

Feb. 10, 1970

E. BOBKOWICZ ET AL
UNIVERSAL OPEN-END SPINNING METHOD OF
MULTICOMPONENT YARNS PRODUCTION

3,494,118

Filed May 14, 1968

3 Sheets-Sheet 1

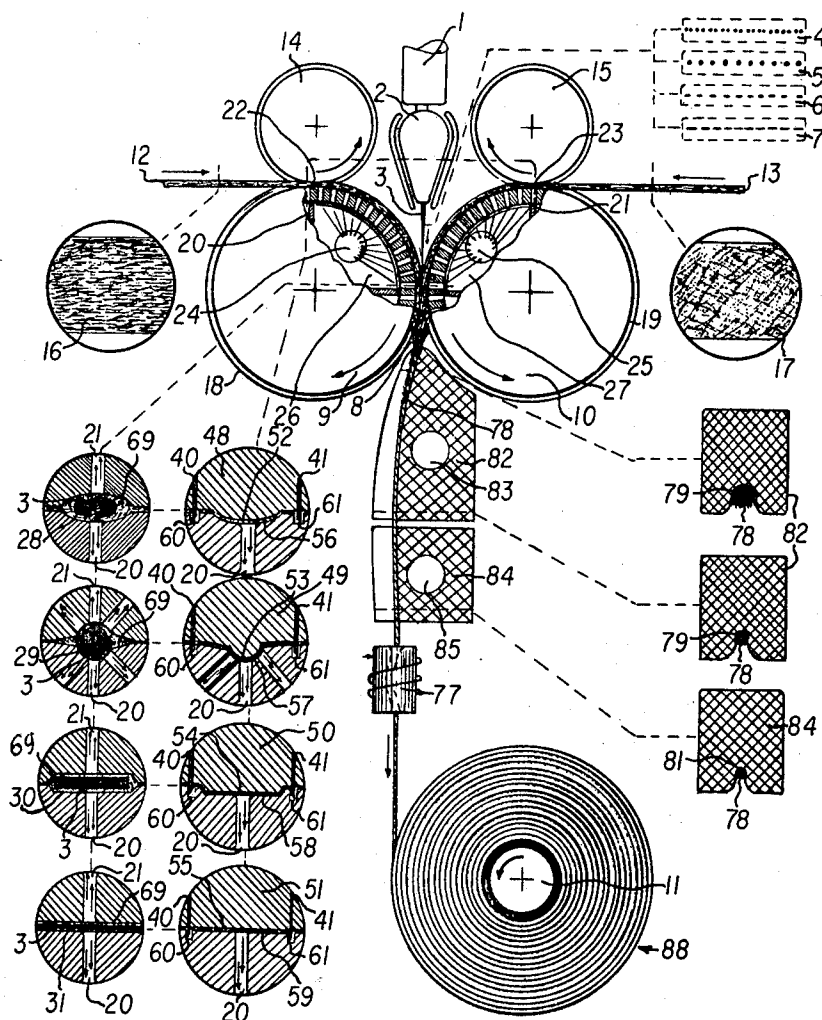


FIG. 1

INVENTOR
Edward Bobkiewicz
By *John J. Golligorsky*

Feb. 10, 1970

E. BOBKOWICZ ET AL
UNIVERSAL OPEN-END SPINNING METHOD OF
MULTICOMPONENT YARNS PRODUCTION

3,494,118

Filed May 14, 1968

3 Sheets-Sheet 2

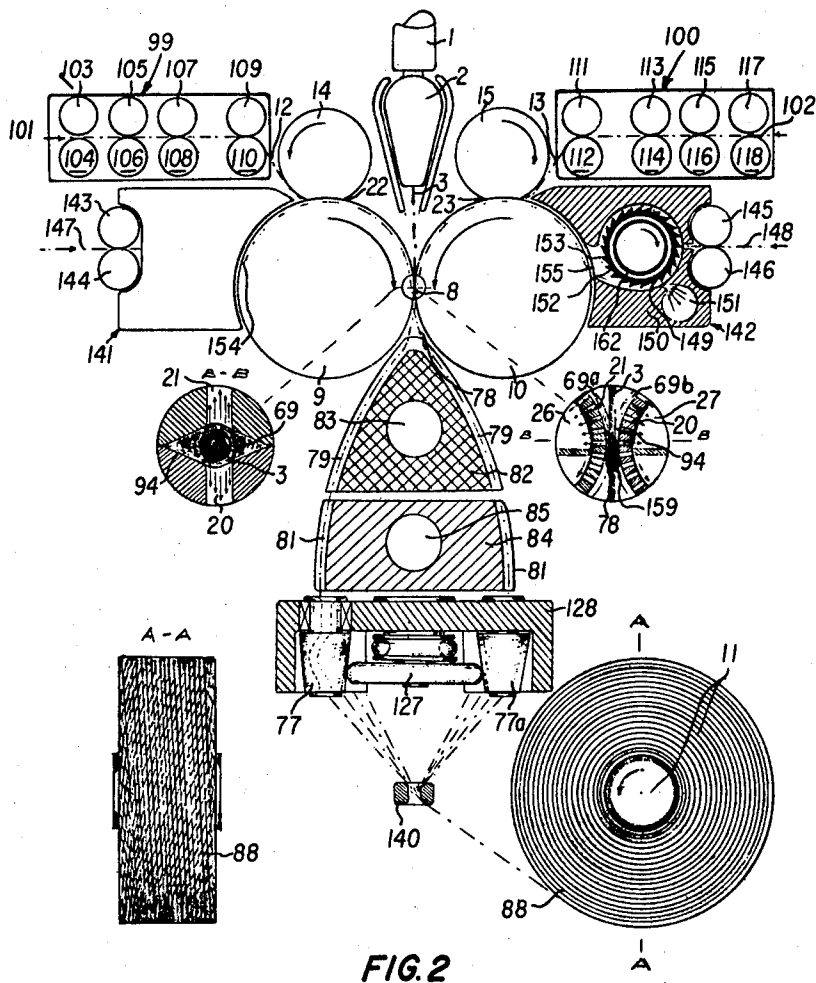


FIG. 2

INVENTOR
Andrew J. Goshen
 Andrew J. Goshen

Feb. 10, 1970

E. BOBKOWICZ ET AL
UNIVERSAL OPEN-END SPINNING METHOD OF
MULTICOMPONENT YARNS PRODUCTION

3,494,118

Filed May 14, 1968

3 Sheets-Sheet 3

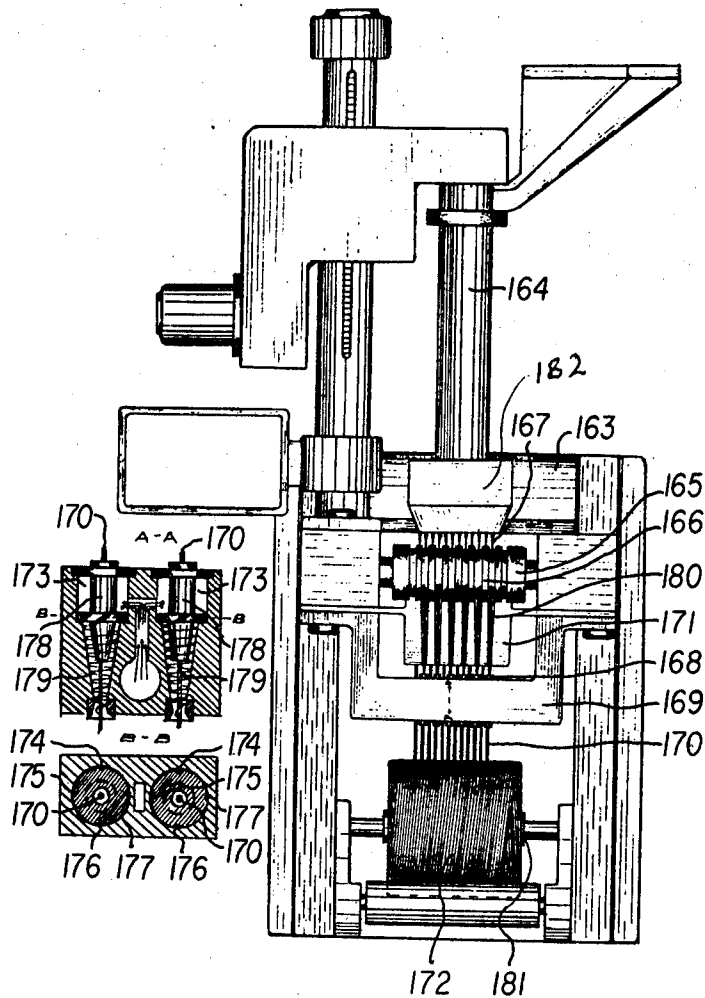


FIG. 3

INVENTOR
Emil Bobkiewicz
Andrew J. Goldkorn

1

2

3,494,118

UNIVERSAL OPEN-END SPINNING METHOD OF MULTICOMPONENT YARNS PRODUCTION

Emilian Bobkowicz and Andrew J. Bobkowicz, both of
1435 St. Alexander St., Room 310, Montreal, Quebec,
Canada

Filed May 14, 1968, Ser. No. 729,089

Claims priority, application Canada, Nov. 20, 1967,
5,641

Int. Cl. D01h 13/30, 1/12, 7/46

U.S. Cl. 57—35

28 Claims

ABSTRACT OF THE DISCLOSURE

A stock-in raw material, consisting of loosely held together staple fibers or of such fibers in combination with a polymer substrate in plastic condition, is continuously introduced into cavities formed at the nip of a pair of rotating perforated drums with continuous circumferential grooves on their surface, said drums being positioned face to face so that each groove of one drum faces the corresponding groove of the other drum thus forming the said cavities, and the so obtained open end is imparted with twisting torque to form twisted yarn which is then linearly wound on a collecting roll, if necessary, after suitable intermediate preforming.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a novel method and apparatus for spinning yarn.

More particularly, the invention relates to a process and device for making yarn by open-end spinning of staple fibers with or without a polymer substrate.

Description of the prior art

It is a recognized fact in the art of yarn making that in order to impart permanent twist to a strand by any means, one end of the strand must be free to rotate. If any attempt is made to impart twist to a strand which is held at both ends, right-hand twist will appear on the strand at one side of the twisting device and will be offset by a left-hand twist at the other side of said device. As soon as an end is released, the strand resumes its untwisted state because the two twists nullify each other. This is commonly known as false-twisting.

In the hitherto predominant ring spinning processes, twist is imparted between front delivery rolls and a circumferentially rotating spindle as the stock-in-supply passes through a traveler revolving on a stationary ring and onto the bobbin of the rotating spindle, the former constituting a removable reservoir which accumulates the yarn and stores the imparted twist. The complexity of the ring spinning system is well known and it is recognized that ring spinning has many physical limitations caused by a narrow range of allowable tensions in the balloon and by the technical restrictions that must be placed on the traveler. Inherently limited by these and other factors, improvements can hardly lead to any marked productivity increases per spindle.

Pot spinning is based on the same principle as ring spinning. The revolving pot acts as a twist imparting and/or yarn collecting device. The twist is collected and stored in the yarn cake formed inside the pot by centrifugal forces. The numerous drawbacks of conventional pot spinning are well known in the art and have precluded to a large degree its widespread application.

Major disadvantages of both systems are the lack of automatic doffing and inadequate tension control, primary factors in the manufacture of satisfactory yarns. The

complexity and discontinuity of operations involved in both systems constitute a barrier towards full automation from bale to yarn.

Numerous attempts have been made towards open-end turbine spinning. These are based upon the utilization of centrifugal forces created inside different kinds of small turbine type devices revolving at high circumferential velocities (velocities as high as 30,000 to 40,000 r.p.m. have been claimed) into which fiber stock-in sliver or roving is fed first for separation into individual fibers which are then rotated inside the turbine by centrifugal forces, producing reassembly, collection, twisting and condensation of the fibers into yarn and its subsequent transfer toward linear wind-up on a bobbin with retention of the twist inserted by this open-end twisting operation. Modern science has shown that there are serious technological drawbacks inherent in these air methods because each type of fiber has different air drag characteristics and because the density of air varies greatly with temperature. Thus, the separation and transfer of the individual fibers by air, their reassembly from the air current, collection, condensation and twisting into a continuous strand by centrifugal forces under controllable conditions and with predictable results on a practical basis constitutes a formidable task which has not yet been solved satisfactorily.

SUMMARY OF THE INVENTION

It is therefore a principal object of the present invention to provide a universal and highly flexible novel method and apparatus for making yarns from any type of staple fibers, and/or from blends of different types of staple fibers, if desired, in combination with a polymer substrate, by the utilization of the major technological advantage of the open-end spinning principle, namely a linear fiber supply and linear yarn wind-up with retention of the inverted twist, but with elimination of the complex aerodynamic turbine spinning principle and means; by virtue of this and by the complete elimination of the ring and pot spinning systems the new method and apparatus provide, for the first time, a practical solution for fully automated and continuous bale to yarn production.

Other objects and advantages of the invention will be apparent from the following more detailed description.

In conventional turbine open-end spinning, the stock is rotated in an air current by centrifugal forces while the individual fibers are dispersed, constituting a loose discontinuous fibrous mass gradually condensed and collected in and through a central orifice of the turbine in the form of a twisted continuous fiber strand, the yarn.

In applicants' novel method, the loose fiber stock is not subjected to centrifugal forces and torque before twisting. According to the present invention, the fiber stock is continuously and linearly supplied to the open-end twist position in the form of narrow fiber webs with loosely held parallel or at random arranged staple fibers the torque is imparted into the ready yarn by a twisting or torque imparting device and the so imparted twist is continuously transferred towards the open-end twist position to engage the loose fiber stock and convert the latter under controlled conditions into a continuous twisted yarn.

The principle of the present invention is based upon the possibility to freely rotate the stock-in supply end of a raw material, consisting of staple fibers or of a combination thereof with a polymer substrate, so as to impart to the latter a twist at high circumferential velocity, said twist being stored and retained in a resulting composite yarn during subsequent high speed linear wind-up operation into large size yarn packages, the entire procedure being carried out in a continuous sequence of operations from staple fibers in sliver or lap form and possibly a polymer substrate, originally used in pellet or any other desired form, to the final yarn package.

According to one embodiment of the invention, a polymer substrate in plastic or fluid condition and loosely held staple fibers are passed together into a predetermined cavity where both the staple fibers and the polymer substrate can be freely rotated and where twist is applied thereto. In this manner the staple fibers become partially bonded at contact points to the polymer substrate while it is in the tacky plastic or fluid condition and the combined material is subjected to a twisting torque and coagulation through cooling. The so obtained linearly wound-up composite yarn has a permanently set twist which will not disappear as in the case of false-twisting.

According to another embodiment of the present invention, staple fibers in loosely held form are subjected to a circumferential torque within a predetermined cavity where the staple fibers can freely move without any restriction whatsoever. When said twisting torque is applied to such fibrous material within the said cavity, the latter retains a permanent twist and forms a twisted yarn which can then be wound linearly on a collecting roll without losing its twist.

In practice these operations can be carried out by providing a pair of positively driven perforated drums with continuous circumferential grooves on their surface and so positioned face to face that each groove of one drum faces the corresponding groove on the other drum thus forming a predetermined cavity. The configuration of such cavity will depend on that of the grooves and it can vary to a large degree; it can be, for example, of oval shape, of a substantially circular or rectangular shape or any combination thereof. The drums are also provided with suction devices therewithin and may incorporate suitable cooling means as well. The suction devices provide suction capable of holding the staple fibers pressed against the surface of the drums until said fibers are released in the cavity for open-end twist imparting, without creating a back torque.

In the case of multicomponent yarn production, polymer substrate capable of being coagulated by cooling is preferably used. It is supplied towards the nip of such drums in a plastic or fluid state together with loosely held parallel or at random arranged staple fibers and the so obtained fluid combination, within the cavities formed between the drums, is then subjected to a twisting torque with simultaneous cooling and pull of the linear wind up means. The twisting can be done by any suitable twist or torque imparting device, such as, for example the type presently employed in false-twisting. This twist or torque imparting device is positioned between the grooved pressure drums and the yarn collecting means. On coagulation of the polymer substrate within the cavities between the drums the twist is heat-set and will not disappear thereafter. The obtained twisted yarn is then simply collected by any desired linear wind-up collecting means to form a large yarn package.

When only staple fibers are to be twisted into yarn, they are supplied while being held by suction against the surface of the said drums, into the resulting cavities where they are suddenly released to form a fiber strand of loose fibers which by the utilization of their inherent cohesion properties and aid of the air drag are twisted into yarn. To start the twisting of said fibers, one may require a lead-in piece of string or yarn in said cavity, whereafter the fibers which are continuously replenished are formed by the open-end principle into a yarn in said cavity by the simultaneous torque, air drag and pull of the linear wind up means.

In a preferred operation, a polymer substrate is extruded in the form of a curtain of parallel strands of any desired cross-section (e.g. round filaments, square strands, etc.) towards the nip of the grooved perforated drums and the staple fibers in the form of a plurality of loosely held fiber web tapes are also supplied toward the nip of said drums on one or both sides of the curtain of strands. These staple fibers are held against the wall

of the drums by suction. The materials fed are picked up by the drums, are contacted and consolidated with each other as well as twisted and heat-set in the cavities formed by the grooves of said drums. At a point in these cavities, when the suction ceases, the staple fibers are released and are bound at contact points to the polymer which is in a fluid tacky state capable to rotate without interference and without creating any counter torque. The polymer substrate may consist of any desired extrudable material which is capable of bonding and coagulation by cooling or setting by thermal conditioning.

The resulting twisted yarn may simply be wound on a linear collecting roll without losing its twist.

The twisting device, which is of any suitable type and preferably of the type now used in false-twisting, is positioned anywhere between the grooved drums and the collecting roll.

Following the grooved drums there may also be provided a condensing member with heating and/or cooling means to achieve a higher degree of mechanical condensation, coagulation and consolidation of the obtained yarn.

Generally speaking, the starting material used according to this invention preferably consists of two thin fiber webs of parallel or at random arranged loose staple fibers. Each web is fed toward the nip of the two circumferentially grooved drums rotating face to face downwards at identical surface speeds. The drums are perforated so as to form at the bottom of each groove a plurality of orifices through which air suction may be imparted from inside of each drum. Each fiber-web is first longitudinally separated into a plurality of fiber strips of desired width by a circular cutter roll superimposed on the top of each drum and preferably comprising a plurality of circular razor blade and spacer discs assembled to match narrow circumferential slots provided for this purpose in each drum. Said cutter rolls rotate in the same direction as the drums matching the latter's general surface configurations and surface speeds and maintaining adequate contact pressure to insure proper separation of the fiber-web into the desired plurality of narrow fiber strips. In order to facilitate the consolidation and downward transportation of the fiber strips at high speeds, air suction is applied in each groove from inside the drums through the orifices starting at the point of separation of the wide web into narrow fiber strips and ending in the cavity between the grooves where the fibers are released and subjected to twist. The separate fibers of each strip are therefore carried under constant air suction toward and into the cavities formed at the nip point of said two drums where two fiber strips supplied in two opposite grooves are brought into close face to face contact with each other at any desired pressure, determined by the shape of the cavities and the controllable pressure applied at the nip of the rotating drums.

Simultaneously with the formation of the above mentioned fiber strips, a thermoplastic polymer substrate is preferably introduced therebetween at the nip of the rotating drums as said strips, form two opposing grooves, are brought into close contact inside each cavity created by said grooves of the fiber carrying drums. The polymer substrate is suitably introduced into each cavity by direct vertical downward extrusion in the form of a curtain of strands of any desired shape. In the cavities, the polymer substrate has a tacky surface onto which the staple fibers of the respective strips are superimposed and partly bound. This occurs at the nip points of said drums under a predetermined pressure to aid continuous formation of partially consolidated yet loose polymer-fiber composite strands. Also, the polymer strands in the cavities must be of adequate plastic or fluid consistency to assure that when subjected to a torque for imparting a permanent twist, they can substantially freely rotate with the superimposed free ends of the individual staple fibers so that the molecules of the plastic

polymer substrate can become together with the fibers helically arranged to form a continuous twisted yarn with its twist being heat-set by a subsequent coagulation, this being done without creating any counter torque forces and thus enabling the high speed linear wind-up of the yarn into large yarn packages.

To impart a desired twist in each of said fiber strands any false-twist type device, known in the art, can be utilized as torque imparting means. Such device must be capable of applying a torque to each individual fibrous strand and may be positioned at any point between the nip point of said drums and the wind-up device. This will transfer the torque upwards, toward the above described cavities between the drums where the actual open-end yarn twisting and formation takes place under substantially controlled conditions of pressure, tension, torque and temperature. A slight outside pressure is exerted by said drums on the fibrous material in plastic state together with air drag forces applied to fibers in each groove. Simultaneously, consolidation of the yarn is aided by the downward tension or pull exerted by the linear winder and combined with the applied twisting torque. All these factors contribute to additional parallelization of the staple fibers and their free helical rearrangement about the still plastic inner polymer substrate. An important step in obtaining property stabilized yarn consists in controlling its temperature at formation through constant cooling of the surfaces of the drum, preferably by air suction and internal water cooling, so that partial coagulation of the soft polymer substrate commences at the nip point thus ensuring formation of substantially helically consolidated individual composite yarns with a permanently stored twist.

Due to a higher linear yarn wind-up speed as compared to the extrusion speed of the polymer filament, some degree of molecular orientation of the polymer in longitudinal direction will take place. This effect will also be aided by the torque to which the fiber-polymer combination is subjected. By increasing their contact pressure, the web separating rolls can function as crush rolls as well, thus pulverizing any impurities that may be present, such as, for instance, leaves, seeds, etc. In disintegrated form these impurities can be removed to a large degree by air suction before the staple fibers reach the twist point in the cavity at the nip of the perforated grooved drums.

To provide a higher degree of condensation of said fibrous strands, right after formation, each of them may be passed through a deep narrow groove rounded at its bottom and which may be continuously tapering toward its exit end. This condensing zone may also comprise two elements, the first being a heating element to soften each individual strand to aid its consolidation and condensation and the second a cooling element to finally coagulate and permanently set the twist in the yarn. One or both may contain at the bottom of each groove a plurality of orifices similar to those of the perforated revolving drums to aid the consolidation and formation of the yarn by means of an air drag using any suitable air suction device.

One clear technological difference between the conventional open-end air turbine spinning operations and the present invention is that according to published expert opinion (e.g. Stiepel, E., paper presented at National Cotton Council Cotton Research Conference, Pine Mountain, Ga., U.S.A.; Daily News Record, p. 40, Feb. 20, 1967) the former "cannot function without centrifugal force," whereas applicants' open-end spinning method makes no use of centrifugal forces.

Furthermore, in the conventional air turbine open-end spinning method, the raw material must first be converted into slivers on the carding machines and preferably pass through two drawing operations before it is suitable for feeding into the turbine where the fibers are again completely separated into a loose mass and then recollected and rearranged by centrifugal forces on the inner cylindrical collecting surfaces which constitute the actual twisting area. In the present case, the parallel arrangement of

staple fibers in a web from a card or drawframe need not be disintegrated but only longitudinally separated into a plurality of fiber strips in a continuous high speed operation under constant control by air suction, until each strip is converted into an open-end spun yarn as described above. This constitutes a considerable saving and a major technological advantage because yarn formation in applicants' method can be achieved at speeds several times higher than is possible by the conventional air turbine methods. In the latter, optimum turbine twisting speeds of up to 30,000 to 40,000 r.p.m. and draw-off speeds of the linear wind-up unit from 75 to 150 ft./min. have been claimed. In the novel method according to this invention, torque is not applied at the twisting point to disintegrated fibers. Moreover, it can be inserted by any conventional false-twist device which, depending on the type utilized, may easily have a twisting speed range from 100,000 to 500,000 r.p.m. The draw off speeds in applicants' method will depend on the delivery speeds of the fiber webs, preferably supplied by a drawframe the newest types of which claim speeds of more than 1,500 ft./min., as well as on the extrusion speed of the polymer filament, the present speed range of which is up to about 4,000 ft./min. Conservatively estimated, the technological advantages resulting from the application of the novel method under highly controllable condition will enable practical production speeds about 5 to 10 times higher than those of the conventional hitherto known open-end turbine spinning methods.

The novel method has none of the previously cited aerodynamic fiber problems which constitute a serious roadblock towards practical application of the turbine systems.

In the case of the present invention the preferred addition of a polymer by direct extrusion (originally using said polymer in its cheapest form, i.e. pellets) provides a considerable cost reduction of the raw material in the manufacture of blend yarns. In the hitherto known open-end methods of conventional spun yarns the raw material made of 100% staple fibers was required. The latter are, particularly in respect to man-made fibers, much more expensive than a polymer resin and also necessitate a fiber to yarn conversion equipment for 100% of the raw material content of the produced yarn, whereas a concrete example in applicants' 50:50 staple fiber and polymer blend yarns require only 50% of the stock to pass through such equipment.

In addition, the introduction of a polymer substrate enables the processing of any type of staple fibers independent of their surface cohesion properties, length, strength and regularity, because the bonding forces of the polymer and its viscosity properties substantially aid the formation and consolidation of the yarn in the novel open-end spinning system.

Due to the possibility of applying a controllable air suction through the numerous orifices in each of the grooves, from within the rotating perforated drums, by means of a stationary suction arrangement inside the latter, adequately strong suction forces can be created which will keep each staple fiber firmly in each groove under strong air drag from the point where the fiber web is slit to the point of twisting at the nip of the drums. Staple fibers without the addition of a polymer substrate can also be processed (twisted) into a continuous yarn in the cavities produced at the point of contact of each pair of corresponding grooves. At this point the suction forces cease and inherent fiber cohesion forces, applied by the torque as well as linear wind-up forces, take over to draw the free fibers out of the air bearing and suction field in each groove and twist them under an air drag created tension to form a continuous twisted yarn with a permanently stored twist. Such 100% staple fiber yarns, when containing or comprising thermoplastic staple fibers, can then be further condensed, heat set and subsequently coagulated by passing each yarn through heated and subsequently cooled grooves, as described above for the poly-

mer containing yarns, to form a balanced yarn with a permanent heat set twist.

In yarns with a polymer substrate, the pressure created in the cavities of the drums, combined with the torque applied, cohesion forces of the fibers and the adhesive forces of the polymer, may suffice to enable the formation of yarns without the application of any air suction from within the grooved drums. The grooves of such drums will therefore not contain any orifices but preferably may have either a highly smooth or rough surface of any configuration depending upon the surface cohesion properties of staple fibers to be converted into yarn by the novel method and intended either to aid or brake the rotating movement of the staple fibers within the cavities created at the nip point of said grooved drums.

Another distinct difference between the present invention and the conventional open-end spinning methods is the established fact that the latter cannot handle any staple fibers longer than 1½-in., whereas due to the entirely different principle applied by the applicants, the length of staple fibers is only restricted by the distance between the fixed slitting and open-end twisting points. Thus, the grooved drums may have any desired diameter, such as, e.g. 10-in., which would enable spinning fibers up to 9-in. long, equivalent in this case to one quarter of the about 36-in. circumference of the drum. The novel process is thus applicable and adaptable to spinning of staple fibers of any length and type (e.g. wool, bast fibers, etc.) even those which cannot be processed by the present air turbine open-end methods.

BRIEF DESCRIPTION OF THE DRAWING

The instant invention will now be described in greater detail with reference to the accompanying drawings in which:

FIGURE 1 is a schematic representation, partly in section, of one embodiment of applicants' novel method and apparatus;

FIGURE 2 is a similar representation of another embodiment; and

FIGURE 3 represents a perspective front view of an apparatus according to this invention with some portions thereof shown in section.

DESCRIPTION OF THE PREFERRED EMBODIMENT

According to the embodiment of FIGURE 1, extruder 1 is provided with a die 2 to extrude a polymer substrate 3, preferably in the form of a linearly arranged curtain of round filaments 4 or 5 or flat strips 6 or 7, directly into the nip point 8 of take up drums 9 and 10 which operate at a higher surface speed than the speed of extrusion of said filament curtains 4, 5, 6 or 7 and preferably at a somewhat lower speed than that of a subsequently provided wind-up arrangement 11. This enables achievement of a certain degree of molecular orientation of the polymer filaments between the extrusion point of the polymer substrate 3 and the nip point 8 before said filaments, while still in tacky and plastic condition, are brought in contact, at said nip point 8, with staple fibers obtained from webs 12 and/or 13 which are first fed towards the cutting points 22 and 23 of cutter press rolls 14 and 15 mounted on drums 9 and 10 and revolving in the same direction and at same surface speed as said drums 9 and 10 to subdivide said fiber webs 12 and 13 into a plurality of narrow fiber strips which are then transported toward the nip point 8 of the drums 9 and 10. Said fiber webs may have parallel arranged fibers 16 or at random arranged fibers 17 and may be supplied by any conventional fiber web forming equipment, e.g. a draw-frame.

Take-up drums 9 and 10 are provided with circumferential grooves 18 and 19 with each groove preferably having circumferential perforations in the form of a plurality of orifices 20, 21. Air suction devices 24 and 25 are incorporated within the rotating drums 9 and 10 in sta-

tionary air chambers 26 and 27 to provide constant air suction and drag forces upon the separated staple fiber strips while they are transported from the cutting points 22 and 23 toward the nip point 8 of drums 9 and 10. The face to face mounting of the drums is such as to form at the nip point 8 desirably shaped cavities 28, 29, 30 and 31 with an arrangement of the suction orifices 20, 21.

The cutting rolls 14 and 15 for dividing the fiber webs 12 and 13 into strips comprise for each groove of the take-up drums 9 and 10 a pair of circular razor blade steel cutters 40, 41 mounted between spacers 48, 49, 50 and 51 each of which has a circumferential relief surface portion 52, 53, 54 or 55 respectively to match the configuration of each corresponding groove 56, 57, 58 or 59 of the take-up drums. The latter are also provided with circumferential narrow grooves 60, 61 receiving the pairs of steel cutters as well as with corresponding suction orifices 20 in each of the grooves 56, 57, 58 and 59.

Each cavity 28, 29, 30 or 31, formed at the nip point 8 of the revolving drums 9 and 10, is continuously supplied with the fibrous material 69 in the form of one or two separated fibrous tapes between which a still plastic polymer substrate 3 is introduced by extrusion from die 2 in the form of one or more round filaments or flat strips 4, 5, 6 or 7. At the nip point 8, each of the resulting composite fibrous polymer strands is subjected to a twist imparting torque by any conventional false-twisting device 77 rotating at high speed while said strand is continuously pulled downwardly by the linear wind-up arrangement 11 and while each said composite strand is kept at the nip point 8 under continuous slight pressure and air drag force without restricting the free movement of the individual staple fibers and the inner plastic polymer substrate imparted by said twisting torque inside the cavities 28, 29, 30 or 31 at the nip point 8 of the drums 9 and 10. This results in an open-end formation of yarn 78 having permanently stored twist and suitable to be linearly wound up on a wind-up arrangement 11.

To aid the consolidation and formation of the yarn 78 while a twisting torque is applied, it may be passed through a downwardly narrowing groove 79 of a condensing member 82 which may be equipped with heating element 83, and subsequently through the groove 81 of a cooling member 84 provided with a cooling arrangement 85. This is intended to achieve a final setting of the twist stored in the yarn 78 making it ready for linear wind-up into a yarn package 88.

FIGURE 2 illustrates an apparatus according to another embodiment of the present invention which comprises the following combination: a conventional extruder 1 provided with die 2 to extrude a polymer substrate 3 in the form of a suitable filament curtain into the nip point 8 of take-up drums 9 and 10 mounted face to face and the surfaces of which are provided with a plurality of circumferential grooves each pair of which will form at the nip point 8 a desirably shaped cavity 94 with inner air suction through orifices 20, 21 imparted circumferentially in said grooves from stationary air suction chambers 26, 27 inside each drum 9 and 10 respectively. At least one and preferably two conventional sliver drawing arrangements 99 and 100 adapted to receive card slivers 101 and 102 and to convert said slivers by passing through several drawing stages preferably between a plurality of rolls 103, 104, 105, 106, 107, 108, 109, 110, and 111, 112, 113, 114, 115, 116, 117, 118, into thin flat fiber webs 12 and 13 of substantially parallel arranged staple fibers. These webs are suitable to be fed to the cutting points 22, 23 between the drums 9, 10 and the rolls 14, 15 mounted thereon and adapted to subdivide the fiber webs 12 and 13 into a plurality of narrow fiber strips the number of which is equal to that of the grooves in said take-up rolls 9 and 10. Each of the fiber strips is continuously carried under constant inside air suction toward the nip point 8 of downwardly rotating drums 9 and 10 where in the obtained cavity 94 the polymer substrate 3 in tacky and plastic or

fluid condition is brought into contact with the subdivided fibrous material 69 preferably with the polymer substrate being sandwiched between two separated fiber strips 69a and 69b as best illustrated in the enlarged view B—B of the nip point 8. A plurality of suitable false-twisting devices 77, 77a, revolving at high speed which is, for example, imparted by a friction device arrangement 127, is mounted in a supporting frame 128 with each such device subjecting each composite fiber-polymer strand 159, formed upon joining the fiber strips 69a and 69b with the polymer substrate 3 in the cavity 94 at the nip point 8, to an adequate torque. This torque, carried upwards, will engage in each cavity 94 said composite polymer-fiber strand material in circumferential open-end twist imparting manner so as continuously to form in each said cavity 94 (under light roll pressure, air drag forces, interbonding action between the staple fibers and the polymer substrate, circumferential torque forces as well as linear pull forces of the subsequent wind-up arrangement 11) a yarn 78 with a permanently set and stored twist in the form of a large traverse wound yarn package 88. Yarn condensing devices 82, 84 which contain a plurality of deep grooves 79, 81 which taper downwards to condense the yarn 78 passing and revolving therewithin may also be provided between the drums 9 and 10 and the twisting devices 77, 77a. Also device 82 may contain a heating element 83 and device 84 a cooling arrangement 85 cooled with the aid of cold water and/or an air flow. Finally, a winding-up arrangement 11 for traverse wind-up into large size packages 88 of the formed yarn 78, is mounted following the twisting devices 77, 77a. This enables continuous winding operation of the yarn, guided and collected through a guide ring 140, and doffing of the ready yarn package especially by providing two wind-up stations of any desired type which may be alternatively used without the necessity to stop the winding operation for doffing. View A—A shows how the package 88 looks from the side.

In an alternative embodiment of applicants' apparatus, the fiber supply arrangement may consist of two aerodynamic fiber-web forming licker-in devices 141 and 142, each comprising two raw material feed-in rolls 143, 144, and 145, 146 which preferably feed in a picker lap staple fiber material 147, 148 into the numerous teeth of conventional licker-in rolls 162 which operate within a chamber 149 formed in frame 150. The chamber 149 is open at one end 153 and also contains an air chamber 151 from which a strong air current is blown for carrying the broken up staple fibers 152 onto the perforated grooved surfaces of the drums 9 and 10. In a case such as this, the inside suction through the orifices of the drums 9 and 10 starts at points 154, 155 respectively, which enables the collection of the loose fibers 152 on the surface of rolls 9 and 10 in the form of an even, continuous fiber web of at random arranged staple fibers. The remaining arrangement and operations are the same as described above.

Finally, FIGURE 3 represents one possible construction of an integrated apparatus for sliver to yarn processing according to the novel open-end principle. This apparatus comprises, for example, a conventional staple fiber sliver drawing frame 163 with an extruder 164 mounted vertically thereon. Below die 182 of said extruder 164 there are provided a pair of circumferentially grooved drums such as already described above, only one of which (drum 165 with grooves 166) is seen in FIG. 3. A curtain 167 of a polymer substrate in the form of a plurality of parallel filaments is extruded from the extruder 164 through die 182, and into the cavities formed by the pair of grooved drums. At the same time, a fiber web is supplied by the drawing frame 163 subdivided into a plurality of longitudinal fiber strips and guided towards the nip point of the grooved drums, where the fiber strips and the polymer filaments are brought into direct contact with each other to form composite fiber-polymer strands which are, at that particular point, still in fluid or plastic condition. Furthermore, a plurality of stationary false

twist spindles 168, which are more clearly shown in the detailed section view A—A, are mounted in a supporting frame 169 and provided with air chambers 173 through which compressed air is injected into each spindle passing by off center orifices 174, 175, 176 and 177 which are clearly shown in section view B—B. Compressed air injected through said orifices 174, 175, 176 and 177 creates inside each spindle 178 a cyclone type air vortex to impart a twisting torque to the yarn 170 passing there-through, right after each said yarn has passed through groove 180 of a condensing member 171. Finally the resulting yarns 170 are linearly wound on a collecting roll 181, mounted below the spindles, to form a large package 172.

In all these embodiments the stock-in supply may consist of loosely held staple fibers or a combination thereof with a polymer substrate in fluid condition.

From the practical view point, the cavities are formed at the nip of a pair of perforated drums with continuous circumferential grooves on their surface, which drums are so positioned face to face that each groove of one drum faces the corresponding groove of the other drum thus forming the cavity for the stock-in supply which, during its introduction into the cavities, is held against, the surfaces of said drums by suction from inside of each drum, and then released within said cavities through removal of this suction, thus forming a fluid open-end which is twisted into yarn.

The obtained yarn may, if desired, be additionally heated, stretched, preformed and consolidated into a more compact, round yarn before it is wound into a package.

The open-end spinning apparatus according to the present invention generally comprises:

(a) A pair of drums with continuous circumferential grooves on their surface, said drums being so positioned face to face that each groove of one drum faces the corresponding groove of the other drum, thus forming a predetermined cavity;

(b) Means for continuously introducing a stock-in supply consisting of loosely held staple fibers alone or in combination with a fluid polymer substrate, within the cavities formed at the nip point of said drums;

(c) Means for releasing said stock-in supply into said cavities to form a fluid open-end;

(d) Means for imparting a twisting torque to said fluid open-end to form twisted yarn; and

(e) Means for collecting said yarn.

The drums of such apparatus may, of course, be performed and suction devices provided therewithin. Said drums may also include cooling means, e.g. air or water cooling devices.

In the case when a polymer substrate is used as part of the stock-in supply, the apparatus will include an extruder capable of extruding a film or a plurality of parallel strands in fluid state into the nip point of said drums.

The twisting torque will be imparted by any suitable false-twisting device positioned following the drums and inbetween said drums and said false-twisting device, there may also be provided a yarn condensing arrangement with heating and/or cooling means.

In summary this invention provides a practical novel high speed universal method and apparatus for open-end manufacture of a wide range of yarns of any desired composition of staple fibers such as cotton, wool man-made fibers, silk, bast fibers, asbestos, etc., used alone or in combination with a suitable polymer substrate, for example based on polyolefins, polyamides acrylics, etc. which can originally be employed according to the invention in the cheapest form, namely pellets. The novel open-end yarn making method and apparatus are indeed universal in respect of the utilization of any textile or other fibers in any desirable blends as well as in combination with any suitable extrudable polymer substrates.

It should, of course, be understood that the invention is not limited to the specific embodiments described above

or illustrated in the appended drawings, but that different modifications and equivalent procedures evident to those skilled in the art may be applied without departing from the spirit of the invention.

We claim:

1. Process for making spun yarns which comprises continuously introducing a stock-in staple fiber containing raw material supply into at least one cavity, condensing said supply in said cavity without restricting the component fibers to move and rotate freely in said cavity, creating a fluid open-end continuous fibrous strand in said cavity, imparting to said open-end fibrous strand a twisting torque to form a spun yarn and collecting said yarn on a linear wind-up arrangement.

2. Process according to claim 1, in which the stock-in raw material supply consists of a combination of a polymer substrate in substantially plastic condition and of loosely held together staple fibers having parallel arrangement.

3. Process according to claim 1, in which the stock-in raw material supply consists only of loosely held together staple fibers having parallel arrangement.

4. Process according to claim 1, in which the stock-in raw material supply consists only of loosely held together staple fibers having random arrangement.

5. Process for making spun yarns comprising: extruding a curtain of polymer strands from an extruder die and into the nip of a pair of perforated rotating drums with continuous circumferential grooves on their surface, said drums being so positioned face to face that each groove of one drum faces the corresponding groove of the other drum thus forming a plurality of cavities; feeding onto at least one of the perforated drums a fibrous web; separating said web into a plurality of longitudinal strips of loosely held together staple fibers; collecting each said strip in one of said grooves by suction; introducing the polymer strands still in plastic condition simultaneously with the fibrous strips into said cavities; condensing the obtained composite staple fiber-polymer substantially fluid strands within said cavities without restricting their free open-end motion; removing the suction in said cavities and simultaneously subjecting said plastic strands, to twisting torque; thereafter consolidating by cooling action said strands into a set of twisted yarns without creating counter torque forces; and collecting said twisted and consolidated yarns onto a linear windup arrangement to obtain a package of yarn with heat set stored twist.

6. Process for making spun yarns comprising: feeding a fibrous web onto at least one of a pair of perforated drums with continuous circumferential grooves on their surface, said drums being so positioned face to face that each groove of one drum faces the corresponding groove of the other drum thus forming a plurality of cavities; separating said fibrous web on said drum into a plurality of longitudinal strips of loosely held together staple fibers; collecting each said strip in one of the grooves of the perforated drums by suction; rotating said drums against each other so as to forward the strips of staple fibers into the cavities between the drums; removing the suction in said cavities to form condensed fiber strands therein without restricting their free open-end motion; simultaneously subjecting each said open-end strand to torque so as to obtain spun yarn; and collecting said yarn with stored twist onto a linear wind-up arrangement.

7. Process according to claim 5, in which the drums are rotated at a surface speed higher than the polymer extrusion speed so that the extruded polymer strands, picked up by said drums, are stretched and thus provided with a degree of molecular orientation in longitudinal direction.

8. Process according to claim 5, in which the collecting of the yarn on the wind-up arrangement is effected at a speed sufficient to provide a light tension on the yarn which is being produced.

9. Process according to claim 6, in which the collect-

ing of the yarn on the wind-up arrangement is effected at a speed sufficient to provide a light tension on the yarn which is being produced.

10. Process according to claim 5, in which the twisting torque is applied onto the formed yarn by means of a high speed twisting device positioned following the drums and is transmitted by said yarn toward the open-end twisting and yarn formation point in the cavities at the nip of the drums.

11. Process according to claim 6, in which the twisting torque is applied onto the formed yarn by means of a high speed twisting device positioned following the drums and is transmitted by said yarn toward the open-end twisting and yarn formation point in the cavities at the nip of the drums.

12. Process according to claim 1, further comprising additionally condensing and preforming the obtained yarn prior to its collecting on the linear wind-up arrangement.

13. Process according to claim 1, in which the stock-in raw material supply consists of a combination of a polymer substrate in substantially plastic condition and of loosely held together staple fibers having random arrangement.

14. An open-end spinning apparatus comprising a pair of rotatable drums with continuous circumferential grooves on their surface, said drums being so positioned face to face that each groove of one drum faces the corresponding groove of the other drum thus forming a plurality of predetermined cavities; means for rotating said drums against each other; means for continuously feeding a stock-in raw material supply into the cavities formed at the nip point of said drum; means for releasing said stock-in supply in said cavities to form a fluid open-end fibrous strand; means for imparting to said open-end strand a twisting torque to form spun yarn; and wind-up means for collecting said yarn.

wind-up means for collecting said yarn.

15. Apparatus according to claim 14, in which said drums are perforated in their grooved surface and are provided with suction devices therewithin.

16. Apparatus according to claim 14, further comprising an extruder for extrusion of a polymer substrate in plastic state into said cavities between the drums.

17. Apparatus according to claim 14, in which said drums are further provided with cooling means.

18. Apparatus according to claim 14, further comprising a yarn condensing, consolidating and preforming member between the drums and the yarn collecting means.

19. Apparatus according to claim 14, in which the means for imparting a twisting torque consist of high speed false twisting devices and are positioned following the drums.

20. An open-end spinning apparatus comprising: a pair of rotatable perforated drums with continuous circumferential grooves on their surface, said drums being so positioned face to face that each groove of one drum faces the corresponding groove of the other drum thus forming a plurality of predetermined cavities; means for rotating said drums against each other; means for cooling said drums; an extruder provided above said drums and adapted to extrude a polymer substrate in plastic state into the cavities formed at the nip point of said drums; means for continuously feeding a fibrous web onto the surface of said drums; means for dividing said web into a plurality of longitudinal strips; means for collecting each said strip in a corresponding groove of the drums; means for imparting from within said perforated drums an air suction to aid continuous forwarding of said strips in each groove under air drag into said cavities at the nip point of the drums simultaneously with the polymer substrate to form continuously within said cavities composite staple fiber-polymer strands in fluid or plastic open-end condition; means for imparting to said fluid or plastic composite strands a twisting torque to form in

13

said cavities open-end spun yarns; and means for linearly collecting said twisted yarns into yarn packages.

21. Apparatus according to claim 20, in which the means for feeding the fibrous web include a set of sliver to fiber web forming means comprising sliver drawing means adapted to form continuous fibrous webs of substantially parallel arranged staple fibers.

22. Apparatus according to claim 20, in which the means for feeding the fibrous web include a set of aerodynamic fiber web forming means incorporating lick-in devices adapted to form on at least one perforated surface of said drums a continuous fiber web of at random arranged staple fibers with the aid of said air suction means from within said drums through said perforated drum surface.

23. Apparatus according to claim 20, in which the means for imparting a twisting torque consist of high speed false twisting devices and are positioned following the drums.

24. Apparatus according to claim 20, in which the means for imparting a twisting torque consist of false twist devices provided with stationary tubes having upper parts and a center, means to inject into said upper parts compressed air through a plurality of fine off-center orifices, means to create inside said tubes a high velocity downwardly directed cyclone type vortex through said center by means of which, inside said stationary tubes, the yarn is guided and continuously subjected to a twisting torque, without there being any moving parts in said false twisting devices.

25. Apparatus according to claim 20, in which the extruder is provided with a die adapted to extrude the polymer substrate in the form of a plurality of parallel strands of a predetermined configuration.

26. Apparatus according to claim 18, in which the preforming member consists of: a condensing member with narrowing grooves through which the yarn is passed, said condensing member being provided in the upper wider section of each groove with air suction means from within said member and also with heating means for softening the yarn passing in the narrowing grooves; and

14

a cooling member following said condensing member and also provided with grooves of predetermined cross-section for coagulation of the yarn; both said condensing and cooling members being positioned directly following the drums.

27. Apparatus according to claim 20, further provided with a pair of slitting rolls having a plurality of cutter and spacer means, said rolls being superimposed on the respective drums and being provided with means to rotate them in the same direction as said drums and at substantially the same speed, with a light pressure being exerted between the rolls and the drums; the latter are also provided with narrow slots matching the cutter and spacer means on the rolls; this being arranged to separate the fibrous web into a plurality of longitudinal strips of loosely held staple fibers which are then forwarded on the drums into the cavities at the nip point of said drums.

28. Apparatus according to claim 20, in which the yarn collecting means comprise a linear wind-up roll; means for rotating said roll at a speed such as to hold the yarn under tension; and means for replacement of one roll by another without necessity to stop the apparatus for yarn package doffing.

References Cited

UNITED STATES PATENTS

1,795,351	3/1931	Stell	57—51
2,289,568	7/1942	Bloch	57—34
2,743,573	5/1956	Hiensch	57—164

FOREIGN PATENTS

590,895	12/1933	Germany.
411,862	6/1934	Great Britain.

STANLEY N. GILREATH, Primary Examiner
WERNER H. SCHROEDER, Assistant Examiner

U.S. Cl. X.R.

57—34, 58.91, 58.95, 77.3, 157, 164; 264—103