

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO EXTRUSION MOULDING MACHINES

(71) We, TOMI KIKAI KOGYO KABUSHIKI-KAISHA, a Japanese Corporation, of 16-4 Koyama 4-chome, Shinagawa-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to extrusion moulding machines and more particularly to extruders for melting or plasticizing resins or resinous compounds for moulding.

In the extrusion moulding operation, resin or resinous compound is fed from a hopper and thence to a screw conveyor of an extruder where the resin or compound is heated by a heater or by internal friction, whereupon the molten or plasticized resin emerges from a die. As is well known in the art, there are provided in such an extruder three zones, i.e., a (solid phase) feed zone, (a phase transition) compression zone and a (liquid phase) metering zone, which zones are formed by changing the root diameter of the screw, the least root diameter being at the feed zone.

In a conventional extruder such as is illustrated in Fig. 1, a screw 10 extends through a barrel 11 and is rotatably supported as a cantilever shaft at a rotatably driven end portion 12 having the smallest root diameter. A long cantilever screw has a tendency, when it is rotated within a cylinder or barrel, to whirl its free end and cause the screw thread to "bite" on the internal wall surface of the barrel. When a cantilever screw is driven to rotate from the narrowest portion where the material strength is least, there is a danger of the screw being broken at this portion during operation. Thus, the conventional screw 10 has to be driven through a reduction gear. When a screw of, for example, 35 mm. in diameter is used, the standard rate of extrusion is set at about 12 kg. at 100 r.p.m. The running of the screw at low speed is liable to cause unevenness in supply

of material due to a pumping action of a low speed screw conveyor.

A further type of conventional extruder is a vertical extruder as illustrated in Fig. 2, where an upright screw 13 is rotatably driven by a drive unit 15 from the lower end portion thereof where the root diameter of the screw is large, so that it may increase the torque to be transmitted. But such an extruder still has the disadvantages that the free end of the cantilever screw tends to whirl, as described above, and further the dismantling of the extruder is difficult, since this involves drawing out of the long screw, which may be restricted by the height of the building. Moreover, a vertical extruder needs a special means to seal the drive unit from molten resin, since the drive unit is arranged at the end towards which the resin is being urged under pressure.

Fig. 3 illustrates a further conventional type of extruder including a screw 16 which has gradually tapering root diameter towards both ends from the centre of the screw. In such an extruder, resin is fed from a pair of hoppers to extrude molten, mixed resin from a nozzle at the centre of the extruder. The screw 16 may be rotatably driven at both ends, but the ends are the narrowest portion, and there is thus the same danger of breakage of the screw at this portion as for the type of extruder illustrated in Fig. 1.

An object of the present invention is, therefore, to provide an extrusion moulding machine having improved extruder which at least partly overcomes the disadvantages mentioned above.

According to the invention, there is provided an extrusion moulding machine, comprising a screw extruder having a barrel with an inlet and at least one outlet for plasticisable material, and a screw rotatably extending through the barrel, wherein the screw

(a) has a larger diameter end adjacent to the or each outlet, the or each such end

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being provided with rotary driving means; (b) has a smaller diameter portion adjacent to said inlet;

(c) is provided at each end with a support; and

(d) is provided with a main thread arranged to urge plasticisable material from the inlet to the or each outlet and, on a portion of the screw beyond the or each outlet and between the outlet and the support at the end of larger diameter, a subsidiary thread of opposite hand to the adjacent main thread to act against leakage of plasticisable material.

The invention will be further illustrated, by way of example, by reference to the accompanying drawings, wherein:

Figs. 1 to 3 schematically show three types of conventional extruders (as previously explained);

Fig. 4 shows, partly in section, an embodiment of extrusion machine according to the invention;

Fig. 5 is an enlarged view of a screw used in the extruder of Fig. 4;

Figs. 6 and 7 are further enlarged fragmentary views of the screw shown in Fig. 5; and

Fig. 8 schematically shows another embodiment of an extruder of the invention.

Fig. 4 shows an extruder according to the invention having a screw 21 rotatably extending through a barrel 22. On the right hand side in Fig. 4, the screw 21 has its root diameter reduced to a minimum and is supported by a bearing 23, while on the left hand side the screw shank 24 is held by a sleeve 25 which in turn is rotatably supported by bearings 26 and 27. A pulley 28 which is connected to a motor (not shown), is fixedly mounted on the outer end of the sleeve 25 for driving the screw 21. The numerical reference 29 is applied to a thrust bearing.

Resin or resinous compound from a hopper 30 is fed at a predetermined rate by means of a screw feeder 31 to the screw 21 in the barrel 22 at the portion where the root diameter of the screw 21 is least. The numerical references 32 and 33 indicate a motor and a reduction gear, respectively, for controlling the drive of the screw feeder 31. The barrel 22 is provided with heaters 34, cooling water inlets 35 and outlets 36 and thermocouples 37 for controlling the temperature of the barrel.

The screw 21 is formed to provide a feed zone 38, a compression zone 39 and a metering zone 40. The minimum root diameter of the screw 21 is at the feed zone 38, while the maximum root diameter is at the metering zone 40. The resin is conveyed, heated and melted or plasticized by the screw 21, and a predetermined amount

of molten resin is forced to be continuously extruded from a die 41.

The screw 21 has, at the portion confronting the port of die 41, a plurality of cross slits on the surface thereof for providing a zone 42 for mixing the molten resin before its feed to the die. Adjacent to this mixing zone 42, the screw 21 is further provided with a thread 43 having an opposite hand, and a smaller pitch, to the thread of the screw 21. This oppositely-handed thread 43 serves to force back the molten resin toward the mixing zone 42, minimising leakage past the screw shank 24. The numerical references 44 and 45 are applied to an inlet and an outlet, respectively, of a suitable medium for controlling the temperature of the barrel 22 at a part where it carries the screw shank 24 so that the molten resin at the reverse thread 43 is kept at a suitable temperature and that the amount of leakage of the molten resin is properly controlled. There is also provided a thread 46 on the screw 21 between the feed zone 38 and the bearing 23, which is of the same hand but smaller in pitch with respect to the thread of the screw 21, so that the bearing 23 is protected from being contaminated by the material fed from the screw feeder 31.

In an example an extruder as illustrated in Fig. 4 was used for the extrusion of high-pressure polyethylene. The extruder had a screw of 35 mm. in diameter, and could be driven to rotate at a rate of 1500 r.p.m., at a throughput of 135 kg/h. If it is desired to obtain such a high rate of extrusion with a conventional extruder under the limit of screw speed at 100 r.p.m., it will be necessary to use a screw of large diameter of about 90 mm. to 100 mm. According to the present invention, however, it is unnecessary to use such a large screw. The use of a conventional, relatively slender screw having a diameter of about 35 mm. can reduce the manufacturing cost of the machine to 1/3; on the other hand the high rate of running of the machine such as employed above will improve the efficiency of the machine five times as high as the conventional machine.

Since the screw of the extruder according to the present invention is supported at both ends thereof and driving force is given to the screw from the larger diameter end, there is no fear of causing breakage of the screw by twisting or "biting" of the screw thread onto the barrel even if the screw is driven to rotate at high speed. In the machine of the invention, the action of the screw on the resinous material is to draw rather than push. In this instance, the force acting on the screw is tension, which permits maximum utilization of the material strength. As is well known, scrupulous

kneading of resinous material improves physical properties of the extruded products. In order to obtain such products, it has been attempted in conventional extruders to increase the L/D ratio of their screws and to raise the compression ratio. But it was difficult to enlarge the L/D ratio in the conventional screws, because they were of cantilever construction or driven from the smaller diameter end of the screw. According to the present invention, however, it is possible to increase the L/D ratio, since the screw is strengthened in construction. The screw of such high L/D ratio can also be driven to rotate at high speeds so that it improves the kneading effect of the resin. It should be also noted that little irregularity of supply of resinous material takes place owing to the drawing action of the screw according to the invention, coupled with its high speed rotation.

According to the invention, substantially no deviation will occur in the screw during its high speed rotation, since it is supported at both ends. This means that it is possible to bore a hole, in the screw body, of a relatively large diameter and extending to the portion of the metering zone 40 so as to provide a temperature control chamber 47. Then the temperature of the molten resin immediately before entering the die 41 may be accurately measured by the use of a thermocouple 48 and, as occasion demands, a suitable heat transfer medium may be introduced into the chamber 47 for raising or lowering the temperature of the molten resin. Such temperature controlling was quite impossible in the conventional cantilever screws because of the limits imposed by the strength of the material and because of their deviation in use.

Fig. 8 shows a modification of the invention, wherein a screw 49 extends through a barrel 50 and is supported at both ends by bearings 51 and 52. The screw 49 is driven to rotate from both ends by means of synchronized motors 53 and 54 via pulleys 55 and 56, respectively. Resin or resinous compound is fed from a hopper 57 and discharged from a pair of dies 58 and 59. In this connection, the screw 49 is formed to provide at the centre portion thereof a feed zone of minimum diameter. The diameter of the screw 49 gradually increases in opposite senses toward each end of the screw.

WHAT WE CLAIM IS:—

1. An extrusion moulding machine comprising a screw extruder having a barrel with an inlet and at least one outlet for plasticisable material, and a screw rotatably

extending through the barrel, wherein the screw

- (a) has a larger diameter end adjacent to the or each outlet, the or each such end being provided with rotary driving means; 65
- (b) has a smaller diameter portion adjacent to said inlet; 70
- (c) is provided at each end with a support; and
- (d) is provided with a main thread arranged to urge plasticisable material from the inlet to the or each outlet and, on a portion of the screw beyond the or each outlet and between the outlet and the support at the end of larger diameter, a subsidiary thread of opposite hand to the adjacent main thread to act against leakage of plasticisable material. 75 80

2. A machine as claimed in Claim 1, wherein the subsidiary thread is of smaller pitch than the main thread. 85

3. A machine as claimed in Claim 1 and 2, wherein the screw is supported by bearings at both ends thereof.

4. A machine as claimed in any preceding Claim, wherein the screw has a mixing portion between the main thread and the subsidiary thread. 90

5. A machine as claimed in any preceding Claim, and having a single outlet.

6. A machine as claimed in Claim 5, wherein the screw is provided with a further subsidiary thread of the same hand as the main thread and of smaller pitch than said main thread, said further subsidiary thread being located between the inlet and the support at the end comprising the portion of smaller diameter. 95 100

7. A machine as claimed in Claim 5 or 6, wherein the screw has a chamber for a temperature-control medium extending longitudinally therethrough from the larger diameter end. 105

8. A machine as claimed in any of Claims 1 to 4, and having two outlets and an inlet located between the two outlets. 110

9. A machine, substantially as hereinbefore described, with reference to Figs. 4 to 7 or to Fig. 8 of the accompanying drawings.

10. Articles whenever produced by extrusion moulding using a machine as claimed in any preceding claim. 115

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kneading of resinous material improves physical properties of the extruded products. In order to obtain such products, it has been attempted in conventional extruders to increase the L/D ratio of their screws and to raise the compression ratio. But it was difficult to enlarge the L/D ratio in the conventional screws, because they were of cantilever construction or driven from the smaller diameter end of the screw. According to the present invention, however, it is possible to increase the L/D ratio, since the screw is strengthened in construction. The screw of such high L/D ratio can also be driven to rotate at high speeds so that it improves the kneading effect of the resin. It should be also noted that little irregularity of supply of resinous material takes place owing to the drawing action of the screw according to the invention, coupled with its high speed rotation.

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2. A machine as claimed in Claim 1, wherein the subsidiary thread is of smaller pitch than the main thread. 85

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