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[54] **CONTROL MEANS FOR HYDROSTATIC EXTRUSION**
10 Claims, 2 Drawing Figs.

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[50] **Field of Search** 72/60, 35, 710, 270, 271, 6, 21, 32, 28, 20

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ABSTRACT: For the control of a press which includes a press stand, an operating cylinder carried by the stand and having an operating piston therein, a pressure chamber arranged in the stand and an extrusion die in the chamber, with a pressure-generating punch connected to the operating piston and inserted in the pressure chamber for compressing a pressure medium isostatically around the billet, a position indicator and a pressure indicator are provided which are connected to a calculating unit to sense when extrusion starts and to calculate, depending on the size of the billet, the allowable movement of the pressure-generating punch, which is interrupted just before the last of the billet is extruded.

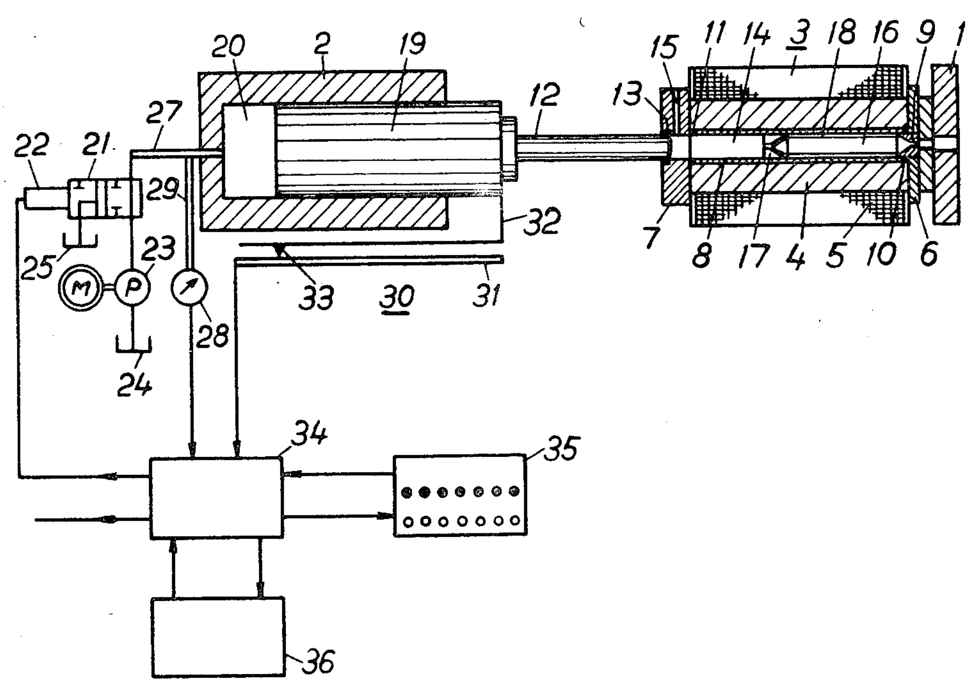

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Fig.1

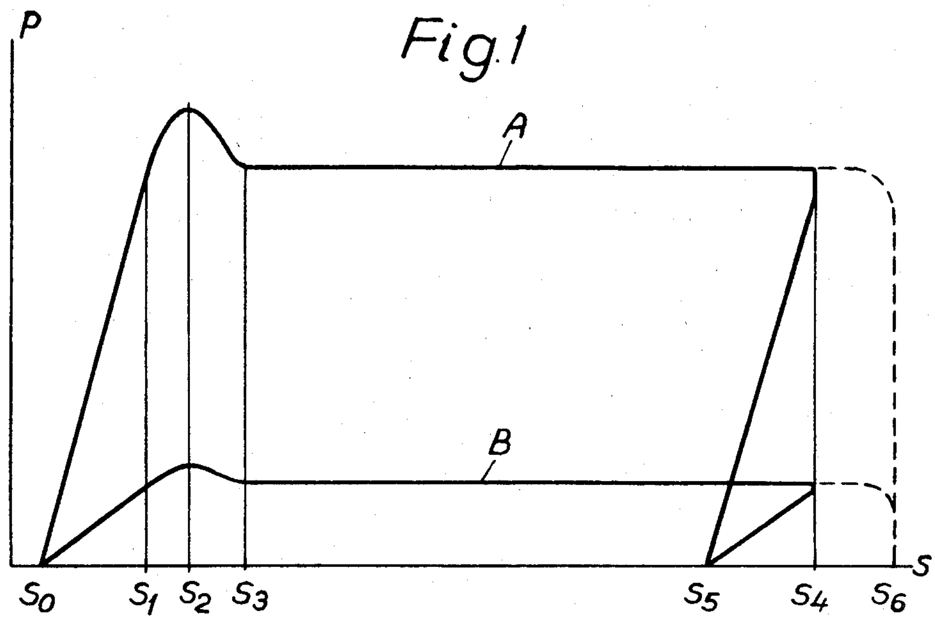
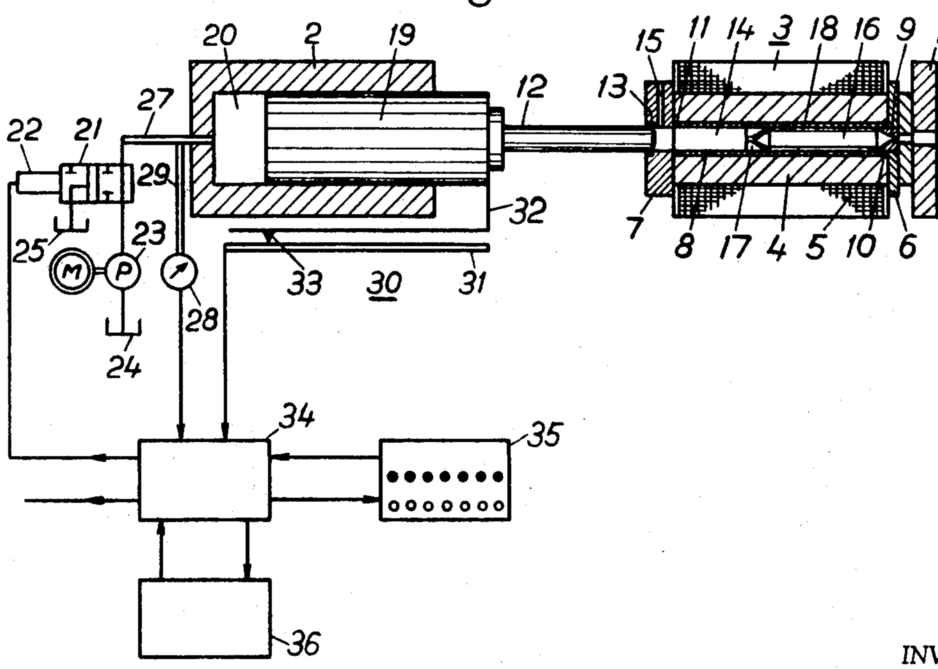


Fig.2



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CONTROL MEANS FOR HYDROSTATIC EXTRUSION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a means for controlling the extrusion process during hydrostatic extrusion in such a way that complete extrusion of the billet through the die is avoided and so that the production rate is high, that is, that only a small quantity of material remains in the die when the extrusion is interrupted.

2. The Prior Art

For hydrostatic extrusion a billet is enclosed in a pressure chamber having a die with an opening of desired cross section and subjected to high-hydrostatic pressure all round so that the material is extruded through the opening. The equipment usually consists of a wire or strip-wound high-pressure cylinder which is inserted in a hydraulic press. The cylinder is closed at one end by a die having an opening with the desired cross section of the component. The pressure is generated by a punch which is pressed by a hydraulic operating piston into the high-pressure cylinder filled with liquid. Usually pressures of between 5 and 25 kilobar are used. At these high pressures the liquid compression is also considerable, often more than 15 percent, and the energy in the compressed liquid is great. If a billet is completely pressed out through the die the liquid expands rapidly when the billet leaves the die and accelerates the rod produced so that this can be deformed or cause damage to surrounding or adjacent equipment. The liquid is forced out with explosive speed and may thus also directly or indirectly cause serious damage. The extrusion must thus be interrupted before the billet is completely extruded and the remaining material scrapped. It is thus advantageous to adjust the press so that the material can be exploited to the fullest extent while complete extrusion is safely avoided. With the high pressures in question it is extremely difficult to arrange bushings for signal conduits in the wall of the high-pressure cylinder and emitters cannot therefore be used inside the cylinder to indicate a suitable moment for the interruption of the extrusion process, for example by measuring when the end surface of the billet has passed a certain point. The great quantity of metal in the cylinder also makes it impossible to measure the volume or position of the billet in the cylinder by inductive methods with sufficient accuracy. The required determination of a suitable moment for interruption of the extrusion must therefore be carried out indirectly by measuring and making use of the available magnitudes.

SUMMARY OF THE INVENTION

The press is provided with a position-indicator which senses the position of the pressure-generating punch and a pressure-emitter which senses the pressure in the operating cylinder which drives the punch. According to the invention the press contains a calculator with at least one memory unit and at least one calculating unit, which calculator receives the output signals of the indicator and emitter and, with the guidance of these signals, senses when extrusion starts and, depending on the size of the billet, calculates the allowable movement of the pressure-generating punch and interrupts the extrusion when the desired volume has been extruded. The pressure in the pressure cylinder itself is thus measured indirectly since the high pressure does not permit connections to the pressure chamber through the wall of the cylinder or the punch. In order to enable correct calculation the entire extrusion equipment can be calibrated by registering the output signals of the indicator and the emitter at known volumes of the billet in the pressure chamber and storing these signals in the memory unit. During calibration the high-pressure cylinder is suitably either completely filled with oil, that is, the billet volume V=0 and the die provided with a plug to prevent pressure medium from leaking out through the die opening, or a billet of approximately the size of those to be later extruded may be inserted in the high-pressure cylinder. Thus a relationship is obtained between the cylinder pressure and the punch movement. This is dependent on the spring action in the press stand, the increase of the cylinder volume due to the pressure, the volume and compressibility of the liquid enclosed and the volume and compressibility of the billet of known size in the cylinder, and so on. The volume of the billets intended to be extruded need not be known. Because during the extrusion the output signals of the indicator and emitter are supplied to the calculator and compared with the values of the output signals stored in the memory part which were obtained during the calibration with known billet volumes, the calculator determines the volume of the billet in question according to a program which has been fed in and the difference between the measured values. The start of the extrusion is indicated by at least one emitter which senses when the extrusion is indicated by at least one emitter which senses when the extrusion starts and the output signal of this emitter is also supplied to the calculator. The previously mentioned indicator and emitter are suitably also used to indicate the start of the extrusion process, the calculator for example analyzing the relationship between the punch position and the pressure and sensing a certain point at the start of the extrusion process because the derivative of the function then rapidly decreases towards zero. The calculator is programmed to determine how much further the punch must be inserted into the cylinder in view of the calculated volume of the billet after the start of the extrusion process has been indicated and to interrupt the feeding or reverse the movement of the punch when the calculated infeeding has been obtained.

Calculators of both digital and analogue type can be used. A single calculator may control one, two or more presses.

The invention enables much better utilization of the material than was previously possible. The measurements can be rapidly reproduced and the volume of the billet in question can be determined with great accuracy. The position of the punch when the extrusion process should be interrupted can therefore also be determined with great safety. At a high ratio between the billet volume and pressure cylinder volume the error in calculation may be 5 percent or lower. Even when great safety against complete extrusion is desired, it is possible to utilize 90 percent of the material or more.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further described with reference to the accompanying drawings.

FIG. 1 shows the ratio between the pressure in a pressure cylinder and the movement of a punch inserted into the cylinder to generate the pressure for extrusion of a billet inserted in the pressure cylinder.

FIG. 2 shows schematically the parts essential for the invention in a press for hydrostatic extrusion and certain auxiliary equipment for adjusting the press.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the diagram according to FIG. 1 the punch movement is indicated along the abscissa and the pressure in the pressure cylinder along the ordinate. The curve A indicates the pressure in the cylinder as a function of the punch movement and the curve B the pressure in an operating cylinder which drives the punch, also as a function of the punch movement. Before the punch has reached the position S_0 where there is a seal between the punch and the washer in the cylinder, no pressure increase is obtained. When the punch is inserted further into the cylinder a distance S_0–S_1, the pressure increases substantially in a straight line. The slope of the curve is in this part a function of the spring action of the press stand, the volume increase of the cylinder due to its suspension, the compression of the punch, die and billet and of the volume and compressibility of pressure medium enclosed in the pressure cylinder. The volume of the pressure medium is in turn a function of the billet volume under otherwise constant conditions. At the position S_1 of the punch the slope of the curve alters noticeably and a maximum is obtained at S_2. The derivatives of the curve thus alter from a constant value to 0 at this part. At the position S_1 such a pressure has been attained that a certain deformation of the front part of the billet projecting into the die is obtained. At the position S_2 of the punch the pressure has reached such a value that the extrusion process through the die opening is initiated. When the material has started to move the resistance decreases and the pressure drops until, when the punch is in position S_3, a constant state is achieved, after which the pressure remains constant during the continued movement of the punch to a position where only a conical part of the billet remains in the die and, when the extrusion process is continued, the area reduction is decreased, and thus the driving pressure required is also decreased. The flow of material through the die then increases and the pressure drops when the speed of the punch is unaltered and at point S_6 the last of the material leaves the die and the pressure medium is expelled through the die with considerable force. The expansion of the pressure medium causes the last of the material to be accelerated to great speed. This may then be damaged and surrounding equipment may also be damaged, and even the press itself because of the recoil. The pressure medium, which has a pressure of 10—20 kilobar may also directly damage those parts with which it comes into contact. In order to prevent complete extrusion the movement of the punch is interrupted at S_4. If the punch is only stopped the extrusion continues under decreasing pressure and stops when the pressure has dropped to a certain level. If, however, the movement of the punch is at a reversed at position S_4, the extrusion is stopped almost instantaneously. During the return movement of the punch the cylinder pressure drops so that it is zero at position S_5. Curve B indicates the pressure in the pressure cylinder as a function of the pressure in the operating cylinder for the punch. This pressure is proportional to the pressure in the cylinder and can therefore be utilized to determine the pressure in the extrusion cylinder.

In FIG. 2, **1** designates a press table, **2** an operating cylinder in a hydraulic press not otherwise shown. In the press is a high-pressure cylinder **3** formed by a steel cylinder **4**, a strip sheath **5** of wire having rectangular cross section and great strength wound on under prestressing, and ends **6** and **7**. In the cylinder are a lining **8**, a die **9** and sealing rings **10** and **11** which seal between the cylinder **4** and the die **9** with respect to a pressure-generating punch **12**. In the end **7** is a seal **13** which seals between the end and the punch **12** while the cylinder is being filled with pressure medium from the cylinder space **14** through a channel **15** in the end **7** before the punch **12** is inserted to generate the pressure necessary for the extrusion process. The press is of the type which has a horizontal, axially movable pressure cylinder in which a billet **16** and a new die **9** are inserted from the side of the press table in the space **18** and where the billet **16** and die **9** are held in the correct position by a piston **17** freely movable in the lining **8**, the piston pressing the billet and the die against the table **1** while the cylinder **3** is returned to the press table. The pressure force is obtained by pressure medium in the space **14** influencing the piston **17** which is pressure determined by spring-loaded overflow valves in the piston **17**. The punch **12** is joined to the piston **19** which is influenced in the direction of the press table **1** by the pressure in the space **20**. The punch is operated in the opposite direction by operating cylinders, not shown. The space **20** communicates through conduit **27** and a valve **21** operated by an electromagnet **22** with either a pump **23** and a pressure medium container **24** or a collection container **25**. If a continuously operating pump is used the pressure medium can be transferred through the same valve directly to the collecting container **25**. A pressure-emitter **28** is connected by a tube **29** to the tube **27** and thus measures the pressure in the space **20** and thus indirectly the pressure inside the cylinder **3**. In the press, for example, is a resistive position-indicator **30** having a stationary part **31** in the press stand and a part **32** joined to the piston **19**, with a trailing contact **33** which follows the piston **19** and the punch **12** during their movement. The pressure-emitter **28** and the position-indicator **30** are connected to a calculator which is connected both to an operating table **35**, a recorder **36** and the operating unit **22** of valve **21**, as well as other operating units for the press, not shown.

The equipment operates in the following way. It is calibrated before the extrusion process is started so that the "-spring constant" of the equipment is known by determining the relationship between the punch movement and the pressure in the cylinder **3** at a known volume of the billet **16**. The cylinder may be completely filled with pressure medium of the type used for the extrusion, that is the billet volume $V=0$ or a billet of arbitrary volume may be inserted. A billet is preferably used which has approximately the same volume as those to be used for the extrusion. The pressure in the cylinder **3** is measured indirectly through the emitter **28** which measures the pressure of the pressure medium in the space **20** which influences the operating piston **19** which drives the pressure-generating punch **12** into the cylinder **3**. The movement of the punch **12** is measured by the resistive position-indicator **30**. The output signals of both emitter and indicator are supplied to the calculator **34** and inserted in its memory unit. For the extrusion a billet **16** is inserted in the pressure cylinder. This may be of arbitrary size, within certain limits. The press is started and the values of the pressure-emitter **28** and the position-indicator **33** are supplied to the calculator **34** and the ratio between pressure and punch movement is compared with the calibration values stored in the memory unit. Because the compressibility of the pressure medium is greater than that of the metallic billet (approximately 15 percent and 2 percent, respectively at 10 kilobar), different volumes of the billet and pressure medium cause the slope of the curve in the area S_0—S_1 to differ from that of the curve registered during the calibration. The difference in slope, the derivative of the curve, is a gauge of the difference between billet volumes. If the equipment has been calibrated with the cylinder completely filled with pressure medium the difference will be great. However, if it has been calibrated with a billet of the size to be used for the extrusion, there will be no difference, or very little. According to a program fed in the calculator calculates the billet volume or the difference between the calibration billet and the billet in the cylinder. When the punch reaches position S_1 the billet starts to be deformed. This means that a certain movement of the punch causes less pressure increase and thus curve A or B, respectively, levels off and gradually obtains a maximum value at S_2. The beginning of extrusion is complete approximately when the punch reaches the position S_2. With most materials a pronounced peak is obtained in the curve just at the start of the extrusion, after which the pressure drops to a somewhat lower level. When the punch is in position S_3 the pressure has dropped, in spite of constant speed of the punch, to a value which continues to be constant. The alteration of the curve derivatives can be used to determine the position of the punch **16** when the extrusion starts. When material is extruded which provides a well-defined pressure peak at the start of the extrusion the calculator may be programmed, when the curve derivatives pass zero, to calculate, with the help of the calculated billet volume, the distance S_2—S_4 the punch must travel further into the cylinder so that, with the desired degree of safety against complete extrusion of the material, the least possible material is left which must be scrapped. The calculator **34** may be programmed to give a control signal to a valve unit which interrupts the supply of pressure medium to the space **20** so that the pressure remains and the extrusion continues until the flow of material ceases at a certain lower pressure. Alternatively a control signal may be sent to the operating member **22** in a valve **21** according to FIG. 2, which immediately unloads the cylinder **2** by placing it in communication with a collecting container **24** for the pressure medium. During the first part of the return movement of the piston **19** and punch **12**, that is from position S_4 to position S_5, the pressure drops to $p=0$.

The calculator **34** is connected to an operating panel with operating buttons and adjusting knobs for operating the press, for example for start, stop, emergency stop, selection of program, correction of program during operation, and so on, and to indication devices for faults, alarm and so on. The calculator may also be connected to a recorder for recording production statistics from the calculator.

The invention is of course not limited to the embodiment shown in the figures. Many variations are feasible within the scope of the following claims.

I claim:

1. In combination with a press comprising a press stand, an operating cylinder arranged in the stand and having an operating piston, a pressure chamber arranged in the stand and an extrusion die arranged in the chamber, a pressure-generating punch connected to the operating piston to generate the required pressure in a pressure medium enclosed in the pressure chamber which isostatically influences a billet in the pressure chamber and a position-indicator which senses the position of the punch and a pressure-emitter means which senses the pressure in the operating cylinder, the improvement comprising a calculator with at least one memory unit and at least one calculating unit, means to supply to the calculator the output signals of the indicator and emitter, said calculator including means responsive to these signals to sense when extrusion starts and, depending on the size of the billet, to calculate the allowable movement of the pressure-generating punch and to interrupt the extrusion when the desired volume has been extruded.

2. Means according to claim 1, in which the calculator has a memory unit, comprising means to supply the output signals of the pressure-emitter means at a known volume of billet in the pressure chamber to the calculator and to store such signals in its memory unit.

3. Means according to claim 2, in which the output signal at a billet volume of zero is supplied to the calculator and stored in its memory unit.

4. Means according to claim 2, said calculator comprising means to compare the output signals of the pressure-emitter means produced by billets of unknown volume with the values of the output signals at known volumes, so that the calculator calculates the volume of the billet with the help of the difference.

5. Means according to claim 4, which has at least one emitter which senses when the extrusion starts and means to supply the output signal of said emitter to the calculator.

6. Means according to claim 5, in which said emitter is constituted by said pressure-emitter means.

7. Means according to claim 6, in which the output signal comprises an alteration in the slope of the curve for the relationship between punch position and pressure.

8. Means according to claim 5, in which the calculator includes means to determine according to a program which is fed distance the pressure-generating punch is to be inserted into the pressure chamber and to deliver an output signal which interrupts the feeding when the punch has been fed in the calculated distance.

9. Means according to claim 2, in which the calculator is of digital type.

10. Means according to claim 2, in which the calculator is of analogue type.