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(54) **ROTARY EXTRUSION MACHINE**

(57) A rotary extrusion machine (20) comprising: a rotatable spindle (21) comprising clamping means (211) for clamping a first end of a workpiece and for rotating said workpiece around a first axis; a punch (22) rotatable around said first axis simultaneously to the rotation of said spindle (21), the punch (22) and the spindle (21) being arranged so that either the punch (22) or the spindle (21) moves longitudinally along said first axis towards said respective spindle (21) or punch (22), so that the punch (22) introduces into the workpiece producing a hollow therein; at least three spinning rolls (23) arranged to be in contact with the external surface of the workpiece, the spinning rolls (23) being rotatable to make the material of the workpiece flow as the punch (22) and spindle (21) rotate, in an opposite direction to the introduction of the punch (22) in the workpiece. The punch (22) comprises a guiding sleeve (24), arranged coaxially to the outside of the punch (22) defining a cavity between the punch (22) and an inner surface of the guiding sleeve (24), the cavity being configured for housing and guiding material of the workpiece as it flows. A process for producing a part (32) using the rotary extrusion machine. A part (32) obtainable by the former process.

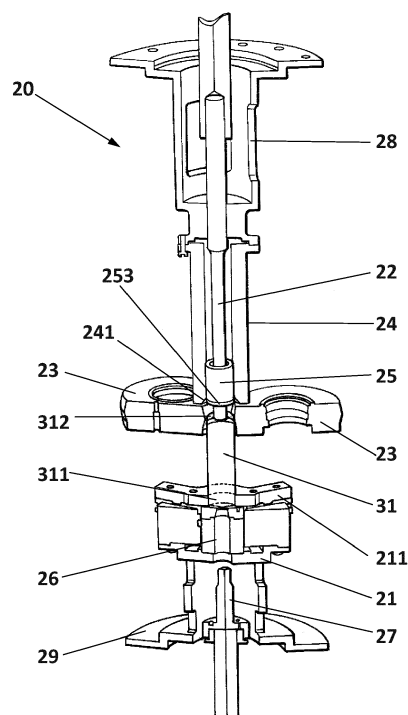


FIG. 2

Description

TECHNICAL FIELD

[0001] The present invention relates to the field of machines tools and, in particular, to rotary extrusion machines for producing axial holes in cylindrical metal workpieces or parts.

STATE OF THE ART

[0002] In the European forging sector, major costs (60-70%) are related to raw material and energy consumption. Therefore, a significant effort must be done in order to develop new technologies that allow a reduction in material and energy consumption. This is especially important in the automotive sector, where costs are very demanding. The forging process plays an important role in the automotive industry thanks to the good mechanical properties of the forged parts. For example, hollow shafts of automotive gearbox are usually manufactured using a combination of forming and metal drilling techniques. Deep drilling is the most common technique for obtaining internal holes in the automotive hollow parts, but it is an expensive method in terms of material usage. Nowadays, the process of manufacturing gearbox shafts is as follows: first a solid part is made; and next its inner part is emptied by means of hard operations of deep drilling.

[0003] Rotary processes such as rotary forging or rotary extrusion are technologies that leads to reduce the material usage and process time needed, as reported for example by J. San José, M. Santos, S. Varela, M. Albea, X. Medan, J. F. Puigjaner in "Material reduction costs by new rotary processes: rotary forging and flowforming": submitted to 30rd SENAFOR 2010 (2010). In this way, the rotary-extrusion process (so called spin extrusion), which is an incremental forming process to produce axisymmetric hollow parts from cylindrical billet, has been reported by R. Neugebauer et al. in "Innovation by cross rolling and spin extrusion technology" (2004) and in "New warm forging process to produce hollow shafts", Journal of Material Processing Technology 119 (2001) p. 277-82. According to these disclosures, the initial billet 11 is clamped in the chuck and rotates on its own axis. The tubular shape is formed with the combined effect of a movement of a punch, co-linear to the axis of the billet 11, and three rollers 13. These tools are subjected to synchronous axial feed. This combination of movements causes the displacement of the material on the surface of the punch and an axisymmetric hollow part is the result of the procedure. Figure 1 shows a scheme of principle on which rotary extrusion is based.

[0004] German patent application DE102008036226-A1 describes a method of obtaining a hollow shaft by heating a semi-finished material at a temperature of 1000-1200 degree Celsius before forging. A preform is produced from the heated semi-finished material by forging -such as die forging- in a forging press having stroke

rate of 80 strokes per minute. The preform is subjected to thermal treatment for transforming it into a hollow intermediate form by borehole drilling. Rotary swaging is applied to obtain the final hollow shaft.

[0005] German patent application DE-102012005106-A1 describes a process for producing a hollow shaft in which the portion of solid semi-finished material is reshaped into a tubular intermediate product through hole pressing process. The tubular intermediate product of the semi-finished material is separated for reshaping with respect to a cavity mold by hollow forward extrusion molding process, by using press ram and die. The cavity mold is reduced to a defined outer and/or inner surface of a hollow shaft.

[0006] German patent application DE-10308849-A1 describes a method and apparatus for producing a hollow part. The apparatus and method include thermal treatment to improve the durability of the hollow body.

[0007] These processes cannot assure a uniform width of the wall of the hollow part obtained thereby. Furthermore, there is a need to improve the quality of the external wall of the piece.

DESCRIPTION OF THE INVENTION

[0008] It is an object of the invention to provide an improved rotary extrusion machine for manufacturing hollow parts or partially-hollow parts.

[0009] According to an aspect of the present invention, there is provided a rotary extrusion machine comprising: a rotatable spindle comprising clamping means for clamping a first end of a workpiece and for rotating said workpiece around a first axis; a punch rotatable around said first axis simultaneously to the rotation of said spindle, the punch and the spindle being arranged so that either the punch or the spindle moves longitudinally along said first axis towards said respective spindle or punch, so that the punch introduces into a second end of the workpiece producing a hollow therein; at least three spinning rolls arranged to be in contact with the external surface of the workpiece, the spinning rolls being rotatable to make the material of the workpiece flow as the punch and spindle rotate, in an opposite direction to the introduction of the punch in the workpiece, The punch comprises a guiding sleeve, arranged coaxially to the outside of the punch defining a cavity between the punch and an inner surface of the guiding sleeve, the cavity being configured for housing and guiding material of the workpiece as it flows.

[0010] In a preferred embodiment, the machine comprises a guiding bushing arranged around said punch and housed in the cavity defined by said guiding sleeve to radially retain the punch as the punch introduces in the workpiece. More preferably, the guiding bushing is arranged to move inside the guiding sleeve pushed by the material as it flows. In a particular embodiment, the guiding bushing comprises a frictional edge for cleaning the external surface of the punch.

[0011] In a particular embodiment, the punch moves longitudinally along said first axis while the spindle remains stationary. In a preferred embodiment, the guiding sleeve moves simultaneously to the punch.

[0012] In a particular embodiment, the guiding sleeve comprises an angled edge for guiding the material of the workpiece into the cavity of the guiding sleeve.

[0013] In a particular embodiment, the machine comprises a support element arranged next to the clamping means, said support element being configured to enable the forming of a passing through hole in said first end of the workpiece, said support element comprising a central hole configured for the introduction of the punch. The machine preferably comprises a retractable supporting element for closing the central hole of said support element until the punch arrives at said first end of the workpiece.

[0014] In a particular embodiment, the spinning rolls are rotatable around a second axis parallel to said first axis.

[0015] In a particular embodiment, the machine comprises at least three retractable spinning rolls for reducing the diameter of the material of the workpiece as it flows.

[0016] In a particular embodiment, the clamping means comprise heating means.

[0017] In a particular embodiment, the first axis is a vertical axis.

[0018] According to another aspect of the invention, a process for producing a part comprising a hollow using the described rotary extrusion machine is provided.

[0019] According to another aspect of the invention a part comprising a hollow obtainable by the previously mentioned process is provided.

[0020] Additional advantages and features of the invention will become apparent from the detail description that follows and will be particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] To complete the description and in order to provide for a better understanding of the invention, a set of drawings is provided. Said drawings form an integral part of the description and illustrate an embodiment of the invention, which should not be interpreted as restricting the scope of the invention, but just as an example of how the invention can be carried out. The drawings comprise the following figures:

Figure 1 shows the principle on which rotary extrusion is based.

Figure 2 shows a cross-sectional view of a rotary extrusion machine according to a particular embodiment of the invention; the starting stage of the process is represented.

Figure 3 shows an expanded view of a portion of the machine shown in figure 2.

Figure 4 shows a cross-sectional view of the rotary

extrusion machine of figure 2, in an intermediate stage of the process, before the through hollow is produced.

Figure 5 shows a cross-sectional view of the rotary extrusion machine of figure 2, in which a tubular part has been produced, including a through hollow.

DESCRIPTION OF A WAY OF CARRYING OUT THE INVENTION

[0022] In this text, the term "comprises" and its derivations (such as "comprising", etc.) should not be understood in an excluding sense, that is, these terms should not be interpreted as excluding the possibility that what is described and defined may include further elements, steps, etc.

[0023] In the context of the present invention, the term "approximately" and terms of its family (such as "approximate", etc.) should be understood as indicating values very near to those which accompany the aforementioned term. That is to say, a deviation within reasonable limits from an exact value should be accepted, because a skilled person in the art will understand that such a deviation from the values indicated is inevitable due to measurement inaccuracies, etc. The same applies to the terms "about" and "around" and "substantially".

[0024] The following description is not to be taken in a limiting sense but is given solely for the purpose of describing the broad principles of the invention. Next embodiments of the invention will be described by way of example, with reference to the above-mentioned drawings showing apparatuses and results according to the invention.

[0025] The rotary extrusion process is divided in two stages that are performed in the same machine: 1) the combined movement of the rollers and the punch forms a quasi-tubular shape; and 2) punch keeps its own movement to cut the part end. Optionally there is a third stage: 3) additional rollers move to get the final external shape. Figures 2 to 5 show a rotary extrusion machine according to an embodiment of the present invention. The machine is configured to produce a hollow in a workpiece. The hollow can be partial, that is to say, the final workpiece has a cavity in its inner part, but the workpiece is not perforated end-to-end; or the hollow can be total, that is to say, the final workpiece has a through hollow that traverses the workpiece end-to-end. In other words, the final workpiece can be open at one end or open at two ends, both ends being connected by a hollow channel. The workpiece produced by the machine is preferably tubular shape. Non-limiting examples of pieces or parts that can be produced by the present machine are tubular parts and hollow shafts for vehicle powertrain including shafts for engine, transmission (gearbox), drive shaft and suspension systems. This tubular shape (complete hollow shape) is obtained without adding any following operation as other incremental forming processes do. It is obtained with the combination of two forming processes:

flow forming and backward extrusion.

[0026] Figure 2 shows a cross-sectional view of the rotary extrusion machine 20. Figure 2 represents a first stage of the rotary extrusion process, in which a block of material, workpiece or preform 31 is grasped or clamped by clamping means 211 of a spindle 21. The preform, workpiece or block of raw material 31 is solid. It can initially take any form, such as a billet, a forged or casted preform, a machined preform or others. Non-limiting examples of possible materials are: metals, such as steel, aluminum, superalloys, plastics and composites. The choice of the material depends of the final part to be produced. The spindle 21 is for example placed on a support 29. The workpiece or block of material 31 is held by the clamping means 211 at a first end 311 of the workpiece 31. The spindle 21 is configured to rotate around a first axis. As it rotates, the spindle 21 makes the workpiece 31 rotate around that same axis. In fact, a longitudinal axis of the workpiece 31 is aligned with a longitudinal axis of the spindle 21. The clamping means can have heating means.

[0027] The machine 20 also comprises a mandrel or punch 22 disposed along the same longitudinal axis as the spindle 21. The punch 22 is configured to rotate around that first axis simultaneously to the rotation of the spindle 21. The punch 22 and the spindle 21 are longitudinally arranged along a same axis. Besides, apart from the rotation of both punch and spindle around that axis, either the punch 22 or the spindle 21 moves longitudinally along that axis towards respectively the spindle 21 (if it is the punch 22 the one moving) or the punch 22 (if it is the spindle 21 the one moving). Thanks to this longitudinal movement that permits that punch and spindle get closer to each other, the punch 22 inserts, introduces or penetrates into the workpiece or block of material 31, producing a hollow therein. The rotation of punch and spindle reduces the contact time between the workpiece and the punch and improves the friction therein. In the embodiment shown in figures 2-5, that axis is a vertical axis (that is to say, the machine takes a vertical disposition), but the axis can alternatively be horizontal or inclined. The machine 20 is preferably disposed vertically (therefore the longitudinal axis is a vertical axis), because forces are more equally distributed and flexion is better prevented. In a vertical disposition, in which the original workpiece or block of raw material 31 and the punch are vertically supported, there is less flexion caused by their weight. This implies more precision and a better final piece. The vertical disposition additionally makes loading and unloading easier. The adjustment and consume of the rollers -not described yet- is better controlled when they are in a horizontal plane. Finally, the vertical disposition implies a reduction in the space occupied.

[0028] The punch 22 and the spindle 21 are activated by motors. In a preferred embodiment, the punch 22 and the spindle 21 are activated by two synchronized motors (each one associated to respective punch and spindle). In an alternative embodiment, a single motor is used to

activate both the punch 22 and the spindle 21.

[0029] The machine 20 also comprises a plurality of spinning rolls 23. There are preferably at least three spinning rolls 23. When there are three rolls 23, they are separated 120 degrees with respect to each other. In this way, the force from the rolls is equally distributed and it creates a good geometry to deform the material. In operation of the machine 20, the spinning rolls 23 rotate in such a way that they make the material of the outer surface of the workpiece 31 flow as the punch 22 and the spindle 21 rotate. This flow of material goes in a direction opposite to the direction of introduction of the punch 22 in the workpiece or block of material 31. The spinning rolls 23 are therefore in contact with the outer surface of the workpiece or block of material 31. In the first stage of the spin extrusion process (that is to say, when the machine 20 starts to work), the spinning rolls 23 are in contact with the end 312 of the workpiece 31 which is opposite to the end 311 grasped by the spindle clamps 211. The spinning rolls 23 are placed near the workpiece 31 but do not contact the workpiece until the punch 22 starts its axial movement. When the introduction of the punch 22 in the workpiece begins, the spinning rolls 23 start to move synchronized with the axial movement of the punch 22. In a final stage of the spin extrusion process, illustrated in figure 4 (when the final part is substantially finished), the spinning rolls 23 are in contact with the end of the workpiece 31 at which the workpiece is grasped by the spindle clamps 211. In a preferred embodiment, each of the spinning rolls 23 is rotatable around a respective second axis parallel to the longitudinal axis of the punch 22. The spinning rolls can be idle or motorized. Alternatively, the axis around which one or more spinning rolls 23 rotate, is not parallel to the longitudinal axis of the punch 22.

[0030] Optionally, there is a plurality of additional spinning rolls, not illustrated. These additional spinning rolls are retractable spinning rolls, configured for reducing the diameter of the material of the workpiece as it flows. There are preferably at least three retractable spinning rolls, not illustrated.

[0031] The punch 22 also comprises a guiding sleeve 24. The guiding sleeve 24 surrounds the punch 22. The guiding sleeve 24 takes the form of a hollow tube having a diameter larger than the diameter of the punch 22. In other words, the guiding sleeve 24 is arranged coaxially to the outside (outer surface) of the punch 22. Therefore, the guiding sleeve 24 is disposed along the same longitudinal axis as the punch 22. The guiding sleeve 24 thus defines a cavity between the punch 22 and an inner surface of the guiding sleeve 24. This cavity is configured for housing and guiding the flowing material of the workpiece 31 as it flows due to the contact of the workpiece 31 with the spinning rolls 23 when they rotate. In a preferred embodiment, the end of the guiding sleeve 24 configured to be closer to the workpiece or block of material 31 has an angled edge 241 for guiding the material of the workpiece into the cavity of the guiding sleeve 24 as

it flows.

[0032] In a preferred embodiment, it is the punch 22 the one that moves longitudinally along its longitudinal axis towards the spindle 21 holding or grasping the workpiece 31. Therefore, in this preferred embodiment, the spindle 21 remains stationary (apart from its rotation around that axis). Although the guiding sleeve 24 can be solidary to the punch 22 and therefore move simultaneously to the punch 22, in a preferred embodiment, the guiding sleeve 24 is not solidary to the punch 22; on the contrary, the guiding sleeve 24 can move freely with respect to the punch 22. Preferably the guiding sleeve 24 moves axially synchronized with the axial movement of the punch 22. The guiding sleeve 24 can be originally displaced or shifted with respect to the punch 22, along a same longitudinal axis, in such a way that the guiding sleeve 24 receives and houses the flowing material from the very first moment of its flow. That is to say, in a vertical configuration, the guiding sleeve 24 is at the beginning higher than the punch 22. Besides, if the guiding sleeve is not solidary with the punch, the guiding sleeve 24 can stop when the punch is about to make the final through hole, the punch keeping on moving.

[0033] Alternatively, it happens the other way round: the punch 22 remains stationary (except for its rotation) and the spindle 21 holding the workpiece 31 move towards the punch 22.

[0034] In a preferred embodiment, the machine 20 comprises a bushing or guiding bushing 25. The bushing 25 is a guiding bushing 25 because one of its purposes is to guide the end of the punch 22 as it penetrates into the workpiece 31. The bushing 25 is arranged around the punch 22, and more precisely, around the end of the punch 22 configured to be in contact with the block of material or workpiece 31 and to penetrate within the workpiece 31. The bushing 25 is preferably shorter in length than the punch 22. The bushing 25 is housed in the cavity defined by the guiding sleeve 24. This means that the outer diameter of the bushing 25 is smaller than the inner diameter of the guiding sleeve 24. The bushing 25 is preferably a hollow tube that totally surrounds the end of the punch 22 configured to be in contact with the workpiece 31. This means that the inner diameter of the bushing 25 is preferably larger than the outer diameter of the end of the punch 22. The bushing 25 retains axially the punch 22 as the punch 22 introduces in the workpiece 31. The bushing thus prevents the end of the punch 22 (or in general the punch 22) from bending as it tries to pierce the material of the workpiece 31, during the complete process.

[0035] Preferably, the guiding bushing 25 is loose, that is to say, it is not fixed to the end of the punch 22 close the workpiece 31. In this way, the bushing 25 is allowed to move inside the guiding sleeve 24, along its longitudinal axis (of the guiding sleeve, the punch and the bushing), when the loose bushing 25 is pushed away by the material of the workpiece as it flows.

[0036] In a preferred embodiment, the bushing 25 com-

prises a frictional edge 253, shown in the expanded view of figure 3. This edge 253 serves to clean the outer surface of the punch 22, that may become dirty due to for example material dust or small portions of material, that can be stuck or adhered to the punch 22 as it penetrates the workpiece 31. Figure 3 is an enlarged view of a portion of the machine 20 illustrated in figure 2. In particular, it also represents the first stage of the rotary extrusion process (when a block of material 31 has not been worked yet).

[0037] In a preferred embodiment, the machine 20 comprises a support element 26 located next to the spindle 21. This support element 26 is arranged to be placed next to the block of material or workpiece 31, that is to say, close to the end of the workpiece 31 opposite the end thereof to be in contact with the punch 22. The outer surface of this end of the workpiece 31 is substantially parallel to this support element 26. This support element 26 is used to enable to finish the through hole to be made in the workpiece 31. In other words, when the machine 20 is working and a part is being produced by inserting the punch 22 into the block of material and portions of material are flowing guided by the guiding sleeve 24, thus forming a tubular part or a substantially tubular part, it is necessary to finish the tubular part by opening the end of the original workpiece 31 that is furthest to the punch 22. In this situation, the support element 26 enables such finishing of the part by enabling the production of the complete passing through hole. At this stage of the process the spinning rolls 23 stop its axial movement whilst the punch will continue to produce a through hollow in the workpiece. The support element 26 preferably has a central hole configured to receive the punch 22 when the punch 22 has already perforated most of the workpiece 31 and only a last step of opening the through hole is missing. Preferably, there is also a retractable element 27 designed to close the central hole of the support element 26 until the punch 22 arrives at said first end of the workpiece 31 to be open. In other words, the retractable element 27 fills the central hole of the support element 26, thus forming a substantially solid element, until the punch 22 needs to penetrate in the central hole of the support element 26 for going through the lower end/wall of the workpiece 31 to produce a completely hollow part. At that moment, the retractable element 27 retracts and leaves room for the punch 22 to introduce into the central hole of the support element 26.

[0038] Figure 4 shows a cross-sectional view of the rotary extrusion machine 20, in an intermediate stage of the process, before the through hollow is produced. Figure 5 shows a cross-sectional view of the machine 20, in which a tubular part 32 has been produced. The workpiece or block of material from which the part 32 has been made, is for example the workpiece 31 shown in figure 2. As the punch 22 was inserted into the workpiece 31, material from the workpiece flowed in a direction opposite the insertion of the punch 22 into the workpiece. That material was guided by the spinning rolls 23 and housed

within the guiding sleeve 24, thus making it take its final shape. While material is accumulated within the cavity defined by the guiding sleeve 24, the bushing advances along the guiding sleeve 24, leaving room for the flowing material. In a final stage of the process, the retractable element 27 which "closes" the central hole of the support element 26, is retracted, leaving the central hole open, in such a way that the punch 22 can perforate the lower wall of the workpiece, thus achieving the final part 32, which is a tubular part or a part having a through hole.

[0039] In order to achieve low energy need, the machine may comprise: carriages for the up/down movement of the spinning rolls which are motorized by electric motors that only consume energy when they apply force to the preform; a hydraulic group having a frequency variator to control the velocity of the carriages motors and consequently to optimize the energy consume; sensors to switch off automatically the control; stand-by systems to reduce the consume while the machine is not working, automatically switching off when the machine spends a defined time in stand-by.

[0040] In conclusion, the rotary extrusion machine of the invention permits saving material and energy. This is especially interesting in the transport industry. Among its advantages with respect to conventional machines, the following can be highlighted: saving of more than 15% in raw material and energy; reduction impact in CO₂ footprint (transport and steel manufacturing); mechanical properties improvement (deformation not cutting of the fibers); flexibility in the initial preform (it can be a billet, forged or casted preform, machined preform...); it is possible to form different section thicknesses during the manufacturing of the piece.

[0041] On the other hand, the invention is obviously not limited to the specific embodiment(s) described herein, but also encompasses any variations that may be considered by any person skilled in the art (for example, as regards the choice of materials, dimensions, components, configuration, etc.), within the general scope of the invention as defined in the claims.

Claims

1. A rotary extrusion machine (20) comprising:

- a rotatable spindle (21) comprising clamping means (211) for clamping a first end (311) of a workpiece and for rotating said workpiece around a first axis,
- a punch (22) rotatable around said first axis simultaneously to the rotation of said spindle (21), the punch (22) and the spindle (21) being arranged so that either the punch (22) or the spindle (21) moves longitudinally along said first axis towards said respective spindle (21) or punch (22), so that the punch (22) introduces into a second end (312) of the workpiece pro-

ducing a hollow therein,

- at least three spinning rolls (23) arranged to be in contact with the external surface of the workpiece, the spinning rolls (23) being rotatable to make the material of the workpiece flow as the punch (22) and spindle (21) rotate, in an opposite direction to the introduction of the punch (22) in the workpiece,

characterized in that the punch (22) comprises a guiding sleeve (24), arranged coaxially to the outside of the punch (22) defining a cavity between the punch (22) and an inner surface of the guiding sleeve (24), the cavity being configured for housing and guiding material of the workpiece as it flows.

2. The rotary extrusion machine of claim 1, further comprising a guiding bushing (25) arranged around said punch (22) and housed in the cavity defined by said guiding sleeve (24) to radially retain the punch (22) as the punch (22) introduces in the workpiece.
3. The rotary extrusion machine of claim 2, wherein said guiding bushing (25) is arranged to move inside the guiding sleeve (24) pushed by the material as it flows.
4. The rotary extrusion machine of either claim 2 or 3, wherein said guiding bushing (25) comprises a frictional edge (253) for cleaning the external surface of the punch (22).
5. The rotary extrusion machine of any preceding claim, wherein the punch (22) moves longitudinally along said first axis while the spindle (21) remains stationary.
6. The rotary extrusion machine of claim 5, wherein the guiding sleeve (24) moves simultaneously to the punch (22).
7. The rotary extrusion machine of any preceding claim, wherein the guiding sleeve (24) comprises an angled edge (241) for guiding the material of the workpiece into the cavity of the guiding sleeve (24).
8. The rotary extrusion machine of any preceding claim, further comprising a support element (26) arranged next to the spindle clamps (211), said support element (26) being configured to enable the forming of a passing through hole in said first end (311) of the workpiece, said support element (26) comprising a central hole configured for the introduction of the punch (22).
9. The rotary extrusion machine of claim 8, further comprising a retractable supporting element (27) for closing the central hole of said support element (26) until

the punch (22) arrives at said first end (311) of the workpiece.

10. The rotary extrusion machine of any preceding claim, wherein said spinning rolls (23) are rotatable around a second axis parallel to said first axis. 5
11. The rotary extrusion machine of any preceding claim, further comprising at least three retractable spinning rolls for reducing the diameter of the material of the workpiece as it flows. 10
12. The rotary extrusion machine of any preceding claim, wherein the clamping means (211) comprise heating means. 15
13. The rotary extrusion machine of any preceding claim, wherein said first axis is a vertical axis.
14. A process for producing a part (32) comprising a hollow using the rotary extrusion machine of any preceding claim. 20
15. A part (32) comprising a hollow obtainable by the process of claim 14. 25

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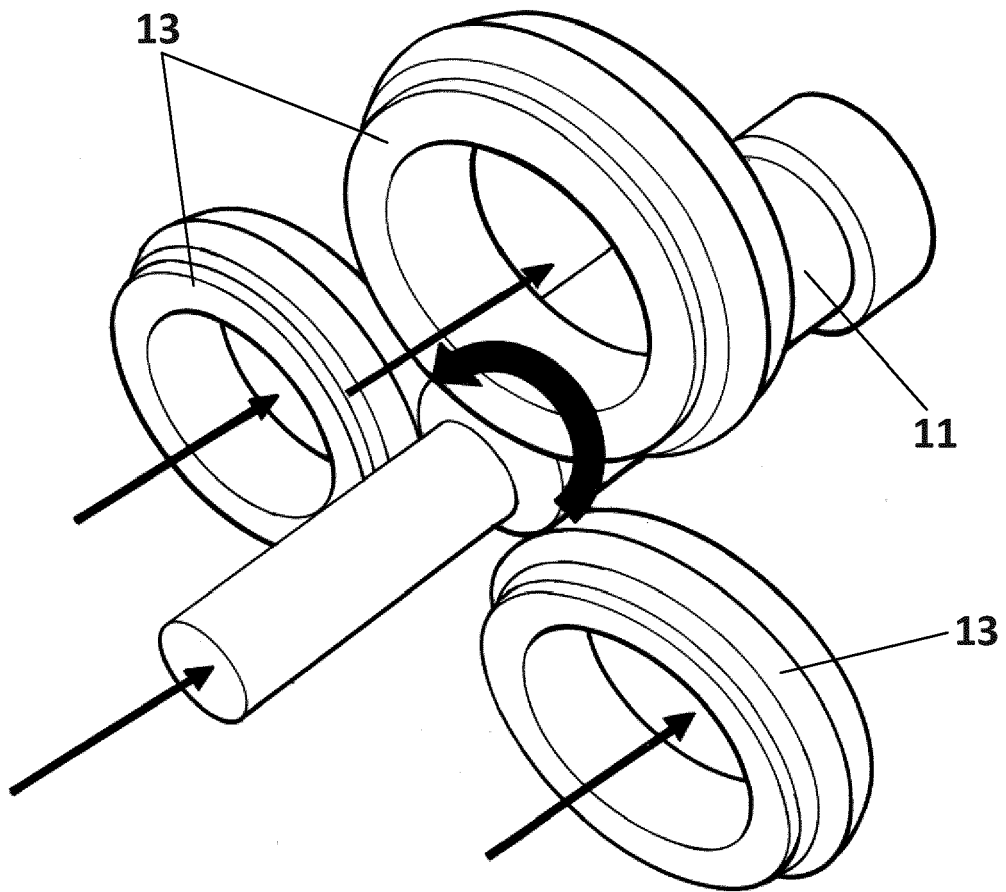


FIG. 1

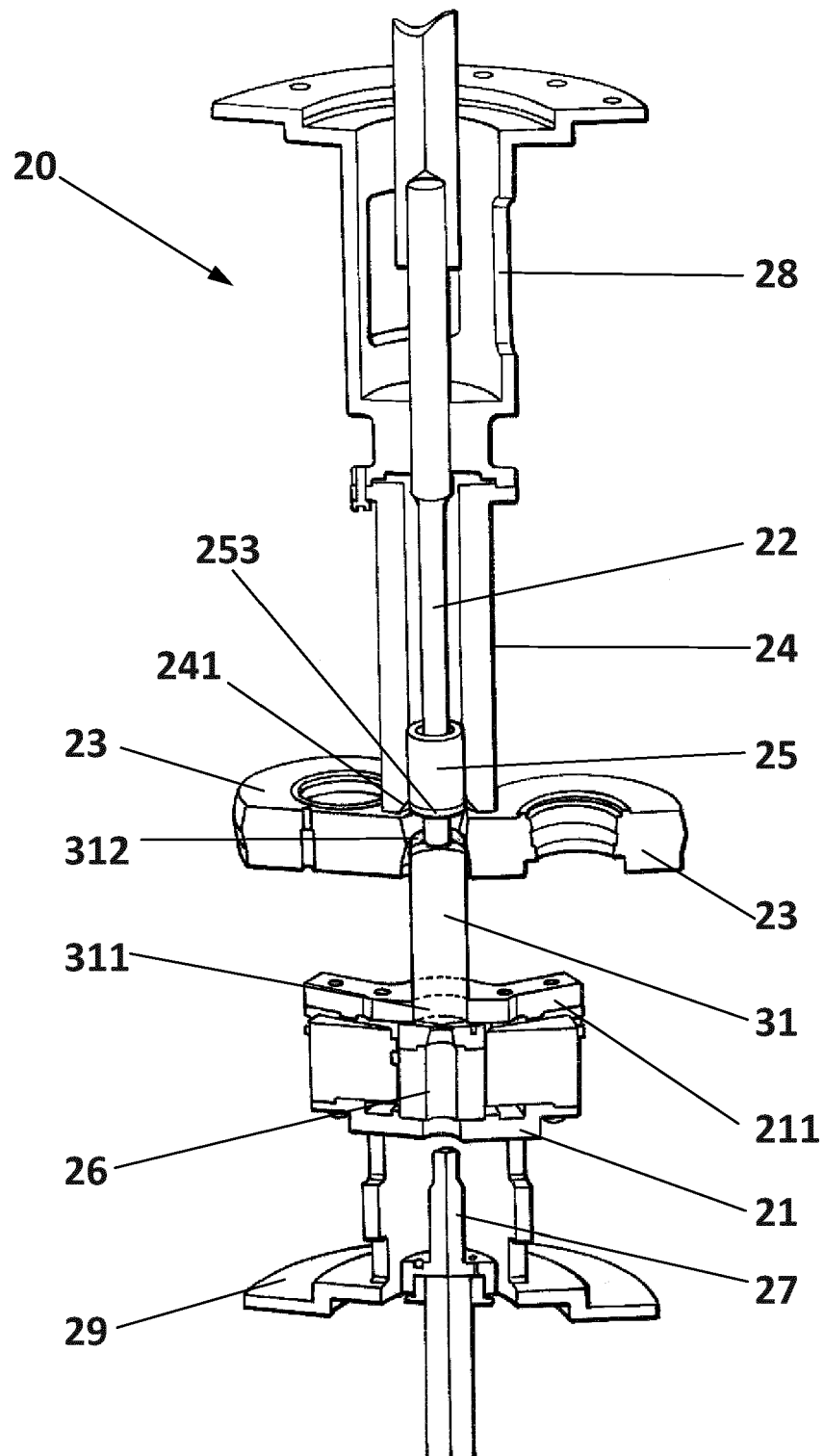


FIG. 2

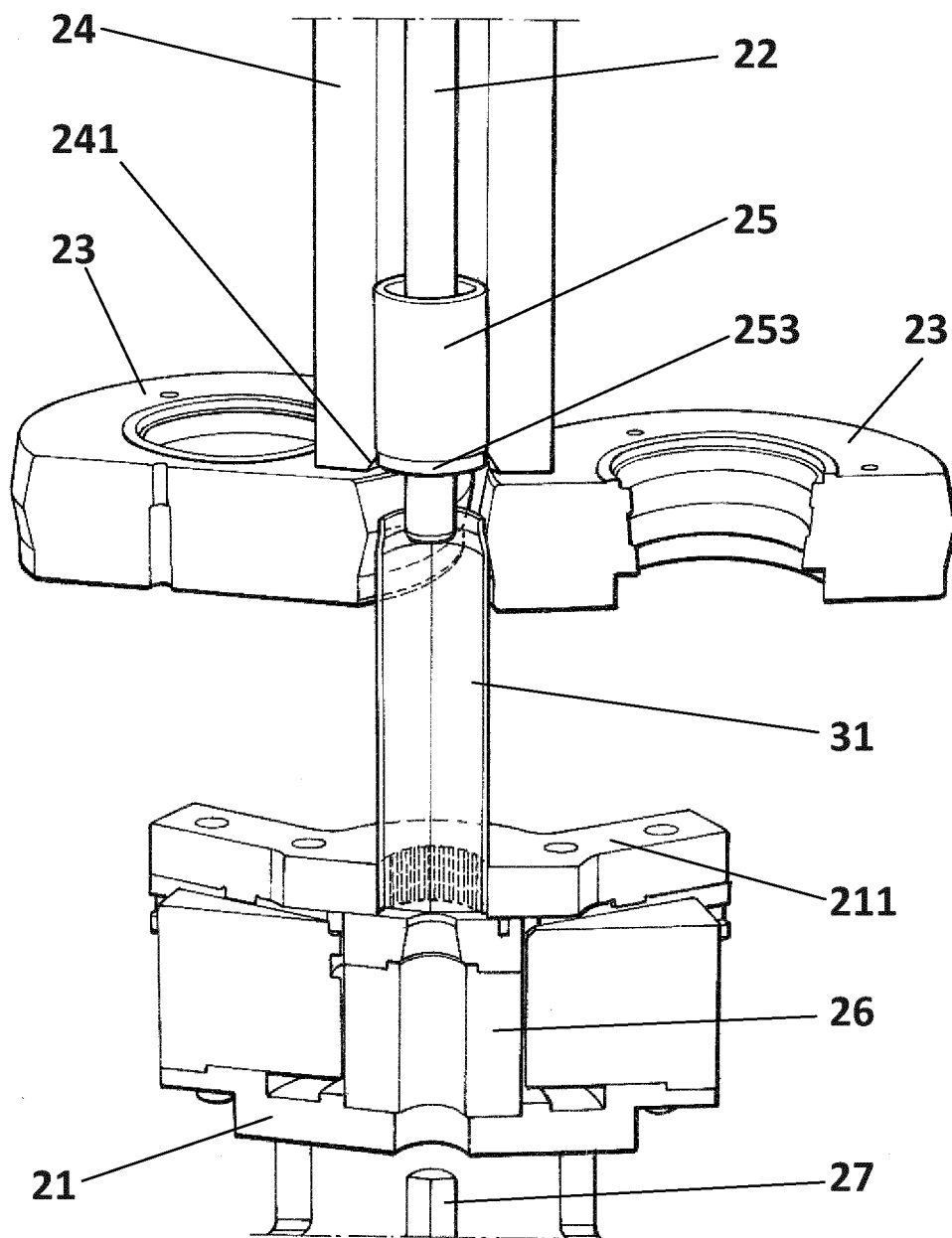


FIG. 3

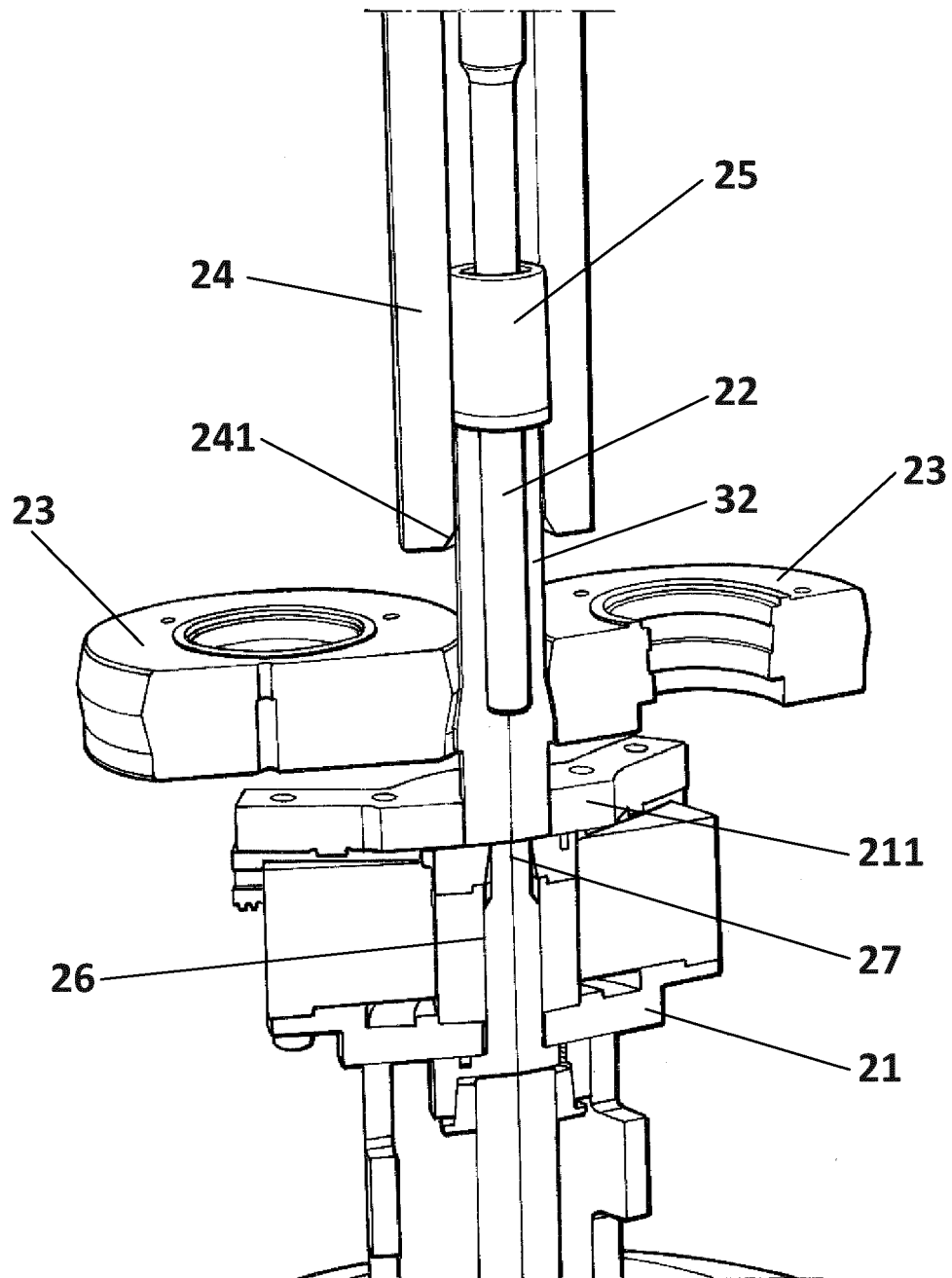


FIG. 4

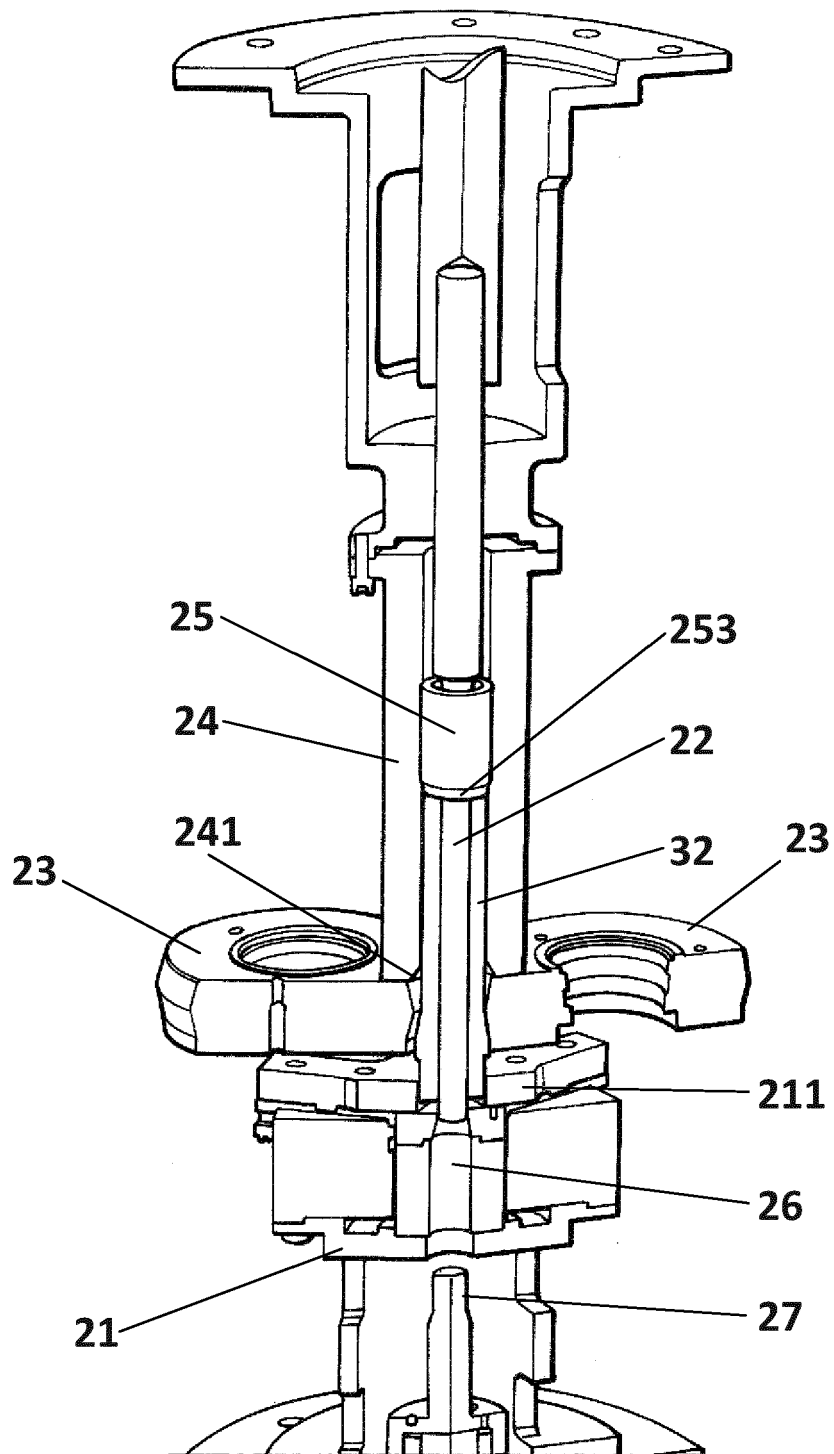


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 15 38 2316

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	DE 10 2012 005106 A1 (FRAUNHOFER GES FORSCHUNG [DE]) 19 September 2013 (2013-09-19)	15	INV. B21D22/16 B21B17/04
A	* figures 4,5 *	1-14	
X,D	DE 103 08 849 A1 (UNIV CHEMNITZ TECH [DE]) 9 September 2004 (2004-09-09)	15	
A	* figure 1 *	1-14	
X,D	DE 10 2008 036226 A1 (VOLKSWAGEN AG [DE]) 4 February 2010 (2010-02-04)	15	
A	* figures 1,2 *	1-14	TECHNICAL FIELDS SEARCHED (IPC) B21D B21H B21J B21B
X	US 2003/046803 A1 (KANEKO RYUICHI [JP]) 13 March 2003 (2003-03-13)	15	
A	* figure 8 *	1-14	
X	US 2008/314113 A1 (MINOGUCHI KAZUNORI [JP]) 25 December 2008 (2008-12-25)	15	
A	* figures 1-12 *	1-14	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 November 2015	Examiner Vinci, Vincenzo
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102012005106 A1	19-09-2013	NONE	
DE 10308849 A1	09-09-2004	NONE	
DE 102008036226 A1	04-02-2010	NONE	
US 2003046803 A1	13-03-2003	JP 4354133 B2	28-10-2009
		JP 2003056701 A	26-02-2003
		US 2003046803 A1	13-03-2003
US 2008314113 A1	25-12-2008	CN 101274347 A	01-10-2008
		CN 102825161 A	19-12-2012
		JP 5435190 B2	05-03-2014
		JP 2008272828 A	13-11-2008
		US 2008314113 A1	25-12-2008
		US 2012131797 A1	31-05-2012

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 102008036226 A1 [0004]
- DE 102012005106 A1 [0005]
- DE 10308849 A1 [0006]

Non-patent literature cited in the description

- **J. SAN JOSÉ ; M. SANTOS ; S. VARELA ; M. ALBEA ; X. MEDAN ; J. F. PUIGJANER.** Material reduction costs by new rotary processes: rotary forging and flowforming. *30rd SENAFOR 2010*, 2010 [0003]
- **R. NEUGEBAUER et al.** *Innovation by cross rolling and spin extrusion technology*, 2004 [0003]
- New warm forging process to produce hollow shafts. *Journal of Material Processing Technology*, 2001, vol. 119, 277-82 [0003]