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(54) INTEGRATED PLATE WELDED-JOINT-FREE VEHICLE WHEEL AND FORMING METHOD THEREOF

(57) The present invention provides forming methods of one-piece weldless wheels made of metal sheets including the steps of rolling, forming a primary wheel rim and a primary wheel disc, roll forming, compressing and shaping, in order to obtain one-piece weldless wheels made of metal sheets. The forming methods of one-piece weldless wheels made of metal sheets of the present invention can form weldless wheels made of metal sheets by rolling, cold roll forming and cold extruding, which can reduce energy consumption by 45-55% and cut down material cost by 5-15% while improve strength of the wheel by 20-30%. A wheel with different thicknesses (The thicknesses of various sections of the wheel are different.) can be formed by the methods of the present invention and such wheel can meet the requirements on mechanical strength. Besides, the methods also can significantly improve the precision of the wheel and reduce the swing value and jerk value to the minimum. Additionally, the wheel produced by the methods of the present invention is safer, and the regular air tight test on the wheel is not necessary. Moreover, the present invention also provides one-piece weldless wheels made of metal sheets which are manufactured by the methods of one-piece weldless wheels made of metal sheets.

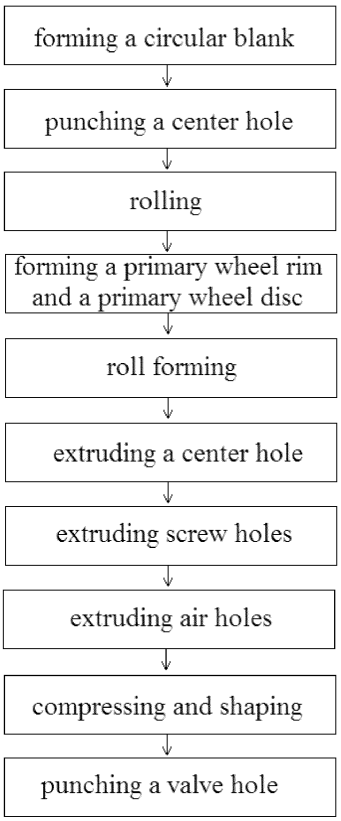

Figure 2

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Description

Field of the Invention

[0001] The invention relates to forming methods of wheels, and particularly relates to forming methods of one-piece weldless wheels made of metal sheets..

Background of the Invention

[0002] In the prior art, the methods for manufacturing wheels made of metal sheets include that manufacturing wheel rims and wheel discs separately, and then integrating the wheel rims and the wheel discs into the whole wheels by welding. The specific process may include the following steps:

The steps of manufacturing the wheel rims including: R-1 uncoiling coiled material; R-2 pressing the material into flat sheets; R-3 butt welding; R-4 curling circles; R-5 butt welding; R-6 scraping slag; R-7 trimming the end; R-8, 9, 10 cold rolling in three processes; R-11 extending and sizing; R-12 punching valve holes;

the steps of manufacturing the wheel discs including: D-1 uncoiling coiled material; D-2 rolling the material into flat sheets; D-3 forming square blanks; D-4 multi-station press forming; D-5 reverse stretching; D-6 punching holes; D-7 extruding to form center holes and screw holes;

the steps of integrating the wheel rims and the wheel discs into whole wheels including: A-1 locating raceways; A-2 assembling the wheel rims and wheel discs by pressing; A-3 welding.

[0003] Thus, it can be seen that the present methods of manufacturing wheels made of metal sheets is extremely complicated. Besides, other auxiliary steps involved in the methods in the prior art are not described herein. Hence the steps of the methods in the prior art generally contain more than twenty steps, resulting to quite low production efficiency. Additionally, complicated air tight tests are necessary for the wheels made of metal sheets manufactured by such methods, which further reduces the production efficiency.

[0004] Moreover, as shown in Figure 1, the wheel made of metal sheets manufactured by the above methods has welding seams 3 between the wheel rim 1 and the wheel disc 2. Besides, there is also a butt welding seam 4 on the wheel rim. Thus, the wheel will not perform well on strength and rigidity, and fatigue breaks will be easily generated at the welding seams 3 and the butt welding seam 4.

[0005] Therefore, there is a need of a forming method of the wheels made of metal sheets to significantly improve the production efficiency, the quality and the strength of the wheels. There is also a need of one-piece wheels made of metal sheets which are manufactured by the said forming method.

Summary of the Invention

[0006] The present invention is directed to provide a forming method of a one-piece weldless wheel made of metal sheets. Compared with the traditional methods of manufacturing wheels, the method of the present invention can significantly reduce the manufacturing steps, and thus significantly improve the production efficiency and produce the wheels with high strength and rigidity performance as well as long service life. Additionally, the method of the present invention also can produce the wheels with high precision. Moreover, the strength of all of the force-bearing surfaces of the wheel manufactured by the method is equal, while the thicknesses of the wheel are different. Besides, the method of the present invention does not include the step of welding, and the wheel manufactured by the method has no welding seam. Thus, air leakage will not happen in the wheel of the present invention and thus the air tight test can be omitted.

[0007] In order to achieve the object of the present invention, the present invention provides a forming method of a one-piece weldless wheel made of metal sheets, comprising the following steps:

(1) rolling: placing a circular blank in a circular rolling mould, and rolling the circular blank into a wheel blank by performing planar synchronous rolling on the circular blank in the rolling mould using at least two rolling wheels symmetrically arranged along the circumferential direction of the rolling mould; (The planar rolling refers to a kind of rolling that the rolling trajectories of the rolling wheels are always in one plane. The synchronous rolling refers to a kind of rolling that the rolling motions of the at least two rolling wheels are synchronous in order to ensure an uniform quality of the rolled surface of the circular blank and ensure a compact or dense surface of the circular blank. Thus, the more the rolling wheels are disposed, the denser the rolling traces are on the surface of the circular blank, the better the quality of the surface is achieved. However, the factors of economic cost and force-bearing state should be taken into account while determining the amount of the rolling wheels.);

(2) forming a primary wheel rim and a primary wheel disc: pressing the wheel blank to form a primary wheel rim and a primary wheel disc of the wheel made of metal sheets by applying pressure in the axial direction of the wheel blank on a concave pressing mould and a convex pressing mould;

(3) roll forming: placing the wheel blank between a concave roll forming mould and a convex roll forming

mould and clamping the wheel blank tightly with the concave roll forming mould and the convex roll forming mould; then rotating the concave roll forming mould and the convex roll forming mould synchronously around the axes thereof while pressing the primary wheel rim (i.e. the lateral wall portion of the wheel blank) in the radial direction of the wheel blank by using one or more lateral pressing rollers, in order to extrude and further form the primary wheel rim precisely, wherein each lateral pressing roller is rotating around the axis thereof when pressing the primary wheel rim;

(4) compressing and shaping: placing the wheel blank between a concave shaping mould and a convex shaping mould and pressing the wheel blank in the axial direction of the wheel blank with the concave shaping mould and the convex shaping mould while pressing the primary wheel rim of the entire circumference of the wheel blank in the radial direction of the wheel blank by using a lateral pressing shaping mould, in order that pressing, compressing and shaping can be performed simultaneously to form a one-piece weldless wheel made of metal sheets.

[0008] The rolling of the forming method of a one-piece weldless wheels made of metal sheets according to the present invention is preferably a planar synchronous staggered rolling. The staggered rolling refers to a kind of rolling that the rolling wheels are disposed mutually staggered in their initial positions in order to prevent the rolling trajectories of the rolling wheels on the surface of the circular blank from coinciding to ensure the surface of the circular blank more compact or denser.

[0009] The forming method of a one-piece weldless wheel made of metal sheets according to the present invention further comprises a step of forming the circular blank and punching a positioning hole which is used for positioning the circular blank stably into the rolling mould before the step (1).

[0010] The forming method of a one-piece weldless wheel made of metal sheets according to the present invention further comprises a step of extruding a center hole between the step (3) and the step (4).

[0011] The forming method of a one-piece weldless wheel made of metal sheets according to the present invention further comprises a step of extruding screw holes between the step (3) and the step (4).

[0012] The forming method of a one-piece weldless wheel made of metal sheets according to the present invention further comprises a step of extruding air holes between the step (3) and the step (4).

[0013] The forming method of a one-piece weldless wheel made of metal sheets according to the present invention further comprises a step (5) of punching a valve hole on the one-piece weldless wheel made of metal sheets.

[0014] The above-mentioned steps of extruding a center hole, a screw hole, and an air hole and punching a positioning hole and a valve hole is essentially similar to the corresponding process in the prior art of manufacturing the wheels made of metal sheets. And thus the present invention will not describe the details of these steps herein.

[0015] According to the forming method of a one-piece weldless wheel made of metal sheets of the present invention, wherein rolling motions of the at least two rolling wheels in the step (1) comprise feed movements of the at least two rolling wheels in a horizontal direction and a rotation of each rolling wheel.

[0016] According to the forming method of a one-piece weldless wheel made of metal sheets of the present invention, wherein in the step (3), pressing the primary wheel rim in the radial direction of the wheel blank by using three lateral pressing rollers, in order to extrude and further form the primary wheel rim precisely, wherein the three lateral pressing rollers are arranged evenly along the circumferential direction of the wheel blank.

[0017] Additionally, the present invention also provides a one-piece weldless wheel made of metal sheets manufactured by the above-mentioned forming method of a one-piece weldless wheel made of metal sheets.

[0018] According to the one-piece weldless wheel made of metal sheets of the present invention, wherein the one-piece wheel is made from carbon steel, aluminum, Mg-Al alloy or stainless steel.

[0019] The forming method of the one-piece weldless wheel made of metal sheets of the present invention is quite different from the methods of manufacturing the wheels made of metal sheets in the prior art. As described in Background of the Invention, the methods of manufacturing the wheels made of metal sheets in the prior art need to produce a wheel rim and a wheel disc separately and then weld the wheel rim and the wheel disc into a whole wheel having welding seams. In contrast, the present invention provides an integral forming process differentiating from the prior art. The differences in view of the prior art are mainly listed as follows:

(1) The step of rolling is introduced into the forming method of the one-piece weldless wheel made of metal sheets for the first time. The step of rolling is a planar rolling forming process, which means that the rolling wheels merely move on the horizontal plane of the rolling mould besides the rotation around the axisesaxes thereof. Meanwhile, the rolling mould are applying a constraining force to the blank,. Thus, the blank is deformed by the interaction force between the rolling wheel and the rolling mould and the deformation happens both on the upper surface and lower surface of the blank. The work piece processed by the step of rolling is more compact or denser in structure, higher in strength, lighter in weight, and lower in material consumption. Additionally, the force applied on the work piece is stronger by adopting

the step of rolling and the deformation precision of the work piece is better because the rolling mould will limit the deformation of the work piece in the rolling process, and then generate a deformation resistance which will extrude the work piece. Besides, the bending fatigue life of the work piece can be greatly prolonged by performing the step of rolling. Moreover, the step of rolling is a kind of coercive forming process, which limits the deformation of the work piece in large scale. This step can gradually and precisely form various wheels with different geometric sections by different shapes of the cavities of the rolling moulds. The formed work piece has a uniform quality in the axial direction and the circumferential direction, and has a high-precision dynamic balance. Moreover, an equal-strength wheel, which means that the strength of all of the force-bearing surfaces of the wheel is equal, can be obtained by performing the step of rolling. The equal-strength wheel has different thicknesses. The thickness of the blank can be modified according to the different requirements of bearing force of each force-bearing point on the wheel. For example, the thickness of the wheel at the position on which less force is applied can be reduced, in order to save material consumption. The wheel with different thicknesses can only be produced by the present invention and cannot be produced by the prior art since the circular blank is formed in the rolling mould primarily, thus, the rolling mould can be designed according to the requirement of the bearing force of the wheel. However, in the prior art, both of the wheel rim and the wheel disc are produced by the way of rolling press and punching press deformation. During the rolling press deformation, the rolling pressing mould is an open type mould which cannot apply a constraining force to the blank. Besides, the rolling press wheel is controlled to move in the radial direction, resulting in only changing of the surface shape of the work piece other than the thickness of the work piece.

(2) The present invention can press the wheel blank to directly form the primary wheel rim and the primary wheel disc of the one-piece wheel made of metal sheets via the step of forming a primary wheel rim and a primary wheel disc (i.e. a step of press forming).

(3) The present invention has the step of roll forming to complete the deformation of the wheel rim, so that the wheel rim of the wheel made of metal sheets is formed precisely directly from the primary wheel rim and the primary wheel disc of the one-piece wheel made of metal sheets. This step is a key step of manufacturing the weldless wheel made of metal sheets. The step of roll forming performs cold rolling, cold extrusion forming, and bending deformation slowly and gradually within the plastic deformation range of the blank, in order to form the wheel rim whose sections possess high strength. It is noted that the shapes of the concave roll forming mould, the convex roll forming mould and the lateral pressing roller should not be limited in the present invention, just like the shapes of the rolling mould should not be limited. The key point of the present invention is the way of forming. The outer contour of the lateral pressing roller can be designed by a person skilled in the art according to the actual requirements of the shapes and the sizes of the products, in order to form the wheel rim meeting the requirements of the shapes.

(4) The present invention has the step of compressing and shaping, in order to ensure the relative position and the offset distance of the wheel rim and the wheel disc are proper and ensure the requirements of the standard diameter and the deflection of the wheel rim are met.

[0020] The steps of the forming method of the one-piece weldless wheel made of metal sheets according to the present invention are much less than the steps of the prior art. Thus, the forming method of the one-piece weldless wheel made of metal sheets according to the present invention can significantly improve the production efficiency.

[0021] Besides, the forming method of the one-piece weldless wheel made of metal sheets according to the present invention can produce a one-piece wheel by using the method including the steps of rolling and roll forming without butt welding, which greatly improves the rigidity, strength and lifetime of the wheel. Accordingly, the devices consumption, such as butt welding device, air extracting device and the like, can be omitted and power consumption of the devices can be saved accordingly. And the pollution (such as the spatter and the smoke) to the environment caused by the welding can be avoided.

[0022] Furthermore, compared with the wheel made of metal sheets integrated by welding, the one-piece weldless wheel made of metal sheets manufactured by the forming method of the one-piece weldless wheel made of metal sheets according to the present invention is safer because there is no welding seam on the wheel, and thereby the regular air tight test on the wheel can be omitted.

[0023] The one-piece weldless wheel made of metal sheets manufactured by the forming method of the one-piece weldless wheel made of metal sheets according to the present invention can be used in passenger vehicles and commercial vehicles as well.

Brief Description of the Drawings

[0024]

Figure 1 shows a structure of a wheel made of metal

sheets in the prior art.

Figure 2 shows a schematic flow diagram of an embodiment of the forming method of the one-piece weldless wheel made of metal sheets according to the present invention.

Figures 3-14 show each step of the flow diagram represented in Figure 2 respectively.

Figure 15 shows a vertical cold rolling and roll forming machine used in the step of roll forming of an embodiment of the forming method of the one-piece weldless wheel made of metal sheets according to the present invention.

Figure 16 shows a structure of a one-piece weldless wheel made of metal sheets according to the present invention.

Detailed Description of Embodiments

[0025] The forming method of the one-piece weldless wheel made of metal sheets according to the present invention will be further described by the following embodiments along with the drawings. However, it is known that the embodiments and related descriptions should not be the limitation of the present invention.

[0026] Figure 2 shows a schematic flow diagram of an embodiment of the forming method of the one-piece weldless wheel made of metal sheets according to the present invention. And Figures 3-14 respectively show each step of the flow diagram represented in Figure 2.

[0027] As shown in Figures 2-14, a one-piece weldless wheel made of metal sheets is manufactured by steps as follows:

B-1: Forming a circular blank 1 (as shown in Figure 3).

B-2: Punching a center hole 2 on the circular blank 1 (as shown in Figure 4).

B-3: Placing the circular blank in a rolling mould 3 with a circular outer profile. And then rolling the circular blank into a wheel blank 5 by performing planar synchronous staggered rolling on the circular blank in the rolling mould 3 using two rolling wheels 4 symmetrically arranged along the circumferential direction of the rolling mould 3. As shown in Figure 5, in the embodiment, the rolling mould has two concave cavities which can correspondingly form two embossments on the lower surface of the rolled wheel blank. The rolling process can be performed by a rolling machine, such as the rolling machine disclosed in Chinese patent CN201744545U. However, it should be known that the devices which can perform the rolling process described in the present invention should not be limited to this rolling machine.

B-4: Press forming (i.e. forming a primary wheel rim and a primary wheel disc): Pressing the wheel blank to form the primary wheel rim and the primary wheel disc of the wheel made of metal sheets by applying pressure in the axial direction of the wheel blank using a concave pressing mould 7 and a convex pressing mould 6 (as shown in Figure 6).

B-5, B-6, B-7: Three-station roll forming: Placing the wheel blank between a concave roll forming mould 9 and a convex roll forming mould 8 and then rotating the concave roll forming mould 9 and the convex roll forming mould 8 synchronously around the axes thereof while pressing the lateral wall portion of the wheel blank in the radial direction of the wheel blank in three times by using three lateral pressing rollers 10, 11 and 12 separately, in order to further form the primary wheel rim precisely. Each lateral pressing roller 10, 11 and 12 is rotating around the axis itself when pressing the primary wheel rim. In the present invention, the concave roll forming mould 9 and the convex roll forming mould 8 fully contact the wheel blank and clamp it tightly. The lateral pressing rollers 10, 11 and 12 press the wheel blank. In the embodiment, the wheel rim is further formed precisely by the lateral pressing rollers 10, 11 and 12 in three separate steps, wherein the lateral pressing roller 10 in step B-5 performs cold rolling and extruding of a deep groove R of the wheel rim by slowly pushing the material into the groove cavity and extruding (as shown in Figure 7); the lateral pressing roller 11 in step B-6 performs cold rolling on the plane portion of the wheel rim in order to form a slope portion P to ensure that the shape of the wheel rim meets the shape requirement of the wheel rim preliminarily (as shown in Figure 8); the lateral pressing roller 12 in step B-7 is used to complete the forming of the R side Q of the wheel rim (as shown in Figure 9).

[0028] In this embodiment, the step of roll forming is performed by a vertical cold rolling and roll forming machine shown in Figure 15. However, it should be known that this vertical cold rolling and roll forming machine shown in Figure 15 is merely one kind of devices which can achieve the step of roll forming and cannot be deemed to be a limitation to the present invention.

[0029] As shown in Figure 15, the vertical cold rolling and roll forming machine in the embodiment includes a frame including upper beam 51, base 52, base support bracket 53 and six upright posts 54 fixedly disposed between the upper beam 51 and the base 52. The six upright posts 54 are evenly disposed on a circumference centered on the axis of the vertical cold rolling and roll forming machine. Namely, the angle between two adjacent upright posts 54 is 60 degree. Lower transmission assembly 55 is disposed on the base 52. Three oil cylinder assem-

blies 56 are fixedly disposed on the upper beam 51. The rods of the oil cylinder assemblies 56 fixedly connect to sliding blocks 57 connecting to an upper press head assembly 58. Thus, the oil cylinder assemblies 56 can drive the upper press head assembly 58 to move along the axial direction (i.e. a vertical direction) of the vertical cold roll forming machine. Hydraulic motor(s) connect with the lower transmission assembly 55 and the upper press head assembly 58, in order to drive the lower transmission assembly 55 and the upper press head assembly 58 respectively rotate around the axial thereof in synchronization manner. Three lateral pressing roller assemblies 59 are evenly arranged on a circumference centered on the axis of the vertical cold roll forming machine. That is, the angle between two adjacent lateral pressing roller assemblies 54 is 120 degree. Each of three oil cylinders for the lateral pressing rollers connects to each lateral pressing roller assembly 59 respectively, in order to drive the lateral pressing roller assembly 59 to move in the radial direction of the circumference. These three lateral pressing roller assemblies can be moved synchronously or separately. Hydraulic motor(s) for the lateral pressing rollers connects with the lateral pressing roller assemblies 59 to drive each of the lateral pressing roller assemblies to rotate around the axis itself. The hydraulic motor(s) for the lateral pressing rollers can drive three lateral pressing roller assemblies to rotate synchronously or separately. A convex roll forming mould 510 fixedly connects to the upper press head assembly 58. A concave roll forming mould 511 fixedly connects to the lower transmission assembly 55. Furthermore, the vertical cold rolling and roll forming machine further includes a control system which is not illustrated in the figures.

[0030] The control system may comprise displacement sensors respectively disposed on each feeding mechanism for the lateral pressing rollers, being used for detecting the feeding position of the lateral pressing roller assemblies; servo valves respectively connected to the hydraulic motor(s), the oil cylinders for the lateral pressing rollers and the hydraulic motor(s) for the lateral pressing rollers; PLC (programmable logic controller) connected to the displacement sensors, the servo valves and the oil cylinder assemblies, being used for controlling the rotating rates and feeding speeds of each element. For the convenience of roll forming process, the position of the lateral pressing roller assemblies in the axial direction (i.e. a vertical direction) of the vertical cold rolling and roll forming machine can be adjusted via an adjustment mechanism for the lateral pressing rollers which is connected to the lateral pressing roller assemblies.

[0031] The roll forming process using the above-mentioned vertical cold rolling and roll forming machine including the following steps:

(1) Placing the wheel blank into the concave roll forming mould 511.

(2) Controlling the oil cylinder assemblies 56 to drive the upper press head assembly 58 to move downward along the axial direction of the vertical cold rolling and roll forming machine until the wheel blank is pressed tightly by the convex roll forming mould 510.

(3) Controlling the hydraulic motor(s) to drive the lower transmission assembly 55 and the upper press head assembly 58 to rotate synchronously in order to rotate synchronously the convex roll forming mould 510, the concave roll forming mould 511 along with the wheel blank.

(4) Controlling the oil cylinders for the lateral pressing rollers to drive the lateral pressing roller assemblies to move in the radial direction (i.e. a horizontal direction) of the circumference in order to apply a deformation force onto the lateral wall portion of the wheel blank. Meanwhile, controlling the hydraulic motor(s) for the lateral pressing rollers to drive each lateral pressing roller assembly to rotate around the axis thereof until the roll forming process is completed.

B-8: Extruding a center hole 13 (as shown in Figure 10).

B-9: Extruding screw holes 14 (as shown in Figure 11).

B-10: Extruding air holes 15 (as shown in Figure 12).

B-11: Compressing and shaping: Placing the wheel blank between a concave shaping mould 17 and a convex shaping mould 16 and pressing the wheel blank in the axial direction of the wheel blank with the concave shaping mould 17 and the convex shaping mould 16 while pressing the primary wheel rim of the wheel blank in the radial direction of the wheel blank by using a lateral pressing shaping mould 18, in order to form a one-piece weldless wheel made of metal sheets (as shown in Figure 13).

B-12: Punching a valve hole (as shown in Figure 14).

[0032] Figure 16 shows a one-piece weldless wheel made of metal sheets, which is manufactured by above-mentioned steps. It can be seen from the figure that the shape of the one-piece weldless wheel made of metal sheets is the same as the shape of the wheel made of metal sheets in the prior art, while the one-piece weldless wheel made of metal sheets has no welding seam on the interim area between the wheel rim and wheel disc, which results in that the one-piece weldless wheel made of metal sheets has a much better performance on strength, rigidity and lifetime than the wheel made of metal sheets in the prior art.

[0033] The above description is merely embodiments in nature and is in no way intended to limit the invention, its application, or use.

Claims

1. A forming method of a one-piece weldless wheel made of metal sheets, comprising the following steps:

   (1) rolling: placing a circular blank in a circular rolling mould, and rolling the circular blank into a wheel blank by performing planar synchronous rolling on the circular blank in the rolling mould using at least two rolling wheels symmetrically arranged along the circumferential direction of the rolling mould;
   (2) forming a primary wheel rim and a primary wheel disc: pressing the wheel blank to form the primary wheel rim and the primary wheel disc of the wheel made of metal sheets by applying pressure in the axial direction of the wheel blank using a concave pressing mould and a convex pressing mould;
   (3) roll forming: placing the wheel blank between a concave roll forming mould and a convex roll forming mould and clamping the wheel blank tightly with the concave roll forming mould and the convex roll forming mould; then rotating the concave roll forming mould and the convex roll forming mould synchronously around the axes thereof while pressing the primary wheel rim in the radial direction of the wheel blank by using one or more lateral pressing rollers, in order to extrude and further form the primary wheel rim precisely, wherein each lateral pressing roller is rotating around the axis thereof when pressing the primary wheel rim;
   (4) compressing and shaping: placing the wheel blank between a concave shaping mould and a convex shaping mould and pressing the wheel blank in the axial direction of the wheel blank with the concave shaping mould and the convex shaping mould while pressing the primary wheel rim of the entire circumference of the wheel blank in the radial direction of the wheel blank by using a lateral pressing shaping mould, in order that pressing, compressing and shaping can be performed simultaneously to form a one-piece weldless wheel made of metal sheets.

2. The forming method of a one-piece weldless wheel made of metal sheets according to claim 1, further comprising a step of forming the circular blank and punching a positioning hole before the step (1).

3. The forming method of a one-piece weldless wheel made of metal sheets according to claim 1, further comprising a step of extruding a center hole between the step (3) and the step (4).

4. The forming method of a one-piece weldless wheel made of metal sheets according to claim 1, further comprising a step of extruding screw holes between the step (3) and the step (4).

5. The forming method of a one-piece weldless wheel made of metal sheets according to claim 1, further comprising a step of extruding air holes between the step (3) and the step (4).

6. The forming method of a one-piece weldless wheel made of metal sheets according to claim 1, further comprising a step (5) of punching a valve hole on the one-piece weldless wheel made of metal sheets.

7. The forming method of a one-piece weldless wheel made of metal sheets according to claim 1, wherein rolling motions of the at least two rolling wheels in the step (1) comprise feed movements of the at least two rolling wheels in a horizontal direction and a rotation of each rolling wheel.

8. The forming method of a one-piece weldless wheel made of metal sheets according to claim 1, wherein, in the step (3), pressing the primary wheel rim in the radial direction of the wheel blank by using three lateral pressing rollers, in order to extrude and further form the primary wheel rim precisely, wherein the three lateral pressing rollers are arranged evenly along the circumferential direction of the wheel blank.

9. A one-piece weldless wheel made of metal sheets manufactured by the forming method of a one-piece weldless wheel made of metal sheets according to claims 1-8.

10. The one-piece weldless wheel made of metal sheets according to claim 9, wherein the one-piece wheel is made from carbon steel, aluminum, Mg-A1 alloy or stainless steel.

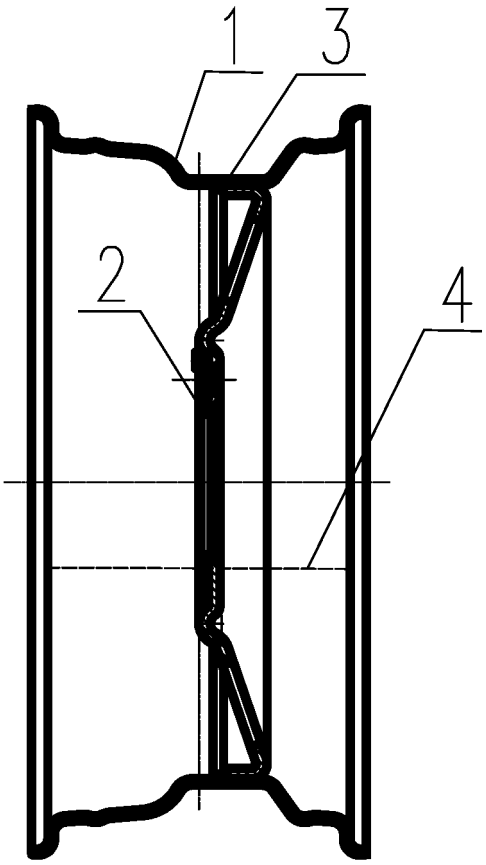

Figure 1

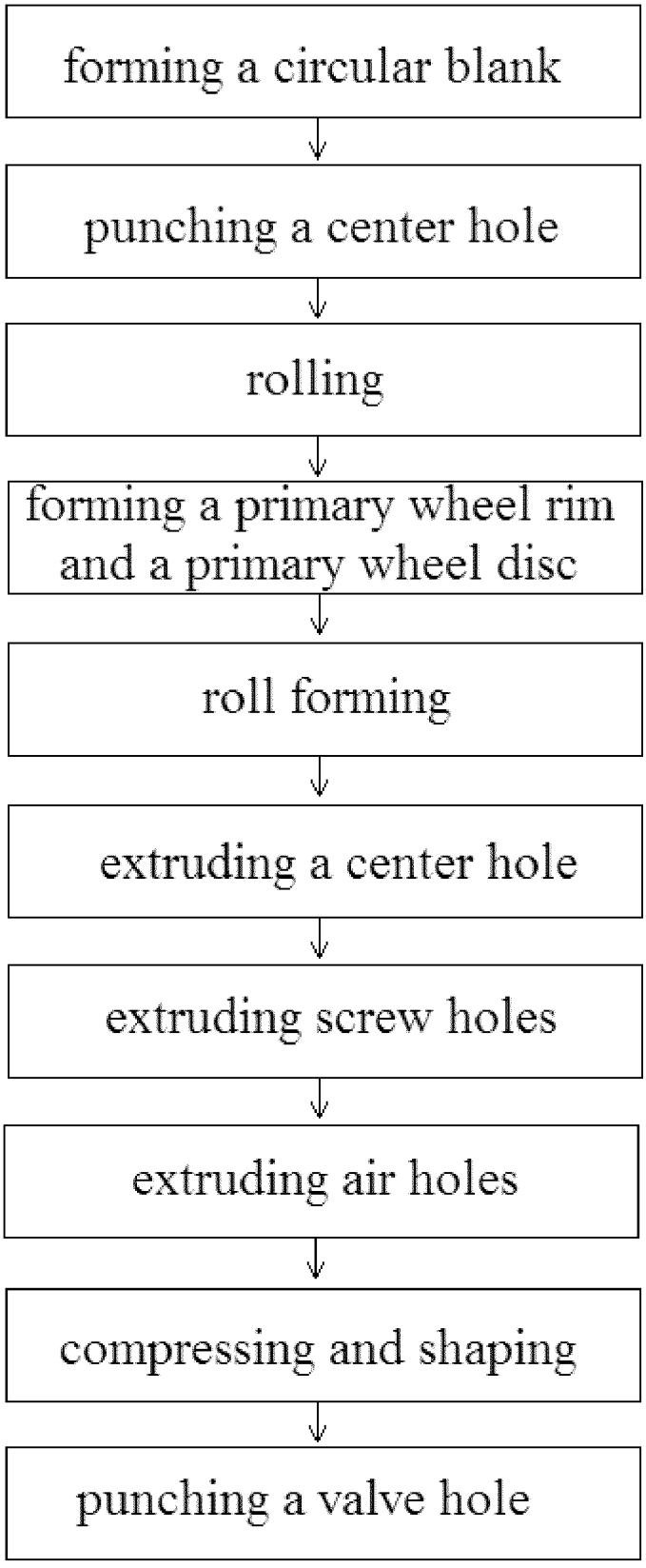
forming a circular blank
punching a center hole
rolling
forming a primary wheel rim and a primary wheel disc
roll forming
extruding a center hole
extruding screw holes
extruding air holes
compressing and shaping
punching a valve hole

Figure 2

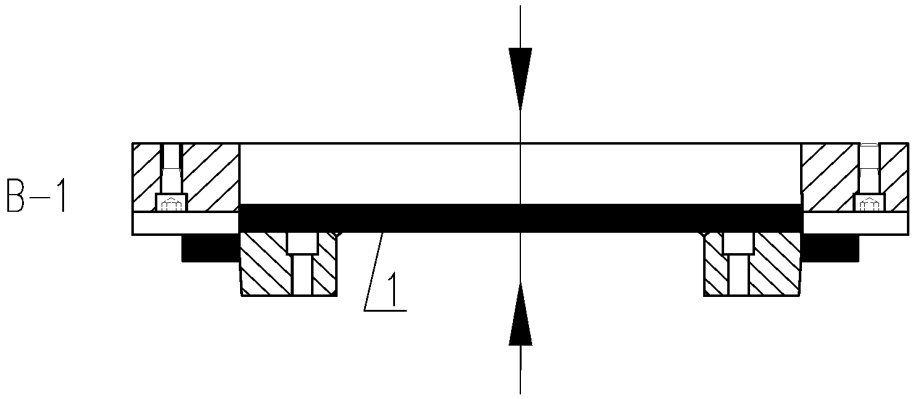

Figure 3

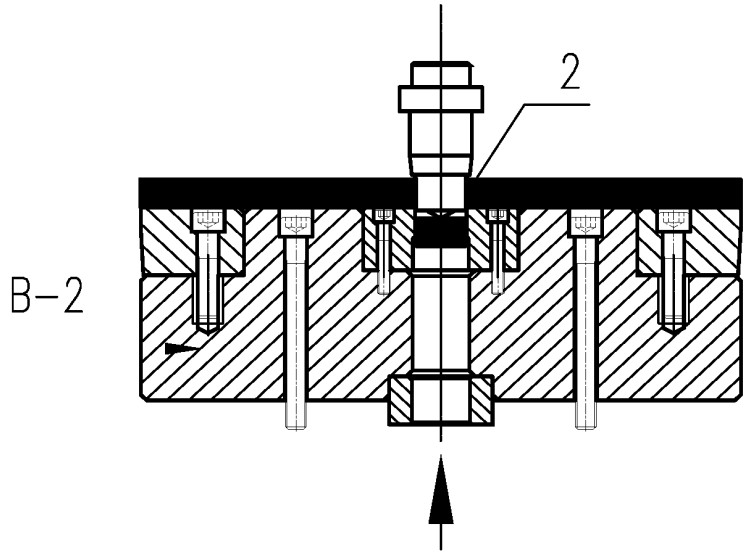

Figure 4

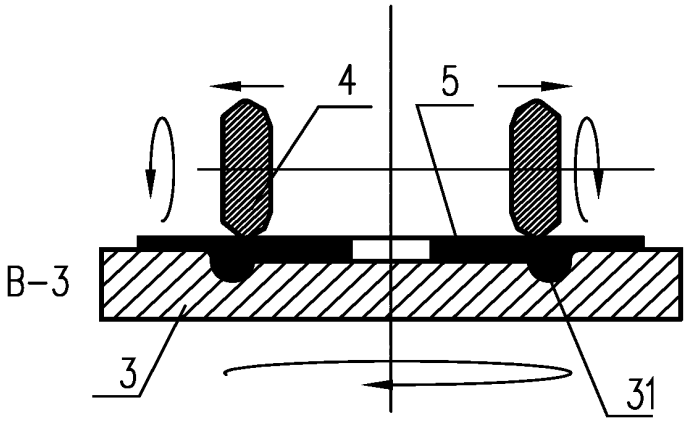

Figure 5

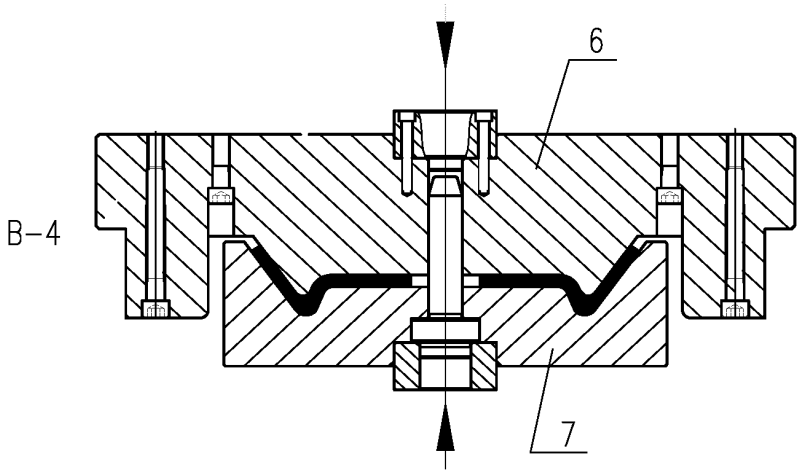

Figure 6

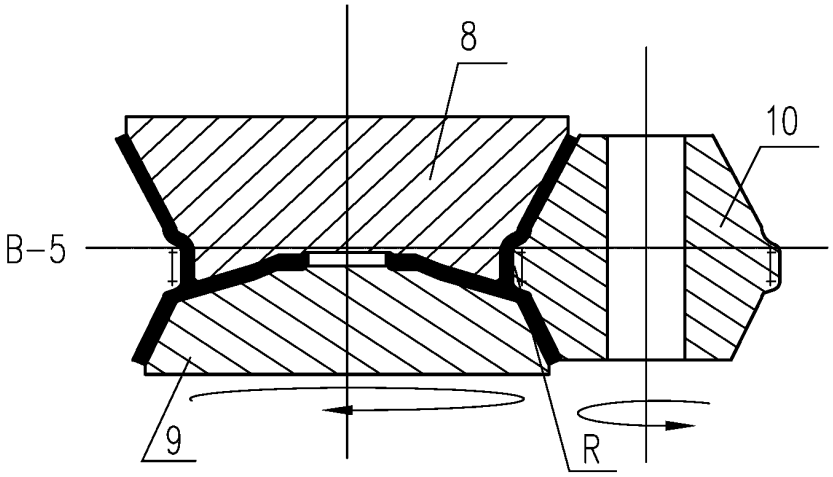

Figure 7

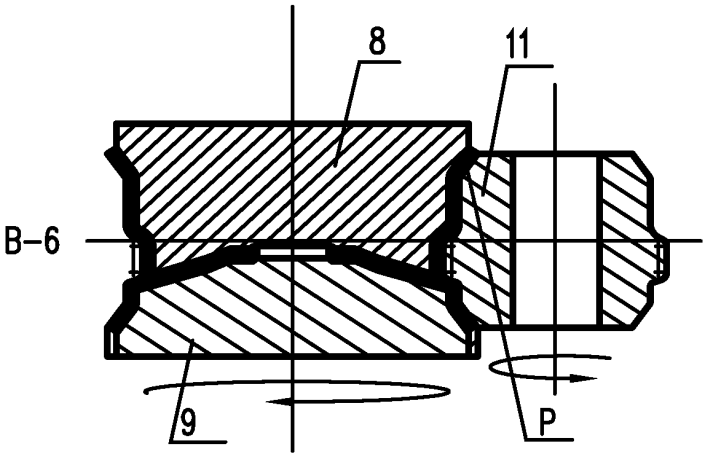

Figure 8

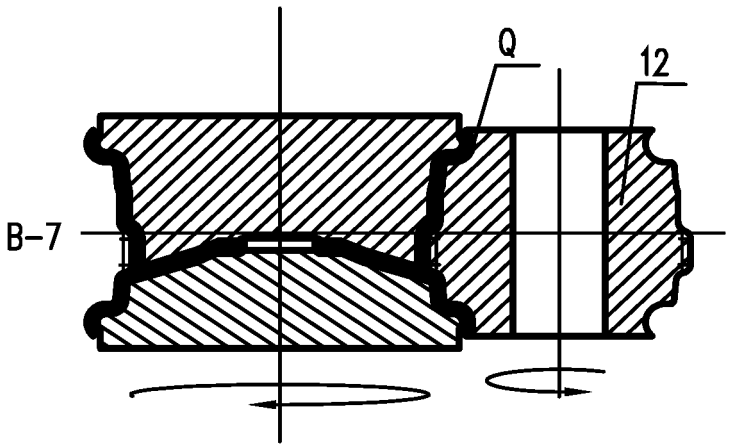

Figure 9

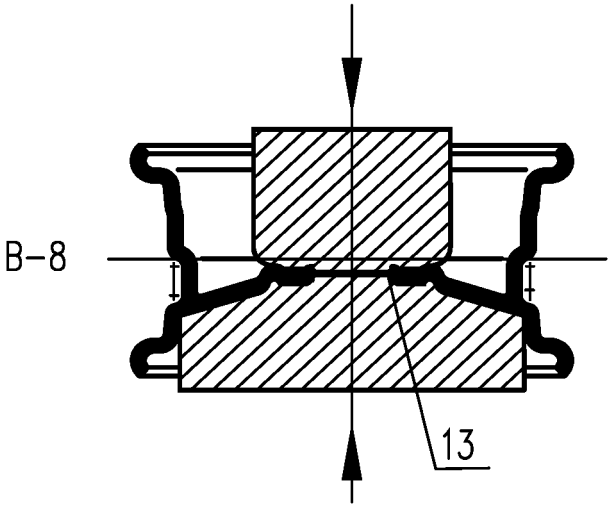

Figure 10

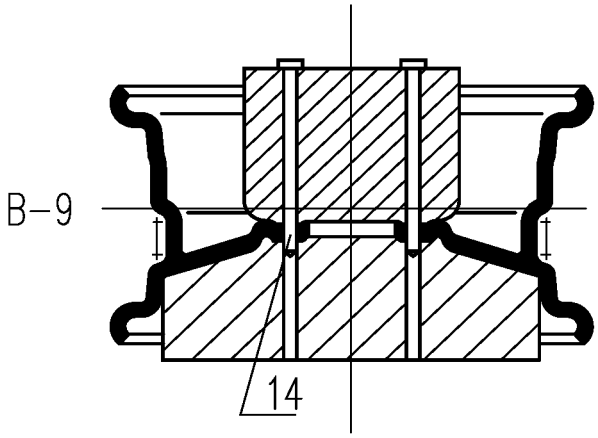

Figure 11

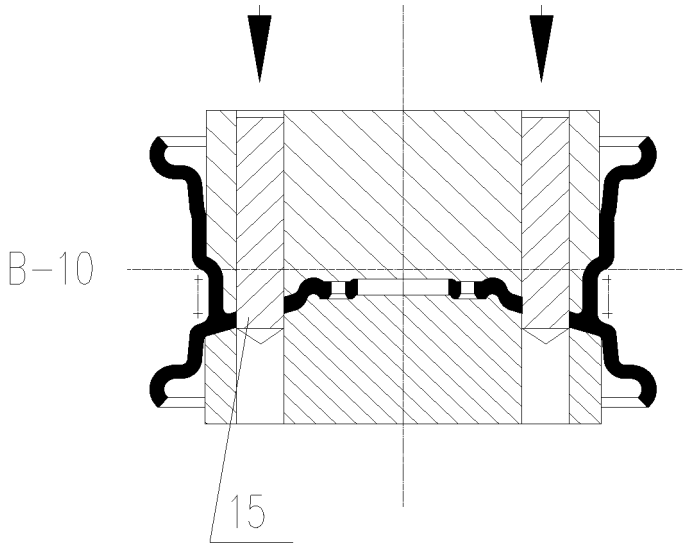

Figure 12

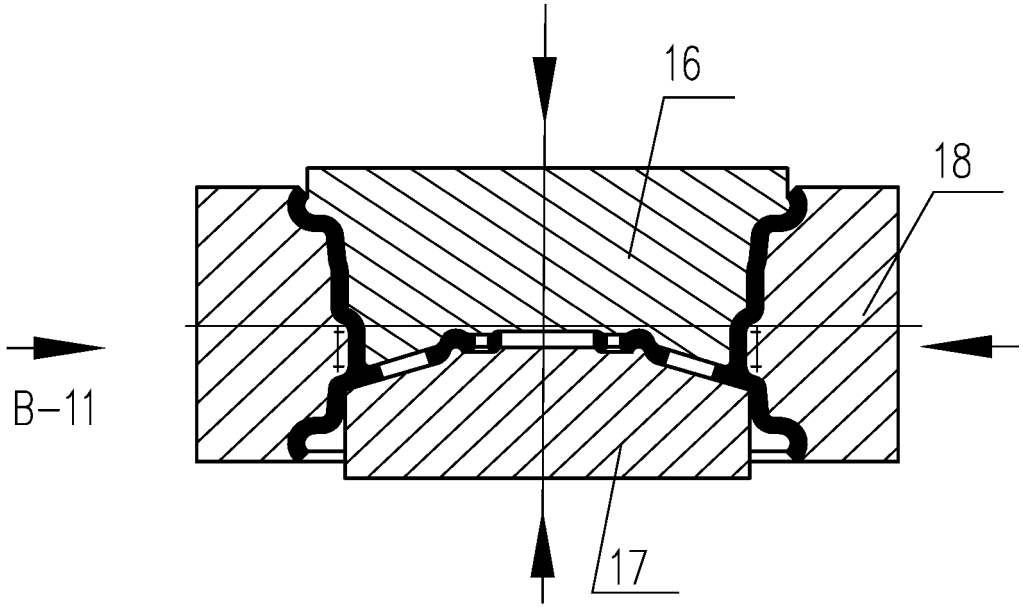

Figure 13

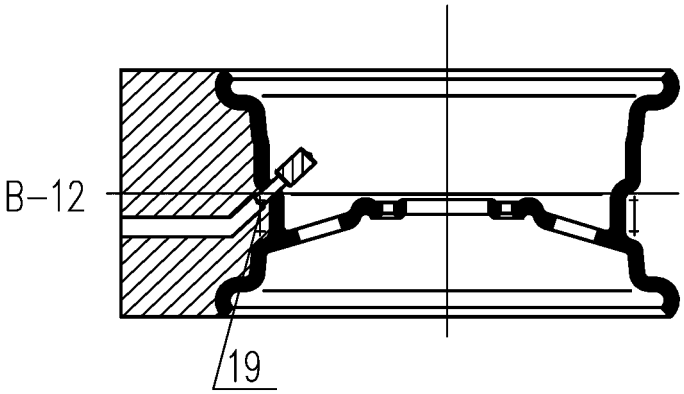

Figure 14

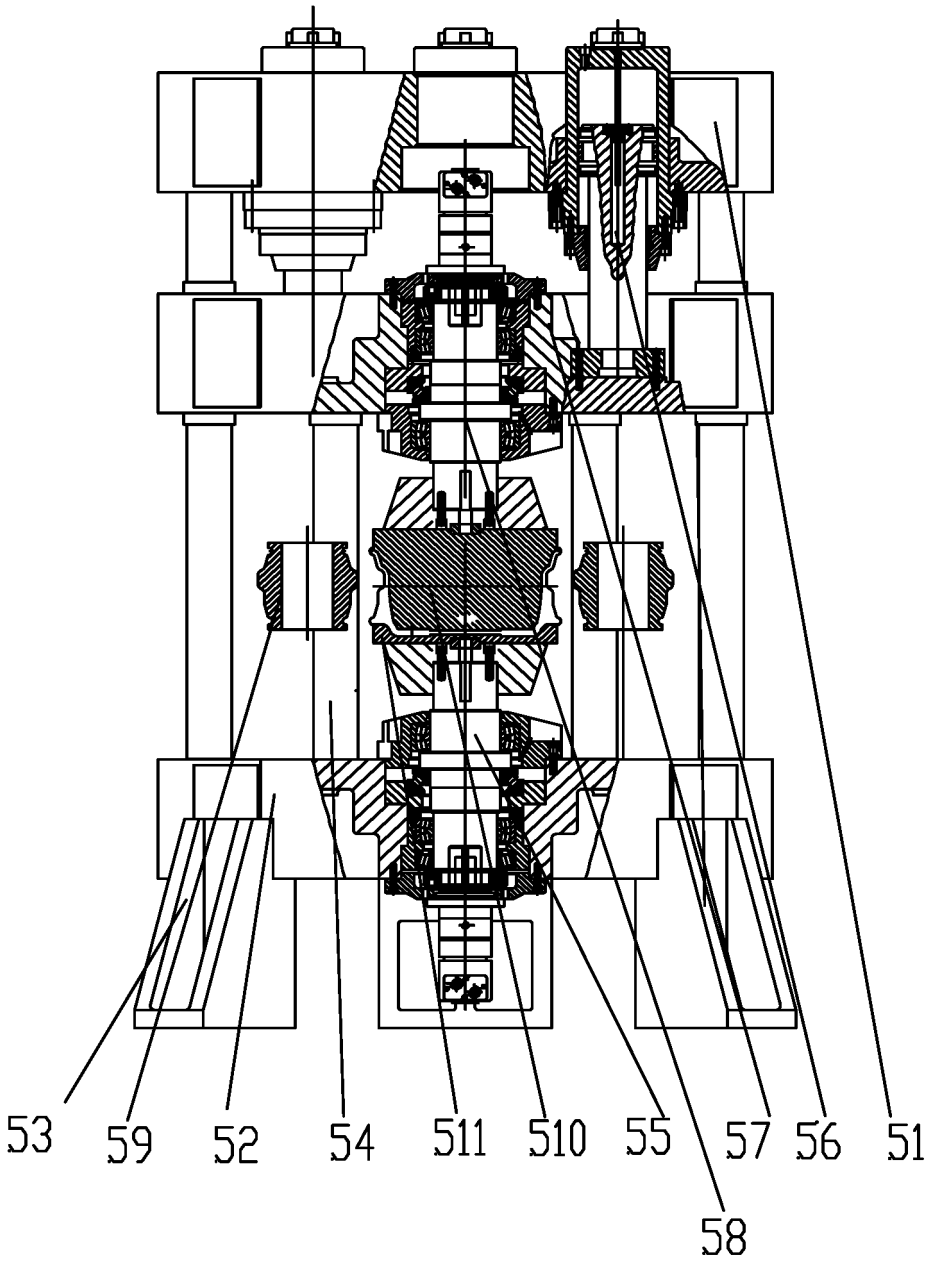

Figure 15

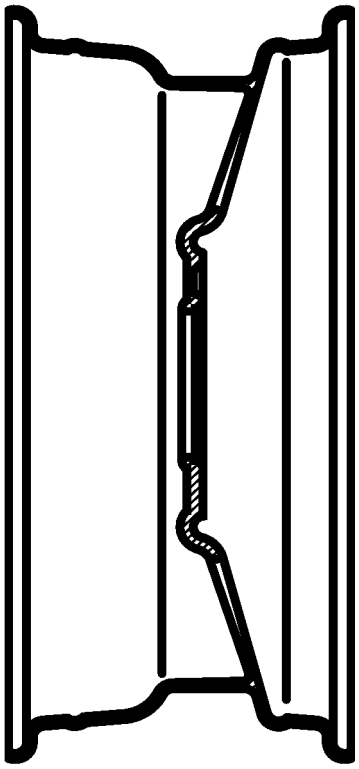

Figure 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/070163

A. CLASSIFICATION OF SUBJECT MATTER

B21D 22/14 (2006.01) i; B21D 17/04 (2006.01) i
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21D, B60B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
CNABS, CNTXT, DWPI, VEN: rolling, spinning, terrace die, side pressure, wheel, hub, spoke, bar, rim, integral, entire, whole, roll, rotary, rotate, spin, die, mould, mold, side, press, shape, size

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 102489658 A (DONGGUAN GANGRUN TECHNOLOGY MACHINERY CO., LTD. et al.), 13 June 2012 (13.06.2012), description, paragraphs 4-12, and figures 1-3	1-10
Y	CN 101722401 A (SHANGHAI BAOLONG AUTOMOTIVE CORPORATION), 09 June 2010 (09.06.2010), description, paragraphs 29-31	1-10
Y	CN 101020286 A (JIAXING STONE WHEEL MANUFACTURE CO., LTD.), 22 August 2007 (22.08.2007), description, page 1, paragraph 3 to page 3, last paragraph, and figures 1-3	3-6, 9-10
Y	CN 101648329 A (LIOHO LIGHT METAL (KUNSHAN) CO., LTD. et al.), 17 February 2010 (17.02.2010), description, page 2, paragraph 3 to page 5, paragraph 5, and figures 1-5	1-10
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A	CN 1827289 A (JIAXING STONE WHEEL MANUFACTURE CO., LTD.), 06 September 2006 (06.09.2006), the whole document	1-10

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 May 2015 (05.05.2015)	**28 May 2015 (28.05.2015)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **HOU, Yanpin** Telephone No.: (86-10) **62084500**

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/070163

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101966555 A (SHANGHAI XINGPU SPINFORMING WHEEL CO., LTD.), 09 February 2011 (09.02.2011), description, paragraphs 13-54, and figures 1-6	1-10
A	US 3991598 A (ASPRO INC.), 16 November 1976 (16.11.1976), the whole document	1-10
A	US 4048828 A (FORGEAL), 20 September 1977 (20.09.1977), the whole document	1-10
PX	CN 104191900 A (SHANGHAI XINGPU SPINFORMING WHEEL CO., LTD.), 10 December 2014 (10.12.2014), claims 1-10	1-10
PX	CN 104191906 A (SHANGHAI XINGPU SPINFORMING WHEEL CO., LTD.), 10 December 2014 (10.12.2014), description, paragraphs 9-59, and figures 1-19	1-10

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/070163

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CN 101648329 A	17 February 2010	None	
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/070163

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
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CN 104191906 A	10 December 2014	None	

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REFERENCES CITED IN THE DESCRIPTION

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