

PROCESS AND APPARATUS FOR COLLECTING
CONTINUOUS BLOW SPUN FIBERS

I. Background and Summary of the Invention

5 **A. Summary of the Invention**

 The present invention provides a process and apparatus for generating a continuous one dimensional array of high strength, small diameter pitch based carbon fibers. In general, the present invention provides a blow spinning process which creates a blow spun product having melt spun product type characteristics at blow spinning speeds. Thus, the current invention improves product uniformity and production economics. While the present invention is particularly useful in blow spinning fibers from carbonaceous pitch, other uses will be apparent from the following disclosure.

B. Background of the Invention

 Since blow spinning operations are well known in the art, they will be discussed only in general terms. A typical blow spinning process utilizes a spinnable substance, an attenuating media, normally a gas, and a spinning die containing fiber forming capillaries. During the spinning process, fibers exit the capillaries and are contacted by the attenuating media which draws or stretches each fiber increasing its length while decreasing its diameter. Since the attenuating media is normally a gas, the quench rate of the fibers is also affected.

 Typically, fibers prepared by blow spinning processes are short discontinuous fibers having lengths of less than two inches. In contrast, melt spun fibers are generally continuous fibers with essentially infinite lengths. Normally, the fiber length of a melt spun fiber is chosen by design, not dictated by the process of

and strict control of the attenuating gas. As demonstrated by melt spinning processes, manufacturers have long recognized that unidirectional fiber lay-down or collection, for example on a spindle or bobbin, would produce the ultimate fiber properties. However, prior to the current invention, the means for achieving this goal in a blow spinning process had not been discovered.

The present invention overcomes the difficulties previously associated with blow spinning fibers by providing an apparatus and process for collecting continuous, blow spun fibers. Additionally, the process and apparatus of the present invention provides for unidirectional collection of the continuous fibers. As used herein, the term "continuous fibers", means fibers having an essentially infinite length. Interruption in the length of continuous fibers generally occurs purposefully or due to a manufacturing problem. Further, fibers generated by the present invention have improved fiber uniformity and tensile strength. Finally, the present invention provides a blow spinning process which generates a melt spun type product at a rate equivalent to blow spinning.

II. Brief Disclosure of the Invention

The present invention provides an apparatus for blow spinning continuous, infinitely long fibers. The novel apparatus includes a blow spinning die having at least one capillary for forming a fiber and means for directing an attenuating gas into contact with the fiber as it exits the capillary. The apparatus also provides a means for placing tension on the fiber until it has thermoset or quenched, i.e. solidified. Further, the present invention optionally provides for the removal of gases and vapors from within the fiber array or bundle prior to collecting the fibers on a receiving device.

the mechanical properties of the fiber. As a result, this invention yields a fiber with a significantly higher tensile strength.

5 Further, the present invention provides a traversed continuous fiber tow, a warp sheet and an unidirectional filament roving fabric prepared from continuous fibers made by a blow spinning process.

10 III. Brief Description of the Drawing

Fig. 1 is a generic depiction of the apparatus of the current invention.

IV. Detailed Disclosure

15 A. Apparatus for Blow Spinning and Collecting Fibers

With reference to the drawing, the present invention provides a blow spinning and fiber collection apparatus 10. Apparatus 10 has a typical blow spinning die represented generically as 20, a vapor removal system 30 and a tensioning device 40 or other suitable means for maintaining tension on the spun fiber.

20 Blow spinning dies are well known in the art. In fact, as previously discussed, there are several well known variations of blow spinning dies. The current invention is suitable for use with all blow spinning dies. For further information on the function of blow spinning dies please see the following references which are incorporated herein by reference: "Vibration and Stability in the Melt Blowing Process", Ind. Eng. Chem. Res., 1993, 32, 3100-3111 by Rao and Shambaugh; "A Macroscopic View of the Melt-Blowing Process for Producing Microfibers", Ind. Eng. Chem. Res., 1988, 27, 2363-2372, Shambaugh; "Three-Dimensional Temperature Field of Rectangular Array of Practical Air Jets", Ind. Eng. Chem. Res., 1994, 33, 730-735, Mohammed and Shambaugh; "Superfine Thermoplastic Fibers," by Van A. Wente, Industrial and Engineering Chemistry, Vol. 48, No.

in any manner known to those skilled in the art such as a warp sheet or traversed continuous filament tow.

**B. Process for Blow Spinning Continuous Straight
Fibers**

With continued reference to the drawing, the present invention provides a process for collecting, continuous, blow spun fibers. As known in the art, various collection methods may generate a warp sheet, a traversed continuous fiber tow or other products. As previously noted, the process for blow spinning fibers is well known. However, while the benefits of collecting blow spun fibers in an unidirectional manner were known, they were not achievable prior to the current invention.

According to the process of the present invention, blow spun fibers are formed by passing a spinnable substance through the capillaries of a blow spinning die. When the as-spun fibers exit the capillaries, they are contacted by an attenuating gas. Following attenuation the fibers are optionally passed by a vapor removal system 30 in order to remove any unreacted monomer or solvents which may be entrained in the array of fibers. Preferably, these materials are removed prior to collecting the fibers. This is particularly true when preparing fibers from solvated pitches as the presence of any retained hydrocarbons would degrade the resulting product.

The process of vapor removal will preferably be achieved by the generation of a cross-flow suction. Preferably, the cross-flow suction will occur after fiber attenuation and prior to fiber collection. The cross-flow suction may be generated by one or more blowers, compressors or other suitable device, not shown. The process of vapor removal should not be confused with the common cross-flow quenching step which typically occurs in

after the continuous fiber is aligned by a tensioning device 40 to accomplish cold or hot drawing and thermal setting functions.

5 C. Continuous Straight Blow Spun Carbon Fibers

 The current invention is particularly useful for spinning continuous, fibers from mesophase pitch and solvated pitches. United States Patent No. 5,648,041, discusses the difficulties of producing straight fibers from solvated pitch and in particular solvated mesophase pitch. As noted therein, the rapid quenching of the fiber in the area of turbulence generated by the attenuating gas tends to generate kinks and bends in the fiber. However, by use of a tensioning device (40) the present invention provides continuous, blow spun fibers. Further, this invention increases the potential for smaller final diameter products while yielding fibers with higher single filament and composite strength translation. Finally, the current invention may allow spinning die capillary diameters to be larger thereby reducing difficulties associated with small capillaries such as plugging.

 Table 1 demonstrates that the fibers of the present invention have improved tensile strength and decreased variation in the as-spun diameter when compared to fibers prepared by prior art methods. The following test results were obtained from fibers spun from a single batch of solvated mesophase pitch using the same blow spinning die. As shown by Table 1, fibers of the current invention, which were collected on a bobbin, had a higher tensile strength and smaller percent coefficient of variation in as-spun diameter than fibers collected as a batt. Percent coefficient of variation (%CV) in fiber diameter is the standard deviation divided by the mean fiber diameter, expressed as a percentage, of a data set. A smaller %CV indicates an improvement in fiber denier uniformity.



We Claim.

1. An apparatus for blow spinning continuous fibers comprising:

5 a blow spinning die having at least one capillary for forming a fiber;

means for directing an attenuating gas on said fiber as it exits said capillary;

10 means for maintaining tension on said fiber following attenuation of said fiber.

2. The apparatus of claim 1, wherein said means for maintaining tension on said fiber is a mechanical device.

15 3. The apparatus of claim 1, wherein said means for maintaining tension on said fiber is selected from the group consisting of bobbins, rolls and windups.

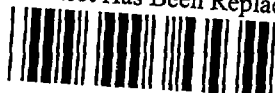
20 4. The apparatus of claim 3, additionally comprising:
a means for exhausting gases and vapors from said fibers following attenuation of said fibers.

25 5. The apparatus of claim 1, wherein said means for maintaining tension on said fibers also provides a means for collecting said fibers.

30 6. A process for preparing continuous straight blow spun fibers from a mesophase pitch, said process comprising:
passing said mesophase pitch through capillaries located within a blow spinning die to form said mesophase pitch into fibers;

attenuating said fibers by contacting said fibers with an attenuating gas;

35 following attenuation, maintaining sufficient tension on said fibers to preclude the formation of slack.





14. The process of claim 13, including the step of removing gases and vapors prior to collecting said fibers.

5 15. The process of claim 13, wherein prior to collecting said fibers cross-flow ventilation is applied to the fibers.

10 16. A traversed continuous fiber tow comprising continuous fibers prepared by a blow spinning process.

15 17. The traversed continuous fiber tow of claim 16, wherein said fibers are spun from the group consisting of carbonaceous pitches, polyamides, nylons, polyesters, polypropylenes, polyurethanes, polyaramides and liquid crystalline materials.

18. A warp sheet comprising continuous fibers prepared by a blow spinning process.

20 19. The apparatus of claim 18, wherein said means for placing tension on said fiber is selected from the group consisting of bobbins, rolls and windups.

25 20. An unidirectional filament roving fabric prepared from continuous fibers prepared by a blow spinning process.

21. The apparatus of claim 20, wherein said means for placing tension on said fiber is selected from the group consisting of bobbins, rolls and windups.

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