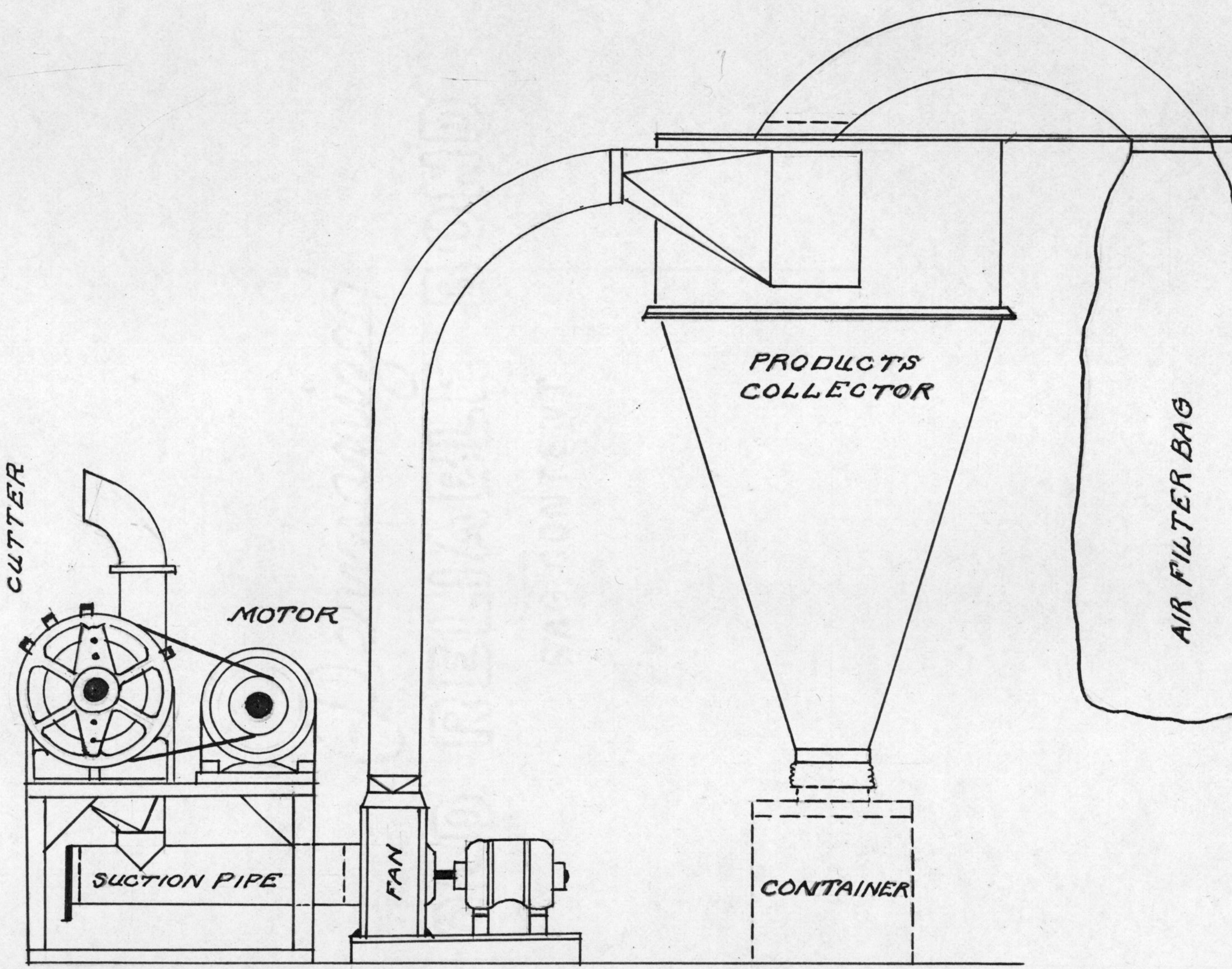
Simonds, R. S., Industrial Plastics, Pitman Publishing Corporation, New York, 1939.

Heat Resistance

(Top Operating Temperature)

	degrees F.
Phenolics (asbestos filler)	450-500
Furfurals (asbestos filler)	400-450
Phenolics (wood flour filler)	300-350
Furfurals (wood flour filler)	250-300
Acetates	200-225
Styrene	180-210
Casein	175-200
Acrylates	160-180
Vinyls	150-170
Ureas	150-160

Simonds, H. R., Industrial Plastics, Pitman Publishing Corporation, New York, 1939.



Cutter With Products Collecting
System

This is used in cutting wood waste materials into very fine products.

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