United States Patent Office

2,899,352

Patented Aug. 11, 1959

2,899,352

MANUFACTURE OF STRUCTURAL BOARD FROM RUMEN

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No Drawing. Application September 24, 1953
Serial No. 382,186

12 Claims. (Cl. 162—148)

The present invention relates generally to a new structural board and the manufacture thereof. More specifically, the present invention is directed to a structural board made from a bacterially treated material.

Many commercial wall boards have been manufactured from various fibrous raw materials including wood, straw, bagasse, waste paper, and the like. Processes developed successfully utilize waste lumber, paper, and the like, which are in scrap form and therefore considered to be of little value. In such processes a similarity is present in that the several steps which are taken are the same with only slight variations irrespective of the starting material utilized. The processes are normally begun with a step in which the basic raw material is comminuted. The only differences which may arise during the comminution step reside in the equipment utilized inasmuch as the nature of the raw material may require different types of equipment. For example, rough wood is usually first passed through a hog or chipper and thereby is comminuted into the desired starting size. Paper or paper-like material, when sterilized, is sometimes shredded or carded by suitable machinery. In many ways, but for the same purpose and with similar results, the various starting materials are comminuted to the correct size for the subsequent manufacture of a structural board having high strength per unit of weight so that it may be used structurally under circumstances where strength is required.

Following comminution, the basic raw material is subjected to a cooking or chemical treatment. This treatment is used normally to partially hydrolyze a portion of the cellulose fibers or lignocellulose material so that this portion may serve as a binder in the finished board. Another important function of this step is to remove the soluble impurities which are capable of imparting to the finished board undesirable properties. If the material is subjected to cooking, pressure cookers are normally utilized. By pressure-cooking the material, it is properly conditioned for subsequent treatment, and any raw material odors present are considerably reduced. One well-known process comprises high-pressure steam cooking, followed by a sudden release of the steam pressure, thereby effecting defibration and partial hydrolysis of the material.

In utilizing chemical treatment there are certain chemicals which are commonly known to be capable of bringing about the reduction of the raw material to fibers. Such chemicals are also utilized to catalyze desirable hydrolysis. Still other chemicals may be added to bring about deodorization and bleaching effects. One well-known and commonly used piece of machinery called the Asplund defibrator combines steaming and mechanical defibration. The chemicals which may be used along with the conditions under which proper cooking is obtained are all well known and are quite conventional.

Subsequent to the cooking or chemical treatment of the comminuted raw material, the resultant fibers are refined so as to separate fiber bundles into smaller bundles or individual fibers and forming therewith a slurry or suspension of these fibers. Various well-known methods of

comminution are utilized in the refining step. This comminution is carried out in such a manner so as to alleviate excessive destruction of the fiber length. Such refining is normally effected by various types of mechanical working. Well-known machines, such as the Jordan, Bauer, Hollander, or Niagara beaters or mills are of the type utilized as pulp beaters or pulp formers. This type of machine mills the fibers in water suspension so as to produce dilute suspensions or slurries of pulp suitable for felting.

Prior to the felting of the stock it is sometimes desirable to incorporate binders or other chemical additives therewith. Among these chemical additives are various thermosetting resins, starch, water-proofing materials, fire-proofing materials, and various insect and vermin repellents or poisons. Examples of the water-proofing materials which may be utilized are petrolatum, oils, waxes, and metal resinates. The fire-proofing materials may include sulphonates, phosphates, and the like. The types of additives aforementioned are used in order to produce a board of desired characteristics. For example, some sort of binder is necessary in order to hold the fibers in an orientated manner, while water-proofing materials are obviously needed when such structural boards are utilized in out-door constructions. Along this same line, the fire-proofing materials are necessities which provide a board of much greater utility. In the same category, protection from various insects and vermin is quite often considered necessary depending upon the various uses of the structural board.

The conventional felting step follows and is accomplished by placing a predetermined amount of pulp slurry, containing the desired additives, in a properly shaped container having a screened surface. Free water is drained off, either by gravity or by the utilization of a vacuum, and the dewatered fibers are collected in the form of a felt on the screen. The free water remaining in the felt is then usually removed as completely as possible by pressure rolls. This latter step may be accelerated by the use of a vacuum.

Upon preparation of the felts, the next step which is necessary in order to produce a structural board is the hot pressing of the felts under sufficient temperatures and pressures to produce a finished board. The formed felt may first be cold-pressed to remove free water, or may go directly to the hot-pressing operation. Hot pressing is ordinarily carried out at temperatures of from 300° to 600° F. and at pressures of from 300 to 2000 pounds per square inch. In hot-pressing a wet mat of fibers it is customary to use a wire screen on the surface of one press plate to provide means for the escape of free water during the initial pressing stage and, after this, to provide means for the escape of steam generated by the vaporization of the remaining moisture. This hot pressing treatment effectively removes all of the moisture and also sets the resin or other thermosetting binder. Various pressing cycles may be used depending upon such factors as temperature; pressure; use of none, one, or two screens; freeness of felt; degree of hydration of certain fibers; nature and amount of resin or other binder; and density or hardness desired. Pressures may vary widely during the pressing cycle depending upon the amount of breathing required to release steam from the press. Another variant which also determines the amount of pressure to be utilized is the desired density of the final board.

The structural board is substantially completed upon the cold and hot pressing of the felts. Certain finishing operations are necessary in order to produce the most desirable board. Such operations include trimming and humidification. The boards may also be tempered or sized after removal from the press if superior water resistance is desired. Usually, the sizing operation is carried out prior to the felting of the fibers. The common sequence followed in carrying out these operations involves first the restoration of the normal moisture level in the board after the removal of the board from the press. This normal moisture level runs approximately 6 percent and is that amount of moisture considered necessary in a fully conditioned structural board. The board may then be trimmed by saws in order to remove rough edges. Following this the board may be sized or tempered. The tempering comprises the submersion of the board in drying oils followed by baking so as to produce a hard, dense board having higher strength.

The total process including the many steps set forth above is commonly referred to as the wet process for hard board manufacture. There are numerous modifications that may be successfully applied. One of the more important variations is the dry process in which dry fibers are thoroughly mixed with dry additives, felted in dry form and hot-pressed without the addition of any appreciable moisture. An alternative process which may be followed involves coating the wet fibers with a synthetic resin binder, drying the fibers rapidly to prevent polymerization of the resin, dry-felting the fibers, and then subjecting the felt to hot pressing. Another variation is a combination of the wet and dry processes which comprises the preparation of a felt by the wet process, drying of the felt, and finally pressing the dry felt at elevated temperatures and pressures. In this process the ventilating screen is not used and the board produced has a smooth surface on both sides. All of the methods described are applicable in carrying out the present invention.

Structural board made from straw can be produced as outlined in the above methods but has the undesirable property of extreme susceptibility to moisture. As a result this disadvantage is usually compensated for by the incorporation of relatively large quantities of binders and water-proofing agents which negates the advantage of the low cost fibers used. Another disadvantage of straw, grass, hay, and cereal fibers as raw materials is the expense accompanying the collection and transportation of such materials to a central processing plant.

Among the objects of the present invention is the utilization of a substantially useless fibrous material in the production of a structural board having certain improved properties over those of presently made commercial structural boards.

Another object is to produce a highly desirable structural board from material which requires less mechanical preparation whose source is centrally and conveniently located, which is available in substantial tonnage, and whose initial cost and processing cost is considerably below such costs of currently made structural boards.

Still another object of the present invention is to make a structural board, the major component of which is a partially digested vegetable fiber from straw, grass, cereals, and other vegetable fibers.

Other objects not specifically set forth will become apparent from the following detailed description:

Generally, the invention comprises the production of a structural board which contains as an essential starting ingredient a particular type of material referred to as rumen.

It has been found that straw, hay, grass, and other such vegetables fiber raw material can be processed to yield an improved structural board having greatly increased resistance to water. A substantial portion of the processing of the aforementioned material may take place within the stomachs of ruminant animals, thereby providing an inexpensive system for concentrating large quantities of raw material at a large meat packing establishment or near a group of such establishments. Comminuted straw, hay, grasses, or other ligno-cellulose vegetable fibers, or pith (e.g., corn cobs and peanut shells) may be treated with organisms normally found in the paunch, rennet, and/or peck of such ruminant animals as cattle, sheep, calves, and goats. The contents of the various stomachs of ruminants are called rumen and provide a rich source of desirable organisms. In defining rumen, the definition should not be extended to include manure, as this material has been degraded to a point where it is no longer suitable for utilization in board manufacture. As the rumen contains large quantities of hay, straw, and the like, and as it has been ground and digested by the animal to the proper degree, it therefore provides excellent fibrous material for the manufacture of structural board. Further, the rumen obtained from slaughtered animals contains undigested comminuted grains which in the present process produce starch suitable as one of the binders. Rumen also differs from manure in that it provides no objectionable odor in the final board when processed according to the present invention.

The general analysis of rumen as obtained from the ruminant animal is as follows:

	Percent
Fat	2
Protein	5
Fiber	10
Water	83

The identity of all the countless micro-organisms found in rumen has not been fully accomplished, but numerous species have been identified. Among the identifiable species are:

(1) Flavo bacterium
(2) Clostridium, including anaerobic cellulolytic organisms such as
  (*a*) Thermophilic spore formers
  (*b*) Non-sporing rods
  (*c*) Cocci
  (*d*) Actinomycetes
(3) Bacteroides
(4) Micrococcus (*Ruminococcus flavefaciens*)
(5) Bacillus
(6) Streptococcus
(7) Amylobacter

Although laboratory cultures of such organisms can be utilized in the present invention, the expense of their culture and attainment of the desired concentration is prohibitive. On the other hand, the natural rumen, obtained as a waste product in meat packing operations, contains a rich source of such organisms in amounts which approach 10 percent of the total insoluble matter. As can be readily seen, the rumen not only is a source of excellent fibrous raw material but is also a source of the micro-organisms which function to produce a superior structural board.

In the practice of the present invention several different procedures may be followed, all of which make full utilization of the rumen micro-organisms. In one form of the procedures the rumen in its naturally occurring state may be removed from the paunch, peck, or rennet of animals and used alone or with binder or chemical additives in the production of a structural board. The rumen used in this manner may be in various stages of fermentation. This fermentation which occurs within the animals due to the presence of the micro-organisms may also occur following the removal of the rumen from the animals. When the action of the micro-organisms takes place upon removal from the animals, the pH of the rumen drops rapidly from 7 to approximately 5, where it remains constant. Further decomposition will occur if the micro-organisms are allowed to act over a substantial period of time. It has been found that rumen removed from the animal's paunch and placed in piles or suitable containers still function satisfactorily upon standing for 30 days. Similar samples were allowed to stand over six months and upon testing appeared to have fermented to a point where a chemical breakdown of the fibers was present and the fibers had little, if any, strength left. In view of this, it is preferred to use rumen as obtained from the animals or fermented stock which is under 40 days of age.

Another procedure has been found satisfactory wherein the rumen is mixed with other suitable fibrous stocks obtained from wood, grass, hay, straw, paper, cobs, peanut shells, and the like. When rumen is used in this manner it inoculates the stock and causes fermentation which eventually produces a raw material suitable for the purposes. In utilizing the inoculation procedure it is preferred that the inoculated material be subjected to fermentation for a period of from 24 hours to one week. In this procedure as in the aforementioned procedure the micro-organisms cause fermentation of the entire material and the pH drops from 7 to approximately 5 and thereafter remains constant. The action by the micro-organisms may be stimulated by the addition of nitrogen or phosphorous compounds.

Additional procedures which may be followed include the mixing of rumen with other comminuted fodder materials such as grass, hay, straw, canes, and so forth. The mixture is allowed to stand for a sufficient time to allow digestion and fermentation by the action of the micro-organisms. In a procedure such as this it may be necessary to add nutrients for optimum activity of the micro-organisms. Other suitable fibrous stocks such as that obtained from wood, paper, cobs, peanut shells, and the like may also be added.

Upon obtaining the fermented stock by one of the procedures set forth above, the stock may then be further refined by conventional mechanical grinding, followed by autoclaving sufficient to retard the fermentation and partially hydrolyze cereal grains and any other feed stuff present. In autoclaving it is preferred to utilize a time period of from 3 to 15 minutes and a steam pressure of approximately 60 pounds. The autoclaving time may be reduced where higher pressures are utilized, or may be increased under lower pressures dependent upon the circumstances. This autoclaving or cooking step completely eradicates the characteristic rumen odor and yields a product having the pleasant odor of ordinary wet hay. The cooking also accelerates the solution of undesirable components so that they are easily drained off, thereby producing at the felting stage a much more freely flowing stock. As a result, the felting time is considerably reduced.

The cooking or autoclaving step is not essential for the production of a satisfactory board from rumen. It has been found that a board containing many highly desirable properties may be made according to conventional practices excluding the cooking. Cooking is necessary when wood chips, straw, paper, etc., are added as these materials are comparatively hard and are composed of bonded fibers. It is necessary to release the fibers and soften them in order that they may be properly felted. When utilizing rumen, the fibers present have been acted upon sufficiently by the chewing action and digestive system of the ruminant so that felting may be satisfactorily accomplished without cooking. It is preferred, however, to cook, inasmuch as it simplifies the remaining steps. Where cooking is utilized it is normally carried out in a closed vessel, the desirable temperature range being approximately 200° to 300° F. and the time required as high as one hour.

No comminuting or grinding is necessary prior to cooking rumen or prior to any other step utilized to properly condition the material. Due to the grinding imparted by the ruminants' teeth and the action of the ruminants' digestive juices on the constituents of rumen, the fiber bundles present are comparatively short and the material is in a highly comminuted form when removed from the animal. This particular condition of the stock materially cuts down the processing necessary to produce a desirable structural board. However, subjecting the starting material to further mechanical refining does aid in the appearance of the finished board.

It has also been found that where the cooking step is utilized, the addition of sufficient alkaline reacting material is helpful. The reason for this is that it has been found advantageous to adjust the stock to an approximate neutrality (pH 7.0 to 7.5). A neutral stock is not absolutely necessary but it does facilitate the addition of resins and other binders, if desired, when these tend to precipitate under acidic conditions. Similarly, other additives may be incorporated during the cooking step in order to produce various desired degrees of hydrolysis, deodorization, bleaching, and so forth. Such additives are well known and the desirability of making use of them depends on the particular type of structural board desired.

Chemical treatment as normally practiced in commercial production of a structural board is not necessary where rumen is used as the major component in the stock. Generally, chemical treatment is utilized primarily to bring about the reduction of the raw material to fibers or fiber bundles. Rumen contains material in its fibrous state due to the reducing action brought about by grinding between the ruminants' teeth and by its digestive juices. The initial fibrous condition of rumen materially aids in reducing the cost of processing involved in the manufacture of a structural board.

The stock, either cooked or raw, may be subjected to a further refining step. If the stock has been cooked it may subsequently be mechanically refined with or without cooling. With a cooked stock wherein the fermentation is arrested, the stock may be stored for future use if so desired. On the other hand, where the fermentation is still in an active state, the material should be subjected to refining and subsequent operations within a reasonable time. The refining of the fibers is readily achieved by passing the stock through a Bauer mill which has been set to a clearance of from 2 to 50 thousandths of an inch, depending upon the fiber size desired. As the slurry of rumen pulp comes from the mill it is mixed, if desired, with other refined stocks such as those obtained from sawdust chips, scrap wood, paper, poultry feathers, scrap leather, and so forth. While the use of a Bauer mill is preferred, it has been found that satisfactory results are also obtained when a Jordan or a Hollander paper pulp beater is used. In instances where the stock contains a high percentage of hard material such as gravel, metal, minerals, or incompletely refined cobs, shells, and so forth, it should be mildly agitated so as to suspend the fibers and to allow the heavy particles to sink. The fibers may then be floated off and introduced into the Bauer mill for further processing. In instances where there is a very high fat content it is advisable to allow the washed refined stock to settle, thereby permitting the removal of the fat by skimming.

While it is preferred that the rumen stock be refined prior to felting, it is nevertheless not essential. The rumen stock in its natural form can be said to be in a refined state due to the grinding and digestive action which has occurred. The only necessary step prior to felting is the forming of a slurry. The comparatively short fiber bundles present and the comparative freedom of these bundles allows the ready formation of a slurry suitable for felting. Where refining is practiced, a more uniform board is obtained but in many instances such uniformity may not justify the use of the special treatment.

The refined pulped slurry, with or without other fibrous stocks, is then pumped to and mixed in a stock chest where other additives may be incorporated accompanied by adequate agitation. At this point binders, if desired, may also be incorporated. Well-known binders such as phenolic resins, casein, animal glue, and so forth, produce satisfactory results. At this point it is also desirable to incorporate additives known to impart improved moisture resistance. Such additives are alkaline silicates, metal resinates, fats, waxes, and petroleum waxes.

The pulp slurry, plus the desired additives, is then allowed to flow onto a screen where the water drains off, producing a felt of the desired thickness and size. Normally, gravity draining is all that is necessary and is preferred. In order to remove more free water, the felt is then given a cold pressing as by squeezing between rolls. Cold pressing is not essential but is considered desirable as it saves steam consumption in the hot press. The hot pressing is preferably carried out at temperatures of from 250° to 400° F. and under pressures of from 100 to 300 p.s.i. An alternative procedure consists in partially drying the cold pressed felt and ultimately subjecting the partially dried felt to hot pressing at higher temperatures and pressures.

Hot pressing may be carried out in a number of stages to permit the escape of steam and other gases. The use of ventilating screens on one or both sides of the felt during pressing also facilitates the escapes of steam. The resultant board coming from the press is bone dry. Normally it is desirable to condition the board in a humidity room so as to increase the moisture content to approximately 6 percent. Following conditioning, the board is trimmed to remove rough edges and then sized or tempered by submersion in a drying oil and baking in accordance with standard practice.

An alternate procedure which may be followed and thereby alleviate the humidity conditioning step is that in which a laminated board is produced by the use of aqueous adhesive. Upon subjecting the laminated board to pressure for purposes of bonding the laminations, the humidification of the laminations is carried out simultaneously, the dry boards gaining moisture from the aqueous adhesive.

The following examples are set forth as illustrative only of the present invention and are not to be consrued as limiting thereto:

EXAMPLE I

The following ingredients were utilized:

3100 grams rumen (wet) fermented 11 days
54 gram sawdust

The rumen was beaten first and then subjected to flotation whereby the fibers were floated and the undesirable constituents were settled. The fibers and sawdust were then beaten in a mechanical pulp beater for 7 minutes and a felt was made. The felt was first cold-pressed to remove excess liquid, and then hot-pressed on a screen at 365° F., using the following cycle:

(1) 0 to 100 p.s.i. in 3 minutes
(2) 100 to 200 p.s.i. in 1 minute
(3) Held under 200 p.s.i. for 12 minutes

The properties of the resultant board appear in Table I.

EXAMPLE II

The following ingredients were utilized:

60% paunch stock (rumen aged 3 days)
10% chrome savings
10% waste paper
10% chicken feathers
10% peanut shells

1600 grams of stock was diluted with 3500 grams of water which resulted approximately in a 4 percent solids slurry. The mixture was beaten in a Hollander beater until the desired reduction of the paper shavings, feathers, and shells was accomplished. The refined stock was then felted in a felting box on a 30 mesh screen. Following felting, the wet felt was removed and hot-pressed on a screen at 200 p.s.i. within the temperature range of 380°–390° F. The resulting board was room conditioned for 24 hours, after which it was humidified at a 65 percent relative humidity for 24 hours.

The properties of a board prepared in this manner are listed in Table I.

EXAMPLE III

The following ingredients were utilized:

60% wet rumen (dry basis) fermented 3 days
10% chrome shavings
10% waste paper
10% feathers
10% peanut shells

A composite stock was formed and was Hollandered for 15 minutes. The stock was then neutralized with sodium carbonate (pH 7.5) after which 3 percent of phenolic resin was stirred in. The resin was precipitated by adding zinc chloride in sufficient amount to lower the pH to within the range of from 6 to 6.5. The slurry was felted and cold-pressed, followed by hot pressing on a screen at 390° F. and 200 p.s.i. for 20 minutes.

The properties are listed in Table I.

EXAMPLE IV

Composite stock of the same composition as that shown in Example III, with the exception that the period of fermentation of the rumen was carried out for 34 days and the rumen was rolled to crush any cereal grains present, was treated with 3 percent of phenolic resin of a 10 percent solution and thoroughly mixed. The resin was precipitated on the fibers by lowering the pH to approximately 6.0 with zinc chloride. The slurry was then felted, cold-pressed, and then hot-pressed on a screen at 375° F. and 200 p.s.i. for 20 minutes.

The properties of such a board are shown in Table I.

EXAMPLE V

Composite stock of the same composition as that shown in Example II, with the exception that the period of fermentation of the rumen was carried out for 3 days, was treated with 1½ percent of phenolic resin prior to felting. The pH of the refined stock was adjusted to a pH of approximately 7.5 to 8 with sodium bicarbonate. To the adjusted solution was added a water solution of the resin. The slurry was then thoroughly mixed and the resin was precipitated on the fibers with zinc chloride. The final pH was adjusted to approximately 6.0–6.5. The stock was then felted, after which it was hot-pressed at 100 p.s.i. for 20 minutes under temperature conditions within the range of 380°–390° F. The formed board was then room conditioned and humidified as set forth above.

The resultant properties are listed in Table I.

EXAMPLE VI

Composite stock of the same composition as that shown in Example II, with the exception that the period of fermentation of the rumen was carried out for 3 days, was treated with 3 percent of phenolic resin prior to felting. The pH of the slurry was controlled in the same manner as set forth in Example V and the binder precipitated as set forth therein. The stock was then felted and hot-pressed at 100 p.s.i. for 20 minutes under a temperature within the range of 380°–390° F. The resultant board was then room conditioned and humidified as set forth above.

The resultant properties of such a board are shown in Table I.

Table I

Example	I	II	III	IV	V	VI
Weight	0.88	-------	0.69	1.01	-------	-------
Specific gravity	0.89	-------	0.84	0.94	-------	-------
Thickness	0.192	0.165	0.160	0.207	0.176	0.221
Maximum load	91	70	55	86	71	111.5
Modulus of rupture	4,950	5,100	4,250	4,000	4,630	4,610
Percent weight increase by absorption	29	41.8	43	24	46.8	42.6
Percent thickness increase by absorption	20	22	14	18	21.4	12.5

The weight of the specimens set forth in Table I is expressed in pounds per square foot. The thickness was measured in inches, and the maximum loads were determined by cross-bending specimens 3 inches wide and using a 4-inch span. The modulus of rupture is expressed in pounds per square inch. The last two values in Table I labeled "Percent weight increase" and "Percent thickness increase" were compiled by measuring the percent weight increase caused by the absorption of water in each specimen and the percent thickness increase caused by the absorption of water in each specimen. In both instances the water-soaking was maintained over a period of 24 hours.

As can be seen from Table I, the properties of boards prepared as set forth in the examples are excellent. The maximum loads which such boards sustain per unit of weight compare favorably with those of structural boards commercially known. The modulus of rupture shown by these boards also compares favorably. The boards so formed are certainly equivalent, if not superior, to currently known commercial boards.

The boards produced as described provide an advantage in that they create a use for material heretofore considered absolutely worthless. Not only has this material been considered worthless but its disposal has been a constant problem in the packing industry. Many advantages of the rumen board have been shown but it should be pointed out that an even greater advantage is also present. The water-resistant qualities of boards made from rumen is clearly established by the figures of Table I. As can be seen from this table, the percent weight increase caused by water absorption is comparatively small, and the percent thickness increase is practically negligible. Structural boards made of straw, etc., by conventional procedures are highly absorbent and, due to this property, have been in many cases unsatisfactory for many purposes where contact with moisture is necessary. As a result, the conventional boards must be waterproofed with expensive waterproofing materials so as to produce an all-purpose board. The wide use of structural board for building purposes has dictated the requirement that the structural boards used have such properties as to withstand weather conditions with which building materials are normally subjected. Not only has the use of large amounts of waterproofing increased the cost of structural boards, but it has also increased the weight thereof, and, as a result, has limited somewhat its utility. As can be seen from Table I, structural boards made principally from rumen display a high natural water-resistant property, and it therefore follows that the amount of waterproofing material necessary to provide a structural board even more water repellent is greatly reduced. Due to this feature the cost of the board is reduced, the extent of treatment involved in manufacture is greatly reduced, and a lighter-weight board having all of the necessary and desirable properties of structural board is formed.

It should also be noted that little, if any, binding agents are necessary in the production of a structural board in which the principal ingredient is rumen. Example I sets forth the production of a board in which the only ingredients utilized are wet rumen and sawdust. As can be seen from the properties of this board, the absence of a binding agent does not materially alter the properties of the finished product. A very substantial and desirable board can be made without the use of additional agents, such as binding agents. This represents another feature of a board made from rumen whereby the expense and labor necessary to produce such a board is materially altered.

The highly desirable properties present in structural boards made from rumen cannot be readily explained. On the basis of the knowledge gained by the hardboard industry from years of experimentation it has generally been conceded that the length of fibers obtained from the various stocks has much to do with the ultimate attainment of desirable properties in the finished board. It has generally been considered that a very desirable stock is that which produces comparatively long fibers and fiber bundles. This has been believed to be necessary in that the strength of the board is substantially dependent on the intertwining or interlacing of the fibers. Rumen, on the other hand, is made up of comparatively short fiber bundles and, therefore, by accepted standards would not normally be considered a proper source material.

Along with the short fiber characteristic of rumen there are other factors which would not ordinarily be considered capable of lending themselves advantageously to the formation of a highly desirable and improved board. The source material which goes into the make-up of rumen consists of such things as grass, hay, oats, etc. Such material contains many components which would normally be considered harmful to the end result of structural board manufacture. Hard joints on the stems of straw where the kernels are attached would normally represent a problem in board manufacture, yet seems to have little effect when present in rumen. The diet of the ruminant varies throughout the year and the rumen collected is non-uniform when analyzed from time to time. Yet the non-uniformity does not appear harmful to the resultant properties of a rumen structural board. The corn which appears in the rumen at certain times in the year seems to have little adverse effect. Fat is quite often found to be present and would normally be considered extremely undesirable. However, small amounts of fat do not appear to have a detrimental effect on rumen boards. While the properties of the boards may vary slightly, the range of variance is only slight and the overall range of properties is well within or above the ranges of acceptability. Such slight variances cannot clearly be traced to the non-uniformity of the stock and, therefore, can be explained adequately as due to production procedures. Such variances are highly prevalent and constantly present in the industry even where standardized stocks are utilized.

Rumen boards have shown strength properties which are comparable to or are better than those of commercial hardboards made today. Yet when using rumen as an essential ingredient the procedure followed in producing a board may be materially altered. As stated above, comminution, cooking, and refining are not absolutely necessary. In many instances, dependent on the composition of the stock, there is no need for them. Boards made of rumen are pressed at pressures ranging from 100 to 300 p.s.i. in contrast to 500 to 750 p.s.i. for conventional hard board manufacture. With this difference in mind it is readily apparent that a material savings in equipment, time, and operational costs may be realized, while a superior board is the resultant product.

In the use of phenolic resin as a binder it has been found that from 1 to 5 percent resin gives desirable results. The resin may be added as an aqueous solution at a pH above 7.0 and then precipitated with the addition of sufficient acid to bring the pH down to below 6.5. It may be desirable to utilize certain acids which not only precipitate the binder but also act on the fibers. Such an acid, for example, is oxalic acid which also serves as a bleaching agent. Other binders give satisfactory results also. Among these are starch and animal glue. When starch it used it may be added directly in its pure form or may be added in situ by comminution of amylaceous cereal grains present in the rumen. Normally, from 1 to 10 percent starch has been found desirable. With respect to animal glue it has also been found that the desirable percentage range is approximately 1 to 10 percent. The glue may be added and then precipitated with formaldehyde or the like. Another method consists in adding from 1 to 10 percent collagenous material which is in pulp form and which has been previously cured so as to yield animal glue with or without formaldehyde when heat or pressure is applied.

Obviously, many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

We claim:

1. In the production of a structural board, wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of stock, said stock including as a major ingredient thereof rumen; felting the said stock whereby a mat of fiber bundles is formed, said mat being suitable for compressing; and thereafter pressing said felted mat under pressures not exceeding 300 pounds per square inch.

2. In the production of a structural board, wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of stock, said stock including as a major ingredient thereof rumen, felting the said stock whereby a mat of fiber bundles is formed, said mat being suitable for compressing; and thereafter hot pressing said felted mat under a pressure within the range of from 100–300 pounds per square inch.

3. In the production of a structural board, wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of stock, said stock including as a major ingredient thereof rumen, felting the said stock whereby a mat of fiber bundles is formed, said mat being suitable for compressing; cold-pressing said felted mat to remove a substantial quantity of liquid therefrom and thereafter hot-pressing said cold-pressed mat under pressures not exceeding 300 pounds per square inch.

4. In the production of a structural board, wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of fibrous stock having rumen incorporated therein, refining said slurry and thereby removing unwanted foreign material therefrom, treating said refined slurry with an alkali to adjust the pH of said slurry above 7.0; adding to said treated slurry a small amount of phenolic resin causing said resin to precipitate upon said fibrous stock by reducing the pH of said slurry below the value of 6.5; felting said fibrous stock to form a mat suitable for compressing and thereafter pressing at a pressure within the range of from 100–300 pounds per square inch and conditioning the fibrous stock whereby a commercial hard board having desirable strength and moisture resistant properties is formed.

5. In the production of a structural board wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of fibrous stock having rumen incorporated therein; refining said slurry and thereby removing unwanted foreign material therefrom; adding starch to said slurry in sufficient amounts to act as a binder therein; felting said slurry to form a mat suitable for compressing and thereafter pressing at a pressure not exceeding 300 pounds per square inch and conditioning the material whereby a commercial hard board having desirable strength and moisture resistant properties is formed.

6. In the production of a structural board wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of fibrous stock having rumen incorporated therein; refining said slurry and thereby removing unwanted foreign material therefrom; adding cured collagenous material in pulp form to said slurry; felting said slurry to form a mat suitable for compressing and thereafter pressing at a pressure not exceeding 300 pounds per square inch and conditioning said mat whereby a commercial hard board having desirable strength and moisture resistance properties is formed.

7. In the production of a structural board wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of fibrous stock having rumen incorporated therein; refining said slurry and thereby removing unwanted foreign material therefrom; adding a comparatively small quantity of animal glue to said slurry followed by the addition of formaldehyde to precipitate said glue on the fibers; felting the slurry to form a mat suitable for compressing and thereafter pressing at a pressure not exceeding 300 pounds per square inch and conditioning said mat whereby a commercial hard board having desirable strength and moisture resistance properties is formed.

8. In the production of a structural board wherein rumen is utilized as a major ingredient thereof, the method which comprises: forming a slurry of fibrous stock which contains as ingredients thereof rumen and a small portion of comminuted amylaceous cereal grains; felting the said stock whereby a mat of fiber bundles is formed, said mat being suitable for compressing; and thereafter pressing said felted mat under pressures not exceeding 300 pounds per square inch.

9. In the production of a structural board wherein rumen is utilized as a major ingredient thereof, the method which consists of forming a slurry of fibrous stock which contains rumen as an ingredient thereof; refining said slurry and thereby removing foreign matter therefrom; introducing into said stock binders and other chemicals whereby the resultant properties of the finished board are controlled; felting said stock to form a mat suitable for compressing and thereafter pressing at a pressure not exceeding 300 pounds per square inch and conditioning said stock whereby a commercial hard board having desirable strength and moisture resistance properties is formed.

10. A method of producing a structural board which comprises fermenting rumen removed from the paunch of cattle to a pH of 5 and for a period not to exceed 40 days, forming an aqueous slurry containing said rumen as a principal ingredient, felting said slurry whereby a fibrous mat is formed, and hot pressing the fibrous mat at a pressure not exceeding 300 pounds per square inch.

11. A method of producing a structural board comprising fermenting a mixture of cattle rumen and other fibrous material to a pH of 5, said mixture containing said cattle rumen as a major ingredient thereof, forming an aqueous slurry of said mixture, felting said slurry whereby a fibrous mat is formed, and hot pressing the fibrous mat at a pressure not exceeding 300 pounds per square inch.

12. The product of the process as described in claim 1.

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