

PATENT SPECIFICATION

(11) 1201485

DRAWINGS ATTACHED

- (21) Application No. 37928/67 (22) Filed 17 Aug. 1967
 (31) Convention Application No. 576577 (32) Filed 1 Sept. 1966 in
 (33) United States of America (US)
 (45) Complete Specification published 5 Aug. 1970
 (51) International Classification B 21 c 23/04
 (52) Index at acceptance
 B3P 10B2 10X 12A
 (72) Inventor FRANCIS JOSEPH FUCHS, Jnr.



(54) METHODS OF AND APPARATUS FOR EXTRUDING SOLID PLASTIC MATERIALS

(71) We, WESTERN ELECTRIC COMPANY, INCORPORATED, of 195 Broadway, New York City, New York State, United States of America, a Corporation organized and existing under the laws of the State of New York, United States of America, 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 generally to a method of and apparatus for extruding solid plastic material through an extrusion die by means of high hydrostatic pressure.

It is known in the hydrostatic extrusion art that many metals and other materials have greatly increased capacity for deformation, without fracture, if they are subjected to hydrostatic pressure sufficiently high to increase their ductility, such metals and other materials being known, accordingly, as "solid plastic materials".

Typically, in the past, such high hydrostatic pressure has been employed to extrude solid plastic material by the process of subjecting such material uniformly, i.e., both the top and sides, to a high hydrostatic pressure, and forcing such material through an extrusion die by means of such uniformly applied hydrostatic pressure; such uniformly applied hydrostatic pressure having both longitudinal and radial components acting on the solid plastic material.

In some prior art hydrostatic extrusion processes, an additional longitudinally applied force, a pulling or pushing force, is employed to assist the longitudinal component of the hydrostatic pressure in forcing the solid plastic material through the extrusion die.

It has been recognized that when the applied high hydrostatic pressure has placed the solid plastic material in a state of high ductility, the longitudinally applied forces,

together with the radially applied forces, tend to cause shearing stresses and even actual shearing between portions of the ductile material. This problem is particularly acute at the point where the ductile material passes through the extrusion die. At this point, such shearing tendency can cause faults, fissures or cleavages in the extruded material, sometimes referred to as chip formations, which can be so severed as to ruin the extruded product.

According to one aspect of the invention, a method of extruding a body of solid plastic material comprises the steps of applying a high hydrostatic pressure to the sides of the body to produce an increase in the ductility thereof and allowing the material to extrude longitudinally through a die in response to a small longitudinal force.

One preferred embodiment of the invention includes the step of restraining one end of the solid plastic material to effectively eliminate, the effect of longitudinal hydrostatic forces and thereby eliminate, or effectively eliminate, any tendency toward shearing between portions of the ductile solid plastic material. Extrusion takes place as a result of the small resultant longitudinal force, as will be discussed hereinafter.

In certain cases it has been found that advantages of hydrostatic extrusion can be realised if a substantial portion of longitudinally applied high hydrostatic forces are neutralized, and the resultant forces are utilized to perform the extrusion.

According to another aspect of the invention a method of extruding a body of solid plastic material comprises the steps of applying to the body high hydrostatic pressure so as to produce lateral and longitudinal pressures therein, applying a neutralizing force to the body to neutralize a substantial portion of the longitudinal pressure, and allowing

the material to extrude through a die under the influence of the resultant pressure.

A more complete understanding of the present invention may be obtained from the following detailed description of an embodiment thereof when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a diagrammatic representation, in cross-section, for assisting in the explanation of the shearing tendency problem of prior art arrangements; and

FIG. 2 is a diagrammatic, cross-sectional representation of structure for assisting in and suitable for the practice of the method of the present invention.

Referring now to FIG. 1, there is shown structure representative of the prior art method of hydrostatic extrusion. A billet of solid plastic material 4 is placed in a fluid filled, high pressure chamber 5 formed in a high pressure vessel 6. The fluid is suitably pressurized, such as by a piston being forced into the pressure chamber, and the billet 4 is subjected to high hydrostatic pressure applied uniformly to both the top and sides of the billet. The applied high hydrostatic pressure, or force, can be considered to be comprised of longitudinal components, represented by the arrow 7, and radial components, represented by the arrow 8. The point of intersections of the arrows is representative of shearing stresses produced by the co-action of both the longitudinal and radial components of the high hydrostatic pressure. Such shearing stresses, as mentioned above, tend to produce faults, fissures and cleavages in the material made ductile by the high hydrostatic pressure, and such tendency toward shearing is particularly acute where the extruded material passes through the extrusion die. At this point, the shearing stresses can cause what is commonly called "chip formation" to occur in the extruded material, which can become so severed as to be ruinous.

As stated above, it has been discovered that hydrostatic extrusion can be accomplished, and the shearing tendency eliminated, if the solid plastic material is subjected solely to radially applied hydrostatic forces to place the solid plastic material in a desired state of ductility, and to force the material through an extrusion die in response to a small longitudinal force. Such radially applied hydrostatic forces cause a smooth curved flow of the material, as represented by the curved arrows 9 in FIG. 2, without the production of shearing stresses.

Generally, a billet of solid plastic material to be extruded by hydrostatic extrusion will be surrounded by the fluid applying the hydrostatic pressure, and the billet will have longitudinally acting forces applied thereto. However it has been discovered, that if such longitudinally applied, or acting, hydrostatic

forces are opposed so as to produce only a small resultant longitudinal force, and only the radially applied hydrostatic forces are utilized to achieve the desired state of material ductility and to force the ductile material being forced through an extrusion die by the said resultant longitudinal force, hydrostatic extrusion of very high quality can be accomplished, without the production of the unwanted shearing stresses.

Further, it has been discovered that if the top of the billet to be extruded is mechanically restrained, and if a longitudinal force of the proper magnitude is applied in a direction opposite to the longitudinal component of the applied high hydrostatic pressure, the longitudinal hydrostatic force component may be effectively eliminated and, hence, the unwanted shearing stresses may be eliminated, so that the ductility of the billet can be increased to the desired state.

Such method of hydrostatic extrusion will now be described in connection with the diagrammatic structural representation of FIG. 2.

Referring now to FIG. 2, there is shown a base 10 to which is suitably secured, typically in removable fashion, a high pressure vessel 14 which is provided with a centrally formed high pressure chamber 16 filled with a suitable fluid 18 capable of transmitting hydrostatic pressure.

An extrusion die 20 is suitably supported by the base 10 internally of, and at one end of, the high pressure vessel 14. The extrusion die is provided with a centrally formed, generally frustoconically shaped bore 22 for accommodating extruding material passing through the extrusion die. A high pressure seal 24 forms a mechanical interface between the extrusion die 20 and the high pressure vessel 14, and prevents the fluid 18 from escaping out of the pressure chamber 16 upon an increase in the pressure of the fluid. The seal 24 may be one of several suitable high pressure seals known to the art, and could be, for example, made of Teflon (Registered Trade Mark) whose characteristics are well known to those skilled in the art.

Mounted for slidable movement within the high pressure chamber 16, is an annularly shaped ram or piston 26 for applying pressure to the fluid 18 which fills the high pressure chamber. Surrounding the piston 26 is a high pressure seal 30 for preventing the escape of the fluid 18 from the pressure chamber 16; the seal 30 may be identical with, or similar to, the seal 24. The piston 26 is provided with a centrally formed bore or passageway 32.

Extending into the high pressure chamber 16, is a piston indicated by the general numerical designation 34. The piston is comprised of a collar portion 36, a block portion

70

75

80

85

90

95

100

105

110

115

120

125

130

38, and a rod 40. The rod 40 extends through the bore or passageway 32 formed in the ram 26, and is dimensioned for slidable movement within the bore. Surrounding the rod 40, intermediate of the bore 32, is a seal 42 also for preventing the escape of the fluid 18 from the pressure chamber 16; the seal 42 also being of some suitable material such as Teflon (Registered Trade Mark).

In the practice of the preferred embodiment of the present invention, the billet 44 of solid plastic material to be extruded, is provided near one end with an enlarged head portion 46, for complementary engagement with the collar 36 of the piston 34. The other end of the billet is fed into the extrusion die 20.

Suitable downward force, such as provided by a conventional press and being represented by the arrows 48, is applied to the piston 26 to force the piston downwardly into the pressure chamber 16 to pressurize fluid 18.

The pressurized fluid subjects the sides of the billet 44 to high hydrostatic pressure, the arrows 50 representing the application of radially applied high hydrostatic forces, and, since the piston block portion 38 and the billet 44 are beneath the surface of the pressurized fluid 18, downwardly acting, high hydrostatic forces, represented by the arrows 52, tend to apply longitudinally acting forces to the billet 44.

However, a predetermined upwardly acting force, or neutralising force, represented by the arrow 56, is applied to the piston rod 40, to reduce the the net downwardly acting, longitudinal hydrostatic force represented by the arrows 52 to a value sufficient to maintain the billet 44 in engagement with the extrusion die 20. Thus, the aforementioned shearing stresses are effectively eliminated, and the billet of solid plastic material 44 is subjected solely to radially applied high hydrostatic pressure or forces. Thus, in this context, it will be understood that the billet 44 is subjected solely to radially applied high hydrostatic forces.

The radially applied high hydrostatic forces place the billet of solid plastic material in the desired state of ductility, and since the top of the billet is mechanically restrained to provide the upwardly acting force described above, the now ductile solid plastic material takes the path of least resistance and is forced through the extrusion die 20.

Thus, it will be appreciated by those skilled in the art, that by the employment of this method, sufficiently high hydrostatic pressure may be applied to a billet of solid plastic material to effect a substantial increase in ductility, which, coupled with the elimination of the shearing stresses present in the prior art hydrostatic extrusion processes, enables the rapid extrusion of the billet with extremely

large reductions in area, in a single pass. For example, with the employment of the present method, copper billets have been cold extruded with up to 80% reduction of area in a single pass with high hydrostatic pressures ranging up to 100,000 psi.

It will be further understood by those skilled in the art, that the magnitude of the upwardly acting or opposition force, indicated by the arrow 56 in FIG. 2, can be determined in any one of several ways. For example, the net longitudinal hydrostatic force acting downwardly on the billet, indicated by the arrows 52, can be calculated mathematically, and the opposition force 56 can be adjusted to be substantially equal to the force 52. Also, the magnitude of the force 56 can be determined empirically by performing a series of extrusions on a series of identical billets. The opposition force 56 can be adjusted to an arbitrarily chosen initial magnitude, an extrusion could be made and the quality of the extrudant observed. If the quality were too low, the amount of opposition force would be increased (perhaps increased in each of several successive extrusions) until the desired quality of extrudant were achieved. If the initial setting produced a satisfactory extrudant, the amount of opposition force could be decreased (perhaps in several successive extrusions) until the extrudant were not of the desired quality, and the opposition force could then be adjusted back to a magnitude producing the desired quality of extrudant.

Referring again to the upwardly acting or neutralizing force 56, it will be understood by those skilled in the art, that depending upon the quality of extrudant desired, or that which can be tolerated in a specific commercial application, the ratio of the opposition force 56 to the force 52 can vary. For example, if a comparatively reduced quality of extrudant were desired, or can be tolerated, the magnitude of the opposition force 56 can be adjusted so as to result in larger downward resultant forces applied to the billet.

It will be understood by those skilled in the art that the expression or term "high hydrostatic pressure" is a relative term connoting the understanding that, depending upon the hardness or brittleness of the solid plastic material to be extruded, various specific hydrostatic pressures must be obtained so as to cause the material to increase in ductility sufficient to permit the material to be extruded without fracture.

Further it will also be understood that the pressure fluid 18 can be any suitable pressure transfer medium, for example, even a suitable soft solid.

With regard to the mechanical interconnection provided by the piston collar 36 and the billet head 46, it will be understood that such arrangement is merely one of several

65

70

75

80

85

90

95

100

105

110

115

120

125

suitable mechanical arrangements for use in practising the present invention.

WHAT WE CLAIM IS:—

1. A method of extruding a body of solid plastic material comprising the steps of applying a high hydrostatic pressure to the sides of the body to produce an increase in the ductility thereof and allowing the material to extrude longitudinally through a die in response to a small longitudinal force.

2. A method of extruding a body of solid plastic material comprising the steps of applying a high hydrostatic pressure to the body so as to produce lateral and longitudinal pressures therein, applying a neutralizing force to the body to neutralize a substantial portion of the longitudinal pressure, the body increasing in ductility as a result of the lateral pressure, and allowing the material to extrude longitudinally through a die under the influence of the resultant pressure.

3. A method according to claim 2 wherein the neutralizing force is applied longitudinally to the body.

4. A method according to claim 2 or 3 wherein the neutralizing force is applied to the end of the body opposite the extrusion die.

5. A method according to claim 4 wherein the neutralizing force is applied by mechanically restraining the end of the body.

6. A method according to claim 3 including the steps of placing the body in an extrusion chamber with one end adjacent an extrusion die, surrounding the body with a pressure transmitting fluid, applying pressure to the fluid to produce the high hydrostatic pressure condition, and applying a longitudinal

force to the body sufficient to neutralize a substantial portion of the longitudinal pressure.

7. A method according to claim 6 including the step of securing to a movable securing means the end of the body opposite to the die, and applying a force to the securing means in a direction away from the die so as to produce the said longitudinal force.

8. Apparatus for carrying out the method of claim 7 comprising an enclosed pressure vessel containing a pressure-transmitting fluid, a die in one wall of the vessel, a ram for producing a high hydrostatic pressure in the body, a means for securing an end of the body to be extruded, a rod attached to the securing means extending from the vessel through a pressure seal, and means for pulling the rod so as to produce tension in the body to oppose longitudinal hydrostatic pressure therein produced by the fluid.

9. A method of extruding solid plastic material substantially as herein described with reference to FIG. 2 of the accompanying drawings.

10. Apparatus for extruding solid plastic material substantially as herein described with reference to and as shown in FIG. 2 of the accompanying drawings.

11. Material extruded in accordance with the method of any one of claims 1 to 5 or 7.

P. S. BROWN,
Chartered Patent Agent,
5, Mornington Road,
Woodford Green, Essex.
Agent for the Applicants.

suitable mechanical arrangements for use in practising the present invention.

WHAT WE CLAIM IS:—

1. A method of extruding a body of solid plastic material comprising the steps of applying a high hydrostatic pressure to the sides of the body to produce an increase in the ductility thereof and allowing the material to extrude longitudinally through a die in response to a small longitudinal force.

2. A method of extruding a body of solid plastic material comprising the steps of applying a high hydrostatic pressure to the body so as to produce lateral and longitudinal pressures therein, applying a neutralizing force to the body to neutralize a substantial portion of the longitudinal pressure, the body increasing in ductility as a result of the lateral pressure, and allowing the material to extrude longitudinally through a die under the influence of the resultant pressure.

3. A method according to claim 2 wherein the neutralizing force is applied longitudinally to the body.

4. A method according to claim 2 or 3 wherein the neutralizing force is applied to the end of the body opposite the extrusion die.

5. A method according to claim 4 wherein the neutralizing force is applied by mechanically restraining the end of the body.

6. A method according to claim 3 including the steps of placing the body in an extrusion chamber with one end adjacent an extrusion die, surrounding the body with a pressure transmitting fluid, applying pressure to the fluid to produce the high hydrostatic pressure condition, and applying a longitudinal

force to the body sufficient to neutralize a substantial portion of the longitudinal pressure.

7. A method according to claim 6 including the step of securing to a movable securing means the end of the body opposite to the die, and applying a force to the securing means in a direction away from the die so as to produce the said longitudinal force.

8. Apparatus for carrying out the method of claim 7 comprising an enclosed pressure vessel containing a pressure-transmitting fluid, a die in one wall of the vessel, a ram for producing a high hydrostatic pressure in the body, a means for securing an end of the body to be extruded, a rod attached to the securing means extending from the vessel through a pressure seal, and means for pulling the rod so as to produce tension in the body to oppose longitudinal hydrostatic pressure therein produced by the fluid.

9. A method of extruding solid plastic material substantially as herein described with reference to FIG. 2 of the accompanying drawings.

10. Apparatus for extruding solid plastic material substantially as herein described with reference to and as shown in FIG. 2 of the accompanying drawings.

11. Material extruded in accordance with the method of any one of claims 1 to 5 or 7.

P. S. BROWN,
Chartered Patent Agent,
5, Mornington Road,
Woodford Green, Essex.
Agent for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1970.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



* C L M S *