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The Compound Technology of Roll Forging-Die Forging of the Blower Blade

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Abstract

This paper is focused on a compound forging technology of the blower blade and the process flow in the production of the blade. It shows this compound technology is reliable and economical for the production of big blades.

Key words: roll forging, blade, technology

Rotor blade is usually made up of blade root and blade body. The shape of the blade root is simple and easy to be manufactured with general forging methods. It is more difficult to manufacture the blade body. This is because geometry and size in each axial sections of the blade body are variable. In addition, the structure of the turbine blade and blower blade is different. The profile of turbine blade is narrow and thick while wide and thin for blower blade, moreover, the torsional angle of turbine blade is larger than the one of blower, so blower blade is harder to be formed than turbine blade. Fig.1 shows the profile of the blower rotor blade made of 0Cr17Ni4Cu4Nb.

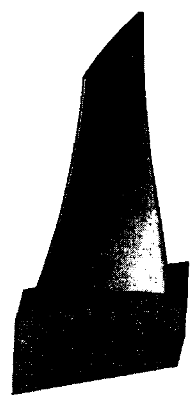

Fig.1 6020.25-1 Blade

There're several features can be found from the drawing:

1. The sections、chords and torsional angle of Blade body are variable, the thickness at the same section is unequal.
2. The sectional shapes of the blade body and blade root are different, and the area of blade root is larger than the one of blade body
3.. Blade body's air-out edge goes beyond blade root.

Because roll forging is mostly fit for stretching, rolling forging process is good for blade body forming.

In order to meet the requirement of geometric precision of the blade root and transition part between blade body and blade root the method of die forging could be adopted. The compound technology of roll forging-die forging is then used for the blade forming.

A. Design and main points of compound technology of roll forging-die forging for 6020.25-1 blower blade die

A) Forgings drawing

1. Machining Allowance

As the forge pieces must be machined in subsequent process, the machining allowance should be left to assure the required dimensional precision and technology requirement of the part. The distribution is as follows:

Blade sectional shape: 2mm in the normal direction for both inner arc and back arc. 4-6mm must be extended at air-in and air-out edge.

Blade tip: Commonly the tip of the air-out edge is hard to be filled completely and the dimensional tolerance exists on the blank, 30mm must be lengthened for the blade tip.

Blade root: In order to assure the relative position between blade root and blade body as well as enough machining allowance at blade root, there's 5mm allowance around blade root.

Blade root face: There is 15mm allowance in blade root face for drilling technique hole.

2. Technology hole

Inspection Method of forge pieces is a way to check the synthetical to lerance.

The basic method is to use vertical frame sample plate and sample plate measuring the gap of inner-back arc of the blade and the sample plate to control synthetical error of the blade. So two technique holes are need in top and down faces of the forging to fix it in the measuring tool, in addition, location reference is necessary while machined by the numerical machine tool. so three location holes should be indicated in the forging drawing. (Fig.2)

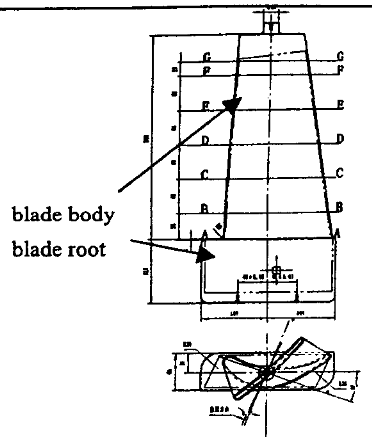

Fig.2 6020.25-1Blade forging

B) Design of wholly forging die

After the finishing roll forging of the blade, the sectional dimensions of blade body have reached the requirement. but blade root, torsion resistance and flatness of blade body, especially the geometry of transition area between blade root and sectional edge curve had not reached the requirement, therefore a wholly forging die is needed for blade root and to size the part. While sizing some deformation tolerance should be left in blade root and the transition area, the other part only need to be sized. Die parting of blade root is located on the diagonal line of the rectangle section and die parting of sectional edge curve is on the maximum value in the horizontal direction on the air- out and air-in side. In this case it is good for positioning and assuring blade stay in the die cavity while sizing. (Fig.3)

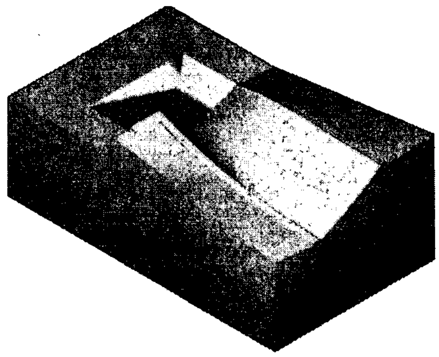

Fig.3 solid forging die of blade

C) Calculation of blank dimensions

The sectional dimensions of the blank rely on the section of the blade root. according to the calculation the round blank of diameter Φ=150mm is selected.

The volume of blank: V（0）= V（blade root）+V(blade body)

V(blade root) = 216×66× 115 = 1639440mm^3

V(blade body) =V(A-B)+V(B-C)

=V(C-D)+V(D-E)+V(E-F)+V(F-G)+V(G-H)=983290mm^3

Volume(blank) V(0)= 1639440 + 983290 = 2622730mm^3

Blank should be heated three times in the process from preforming roll forging to sizing. and there's some heating loss each time, plus flash during die forging, the volume of the blank should be increased 15%.

So blank volume: V=V(0)×(1+15%)= V(0)×(1+15%)=3016140mm^3

blank length: L=3016140/17662.5=171mm

Through experiments and considering the other factors the final length of the blank should be : L=180mm

D) Design of finishing roll forging die

Forging die usually is used to roll final geometry and dimensions (not including torsional angle) of the blade, the forging drawing is the design base of. In order to reduce axial force during the roll forging process, sectional edge curve should be set level and the torsional angle will be forged on the step of sizing.(Fig.4)

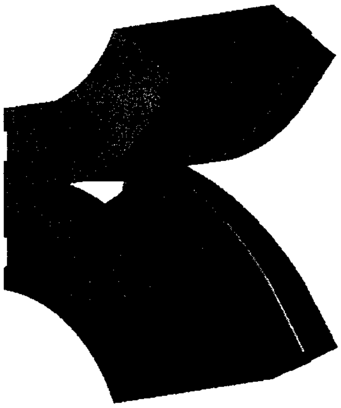

Fig4 finishing roll forging die

E) Design of preforming roll forging die, roll forging passes and forging die of blank based on the roll forging machine and friction press

Preforming roll forging and roll forging of blank usually be used to reduce sectional area of the blank and make geometry of sections approximate to finishing-forging sections, therefore it's trouble-free operation directly contribute to end forging of the blade. To calculate sectional dimensions of performing roll forging die, according to the principle of uniform depressing, deformation value selected and extension value. To calculate corresponding sectors length of preforming roll forging die according to the principle of unchanged volume. To calculate the maximum permitted deformed area according to press tonnage. It is then could determine preforming roll forging passes and the design of blank forging dies. (Fig.5)

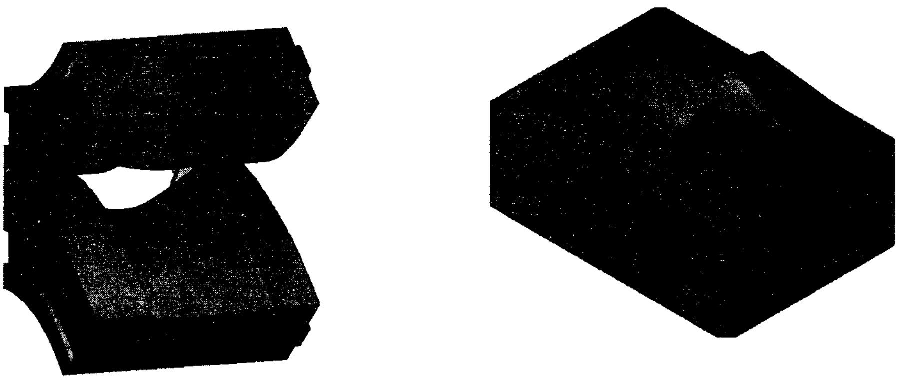

Fig.5 preforming roll forging die and forging dies of blank

F) Design of roll forging die of blank

Because of the great changes of sectional area in the blade forging die of blank, roll forging of blank is necessary in order to fill cavity completely and save material. To design the last pass roll forging die of

blank according to the length of sectional edge curves, to design frontal passes roll forging die of blank

according to proper lengthening coefficient. The process of roll forging of blank is as follows: (Fig.6)

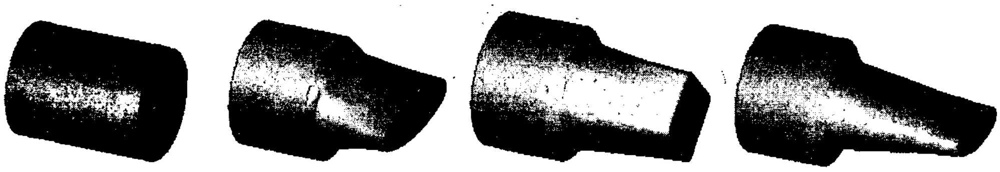

Fig.6 passes of roll forging of blank

B. Process flow of roll forging-die forging of blower blade

A) Blank preparation

Cut the blank Φ 150x180 with hacksaw, turn the two faces with lathe.

B) Roll forging and die forging of blank

Three pairs of roll forging dies of blank are assembled in the three positions of Φ 680 roll forging machine. The forging die is fixed in the die seat of 1600T frictional press. The clipping die is fixed in the clipping press. The blank is heated to a temperature of 1180℃ in the furnace and hold for 60 minutes, and take it out, and undertaken the roll forging, die forging and clipping.

The lubrication should be added onto the die and mould during the roll forging and die forging process.

C) Finishing roll forging, die forging and sizing:

Assembling two pairs of forming roll die in two positions of the roll forging machine of Φ 680, fixing the wholly forging die in the die seat of a 1600T frictional press, assembling wholly clipping die in 250T clipping press, heating the blank finished by the last step to 1180 ℃ in the furnace and hold for 60 minutes, taking out them to carry out the process of roll forging, utilizing the residual heat to process die forging of the blade root and the sizing of the blade body. Also, it is necessary to add lubrication in the cavities of the die during the process.

D) Forging heat treatment

First heat the blade cleaned after the last forging step to 1050℃ and hold for 60 minutes, sizing them with wholly forging die and then quench them with wind promptly. After quenching heat the forgings to 820℃ and hold for 30 minutes and then aging in the air to room temperature, heat them to 610℃ again, holding for five hours than cool in the air.

C. Conclusion

Compare with the traditional free forging-die forging technology, the compound technology of roll forging-die forging of the blower blade has advantages. Although one more roll forging machine should be added in this compound technology, less production conditions are required. The investment for the equipment is less. Also the equipment with less occupation space and low noises, high security is easy to operate ,in addition each forging could save valuable metal Ocr17Ni4CuNb for 5 kilograms. Therefore we could get a concept that this compound technology has significant technological and economical benefit for the production of big blower blades.