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Language of the proceedings: EN

Title of invention:
RADIAL TURBINE ROTOR BLADE

Patent Proprietor:
Mitsubishi Heavy Industries, Ltd.

Opponent:
BMTS Technology GmbH & Co. KG

Headword:

Relevant legal provisions:
EPC Art. 100(a), 54(2)

Keyword:
Novelty - (no)

Decisions cited:

Catchword:

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Case Number: T 1724/20 - 3.2.04

D E C I S I O N
of Technical Board of Appeal 3.2.04
of 11 November 2022

Appellant: (Patent Proprietor)	Mitsubishi Heavy Industries, Ltd. 16-5, Konan 2-chome Minato-ku Tokyo 108-8215 (JP)
Representative:	Mader, Joachim Bardehle Pagenberg Partnerschaft mbB Patentanwälte, Rechtsanwälte Prinzregentenplatz 7 81675 München (DE)
Respondent: (Opponent)	BMTS Technology GmbH & Co. KG Löwentorstrasse 68 70376 Stuttgart (DE)
Representative:	Herrmann, Jochen Herrmann Patentanwälte Königstrasse 30 70173 Stuttgart (DE)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 16 June 2020 concerning maintenance of the European Patent No. 2940271 in amended form.**

Composition of the Board:

Chairman	A. de Vries
Members:	G. Martin Gonzalez
	C. Heath

Summary of Facts and Submissions

I. The appeal was filed by the appellant (proprietor) against the interlocutory decision of the opposition division to maintain the patent in amended form.

The division held that the main request and auxiliary requests 1-2 lacked novelty over D1, and that auxiliary request 3 was unclear. It maintained the patent according to auxiliary request 4 before it.

II. In preparation for oral proceedings the Board issued a communication setting out its provisional opinion on the relevant issues.

Oral proceedings were held before the Board on 11 November 2022.

III. The appellant proprietor requests to set aside the decision under appeal and to maintain the patent as granted (main request), or auxiliarily to maintain the patent according to one of auxiliary requests 1-5 filed with the grounds of appeal on 26 October 2020, where auxiliary requests 1-3 correspond to the identically numbered requests before the opposition division, while auxiliary request 5 corresponds to the upheld claims.

The respondent opponent requests dismissal of the appeal.

IV. Independent claim 1 of the requests relevant for this appeal reads as follows:

(a) Main request

"A radial turbine blade (50; 60; 80; 90) configured to drivingly rotate a turbine rotor (13) with working gas flowing in a radial direction from a spiral scroll (7) formed in a turbine casing (5) to the turbine blade (50; 60; 80; 90) of the turbine rotor (13) positioned on an inner side of the scroll (7) to act on the turbine blade (50; 60; 80; 90) and then flowing out in an axial direction, comprising a variable nozzle mechanism (27) in which a plurality of nozzle vanes (25) are disposed at an equal interval along a circumferential direction of a turbine (1) on an inner circumference side of the scroll (7), and a blade angle of the nozzle vanes (25) is changed, wherein the turbine rotor (13) includes a hub (17) fixed to an end portion of a rotor shaft (15) and a plurality of the turbine blades (50, 60, 80, 90) fixedly adhering to an outer circumference of the hub (17) at an equal interval in a circumferential direction, and wherein a hub-side end portion (Pa) at a leading edge (51; 61; 81; 91) of the turbine blade (50; 60; 80; 90) and on a surface of the hub (17) is formed to be positioned more on a rear side in a rotation direction of the turbine blade (50; 60; 80; 90) than a shroud-side end portion (Sa, Sc) at the leading edge (51; 61; 81; 91), characterized in that a straight line, connecting between the shroud-side end portion (Sa, Sc) and the hub-side end portion (Pa), is inclined with respect to a straight line, extending in a rotation axis direction from the shroud-side end portion (Sa, Sc) at the leading edge (51; 61; 81; 91) onto the surface of the hub (17), by an angle (E) in a range from 30° to 70° in a radial direction view of the turbine blade (50; 60; 80; 90)."

(b) Auxiliary request 1

Claim 1 as in the main request amended to specify a new angle E range of 40° to 60° as follows (emphasis by the Board to indicate modified text):

"..., by an angle (E) in a range from ~~30~~40° to ~~70~~60° in a radial direction view of the turbine blade (50; 60; 80; 90)."

(c) Auxiliary request 2

Claim 1 as in the main request with the following added features (emphasis by the Board to indicate modified text):

"...the turbine rotor (13) includes a hub (17) fixed to an end portion of a rotor shaft (15) and a plurality of the turbine blades (50, 60, 80, 90) fixedly adhering to an outer circumference of the hub (17) at an equal interval in a circumferential direction, and
wherein
the turbine blade (50: 60: 80: 90) includes:
a leading edge (51; 61; 81; 91) on a side from which the working gas flows in;
a trailing edge (53) that guides the working gas that has passed through a space between the turbine blades (50; 60; 80; 90) to be discharged in the axial direction to reach a gas outlet (9); and
an outer circumference edge portion (55) which is adjacent to and rotates along an inner circumference of a shroud portion of the turbine casing (5), and wherein
a hub-side end portion (Pa) at ~~a~~the leading edge (51; 61; 81; 91) of the turbine blade (50; 60; 80; 90) and on a surface of the hub (17) is formed to be positioned more on a rear side in a rotation direction

of the turbine blade (50; 60; 80; 90) than a shroud-side end portion (Sa, Sc) at the leading edge (51; 61; 81; 91), characterized in that..."

(d) Auxiliary request 3

Claim 1 as in auxiliary request 2 amended to clarify that the circumference edge portion is a free edge portion as follows (emphasis by the Board to indicate modified text):

"... an outer circumference edge portion (55) which is adjacent to and rotates along an inner circumference of a shroud portion of the turbine casing (5), wherein the outer circumference edge portion (55) forms a free edge portion, and wherein..."

(e) Auxiliary request 4

Claim 1 as in auxiliary request 3 amended to specify that the free edge portion is a cover-free edge portion as follows (emphasis by the Board to indicate modified text):

"... an outer circumference edge portion (55) which is adjacent to and rotates along an inner circumference of a shroud portion of the turbine casing (5), wherein the outer circumference edge portion (55) forms a cover-free edge portion, and wherein..."

V. In the present decision, reference is made to the following document:

D1 DE 101 21 390 A1

VI. The appellant's arguments can be summarised as follows:

Claim 1 of all requests is new over the cited documents.

VII. The respondent's arguments can be summarised as follows:

Claim 1 of the main and auxiliary requests 1 to 4 lacks novelty over D1.

Reasons for the Decision

1. The appeal is admissible.

2. Background.

The invention relates to a radial turbine blade that is used in a variable geometry exhaust turbocharger of an internal combustion engine, see patent specification paragraph [0001], [0005]-[0011]. The claimed blade geometry seeks to improve the turbine efficiency during throttling of the variable geometry turbocharger. During throttle a flow rate entering the turbine rotor is reduced and a flow velocity is increased, which may cause loss due to impact of inflowing gas at the leading edge of the turbine. Inclining the leading edge of the turbine blade at an angle E (see figure 1) reduces the impact loss of inflowing gas and thus increases turbine efficiency, see paragraph [0022]. An inclination angle E in a range from 30° to 70°, preferably in a range from 40° to 60°, achieves this effect, see paragraphs [0025]-[0028].

3. Main request - Novelty.

3.1 The appellant contests the opposition division's finding of lack of novelty over D1 for claim 1 of the main request, see section 3 of the impugned decision.

3.2 It is not disputed that document D1 discloses a radial turbine blade 6 that is used in an exhaust gas turbocharger (paragraph [0023]; figures 1-2) comprising a scroll casing 2 and a variable nozzle mechanism 15 with a plurality of variable guide vanes upstream of a turbine rotor wheel 3 with turbine blades 6 fixedly adhered to a hub 5. It is also undisputed that the known rotor blade 6 has a leading edge 9 extending between a hub-side end 14 and a shroud-side end 7. The leading edge 9 of the blades is curved such that said hub-side end portion of the leading edge 9 is arranged more on a rear side in a rotation direction than a shroud-side end portion of the leading edge 9.

3.3 The only feature that is in dispute is that of an angle E, as required by claim 1, in a range from 30° to 70° degrees. The appellant argues that D1 does not anticipate this feature.

3.4 It is generally agreed that angle E as defined in claim 1 is the angle between the (direction of the) rotor's rotation axis and *a line connecting the* two leading edge ends (the shroud-side and base-side ends, points referred as Sa and Pa in figure 1 of the contested patent). Angle E therefore represents a measure of the rotor blade's leading edge inclination vis-a-vis the axis of rotation. According to the claim this angle lies between 30° and 70°.

3.5 D1 is concerned with the very same problem of reducing the impact of flow on the turbine blades and likewise proposes inclining the turbine appropriately, see paragraph [0037]. However, it describes the inclination of the geometry of the leading edge in a different way using angle **γ**, described as the tangential angle of the leading edge 9 at its hub-side end with respect to the plane of hub base ("Rückwand") 14 corresponding to the hub 17 of the patent (see figure 1), cf. D1 paragraph [0037] and figure 4. According to D1, paragraph [0037], inclination angle **γ** must be *smaller than 50° (i.e. 0° to 50°).*

As is evident in the side view of figure 4 **γ** is the complement of inclination angle taken with respect to the axis of rotation: **α = 90° - γ**, so that the range **γ** *smaller than 50°* corresponds to a range of angles **α** with respect to the rotation angle *greater than 40° (40° to 90°)* as also recognized by the appellant proprietor (statement of grounds, p.13, last line) which would overlap with the claimed range.

3.6 The appellant proprietor argues that because the leading edge in D2 is curved (column 3, line 4, see also figure 4), angles **α** (tangent) and **E** (line segment connecting ends) are not the same, not even approximately. Nor is this proven by the formula in paragraph [0037] as it is incorrect. Therefore the corresponding value of **E** cannot be established *without a doubt*, i.e. there is no direct and unambiguous disclosure of a value within the claimed range.

3.6.1 The Board is unconvinced. Firstly, as is evident from figure 4, curvature of the leading edge is only slight and any differences will be small. That figure may be schematic in nature, but curvature of the leading edge

is purposefully drawn much smaller than say the middle section of the blade (under the shroud). Thus, the two angles will be the same by a small margin.

3.6.2 This also follows from the formula in paragraph [0037] which the Board, contrary to the appellant-proprietor's view, holds to be correct. This formula relates the angle φ defined as the blade's inlet angular width ("Winkel φ, der in axialer Richtung gesehen die Winkelbreite jeder Turbinenschaufel im Bereich des Radeintritts angibt") to the tangent angle **γ** by the expression **φ = x * cos(γ) / r.**

This is the angle subtended by the leading edge 9 of the blade in the plane of the hub along the periphery of the turbine, as is apparent from figure 3, which is a view of the turbine from above (perpendicular to its axis of rotation). Thus it corresponds to the projection of the leading edge in the axial direction ("in axialer Richtung") onto the hub plane. This describes an arc segment along the periphery of the turbine; its ratio to the turbine radius **r** expresses the angle in radians (the result would be 2π if the arc segment extended around the entire periphery) and is thus indeed dimensionless. This is therefore not proof of an error in the formula as argued by the appellant proprietor.

As will be evident from straightforward mathematical considerations, the formula above is approximative as it approximates the projection of the leading edge using the simple trigonometric expression **x * cos(γ).** That expression applies for the projection of a *vector* of length **x** oriented at angle **γ** with respect to a reference plane onto that plane, here the hub plane. Here **x** is meant to represent the length of what is in

fact a *curved* edge and can therefore only be approximate, as also expressly recognized in the last sentence of paragraph [0037]. Similarly, **γ** the tangent angle at the hub base can only be approximative for a curved edge (if the leading edge were straight and its tangent angle thus represented the entire edge the expression would be exact). From straightforward mathematical considerations the expression is furthermore only an approximation to the extent that deviations are small, for example that the curvature of the edge is small. In the normal mathematical understanding of the skilled person, this means that deviations from the ideal (straight line) are within a small margin, in the order of only several percent for length and angle. This translates into several degrees for **γ** and thus also **α**. Consequently, **α** corresponds to **E** with an error margin of several degrees. Therefore, the requirement in D1 that **γ** is smaller than 50° vis-a-vis the hub base is seen to correspond with a value of **E** greater than 40° ± several degrees. For the curve as shown in figure 4 the line segment will always be inclined slightly *closer* to the axis of rotation, that is the lower limit will be several degrees less than 40° based on this error margin. Whatever the case, there is no doubt that the resultant range above this value not only includes a value within the claimed range but overlaps considerably with it.

3.7 Since as explained above the remaining claimed features are also disclosed by D1, the Board holds that the opposition division correctly concluded that granted claim 1 lacks novelty, Article 54(2) EPC.

4. Auxiliary request 1 - Novelty

4.1 As put forward by the Board in its preliminary written opinion, the amended range of E between 40° and 60° of auxiliary request 1 is not sufficiently far removed from the specific example of D1 of 40° and it is thus also not novel, see also impugned decision section 4. This is so considering also an error margin of several degrees and considering that the value of 40° represents only the lower limit of a much wider range. Clearly here also the claimed range overlaps with that inferred from D1.

4.2 The appellant refrained from further comment as regards this request. The Board sees otherwise no reason to modify its preliminary opinion and concludes that claim 1 lacks novelty over D1.

4.3 Auxiliary requests 2-4 - Novelty

4.4 The amendments in auxiliary requests 2-4 do not establish novelty over D1.

4.5 Claim 1, in all requests, defines a blade's leading edge and a blade's trailing edge at the inlet and the outlet areas. These are also described in D1, see figure 2 leading edge 9 and trailing edge 10. They further require that the turbine blade includes (between leading and trailing edges) an outer circumference edge portion rotating adjacently to the turbine casing shroud.

Auxiliary requests 3 and 4 further clarify that the outer circumference edge portion is a free edge portion or a cover-free edge portion, respectively.

4.6 While D1's rotor blades have a cover ring or shroud 7 in the curved portion of the blade edge between the leading and trailing edges area, see paragraph [0024] and figure 2, it also discloses embodiments where the cover ring 7 extends only over part of the blade edge between inlet and outlet, see paragraph [0025]. In these cases, the rotor blade of D1 necessarily then comprises outer circumference edge portions without cover ring. They are thus edge portions rotating adjacently to the turbine casing acting as shroud as required by the claim. Since they are not covered by the ring 7, they also meet the further limitations of auxiliary requests 3 and 4 to be a "free edge portion" or a "cover-free edge portion".

4.7 The Board is not convinced by the appellant's argument that the wording of claim 1 requires that the circumference edge portion extending between leading and trailing edges of the blade is free or cover free along its entire length. As worded, it merely requires that the turbine blade "includes" a leading edge, a trailing edge and an outer circumference edge portion that can be free or cover free. The term *includes* in its normal meaning does not imply an exhaustive list of parts or portions. The present formulation therefore does not exclude that the claimed blade can include other circumference edge portions, for example ones that might not be free or cover free. The term *portion* itself also indicates that it only defines a part of the whole and therefore also encompasses the possible presence of other portions with different features. In conclusion, the wording of claim 1 does not exclude blades with an additional non-free or covered outer circumference edge portion. Thus, the embodiments of D1 where ring 7 partially covers the blade edge deprives

claim 1 of auxiliary requests 2-4 of novelty, since they include an outer circumference edge portion that is free or cover free adjacent the turbine casing.

4.8 The Board thus concludes that claim 1 of auxiliary requests 2 through 4 also lack novelty over D1.

5. Auxiliary request 5 corresponds to the patent as upheld by the division and is not open to examination in the present appeal in view of the principle of prohibition of reformatio in peius. As all other appellant's requests fail, the Board upholds the opposition division's decision.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

G. Magouliotis A. de Vries

Decision electronically authenticated