

(19)



(11)

EP 2 422 896 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
13.11.2013 Bulletin 2013/46

(51) Int Cl.:
B21H 1/18 (2006.01)

(21) Application number: **11461502.4**

(22) Date of filing: **03.01.2011**

(54) **Method for rotary compression of hollow parts by cross rolling**

Verfahren zur Rotationsverdichtung von Hohlteilen durch Querwalzen

Procédé pour la compression rotative de parties creuses par laminage transversal

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **30.08.2010 PL 39227510**

(43) Date of publication of application:
29.02.2012 Bulletin 2012/09

(73) Proprietor: **Politechnika Lubelska
20-618 Lublin (PL)**

(72) Inventors:
• **Pater, Zbigniew
20-258 Turka, Lublin (PL)**

• **Tomczak, Janusz
20-128 Lublin (PL)**

(74) Representative: **Tylinska, Irena et al
POLSERVICE
Kancelaria Rzeczników
Patentowych sp. z o.o.
Ul. Bluszczanska 73
00-712 Warszawa (PL)**

(56) References cited:
**DE-A1- 3 144 695 JP-A- 59 120 336
JP-A- 63 040 631**

EP 2 422 896 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] This invention relates to a method for rotary compression of hollow parts by cross rolling, in particular of hollow shafts and axles. The notion of "hollow part" is to be understood as a tubular element which has a cylindrical or shaped hole located centrally along its axis.

[0002] JP-A-63040631 discloses a method for rotary compression of a hollow part by cross-rolling, in which the hollow workpiece is clamped in a chuck and rolled by three working rolls, which are moved radially towards the axis of the workpiece.

[0003] A great number of forming methods for hollow parts have been developed so far. The most commonly used include, for instance, mechanical working processes - metal machining, in which the required shape of the formed element is obtained by removing consecutive material layers. The method for producing hollow parts in metal machining processes has been described in the literature (J. Kaczmarek "Podstawy obróbki wiórowej, ściemej i erozyjnej," WNT, Warszawa 1997). Plastic methods for forming hollow parts - hollow shafts, are also known, and they include such processes as drawing, forging and punching, rotary swaging, rotary forging, hydroforming, cold extrusion, cold extrusion with deep drilling as well as cross wedge rolling. A detailed description of the above processes has been given in the literature (J. Bartnicki, Z. Pater "Walcowanie poprzeczno-klinowe wyrobów drażonych," Wydawnictwo Politechniki Lubelskiej, Lublin 2005). The most accurate parts are obtained in drawing processes, whose application to the forming of hollow parts is, however, limited owing to a small number of possibilities as for shapes that can be obtained. The forging process is applicable only in the case of forming shafts with large dimensions and masses. Punching is used for producing thick-walled and short sleeves. Rotary swaging processes allow for reducing diameters of rods and tubes. Elements formed thereby are noted for their high accuracy, and if mandrel forged, they can have very accurate cylindrical and conical holes. Another method for producing hollow parts is the process of hydrostatic drawing, which allows for the production of complex geometry parts. In this method, a part is formed under high pressure generated inside this part. Cold extrusion processes, in which metal is extruded through a hole in a die, are also widely used in industries for producing hollow parts. In recent years, a number of methods for forming hollow parts by cross wedge rolling and wedge rolls rolling, have been developed. Both in cross wedge rolling and in wedge rolls rolling at least one of the forming tools is either a flat wedge or a roller wedge which drives into the blank and thus decreases its diameter, moving some volume of the material to the sides. As a result, the product is elongated during forming and its wall-thickness in the necking zone is decreased. This leads to the weakening of the product in the rolled step area and necessitates the use of thick-walled blanks which can only be hot formed. Additionally, the method

requires the use of complex wedge tools of large overall dimensions, which results in high implementation costs of the cross wedge rolling technology.

The essence of the method for rotary compression of hollow parts by cross rolling, especially of hollow axles and shafts, lies in that the hollow part to be formed - the blank - in the form of a tube, is positioned on two powered working rolls - the tools -, which rotate in the same direction with a first constant velocity, while the third, upper roll rotates with the first constant velocity in the same direction as the other rolls and radially moves in a reciprocating manner with a second constant velocity, and as a result of this motion the rolls approach one another in such a way so as to be positioned in the final phase of the sizing process at every $120^\circ \pm 20^\circ$, the preferable position being that at every 120° , then the plane motion of the upper roll is stopped, and the three rotating rolls eventually correct shape inaccuracies of the hollow part. As the blank sections of rod or tube sections are used, this allows for rotary compression of such parts as hollow axles and shafts. The compression process for hollow shafts and axles is done with or without a mandrel, which allows obtaining accurate holes in the product or accurately shaped holes. The process is done with three working rolls - the tools -, which rotate and move in a reciprocating manner radially to the axis of the product.

[0004] One beneficial effect of the invention is that it allows for the application of simple forming tools based on three rolls which can be manufactured at a relatively low cost to produce such parts as hollow stepped shafts. Hollow parts are more and more often used in machine constructions, in automotive industry, and particularly in aerospace industry. Owing to the use of such parts, the construction mass of elements can be decreased, while their strength and functional properties are at the same time retained. For forming hollow shafts, thick-walled tubes can be used as the blank, which makes additional drilling operations unnecessary as well as it eliminates material loss which occurs during machining. Additionally, it is possible to obtain the finished product - the stepped shaft, from the blank in the form of a tube section within one plastic forming operation. Owing to the use of rotational forming tools - the rolls, it is possible to roll products of different diameters by means of the same set of working rolls. The formed hollow shaft will have a more advantageous structure, which will improve strength properties of the part. Another beneficial effect of the invention is the fact that during compression, the material flows mainly in the radial direction, which increases the wall-thickness of the shaft in the necking zone and, thus, increases strength properties of the part. One more beneficial effect of the method is its universality, as the method can be used to form all metals and alloys which are suitable for metal machining.

[0005] The method for rotary compression of hollow parts by cross rolling, especially of hollow shafts and axles, has been schematically illustrated in two figures, where Figure 1 presents both the beginning of the forming

process for a hollow stepped shaft and type of the blank used, while Figure 2 shows the end of the rolling process for the hollow shaft as well as the hollow part obtained from the compression process.

[0006] The method for rotary compression of hollow parts, especially of hollow axles and shafts, consists in positioning the blank 1 in the form of a tube section on two working rolls 2 and 3 - the tools. Next, the rolls 2 and 3 begin to rotate in the same direction with the first velocity n_1 , and the upper roll 4 moves radially in a reciprocating manner with the second velocity V towards the axis of the blank 1. As a result of the reciprocating motion of the upper roll 4, the rolls 2, 3, 4 - the tools -, relatively approach one another in such a way that in the final phase of the sizing process they are positioned at every 120° . The rotational motion of the working rolls 2, 3, 4 makes the blank 1 rotate around its axis with the third velocity n_2 , at the same time the rolls 2, 3, 4 - the tools -, relatively shift in the radial direction forming on the surface of the blank 1 a profile of the finished product 5. In the final phase of the process, when the part 5 reaches the assumed dimensions, the progressive motion of the upper roll 4 is stopped, while the three working rolls 2, 3, 4 still rotate and eventually form the ultimate shape of the rolled product 5, removing surface irregularities which have occurred at the beginning of the process. The shape of the rolling tools 2, 3 and 4 mirrors in the contact phase the shape of the finished product 5. The shape of the compressed hollow shaft is formed on the contact boundary of consecutive points marked by the rotating tools, which allows for rolling of products of different diameters.

Claims

1. A method for rotary compression of hollow parts by cross rolling, especially of hollow shafts and axles, **characterized in that** the hollow part to be formed - the blank (1) - in the form of a tube is positioned on two powered working rolls (2), (3) - the tools-, which rotate in the same direction with a first constant velocity (n_1), while a third, upper, roll (4) rotates with the first velocity (n_1) in the same direction as the rolls (2) and (3) and radially moves in a reciprocating manner with a second velocity (V), and as a result of this motion the rolls ((2), (3), and (4)) approach one another and in the final phase of the sizing process they are positioned at every $120^\circ \pm 20^\circ$, the preferable position being that at every 120° , then the plane motion of the roll (4) is stopped, and the rotating rolls ((2), (3) and (4)) eventually correct shape inaccuracies of the hollow part (5).
2. The method according to claim 1, **characterized in that** as the blank (1) sections of rod or tube sections are used, which allows for rotary compression of parts (5) such as hollow axles and shafts.

3. The method according to claim 1, **characterized in that** the compression process for hollow shafts and axles is done with or without mandrel, which allows obtaining accurate holes in the product (5) or shaped holes.

4. The method according to claim 1, **characterized in that** the process is done with three working rolls ((2), (3) and (4)) - the tools-, which rotate with the first velocity (n_1) and move in a reciprocating manner with the second velocity (V) radially to the axis of the product (5).

Patentansprüche

1. Verfahren zum Drehverengen der Hohlwerkstücke durch Querwalzen, insbesondere der Hohlwellen und -achsen, **dadurch gekennzeichnet, dass** das zu formende Hohlwerkstück - Rohling (1) - in Form eines Rohrs auf zwei angetriebenen Arbeitsrollen (2), (3) - Werkzeugen - angeordnet ist, die sich in derselben Richtung mit der ersten konstanten Geschwindigkeit (n_1) drehen, während eine dritte, obere Rolle (4) sich mit der ersten Geschwindigkeit (n_1) in derselben Richtung, wie die Rollen (2) und (3) dreht und die hin- und hergehende Bewegung in der radialen Richtung mit der zweiten Geschwindigkeit (V) ausführt, wobei sich die Rollen [(2), (3) und (4)] infolge dieser Bewegung zueinander nähern, damit sie in der Endphase des Kalibrierens je $120^\circ \pm 20^\circ$ angeordnet sind, wobei die Anordnung je 120° bevorzugt wird, und dann die Schubbewegung der Rolle (4) abgeschaltet wird und die sich drehenden Rollen [(2), (3) und (4)] die Ungenauigkeiten der Form der Hohlwerkstücke (5) endgültig korrigieren.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** als Rohling (1) Abschnitte von Stangen oder Röhren verwendet werden, was das Drehverengen der Werkstücke (5) in Form der Hohlachsen und -wellen ermöglicht.
3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Verfahren des Verengens der Hohlwellen und -achsen frei oder auf einer Dornstange, die das Erreichen der genauen Öffnungen oder Formöffnungen im Erzeugnis (5) ermöglicht, durchgeführt wird.
4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Verfahren mit drei Arbeitsrollen [(2), (3) und (4)] - Werkzeuge - durchgeführt wird, die sich mit der ersten Geschwindigkeit (n_1) drehen und die Hin- und Herbewegung mit der zweiten Geschwindigkeit (V) radial zur Achse des Erzeugnisses (5) ausführen.

Revendications

1. Procédé de sertissage rotatif des produits creux provenant du laminage transversal, notamment des arbres et des essieux creux, **caractérisé en ce que** le produit creux formé - demi-produit (1) sous la forme de tube est placé sur deux rouleaux opératoires entraînés (2), (3) - outils-qui tournent dans la même direction avec la première vitesse constante, (n_1), et le troisième rouleau (4) - supérieur tourne avec la première vitesse (n_1) dans la même direction que les rouleaux (2) et (3) et effectue un mouvement alternatif dans la direction radiale avec la deuxième vitesse (V), à la suite de ce mouvement les rouleaux (2), (3) et (4) s'approchent mutuellement pour que dans la phase finale du processus - d'étalonnage soient arrangés à chaque $120^\circ \pm 20^\circ$ la disposition à chaque 120° étant préférée, alors le mouvement de coulissement du rouleau (4) s'arrête, et les rouleaux en rotation (2), (3) et (4) corrigent définitivement les inexactitudes de la forme du produit (5) creux.

5
10
15
20
2. Procédé selon la revendication 1, **caractérisé en ce que** le demi-produit (1) est sous la forme des sections de barres ou de tubes, qui permet à sertir les produits (5) sous la forme d'essieux et d'arbres creux.

25
3. Procédé selon la revendication 1, **caractérisé en ce que** le processus de sertissage des arbres et des essieux creux est réalisé librement ou sur un mandrin, qui permet d'obtenir des orifices précises dans le produit (5) ou des orifices profilés.

30
35
4. Procédé selon la revendication 1, **caractérisé en ce que** le processus est réalisé dans un système dans lequel les trois rouleaux (2), (3) et (4) opératoires - outils effectuent un mouvement rotatif avec la première vitesse (n_1) et un mouvement alternatif dans la direction radiale avec la deuxième vitesse (V) par rapport à l'axe du produit (5).

40
45
50
55

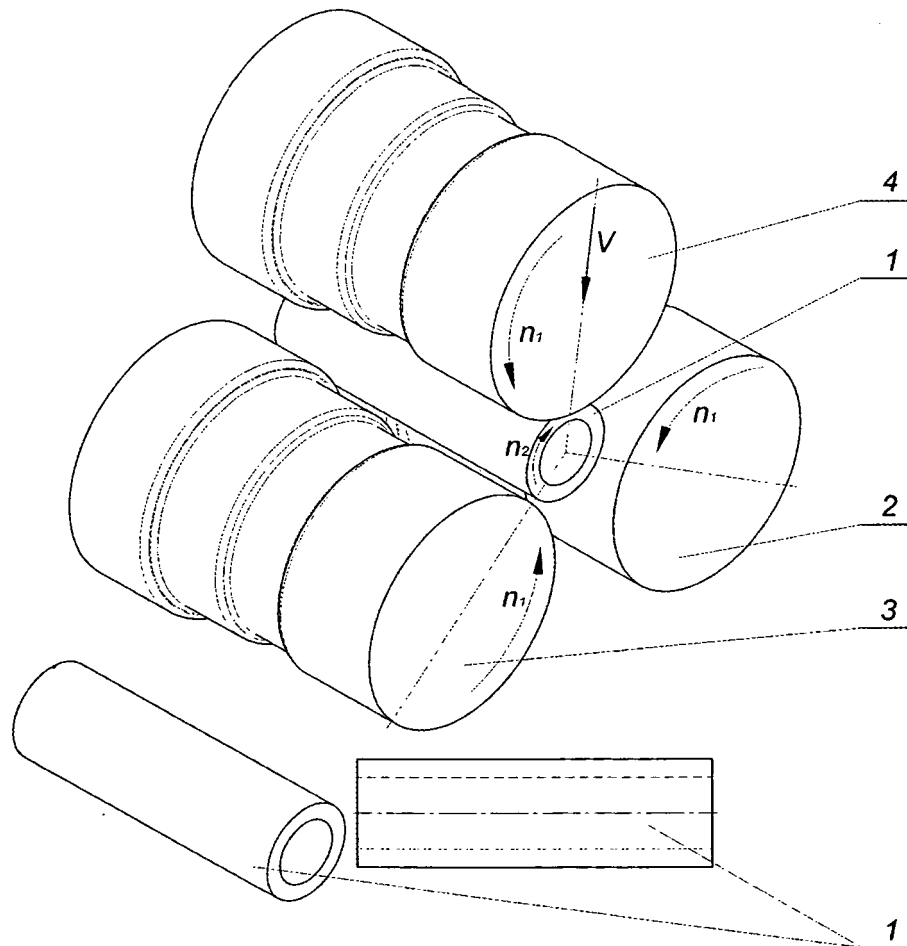


Fig. 1.

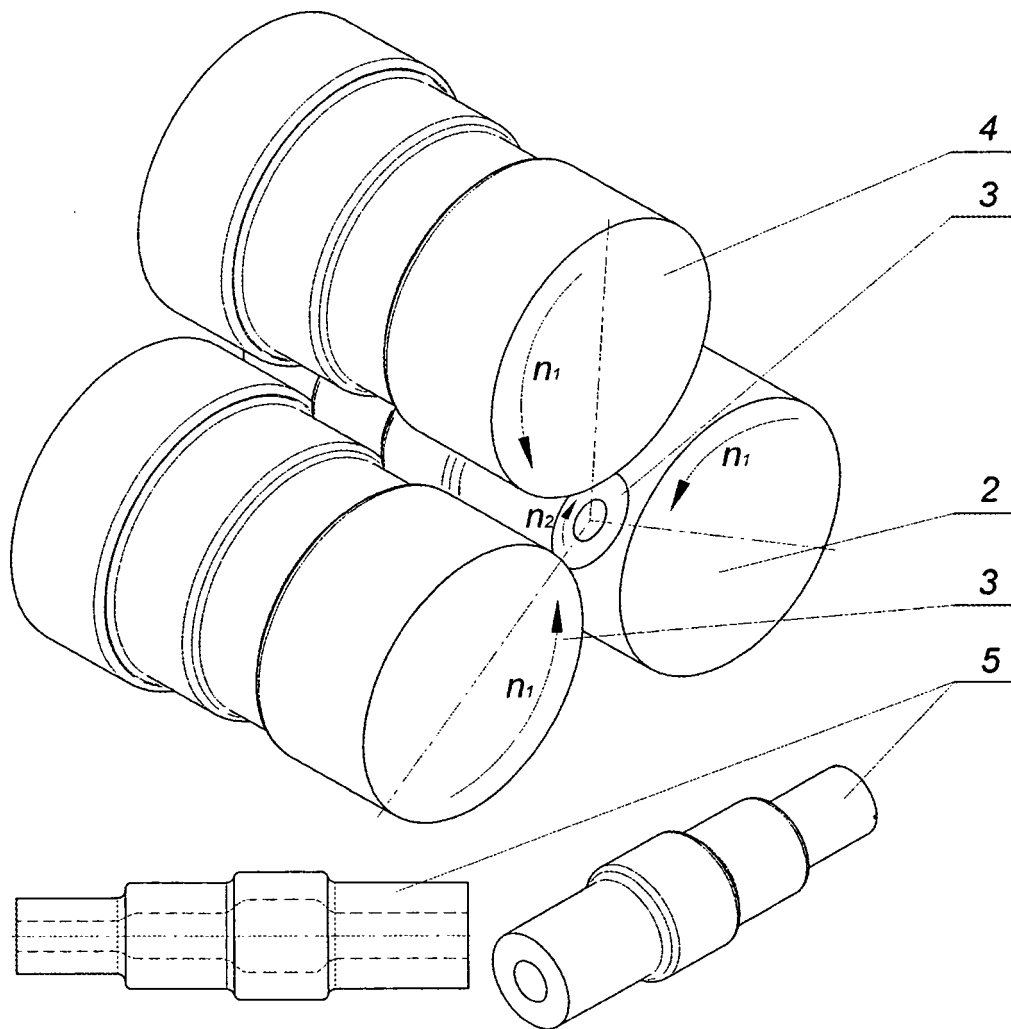


Fig. 2.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 63040631 A [0002]

Non-patent literature cited in the description

- **J. KACZMAREK.** Podstawy obróbki wiórowej, ściemej i erozyjnej. WNT, Warszawa, 1997 [0003]
- **J. BARTNICKI ; Z. PATER.** Walcowanie poprzeczno-klinowe wyrobów drażonych. Wydawnictwo Politechniki Lubelskiej, Lublin, 2005 [0003]