

Method for Forming Aerospace Engine Nozzle Parts

Technical field

The invention relates to the field of aerospace engine nozzles, and in particular to
5 a method for forming aerospace engine nozzle parts.

Background technique

The thrust section is a component in the liquid rocket engine that is responsible for mixing and burning fuel to produce high-temperature and high-pressure fuel gas,
10 which is accelerated and discharged through the throat to obtain reverse thrust. The thrust section is generally a Laval profile structure, and consists of a cylindrical section, a contraction section and an expansion section. In order to withstand the high temperature of the fuel gas, the nozzle, which is composed of an outer wall and an inner wall with milling grooves, generally adopts regenerative cooling technology. At
15 the same time, because the fuel gas temperature is as high as 3500K and the wall surface heat exchange power can reach 100 megawatts, the material of the inner wall of the thrust section is mostly copper alloy.

The structure of the nozzle includes rod, forging ring, plate or cylinder.

In the prior art, the processing method of rod, forging ring and plate is machining,
20 and the processing method of plate and cylinder is spinning or stamping after tailor welding. Among them, the specific method for mechanical processing of rod, forging ring and plate is: take a rod, forged ring, and/or plate for subtractive processing to obtain the required nozzle parts, and then perform tailor welding. The disadvantages of this method are: the material utilization rate is low, the machining workload is huge,
25 and at the same time, it is difficult to process large-size nozzle parts for the limitation

by the thickness of the material. The specific method for spinning a plate or a cylinder is: the forming process in which a plate or a barrel-shaped part being screwed onto a mold forcibly. The disadvantages of this method are: (1) it is difficult to process parts with large diameter and large shaft diameter ratio, and it is easy to produce defects such as cracks thus cause scrap; (2) the manufacturing process requires a series of spinning tires for the first locus, the second locus, the third locus, and so on, especially when the diameter is very large, the size of the spinning tire will be very large; and (3) the spinning process is usually accompanied by heating during hot spinning, heat treatment and other heating processes, which changes the properties of the raw materials. The specific method of stamping after tailor welding of plates or cylinders is as follows: firstly bending the plates into melon petals of 120° or 60° or the like; then aligning 3 or 6 or the like pieces of the same plates, and performing a tailor welding for these plates along the longitudinal seam thereof, thus obtaining a part with a complete circumference; and then placing it into a shaping-tire for stamping and forming. At present stage it is mainly used for the forming of stainless steel, titanium alloy and other materials. The disadvantages of this method are: (1) the process is relatively complicated; (2) the requirement for equipment is high, and large-scale shaping-tire and stamping equipment are required, and welding seams are prone to problems during the stamping process; (3) the product deformation is large and the product consistency is poor; and (3) only contraction-only or expansion-only structural parts can be processed, and parts with both contraction section and expansion section cannot be obtained at one time.

Therefore, it is a technical problem to be solved urgently by those skilled in the art as how to provide a method for forming aerospace engine nozzle parts that has simple procedures, is not limited by shaft diameter ratio and size, can be inspected

and measured in the process, is integrally formed, has high production stability, and is suitable for mass automated production.

Summary of the invention

5 In order to solve at least part of the above technical problems, the present invention provides a method for forming aerospace engine nozzle parts, wherein the method includes the following steps: step one: cutting out a plurality of coaxial circular cone rings in a sheet; step two: performing spinning correction on the circular cone rings that are too large or similar in size; step three: large-opening and
10 small-opening ends of all the circular cone rings are turned into toruses for welding with each other; and step four: according to the order of the size of a large-opening end from small to large or from large to small, a plurality of the circular cone rings are sequentially welded into a whole body, wherein the large-opening end of any one of the circular cone rings in the middle is welded to the small-opening end of one
15 adjacent circular cone ring, and the small-opening end thereof is welded to the large-opening end of another one adjacent circular cone ring.

 In some embodiments, in the method for forming aerospace engine nozzle parts, the method further comprises step five, in which a size information of the nozzle parts to be processed is known, and an inner wall and an outer side wall of the whole body
20 obtained in the step four are modified according to the size information of the nozzle parts to be processed

 In some embodiments, in the method for forming aerospace engine nozzle parts, the width of the torus is 25mm~30mm.

In some embodiments, in the method for forming aerospace engine nozzle parts, in the step three, the large-opening end and the small-opening end of the circular cone ring are machined into a torus with a width of 25 mm.

In some embodiments, in the method for forming aerospace engine nozzle parts,
5 in the step four, friction stir welding, laser welding or electron beam welding is used to weld the plurality of circular cone rings into a whole body.

In some embodiments, in the method for forming aerospace engine nozzle parts, the sheet is a copper alloy sheet, a titanium alloy sheet, a stainless steel sheet or an aluminum alloy sheet.

10 In some embodiments, in the method for forming aerospace engine nozzle parts, after the spinning correction in the step two, a plurality of the circular cone rings are arranged coaxially according to the size of the large-opening end from small to large, and the adjacent opening ends of the two adjacent circular cone rings have the same dimension.

15 In some embodiments, in the method for forming aerospace engine nozzle parts, further comprising: before the step one, according to the large-opening end diameter, small-opening end diameter, axial length and pipe wall thickness of the parts to be processed, designing the number and size information of the circular cone ring so that
20 the small-opening end diameter of the circular cone ring with the smallest size information is equal to the diameter of the small-opening end of this parts, the large-opening end diameter of the circular cone ring with the largest size information is equal to the diameter of the large-opening end of this parts, and the axial length of the whole body welded by the plurality of the circular cone ring is equal to the axial length of this parts.

In some embodiments, in the method for forming aerospace engine nozzle parts, in the step two, cold spinning is adopted to correct the circular cone ring.

In some embodiments, in the method for forming aerospace engine nozzle parts, in the step two, a spinning correction area is less than or equal to 40% of an area of
5 the circular cone ring.

The method for forming aerospace engine nozzle parts of the embodiment of the present invention has at least one of the following beneficial effects:

The method for forming aerospace engine nozzle parts of the present invention
10 solves the following problems in the prior art: the size limitation of the inner and outer walls of the aerospace engine nozzle, low material utilization, high requirements for production equipment, and the consistency in mass production.

The method for forming aerospace engine nozzle parts of the present invention has the following advantages: having simple procedures, not being restricted by shaft
15 diameter ratio and size, the technological process is detectable and measurable, allowing integrally molding, high production quality stability, and being suitable for mass automated production.

In the method for forming aerospace engine nozzle parts of the present invention, the circular cone ring with suitable cone angle is calculated and cut, the material
20 utilization rate is high, the machining accuracy is ensured by turning machining, and the workload of machining is greatly reduced.

In the method for forming aerospace engine nozzle parts of the present invention, there is no heating process in the manufacturing, and the properties of the material are not changed; the various circular cone rings are welded into a whole body by friction

stir welding, no melting phase is generated, the uniformity of the structure is good, and the material performance is not lost.

In the method for forming aerospace engine nozzle parts of the present invention, if the size of the alloy sheet is sufficient, the nozzle parts with a large size and a large
5 shaft diameter ratio can be processed.

Description of the drawings

Fig. 1 is a flow chart of the method for forming aerospace engine nozzle parts described in one of the embodiments of the present invention;

10 Fig. 2 is an alloy sheet in the method for forming aerospace engine nozzle parts described in one of the embodiments of the present invention;

Fig. 3 is a schematic diagram of the wire cutting process in the step one of the method for forming aerospace engine nozzle parts in one of the embodiments of the present invention;

15 Fig. 4 is a schematic diagram of the structure of the truncated cone body cut from the alloy sheet in the step one of the method for forming aerospace engine nozzle parts in one of the embodiments of the present invention;

Fig. 5 is a schematic diagram of the spinning correcting process in the step two of the method for forming aerospace engine nozzle parts in one of the embodiments of
20 the present invention;

Fig. 6 is a schematic diagram of the machining process in the step three of the method for forming aerospace engine nozzle parts in one of the embodiments of the present invention;

Fig. 7 is a schematic diagram of the welding process in the step four in the method for forming aerospace engine nozzle parts in one of the embodiments of the present invention;

Fig. 8 is a schematic diagram of the modification process in the step five in the method for forming aerospace engine nozzle parts described in one of the embodiments of the present invention;

Fig. 9 is a schematic diagram of the structure of the bell-shaped copper inner wall of the nozzle produced by the method for forming aerospace engine nozzle parts described in one of the embodiments of the present invention.

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Reference signs list:

1 represents the sheet, 2 represents the position of the locus in the wire cutting, 3 represents the circular cone ring, 4 represents the spinning correction wheel, 5 represents the turning tool, 6 represents the welding tool, 7 represents the welded whole body, and 8 represents the modified whole body.

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Detailed description

Various exemplary embodiments of the present invention will now be described in detail. The detailed description should not be considered as a limitation to the present invention, but should be understood as a more detailed description of certain aspects, characteristics, and embodiments of the present invention.

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It should be understood that the terms described in the present invention are only used to describe specific embodiments and are not used to limit the present invention. In addition, for the numerical range in the present invention, it should be understood that the upper limit and the lower limit of the range and each intermediate value

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between them are specifically disclosed. Any other stated value or intermediate value within the stated range and each smaller range between any stated value or intermediate value within the stated range are also included in the present invention. The upper and lower limits of these smaller ranges can be independently included in
5 or excluded from the range.

Unless otherwise specified, all technical and scientific terms used herein have the same meaning as commonly understood by those skilled in the art in the field of the present invention. Although the present invention only describes preferred methods and materials, any methods and materials similar or equivalent to those described
10 herein can also be used in the practice or testing of the present invention. All documents mentioned in this description are incorporated by reference, to disclose and describe methods and/or materials related to the documents. In the event of conflict with any incorporated document, the content of present description shall prevail.

15 Without departing from the scope or spirit of the present invention, various improvements and changes can be made to the specific embodiments of the present description, which is obvious to those skilled in the art. The description and examples of this application are only exemplary.

As used herein, “including”, “comprising”, “having”, “containing”, etc., are all
20 open terms, which means including but not limited to.

Regarding the “and/or” used herein, it includes any or all combinations of said things.

Hereinafter, the present invention will be further described through specific embodiments in conjunction with the accompanying drawings.

As shown in Figures 1 to 9, the present invention provides a method for forming aerospace engine nozzle parts, wherein the method includes the following steps:

Step one: cutting out a plurality of coaxial circular cone rings 3 in the sheet 1;

Step two: performing spinning correction on the circular cone rings 3 that are too large or similar in size;

The circular cone ring 3 that needs spinning correction includes the following two situations: first, the size of the circular cone ring 3 is too large, and it can be processed into an approximate circular cone ring 3 and then being spinning corrected; second, if the calculated sizes of the cone-shaped barrel shape of each segment are too close, they will interfere each other on a single sheet, and it is impossible to cut out on a single sheet, and then it is necessary to perform spinning correction on the cut circular cone rings 3. The spinning correction in the step two is a small-range, small-deformation correction process, and cold spinning or hot spinning can be used. That is, the plastic deformation of spinning can be within 40%, and it can be completed by a few locus of spinning. The spinning can be heated or not heated, the spinning wheel can be set with a proper feed speed, the spinning spindle can be set with a proper speed, and the spinning die, which fits the tire, can also be provided if necessary, according to the processing accuracy requirements.

Step three, the large-opening and small-opening ends of all the circular cone rings 3 are turned into toruses for welding with each other; the width of the torus is 25mm~30mm; for example, the width of the torus is 25mm, 26mm, 27mm, 28mm, 29mm or 30mm, the torus is used as the butt joint of the welding in the step four.

Step four: according to the order of the size of the large-opening end from small to large or from large to small, a plurality of the circular cone rings 3 are sequentially welded into a whole body 7, wherein the large-opening end of any one of the circular

cone rings in the middle is welded to the small-opening end of one adjacent circular cone ring, and the small-opening end thereof is welded to the large-opening end of another one adjacent circular cone ring.

Rigidly clamp the connecting sections of the two adjacent circular cone rings 3 with the largest size, and select the appropriate welding head rotation speed and feed speed for welding, and then install the second and third largest circular cone rings 3 in sequence and weld them, until all the sections are welded together.

In the present invention, a thick sheet 1 is wire-cut into a plurality of coaxial circular cone rings 3, and some of the circular cone rings 3 are spinning corrected, the butting surfaces of all circular cone rings 3 are processed, all circular cone rings 3 are butted together, the adjacent circular cone rings 3 are connected into a whole body 7 by means of friction stir welding, and finally the inner and outer profiles are processed by CNC lathe, thus obtain the aerospace engine nozzle parts.

In the above solution, the method further includes step five, which is to modify the inner wall and outer side wall of the whole body 7 obtained in the step four. In the step five, the size information of the nozzle parts to be processed is known, and in step five, the whole body 7 is modified according to the size information of the nozzle parts to be processed.

Before processing in the CNC lathe, a first three-dimensional data of the nozzle parts to be processed and the each point data of the nozzle parts to be processed are pre-stored in the database, the whole body 7 obtained in the step four is scanned to obtain a second three-dimensional data of the whole body 7, the first three-dimensional data is compared with the second three-dimensional data, and the specific points of the whole body 7 are processed by CNC lathe, so that the inner and

outer walls of the whole body 7 are exactly the same as the nozzle parts to be processed.

In the above solution, in the fourth step, friction stir welding, laser welding or electron beam welding is used to weld the plurality of circular cone rings 3 into a whole body 7. During the welding process, there is no need to process the material. During the process, the performance of the material will not change, and the material will not be deformed, ensuring the machining accuracy.

In the above solution, in the step three, the large-opening end and the small-opening end of the circular cone ring 3 are machined into a torus with a width of 25 mm. The torus serves as a butt joint for welding adjacent circular cone rings 3 to facilitate welding the circular cone rings 3 into the whole body 7.

In the above solution, the sheet is a copper alloy sheet, a titanium alloy sheet, a stainless steel sheet or an aluminum alloy sheet.

In the above solution, after the spinning correction in the step two, a plurality of the circular cone rings 3 are arranged coaxially according to the size of the large-opening end from small to large, and the adjacent opening ends of the two adjacent circular cone rings 3 have the same dimension.

Arrange all the circular cone rings 3 in the order of the size of the large-opening end from small to big, and the two adjacent circular cone rings 3, of which the large-opening end of one circular cone ring 3 and the small-opening end of the other circular cone ring 3 are arranged correspondingly, and the size of this large-opening end is the same as the size of the corresponding small-opening end, which is convenient for welding two adjacent circular cone rings 3.

In the above solution, before the step one, it also includes: according to the large-opening end diameter, small-opening end diameter, axial length and pipe wall

thickness of the parts to be processed, designing the number and size information of the circular cone ring 3 so that the small-opening end diameter of the circular cone ring 3 with the smallest size information is equal to the diameter of the small-opening end of this parts, the large-opening end diameter of the circular cone ring 3 with the largest size information is equal to the diameter of the large-opening end of this parts, and the axial length of the whole body 7 welded by the plurality of the circular cone ring 3 is equal to the axial length of this parts.

For example, as shown in Figure 9, a bell-shaped copper inner wall of a nozzle needs to be processed, the size information thereof is: the diameter of the large end is ϕ 800mm, the diameter of the small end is ϕ 200mm, the axial length is 600mm, and the wall thickness is 5mm. Optionally, an alloy sheet with a diameter of 830mm and a thickness of 150mm can be chose, and it is necessary to cut out 4 circular cone rings by dividing the axial length by the thickness of the plate (if not evenly divisible, the principle of further rounding is used). At the same time, the cone angles of the inner and outer contours of the circular cone ring go through a section envelope quadrilateral formed by expanding by 1mm-10mm from the inner wall of the 150mm inner nozzle toward the inner and outer sides, respectively, to obtain the inner and outer contour diameters and cone angles of each part.

In the above solution, in the step two, cold spinning is adopted to correct the circular cone ring 3. In the step two, the spinning correction area is less than or equal to 40% of the area of the circular cone ring 3. The spinning correction is to perform small-range and small-angle correction on the circular cone ring 3.

Without departing from the scope or spirit of the present invention, various improvements and changes can be made to the specific embodiments of the present

description, which is obvious to those skilled in the art. Other embodiments derived from the description of the present invention will be obvious to those skilled in the art. The description and examples of present application are only exemplary.

CLAIMS

1. A method for forming aerospace engine nozzle parts, wherein the method includes the following steps:

5 step one: cutting out a plurality of coaxial circular cone rings (3) in a sheet (1);

 step two: performing spinning correction on the circular cone rings (3) that are too large or similar in size;

 step three: large-opening and small-opening ends of all the circular cone rings (3) are turned into toruses for welding with each other; and

10 step four: according to the order of the size of a large-opening end from small to large or from large to small, a plurality of the circular cone rings (3) are sequentially welded into a whole body (7), wherein the large-opening end of any one of the circular cone rings in the middle is welded to the small-opening end of one adjacent circular cone ring, and the small-opening end thereof is welded to the large-opening
15 end of another one adjacent circular cone ring.

 2. The method for forming aerospace engine nozzle parts according to claim 1, further comprising step five, in which a size information of the nozzle parts to be processed is known, and an inner wall and an outer side wall of the whole body (7)
20 obtained in the step four are modified according to the size information of the nozzle parts to be processed.

 3. The method for forming aerospace engine nozzle parts according to claim 1, wherein, the width of the torus is 25mm~30mm.

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4. The method for forming aerospace engine nozzle parts according to claim 3, wherein, in the step three, the large-opening end and the small-opening end of the circular cone ring (3) are machined into a torus with a width of 25 mm.

5 5. The method for forming aerospace engine nozzle parts according to claim 1, wherein, in the step four, friction stir welding, laser welding or electron beam welding is used to weld the plurality of circular cone rings (3) into a whole body (7).

6. The method for forming aerospace engine nozzle parts according to claim 1,
10 wherein, the sheet is a copper alloy sheet, a titanium alloy sheet, a stainless steel sheet or an aluminum alloy sheet.

7. The method for forming aerospace engine nozzle parts according to claim 1, wherein, after the spinning correction in the step two, a plurality of the circular cone
15 rings (3) are arranged coaxially according to the size of the large-opening end from small to large, and the adjacent opening ends of the two adjacent circular cone rings (3) have the same dimension.

8. The method for forming aerospace engine nozzle parts according to claim 1,
20 further comprising: before step one, according to the large-opening end diameter, small-opening end diameter, axial length and pipe wall thickness of the parts to be processed, designing the number and size information of the circular cone ring (3) so that the small-opening end diameter of the circular cone ring (3) with the smallest size
information is equal to the diameter of the small-opening end of this parts, the
25 large-opening end diameter of the circular cone ring (3) with the largest size

information is equal to the diameter of the large-opening end of this parts, and the axial length of the whole body (7) welded by the plurality of the circular cone ring (3) is equal to the axial length of this parts.

5 9. The method for forming aerospace engine nozzle parts according to claim 1, wherein, in the step two, cold spinning is adopted to correct the circular cone ring (3).

10 10. The method for forming aerospace engine nozzle parts according to claim 1, wherein, in the step two, a spinning correction area is less than or equal to 40% of an area of the circular cone ring (3).