PROCESS OF DYING COTTON FIBERS WITH INDOGO VAT DYES
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This invention relates to the treatment of cotton fibers or cotton warp yarns with indigo dyestuff and to the method of continuously applying hot indigo initially as a bottom dye and the continuous application of a cold indigo dye as a topping dye to obtain superior color intensity and penetration.

The application of indigo dyes to cotton and particularly to denim is quite well known in the dye art. However, heretofore in the continuous dyeing systems for cotton warp yarns it has been conventional to employ a series of vats including an initial vat for boil off and another vat for rinsing with subsequent vats of cold indigo dye being utilized with the number of dips varying according to the depth of shade and to the concentration of the vat. A larger number of dips in weak vats yields faster dyeings than less dips in strong vats with the cotton yarn being immersed in the vat for a period sufficient for the liquor to penetrate the fiber after which the material or yarn, after squeezing, is aired or skyed through the atmosphere for reoxidation and color development. The airing or skyed between dips in cold indigo vats as well as dips in cold water after the dips in indigo will usually increase the rate of oxidation or reoxidation of the indigo ultimately to obtain the desired share or color intensity.

Penetration of cold indigo dyestuff has been found to be limited severely as exemplified in denim fabrics that have been subjected to abrasion tests revealing that the core or inner portion of the fibers of the cotton yarn do not absorb uniformly the dyestuff as the penetration into the inner fibers or core of the yarn is apparently limited whether due to the lack of dye penetration or for the reason that the superficial penetration precludes or serves as a filter against further or increased indigo penetration. This feature is exemplified by the considerably lighter shade in the interior of the cotton yarn that is subjected to abrasion testing. Therefore, various processes have been attempted to achieve more efficient or increased dye penetration to obtain not only the desired shade but also increased penetration of the fibers so that upon wear the lack of dye penetration into the depth of the yarns will not exhibit non-uniform color penetration and that the white core will not "grin" through the surrounding colored yarn or fibers.

The present invention has as one of its objectives the application of a continuous process for applying hot indigo dyes for maximum yarn penetration as a bottom dye and thereafter subjecting the yarns to a cold indigo solution as a top dye to obtain the desired dye penetration, achieve ultimate shade or color intensification and penetration.

Another objective of this invention is to obtain increased indigo penetration of cotton fibers by utilizing a continuous dyeing system in which hot indigo is employed as a bottom dye through a series of hot dips in a continuous path of travel of the yarns and then subjecting the hot indigo dipped yarns to a series of cold indigo dips with intermediate airing or skyed for oxidation and reoxidation.

Still another objective of this invention is to provide a process and product in which a hot bottom indigo dye is applied to cotton fibers for increased dye penetration to achieve fast color fabric characteristics and a top cold indigo dye for optimum color intensification.

Yet another objective of this invention is to apply a continuous dye system method in which a series of hot indigo dye baths are utilized to achieve increased dye penetration followed by a series of cold indigo dye bath dips applied at temperatures of less than 100 degrees F. to obtain optimum color intensification and penetration of the cotton fibers.

Other objectives and many of the attendant advantages of this invention for producing a penetrated vat dye indigo will become more readily apparent to those skilled in the fabric dyeing art from the following detailed description taken in conjunction with one illustration of an apparatus which is schematically illustrated for employing this invention, and wherein:

FIGS. 1A, 1B, and 1C are schematic or diagrammatic illustrations, in sections followed sequentially, of one system of apparatus employing the process of this invention for producing a cotton warp yarn having increased dye penetration and color intensity.

Briefly, the process employed for obtaining greater indigo dye penetration to cotton warp yarns may be utilized with conventional apparatus presently being employed and includes the introduction of the cotton yarns that are traveling continuously through a series of hot-indigo-dye vats that are maintained at temperatures varying from the first vat of 150 degrees F. down to a vat at approximately 120 degrees F. which will be within the range for applying the hot indigo to the continuously traveling yarns. Thereafter, the yarns may be introduced directly into a series of cold indigo vats arranged in series and maintained at a temperature of 100 degrees F. or less with the number of dips varying and depending upon the ultimate color intensity desired. Airing or skyed between the hot indigo last dip and the introduction of the yarn to the first cold dip is a matter of choice but it has been found desirable to employ skyed between successive cold dips to achieve the desired shade. After exiting from the last cold dip of indigo in a standard or normal charge, a series of cold rinses will be employed followed by a dip into a vat containing a suitable softener before the continuous yarns are dried by passing them over heated revolving drums maintained at a temperature of approximately 225 degrees F. to 240 degrees F.

Referring to the drawings and particularly to FIG. 1A, there is illustrated schematically a flow diagram for cotton warp yarn 10 that may be unwound from warping wheel 11 wound on a beam with the yarn passing over roller 12 and guide rolls 13 with an intermediate compensating roll 14 guiding the yarns into the first hot indigo bath 15 con-
tained within the vat or tank 16. The bath 15 is a charge of indigo dye stuff preferably maintained at a temperature of 160 degrees F. constituting the first dye bath to which the yarns are subjected. If desirable, a suitable boil off be given to the yarns prior to entering the vat or tank 16 before the yarns enter the first dye box 16 as is conventional practice although it has been found that very satisfactory results have been achieved without the use of the conventional boil off and rinse boxes. As the yarns leave the first dye box 16, a pair of squeeze rolls 17 are rotatably mounted at the exit of the dye box 16 to remove excess liquor from the traveling yarns which are subjected to a continuous pressure from the rolls before the yarns are introduced into the next dye box 18 in which there is a second charge of hot indigo 19 that may be maintained at a temperature of approximately 140 degrees F. The yarns will travel continuously through the second dye box 19 by following a circuitous path of travel, in the same manner as in the first dye box 16 guided by the lower guide rolls 20 and upper guide rolls 21 before passing to the pair of squeeze rolls 22 mounted for rotation at the exit end of the second dye box 18 for removing excess liquor and returning it into the dye bath 19. The yarns will continue to travel and pass into the third dye box 23 in which there is also a charge of hot indigo similar to or substantially similar to the dye charge in the dye boxes 16 and 18 with the dye solution 24 being maintained at a temperature of approximately 120 degrees F. The yarns will travel continuously through the dye box 23 guided by the rolls 20 and 21 before exiting or leaving the dye box 23 with the yarns passing between the squeeze rolls 25 for removing excess dye solution from the yarns and returning the solution into the dye bath 24.

In the embodiment illustrated in FIG. 1A, a series of rollers 27 and 28 guides the yarn from the hot indigo dye bath to the series of cold indigo dye baths permitting an intermediate stage for airing or skying, however, this intermediate stage may be eliminated entirely and the continuously traveling yarns may pass directly from the squeeze rolls 25 mounted on the dye box 23 into the first cold indigo dye bath 29 contained within the dye box 30. The yarns will be guided in their continuous flow with in the dye box 30 by means of the rotatably mounted rollers 31 and 32 that are horizontally spaced from each other and vertically spaced to form a circuitous path of travel for the yarn in a horizontal flight and in a vertical path through the dye box enabling the yarns to exit and pass between the squeeze rolls 25 and 26 as described above for the dye box 30 guided by the vertically spaced apart rolls 34 and 35 during which skying the yarns having the cold indigo thereon will be oxidized. After leaving the first skying operation over dye box 30, the yarns will then be introduced into the second cold indigo dye box 36 in which there is also a normal or standard indigo solution 37 similar to the charge in dye box 30. The yarns will travel through the dye bath 37 and leave the dye box to pass through the squeeze rolls 38 in the yarn path of travel to the skying apparatus 39 directly over the dye box 36 with the yarn being guided over the guide rolls 40 in a similar manner as over the first cold indigo dye box 30. The yarns traveling from the skying apparatus 39 will pass into, in sequence, additional dye boxes 40, 44, 47, 50, 53 and 56 in which normal or standard indigo charges 41, 45, 48, 51, 54 and 57 are contained with the yarns passing from the cold indigo solutions that are maintained at about 160 degrees F. or less and pass through squeeze rolls comparable to those shown in dye boxes 30 and 36 preparatory for the skying apparatus 43, 46, 49, 52, 55 and 58. After the requisite or desired number of cold dips, which may vary from two to seven or eight, depending upon the desired shade, the yarns are introduced into rinse boxes. Thereafter, the yarns are passed through cold water rinses 58, 61, 64 and 67 contained in rinse boxes 57, 60, 63 and 66 with or without intermediate skying in the skying apparatus 59, 62, 65 and 68. Ultimately the yarns are passed through a softener solution 70 and 73 contained within vats 69 and 72 and may pass through the skying apparatus 74 before the yarns are finally subjected to a drying sequence over revolving heated drums that will dry the yarn and pass the yarn to a collection location.

One suitable solution for the hot indigo dye boxes used in dye boxes 16, 18 and 23, is a charge of 300 gallons which will be heated to a temperature of 160 degrees F. and contains 12% pounds caustic soda (50%), (liquid caustic), 5 pounds of sodium hydroxulfite (Na2SO3) (hydro powder), 407 pounds of indigo stock liquor (41.5 gallons) a solution of reduced indigo, 12% pounds of Tergitol 4 (or any other suitable wetting or penetrating agent). The charges in the dye boxes 18 and 23 may be of the same materials but the temperature in dye box 18 will be maintained at approximately 140 degrees F. and the temperature in dye box 23 maintained at a temperature of approximately 120 degrees F. It will be desirable to maintain a continuous feed or make up for the dye boxes 16, 18 and 23 from a 100 gallon solution maintained at a temperature of approximately 120 degrees F. that is fed into each dye box containing 3½ pounds of caustic soda (50% liquid caustic) 10 pounds of hydro powder, 215 pounds of indigo stock liquor (22 gallons) and 4 pounds of Tergitol 4 with the remainder making up the 100 gallons being water. Similarly in the 300 gallon charge, water will make up the difference to form the charge.

In the stock formula for the normal solution contained in the cold indigo vats, a normal charge is formed of a diluted indigo and the stock may be 8% indigo powder, 16% caustic soda (50% liquid) 6% hydro powder and 70% water in a volume of approximately 2,400 gallons which is fed approximately every fifteen minutes to replenish the indigo.

It is desirable in at least one or both of the last vats 69 and 72 to employ a suitable water dispersible softener. It has been ascertained that abrasion tests conducted on cotton warp woven into fabric to form denim that has been subjected to the bottom hot penetrating indigo dye and the top application of cold indigo dye have revealed very substantial increased penetration of the dye into the core of the cotton fibers.

Obviously many modifications may be made in the number of dips for the warp in the hot indigo, the number of skying steps into the air chamber for skying dipping, and the number of dips into the cold indigo dye boxes also vary depending ultimately upon the desired shade without departing from the purpose and spirit of this invention and the illustrated example is not intended to limit the scope of the claims appended hereinafter. Therefore, the process and product described for this invention and variations thereof are contemplated within the scope of the appended claims.

What I claim is:

1. In the process of dying cotton fibers comprising the steps of applying indigo at a temperature of from between 150 degrees F. to 180 degrees F. to continuously traveling cotton yarns, applying indigo at temperatures below 100 degrees F. to the continuously traveling yarns in one or more dips to obtain the desired color intensity, and oxidizing the indigo applied yarns after each indigo application by skying.

2. In the process of dying cotton fibers comprising the steps of applying indigo at a temperature of from between 150 degrees F. to 180 degrees F. to continuously traveling cotton yarns, applying indigo at temperatures below 100 degrees F. in a series of sequential dips to the continuously traveling yarns, and skying the indigo applied yarns after each cold indigo dip application.

3. In the process of dying cotton fibers, comprising the steps of applying hot indigo at a temperature of from between 125 degrees F. to 180 degrees F. to continuously
traveling cotton yarns by sequential dips, applying indigo as a topping dye at temperatures below 100 degrees F. to the continuously traveling yarns, and skying the indigo applied yarns after each of a series of sequential indigo dip applications.

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