

The present invention relates to a process for the quasi-isostatic press forming of high-performance explosive bodies of high dimensional accuracy and high homogeneity, the inner or outer mould being provided by a body of stable shape and high surface quality and being at least partially rotationally symmetrical and having a finite incline relative to the axis of rotation. The invention further relates to an apparatus and to the use of the process.

Isostatic press forming is used predominantly in metallurgy. Usually, metal press moulds which are applied with pressurized oil or silicone grease by way of more or less complicated supply lines and tools are provided. Isostatic hot and cold presses are known. In the field of the production of explosive bodies, isostatic cold press forming was used. This served in particular for the prefabrication and production of precision firing charges for special weapon systems.

In known apparatus and processes of this type (EP-A-0 010 459) for producing bodies of pressed powder, there is a pressurized container in which an isostatic pressure is generated. A case which is of a resilient material and which has a constant wall thickness is constructed to be cylindrical or barrel-shaped and contains a metal core, in particular a rod, and a peg or plug for closing the resilient case. This known process serves in particular for producing pressed bodies from powder for explosive charges and amunitions.

This apparatus and process are suitable for producing substantially cylindrical bodies. However, there is no indication as to how for example hollow charge explosive bodies could be produced with dimensional accuracy. The use of corresponding inner or outer moulds of stable shape is not described, nor is it obvious.

It is the object of the invention to provide a process and an apparatus which permit the production of precision explosive charges, in particular in their critical zones. It should thereby be possible to produce pyrotechnic charges of any given shape, including those with one or more open hollow spaces, having high homogeneity and few internal stresses acting as the

potential source of disruption.

This is achieved in that in a first process step the inner or outer mould is delimited by a resilient case, the latter being brought against the inner or outer mould with form fit with respect to the largest edge region and pressed thereon mechanically so that a loadable press mould is produced, in that in a second process step the hollow space of the press mould is filled with pulverulent explosive material, and in that the inner space and the explosive material as well as the space outside the press mould are evacuated, in that in a third process step the inner space is closed off and the filled press mould is introduced into a pressure chamber filled with liquid, and in that the interior of the pressure chamber is acted upon by a pressure, in that the pressure is continuously increased until a value determined by the density to be achieved and the strength of the explosive material is reached, and in that finally, by a continuous release of pressure, the filled press mould is returned to normal pressure and the pressed part is removed for a mechanical final machining.

The wording used in the pre-characterizing clause of Claim 1, "finite incline relative to the axis of rotation", takes into account the fact that there is no isostatic effect of press moulding with explosive bodies having axially parallel inner or outer moulds, and that when the pressure on such a pressed part is released disruptive internal stresses would arise.

This requires the explosive charge to be shaped such that in the critical region the inner or outer mould acting as an anvil has no surfaces running perpendicular or nearly perpendicular to the axis of rotational symmetry.

This eliminates disruptive marginal effects (local disruption of the explosive material homogeneity) as a result of the resilient pressure release of the pressed explosive material along the inner or outer surface or towards the liquid generating the pressure. - However, this requirement allows the production of modern precision explosive charges whereof decisive functional regions usually have the shape of a cone, a bell or a sphere. The external cylindrical shape usually required by the

incorporation of the explosive charge into the ammunition body can easily be achieved by mechanical or subsequent machining, for example by lathing.

The subsequent dependent claims describe advantageous further developments of the subject of the invention.

In accordance with Claim 2, water, which ensures a clean, simple and operationally reliable action on the press mould, has proved successful as the pressure medium.

The pressures specified in Claim 3, of 1000 to 5000 bar, for producing high-performance explosive charges have proved advantageous.

The pressure increase must be continuous in order that no impermissible friction with the risk of detonation arises in the interior of the explosive material body. Pressure increases of 800 to 1200 bar per minute have proved successful, with the average value of 1000 bar being considered the optimum as regards the performance of the process.

Similarly, for the same reasons, the pressure release should not take place abruptly. The return of the pressure medium to atmospheric pressure, in accordance with Claim 5, within 20 to 100 seconds, preferably within less than 60 seconds, allows short cycle times without there being a danger of incidents.

An apparatus of simple construction in accordance with Claim 6, whereof the form guarantees a high degree of operational reliability as a result of its simple geometric shapes has proved successful.

The apparatus in accordance with Claim 7 is particularly economical and can be implemented without particular knowledge of mould construction.

A simple screw clamp in accordance with Claim 8, as is used commercially in general pipeline construction, has proved successful.

Advantageously, the apparatus uses a resilient connection piece in accordance with Claim 9 for filling with pulverulent material and clamping off the vacuum.

In practice, the process for producing charges in accordance with Claim 10, which provides an increase in the armour-breaching

effect by comparison with conventionally produced charges, for example those produced by press forming, has proved highly successful.

Example embodiments of the invention will be explained in more detail below with reference to drawings. In all the drawings, like reference numerals are used for like functional parts.

In the drawings:

Fig. 1 shows a pressure chamber having a press mould illustrated diagrammatically by way of example,

Fig. 2 shows a press mould in implementation, as used for producing an explosive body component for armour defence rockets,

Fig. 3 shows a press mould for a transfer charge of a conventional hollow charge, and

Fig. 4 shows a further press mould for projectile charges.

In Fig. 1, 1 designates the inner and partly outer mould for producing an explosive material body 2 characteristic of the subject of the invention. The individual components of the mould 1, the parts 1a, 1b and 1d are constructed to be rotationally symmetrical about the axis A and are held together by a screw connection 1f. The explosive material 2 is delimited by a resilient case 3 of synthetic rubber (neoprene). This case 3 bears in self-sealing manner against the largest edge regions 1', with the two largest diameters, and encloses the end sides of the inner/outer mould 1. A charging opening 5 is acted upon through a conical closure 4, as is the entire press mould 6, by the pressure p prevailing in a pressure chamber 7. The pressure chamber 7 substantially comprises a pressure tube 8, a rotational cylinder of high-strength material, of stainless steel, which is closed at its lower end side 9. At its opposite side, a threaded cover 10 is screwed by means of its external thread 13 into an internal thread 14 of the pressure tube 8. This closes the inner space of the pressure chamber 7 in a liquid- and pressure-tight manner by way of a sealing flange 12. A simple manipulation is provided by a lever handle 11 on the threaded cover 10. A supply line 15, by way of which water is supplied as the pressure medium, is set in sealed manner in the centre of the threaded

cover 10. In the lower end side 9 there is set, also centrally, a removal line 16 which allows the liquid to be pumped away. The entire arrangement is surrounded in its pressure-loaded part by an oversized protective tube 17.

An explosive material body 2 is produced in the following manner:

The inner or the outer mould 1 is produced with dimensional accuracy in a manner known per se, according to the inside and end-side shape to be achieved of the explosive charge from high-strength material, a stainless steel with a lapped and polished surface. The case 3 is now slipped over the inner or the outer mould. Then, the conventional pulverulent explosive material 2 is introduced through the charging opening 5 (bore) provided on the end side in the inner or the outer mould 1 and is pre-compressed somewhat by shaking.

The press mould thus formed is now put into a commercially available vacuum chamber and there exposed to a vacuum of a few mbar for some minutes. This on the one hand de-gasses the explosive material and on the other hand evacuates the hollow spaces within the press mould 6. Also within the vacuum chamber, the conical peg 4 is inserted in the charging opening 4 and thereafter atmospheric pressure is let into the vacuum chamber and the charged press mould 6 is removed.

Then, the press mould 6 is put in the interior of the pressure chamber 7, which is partly filled with water. The threaded cover 10 is now screwed in sealed manner into the pressure tube 8 by means of the lever handle 11, and a pressure line coming from a commercially available multi-stage high-pressure pump is attached and screwed onto the supply line 15. By way of the supply line 15, the interior of the pressure chamber 7 is now first completely filled with water and is then acted upon with a continuous increase until pressure p is reached, with the pressure increase being approximately 1000 bar per minute and the pressure p reaching a maximum value of 3000 bar. After a dwell time of some seconds (approximately 10 to 40 seconds), the pressure is returned to normal pressure in less than 100 seconds by way an arrangement known per se, comprising

a relief valve and by-pass line.

Pressing of the explosive material body 2 is thus complete and it can be removed from the press mould 6 in simple manner, with the screw connection 1f, visible in Fig. 1, being loosened in the Fig. 1e and the components of the inner or the outer mould 1, the parts 1a (core), 1d, 1b, also being loosened and pushed apart or separated. The liberated explosive material body 2 can now be supplied to a conventional mechanical subsequent machining in the outer mould thereof. - The inner mould on the two end sides are dimensionally accurate and of stable shape and require no further machining, but may be subjected to a subsequent machining.

The subsequent figures show deviations in the construction of the press mould 6. The basic structure and the process steps are the same as in Fig. 1.

The further press mould 6, in Fig. 2, again has an inner mould 1b, 1b', but with two mutually symmetrical pegs 1c. Furthermore, there are provided here two outer moulds, a conical outer mould 1d and a cylindrical outer mould 1d'. If a precisely defined quantity of explosive material 2 is introduced into this press mould by way of the filling and evacuation connection piece 18, then the result is a dimensionally accurate shaped body, since the pressure action p for generating the isostatic effect acts radially on the case 3 of elastomer. For fixing the case 3 and for sealing, there is respectively an upper and a lower screw clamp 19, a commercially available hose clamp.

The filled filling and evacuation connection piece, also of elastomer, is stuck by adhesive in one piece with the case 3. After evacuation - as in the first example - the filling and evacuation connection piece is in this case clamped off by a clamp to be vacuum-tight. For this, too, commercially available clamps have proved successful.

The variant of the press mould in Fig. 3 is again composed of individual parts 1b and 1d. The central part 1b has a recess 1b' which forms a web in the finished explosive charge 2. Furthermore, reinforcing elements 31 to 36 are provided, as well as two edge region elements 37 and 38, which overall distribute

the pressure acting on the case 3 and ensure that the latter acts in the axial direction, as drawn in in Fig. 3, on the explosive material 2.

The press mould 6 in Fig. 4 contains an inner or outer mould 1c substantially constructed as a sphere segment. Again, an edge region 38 is provided, which on the one hand centres the mould 1c and on the other hand guarantees reliable securing in the largest region 1' of the inner or the outer mould 1c. Here, too, a screw clamp 19 is attached.

The example embodiments discussed above show the universal nature of the subject of the invention. For example, it allows the most precise possible implementation of hollow charge shapes determined by computer and having a high degree of armour-breaching action. The use of conventional pressure generating means and the use of water as the pressure medium guarantee a high degree of operational reliability and a very efficient use of the operating means.

The apparatus used to carry out the process according to the invention may be constructed in the greatest variety of ways; instead of stainless steel for the pressure chamber, reinforced plastics or laminates could conceivably be used.

Claims

1. Process for the quasi-isostatic press forming of high-performance explosive bodies of high dimensional accuracy and high homogeneity, the inner or outer mould (1) being provided by a body of stable shape and high surface quality and being at least partially rotationally symmetrical and having a finite incline relative to the axis (A) of rotation, characterized in that in a first process step the inner or outer mould is delimited by a resilient case (3), the latter being brought against the inner or outer mould with form fit with respect to the largest edge region (1') and pressed thereon mechanically so that a loadable press mould (6) is produced, in that in a second process step the hollow space of the press mould is filled with pulverulent explosive material (2), and in that the inner space and the explosive material (2) as well as the space outside the press mould are evacuated, in that in a third process step the inner space is closed off and the filled press mould (6) is introduced into a pressure chamber (7) filled with liquid, and in that the interior of the pressure chamber (7) is acted upon by a pressure (p), in that the pressure (p) is continuously increased until a value determined by the density to be achieved and the strength of the explosive material is reached, and in that finally, by a continuous release of pressure, the filled press mould (7) is returned to normal pressure and the pressed part is removed for a mechanical final machining.
2. Process according to Claim 1, characterized in that, as the pressure medium, water is introduced into the pressure chamber.
3. Process according to Claim 1 or 2, characterized in that the pressure medium is introduced into the pressure chamber (7) at a pressure (p) of 1000 to 5000 bar.
4. Process according to Claim 1 or 3, characterized in that the pressure increase of the pressure medium is controlled to increase by 800 to 1200 bar within a minute.
5. Process according to Claim 1, characterized in that the pressure medium in the pressure chamber (7) is returned to normal pressure within 20 to 100 seconds.



6. Apparatus for the quasi-isostatic press forming of high-performance explosive bodies of high dimensional accuracy and high homogeneity, having an inner or outer mould (1) which comprises bodies of stable shape and high surface quality and which is at least partially rotationally symmetrical and which has a finite incline relative to the axis (A) of rotation, in accordance with one of the preceding Claims 2 to 5, characterized in that the inner or outer mould is limited by a resilient case (3) having means (19) in order to secure the case (3) to the inner or outer mould with form fit with respect to the largest edge region (1'), and in that the pressure chamber (7) is a rotational cylinder arranged vertically and made of high-strength material, whereof the lower end side (9) is permanently closed and whereof the upper side is closed by a threaded cover (10), and in that the supply line (15) for the pressure medium is in the centre of the threaded cover (10) and the removal line (16) is guided centrally in the permanently closed side (9).

7. Apparatus according to Claim 6, characterized in that the resilient case (3) is a rotationally symmetrical elastomer whereof the largest edge region (1') is constructed with form fit with respect to the inner or outer mould (1).

8. Apparatus according to Claim 7, characterized in that a screw clamp (19) is provided which presses the elastomer mechanically against the largest inner or outer mould (1) in the largest edge region (1') thereof.

9. Apparatus according to Claim 7, characterized in that a filling and evacuation connection piece (18) is provided on the resilient case (3) at one end side.

10. Use of the process according to Claim 1 for manufacturing precision explosive charges with a directed action, such as hollow charges and mines.

