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(54) **METHOD OF OBTAINING TOOLS BY MEANS OF CONCRETE MOULD FORGING**

(57) A manufacturing method for dies, moulds and unique pieces or for a small quantity by means of forging in a forming mould is provided. The method consists in the construction of a forming mould which is able to bear high temperatures and mechanical stressing which occur when forging material in a closed system. It does not matter if the forming mould is destroyed during the forging process if the material of the mould, die or piece is deformed; the forming mould is sufficiently economically so that its cost does not exceed the cost reduction in relation to the machining process. The materials which are used

for the construction of the forming mould should be the most economical, but they must have the thermal and mechanical characteristics which are necessary for the forging process. In particular, preferred materials for the moulds are mortar and concrete with cements of a high resistance, with refractory cements, with basaltic aggregates, sand and other refractory aggregates, and other aggregates which are normally used for construction. Also other mortars can be used.

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Description

SUMMARY OF THE INVENTION

[0001] The invention which is the object of this application concerns a production method (and the produced elements) which consists in fabricating moulds, dies or any other unique pieces or small series (always metallic pieces or compounds with a metallic basis) by means of a closed forge. In the production process, a concrete or mortar forming mould is used (in particular, concretes or mortars made of high resistant concretes and/or refractory material on the basis of porcelanates, corundum, silicates... and with basalt aggregates, silicon oxides, or other aggregates which normally are applied in construction, or aggregates on the basis of aluminium or other refractory materials).

[0002] The main concern of this invention is the drastic cost reduction and time saving by using a closed forge to produce metallic pieces with a complex geometry. For the case of the present invention (obtaining moulds, dies and small series), it is fundamental that the production costs of the forming mould are not excessively high.

[0003] Another point of concern is the possibility of forming materials, on a metallic basis, which are difficult to machine or which cannot be machined, but which have on the other hand in hot condition sufficient yielding in order to be shaped through forging.

BACKGROUND AND SITUATION

[0004] In industrial applications, if a large series of plastic or metallic pieces have to be produced, in general, they are fabricated using permanent moulds and dies. The construction of a mould or a die is almost always very expensive. However, if a high number of pieces are produced those costs are generally recovered.

[0005] Any element which is used to form or shape metallic pieces, polymers, ceramics or composites of these is considered a mould or die. (The form of a mould or die can be the negative of the piece which has to be produced as is the case with injection moulding, pressing, dies for deep drawing, bending, stamping or any other method of shaping. It can also be a bent section as is the case with some cutting dies). The mould or die can be used in order to get just one piece or, as usual, hundreds up to millions of pieces by repeated actions. Very often, they are also used to get more than one piece with each step of shaping.

[0006] ANNOTATION TO CLARIFY TERMINOLOGY: Very often "shaping or forming" is understood in the industrial sector of sheet stamping as a very concrete operation which consists in deforming a plane sheet until the sheet acquires a definite shape (generally, the final piece). This can be reached with one or more operations. In this document, the expression "shaping or forming" is used to designate any operation in which a material is deformed by a mould or a die (examples of operations

designated as "shaping or forming" are: cutting, stamping, deep drawing, hot forging, cold forging, extrusion, press moulding, gravity moulding, thermal shaping, pressing, blow forming, ...)

5 **[0007]** ANNOTATION TO CLARIFY TERMINOLOGY: In this document, the name "forming mould" designates any container which is able to give a metallic piece a specific form by means of a closed forge (also generally denominated: forging die, forging mould, forging devices).

10 **[0008]** Depending on the application, three main types of moulds and dies can be distinguished. However, there are not only differences in the application, but also in the kind of materials used to build moulds and dies and in the process:

1. Moulds to shape polymers (thermoplastics and thermo stables). [Typical shaping operations for this case are: injection, thermo shaping, thermal setting, blow forming, pressing of thermostables...]

20 2. Hot work moulds and dies: Shaping of any metallic alloy at high temperature, in general temperatures higher than 0,5 Tm (Tm being the absolute temperature of the melting point) and very often with the alloy in liquid condition. [Typical shaping operations for this case are: hot injection or pressing, extrusion, closed forging, deep drawing and hot stamping...]

25 3. Cold work moulds and dies: Shaping of metallic alloys at lower temperatures than 0,5 Tm. [Typical shaping operations for this case: cutting, deep drawing, stamping, bending...]

30 At present, basically two methods are used to obtain moulds and dies for the above mentioned applications: machining by stock removal and casting. Every method has its advantages and disadvantages. Which one of them is finally more economically interesting depends on the geometry of the piece which shall be produced and the number of pieces to be obtained with it.

35 **[0009]** When machining by stock removal, a metallic form with the desired geometry is obtained by eliminating the dispensable material (in general, the basic material is a forged block or a block which has been cut from a forged or rolled ingot, however, also melted blocks are used). The toughness of a forged alloy is much higher than the toughness of the same alloy in "as melted" or cast state. The higher toughness results very often in a longer life of the produced tool (ANNOTATION: In this document the term "tool" designates moulds and dies at the same time). This method is used to make dies and moulds which should produce high numbers of pieces and which are fairly even (it doesn't take excessive stock removal to attain the desired shape). Machining by stock removal is an expensive process. The more the material that has to be removed, the more material is converted into chips, and the more hours and energy are invested. Moreover, the increase of toughness which has been obtained by forging or rolling decreases as material is re-

moved and the deeper layers of the original block become the working surface of the tool. This means that if much material has to be removed in order to shape the working zone, then this zone will practically have the structure and the characteristics of cast material. Thus, seldom this method is used for tools with spot height differences of more than 400 mm with most materials usually employed for constructing moulds and dies. The method is the preferred one for large productivity as the produced tools normally have a longer lifecycle. In fact, this method principally is farfetched as the melted material is cast into ingots and not directly into a geometry which is similar to the final one. The ingots are then forged in order to convert them into billets. The billets are forged or rolled again in order to obtain forged blocks or bars. In the latter case, the bars have to be cut in order to get the desired block. In both cases (forged block or cut bar), the block has to be machined by stock removal or electro-erosion in order to obtain the desired geometry. The processes before hardening, final machining, ... are common for both production methods.

[0010] Of all processes in which tools are obtained by casting, the one which is currently most used is the process in which the material is melted in a sand mould and a poly-styrene model which is consumed when the mould is filled. Normally, a pre-form is obtained. Thus, the tool has to be machined by stock removal in order to get the appropriate tolerances in the working areas. The geometry of the pre-form is similar to the final one. Hence, less material has to be removed and thrown away. By using this method, moulds and dies can be obtained in a more economic way (when compared to departing from a forged block, the economic difference is bigger when there are big differences in the spot heights and, consequently, the more material has to be eliminated when departing from a solid block). However, those moulds and dies have a lower durability. It is the preferred method if a small quantity of pieces has to be produced and if the variability in the spot heights is high.

[0011] Since many years, forging is used in order to get pieces of a specific form. In general, this process is called "closed forging" as a forming mould or cavity has to be used in order to get pieces with the desired shape. When filling the mould or cavity, the soft material adopts the form of the forming mould or cavity. In this process, metallic or ceramic forming moulds are used. This is a technology to get several pieces with the same mould in order to amortise the costs of the mentioned mould. In the present invention, since the moulds and dies are in general unique and since there are only rarely more than ten cavities or segments of the same geometry, the cost of the mould has to pay itself off after the production of one or only a few pieces. Consequently, the fabricated product, the mould or die, must have a cost which is net superior of the cost of the forming mould. This is also the case if moulds and dies are obtained by melting in a sand forming mould.

OBJECT OF THE INVENTION

[0012] By means of the process which is matter of this invention, moulds and dies can be obtained as economically and as simply as is the case of casting which is the currently the process most widely used. At the same time, those obtained moulds and dies have the same or even a higher lifecycle as the moulds and dies which are obtained by machining forged or rolled blocks (very often blocks cut off from forged and/or rolled bars). The method allows the use of materials which are difficult to machine (even materials which are considered as "not machinable"). With the use of such materials, the lifetime and/or the productivity of the manufactured tools or pieces will be considerably higher.

[0013] The present invention consists in providing a production method for dies, moulds and unique pieces or for a small quantity by means of forging in a forming mould. The method consists in the construction of a forming mould which is able to bear high temperatures and mechanical stressing which occur when forging material in a closed system (it does not matter if the forming mould is destroyed during the forging process if the material of the mould, die or piece is deformed; the forming mould is sufficiently economically so that its amount does not exceed the cost reduction regarding the machining process). The optimisation of the forging parameters (in particular, temperature and deforming speed) as well as the geometry of the form which shall be obtained and the material of which the mould or die shall be constructed have a big influence on the forces which act on the forming mould and, hence, determine considerably potential materials for the construction of the forming mould.

[0014] The materials which are used for the construction of the forming mould should be the most economical, but they must have the thermal and mechanical characteristics which are necessary for the forging process. In particular, mortar and concrete have to be mentioned: with cement of a high resistance (on the basis of porcelanates, silica, ...), with refractory cement (on the basis of alumina, aluminosilicate, ...), with basaltic aggregates, sand (SiO₂), and other refractory aggregates (on the basis of alumina), and other aggregates which are normally used for construction. Also other mortars can be used (on the basis of MgO, SiC, ZnO, Cr₂O₃, ZrO₂, B₂O₃, Al₂SiO₅, CeO₂, C₂Si₃, CaF₂, silica, graphite, magnesite, silicates, lignosulphonates, phosphates (of boron, aluminium, ...)). Some of the previously mentioned aggregates can also be used with a binding agent (for instance, aluminium phosphate).

[0015] It is also an advantage if one part of the invention is used for obtaining moulds and dies by melting, as forming moulds of mortar and concrete are employed. The dimension tolerances which can be obtained as well as the quality of the final machining are notably higher.

[0016] The present invention is also a big advantage for obtaining final pieces or pre-forms (in particular, with unique pieces or a small quantity), especially, if the ma-

terial which is used to get the piece is difficult to machine or if it's of a high cost. Some geometry can not be obtained in a affordable manner unless the method of the present invention is employed, such is the case of very difficult to machine materials as metal matrix composites with ceramic reinforcement.

[0017] The invention also implies an important economic advantage when obtaining sintered pieces in concrete forming moulds, especially, if concrete of a high resistance is used. During this process, the material of which the mould, die or piece shall be made of is filled into the forming mould as powder. Afterwards, cold or hot pressing is executed in order to get the final geometry or the pressed green pre-form, a little bit sintered or totally sintered with or without liquid phase.

[0018] PRELIMINARY NOTE: In all the claims, where the term "mould or die by forging" appears, it must also be understood the obtaining by forging in a shaping mould of any kind of pre-form which simplifies the machining for obtaining the final mould or die.

Claims

1. Method for producing moulds or dies by forging in a concrete or mortar mould. The materials employed for the construction of the moulds or dies can be metals, metallic alloys or composites with metallic phase (either the die or any of the phases).
2. Method for producing single pieces or low production volume pieces by forging in a concrete or mortar mould. The metallic materials employed for the construction of the moulds or dies can be metals, metallic alloys or composites with metallic phase (either the die or any of the phases).
3. Any mould, die or piece produced by means of forging in a concrete or mortar shape mould.
4. Claims 1 to 3 when the forging process is made in the regime of superplastic forming, in concrete or mortar moulds which are pre-heated or warmed up during the forging process.
5. Claims 1 to 4 when the shaping concrete mould is placed inside a compression ring with a stress strength higher than the mortar or concrete employed for the construction of the shaping mould. (Also when the higher stress strength is partly due to the temperature gradient, especially when the compression ring is cooled).
6. Claims 1 to 5 when the shaping mould is fabricated with a high mechanical resistance concrete or mortar ($R_m \geq 25\text{MPa}$).
7. Claims 1 to 5 when the shaping mould is fabricated with a refractory concrete or mortar, with special mention made to concrete or mortar made with higher than 20% alumina content cements.
8. Claims 1 to 5 when the shaping mould is fabricated with a refractory high resistance concrete or mortar ($R_m \geq 25\text{MPa}$).
9. Claims 1 to 5 when the shaping mould is fabricated with a refractory high resistance concrete or mortar ($R_m \geq 25\text{MPa}$), with special mention to concrete or mortar made with higher than 20% alumina content cements.
10. Claims 1 to 5 when the shaping mould is fabricated with cement or mortar where any of the aggregates has an alumina content exceeding 10%.
11. Claims 1 to 5 when the shaping mould is fabricated completely or in part with any of the following materials: MgO, SiC, ZnO, Cr_2O_3 , ZrO_2 , B_2O_3 , Al_2SiO_5 , CeO_2 , C_2Si_3 , CaF_2 , silica, graphite, magnesite, silicates, lignosulphates, phosphates (boron, aluminium...), porcelanates, alumina or aluminium-silicates.
12. Claims 1 to 5 where the shaping mould is partly made with any of the following materials: sand (with or without binding material), granulate or powder of any refractory material or basalt.
13. Claims 1 to 5 when the shaping mould is fabricated with refractory granulate or powder or any aggregate and a binding material is used, based on cement or not, like for example a phosphate based binding material (with special mention to the aluminium phosphate).
14. Claims 1 to 5 when the shaping mould is fabricated with any non-metallic material.
15. Claims 1 to 14 when any type of thermal barrier or paint is employed on the shaping mould. It is understood as a paint or thermal barrier any layer of less than 5 mm thickness with refractory characteristics, in particular when the thermal emissivity is higher than that of the shaping mould material. Also paints or coatings with a higher resistance to the working temperature. (Typical paints or coatings can be based on: SiO_2 , BN, ZrO_2 , YO_2 , Al_2O_3 ,.....)
16. Claims 1 to 15 where a metallic compression ring is employed to lower the tensile stress load on the shaping mould (the compression ring can be cooled during the forging process to increase its mechanical strength and/or to increase the interference with the shaping mould).

17. Claims 1 to 16 when the shaping mould is pre-heated before the material to be forged is introduced.
18. Claims 1 to 17 when the shaping mould is heated up to a temperature similar to that of the material to be shaped into a mould, die or piece, also when the material is heated up inside the shaping mould itself.
19. Claims 1 to 18 when the shaping mould is thermally isolated to minimize the heat loss. Also when the shaping mould is heated during the forming process of the die, mould or piece, the heating being made through radiant screens, resistances embedded in the shaping mould, heating blankets or any other heating device.
20. Claims 1 to 19 when the forging deformation to obtain the mould, die or piece is applied in the superplastic deformation regime of the material employed to make the die, mould or piece.
21. Claims 1 to 20 when the forging deformation to obtain the mould, die or piece is applied in the dynamic recrystallization deformation regime of the material employed to make the die, mould or piece.
22. Claims 1 to 21 when the forging deformation to obtain the mould, die or piece is applied in the dynamic restoration deformation regime of the material employed to make the die, mould or piece.
23. Claims 1 to 22 when the strain rate employed during the forging process exceeds 0.1 s^{-1} .
24. Claims 1 to 23 where the shaping mould has been obtained from a mechanised model, the model being made of an easy to machine material (polymer, wood or light alloy)
25. Claims 1 to 23 where the shaping mould has been obtained from a model, the model being cast or injected.
26. Claims 1 to 23 where the shaping mould has been obtained from a model, the model being made of high-density expanded polystyrene.
27. Claims 1 to 26 when the material employed for the fabrication of the die, mould or piece is a metal or metallic alloy.
28. Claims 1 to 26 when the material employed for the fabrication of the die, mould or piece is a metal matrix composite.
29. Claims 1 to 26 when the material employed for the fabrication of the die, mould or piece is a polymeric matrix composite.
30. Claims 1 to 26 when the material employed for the fabrication of the die, mould or piece is steel.
31. Claims 1 to 26 when the material employed for the fabrication of the die, mould or piece is a tool steel.
32. Any die, mould or piece fabricated through casting in a shaping mould made of concrete or mortar.
33. Any die, mould or piece fabricated through casting in a shaping mould made of a high resistance concrete or mortar. ($R_m \geq 25 \text{ MPa}$).
34. Any die, mould or piece fabricated through casting in a shaping mould made of a refractory concrete or mortar, with special mention made to concrete or mortar fabricated with higher than 20% alumina content cements.
35. Any die, mould or piece fabricated through casting in a shaping mould made of a refractory high resistance concrete or mortar ($R_m \geq 25 \text{ MPa}$)
36. Any die, mould or piece fabricated through casting in a shaping mould made of a refractory high resistance concrete or mortar ($R_m \geq 25 \text{ MPa}$), with special mention made to concrete or mortar fabricated with higher than 20% alumina content cements.
37. Any die, mould or piece fabricated through casting in a shaping mould made of cement or mortar where any of the aggregates has an alumina content exceeding 10%.
38. Method for obtaining moulds, dies and pieces by the pressing of powders in a concrete or mortar shaping mould. The material which is to be employed to fabricate the mould, die or piece, is introduced in the shaping mould as a powder and cold pressing or hot pressing is applied to obtain the desired geometry or a pre-form which can be green-pressed, partially sintered or totally sintered with or without liquid phase.
39. Any die, mould or piece obtained by the process described in claim 38.
40. Claims 38 and 39 when the shaping mould is made with concrete or mortar where the cement and/or any of the agglomerates employed has an alumina content exceeding 10%.
41. Claims 38 and 39 when the shaping mould is made with high resistance concrete or mortar (it is understood as a high resistance concrete or mortar when the mechanical resistance thereof is higher than 40 MPa).

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT

(PCT Article 17(2)(a), Rules 13ter.1(c) and 39)

Applicant's or agent's file reference	IMPORTANT DECLARATION	Date of mailing (<i>day/month/year</i>) 11 February 2005 (11.02.2005)
International application No. PCT/ES 2004/000510	International filing date (<i>day/month/year</i>) 16 November 2004 (16.11.2004)	(Earliest) Priority Date (<i>day/month/year</i>)
International Patent Classification (IPC) or both national classification and IPC		
Applicant ROVALMA, S.A., VALLS ANGLES, Isaac y otro.		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below.

1. The subject matter of the international application relates to:
 - a. scientific theories.
 - b. mathematical theories.
 - c. plant varieties.
 - d. animal varieties.
 - e. essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes.
 - f. schemes, rules or methods of doing business.
 - g. schemes, rules or methods of performing purely mental acts.
 - h. schemes, rules or methods of playing games.
 - i. methods for treatment of the human body by surgery or therapy.
 - j. methods for treatment of the animal body by surgery or therapy.
 - k. diagnostic methods practised on the human or animal body.
 - l. mere presentations of information.
 - m. computer programs for which this International Searching Authority is not equipped to search prior art.
2. The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:

<input checked="" type="checkbox"/> the description	<input checked="" type="checkbox"/> the claims	<input type="checkbox"/> the drawings
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3. The failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions prevents a meaningful search from being carried out:

<input type="checkbox"/> the written form has not been furnished or does not comply with the standard.
<input type="checkbox"/> the computer readable form has not been furnished or does not comply with the standard.
4. Further comments:

Name and mailing address of the ISA/ S.P.T.O.	Authorized officer
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