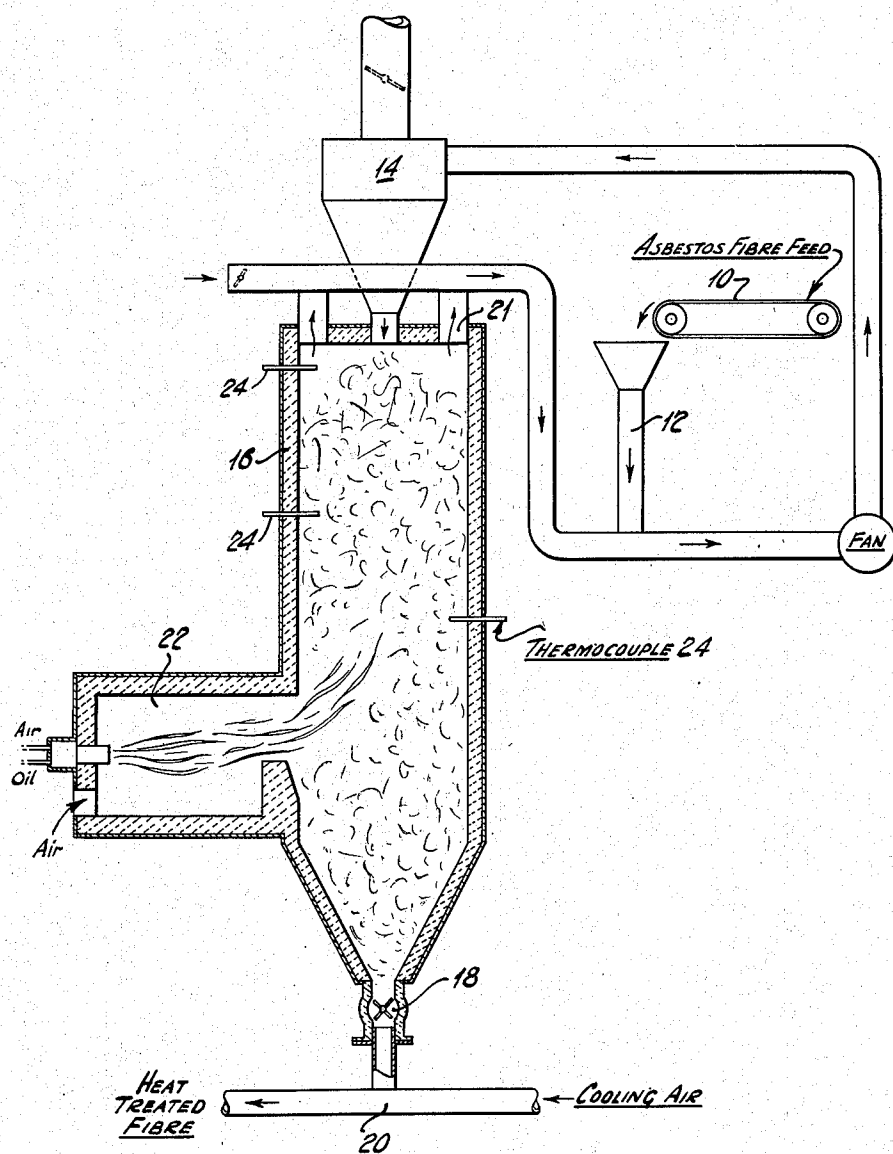


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FIBER AND METHOD OF MAKING
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PARTIALLY DEHYDRATED CHRYSOTILE
FIBER AND METHOD OF MAKING

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This invention relates to water-laid asbestos fiber sheets, and is particularly directed to a method of improving chrysotile asbestos fibers to better adapt such fibers for producing sheets and other products by an operation involving deposition of the fibers from an aqueous suspension thereof, accompanied by separation of water by filtration.

The present application is a continuation in part of our copending U. S. patent application, Serial No. 620,388, filed October 4, 1945, for Treatment of Asbestos Fibers, now abandoned; and of our earlier abandoned U. S. patent application Serial No. 536,420, filed May 19, 1944, for Manufacture of Water-Laid Asbestos Sheets.

A substantial proportion of the total production of asbestos fibers consists of chrysotile asbestos, which is largely employed for the manufacture of water-laid and felted asbestos fiber sheets such as paper or millboard, and as a reinforcing fiber in asbestos-cement sheets and in other bonded asbestos reinforced products. Crude chrysotile asbestos fiber consists of bundles or aggregates of very fine individual fibrous crystals. After separation of the crude fiber from adhering dust, rock and gangue, the fiber is usually subjected to willowing and refining treatment designed to open up the fiber bundles and to produce finer fiber aggregates or filaments, while avoiding substantial disintegration or shortening of the fibers. In the manufacture of paper and other water-laid sheets, the willowed and refined fibers are subjected to the action of a beater engine whereby they are further broken down both longitudinally and transversely into finer fibrous aggregates of shorter length. During such opening and refining operations the ends of the crystal aggregates are shattered or frayed to develop a great number of minute hair-like fibrous filaments. These fiberizing treatments improve the felting characteristics of the fibers and thereby improve the strength of sheets produced by the wet process sheeting operation. A primary object of the present invention is to so treat the fibers as to further improve them for manufacture of water-laid sheets and shapes.

One of the chief difficulties which is encountered in the formation of water-laid asbestos fiber sheets is in the comparative slowness with which water separates from the sheet by filtration as the sheet is being formed. The slow filtering rate of such water-laid felted fibers materially reduces the speed of operation of the sheet forming process.

A particular object is to provide a method of

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treating asbestos fibers to improve their freeness or filtering properties to better adapt them for a wet process sheet forming operation.

Various methods have been heretofore proposed for treating asbestos fibers to improve such fibers for a particular purpose. In general such methods have had a serious adverse effect on the strength or felting characteristics of the fibers. Any treatment of the fibers which tends to impart brittleness thereto, or which increases their tendency to form agglomerates or flocks in water suspension, has an adverse effect on the use of the fibers for wet process sheet manufacture by reducing the possibility of forming a uniformly felted fiber sheet of suitable strength and of uniform fine texture.

Another object is to provide a method of increasing the free filtering characteristics of asbestos fibers without substantial adverse effect on the tensile strength and felting characteristics of the fibers.

With the above objects in view the invention consists in the improved method of treating asbestos fibers to impart freeness thereto which is hereinafter described and more particularly defined by the accompanying claims.

In the accompanying description reference will be made to the attached drawing, in which the single figure portrays in vertical section, with parts in elevation, a shaft furnace which may be used for flash heating chrysotile asbestos fibers in accordance with this invention.

Asbestos fibers of the chrysotile type which give the most difficulty in paper and sheet forming operations because of slow filtering characteristics, develop a slimy surface coating when wet. The invention is based on the discovery that such fibers of slimy and slow filtering characteristics can be converted by a moderate and short heat treatment into fibers of comparatively much improved filtering characteristics having no tendency to become slimy when wet. During the heat treatment, the crystal filaments forming the core of a chrysotile fiber bundle or aggregate retain substantially their original composition and structure, while the outer shell or surface layers of the fiber lose some water of crystallization and any associated incrustations of magnesium hydrate are converted to substantially anhydrous magnesium oxide. The invention contemplates specific limitations as to temperature and duration of the heat treatment whereby it is possible to develop a high proportional increase in the filtering rate or freeness without substantial re-

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duction of tensile strength and felting properties of the fibers.

The invention has general application to the treatment of chrysotile asbestos fibers to enhance their filtering characteristics for use in the manufacture of water-laid felted fiber sheet products. The process has particular utility for treating the shorter commercial grades of chrysotile asbestos fibers ranging as to size classification over groups 3-7, including floats, in accordance with the Standard Quebec Screen Classification Scale.

The process consists essentially of subjecting the fibers to brief heat treatment whereby the fibers are heated to a temperature in the range 600°-1200° F. and are then cooled after being heated at such temperature for a period not exceeding three minutes. By careful control of the temperature and time of heat treatment the filterability of the fibers can be greatly improved without serious adverse effect on the strength and felting properties of the fiber.

The freeness or filterability of chrysotile asbestos fibers is improved by raising the fiber surfaces to temperatures in the range between 600°-700° F. and 900° F., and maintaining the fiber at such temperatures for about three minutes. As little as five to ten seconds exposure of a chrysotile fiber to direct contact with hot gases at gas temperatures in the range of 1200°-1500° F. has the effect of markedly reducing the water of crystallization at the fiber surfaces and improving the filtering characteristics. Any heating of the fibers at a fiber temperature above 1200° F. for more than three minutes has a serious adverse effect on the tensile strength and felting properties of the fiber.

One method of carrying out the heat treatment is by loading the loose fibers at room temperature in a layer of 1-3 inch thickness on a conveyor belt, and transporting the fibers at a controlled rate through the combustion chamber section of a drying oven in which the gas temperatures are maintained within the range of about 900°-1500° F. The fibers are heated within the chamber for a short period, and are then removed from the chamber for quick cooling to avoid the harmful effects of prolonged exposure to the high temperature gases. This particular method of heat treating the fibers is not the preferred method because of non-uniformity of heat transfer between the heating gases and fibers throughout the full depth of the bed of fibers.

It is difficult to effect uniform controlled heating of asbestos fibers by exposing them in a layer or deep bed to hot gases flowing over or around the bed. Some time is required to preheat the fibers from room temperature up to the temperature of the hot gases. Furthermore, the rate of heat transfer between hot gases and fiber surfaces varies with the temperature differential between the gases and the fibers, and with the relative rates of movement of gas and fibers, and is much more rapid at the surface of a deep layer of fibers than it is in the interior of the layer.

According to another heating method a body of commercial chrysotile fibers is introduced through a fluff box onto the surface of an endless conveyor, while advancing the conveyor at a rate controlled to build up a bed of the fibers several inches thick. The fibers are well opened and fluffed during their passage through the fluff box, and the layer of fibers on the conveyor is compressed by a press roll to a mat. The mat of fibers thus formed is transferred to the surface

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of an endless asbestos fabric conveyor which carries the fibers through a dielectric heating field between electrodes of a radio frequency electromagnetic heater. Using a heater having electrodes with a heating area of 2 ft. x 6 ft., and with the conveyor travelling at a speed of 1.65 ft. per minute, a bed of fibers weighing 20 lbs. was exposed to the heating field for a period of about 3.5 minutes. This method of heating rapidly raises the fibers throughout the bed from a temperature of 50° F. to 600°-900° F. Immediately after the fibers have been exposed to the electro-magnetic field for not to substantially exceed three minutes at the indicated temperature, the fibers are transferred from the asbestos conveyor to a pneumatic conveyor by means of which the heat treated fibers are transported to a collector and simultaneously cooled by the air which serves as the carrier medium.

The freeness or filterability of fibers thus heated was improved as much as 90-95%, while the water of crystallization was reduced only about 10% from an original average value of about 13½%, to 12-12½%. The tensile strength of the fibers was not lowered more than 25% by the heat treatment. The heat treatment is usually applied to fibers containing not to exceed about 2% by weight of uncombined or surface moisture. The heating operation is controlled as to time and temperature to effect a large increase in fiber freeness while avoiding substantial loss of fiber strength and felting properties.

A very satisfactory method of carrying out the heat treatment is to project or drop the fibers in loose form into a flowing stream of hot gas, in such a way as to expose each individual fiber to direct hot gas contact for a short heating period, followed by removal of the fibers from the heating gas stream, and rapid cooling. This method is easy to control to secure uniformity of heat treatment, because it is possible to develop a substantially uniform period of contact of each fiber with the hot gas, and to provide for a substantially uniform rate of heat transfer between the hot gas and the fibers.

As shown in the attached drawing, chrysotile fibers can be continuously fed at a controlled rate by feeder belt 10 and chute 12 into a carrier stream of recycled hot combustion gases which impart some degree of preheat to the fibers, after which the gas suspended fibers enter a cyclone separator 14 and are projected downwardly therefrom in gas suspension into and through a rising stream of hot combustion gases in a vertical shaft 16 having smooth walls. The fibers fall by gravity countercurrently to the upwardly moving gas, and the thus heat treated fibers are finally discharged from the base of the chimney through a rotary sealing valve 18 into a carrier stream of cooling air moving through a pipe 20 at substantially atmospheric temperature. The hot gas exits from the top of the shaft through offtakes 21 and at least part of this gas is recycled as carrier gas for transporting more fiber to the top of the shaft. It has been found possible to effect substantial improvement in the freeness or filterability of the fibers without serious reduction in water of crystallization and tensile strength, when the fibers are in contact with the hot gases in shaft 16 at maximum gas temperatures between 900°-1500° F., for periods ranging between five and thirty seconds. During such short period of contact of the fibers with the hot gases at such temperatures (as measured by thermocouples), the temperature of the fiber is raised

to about 600°-1200° F., as determined by calorimeter. With the temperature of the gases entering the shaft from a combustion chamber 22 at 1200°-1500° F., and with the temperature of the fibers leaving the base of the chimney at about 900°-1200° F., satisfactory improvement of the freeness of the fiber is effected when the time of heat treatment within the shaft is as short as five seconds. Under these conditions the freeness is improved by as much as 90-100% with not to exceed 15% loss of molecular water and not to exceed 20% drop in fiber tensile strength.

The degree of improvement of filterability of the chrysotile fibers is directly proportional to the temperature and time of heat treatment. The strength of the fibers is adversely effected by prolonged heating at temperatures at which the filtering characteristics are substantially improved. Consequently there are optimum ranges of temperature and heating times which develop satisfactory improvement in the filtering characteristics of the fibers without serious adverse effect on the strength and felting characteristics. An optimum improvement in filterability of as much as 90-100% can be effected without reducing the reinforcing strength and felting characteristics of the fibers by more than 25%, by heating the fibers at actual fiber temperatures averaging 700°-900° F. for periods of time which are so short (less than three minutes) as to prevent a loss of combined water in excess of 20%.

When using hot gases as the heating medium, good flash heating results are obtained when the temperature of the hot gas which contacts the fiber is about 200° to 300° F. higher than the desired maximum temperature to which the fiber is heated. Whereas in high frequency electromagnetic heating the fibers may be heated to a temperature of say 900° F. by a heater which is set to develop this same temperature, a hot gas contact flash heater is advantageously operated with hot gases averaging 1000°-1200° F. when it is desired to develop actual fiber temperatures of 700°-900° F. Under these conditions the heating of the fibers proceeds at a satisfactory rate, and it is possible to limit the total period of heating within the range five seconds to thirty seconds, during which the fiber temperature is raised from room temperature, or from a preheat temperature not exceeding about 400° F., to the indicated maximum temperature.

The following operations were carried out in a flash heating shaft furnace 16 having an overall height of 26 ft. and an internal diameter of 7 ft. Hot combustion gases enter the stack from combustion chamber 22 at one side thereof at a point about 6 ft. from the base of the stack. The effective heating length of the stack is, therefore, about 20 ft. The combustion gases rise within the stack at a velocity of about 1 ft. per second, and fibers were fed to the top of the stack continuously at feed rates of 1-2 tons per hour. Thermocouples 24 are disposed at intervals throughout the length of the stack, and calorimeter measurements were made at frequent intervals of the actual temperatures of fibers withdrawn from the base of the stack.

When operating with a maximum gas temperature of about 950° F. at a point in the stack of about 1-2 feet above the level at which combustion gases enter the stack, and feeding fibers to the stack at the rate of two tons per hour, the fibers were in contact with the hot gases within the stack for a period of about five seconds, and were heated to a maximum fiber temperature of

approximately 650° F. The thus treated fibers developed a freeness or filterability improvement of about 30%-50%, with a loss in tensile strength of only about 2 to 3%. Operating at the same rate of fiber feed with a maximum gas temperature of 1035° F. and maximum fiber temperature of approximately 732° F., an improvement in freeness or filterability of 67% was obtained with about 5% reduction of fiber tensile strength. Operating at the same feed rate with a maximum gas temperature of 1110° F., the fibers were heated to a temperature of about 800° F. and developed about 80% improvement in filterability with approximately 3% drop in tensile strength. With the same feed rate at a gas temperature of 1303° F. at the same position in the stack, the actual fiber temperature was about 1000° F. and the improvement in filterability was about 95%, with about 15% loss of tensile strength.

The improvement in freeness or filterability was determined by comparative filtration rate determinations on felted fiber sheets formed by using heat-treated and non-heat-treated fibers. The tensile strengths of some of the heat treated fibers were determined by actual strength measurements, in comparison with tensile strengths of equivalent fibers before heat treatment. Comparative tensile strength and fiber felting property determinations were also made by making up sample sheets of paper incorporating the heat-treated fibers, and testing said sheets for strength in comparison with similar sheets made up with non-heat-treated chrysotile of the same grade.

As illustrating the effect of heat treatment on the speed of manufacture of water-laid asbestos-cement sheets and on the properties of sheets so formed, a body of chrysotile asbestos fibers of suitable short fiber grade was divided into two batches. One batch of the fibers was heat treated in a bed for a period of about three minutes by contact with heating gas at a temperature of 1200° F. The batch of thus heat treated fibers was incorporated with finely divided Portland cement in a conventional asbestos-cement aqueous slurry containing cement and asbestos fibers in approximately the ratio of 3:1 by weight. The batch of untreated fibers was likewise made up into a slurry of similar composition. The slurries so formed were allowed to flow onto filtering beds of a sheet forming press, and the ram of the press was actuated to express from the fiber sheets thus formed a major proportion of the water by filtration through the felted fibers and a supporting screen, under relatively low initially applied pressure. Comparison of the initial dewatering rate of the sheet incorporating heat treated asbestos fibers, with the dewatering rate of the corresponding sheet made with the same relative proportion of untreated fibers by conditions otherwise the same, demonstrated an increase of about 75% in the initial dewatering rate and filterability of the sheet formed with heat treated fibers.

Sheets thus formed were compressed under pressures of the order of 2000 lbs. to the square inch, and the dense products thus formed were then cured to develop a hardening set. The resulting cured sheets were then subjected to transverse strength tests, and such tests demonstrated that the strengths of the sheets incorporating the heat treated asbestos fibers were at least 75-85% of the strengths of the corresponding

sheets embodying conventional non-heat-treated fibers.

Filtration rate tests were also made by sheeting out asbestos fibers from an aqueous furnish on a screen filter employing a light vacuum as a means of developing a pre-determined low pressure differential on opposite faces of the wet asbestos fiber sheet. Comparative filtration rate measurements thus made demonstrated that a filter sheet made from a unit weight of fibers heat-treated by contact with hot gas at 1200° F. for a period of about three minutes allows a unit weight of water to filter therethrough at a rate which is 75%-95% faster than the rate at which the same amount of water filters through a sheet of conventional non-heat-treated fibers. Another good way of determining comparative filterability is by measuring the pressures required to force a definite volume of water through a filter sheet of unit fiber content at a constant rate. The improvement in filterability of a sheet product incorporating the heat-treated fibers is marked even when such sheet contains binder materials such as Portland cement or starch, or when the sheet contains comparatively high proportions of wood fibers or non-heat-treated chrysotile fibers admixed with 20-75% by weight of heat treated chrysotile fibers.

Canadian #1 crude chrysotile asbestos fiber has an average tensile strength of about 130,000 lbs./sq. in. After one of these fibers had been exposed for three minutes to a temperature of 800° F. in a high frequency electro-magnetic heating field, and then rapidly cooled, its tensile strength was found to have dropped by about 20% and its cross-sectional area had increased somewhat. The actual increase in the cross-section of the fiber which results from a short period of heat treating is accompanied by a substantial increase in the total surface area of the fiber. The heat treatment yields a fiber which is more open and of increased freeness or filterability, and which has greater absorptive power and lower density. The heat treatment effects some release of molecular water, which causes a surface rupture of the individual fibrils, and these fibrils increase the surface area and impart a roughened surface to the fiber. Although this increase in surface area is small for any single fiber, it is magnified greatly in a given fiber mass. Therefore, the resulting fiber mass is springy and releases water rapidly during the wet filtration operation.

The effect of heat when applied to chrysotile asbestos is to first reduce uncombined surface moisture and to thereafter release chemically bound water of crystallization. If the temperatures and time of heating are excessive, the fiber is completely dehydrated and the molecules rupture to form magnesium silicate and silica. It is important for the objectives of the present invention to limit the heat treatment to temperature and time limits within which satisfactory improvement of freeness is obtained with not to exceed 20-25% loss of molecular water and tensile strength.

The invention which has been thus described

by detailed example is not limited as to such details and it is to be understood that variations, changes and modifications are contemplated within the scope of the invention as defined by the following claims.

What we claim is:

1. The method of treating chrysotile asbestos fibers to improve the filtering properties thereof which comprises, heating the fibers up to a temperature of 600-1200° F., maintaining the fibers at such temperature for a period of between five seconds and three minutes, and cooling the thus heated fibers.

2. The method of treating chrysotile asbestos fibers to improve the filtering properties thereof which comprises, heating the individual fibers to a temperature within the range 600-900° F., limiting the period of heating of the fibers at such temperatures to about three minutes, and cooling the thus treated fibers.

3. A process of heat treating chrysotile asbestos fibers to improve the filtering properties thereof which comprises, forming a suspension of the fibers in a flowing stream of hot gas at gas temperatures ranging from 900-1500° F., removing the fibers from the hot gas stream after a period of contact with the gas of between five seconds and ½ minute, and rapidly cooling the thus heated fibers.

4. A process of treating chrysotile asbestos fibers to enhance the filtering properties thereof which comprises, heating the individual fibers by contact with a flowing stream of hot dry gases at gas temperatures in the range 900-1500° F., limiting the time of exposure of a fiber to such temperature within a period of five seconds to ½ minute, and rapidly cooling the thus treated fibers.

5. Heat treated chrysotile asbestos fibers having the properties obtained by heating chrysotile fibers in accordance with the process of claim 1.

6. Heat treated chrysotile asbestos fibers having the properties obtained by heating chrysotile fibers in accordance with the process of claim 3.

7. Heat treated chrysotile asbestos fibers having the properties obtained by heating chrysotile fibers in accordance with the process of claim 4.

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