SPLICED COATED ABRASIVE BELT

INVENTOR.
ROBERT N. HOWARD

BY

ATTORNEYS
This invention relates to endless coated abrasive belts, and it particularly relates to a novel splice therefor.

For many years coated abrasive belts have been made by joining together the two ends of an elongated strip of coated abrasive sheet material. The most common splice in commercial use today is the so-called "lap" splice, where one belt end is lapped over and adhered to the other belt end, the abrasive granules having first been removed from at least one portion of the lapped ends. No matter what variation in grinding technique or adhesives may be employed, such splices are always somewhat stiffer than the rest of the belt, a condition which both predisposes them to failure by delamination when they are placed around small contact rolls and causes a bump or chatter in many abrading operations. Such belts are recommended for running in only one direction to minimize the chance of snagging the upper layer of the splice.

Another means of joining coated abrasive belt ends is the so-called "butt" splice. In this type of splice the belt ends are abuttingly juxtaposed and a uniting means employed to hold them in this arrangement. Such a uniting means may be a thin piece of linen, a piece of material similar to the belt backing, or the like, adhered to the back of the belt ends in the area immediately adjacent the line of abutment. Although such belts can be run in either direction, they suffer from the other disadvantages inherent in lap splices.

Attempts have been made to improve the butt splice; for example, Miller and Riedesel U.S. Patent No. 2,391,731 discloses a butt splice in which the uniting means is a stranded material, such as wire screen, which is physically forced into the backing adjacent the edges of the butt ends. This product, although forming a smooth uniform caliper splice which is outstanding in a large number of abrading operations, tends to fail by fatigue of the stranded material when the belt is driven around a small contact wheel or flexed sharply. U.S. Patent No. 2,733,181 discloses a butt splice in which grooves or slots parallel to the length of the belt are formed in the juxtaposed belt ends, many fine strong linearly aligned filaments being forced into the grooves from the back and held in place by an adhesive. This splice is fatigue-resistant and versatile when properly made, but rigorous control of temperature, humidity, and depth of grooving is necessary during its formation to avoid flaking off of the mineral layer during heavy duty sanding operations; further, the many lengthwise grooves may form the starting points for longitudinal splits. Like its predecessors, this splice is substantially denser than the remainder of the belt, and sometimes "hinges" at either the line of abutment or one of the outboard edges of the splice, often when being mounted on an abrading machine.

I have now devised a novel splice for the butt-joining of coated abrasive belt ends to provide a belt which runs equally well in either direction. This splice is extremely easy to fabricate, lending itself to the use of automatic machinery, and is essentially universal in the coated abrasive materials to which it can be applied. The splice may be made of substantially the same thickness, density and flexibility as the remainder of the belt, and it is essentially free from the problems of hinging and bumping which have been characteristic of prior splices. It can be entrained over small or extremely soft contact wheels with-out delaminating, splitting, or premature sand loss at the splice area. Other advantages of the invention will become apparent as the description proceeds.

In the formation of my novel splice, two coated abrasive belt ends which are to be spliced are juxtaposed and a splicing strip of a composition to be described hereinafter firmly adhered in place. Tapering of the belt ends may be accomplished by scuffing the backing with a coarse grit grinding wheel or coated abrasive. The splicing strip is a composite sheet comprising a multiplicity of lineally aligned strong, tough, synthetic filaments, a thin, strong, tough, tear-resistant non-woven mat formed from randomly disposed synthetic fibers, and a film-forming adhesive which, during the process of being heat-cured, passes first through a fluid stage and then quickly hardens to a heat-resistant water-resistant state. The splice is formed by adhering the reinforcing strip to the tapered belt ends in a heated splicing press, the heat causing the resinous material to flow between the belt ends and at least partially to overlie the abrasive-coated surface.

My invention will be better understood by referring to the attached drawing which is a view in perspective of a splice formed according to my invention.

In the drawing juxtaposed belt ends 10 and 10a, comprising backing 11 coated with mineral particles 12 and adhesive 13 are shown tapered and juxtaposed, the tapered ends defining a hollowed out space which is occupied by strong, thin, tear-resistant backup strip 14, which in turn is made up of a randomly laid mat 15 of oriented fibers 16, a multiplicity of lineally aligned strong synthetic fibers 17, and a film forming resinous material 18. The longitudinal tensile strength of backup strip 14 when separately formed and cured is preferably such that it exceeds the corresponding lengthwise tensile strength of the belt ends 10 and 10a. Random mat 15 reduces any tendency to lengthwise or crosswise narrowing which might occur in unsupported abrading operations and/or when the workpiece is sharp or irregular.

It will be observed from the drawing that the resinous material 18 extends between the belt ends, despite the fact that they are in substantial contact throughout their line of abutment, unifying the belt ends, reducing the opportunity for accidentally gouging or lifting the trailing belt end during abrading operations, minimizing any tendency to "hinge" or gap at the line of abutment, and greatly enhancing the strength of the finished splice. The effectiveness of this construction is particularly surprising in view of Riedesel's teaching that reinforcing filaments should penetrate the backing and lie as close to the abrasive surface of the belt as possible. Since it is difficult to tell whether the resin has flowed only between the closely positioned belt ends, it has been found convenient to note whether the resin extends slightly over the abrasive coated surface in the area immediately adjacent the belt ends. The resin in this location serves to indicate the degree of success obtained in having the resin flow between the belt ends. Microscopic examination of splices exhibiting suitable resin flow reveals that the resin/fiber ratio is higher along the line of abutment 19 than at the outer edges 20 of the splice; it is believed that this readjustment may render more gradual the transition from the body of the belt to the splice during abrading operations, insure firm adhesion between the belt ends, and hence contribute to the life of the belt.

This invention has proved equally successful in splicing paper-backed, film-backed, or cloth-backed coated abrasive belts. For purposes of illustration but not of limitation, the invention will now be described with respect to an example in which the belt is fabricated from abrasive sheet material having an impregnated cloth base.
3,154,897

EXAMPLE

Preparation of Splicing Sheet Material

A 2-ply non-woven mat having a thickness of .004" to .005" and weighing about 20 grains per 24 square inches was formed on a garnett machine from a blend of equal parts by weight of 8-denier 1/4-inch undrawn staple polyethylene terephthalate fibers having a melting point of about 400°F. and 15-denier 1/4-inch semi-dull polyethylene terephthalate fibers having a melting point of about 500°F. The mat was unifed by passing it over a hot roll at a temperature sufficient to fuse the 8-denier fibers, the tensile strength of the finished mat being about 20 lbs. per inch of width in the machine direction and about 10 lbs. per inch of width in the cross direction. Tear-resistance was excellent.

To the random mat just described was now continuously laminated a large number of linearly aligned yarns of multi-filament tensilized preshrunk nylon. Each yarn was made up of 30 7-denier filaments, 50 yarns being applied per inch of width. Other fine, strong, tough filaments such as "Dacron" polyethylene terephthalate or "Orlon" acrylic polymer may be used in place of the nylon. The laminating adhesive was a resins composition consisting of a blend of approximately equal weights of polyvinyl butyral such as "Vinyline XY50" and a heat-adhesive formaldehyde resin compatible therewith and having a phenol:formaldehyde molar ratio of 5:9, dissolved in ethylene glycol monomethyl ether to a solids content of 27-30%. Lamination was effected by positioning the nylon yarns above the random mat and passing both under a roller while simultaneously applying about 75 grains (wet) of the laminating adhesive per 24 square inches. The composite structure was then passed through a 20 ft. long drying tunnel maintained at 225-250°F. at a rate of about 5 ft. per minute, after which it was sufficiently tack-free to be wound into a roll. At this point, the condition of the resin was such that it existed as a readily deformable self-supporting film which upon being subjected to heat and pressure exhibited extensive flow characteristics but which was capable of being quickly cured to a tough hardened condition. The composite product weighed about 52 grains per 24 square inches.

A sample of the composite splicing sheet was heated for 30 minutes at 200°F. and thereafter cured by being pressed between heated platens maintained at 350°F. and 2,000 lbs. per square inch pressure for 30 seconds. Upon being removed the strip was found to have a tensile strength parallel to the direction of the nylon filaments of about 150 lbs. per inch of width.

Scuffing and Tapering the Belt Stock

A 50-yard roll of 4-inch wide Grade 120 aluminum oxide coated abrasive belt stock, having a glue- and starch-filled drill cloth backing and a phenolic resin bond adhesive, was marked at 84-inch intervals with a 45° line extending across the belt. The thickness of the cloth backing was about 0.015 inch, while the overall thickness of the coated abrasive belt stock was about 0.029 inch. At each of the markings scuffing was now accomplished in the following manner:

A 1/2-inch x 5-inch Grade 46 aluminum oxide grinding wheel was adjustably positioned above a rigid steel plate and driven at 1,800 surface feet per minute. The belt stock was placed with the mineral side in contact with the steel plate and held firmly against the grinding wheel so that the axis of the wheel was at right angles to the edge of the steel. The wheel was then urged against the backing of the belt stock to be scuffed, so as to remove in a shallow double-tapered groove approximately 0.003 inch of cloth along the 1/2-inch of the marked line and a gradually decreasing amount up to 1/8-inch on each side of the line. The grinding wheel was repeatedly laterally repositioned so as to remove 0.003 inch of material along the entire line to be scuffed. A scuffed but unjoined 84-inch x 4-inch belt was now fabricated by severing the belt stock along the mid-point of two adjacent grooves.

Splicing of the Scuffed Belt Ends

The splicing sheet material was now cut at 45° to the linearly aligned nylon filaments to form 1/4" x 45° parallelogram-shaped splicing strips in which the nylon fibers were approximately 1/2-inch long. The belt ends were next positioned, abrasive side up, over a rigid steel plate coated with polytetrafluoroethylene, and a splicing strip centered under the line of abutment with the linearly aligned fibers parallel to the length of the belt strip and in contact with the back surface thereof. A strip of unsized canvas cloth was then laid over the abrasive side, again covering the line of abutment. The entire assembly was then placed in a conventional coated abrasive splicing press having platens heated to 350°F. The bars were closed and contact pressure applied for 5 seconds, after which the pressure was increased to approximately 2,000 lbs. per square inch for 25 seconds. The spliced belt was then removed from the press and the excess splicing strip trimmed from the sides of the belt. Visual observation revealed that the resin had flowed between belt ends and juxtaposed edges of the abrasives for about 3/4-inch on each side of the line of abutment. The caliper of the splice was found to be .029 inch, the same thickness as the rest of the belt. The splice felt slightly stiffer than the remainder of the belt but upon being gently manipulated by hand it softened and could not be tactilely distinguished therefrom.

Performance of Spliced Belt

Three 1" x 45" Grade 150 aluminum oxide belts having a glue- and starch-filled backing and a phenolic resin bond and sandsize were prepared in accordance with the preceding example and subjected to a test simulating the sanding of blades for jet engines. In this test the belt was entrained over a 9/8-inch diameter roller and driven at 2,240 surface feet per minute. The 9/8" roller was then used to support the belt while a section of cold rolled steel bar stock having a 1/4" x 7 3/4" cross section was urged against it, the 7 3/4" dimension extending at right angles to the direction of belt travel, under a total force of 4 1/2 lbs. The three belts averaged a total running time of 6 1/2 minutes before failure by separation of one belt end from the splicing strip and subsequent breakage. Splices made in the same way with the same splicing film, the only difference being that the belt ends were slotted as taught in Riedesel U.S. Patent No. 2,733,181, performed equally well and failed in the same way. Belts spliced according to Miller and Riedesel U.S. Patent No. 2,591,731, however, failed after only 1/2 minutes, the wire screen fatigue and breaking across the splice at the middle thereof. Belts made with the best commercially available overlap splice failed by delamination after two minutes.

A 3" x 4" Grade 60 aluminum oxide belt made in accordance with this example was used in a test simulating the sanding off of gates on castings. In this test, the belt was entrained over an 80-durometer serrated rubber wheel, having a diameter of 8 inches with 3/16" wide lands alternating with 3/16" wide grooves, while the edge of a cold-rolled steel ring 1/8-inch thick and 9 inches in diameter was positioned beneath the belt at a force of 15 lbs. In this test the belt functioned successfully for 7 minutes and removed 142 grams of metal before falling by sand loss at the splice. A splice prepared according to Riedesel 2,733,181, i.e., where the belt ends were slotted and a film substantially identical to the one employed in the splice of this example forced therein, showed severe sand loss at the splice and in the 7 3/4" minute after running and failing by wearing a hole through the backing at the
splice in less than 4 minutes after cutting only 88 grams of metal. It is thus apparent that the novel splice of the present invention is not only easy to make but also extremely versatile. I have successfully built a factory line on any known coated abrasive sheet material from which belts are fabricated, including paper, cloth, polymeric films, nonwoven mats, and the like, certain recommendations may be profitably observed. For example, paper belts, which are somewhat less compressible than cloth belts, should probably be scuffed deeper than the otherwise identical cloth product if caliper control is of great significance. Caliper control is ordinarily not critical for Grade 60 or coarser grits, but, on the other hand, adhesion of the splicing strip to coarse grit belts is of increased significance. Accordingly, I find it generally desirable to scuff all grits prior to splicing belts. Where, however, increased density of the splice area and/or decreased adhesion is not a deterring factor, the hollowed out area may be created in effect by compressing the splicing backing strip into the portion of the belt ends immediately adjacent the line of abutment.

3,154,897

1

Adhesion between the belt ends themselves, as well as between the belt ends and the splicing strip, and consequently belt performance, can be still further improved by priming with flexible, heat-resistant, water-resistant polymers which can be applied from a highly penetrating low viscosity solution and thereafter cured to form an adhesive thermostetting resin, e.g., polyurethanes, bis-amide polyesters, epoxy polyamides, bis-ketenes, di-acrylates, styrene-polyesters, and the like.

A preferred priming procedure involves coating the belt ends with a 200:9 polyester urethane:trisocyanate blend (solids basis) and allowing the blend to penetrate and dry to a tacky condition (about 10 minutes), after which splicing is effected as previously indicated. A suitable polyester urethane may be prepared by reacting at 75° C. for 18 hours 1,000 parts of dry hydroxy-terminated ethylene glycol adipate of molecular weight 2,000 with 87 parts of toluene diisocyanate. A suitable trisocyanate is the reaction product of 3 mols of toluene diisocyanate and 1 mol of trimethylene diisocyanate in ethyl acetate to a solids content of 75%. Grade 150 aluminum oxide belts primed in this way before joining showed no signs of failure after 17 minutes of sanding on the simulated jet blade test previously described.

Care should be exercised in scuffing cloth belts, preferably with other types of backing, to avoid excessive scuffing, e.g., deeper than half the thickness of the backing. The reason lies in the fact that, although many of the woof yarns of the cloth may be removed without serious impairment of the splice, excessive removal of the warp yarns tends to result in a product which is subject to all belts under operating conditions. The method of scuffing parallel to the warp yarns as disclosed in the preceding example, minimizes injury to them.

The technique of scuffing the belt stock before cutting it into belt strips is convenient and readily controllable. It also minimizes the number of preparation steps required and allows itself to automatic or semi-automatic operations. Where desired, however, the strip may be cut to size and the ends thereafter scuffed individually.

In addition to the polyvinylbutyral:phenol formaldehyde resin disclosed in the preceding example, various other adhesives may prove suitable. Among these are phenolic-aldehyde and polyvinyl butyral resins, polyamide and phenol-aldehyde resins, polyamide and epoxy resins, polyester-isocyanate resins, and polyamide-resorcinol phenol aldehyde resins.

Having disclosed my invention with the aid of a detailed illustrative example, what I claim is:

1. A spliced strip of flexible abrasive-coated sheet material comprising a backing sheet having first and second surfaces and abrasive grains firmly affixed to the first surface thereof by a binder adhesive, and having a joint uniting two complementary abuttingly juxtaposed ends, the sheet material immediately adjacent each of said ends being contoured in such a manner that said first surface is essentially undisturbed and that said second surface is tapered toward each of said ends to define a single hollowed-out space across the entire width of said strip, said space being occupied by a thin, strong flexible tear-resistant composite backup strip, said strip comprising a layer of strong synthetic fibers at least a substantial number of which extend across the line of abutment and lie generally crosswise of the belt, and a layer of fine strong synthetic fibers aligned parallel to the length of the belt, said layers being impregnated and firmly adhered to each other and to said ends by a flexible cured, hardened film-forming material extending between and firmly adhered to said ends.

2. An endless belt of flexible abrasive-coated sheet material comprising a backing sheet having first and second surfaces and abrasive grains firmly affixed to the first surface thereof by a binder adhesive, and having a joint uniting two complementary abuttingly juxtaposed ends, the sheet material immediately adjacent each of said ends being contoured in such a manner that said first surface is essentially undisturbed and that said second surface is tapered toward each of said ends to define a single hollowed-out space across the entire width of said strip, said space being occupied by a thin, strong flexible tear-resistant composite backup strip, said strip comprising a layer of strong synthetic fibers at least a substantial number of which extend across the line of abutment and lie generally crosswise of the belt and other fine strong synthetic fibers aligned parallel to the length of the belt, said fibers being impregnated and firmly adhered to each other and to said ends by a flexible cured, hardened film-forming material extending between and firmly adhered to said ends.

3. An endless belt of flexible abrasive-coated sheet material comprising a backing sheet having first and second surfaces and abrasive grains firmly affixed to the first surface thereof by a binder adhesive, and having a joint uniting two complementary abuttingly juxtaposed ends, the sheet material immediately adjacent each of said ends being contoured in such a manner that said first surface is essentially undisturbed and that said second surface is tapered toward each of said ends to define a single hollowed-out space across the entire width of said strip, said space being occupied by a thin, strong flexible tear-resistant composite backup strip, said strip comprising a layer of strong synthetic fibers at least a substantial number of which extend across the line of abutment and lie generally crosswise of the belt and other fine strong synthetic fibers aligned parallel to the length of the belt, said layers being impregnated and firmly adhered to each other and to said ends by a flexible cured, hardened film-forming material extending between and firmly adhered to said ends.

4. The method of preparing an endless belt from a roll of flexible coated abrasive sheet material including the steps of cutting a strip of the desired length, tapering the back of said strip immediately adjacent each of the ends thereof and across the entire width thereof with an abrasive grinder driven in the same direction as the long dimension of said strip, abuttingly juxtaposing the tapered ends, positioning in the single hollowed-out space defined by the juxtaposed ends a composite splicing strip comprising a layer of nonwoven randomly disposed fine strong tough synthetic fibers and a layer of fine strong
lineally aligned synthetic fibers, said layers being impregnated and united by a flexible, precurable, readily deformable film-forming resinous composition which flows readily under heat and pressure and which is quickly curable to a hard heat-resistant water-resistant condition, said splicing strip being disposed with said lineally aligned fibers extending parallel to the length of the belt, placing the positioned splicing strip and belt ends in a heated splicing press, and applying heat and pressure to cause said resinous composition to flow between said belt ends and thereafter harden, thereby firmly uniting said belt ends to each other and to said splicing strip.

5. The method of preparing an endless belt from a roll of flexible coated abrasive sheet material including the steps of cutting a strip of the desired length, tapering the back of said strip immediately adjacent each of the ends thereof and across the entire width thereof with an abrasive grinder driven in the same direction as the long dimension of said strip, abuttingly juxtaposing the tapered ends, positioning in the single hollowed-out space defined by the juxtaposed ends a composite splicing strip comprising a layer of nonwoven randomly disposed fine strong tough synthetic fibers and a layer of fine strong lineally aligned synthetic fibers, said layers being impregnated and united by a flexible, precurable, readily deformable film-forming resinous composition which flows readily under heat and pressure and which is quickly curable to a hard heat-resistant water-resistant condition, said splicing strip being disposed with said lineally aligned fibers extending parallel to the length of the belt, applying a priming layer to one of the strips between the splicing strip and tapered ends, placing the positioned splicing strip and belt ends in a heated splicing press, and applying heat and pressure to cause said resinous composition to flow between said belt ends and thereafter harden, thereby firmly uniting said belt ends to each other and to said splicing strip.

References Cited in the file of this patent

UNITED STATES PATENTS

299,747 Coy ------------ June 3, 1884
756,220 Elston ------------- Apr. 5, 1904
2,189,734 Cherrington --------- Feb. 13, 1940
2,733,181 Reidesel ------------ Jan. 31, 1956