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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/117,166	05/27/2011	Igor Tsypkaykin	1033275-000880	7019

117185 7590 09/22/2016
ALSTOM TECHNOLOGY, LTD.
Studio Torta
C/O Buchanan Ingersoll & Rooney PC
1737 King Street, Suite 500
Alexandria, VA 22314

EXAMINER	
HANN, JAY B	

ART UNIT	PAPER NUMBER
2123	

NOTIFICATION DATE	DELIVERY MODE
09/22/2016	ELECTRONIC

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte IGOR T. TSYPKAYKIN and ANDRE M. SAXER

Appeal 2015-006898
Application 13/117,166
Technology Center 2100

Before ERIC B. CHEN, JEREMY J. CURCURI, and
GREGG I. ANDERSON, *Administrative Patent Judges*.

ANDERSON, *Administrative Patent Judge*.

DECISION ON APPEAL

Appellants appeal under 35 U.S.C. § 134(a) from the Examiner's rejection of claims 1, 3, and 5.[1] Claims 2 and 4 were cancelled previously. We have jurisdiction under 35 U.S.C. § 6(b).

We affirm.

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[1] In this Opinion, we refer to the Appeal Brief ("App. Br.," filed February 2, 2015), the Reply Brief ("Reply Br.," filed July 15, 2015), the Final Office Action ("Final Act.," mailed May 29, 2014), and the Examiner's Answer ("Ans.," mailed May 15, 2015), and the original Specification ("Spec.," filed May 27, 2011).

STATEMENT OF THE CASE

A. The Invention

Appellants' invention relates gas turbine blades and the surrounding shroud. Spec. ¶ 2. Specifically, Appellants disclose a method for producing a turbine blade that optimizes the contact surfaces between the interlocking surfaces of the abutting shroud segments of adjacent blades of a rotor blade row. *Id.* at ¶ 7. The narrowly delimited contact surfaces with high pressure stresses can be reliably avoided without forfeiting the necessary sealing tightness between the adjacent shroud segments. *Id.*

More specifically, the invention takes into account deformation of the blade attached to the shroud resulting from operation induced loads, including pressure variations between shroud segments. Spec. ¶ 15. The loads of interlocking adjacent shroud surfaces in an unloaded state does not take deformation into account. *Id.* Design of the blades according to the invention maintains contact over a large area between the adjacent interlocked shroud segments in the loaded state. *Id.*

Independent claim 1, reproduced below, is illustrative:

> 1. A method for optimizing the contact surfaces of abutting shroud segments of adjacent blades of a rotor blade row of a gas turbine, the method comprising the steps of:
>
> a) providing a 3-D model of an individual blade, the individual blade including a shroud segment delimited in a circumferential direction by contact surfaces including an interlocking surface and wedge surfaces disposed on each side of the interlocking surface, the interlocking surface and wedge surfaces being arranged in a zig-zag manner;
>
> b) calculating a geometry of the individual blade based on the 3-D model using a computer, the calculating including consideration of centrifugal forces, temperature stresses,

pressure loads experienced in a loaded state of the blade during operation, material used for the blade, blade wall thicknesses, blade length, blade shape and operating location of the individual blade in combination with adjacent blades;

c) optimizing the contact surfaces within the 3-D model, including the interlocking surface and wedge surfaces, of the abutting shroud segments of adjacent blades in the loaded state of the blade such that the optimized adjacent respective interlocking surfaces and wedge surfaces are substantially parallel and so as to avoid an increase in contact pressure between the respective contact surfaces as a result of ensuing operating temperature of the blades;

d) determining a geometry of the interlocking surfaces and of the wedge surfaces in an unloaded state corresponding to the optimized contact surfaces in the loaded state of the blade within the 3-D model; and

e) producing a blade for a rotor blade row of a gas turbine according to the determined geometry.

B. The Rejections

Claims 1, 3, and 5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Boegli et al (US 2007/0231143 A1, published Oct. 4, 2007); Durcan (US Patent 6,223,524, issued May 1, 2001); and Paquet et al (US 2005/0079058 A1, published Apr. 14, 2005). Final Act. 4–17.

C. Issue

Only those arguments actually made by Appellants in the Briefs have been considered in this Decision. Arguments that Appellants did not make in the Briefs are waived. *See* 37 C.F.R. § 41.37(c)(1)(iv)(2012).

Appellants' arguments present the following issue:

Has the Examiner erred by finding that the combination of Boegli, Durcan, and Paquet teaches or reasonably suggests "optimizing the contact surfaces within the 3-D model . . . of the abutting shroud segments of adjacent blades in the loaded state of the blade such that the optimized adjacent respective interlocking surfaces and wedge surfaces are substantially parallel," as recited in claim 1 under 35 U.S.C. § 103? App. Br. 6–11.

ANALYSIS

Independent claim 1, reproduced above, is a method claim including steps a, b, c, d, and e. Appellants contest only step c of claim 1. App. Br. 6–11, *see also* Reply Br. 2 ("The arguments in Appellants' Appeal Brief regarding the contacts surfaces are primarily directed to pointing out that the Boegli publication relates to an optimization of the relation of the contact surfaces to other contact surfaces and not to optimization of the contact surfaces themselves.").

A. Overview of Prior Art

The Examiner finds Boegli teaches adjusting the gaps, i.e., "contact surfaces," between adjacent shroud segments of blades in a turbomachine. Final Act. 4 (citing Boegli ¶ 3). The Examiner also cites to Boegli's teaching that the gaps are reduced during operation. *Id.* (citing Boegli ¶ 11). The Examiner quotes from Boegli that "the shroud elements of the blades are thus adjacent to one another and thus form a shroud which is closed on the circumference" (Boegli ¶ 3) and thus "delimited in a circumferential direction," as recited in claim 1. *Id.*

The Examiner cites to Durcan which, in the context of turbine blades, teaches:

> [U]sually the blade geometry and disk geometry are complex with non-uniform stress and temperature distributions. A Finite Element Model (FEM) and Finite Element Analysis (FEA) are often used to determine the blade and disk stress distributions,

> temperature distributions, and blade tip radial deflection at various operating conditions.

Final Act. 4–5 (quoting Durcan 6:54–60). The Examiner asserts that "[a] Finite Element Model of a blade is a 3D model." *Id.* at 5. Appellants do not contest this finding by the Examiner.

Paquet is concerned with "determining a desired shroud design for a given turbine blade design." Paquet ¶ 10. Paquet's Figures 2 and 3 show contact faces of a turbine blade shroud arranged in a zigzag pattern. *Id.* ¶ 21, Figs. 2, 3. The Examiner relies on the preceding disclosures of Paquet to show "the interlocking surface and wedge surfaces being arranged in a zigzag manner," as recited in claim 1.

B. Optimizing the Contact Surfaces

As set forth above, the issue here is the "optimizing the contact surfaces" limitation, step c of claim 1. Boegli teaches "[a]n *inclination angle* of 0° means that the platform[2] section which is arranged at an inclination angle abuts against the platform section of the adjacent blade without any step being formed." Boegli ¶ 24 (emphasis added). The Examiner relies on this disclosure in Boegli to contend "[t]he inclination angle and the platform sections are interlocking surfaces because they abut." Final Act. 7.

Boegli further describes an additional inclination angle α "chosen such that an effective *additional inclination angle* α-eff of more than 0° is produced *during operation* of the blade." Boegli ¶ 59, lines 5–9 (emphasis added). The Examiner contends that "during operation" is in the loaded

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[2] Boegli describes the shroud elements as "platforms." *See* Boegli ¶ 3 ("The shroud elements are generally in the form of platforms and extend essentially at right angles to the blade longitudinal direction.")

state. Final Act. 7. The Examiner cites to the Durcan disclosure of the 3D model. *Id.*

Step c further recites "and so as to avoid an increase in contact pressure between the respective contact surfaces as a result of ensuing operating temperature of the blades." Boegli teaches that "the shrouds, particularly for turbine stages, are often additionally subject to very high temperature from the main flow." Boegli ¶ 7, lines 1–3. The Examiner finds that temperature during operation is expressly considered. Final Act. 8. The Examiner notes that Boegli "does not explicitly disclose optimizing or adapting to avoid contact pressure as a result of operating temperature" but relies on the following disclosure from Durcan:

> Preferably, the ring 30 is sized so that the amount of interfering contact between the ring 30 and the blade tip 25 is at a maximum at assembly and near an acceptable minimum during operation. A ring 30 having minimum interfering contact during operation will also have a total stress which is at a minimum, thereby providing a ring 30 which maximizes its low cycle fatigue life.

Final Act. 8 (quoting Durcan, 6:12–32).

The Examiner finds Boegli considers that temperature during operation is expressly considered, i.e., "the shrouds . . . are often additionally subject to very high temperatures." Final Act. 8 (citing Boegli ¶ 7). The Examiner finds the person of ordinary skill in the art would have been motivate to "minimiz[e] interfering contact and total stress during operation into the system of designing a turbine blade with a shroud for the purpose of maximizing low cycle fatigue life." *Id.* (citing Durcan, 6:12–32).

Appellants acknowledge Boegli's additional inclination angle, α, "relates to an optimization of the relation of shroud elements to other shroud elements." App. Br. 6–8. However, Appellants contend "[t]he Boegli publication does not specifically disclose contact surfaces." *Id.*; *see also* Reply Br. 2 (Boegli "is not concerned with the optimization of the contact surfaces themselves."). Optimization of the inclination angle is not optimizing the surface geometry, as per claim 1. Reply Br. 3. The gap between shrouds, according to Appellants, is not completely closed in Boegli. App. Br. 7–8 (citing Boegli ¶ 59, Fig. 3b).

Appellants argue Durcan discloses a "continuous shroud ring and not a segmented shroud ring." App. Br. 9–10 (citing Durcan, Fig. 3). As a result, Durcan's ring is "self-supporting and is not arranged on the blade tips." *Id.* at 9 (citing Durcan 5:40 *et seq.*); Reply Br. 3. Further, Appellants argue, Durcan's Finite Element analysis "determine[s] the blade and disk stress distributions, temperature distributions, and blade tip radial deflection at various operating conditions" and not "to optimize contact surfaces of abutting shroud segments." App. Br. 10; Reply Br. 4.

Appellants acknowledge Paquet's shroud is designed with a constant thickness "[t]o achieve a desired level of contact stress." App. Br. 10–11. Appellants also note "the thickness of one or both contact faces '40' increases to increase the contact area and reduce the contact stress accordingly." *Id.* (citing Paquet, Fig. 4).

We agree with the Examiner that abutting adjacent shrouds results in a contact surface. *See* Ans. 2. The Examiner relies on that portion of Boegli which discloses that platform sections abut each other. *Id.* (citing Boegli ¶ 24). The fact that Boegli's Figure 3b shows there is a gap between shrouds is of no avail to Appellants. Boegli's Figures 3a and 3b illustrate how α ("a" in Fig. 3a) is designed so that during operation it is reduced to α-eff ("a-eff" in Fig. 3b). The written description in paragraph 59 of Boegli, which is relied on by the Examiner, states that during operation the "effective inclination angle α-eff" is 0°. Boegli ¶ 59; *see also* Boegli ¶ 60 ("The centrifugal force bending which acts on the pressure-side platform section admittedly reduces the offset α to an effective offset α-eff, although *it does not initially return to zero*." (emphasis added)).

The Examiner concludes a person having ordinary skill in the art at the time of the invention would have been motivated to combine Durcan and Boegli. The finite element modeling taught by Durcan would have been used in the "designing a turbine blade with a shroud for the purpose of 'determin[ing] the blade and disk stress distributions, temperature distributions, and blade tip radial deflection at various operating conditions.'" Ans. 5 (citing Durcan 6:58–60). The motive for the combination is rationally based and is not specifically contested by Appellants. Accordingly, Appellants' argument that Durcan does not specifically relate to designing contact surfaces is not persuasive.

Appellants' arguments relating to Paquet are not relevant to the finding of the Examiner regarding "optimizing the contact surfaces." Paquet shows, and Appellants do not dispute, "the interlocking surface and wedge surfaces being arranged in a zig-zag manner" of claim 1. *See* Final Act. 5 (citing Paquet, Figs. 2, 3).

We sustain the Examiner's rejection of claim 1.

C. Claims 3 and 5

Appellants make no additional arguments relating to claims 3 and 5, contending they are patentable for reasons similar to those discussed in connection with claim 1. App. Br. 11; Reply Br. 4–5.

We therefore sustain the Examiner's rejection of claims 3 and 5.

CONCLUSION

The Examiner did not err in rejecting claims 1, 3, and 5 under § 103.

DECISION

The Examiner's decision rejecting claims 1, 3, and 5 is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED