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(54) HOT MOULDING PROCESS FOR BLOCKS OF TWO-COMPONENT PROPELLANTS

(71) We, SOCIETE NATIONALE DES POUDRES ET EXPLOSIFS, a French Corporate Body, of 12, quai Henri IV – 75181 Paris, Cedex 04, France, 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:–

Blocks of two-component propellant charges containing nitrocellulose, nitroglycerine and various additives have hitherto been moulded by hot extrusion using a drawing press or a screw press. Hwever, only solid blocks or blocks having central channels which emerge at both ends can be manufactured by this process, and the finishing of such blocks frequently requires numerous machining operations in order to obtain contours external or internal contours which cannot be produced directly by the extrusion process.

In a hot moulding process for blocks of two-component propellants described in French Patents Nos. 1,402,342 and 1,604,957, attempts are made to reach the thermoplastic state of the propellant whilst keeping the latter in a heated mould, into which a piston of a hydraulic press moves until the propellant flows to completely fill the mould cavity.

The forming temperature zone within which these operations can be carried out in sufficient safety is limited to a value below 85°C for two-component propellants because there is a danger of self-ignition above this temperature.

However, in the temperature zone indicated, the two-component propellants are not in a sufficiently thermoplastic state for the thermoforming operations to be carried out satisfactorily, and it is generally necessary to exceed greatly the temperature of 85°C in order to reach the required thermoplastic state.

The present invention aims at overcoming the above drawback and in accordance with a first aspect provides a process for hot moulding propellant charges, comprising the steps of:

placing a blank of propellant in a mould defining moulding cavity and including a movable punch member;

and producing a vacuum in the mould cavity;

closing the mould heating the mould and blank to a thermoforming temperature in the range of 50°C to 120°C;

moving the punch into the moulding cavity to press the blank into shape; and

removing the shaped charge from the mould

The moulding cavity is evacuated, preferably to a high vacuum of less than 30 millibars and even less than 10 millibars when the pressure exerted by the punch is above 150 bars. This high vacuum is preferably maintained during the entire movement of the punch.

Operating in vacuo and in an air-tight mould avoids, on the one hand, any dangerous adiabatic compression of the residual air in the moulding cavity during the blank compression phase (movement of the punch), which may give rise to the phenomenon of self-ignition of the propellant, and on the other hand, the introduction of air bubbles into the propellant mass; it is also possible to remove decomposition gases which could be produced during the hot flow of the propellant, it being possible for this occluded air and these decomposition gases to give rise ro the said phenomenon of self-ignition.

The blank is advantageously formed on an extrusion press by hot extrusion of a cylinder of propellant, and by cutting this cylinder into blanks having the weight and volume of the charge to be produced.

The volume of the blank can be equal to the residual volume of the moulding cavity, i.e. the volume of the cavity when the punch is fully inserted, or it can be slightly greater than this residual volume which in a preferred arrangement is determined by the piston stroke of a hydraulic press which moves the punch.

The blanks are preferably heated to the thermoforming temperature before being placed in the moulding cavity, for example by storing them in a chamber heated to the required temperature, preferably as soon as they leave the extrusion press.

The moulding cavity and the punch are preferably heated to a temperature above 87°C, and more particularly to a temperature in the range of 90 to 110°C.

The pressure exerted on the blank by the punch is advantageously between 150 and 1,200 bars, and preferably between 250 and 1,000 bars.

The propellant used is advantageously a two-component propellant (nitrocellulose/nitroglycerine) manufactured by extrusion or by rolling in accordance with the so-called "solventless" technique.

Two-component propellant compositions of this type are given below, by way of non-limiting examples.

Composition No. 1

Nitrocellulose	58 parts by weight
Nitroglycerine	42 parts by weight
Centralite	1 part by weight

Composition No. 2

Nitrocellulose	59 parts by weight
Nitroglycerine	31 parts by weight
Diethyl phthalate	8 parts by weight
Ethylcentralite	3 parts by weight

Composition No. 3

Nitrocellulose	56 parts by weight
Nitroglycerine	37 parts by weight
Potassium cryolite	3 parts by weight
Centralite	2 parts by weight

In accordance with a second aspect the invention provides a device for carrying out the above process, comprising: a mould consisting of a closable moulding cavity shaped according to the external profile of the charge to be produced, a movable punch shaped according to the profile of the charge to be produced, means for moving the punch into the said moulding cavity in order for pressing a blank placed in the cavity, and means for removing the moulded blank from the mould; means for producing a vacuum in the closed moulding cavity; and means for heating the mould and the punch to a temperature in the range of 50 to 120°C, a frangible element being mounted on the bottom of the mould, whereby the moulding cavity is openable in the event of ignition of the propellant therein.

A better understanding of the invention will be had from the following detailed description, which is given by way of example with reference to the accompanying drawings, in which:—

Figure 1 is a side elevation shown partly in cross-section of a thermoforming device for hot moulding propellant charges;

Figures 2, 3 and 4 shown in cross-section, blocks of propellant produced according to the invention;

Figure 5 is a schematic view showing the positioning of an insert; and

Figure 6 is a cross-sectional view showing a propellant block fitted with its insert.

In Figure 1, the solid lines in the upper half of the Figure shows the punch in an intermediate position B and pressing on a blank of propellant on the start of the thermoforming process; the dotted lines on the lower left-hand side of Figure 1 show the punch in a completely lowered position C, the blank being fully compressed; the dot-and-dash lines on the lower right-hand side of Figure 1 show the punch in a raised position A, at the end of the moulding operation.

The thermoforming device (shown on its side in Figure 1) comprises a mould 1 having a vertical axis and consisting of a generally cylindrical sheath 2 with a lower part which is closed by a plug 3 fitted with an 0-ring seal 3*a*. The sheath is surrounded by a heating jacket 4 equipped for oil circulation, for raising the temperature of the mould. The bottom of the mould consists of a nut 5 which has an internal support flange and is screwed to the end of the said sheath 2, a safety diaphragm 6 inserted between the nut and the end of the sheath. The diaphragm can shear to make it possible for the plug 3 to be ejected and hence the mould to be opened in the event of premature ignition of the propellant in the mould.

The inner wall of the sheath 2 and the plug 3 define a moulding cavity 7 having the external profile of the block of propellant to be obtained.

The complementary profile of the block to be obtained is imparted by a punch 8 mounted coaxially on a punch carrier 9 which is firmly fixed to a movable base-plate 10 which is slidable on two vertical tie bars 11 and 11′ firmly joined to a fixed base-plate 12 of the frame 13 which holds the mould 1. The vertical movement of the movable base-plate is controlled by a jack 14.

The punch carrier 9 is slidable inside a movable sheath 15 which is connected to the movable base-plate 10 by springs 16. An 0-ring seal 17 is inserted in the upper part of the said sheath, between the latter and the punch carrier. The lower part of the sheath is hollowed out and, together with the said punch carrier, delimits an annular chamber 18 which through an opening 19 is connected to a vacuum pump.

An extracting device 20, having the shape of a cylindrical tube is slidably mounted on the punch carrier, in the annular chamber 18, and abuts by means of an upper collar 20*a* against the bottom of the movable sheath 15 or against a shoulder 9*a* of the punch carrier 9, under the action of a return spring 21 which bears against a retaining ring 22 provided inside the lower patr of the said movable sheath 15. The lower part of the sheath additionally comprises, on the outside, a collar 15*a* which can be blocked by an end stop 23, during the raising of the movable base-plate 10, thus making it possible to remove from the punch the moulded block of propellant, which butts against the extracting device 20 while the punch carrier continues to travel upwards.

The lower face of the collar 15*a* is also provided with an 0-ring 24 which ensures air-tight closure of the mould when the movable sheath 15 is lowered and bears against the upper edge of the sheath 2 of the mould, thus making it possible to produce a vacuum

in the moulding cavity 7.

In operation, with the punch 8 and the movable base-plate 10 being completely raised into the uppermost position denoted by the letter A, a cylindrical blank 25 of two-component propellant corresponding to composition No. 3 described above, is introduced into the moulding cavity 7.

The punch 8 and the movable element are lowered towards the position denoted by the letter B, until the movable sheath 15 bears and seals against the upper edge of the sheath 2 of the mould. The heating device 4 is started, and the vacuum pump is operated until the temperature of the mould and the punch has reached 95 ± 5°C and a vacuum pressure of 10 millibars has been established in the moulding cavity 7. The jack 14 is then operated to completely lower the punch 8 into the position indicated by the letter C in order to press the softened propellant under a pressure of 250 to 300 bars. The punch is lowered gradually (without impact) due to the presence of the return spring 21 which acts on the collar 20*a* of the extracting device 20, the collar itself acting on the shoulder 9*a* of the punch carrier 9. The operation of the vacuum pump is maintained throughout the entire duration of the thermoforming process. The vacuum is then broken, the mould is cooled, and the punch and the moulded blcok are withdrawn from the die to the upper-most position indicated by the letter A. The block is separated from the punch by means of the extracting device 20.

The duration of the thermoforming of the block of two-component propellant is 2/100 second, without taking account of the time necessary to bring the mould and the blank to the required temperature.

Using the conical punch, which is extended by a cylindrical point, as represented in the drawing, it is possible to manuacture blocks of two-component propellants, for example having an external diameter of 30 mm, a length of 50 mm, and a cross-section as shown in Figure 2 of the drawing.

By altering the shape of the punch, for example by giving it a cylindrical path with a smaller diameter than that of the moulding cavity, it is possible to manufacture self-combustible holders, for example having an external diameter of 10 mm, a length of 15 mm and a cross-section as shown in Figure 3, the process being carried out at a thermoforming temperature of 95°C, and under a compression of 650 bars, using propellant Composition No. 3 defined above, or at 80°C with a compression of 950 bars, using Composition No. 1 or No. 2

By altering both the shape of the punch and that of the moulding cavity, it is possible to manufacture radially ribbed wads, for example having an external diameter of 30 mm, a height of 5 mm and a cross-section as illustrated in Figure 4, the process being carried out at a temperature of 95 ± 5°C and under a compression of 250 to 300 bars.

Furthermore, an insert can be placed in a propellant block; for this purpose, as shown in Figure 5, the insert 26, which is a screw in this example, is screwed axially into the punch 8 which preferably has the shape of a piston. The screw is forced into a propellant blank 25, previously placed in the cavity 7 of the mould which is brought to the desired tempertaure and kept under vacuum as described above. The block of propellant and embedded screw are unscrewed from the punch.

A propellant block provided with an insert in this way, is shown in cross-section in Figure 6.

WHAT WE CLAIM IS:—

1. A process for hot moulding propellant charges comprising the steps of: placing a blank of propellant in a mould defining a moulding vacity and including a movable punch member; closing the mould and producing a vacuum in the mould cavity; heating the mould and blank to a thermoforming temperture in the range of 50°C to 120°C; moving the punch into the moulding cavity to press the blank into shape; and removing the shaped charge from the mould.

2. A process according to claim 1, wherein the thermoforming temperature is above 87°C.

3. A process according to claim 2, wherein the thermoforming temperature is between 90°C and 110°C.

4. A process according to claim 1, wherein the vacuum pressure produced in the moulding cavity is less than 30 millibars.

5. A process according to any one of claims 1 to 4, wherein the vacuum in the moulding cavity is maintained throughout the entire duration of the hot moulding operation.

6. A process according to claim 1 or claim 4, wherein the pressure exerted on the blank by the punch is in the range of 150 bars to 1,200 bars.

7. A process according to claim 6, wherein the pressure is between 250 bars and 1,000 bars.

8. A process according to claim 6, wherein the residual pressure in the moulding cavity is not greater than 10 millibars.

9. A process according to claim 1, wherein the volume of the blank is substantially equal to that of the charge to be produced.

10. A process according to claim 1, wherein the volume of the blank is substantially equal to the residual volume of the moulding cavity.

11. A process according to claim 1, wherein the blank is heated ot the thermoforming temperature before it is placed in the mould.

12. A shaped charge of two-component propellant obtained by the process according to any one of claims 1 to 6.

13. A shaped charge of two-component propellant according to claim 12, provided with a metal insert.

14. A device for carrying out the process

axcording to claim 1, comprising: a mould consisting of a closable moulding cavity shaped according to the external profile of the charge to be produced, a movable punch shaped according to the profile of the charge to be produced, means for moving the punch into the sadi moulding cavity in order for pressing a blank placed in the cavity, and means for removing the moulded blank from the mould; means for producing a vacuum in the closed moulding cavity; and means for heating the mould and the punch to a temperture in the range of 50 to 120°C, a frangible safety element being mounted on the bottom of the mould whereby the moulding cavity is openable in the event of ignition of the propellant therein.

15. A process for hot houlding propellant charges substantially as herein described.

16. A device for hot moulding propellant charges substantially as herein described with reference to the accompanying drawings.

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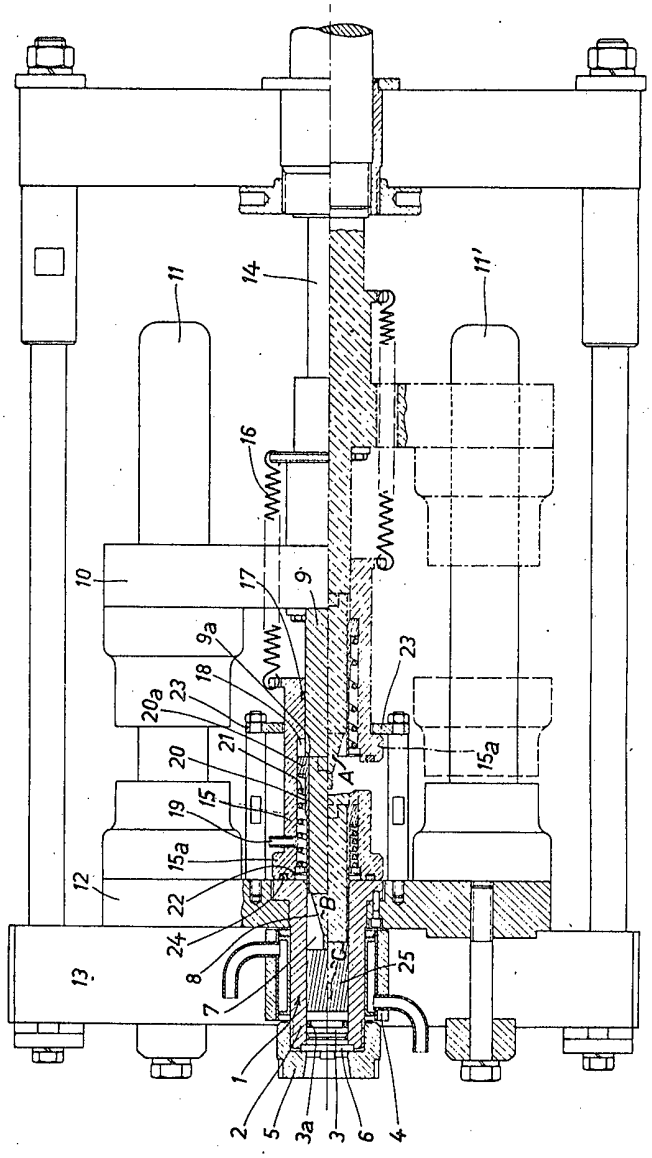
1580948 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.1



1580948 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

FIG.2

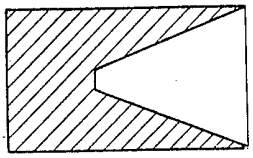


FIG.3

FIG.4

FIG.5

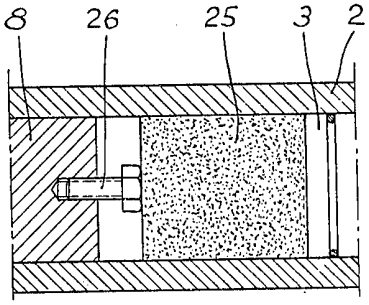


FIG.6