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3,741,821

PROCESSING FOR INTEGRAL GAS TURBINE DISC/BLADE COMPONENT

Filed May 10, 1971

2 Sheets-Sheet 1

FIG. 1

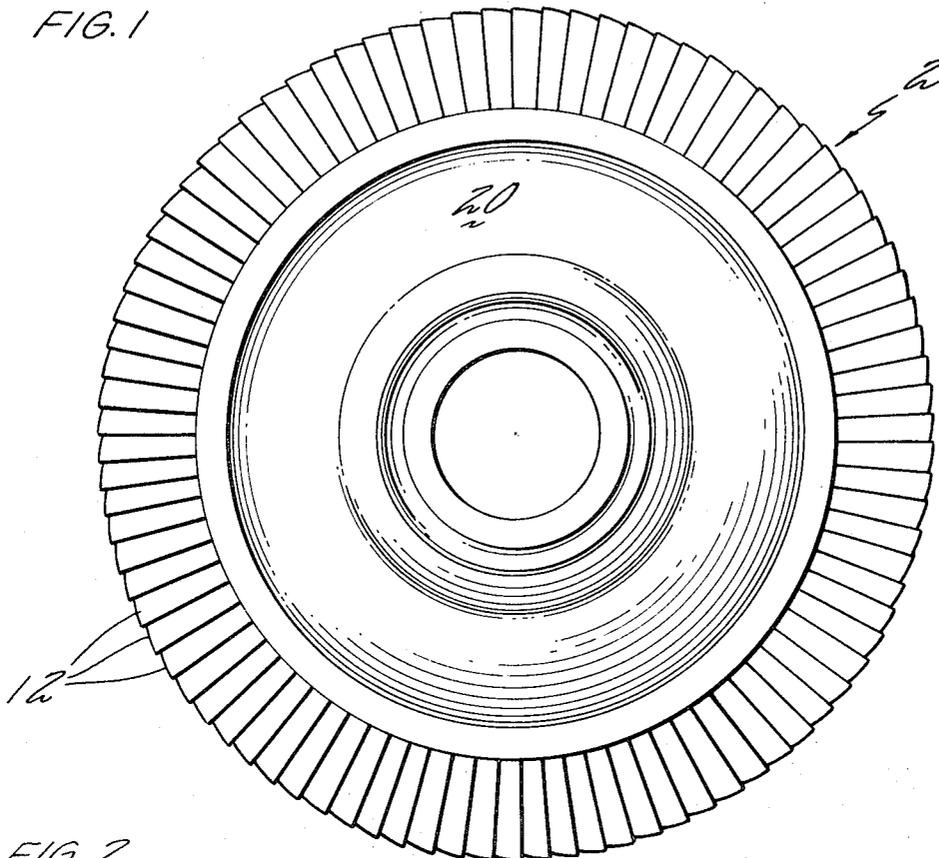


FIG. 2

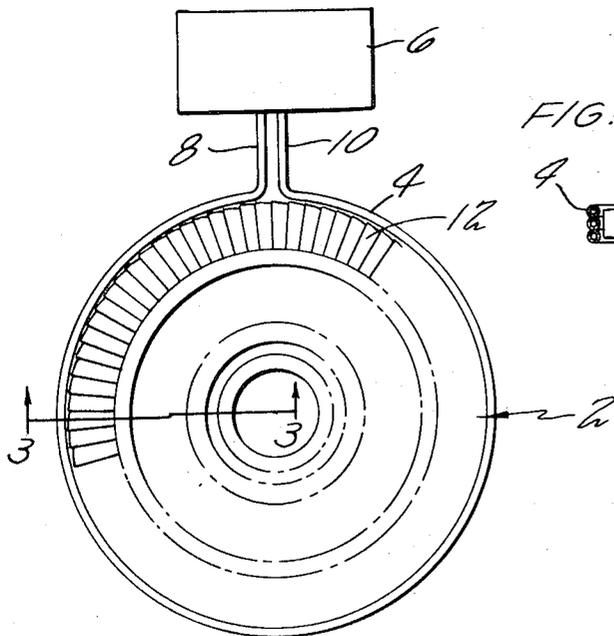
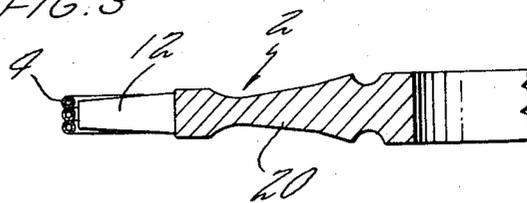


FIG. 3



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FIG. 4

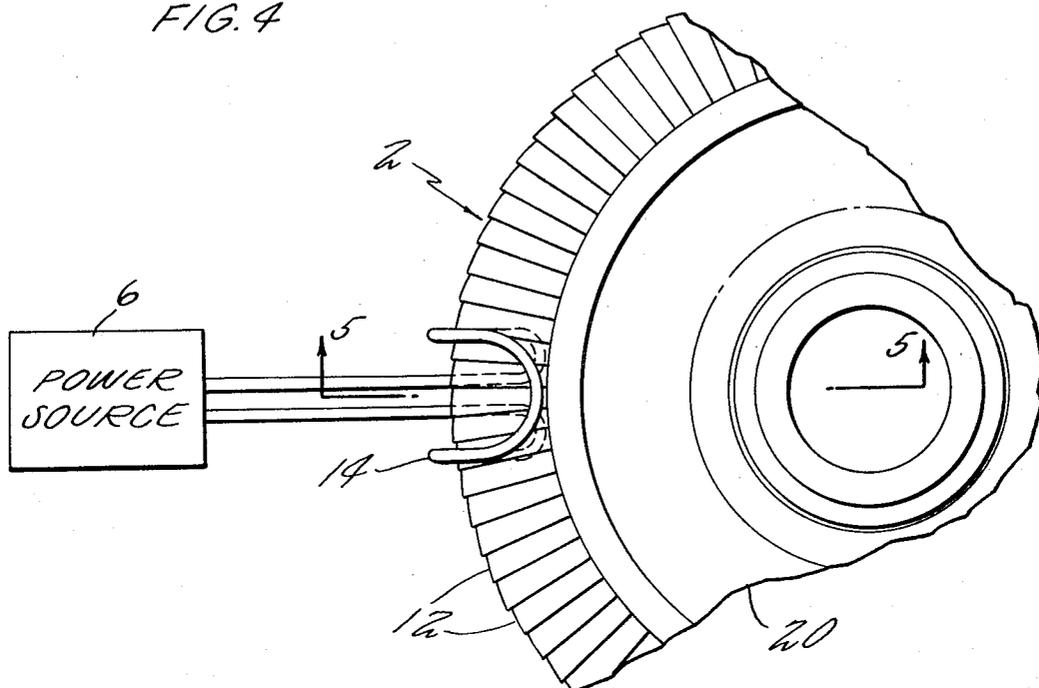
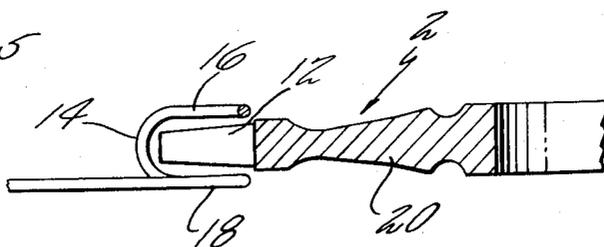


FIG. 5



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**PROCESSING FOR INTEGRAL GAS TURBINE
DISC/BLADE COMPONENT**

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4 Claims

ABSTRACT OF THE DISCLOSURE

Integral blade/disc components for gas turbine engines, formed from the high temperature age-hardenable alloys, are differentially heat treated to provide one set of primary properties at the periphery and another set of primary properties radially inward thereof.

BACKGROUND OF THE INVENTION

The present invention relates in general to the processing of age-hardenable alloy components.

In the patent to Moore et al. 3,519,503, of common assignee with the present invention, there is described a forging process for the high strength, precipitation-hardenable alloys, particularly those alloys which are difficult to forge by conventional forging techniques. Utilizing this process, it is now feasible, not only to utilize certain of the advanced alloys in applications never before achievable, but also to forge these alloys to very precise dimensions in very complex configurations. It has been demonstrated, for example, that it is possible not only to form gas turbine engine discs from the very high strength alloys, to which blades may subsequently be attached, but in addition to actually form such discs with the blading integral therewith.

In the processing, the materials being forged are, by specific thermomechanical procedures, provided in a temporary condition of low strength and high ductility, which is maintained during forging. Subsequent to the forging operation, the forging is heat treated to restore the alloy to a high strength condition.

Normally, a particular component so processed is simply heat treated prior to use to optimize the alloy microstructure for the particular set of mechanical properties desired, for example, for maximum rupture strength or creep resistance. However, in the case of some components, as for example integral disc/blade units, different properties are required in the blade and disc areas. Accordingly, differing heat treatments are required in the respective areas of such components to provide the optimum overall properties.

SUMMARY OF THE INVENTION

The present invention contemplates processing for wrought integral disc/blade components formed from the age-hardenable alloys whereby optimum mechanical properties are provided in respective areas thereof. In particular, means are provided for heat treating the blade area of such components under one set of temperature conditions and heat treating the disc area under a different set of conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a drawing of an integral disc/blade component.

FIG. 2 illustrates apparatus for selectively heating the blade area of an integral disc/blade component utilizing an induction coil peripherally surrounding the component.

FIG. 3 is a view of the apparatus of FIG. 2 taken along the line 3—3.

FIG. 4 is a view of apparatus for selectively heating the

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blade area of an integral disc/blade component utilizing a plurality of induction coils of generally U-shaped cross-section.

FIG. 5 is a view taken along line 5—5 of FIG. 4.

**DESCRIPTION OF THE PREFERRED
EMBODIMENTS**

The basic objective of the processing herein described is to develop in the blading of an integral wrought disc/blade component a relatively coarse grain size providing good high temperature rupture properties while establishing in the disc portion, usually exposed to lower temperatures than the blading, a relatively fine grain size providing high tensile strength and fatigue resistance.

A particularly advantageous nickel-base superalloy composition for use in the turbine section of a gas turbine engine is formulated as follows:

	Wt. percent
Carbon -----	0.03-0.09
Chromium -----	14-16
Cobalt -----	16-18
Molybdenum -----	4.5-5.5
Titanium -----	3.35-3.65
Aluminum -----	3.85-4.15
Boron -----	0.02-0.03
Nickel -----	Balance

This alloy is hereinafter identified as Alloy A.

The established processing for this alloy in the industry applicable to heat treatment of blading involves the following:

(a) Solution heat treatment—heat to 2125° F., hold for 4 hours, and air cool or faster, heat to 1975° F., hold 4-6 hours, and air cool;

(b) Stabilization heat treatment—heat to 1550° F., hold for 4 hours, and air cool or faster;

(c) Precipitation heat treatment—heat to 1400° F., hold for about 16 hours, and air cool or faster.

For the development of the fine grained microstructure in the disc portion of Alloy A, the following heat treatment schedule is conventionally applied:

(a) Solution heat treatment—heat to a temperature of 1975°-2075° F., hold for 4 hours, and quench in molten salt bath at 600° F., stabilize at bath temperature, and air cool.

(b) Stabilization heat treatment—heat to 1600° F., hold for 8 hours, air cool or faster; heat to 1800° F., hold for 4 hours, air cool or faster.

(c) Precipitation heat treatment—heat to 1200° F., hold for 24 hours, air cool to room temperature; heat to 1400° F., hold for 8 hours, and air cool.

The requisite differential heat treatment required for the integral disc/blade component 2 (FIG. 1) may conveniently be provided utilizing induction heating apparatus of the type shown in the drawing in one stage of solution heat treatment. Referring to FIGS. 2 and 3, the integral disc/blade component 2 is mounted for rotation within a circular induction coil 4. The induction coil is of conventional construction comprising a plurality of turns of suitable inductor such as copper closely surrounding the periphery of the component 2. As power is supplied to the induction coil from a suitable source 6 through leads 8 and 10, the blades 12 of the disc/blade component are rapidly brought to a high solution temperature. A wide variety of suitable induction heating equipment is available on the market. In the case of a component formed from Alloy A, the blades are brought to a temperature of about 2125° F.

In the apparatus shown in FIGS. 2 and 3, heating proceeds radially inward. Thus, this apparatus is most suitable for blades of short length. For components whose

blading is of longer length when the desired solution temperature cannot be attained over substantially the entire blade length utilizing the peripheral induction coil of FIG. 2, the apparatus shown in FIGS. 4 and 5 is preferred. For uniformity of heating, the component is slowly rotated within the induction coil. In the apparatus of FIGS. 4 and 5, one or more, induction heating units 14 of generally U-shaped cross-section provide the heat source for the solutioning of the blading. The legs 16 and 18 of the U-shaped (in cross-section) induction heating units are of sufficient length to essentially encompass the entire length of the blades. In the apparatus of FIGS. 4 and 5, it is of course necessary to rotate the component within the induction heating units 14 to provide uniform heating and a uniform heating sequence for each blade. Rotational speeds suitable merely to provide temperature uniformity will normally be satisfactory. Depending upon the size of the component and the character of the surrounding environment, a plurality of induction heating units may be desirable.

Utilizing the above apparatus, the processing of the integral disc/blade component is conducted to provide a high solution heat treatment and grain growth in the blade portion of the component and a lower solution treatment and finer-grained microstructure in the disc portion 20 of the component. Subsequently heat treatments for stabilization or aging correspond to that normally associated with heat treatment of the disc portion.

In connection with Alloy A, the processing according to the present invention is as follows:

(a) Solution heat treatment

(1) preferred—heat only the blade area of the disc/blade component to 2125° F.–2200° F., hold for time necessary to accomplish required grain growth and air cool or faster; heat the entire component to a temperature of about 2025° F., hold for 4 hours, and quench, preferably quenching in a molten salt bath at 600° F., and air cool; or

(2) heat the component to a temperature of 2025° F., hold for 4 hours, and quench; heat only the blade area to a temperature of 2125° F.–2200° F., hold for time necessary to accomplish blade grain growth and air cool or faster.

(b) Stabilization heat treatment—heat the entire component to 1600° F., hold for 8 hours, air cool or faster; heat to 1800° F., hold for 4 hours, air cool or faster.

(c) Precipitation heat treatment—heat the component to 1200° F., hold for 24 hours, air cool to room temperature; heat to 1400° F., hold for 8 hours, and air cool.

From the foregoing it will be seen that, in summary, the processing of the present invention contemplates, with a wrought integral disc/blade component,

(a) Subjecting the component to a differential, duplex solution heat treatment wherein the blade area is heat treated to develop good high temperature rupture properties and the disc portion is heat treated to furnish high tensile strength and good fatigue resistance. The solution heat treatment applied to the blading, wherein the coarser grain is sought, is higher than that applied to the disc portion wherein a fine grain microstructure (typically ASTM 3–4 or finer in the embodiments described) is desired. The high temperature solutioning of the blading can be affected before or after solutioning of the disc, although as a matter of production practice, it is desirable to provide the blading solution first. The lower temperature heat treatments thereafter applied to develop the desired properties in the disc also further develop the desired properties in the blading.

(b) As appropriate, suitable coatings may be applied to the component or sections thereof prior to or during a portion of the heat treatment cycle. For example, the aluminide coating referred to in the Joseph Pat. No.

3,102,044 may be applied to the solutioned blades with the requisite coating/substrate diffusion being provided by the heat treatment for the disc portion.

In the case of the alloy of the nominal composition, by weight, comprising

Carbon	-----	0.03–0.1
Chromium	-----	18–21
Cobalt	-----	12–15
Molybdenum	-----	3.5–5
Titanium	-----	2.75–3.25
Aluminum	-----	1.2–1.6
Zirconium	-----	0.05–0.12
Boron	-----	0.003–0.01
Nickel, balance.		

This alloy is hereinafter identified as Alloy B.

In connection with Alloy B, the preferred processing according to this invention is as follows:

(a) Solution heat treatment—heat the blade area of the disc/blade component to 1975° F., hold at temperature to provide the desired grain growth and air cool or faster; heat to a temperature of 1875° F., hold at temperature for 4 hours, cool at a rate equivalent to air cool or faster.

(b) Stabilization heat treatment—heat to 1550° F., hold at heat for 4 hours, and cool in air.

(c) Precipitation heat treatment—heat to 1400° F., hold at heat for 16 hours and cool in air.

Although the invention has been described in connection with certain preferred embodiments, no limitation is intended thereby. The particular process parameters employed are, of course, dependent not only upon the alloy being processed but also upon the particular objectives or applications for the component that the processor has in mind. Further, additional elements may be introduced into the process, as appropriate, including the use of protective atmospheres in certain instances.

Thus, the invention in its broader aspects is not limited to the specific details described for obvious modifications and improvements will occur to those skilled in the art without departure from the principles of the invention and without sacrificing its chief advantages.

What is claimed is:

1. The method of processing a wrought, integral disc/blade component formed from an age-hardenable alloy having physical and mechanical characteristics suitable for use in gas turbine engine applications which comprises:

solution heat treating only the blade portion of the component in the higher temperature region of the solution temperature range for a period of time efficient to provide substantial grain growth and promote high temperature creep rupture strength and solution heat treating the entire component in the lower temperature region of the solution temperature range for a time selected to minimize grain growth and promote high tensile strength and fatigue resistance in the disc portion of the component;

subsequently, stabilization heat treating the entire component at a temperature below the solution temperature of the alloy; and then, aging the component to precipitate the strengthening phases and maximize alloy strength.

2. The method of processing a wrought, integral disc/blade gas turbine engine component formed from an age-hardenable alloy having physical and mechanical characteristics suitable for use in gas turbine engine applications which comprises:

induction heating only the blade portion of the component to a temperature in the higher temperature region of the solution temperature range and holding at temperature for a period of time sufficient to provide substantial grain growth and promote high temperature creep rupture strength;

solution heat treating the entire component in the lower temperature region of the solution temperature range

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for a time selected to minimize grain growth and promote high tensile strength and fatigue resistance in the disc portion of the component;

stabilization heat treating the entire component at a temperature below the solution temperature of the alloy; and

aging the component to precipitate the strengthening phases and maximize alloy strength.

3. The method according to claim 2 wherein: the age-hardenable alloy is a nickel-base superalloy.

4. The method according to claim 2 wherein: subsequent to the induction heating of the blade portion but prior to the solution heat treating of the entire component,

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aluminizing at least the blade portion of the component, the solution heat treatment and subsequent processing providing aluminum/alloy interdiffusion and the development of a protective aluminide coating.

References Cited

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10 RICHARD O. DEAN, Primary Examiner

U.S. Cl. X.R.

148—31.5, 32.5, 39, 142, 162