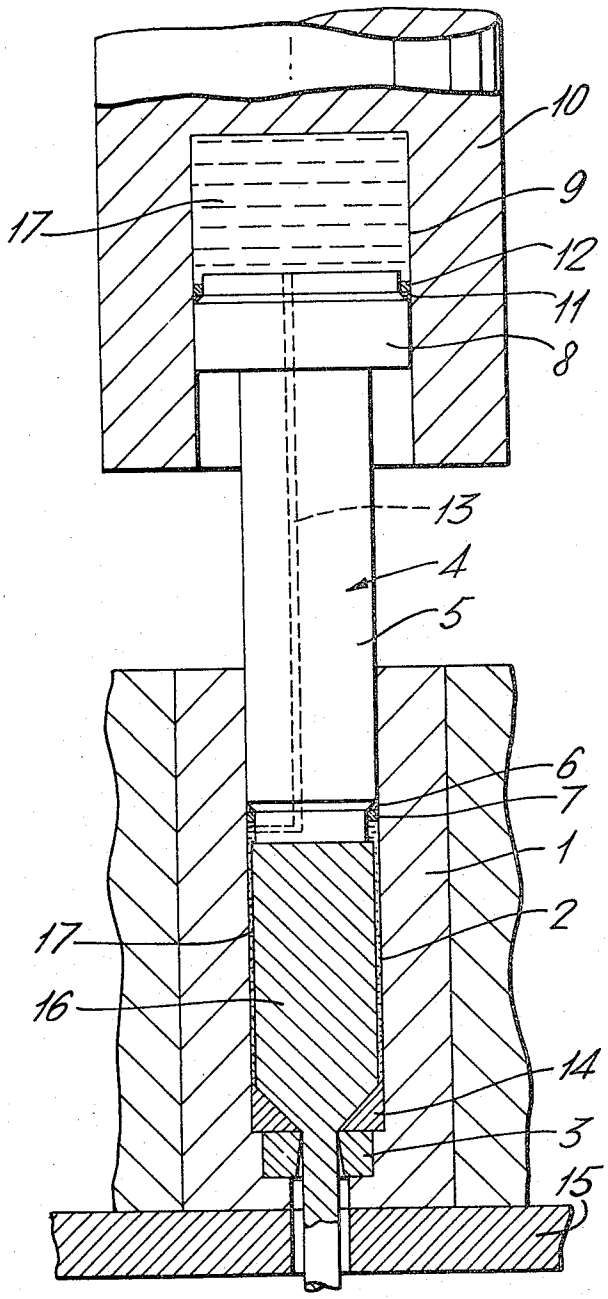
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HYDROSTATIC EXTRUSION PROCESSES

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HYDROSTATIC EXTRUSION PROCESSES

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ABSTRACT OF THE DISCLOSURE

An extrusion process comprises the steps of pressurizing a hydraulic liquid which envelops a billet in an extrusion chamber to a constant applied pressure to thereby subject the billet to a hydrostatic stress system, applying a direct mechanical axial loading on the billet, by means of a plunger, in a direction towards the extrusion die through which the billet is to be extruded from the extrusion chamber, and bleeding of liquid in a controlled manner from the bore of the extrusion chamber while extrusion of the billet proceeds. The latter step maintains the free space in the bore of the extrusion chamber about the billet full of hydraulic liquid at the constant applied pressure. Bleeding may be accomplished by a passage formed in the plunger interconnecting the bore of the extrusion chamber with a cylinder formed in a ram for driving the plunger.

This invention relates to extrusion processes and in particular to hydrostatic extrusion processes. In a conventional extrusion process a billet held within a chamber is subjected to a direct mechanical loading to extrude the billet from the chamber through a die. The billet is a close fit in the chamber and extrusion pressure is applied on the end face of the billet by a ram operating in the bore of the chamber. Hydrostatic extrusion has several advantages over conventional extrusion and differs from conventional extrusion in that a liquid is used to apply extrusion pressure on the billet. The liquid envelops the billet in the chamber and is pressurised to act directly on the billet. Because the liquid envelops the billet there is no frictional contact between the chamber and the billet. Die friction is also reduced because the pressurised fluid adjacent the throat of the die provides hydrodynamic lubrication between the extruding material and the die.

In hydrostatic extrusion the material of the billet is subjected to a hydrostatic stress system but it is the axial component of stress acting in the billet in the direction towards the die orifice and the consequent radial reaction at the die throat which results in extrusion of the material of the billet through the die.

The axial component of stress set up in the billet and hence the forces acting to extrude the material of the billet through the die is dependent on the pressure applied in the liquid surrounding the billet. The degree of pressure which must be applied in the liquid to cause extrusion depends on the yield stress of the material to be extruded.

In the case of material having a very high yield stress the pressure required in the liquid to effect hydrostatic extrusion may be prohibitively high because of the difficulties arising from containment of liquids subjected to such high pressure.

According to the present invention these difficulties are overcome by operation of a hydrostatic extrusion process so that the billet, as well as being subjected to a hydrostatic stress system by the pressurisation of liquid in a chamber surrounding the billet, is also subjected to a direct mechanical axial loading as in a conventional extrusion process. In this process the axial component of stress in

the billet, which as explained above is responsible for the forces resulting in extrusion of the material through the die, therefore arises partly from the hydrostatic stress system set up in the billet by the pressurisation of the liquid surrounding the billet and partly from the direct mechanical axial loading applied to the billet. The total axial stress component produced in the billet must be sufficient to give rise to the forces necessary to effect extrusion of the material of the billet through the die. However, as the direct mechanical axial loading applied to the billet supplements the axial component of hydrostatic stress set up in the billet due to the pressure in the liquid enveloping the billet, a total axial stress component of the magnitude required to effect extrusion is produced in the billet using a much lower pressure in the liquid enveloping the billet than is required in the liquid for operation of a purely hydrostatic extrusion process.

In this process the problems arising from the use of very high liquid pressures which are necessary for the hydrostatic extrusion of materials having a high yield stress are avoided whilst the advantages inherent in the hydrostatic extrusion process are retained.

One form of apparatus for carrying out the process of the invention comprises an extrusion chamber having a bore with an extrusion die at one end, means for pressurising hydraulic liquid in the bore of the extrusion chamber about a billet contained therein, a plunger entered into the bore of the extrusion chamber at its other end, means for loading the plunger to apply a mechanical axial loading on the billet in the extrusion chamber and means for bleeding hydraulic liquid from the bore of the extrusion chamber as extrusion proceeds so that the plunger remains in contact with and maintains a mechanical axial loading on the billet during extrusion of the billet.

In a particular form of apparatus as described above the plunger has a head outside the bore of the extrusion chamber of larger cross sectional area than the cross sectional area of the body of the plunger, the head of the plunger coupling with a cylinder, a passageway defined in the plunger leading from the cylinder to the bore of the extrusion chamber, means being provided for pressurisation of liquid in the cylinder to act on the head of the plunger, the passageway in the plunger providing for transmission of pressure from the liquid in the cylinder to liquid in the extrusion chamber about a billet contained therein and the passageway also providing for bleeding of liquid from the bore of the extrusion chamber into the cylinder as extrusion proceeds and the plunger moves into the bore of the extrusion chamber in contact with the billet.

In this form of apparatus the cylinder may be blind ended with the head of the plunger sliding in the bore of the cylinder, liquid being pressurised in the bore of the cylinder to act on the head of the plunger by external loading of the cylinder.

Alternatively the head of the plunger may be in fixed engagement with one end of the bore of the cylinder, which is movable with the plunger, liquid being pressurised in the bore of the cylinder to act on the head of the plunger by a ram entered into the bore of the cylinder from its other end.

In operation of apparatus of the particular forms described above the free space in the cylinder and in the extrusion chamber surrounding a billet contained therein are filled with hydraulic liquid. The passageway leading through the plunger from the cylinder to the extrusion chamber provides that when the hydraulic liquid in the cylinder is pressurised, the hydraulic liquid in the extrusion chamber surrounding the billet is subjected to the same degree of pressurisation. The body of the plunger in the extrusion chamber bears against the end of the bil-

let and the pressure of the hydraulic liquid in the cylinder acting on the larger area of the head of the plunger forces the plunder to apply a mechanical axial loading on the billet. The axial component of stress produced in the billet due to the combined effect of the hydrostatic pressure applied on the billet and the mechanical axial loading of the plunger on the billet gives rise to forces at the die causing extrusion of the billet from the extrusion chamber through the die.

As extrusion proceeds the billet remains the same diameter but reduces in length in the extrusion chamber. The plunger moves into the bore of the extrusion chamber as extrusion proceeds and maintains contact with the end of the billet so that the mechanical axial loading of the plunger on the billet is applied throughout the extrusion process. As the plunger moves into the bore of the extrusion chamber in contact with the end of the billet during extrusion, hydraulic liquid is transferred from the extrusion chamber into the cylinder through the passageway leading through the plunger.

One embodiment of the invention will now be described by way of example with reference to the sole figure of the accompanying drawing which is a longitudinal sectional elevation of an extrusion press in accordance with the invention.

The apparatus shown in the drawing comprises a cylindrical extrusion chamber 1 having a bore 2 fitted with a die 3 at its lower end. A plunger 4 has a main body 5 entered into the bore 2 of the extrusion chamber 1. The body 5 of the plunger 4 is sealed in the bore 2 of the extrusion chamber 1 by a copper ring 6 and rubber "O" ring 7. The plunger 4 has a head 8 of larger diameter than the body 5 of the plunger 4. The head 8 of the plunger 4 operates in a cylinder 9 formed in the ram 10 of a hydraulic press. The head 8 of the plunger 4 is sealed in the cylinder 9 by a copper ring 11 and rubber "O" ring 12. A passageway 13 for liquid is formed in the plunger 4 leading from the cylinder 9 to the bore 2 of the extrusion chamber 1. The die 3 is provided with a lead-in ring 14 and the extrusion chamber 1 is mounted on the base 15 of the hydraulic press.

In use of the apparatus described above both the space in the cylinder 9 above the head 8 of the plunger 4 and the space in the extrusion chamber 1 surrounding a billet 16 to be extruded contain hydraulic liquid 17. The plunger 4 bears against the end of the billet 16 in the extrusion chamber 1. The ram 10 of the hydraulic press is forced downwards so that the hydraulic liquid 17 in the cylinder 9 is pressurised. As the cylinder 9 is connected with the bore 2 of the extrusion chamber 1 by the passageway 13 the hydraulic liquid surrounding the billet 16 in the extrusion chamber 1 is pressurised to the same degree as the hydraulic liquid 17 in the cylinder 9. As the head 8 of the plunger 4 is of larger diameter than the body 5 of the plunger 4, the pressure of the hydraulic liquid 17 in the cylinder 9 acting on the head 8 of the plunger 4 applies a downwards loading on the plunger 4. Thus the plunger 4 applies an axial compressive mechanical loading on the billet 16 in addition to the hydrostatic stress applied on the billet 16 by the pressure of the hydraulic liquid 17 in the extrusion chamber 1. The combined hydrostatic and axial mechanical stresses applied to the billet 16 cause extrusion of the billet 16 through the die 3.

As the billet 16 is extruded it remains at the same diameter within the extrusion chamber 1 but the length of the billet 16 in the extrusion chamber 1 reduces. The plunger 4 moves into the bore 2 of the extrusion chamber 1 as extrusion proceeds and remains in contact with the end of the billet 16 so that the axial compressive loading applied by the plunger 4 on the billet 16 is maintained throughout the extrusion process. During extrusion as the plunger 4 moves into the bore 2 of the extrusion chamber 1 in contact with the end of the billet 16 the hydraulic liquid 17 surrounding the billet 16 in the bore 2 of the extrusion chamber 1 is gradually expelled from the bore 2 of the extrusion chamber 1 into the cylinder 9 through the passageway 13 leading through the plunger 4. Finally when the majority of the billet 16 has been extruded the plunger 4 will be almost at the bottom of the bore 2 of the extrusion chamber 1 and most of the hydraulic liquid 17 in the bore 2 of the extrusion chamber 1 will have been expelled into the cylinder 9.

The forces acting to extrude the billet 16 through the die 3 are derived from the axial components of stress produced in the billet 16. The axial components of stress in the billet 16 arise partly from the hydrostatic stress system set up in the billet 16 by the pressure of the hydraulic 17 surrounding the billet 16 and partly from the direct mechanical loading applied axially on the billet 16 by the plunger 4. As the direct mechanical loading applied to the billet 16 by the plunger 4 supplements the axial hydrostatic stress components in the billet 16 a total axial stress component of the magnitude required to effect extrusion is produced using a much lower pressure in the hydraulic liquid 17 surrounding the billet than would be required in the hydraulic liquid 17 for operation of a purely hydrostatic extrusion process.

The apparatus described above possesses a further advantage over apparatus for carrying out purely hydrostatic extrusion processes. In the normal hydrostatic extrusion process when the billet has been almost completely extruded the extrusion chamber holds a substantial amount of hydraulic liquid under high pressure. The tail end of the extrusion billet is finally ejected through the die in a violent manner by the pressure of the hydraulic liquid in the extrusion chamber. This is a dangerous effect of normal hydrostatic extrusion apparatus and is avoided in apparatus in accordance with the present invention. At the end of extrusion using apparatus in accordance with the invention very little hydraulic liquid remains in the extrusion chamber 1 most of the liquid in the extrusion chamber 1 having been expelled into the cylinder 9 by movement of the plunger 4 into the extrusion chamber 1 during the extrusion process. If the passageway 13 through the plunger 4 is made of small bore this acts as a throttle preventing ejection of the tail end of the billet through the die under the action of the pressurised hydraulic liquid in the cylinder passing back into the extrusion chamber 1.

I claim:

1. An extrusion process comprising the steps of pressurising a hydraulic liquid which envelops a billet in an extrusion chamber to a constant applied pressure to thereby subject the billet to a hydrostatic stress system, applying a direct mechanical axial loading on the billet in a direction towards an extrusion die through which the billet is to be extruded from the extrusion chamber, and bleeding of liquid in a controlled manner from the bore of the extrusion chamber through a passageway into a reservoir of liquid which is maintained at the same pressure as the liquid which envelops the billet in the extrusion chamber whilst extrusion of the billet proceeds to maintain the free space in the bore of the extrusion chamber about the billet full of hydraulic liquid at the constant applied pressure.

2. Apparatus for carrying out an extrusion process comprising an extrusion chamber having a bore with an extrusion die at one end, means for pressurising hydraulic liquid to a constant applied pressure in the bore of the extrusion chamber about a billet contained therein, a plunger entered into the bore of the extrusion chamber at its other end, means for loading the plunger to apply a mechanical axial loading on the billet in the extrusion chamber in the direction towards the extrusion die and controlled bleed means comprising a passageway leading from the bore of the extrusion chamber into a reservoir for liquid, said reservoir having means for pressurizing the liquid therein to the same pressure as liquid in the

bore of the extrusion chamber, said controlled bleed means constituting means for bleeding of liquid from the bore of the extrusion container as extrusion of the billet proceeds to maintain the free space in the bore of the extrusion chamber about the billet full of hydraulic liquid at the constant applied pressure.

3. Apparatus as claimed in claim 2 wherein the plunger has a head outside the bore of the extrusion chamber of larger cross sectional area than the cross sectional area of the body of the plunger, the head of the plunger coupling with a cylinder, a passageway being provided leading through the plunger from the cylinder to the bore of the extrusion chamber, means being provided for pressurisation of liquid in the cylinder to act on the head of the plunger, and force the plunger to apply a mechanical axial loading on the billet, the passageway leading through the plunger providing for transmission of pressure from liquid in the cylinder to liquid in the extrusion chamber about a billet contained therein and the passageway also providing for bleeding of liquid from the bore of the extrusion chamber into the cylinder as extrusion proceeds and the plunger moves into the bore of the extrusion chamber in contact with the billet.

4. Apparatus as claimed in claim 3 wherein the cylinder is blind ended with the head of the plunger silding in the bore of the cylinder, liquid being pressurised in the bore of the cylinder to act on the head of the plunger by external loading of the cylinder.

5. Apparatus as claimed in claim 3 wherein the head of the plunger is in fixed engagement with one end of the bore of the cylinder, which is movable with the plunger, liquid being pressurised in the bore of the cylinder to act on the head of the plunger by a ram entered into the bore of the cylinder from its other end.

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