United States Patent [19]

Ruf

[11] **3,740,025**

[45] **June 19, 1973**

[54] **APPARATUS FOR CONVEYING, MIXING AND HOMOGENIZING HIGH VISCOSITY MATERIALS**

[75] Inventor: **Eberhard Ruf,** Bergen-Enkheim, Germany

[73] Assignee: **Zimmer Aktiengesellschaft Planung und Bau von Industrieanlagen,** Frankfurt am Main, Germany

[22] Filed: **Dec. 16, 1971**

[21] Appl. No.: **208,701**

[30] **Foreign Application Priority Data**

Dec. 18, 1970 Germany ..... P 20 62 469.5

[52] **U.S. Cl.** **259/7**

[51] **Int. Cl.** **B01f 7/24**

[58] **Field of Search** 259/7, 8, 23, 24, 259/43, 44; 23/252

[56] **References Cited**

UNITED STATES PATENTS

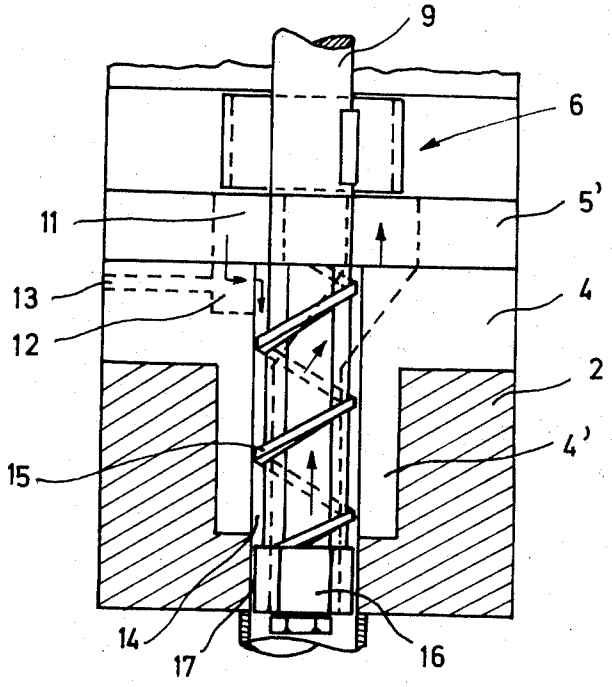
3,051,455	8/1962	Magester	259/8
3,207,486	9/1965	Rosenthal	259/8
3,220,801	11/1965	Rill	259/8
3,420,506	1/1969	Gurley	23/252

Primary Examiner—Robert W. Jenkins
Attorney—Molinare, Allegretti, Newitt & Witcoff

[57] **ABSTRACT**

In a pump for conveying, mixing and homogenizing a highly viscous material wherein an additive is to be admixed, improved mixing is obtained by providing a casing communicating with the pump outlet. The casing contains a rotatable worm synchronously connected to the pump shaft. Rotation of worm induces mixing of the additive and viscous material. The improved pump is particularly suited for linear high polymers or copolymers.

10 Claims, 3 Drawing Figures



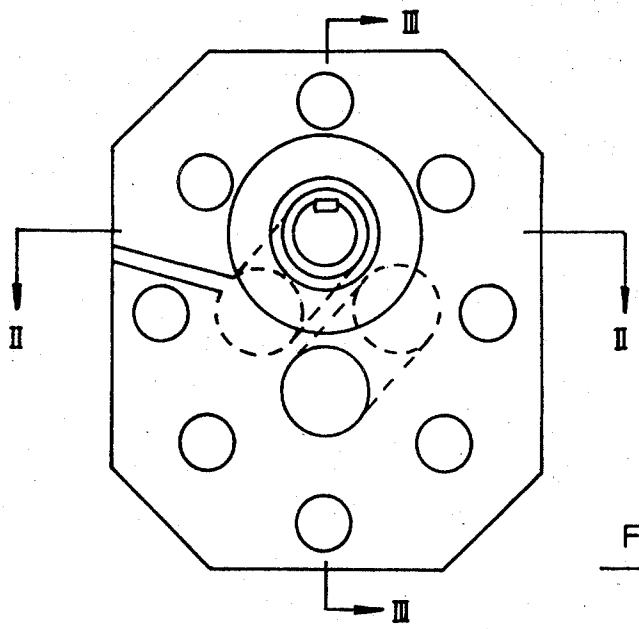


FIG. 1

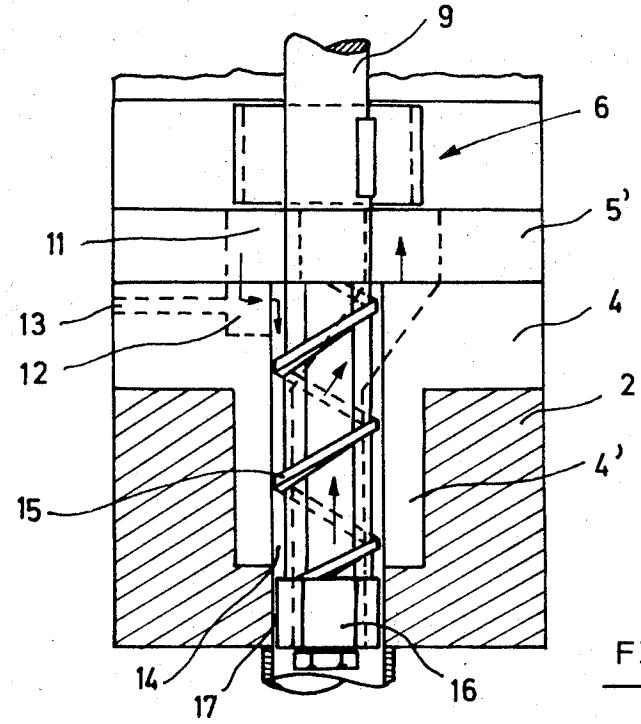


FIG. 2

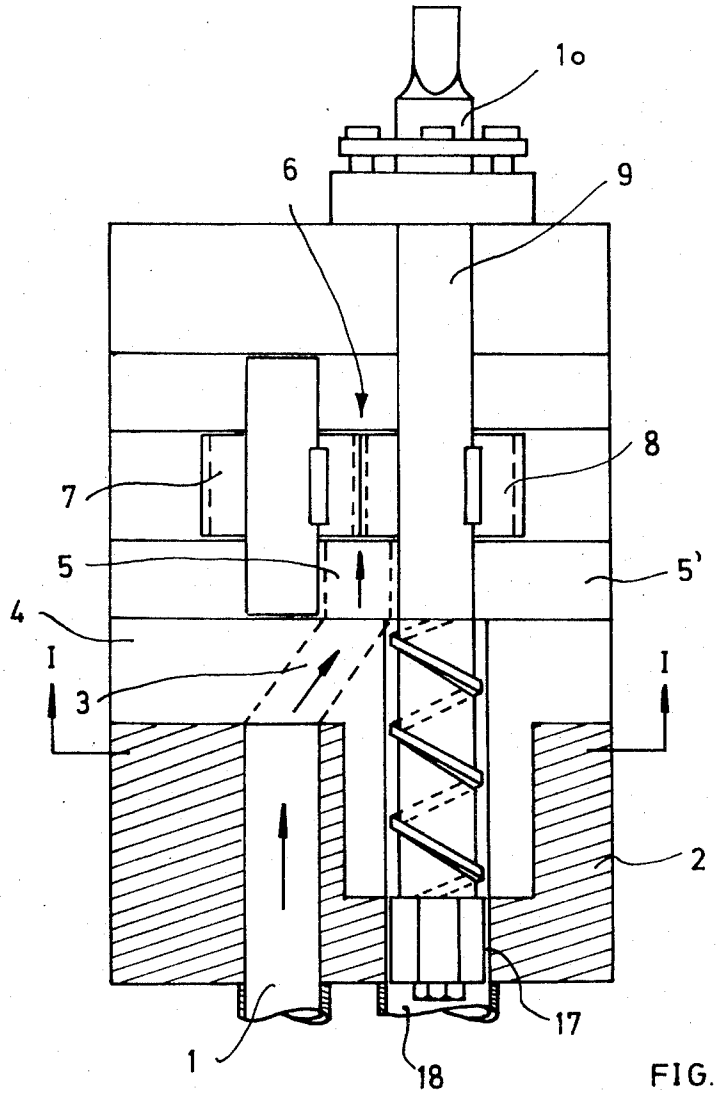


FIG. 3

APPARATUS FOR CONVEYING, MIXING AND HOMOGENIZING HIGH VISCOSITY MATERIALS

BACKGROUND OF THE INVENTION

The invention relates to a device for the conveying, mixing and homogenizing of a highly viscous material. In particular, this invention relates to a device for conveying, mixing, and homogenizing a melt of synthetic, linear high polymers and their copolymers containing an additive, with a gear wheel pump which has connected with it, in series, on the pressure side, a space intended for the addition of an additive stream and a mixing part.

In present spinning processes for the production of threads, fibers, cables, bands, etc. of synthetic linear high polymers, a highly viscous melt is supplied by means of one or more suitable dosing or spinning pumps. In general the polymers are processed through gear wheel pumps and a spinning nozzle block, wherein the polymer is pressed through sieve arrangements and supporting plates situated in the block. By means of subsequent nozzle openings provided frequently by multi-hole spinning nozzle plates, the polymers are formed, for example, into threads. The spinning pump has the function, first, of supplying the melt in exactly apportioned time-constant amounts to the spinning nozzle plate and, second, of building up the high pressure required for the spinning out of the threads and the like, i.e., up to 120 atmospheres excess pressure (gauge pressure) and above.

As a consequence of the high viscosity of the thread-forming material and the laminar flow conditioned by it, there develop within the product lines, flow threads of differing flow velocity and, therefore, a heterogeneous staying-time spectrum of the melt in the product line. This has the consequence that, under unfavorable conditions, there occurs, in part, considerable temperature differences within the melt stream since the flow threads flowing slowly on the tube wall are more strongly heated, first because of their position and, second, because of their greater staying time, as compared to the more rapidly flowing core stream threads. These velocity differences lead to various disadvantageous alterations of the melt, for example, thermal decomposition. Especially disadvantageous is the fact that the differing flow velocity of the flow threads remains substantially preserved even after the passage through the sieve arrangement and the supporting plates and leads. This results in differing properties in the threads or the like emerging from the spinning openings, depending on their position in the multi-hole spinning nozzle plate. This is especially troublesome if the melt contains an additive such as a pigment, the admixture of which in many cases takes place only shortly before the spinning-out, i.e., before the emergence of the melt from the spinning nozzles. In this case the individual threads emerging from the spinning nozzles of a multi-hole spinning nozzle plate differ considerably from one another in their additive concentration. A thread assembly consisting of such individual threads, would be altogether unsuited for further processing.

In order to meet this difficulty, it has been proposed to achieve a substantially uniform flow velocity and mixing of the thread-forming material by means of suitable installations in the product line. Thus, according to DAS 1,203,417 (German published patent application) there is shown a device which provides, in the

product line, a stationary distributor body with channels for the subdivided feed of the thread-forming material into a collecting space before the filter pack, in which the channels of the distributor body cross each other before issuing into a common collecting space. Through this distributor body, the melt stream is to be branched into several partial streams which are guided in such a way that they are brought into contact with one another in a number of over-cutting points. Through these intersection points, there is thought to be achieved a thorough mixing and a compensation of the differing velocities of the partial streams and, as a result, mixing the individual stream threads. Before the distributor body, there is provided, a space for the addition of an additive stream, in which the additive is to be admixed with the melt stream with the aid of the distributor body.

A mixing of the additive with the melt stream, however, cannot be achieved with this proposed static mixer. In front of the stationary distributor body, the stream threads of the melt stream move with differing velocities, so that the additive is not received uniformly from all the stream threads but by one or two stream threads. There is not achieved at the end of the distributor body, a homogenized melt stream even if, in pursuance of the thought underlying this published patent application, each partial cam is in contact with all the other partial streams at least one crossing point. If, for example, a crossing point is considered at that point at which two partial streams meet, in the laminar flow present here, it clearly proves that the partial streams again divide. In each case, the half of the one partial stream and the half of the other partial stream flow onward with formation of a clear line of separation between the two streams.

The achievement of a uniform staying-time spectrum of the melt stream is not possible with this known static mixer. To achieve this, first, the edge stream threads flowing more slowly on the wall of the product line would have to be conducted inward and, secondly, the more rapidly flowing core stream threads would have to be conducted outward. This, however, does not occur with the known device. As a further disadvantage, the proposed distributor body presents an appreciable flow obstacle and because of the high spinning pressure required, considerable demands have to be placed on the gear wheel spinning pump.

SUMMARY OF THE INVENTION

Underlying this invention, therefore, is the problem of overcoming these drawbacks and of creating a device of the category mentioned at the outset. This device makes possible in a simple manner a homogenizing of the melt stream and, if need be, a mixing of the melt stream with an additive stream, immediately before the spinning-out, with very small space requirement.

According to this invention, these problems are solved in a device of the category mentioned, by a mixing part that is a worm driven synchronously with the gear wheels of the gear wheel pump in a space closely surrounded by a casing. A substantial advantage of the device of this invention is that immediately after the addition of an additional stream and immediately before the spinning out of the stream, through the driven worm inside the mixing part, there arise drag, pressure and splitting flows thereby bringing about a dynamic mixing process. Through the active effect of the driven

worm on the melt stream, the individual stream threads are altered, in respect to their position and velocity, in the product line during their passage through the mixing portion. After emergence from the mixing portion, there is achieved a uniform staying-time spectrum in the melt stream. An admixed, additional stream is mixed uniformly and completely into the melt stream through the intensive mixing action of the shearing forces arising at the path edges of the worm. The highly viscous material emerge in uniform composition from all the nozzle openings leading to a plurality of individual threads of the same nature and quality.

The high design accuracy of the gear wheel pump required for the melt spinning process remains fully preserved according to the invention. Through the installation of the mixing part on the pressure side of the gear wheel pump, the pressure built up by the gear wheel pump is broken down to a certain degree with transformation of pressure energy into flow energy for the purposes of intensive homogenization and thorough mixing.

The mixing part, accordingly, can be laid out in its geometry in such a way that, at a certain length-diameter-ratio and a certain turning rate, it exerts an optimal mixing and homogenizing function. Since the drive of the worm, according to the invention, is accomplished synchronously with the gear wheels of the gear wheel pump, the turning rate of the gear wheel pump always corresponds to the turning rate of the worm. As a result, there is fully preserved, within certain turning rate ranges, the optimal mixing and homogenizing effect through the constructive execution of the worm. By means of a single, suitable regulating gear, the turning rate of the gear wheel pump is always controlled in common with the turning rate of the mixing portion. When utilized at 100 percent filling of the suction side of the pump, the mixing part, engaged at outlet end of the gear wheel pump, requires no higher pressure than is needed in the case of corresponding devices without a mixing part.

The drive of the mixing part takes place by a directly driven gear wheel shaft on the pressure side of the gear wheel pump. The pump is provided with an extended shaft end, to which the worm is fastened securely against turning coaxially. With this solution, as simple as it is effective, a device that is not subject to malfunctioning is created. This device is constructed with utmost saving of space and thus makes possible its use in very closely dimensioned spinning installations.

To the mixing part there falls, as already mentioned above; only the function of mixing and homogenizing, since the pressure required for the spinning out is built up by the gear wheel pump alone. Thus, the execution or turning of the worm in casing can be exclusively developed with a view to an optimal mixing and homogenizing function. According to this invention, in an execution or process well suited for this, the inner wall of the casing is constructed essentially cylindrically and provided with worm passages. Accordingly, the shearing effect important for the mixing and homogenization takes place, not only between the path or band edges of the worm and a smooth casing wall, but to a reinforced degree between the path edges of the worm and the path edges of the worm courses situated in the casing wall. Likewise for the reinforcement of the functions mentioned, the worm courses of the casing can be multiple and/or be constructed in opposite direction to the worm courses of the worm.

A further advantageous embodiment of the invention provides that the conveyance direction of the worm is directed oppositely to the flow direction of the product stream. As a consequence of the conveyance effect of the worm, acting countercurrently to the flow direction of the product stream, there arise, on the fillet or helical edges, strong splitting flows, which result in an intimate and thorough mixing and homogeneity of the melt. The effect of the shearing forces is advantageously further intensified if the fillets or edges of the worm are interrupted by longitudinal grooves.

For the promotion of the mixing action of the worm, one embodiment of the device of the invention provides that the worm is coaxially and untwistably connected with a polygonal added piece surrounded by a cylindrical casing with formation of narrow gaps. After leaving the worm casing proper, the melt is here subjected to the action of the flat or very nearly flat surfaces of the polygonal added piece. For example, a hexagonal added piece, rotating in a cylindrical casing, subjects the polymer to high pressure, as it is pressed through small gaps between the chambers formed by the surfaces of the rotating polygon and the stationary element. The effect of the wedge-shaped spaces between the rotating surfaces and the wall of the casing, in cooperation with the narrow gaps, leads to vigorous churning movements, whereby the melt effectively undergoes a further intermixing in a narrow space.

The device of the invention is characterized, according to an advantageous embodiment, in that it is composed of a gear wheel pump constructed in a known manner. An intermediate plate is fastened to the pump and is provided with a casing of a worm. A closure plate is fastened to the worm casing thereby enclosing the casing and the polygonal added piece, entirely or partially. It is advantageous if an intermediate plate is provided in the zone of the part receiving the casing of the worm. Preferably, a cylindrical addition reaches into a complementarily constructed recess of the closure plate. With use of the known construction elements for the gear wheel pump and the intermediate and closure plates constructed according to the invention there is hereby proposed a construction, as efficient as it is simple, which, besides trouble-free operation, fulfills the important small space requirement for the installation.

DESCRIPTION OF DRAWINGS

Details of the invention are more particularly explained in the following description of the drawings accompanying this specification.

FIG. 1 shows a section along the Line I—I of FIG. 3;

FIG. 2 shows a section along the Line II—II of FIG. 1 and

FIG. 3 shows a section along the line III—III of FIG. 1.

In a melting apparatus (not shown) the thread-forming material, which was supplied, for example, in granulate form, is continuously melted into a highly viscous melt stream. This viscous melt is fed by a suitable manner into a feed line 1 to a closure plate 2 (FIG. 3). The melt passes, after leaving the feed line 1, through an obliquely running bore 3 in an intermediate plate 4 into a passage bore 5 situated in an intermediate plate 5' and from there to the suction or inlet side of the gear wheel pump 6 of the device. The gear wheel pump 6

consists, in the example of execution of the device of the invention shown, of gear wheels 7 and 8, which are directly driven by means of the shaft 9 and a connection piece 10. From the suction side of the gear wheel pump 6, the melt is conveyed over the pressure side through a bore 11 (FIG. 2) situated in the intermediate plate 5' into a hollow space or outlet 12 of the intermediate plate 4. Through a bore opening 13, an additive stream can be fed into a hollow space 12. The hollow space 12 of the intermediate plate 4 is in direct communication with a casing 14. The casing 14 received a worm 15, which, as well as a polygonal added piece 16 is mounted, unturnably, on the extended end of the shaft 9. The intermediate plate 4 has, in the zone of the part receiving the casing 14 of the worm 15, a cylindrical added piece 4', which engages in a complementarily constructed recess of the closure plate 2. The closure plate 2 receives the casing 17 and the polygonal added piece 16. The melt is supplied by means of the gear wheel pump 6 over the hollow space 12 to casing 14 with the worm 15 and leaves the device through the casing 17 containing the polygonal added piece 16. A conduit 18 is connected to casing 17 and leads to a spinning nozzle pack known per se (not shown).

What is claimed is:

1. In a pump for conveying, mixing and homogenizing a highly viscous material such as a linear high polymer or copolymer having an inlet, an outlet, and a rotatable pump shaft wherein an additive is to be admixed with the viscous material, the improved pump construction which comprises

i. a casing having an inlet, outlet and casing wall said casing inlet communicating with the pump outlet,

ii. a rotatable worm having helical edges contained within said casing and synchronously connected to the pump wherein the edges of said worm are in close proximity to the inner casing wall, and

iii. means for introducing the additive to a liquid emanating from the pump discharge whereby the material and additive are initially admixed and are further mixed in the casing by the rotating action of said worm.

2. A pump according to claim 1 wherein said worm comprises a helical edge affixed to an extension of the pump shaft.

3. A pump according to claim 2 wherein the worm courses in the casing are orientated countercurrently to the worm courses of the rotatable worm.

4. A pump according to claim 1 wherein the inside wall of the casing is cylindrical and provided with a worm course.

5. A pump according to claim 4 wherein there are multiple worm courses.

6. A pump according to claim 1 wherein the conveying direction of the rotatable worm is countercurrent to the direction of liquid flow.

7. A pump according to claim 1 wherein the edges of the rotatable worm are interrupted by longitudinal grooves.

8. A pump according to claim 1 wherein a substantially planar polygonal piece having edges extending longitudinally to the casing axis is coaxially affixed to the end of the worm, and said edges of the polygonal piece are in close proximity to the inner casing wall.

9. A pump according to claim 1 wherein the pump comprises a gear wheel pump having a directly driven gear wheel pump shaft.

10. A pump according to claim 9 wherein said worm comprises a helical edge affixed to an extension of said directly driven shaft.

* * * * *