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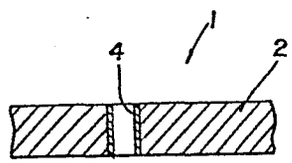
(54) **Spinneret plate for melt spinning and method of manufacture thereof.**

(57) A spinneret plate including a nozzle plate having press fit therein at least one hollow pipe for conducting spinning material therethrough.

FIG. 3



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SPINNERET PLATE FOR MELT SPINNING AND METHOD OF MANUFACTURE THEREOF

The present invention relates to a spinneret plate provided with a spinning nozzle which is most suitably employed in melt spinning such as the spinning of pitch carbon fibers.

Hitherto, the spinning of materials such as pitch has been carried out using a spinneret plate with a plurality of nozzle holes formed therein and arranged in circumferential rows around the center of the plate. In order to satisfactorily melt-spin a fine fiber over a long period of time, it is important that each nozzle hold provided in the spinneret plate should be sufficiently small and have a smooth inner surface and a uniform inner diameter, i.e., a uniform aspect ratio.

In the manufacture of such a spinneret plate the nozzle holes are generally formed by boring through a nozzle plate using a drill or an electron beam. The method in which boring is effected using a drill, however, encounters various problems as the nozzle hole diameter decreases. The first of the problems is that it is difficult to machine the nozzle holes to a high degree of accuracy. More specifically, the drill itself has a tendency to oscillate when rotating. In addition, when drilling the nozzle plate, the drill oscillates owing to drilling resistance, resulting in a hole which had different diameters at the start of drilling and the end of drilling, as shown in Fig. 1. Moreover, as the drill diameter is reduced, the edge of the drill blunts faster, resulting in a marked reduction in drilling capacity. It is impossible to grind the edge of such a small-diameter drill; hence, it is necessary to replace the drill frequently. In addition, the frequency with which the drill breaks increases, which not only lowers the drilling efficiency, but also increases the cost of manufacturing the spinneret plate.

The electron beam method has been proposed in order to overcome these disadvantages with the boring method using a drill. This method, however, has the disadvantage that the

electron beam remains inside the hole during the boring to form a hole whose inner part is expanded, as shown in Fig. 2, so that a nozzle with such a hole would degrade the orientation of the fiber.

Summary of the Invention

Accordingly, it is a primary object of the invention to provide a spinneret plate which has a plurality of nozzles, each with a smooth inner surface as well as a uniform hole diameter so that it is able to spin a fine fiber, such as a pitch carbon fiber, over a long period of time.

It is another object of the invention to provide a method of manufacturing a spinneret plate which makes it possible to manufacture a spinneret plate provided with a plurality of nozzles, each with a smooth inner surface as well as a uniform hole diameter, at an extremely high accuracy and a high efficiency within a short period of time.

The spinneret plate comprises a metal nozzle plate having at least one hole formed therein and a metal hollow tube or pipe press fit mounted in said hole. The upper and lower ends of the pipe are shaped to conform to the inlet and outlets of the nozzle plate. The press fitting procedure may be achieved by heating the nozzle plate, preferably composed of steel, inserting the hollow pipe, also preferably composed of steel, into the hole, and thereafter cooling the plate thereby producing a pipe press fit mounted in the nozzle plate hole.

Brief Description of the Drawings

Figures 1 and 2 illustrate in cross section nozzles prepared in accordance with prior art techniques.

Figures 3-5 illustrate in vertical cross section different embodiments of spinneret plates of the present invention, with the same reference numerals representing corresponding parts in the embodiments.

Figures 6-8 are drawings illustrating the sequential preparation of the spinneret plates of the embodiments shown in Figs. 3-5.

Description of the Preferred Embodiments of the Invention

A spinneret plate 1 constructed in accordance with the present invention in the embodiment shown in Fig. 3, comprises a nozzle plate 2 of a predetermined thickness, and a hollow tube or pipe 4 of a desired diameter which is mounted in or attached to the nozzle plate 2 by press fitting or the like, into a hole formed in the plate. The interior of the pipe 4 defines the nozzle hole for the spinneret.

Preferably, the nozzle plate 2 is made of a stainless steel plate (SUS 304), and typically has a thickness of 4 mm when melt spinning pitch carbon fibers or the like. The hollow pipe 4 may also be made of a stainless steel and, by way of example, may have the following sizes: inner diameter of 0.55 mm and an outer diameter of 1.5 mm. In addition, although the nozzle holes formed by the hollow pipes 4 can be disposed in any desired arrangement, they preferably are arranged in one or more concentric rows in the circumferential direction around the center of nozzle plate 2, when a melt spinning pitch carbon fibers, for example.

Spinneret plates 1a and 1b in accordance with other embodiments of the invention are illustrated in Figs. 4 and 5. In the spinneret plate 1a shown in Fig. 4, the hollow pipe 4 mounted in nozzle plate 2, the pipe 4 does extend through the entire thickness of the nozzle plate 2, but is provided through substantial portion (e.g., about half) of the thickness of the nozzle plate 2 on the outlet side thereof. An enlarged, tapered inlet 6 in the upstream side of the nozzle plate 2 guides the molten spinning material into the nozzle hole defined by the hollow pipe 4.

The spinneret plate 1b shown in Fig. 5 has a structure substantially similar to that of the spinneret plate 1a of Fig. 4. The spinneret plate 1b, however, differs from the spinneret

plate 1a in that the hollow pipe 4 projects slightly beyond the outlet surface of the nozzle plate 2 so as to form a projecting nozzle. The spinneret plate 1b with such a projecting nozzle provides an excellent shedding effect between the molten spinning material and the spinneret plate. In order to reinforce the projecting part of the hollow pipe 4 on the outlet side of the nozzle plate 2, it is preferable to secure the projecting part to the nozzle plate 2 by forming brazed reinforcing shoulders 8.

Spinneret plates 1, 1a, and 1b may be manufactured by processes which will be described with reference to the sequential drawings of Fig. 6, 7 and 8.

Referring first to Fig. 6, the nozzle plate 2 is provided with a preliminary hole 4' bored at the position at which the spinning nozzles is to be formed, as illustrated in 6(a). The hollow pipe 4 is press-fitted into the prepared hole 4', as illustrated in 6(b). The press-fitting operation may be carries out as follows. When a stainless steel pipe with an outer diameter of 1.5 mm and an inner diameter of 0.55 mm, for example, is employed as the hollow pipe 4, the preliminary hole 4' is finished so as to have an inner diameter of 1.5 mm, and the nozzle plate 2 is heated to between 150 and 300^{o}C to expand the hole slightly. The hollow pipe 4 is maintained at room temperature, or is cooled at lower temperature and is inserted into the preliminary hole 4', and then the nozzle plate 2 is cooled resulting in an interference fit. Subsequently, if the hollow pipe 4 projects from the nozzle plate 2, the projecting parts of the hollow pipe 4 are ground so that the end of the hollow pipe 4 is flush with the upper and lower surfaces of the nozzle plate 2, as illustrated in 6(c).

Fig. 7 illustrates the method of manufacturing the spinneret plate of Fig. 4. In this embodiment, the preliminary hole illustrated in 7(a) formed in the nozzle plate 2 may be formed: by drilling a small-diameter part 4' through the plate 2 and then enlarging the inlet side of the hole at 4''' and tapering the section between 4' and 4''' forming transition

section 4''. The hollow pipe 4 is press-fitted into the small-diameter part 4 of the preliminary hole in the same way as above method described with reference to Fig. 6, resulting in the assembly illustrated in 7(b). The part of the hollow pipe 4 projecting upward from the small-diameter part 4' of the preliminary hole is then expanded toward the transition part 4" of the preliminary hole to bring it into close contact with the wall surface of the transition part 4" (see Fig. 7(c)). Then the part of the hollow pipe 4 projecting beyond the outlet side of the nozzle plate 2 is ground so that the end of the hollow pipe 4 is flush with the surface of the nozzle plate 2. In addition, if desired, the part of the hollow pipe 4 in close contact with the transition part 4'" of the preliminary hole can be ground by a special tip to provide a smoother transition from section 4'" to the passage in nozzle 4. Thus, the large-diameter part 4'" and the transition part 4" in combination form the inlet hole 6 as illustrated in 7(d).

Fig. 8 illustrates the method of manufacturing the spinneret plate 1b with a projecting nozzle. The step of machining the preliminary hole in the nozzle plate 2 and the step of press-fitting the hollow pipe (see Figs. 8a and 8b, respectively) are similar to those described with reference to Fig. 7. This method differs from the previous method only in that the hollow pipe 4 projects further beyond the outlet side of the nozzle plate 2. The upper end of the thus press-fitted hollow pipe 4 is expanded toward the transition part of the preliminary hole. In addition, brazing 8 is applied to the outer peripheral portion of the projecting part of the hollow pipe 4 (see Fig. 8c). This brazing operation may be effected by a conventional method, e.g., by heating in an electric furnace. Upon the completion of the brazing operation, both the part of the hollow pipe projecting from the outlet side of the nozzle plate 2 and the brazed part of the hollow pipe 4 are ground to a predetermined configuration. Finally, if desired, the part of the hollow pipe 4 in close contact with the transition part of the prepared hole can be ground by a special tip to cut off the bent part forming the plate 1b illustrated

in 8d.

The present invention thus provides spinning nozzle a ready-made hollow pipe which has excellent roundness and straightness. Therefore it is possible to provide an accurate spinneret plate which has a spinning nozzle with an extremely smooth inner surface and a uniform aspect ratio. Further, according to the invention, it is possible to provide a multi-nozzle spinneret plate provided with a plurality of such accurate nozzle holes. The employment of the spinneret plate in accordance with the present invention makes it possible to spin pitch carbon fibers or the like stably over a long period of time.

CLAIMS

1. A spinneret plate for melt spinning comprising (a) a nozzle plate having a hole formed therein and (b) a hollow pipe of a predetermined inner diameter mounted in said plate for conducting melt spinning material.

2. The spinneret plate of claim 1 wherein said pipe is press fit mounted in said hole of said plate.

3. The spinneret plate of claim 2 wherein the opposite ends of the pipe are flush with the upper and lower surface of the said nozzle plate.

4. The spinneret plate of claim 2 wherein the pipe extends only through a lower portion of the nozzle plate and the hole in an upper portion of the nozzle plate is larger in diameter than the pipe.

5. A method of manufacturing a spinneret plate for melt spinning comprising the steps of (a) forming a preliminary hole in a metal nozzle plate; (b) press-fitting a hollow metal pipe into said preliminary hole, and (c) shaping the end parts of the hollow pipe press-fitted into said preliminary hole into predetermined configurations.

6. The method as defined in claim 5 wherein the upper and lower ends of the pipe are shaped to be flush with the upper surface and lower surface, respectively, of the nozzle plate.

7. The method of manufacturing a spinneret plate for melt spinning according to claim 5, wherein said press-fitting step is carried out by: heating said nozzle plate to between 150 and 300^{o}C; maintaining said hollow pipe at room temperature or cooling it at a lower temperature; inserting said hollow pipe into said nozzle plate; and cooling said nozzle plate.

8. The method of manufacturing a spinneret plate for melt spinning according to claim 5, wherein said preliminary hole has a large-diameter inlet part and a small-diameter part, and said hollow pipe is press-fitted into said small-diameter part.

9. The method of manufacturing a spinneret plate for melt spinning according to claim 8, wherein said hollow pipe is positioned so as to project below the lower surface of said nozzle plate.

10. The method as defined in claim 5 wherein said nozzle plate and said pipe are made of steel.

FIG. 1

PRIOR ART

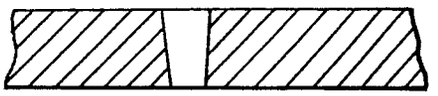

FIG. 2

PRIOR ART

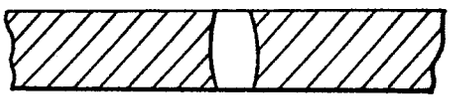

FIG. 3

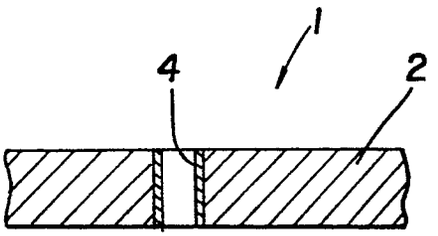

FIG. 4

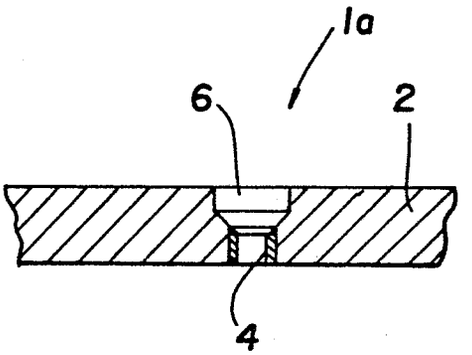

FIG. 5

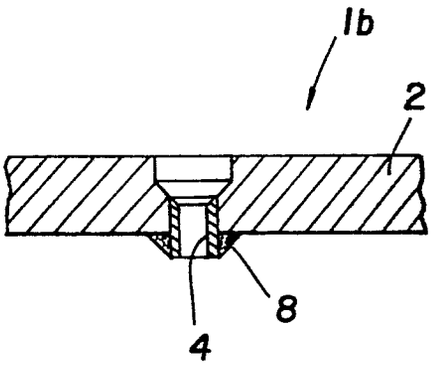

FIG.6a

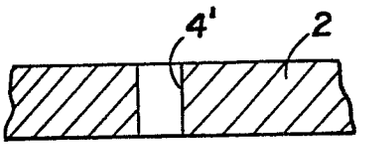

FIG.6b

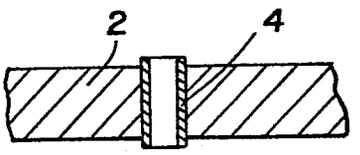

FIG.6c

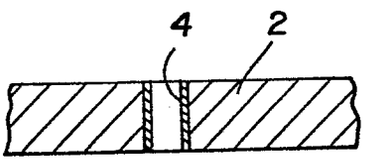

FIG.7a

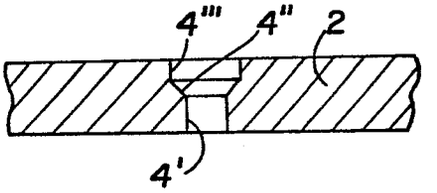

FIG.7b

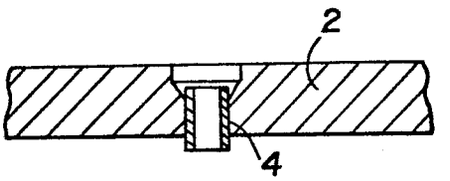

FIG.7c

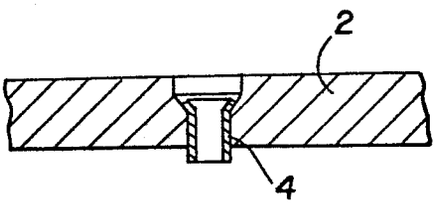

FIG.7d

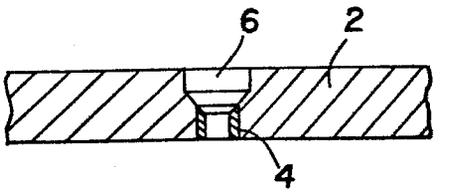

FIG. 8a

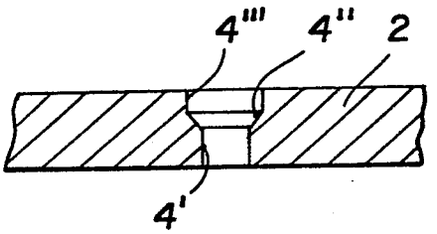

FIG. 8b

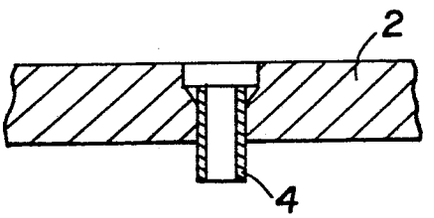

FIG. 8c

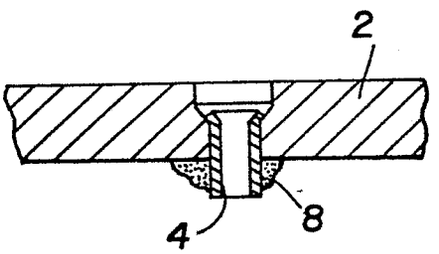

FIG. 8d