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PREVENTION OF DIE-FACING OF THERMOPLASTIC FILAMENTS

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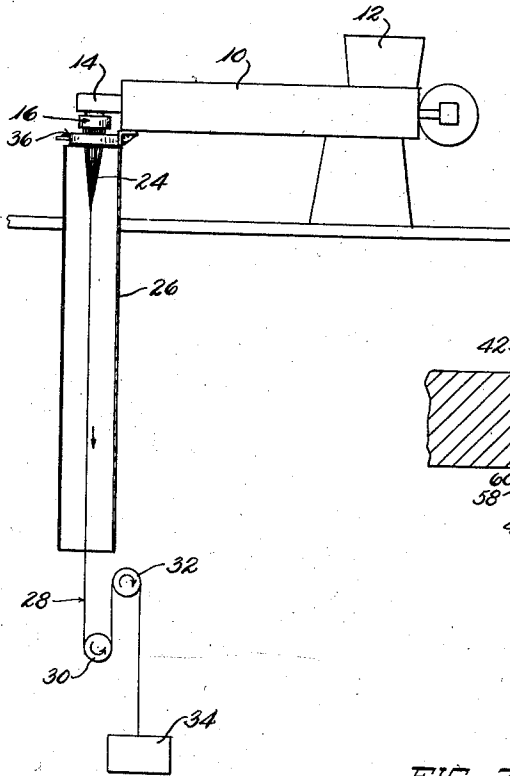


FIG-1

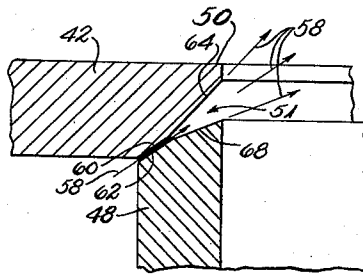


FIG-3

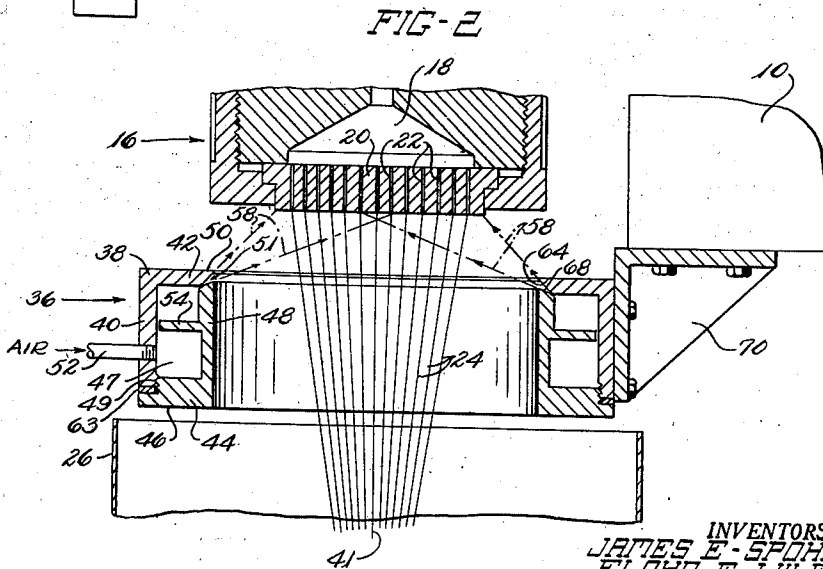


FIG-2

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PREVENTION OF DIE-FACING OF THERMO- PLASTIC FILAMENTS

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2 Claims. (Cl. 18—8)

This invention relates to the prevention of "die-facing" in the melt-spinning of filaments from thermoplastic resins.

In the melt-spinning of thermoplastic filaments, the semi-molten resin filaments emerging from the holes in the dies tend to cling to the edges of the holes on the one side or another, and to work their way up against the face of the die so that eventually the die becomes fouled. This phenomenon is known as "die-facing." This fouling of the die-face cuts down on production, and also spoils the filaments by periodically breaking off from the face of the die and becoming entangled in the filaments. Various means have been proposed to prevent this die-facing phenomenon. For instance, it has been proposed to provide a shielded enclosure about the die, and to keep this flushed at all times with an inert gas, it being thought that the die-facing was partly due to oxidation of emerging filaments. Likewise it has been proposed to make the die of special materials, or to coat the die with special materials, such as polytetrafluoroethylene, silicones and the like. These devices have either not proven very successful or have not been practical to operate. In particular, the use of an inert gas enclosure, while somewhat effective, interferes with the operation and management of the spinning apparatus.

Accordingly it is an object of this invention to provide a novel means for preventing die-facing in the melt-spinning of thermoplastic filaments.

Another object is to provide such means which will be inexpensive.

A further object is to provide such means which will not be cumbersome and which will not interfere with the operation and adjustment of the filament spinning equipment.

The invention will be described in connection with the annexed drawing, in which:

Fig. 1 is an overall schematic view of a filament extruding machine with associated apparatus adapted for the practice of this invention,

Fig. 2 is a detailed sectional view of a portion of the apparatus in Fig. 1, and

Fig. 3 is a greatly enlarged sectional view of the air passages in the apparatus shown in detail in Fig. 2.

Synopsis of the invention

The above and other objects are secured, in accordance with this invention, by impinging a jet of air upon the face of a die from which thermoplastic filaments are being melt-spun, the direction of the jet having at least a small component in a direction upward and against the face of the die. A priori, it might be expected that the jet would drive the filaments against the die and thus aggravate the die-facing problem. Surprisingly, however, the jet substantially eliminates the die-facing tendency of the freshly spun filaments. Without absolute commitment to this theory, it is thought probable that the air jet cools a microscopic surface film on the emerging filament, so as to reduce its tackiness and its tendency

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to cling to the die orifice. In the practice of this invention the jet is usually directed against the die-face obliquely from one side so that the orifice from which the jet emerges will not become engaged with the filaments as they pass downwardly away from the die. In the most preferred form, since the spinning die and the array of filaments emerging therefrom are in general circularly symmetrical about the vertical axis of the die, the jets employed in this invention are provided by means of an inwardly directed annular jet orifice coaxial with the axis of the extruding die and located in close proximity to the periphery of the die so that the annular jet converges in all directions inwardly and upwardly against the face of the die to provide a gentle to vigorous flow of air about the filaments at the very points at which they issue from the orifices in the die. Melt-spinning operations carried out in this way are substantially free from die-facing difficulties, it being possible to operate the apparatus for extended periods of time without having to break up any die-facing deposits.

The resins to be extruded as filaments in the practice of this invention

The present invention is applicable to the melt-spinning of any of the thermoplastic resins which are conventionally processed in this manner. The melt-spinning process consists in general in a procedure in which a thermoplastic resin is melted and placed under pressure to force the molten resin through orifices in a die to form filaments. The resins which may be processed in this manner include the orientable-crystalline resins, such for instance, as the nylon resins, which are high molecular weight condensation products of dicarboxylic acids with diamines, or of amino acids alone, or of mixtures of amino acids with dicarboxylic acids and diamines. The nylon resins are particularly adapted for use in this invention, and outstanding results have been obtained therewith. However, the invention is also applicable to the processing of other crystalline resins, such, for instance, as the vinylidene chloride resins, which are polymers of vinylidene chloride and copolymers thereof with up to 20% of other unsaturated compounds copolymerizable therewith, such for example, as vinyl chloride, vinyl fluoride, vinyl acetate, styrene, esters of acrylic and methacrylic acids such as methyl methacrylate, and ethyl methacrylate, acrylonitrile, vinyl type ethers and ketones such as methyl vinyl ether, methyl vinyl ketone and related compounds such as methyl isopropenyl ketone and the like. For a more complete list of compounds known to copolymerize with vinylidene chloride to produce crystalline resins which can be processed as described herein see Krczil "Kurzes Handbuch Der Polymerisation Technik," vol. II "Mehrstoff Polymerization" Edwards Bros. Inc. page 739, the items indented under "Vinyliden Chlorid." Likewise there may be employed aromatic polyester resins such as "Terylene" or "Dacron" which are condensation products of terephthalic acid and ethylene glycol; polyethylene; and polymers of 2,3-dichlorobutadiene-1,3 such as described in the patent to Kuhn 2,451,195.

Apparatus suitable for the practice of this invention

An apparatus suitable for the practice of this invention is shown in Figs. 1 and 2 as comprising a melt-extrusion machine 10 having a hopper 12 into which a thermoplastic resin may be supplied, the extruder having a head 14 through which the extruder forces molten thermoplastic materials to a die assembly 16. As shown in Fig. 2, the die assembly more particularly comprises a conical distributing passage 18 into which the molten resin is forced by the extruding machine 10, which passage heads downwardly to the upper side of a die plate 20 having a plu-

ality of spinning orifices 22 formed therein. The molten resin is extruded through the die orifices 22 and emerges therefrom as an array of filaments 24 which pass downwardly through a cooling and stretching tower 26 in which the filaments are reduced in size to some extent and cooled to solid state. The filaments emerging at 28 from the cooling tower pass downwardly to a revolving capstan 30 and over a second revolving capstan 32 to a winding drum 34 on which the filaments are wound up on a suitable reel for further processing.

In order to prevent the phenomenon of die-facing on the lower surface of the die plate 20, there is provided, in accordance with this invention, an annular jet 36 disposed concentrically of the die-face and closely adjacent to periphery thereof. This jet directs a converging stream of cooling air from all sides upwardly against the face of the die plate 20, which current of air (as has been discovered by this invention) has the effect of substantially completely preventing the phenomenon of die-facing.

The annular jet 36 more particularly consists of an outer main body member 38 comprising a cylindrical wall 40 coaxial with the axis 41 of the die and a discoidal inwardly directed flange portion 42. A core member 44 is disposed within the outer member 38 and comprises an outwardly directed flange 46 threaded at 49 into the bottom of the wall 40; and a cylindrical interior wall portion 48 concentric with the axis 41 and extending upward to the lip 50 of the flange 42 so as to define therewith the annular gap or nozzle 51. Air is supplied through a pipe 52 into the space between the walls 40 and 48 and flanges 42 and 46 which define a plenum chamber 47 for receiving this air and supplying it to the annular nozzle 51. A fin 54 extends outwardly from the wall into close proximity with the wall 40 to serve as a baffle to distribute the air evenly on all sides of the nozzle 51. Air leaving the nozzle 51 forms a jet directed inwardly from all sides and upwardly as indicated by the arrows 58 upon the die-face 20, and prevents die-facing of the fibers 24 as they emerge from the orifice 22.

Referring now to Fig. 3, in the particular embodiment shown, the surfaces 60 and 62 of the flange 42 and wall 48, which define the throat of the nozzle 51, are parallel frusta of cones which have their apices directed upwardly and which are coaxial with the axis 41 of the die. Their generating lines make an angle of approximately 55° with the axis 41, and the surfaces 60 and 62 normally have a clearance from each other of approximately .026 inch. This clearance may be adjusted by threading the core member 44 into and out of the threads 49. A shim-gasket 63 is provided to regulate this clearance and provide a seal for the air in the chamber 47. The length of the portion 60, measured toward the apex, is approximately 3/32 inch. The surface 64 of the flange 42 is frustoconical with an apical angle of 43° with the axis 41 and the surface 66 of the wall 48 is frustoconical with an apical angle of approximately 68° with the axis 41, so that the portion of the nozzle 51 beyond the initial parallel-walled throat section defined by the surfaces 60 and 62 diverges slightly so as to approximate the ideal divergent outline desirable in nozzles. The air streams 58 flowing from the nozzle 51 play upwardly upon the die-face 20 at angles roughly between 20° and 50°, the angles being measured from the face of the die 20 to the lines from the face to the nozzle 51.

The assembly 36 may be supported on the apparatus in any suitable manner, for instance by means of a bracket 70 mounted on the extruding machine 10 and carrying the assembly 36 at its outboard end, or by supports at the top of the cooling tower 26.

In one example of operation, air at a pressure of approximately 3.0 pounds per square inch gauge is supplied to the pipe 52, corresponding to a velocity through the jet 51 of approximately 100 feet per minute. The distance from the throat of the jet 51 to the axis 41 of the die was approximately 2.5 inches and the throat was approximately 1.25 inches below the face of the die 20.

Under these conditions polycapramide nylon was extruded at a temperature of 260° C. through the orifices 22 and down column 26 to form filaments .002 inch in diameter which were wound up continuously on the winder 34. Die-facing was practically eliminated; in repeated runs covering 9 to 11 hours each over several weeks, no instances of die-facing occurred. In the absence of the air jet, production was interrupted as often as two or three times an hour by die-facing.

It will be understood that the dimensions of the apparatus and the conditions of operation cited above are illustrative only, and may be varied over wide ranges. Excellent results have been secured with the use of air pressures as high as 7 and as low as 0.5 pounds per square inch; with clearances between the surfaces 60 and 62 of .005 inch to .030 inch; and with filaments varying from .002 inch to .018 inch in unstretched diameter. Wider ranges than these are possible within the scope of this invention.

From the foregoing general disclosure and detailed specific description, it will be evident this invention provides a novel, effective, economical method for the prevention of die-facing in the extrusion of thermoplastic filaments. The apparatus employed is simple and in no way interferes with the management or operation of the spinning equipment.

What is claimed is:

1. An apparatus for melt-spinning a thermoplastic resin into filaments, comprising a die having a plurality of orifices, means for supplying fused resin to said die under pressure to force the fused resin through the orifices to form the resin into an array of filaments, and an annular nozzle disposed concentrically of the face of said die and closely adjacent to the periphery thereof, and surrounding said array of filaments and arranged to direct a jet of air radially inwardly from all sides of said die and upwardly against said die in the region of the emergence of said filaments from said die.

2. An apparatus for melt-spinning a thermoplastic resin into filaments, comprising a die having a plurality of orifices, means for supplying fused resin to said die under pressure to force the fused resin through the orifices to form the resin into an array of filaments, and an annular nozzle disposed concentrically of the face of said die and closely adjacent to the periphery thereof, and surrounding said array of filaments and arranged to direct a jet of air radially inwardly from all sides of said die and upwardly against said die in the region of the emergence of said filaments from said die, said annular nozzle comprising an annular plenum chamber coaxial with said array of filaments and having an annular gap in the walls thereof concentric with said array of filaments and directed radially inwardly and upwardly against said die, and means for supplying air to said plenum chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

2,252,689	Bradshaw	Aug. 19, 1941
2,542,973	Abernathy	Feb. 27, 1951
2,605,502	Culpepper	Aug. 5, 1952
2,730,758	Morrell	Jan. 17, 1956