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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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[Continued on next page]

(54) Title: A FORGING PROCESS FOR MANUFACTURE OF ALUMINIUM ALLOY WHEEL DISC

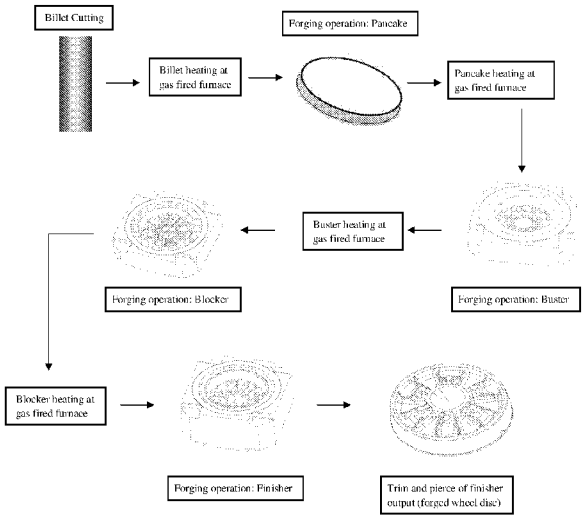

Figure 1

(57) Abstract: A forging process to manufacture Aluminium wheel discs for heavy vehicles using small tonnage hammer is disclosed. It uses step-wise forging operation to achieve final shape of the alloy wheel. A minimal amount of machining is required. The process starts with a preform made from a round extruded billet and follows through with a pancaking and buster operations further followed by blocker and finisher operations. It is noted that grain flow lines in the product are continuous because the initial flow lines are present in extruded billet and it has greater material strength than the products manufactured with conventional processes that involve joints and welding.

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— *with amended claims (Art. 19(1))*

A Forging Process For Manufacture Of Aluminium Alloy Wheel Disc

Field of the Invention:

The present invention relates to a manufacturing method for an Aluminium alloy (AK-6) wheel disc. In particular, wheels of large diameter, complex geometry, material flow difficulty and heavy weight are referred to and which are manufactured with forging process using small capacity equipments (25000 lbs hammer) resulting into better strength and quality product than the conventionally manufactured Aluminium discs.

Background of the invention:

Use of Aluminium is well established in certain industries. However, its use in structural components in heavy vehicle industry is extremely limited. This is because the forging processes of making Aluminium parts suitable for use in large vehicles are cumbersome.

The difficulties involved in forging of large parts may be metallurgical or related to the shape and geometry of parts such as wheels. For instance, unlike alloy steel forging, the Aluminium forging needs to operate in a narrow temperature range of 490^0C +/- 10^0C. In contrast, the alloy steel has an operational temperature range of 1150^0C to 1280^0C (Aluminium can easily crack with wider temperature range). It is also important in the case of Aluminium forging that the flame should not

touch the billet; instead the heating is carried out using hot air. This requires a specially designed furnace. Furthermore the speed of handling Aluminium forged parts during the forging process needs to be very fast. For these reasons, the forging industry has generally avoided using Aluminium for large components such as vehicles wheels.

The components such as vehicle wheels have a hub in the center, and an outer annular flange. Joining these two requires a step of combination of complex corrugated sets of webs & ribs. All these are at varying heights with higher steps. This up and down shape necessitates material to flow non-uniformly, resulting in folds and cracks, unlike the material flow in straight path which always results in defect free forging.

The use of Aluminium in vehicle manufacture is well documented. However, its use in manufacturing of wheels for heavy vehicles is limited to parts of the wheels rather than entire wheel or a major portion of the wheels.

Aluminum alloys have been employed in the manufacture of vehicle wheels. For example, US patent 6,315,367 discloses a cast Aluminium truck wheel which claimed to eliminate the welding of a separately manufactured wheel disc and wheel rim.

Specific alloys such as the Aluminium alloy 6061 have been employed in the commercial manufacture of truck wheels. Aluminium alloy 6061 was used in creating forged Aluminium wheels by subjecting the forging to solution heat treatment followed by a water quench and artificial aging. The US patent 4,316,637 also suggested the use of casting alloy 356 in making wheels. The use of Aluminium alloy 6061 as well as 5454 and A356 was disclosed in US patent 5,441,334. (See also US patent 5,210,948 which disclosed an Aluminium alloy 6013 wheel for a track-laying vehicle (e.g., a military tank))

The US patent 4,345,360 discloses an extrudable Aluminium alloy which is extruded, cut, deformed to the desired shape and welded such as by cold pressure welding.

The use of Aluminium wheels on commercial vehicles was suggested in the US patent 5,026,122 (also refer to the two-piece wheel disclosure of US patent 5,740,609).

The use of copper bearing Aluminium alloy 7075 has been disclosed for use in the generally C-shaped tread member on a non-pneumatic tire wheel combination. See US patent 4,558,727.

Published U.S. patent application 2002/0003373 discloses the use of copper bearing Aluminium alloys 7050 and 7075 in creating cold forged wheels and spun light alloy rims. The rim is said to be made of a 5000 series Aluminium alloy which is said to have strength and light weight similar to a cold forged alloy rim.

The US patent 4,490,189 discloses stamping or forging of 2000, 6000 or 7000 series Aluminium alloys, but does not relate to the vehicle wheels and focuses on certain sequences of thermal treatments.

It is clear that for nonintegrated design of a large and complex shaped component, one has to make many components either by sheet metal process, casting, or machining, and weld these together to make one large component. This involves plenty of quality checks and an increased amount of scrap. The life of parts fabricated in such manner is also short requiring frequent replacement which also means more downtime for vehicles using such parts.

In spite of the foregoing disclosures, there remains a very real and substantial need for wheels having improved properties.

Summary of the Invention:

A forging process to manufacture Aluminium wheel discs for heavy vehicles using small tonnage hammer is disclosed. It uses step-wise forging operation to

achieve final shape of the alloy wheel. A minimal amount of machining is required. The process starts with a preform made from a round extruded billet and follows through with a pancaking and buster operations further followed by blocker and finisher operations.

Brief Description of Figures:

Figure 1 shows the forging process of the present invention.

Detailed Description of the Invention:

The present invention is applicable to manufacturing of Aluminium wheel disc used for heavy vehicles.

The key inventive feature of the present invention lay in the fact that large parts such as entire wheel of an automotive vehicle, which if formed by conventional forging would require equipment of 20000 tonnes and above capacity press, is forged using relatively small capacity, forging hammer of 12 tonnes (25000 lbs) capacity.

In order to overcome the flaws in forged Aluminium product resulting from non-uniform material flow experienced in components of complex geometry such as a hub and spoke wheel, the present invention proposes a forging process using Aluminium that is carried out in four distinct operations: pancake, buster, blocker

and finisher. The magnitude of steps height is reduced by distributing the material in these four operations. This has surprisingly led to material flows that are smooth and lead to defect-free product.

As shown in Figure 1, the invented process of Aluminium wheel disc manufacturing typically involve the following steps:

1. Billet cutting into flat-faced billets and preparing billets for pancake formation
2. Pancake making and preparing pancakes for buster formation
3. Forming busters by forging process using a small capacity forging hammer and get them ready for forming blockers
4. Forming blockers by a further forging process to form a finisher
5. Forming a finisher by a still further forging process and treating the finisher by trimming and piercing

The details of each step are provided below.

Billet Formation:

- The billets are extruded.
- Billet identification based on heat code and heat number, the input billet was inspected dimensionally, material cleanliness and soundness criteria using ultrasonic testing.

- In the preparation stage, it is necessary to ensure the billet doesn't have sharp edge i.e. chamfers should be provided at billet edges and it is also necessary to ensure billet top and bottom faces doesn't have any tapered faces. If tapered faces are present then it is necessary to do the required machining and ensure the flatness of billet top and bottom surfaces.
- Billet heating in a furnace at 480^0-500^0 C temp range.

Pancake Formation:

- Pancakes are forged in flat dies using hammer. Both top and bottom flat dies are lubricated before forging. The heated billets from the furnace are subjected to forging operation. It is ensured that the billets are kept on a flat die at the center vertical position and then gradually forged by number of blows. The article that is being forged is radially rotated periodically to avoid buckling or oval shape of the pancake, also to nullify the taper i.e. uneven thickness due to potential errors in making flat dies parallelism. Pancake was maintained to required thickness
- Pancake hot air heating in a furnace at 480^0- 500^0 C temp range.

Buster Formation by Forging:

The heated pancakes from the furnace are forged in a Buster die by positioning them centrally on the die impression. Both bottom and top dies of the buster are

lubricated before giving the first blow. Lubrication is necessary as there will be sparking due to friction between dies and job, if not lubricated.

In order to locate properly in each forging, two locator lugs are provided in buster, blocker and finisher bottom dies in flash area. These lugs get removed in finisher trimming.

Steps involved in buster forging operation are as follows:

- Forging buster, Buster hot air heating in a furnace at 480^0- 500^0 C temp range.

Blocker Formation by Forging:

For the formation of blockers by forging, the heated busters from the furnace are centrally positioned on the blocker die impression. Both the top and bottom dies of the finisher are lubricated before first blow. Numbers of blows are given using a hammer for completely filling the blocker bottom die. Lubrication is necessary for avoiding sparking which may occur due to the friction between dies and the article that is being forged if not lubricated

Steps involved in blocker forging operation are as follows,

- Forging blocker, Blocker hot air heating in a furnace at 480^0- 500^0 C temp range.
- Lubrication to top and bottom finisher die

Finisher Formation by Forging:

The heated blockers from the furnace are centrally positioned on a finisher die impression. Both the top and bottom dies of the finisher are lubricated before first blow. Numbers of blows are given using hammer for completely filling up of the finisher bottom die. Lubrication is necessary as there will be sparking due to friction between dies and job if not lubricated.

- The forged finisher jobs were then proceeding towards trimming and piercing operation. The hot job was located centrally using 120^0 apart lugs on trimmer impression and simultaneously flash trimming and piercing was done using mechanical press. The 120^o apart lugs were also removed in finisher trimming.
- Finally machining has been done on components at outer surface.

Advantages of the invention:

The forging of entire parts such as a wheel, if made by a forging process, would according to the conventional processes, require heavy machinery capable of applying 20000 tonnes and above load. The present invention allows the forging to be carried out using relatively small capacity forging hammer of (12 tonnes), for example. The process of the invention offers other specific advantages. For example, the pancake formation distributes the material in a manner that allows the buster operation with low blow energy. Similarly, the blocker operation of the present invention distributes the material further in a manner that allows the

finisher operation to be performed at low energy. Imparting low energy results in lower stresses in the dies (relative to the conventional processes), which consequently improves the die life.

In another aspect of the invention the furnaces used for various stages of the process of invention is different. The furnaces used in the process of the invention at its various stages is a gas fired furnace or any other suitable commercially available furnace, having hot air circulation for heating.

Any of the operations discussed herein (pancaking, buster, blocker and finisher operations) are carried out on a single hammer or optionally on individual hammers.

In a further aspect of this invention, the forging process for manufacture of Aluminium alloy wheel disc is carried out using an individual furnace for each of the billet heating, pancaking, buster, blocker, and finisher operations.

The main advantage of our forging process sequence that we are forging one piece Aluminium Alloy wheel (no joining process involved). Hence it is strength wise stronger over wheel making process involve welding. Due the process sequence, distortion in alloy wheel while forging is avoided. Also eliminated surface defects by blending the rib, web profile smoothly and balancing the volumes in blocker

and buster operations. Also there is very negligible wear occurs during this forging process sequence. The shape of wheel it is very complex. The material flow in the forging operation for Aluminium alloy is very difficult for web and rib profiles. But due to our process sequence, the path of material changes gradually. And the problem of difficult to material flow is eliminated. Also this forging process sequence helps to make the product defect free. For example if any of one operation is eliminated, it will give a lot of cracks and cold shuts (Forging Defect). Hence use of the said forging process sequence is resulting into economical product with good quality.

Thus the following advantages and superior material properties are experienced for the product obtained by the method of present invention:

- grain flow lines are continuous because the initial flow lines are present in extruded billet. It forms radial flow lines while making pancake and further at every stages like buster, blocker and finisher, flow lines take shape concentric to the final product.
- the parts have greater material strength than the products manufactured using conventional processes that involve joints and welding
- distortion is either avoided or minimized compared to conventional processes

- since the rib and web profiles are blended smoothly and since the volumes in blocker and buster operations are balanced, surface defects are eliminated
- the nature of the process is such that material wear is minimized
- the unique process sequence makes the product defect-free overall (unlike the conventional processes where elimination of any step will lead to cracks and cold shuts)

It is evident from the foregoing discussion that the invention has a number of embodiments. These are:

1. A forging process for manufacture of Aluminium alloy wheel disc characterised in that said process comprises a step-wise forging operation starting with a round extruded billet being cut into flat faced billets that are subjected to heating in a furnace, and follows through with pancaking and buster operations further followed by blocker and finisher operations, further followed by trimming and piercing operations.
2. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiment 1, characterised in that said stepwise forging operation is carried out on a forging equipment.
3. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 2, characterised in that said forging equipment is a forging hammer.

4. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 3, characterised in that said forging hammer is 12 ton in capacity.

5. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 4, characterised in that said pancaking operation further comprises forging of extruded billet from the furnace in flat dies using hammer said flat faced billet into a pancakes wherein both top and bottom flat dies are lubricated before forging ensuring that said billets are kept on a flat die at the center vertical position and then gradually forged by number of blows.

6. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 5, characterised in that hot air in the furnace used for the pancake operation is maintained at 480^0- 500^0 C temperature range.

7. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 6, characterised in that the said buster operation comprises heated pancakes from the furnace in a buster die by positioning them centrally on the buster die impression, wherein both bottom and top dies of the buster are lubricated before giving the first blow, followed by providing a numbers of blows using said hammer for completely filling the buster dies.

8. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 7, characterised in that that hot air in the furnace used for the buster operation is maintained at 480^0- 500^0 C temperature range.

9. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 8, characterised in that the said blocker operation comprises heated busters in a blocker die by centrally positioning them on the blocker die impression, wherein both the top and bottom dies of the blocker are lubricated before first blow, followed by providing a numbers of blows using said hammer for completely filling the blocker dies.

10. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 9, characterised in that hot air in the furnace used for the blocker operation is maintained at 480^0- 500^0 C temperature range.

11. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 10, characterised in that the said finisher operation comprises heated blocker by centrally positioning them on a finisher die impression, wherein both the top and bottom dies of the finisher are lubricated before first blow, followed by providing a numbers of blows using said hammer for completely filling up of the finisher dies.

12. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 11, characterised in that two locator lugs are provided in buster, blocker and finisher bottom dies in flash area.

13. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 12, characterised in that the forged finisher jobs were further subjected to trimming and piercing operations wherein the hot finisher job is located centrally using locator lugs on trimmer impression and simultaneously flash trimming and piercing is carried out using a mechanical press or a hydraulic press, where after the locator lugs are removed in finisher trimming.

14. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 13, characterised in that said furnace is a gas fired furnace.

15. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 14, characterised in that either an individual furnace or same furnace is used for each of the billet heating, pancaking, buster, blocker, and finisher operations.

16. A forging process for manufacture of Aluminium alloy wheel disc as disclosed in embodiments 1 to 15, characterised in that either an individual hammer or same hammer is used for each of the pancaking, buster, blocker, and finisher operations.

While the above description contains much specificity, these should not be construed as limitation in the scope of the invention, but rather as an exemplification of the preferred embodiments thereof. It must be realized that modifications and variations are possible based on the disclosure given above without departing from the spirit and scope of the invention. Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the appended claims and their legal equivalents.

Claims:

1. A forging process for manufacture of Aluminium alloy wheel disc characterised in that said process comprises a step-wise forging operation starting with a round extruded billet being cut into flat faced billets that are subjected to heating in a furnace, and follows through with pancaking and buster operations further followed by blocker and finisher operations, further followed by trimming and piercing operations.
2. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claim 1, characterised in that said stepwise forging operation is carried out on a forging equipment.
3. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 2, characterised in that said forging equipment is a forging hammer.
4. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 3, characterised in that said forging hammer is 12 ton in capacity.
5. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 4, characterised in that said pancaking operation further comprises forging of extruded billet from the furnace in flat dies using hammer said flat faced billet into a pancakes wherein both top and bottom flat dies are lubricated before forging ensuring that said billets are

kept on a flat die at the center vertical position and then gradually forged by number of blows.

6. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 5, characterised in that hot air in the furnace used for the pancake operation is maintained at 480^0- 500^0 C temperature range.

7. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 6, characterised in that the said buster operation comprises heated pancakes from the furnace in a buster die by positioning them centrally on the buster die impression, wherein both bottom and top dies of the buster are lubricated before giving the first blow, followed by providing a numbers of blows using said hammer for completely filling the buster dies.

8. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 7, characterised in that that hot air in the furnace used for the buster operation is maintained at 480^0- 500^0 C temperature range.

9. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 8, characterised in that the said blocker operation comprises heated busters in a blocker die by centrally positioning them on the blocker die impression, wherein both the top and bottom dies of the blocker are lubricated before first blow, followed by providing a numbers of blows using said hammer for completely filling the blocker dies.

10. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 9, characterised in that hot air in the furnace used for the blocker operation is maintained at 480^0- 500^0 C temperature range.

11. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 10, characterised in that the said finisher operation comprises heated blocker by centrally positioning them on a finisher die impression, wherein both the top and bottom dies of the finisher are lubricated before first blow, followed by providing a numbers of blows using said hammer for completely filling up of the finisher dies.

12. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 11, characterised in that two locator lugs are provided in buster, blocker and finisher bottom dies in flash area.

13. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 12, characterised in that the forged finisher jobs were further subjected to trimming and piercing operations wherein the hot finisher job is located centrally using locator lugs on trimmer impression and simultaneously flash trimming and piercing is carried out using a mechanical press or a hydraulic press, where after the locator lugs are removed in finisher trimming.

14. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 13, characterised in that said furnace is a gas fired furnace.

15. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 14, characterised in that either an individual furnace or same furnace is used for each of the billet heating, pancaking, buster, blocker, and finisher operations.

16. A forging process for manufacture of Aluminium alloy wheel disc as claimed in claims 1 to 15, characterised in that either an individual hammer or same hammer is used for each of the pancaking, buster, blocker, and finisher operations.

AMENDED CLAIMS
received by the International Bureau on 22 January 2016 (22.01.16)

1. A forging process for manufacture of Aluminium alloy wheel of complex geometry characterised in that said process comprises a step-wise forging operation carried out using a forging hammer of small capacity starting with a round extruded billet being cut into flat faced billets that are subjected to heating in a furnace, and follows through with pancaking and buster operations further followed by blocker and finisher operations, further followed by trimming and piercing operations.

2. A forging process for manufacture of Aluminium alloy wheel as claimed in claim 1, characterised in that said forging hammer is about 12 tonnes (25,000 lbs) in capacity.

3. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 2, characterised in that said pancaking operation further comprises forging of extruded billet from the furnace in flat dies using hammer said flat faced billet into a pancakes wherein both top and bottom flat dies are lubricated before forging ensuring that said billets are kept on a flat die at the center vertical position and then gradually forged by number of blows.

4. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 3, characterised in that hot air in the furnace used for the pancake operation is maintained at 480^0- 500^0 C temperature range.

AMENDED SHEET (ARTICLE 19)

5. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 4, characterised in that the said buster operation comprises heated pancakes from the furnace in a buster die by positioning them centrally on the buster die impression, wherein both bottom and top dies of the buster are lubricated before giving the first blow, followed by providing a numbers of blows using said hammer for completely filling the buster dies.

6. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 5, characterised in that that hot air in the furnace used for the buster operation is maintained at 480^0- 500^0 C temperature range.

7. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 6, characterised in that the said blocker operation comprises heated busters in a blocker die by centrally positioning them on the blocker die impression, wherein both the top and bottom dies of the blocker are lubricated before first blow, followed by providing a numbers of blows using said hammer for completely filling the blocker dies.

8. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 7, characterised in that hot air in the furnace used for the blocker operation is maintained at 480^0- 500^0 C temperature range.

9. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 8, characterised in that the said finisher operation comprises heated blocker by centrally positioning them on a finisher die impression,

wherein both the top and bottom dies of the finisher are lubricated before first blow, followed by providing a numbers of blows using said hammer for completely filling up of the finisher dies.

10. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 9, characterised in that two locator lugs are provided in buster, blocker and finisher bottom dies in flash area.

11. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 10, characterised in that the forged finisher jobs were further subjected to trimming and piercing operations wherein the hot finisher job is located centrally using locator lugs on trimmer impression and simultaneously flash trimming and piercing is carried out using a mechanical press or a hydraulic press, where after the locator lugs are removed in finisher trimming.

12. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 11, characterised in that said furnace is a gas fired furnace.

13. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 12, characterised in that either an individual furnace or same furnace is used for each of the billet heating, pancaking, buster, blocker, and finisher operations.

14. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 13, characterised in that either an individual hammer or

same hammer is used for each of the pancaking, buster, blocker, and finisher operations.

15. A forging process for manufacture of Aluminium alloy wheel as claimed in claims 1 to 14, characterised in that said wheels are of hub and spoke type.

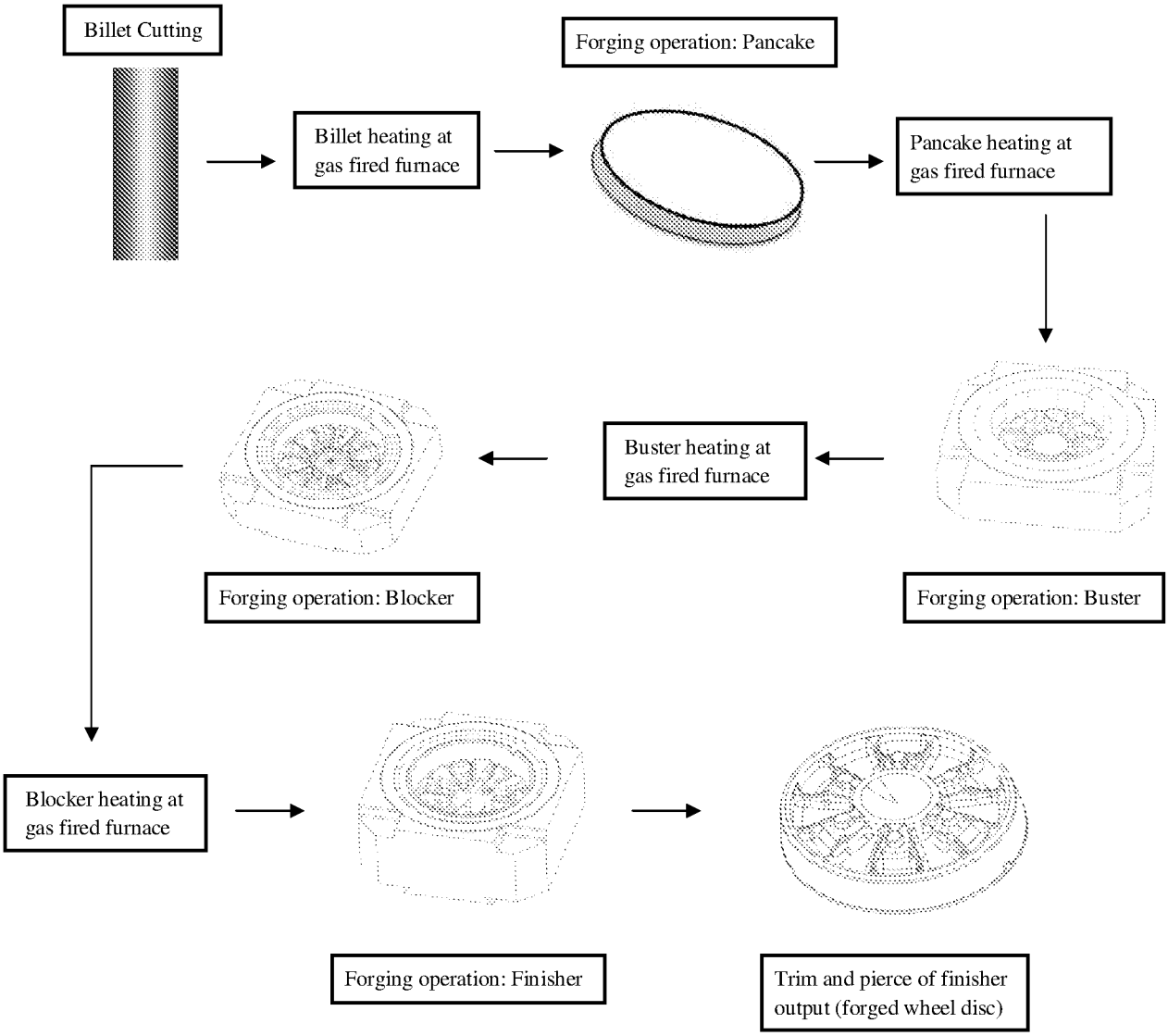
Billet Cutting
Billet heating at gas fired furnace
Forging operation: Pancake
Pancake heating at gas fired furnace
Forging operation: Buster
Buster heating at gas fired furnace
Forging operation: Blocker
Blocker heating at gas fired furnace
Forging operation: Finisher
Trim and pierce of finisher output (forged wheel disc)

Figure 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/056201

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21K1/32 B21K1/38
ADD.

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)
B21K

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/096212 A1 (WASHI KOSAN KK [JP]; ONO KOTARO [JP]; MOCHIKAWA AKIJI [JP]) 11 August 2011 (2011-08-11) paragraphs [0065], [0083], [0084]; figures 1-4	1-16
X	US 3 263 315 A (O'BRIEN PAUL R) 2 August 1966 (1966-08-02) column 3, line 6 - column 14, line 114; figure 1	1-16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
13 November 2015	23/11/2015

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2015/056201

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