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(54) FASTENING ASSEMBLY FOR BLADES OF TURBOMACHINES HAVING AXIAL FLOW AND METHOD FOR PRODUCING SUCH AN ASSEMBLY

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(57) ABSTRACT

A fastening assembly for blades of turbomachines through which axial flow can take place, preferably compressors, includes a blade carrier having a lateral face, in which retaining groves are distributed along the circumference, with blades being inserted in the grooves, wherein a resilient tensioning element is provided between each groove base and the underside of the respective blade foot, the underside being located opposite of the groove base. The tensioning element is supported on the respective underside and on the respective groove base in a pretensioning manner, wherein a channel is provided both in the groove base and in the underside, with the tensioning element resting in the channels.

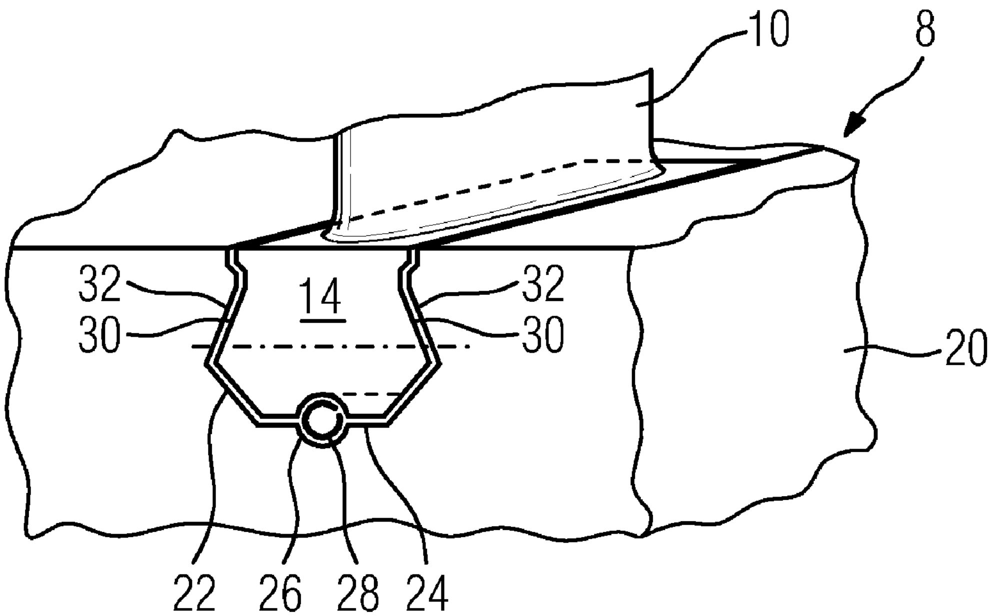


FIG 1

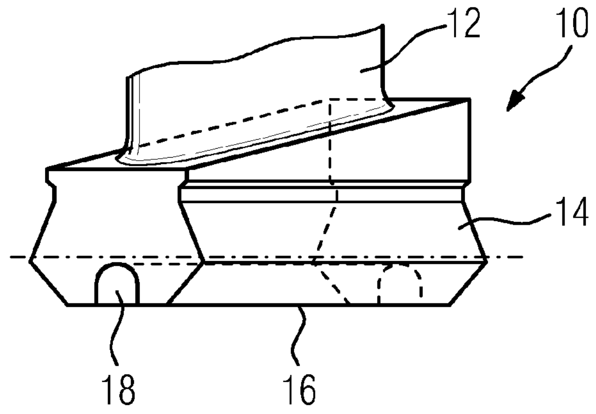


FIG 2

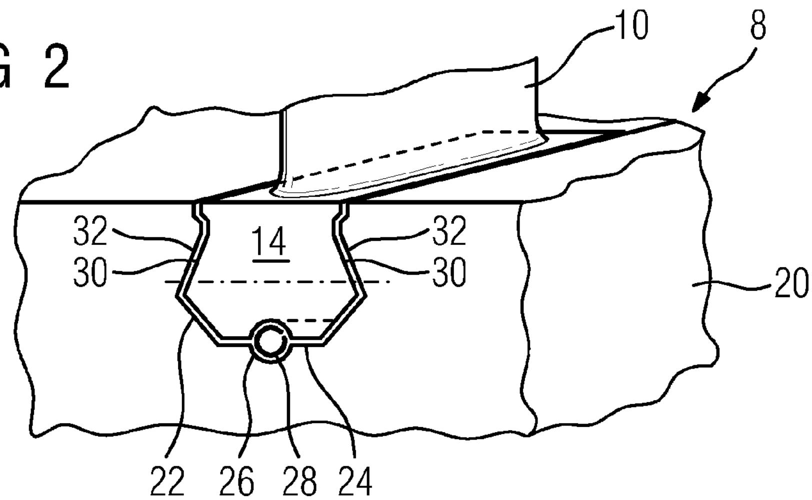


FIG 3

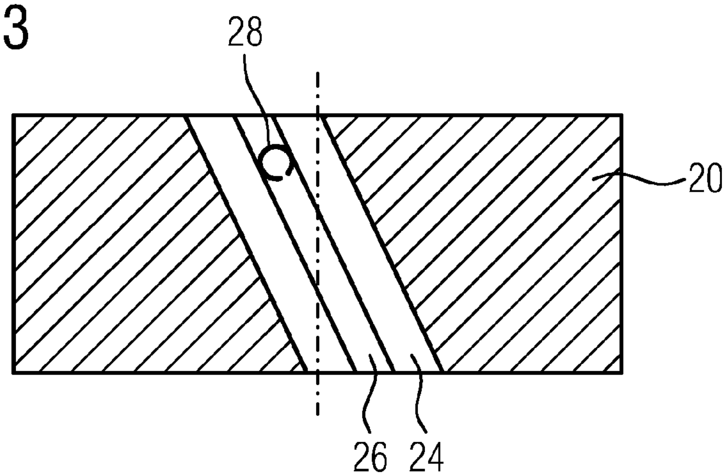


FIG 4

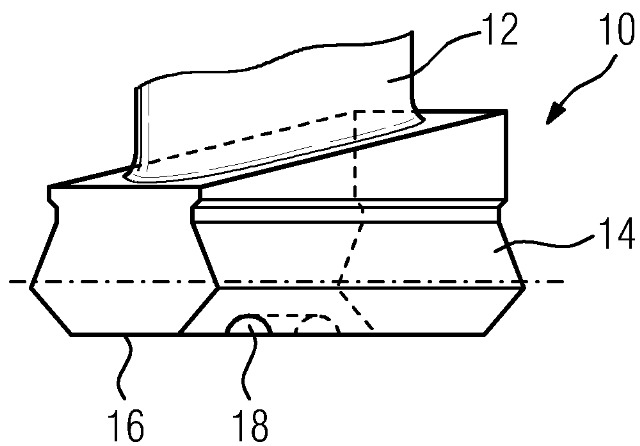
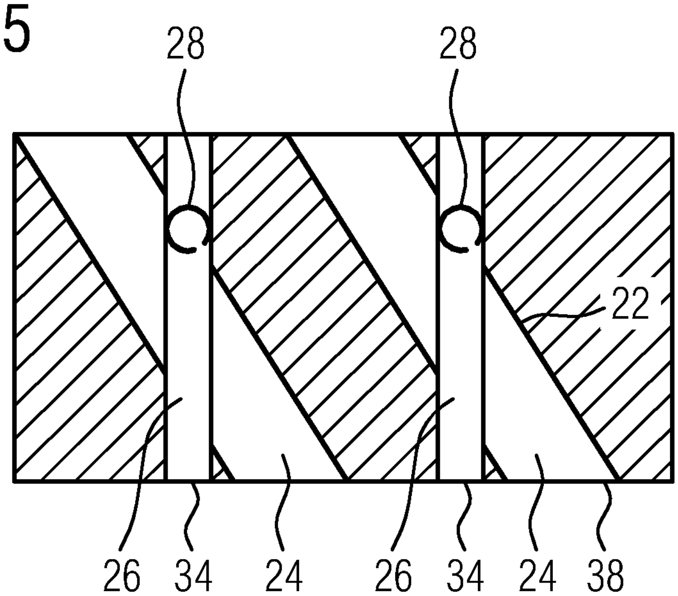


FIG 5



FASTENING ASSEMBLY FOR BLADES OF TURBOMACHINES HAVING AXIAL FLOW AND METHOD FOR PRODUCING SUCH AN ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the US National Stage of International Application No. PCT/EP2011/057628, filed May 11, 2011 and claims the benefit thereof. The International Application claims the benefits of European application No. 10005079.8 EP filed May 14, 2010. All of the applications are incorporated by reference herein in their entirety.

FIELD OF INVENTION

[0002] The invention relates to a fastening assembly according and further relates to a method for producing such a fastening assembly.

BACKGROUND OF INVENTION

[0003] The present invention concerns the mechanical connection of stationary or rotating blades of the flow path of a turbomachine having axial flow. In this case, these blades are guide blades, which are fastened to the housing or to a corresponding guide blade support, or are moving blades, which are arranged on the rotor of the turbomachine. In a stator system according to the prior art, guide blades of a blade ring are assembled in a groove running in a peripheral direction. In rotating systems, it is known that moving blades are each inserted into a respective groove running in the axial direction. For example, a resilient fastening of moving blades in a peripheral groove in the turbine rotor is known from U.S. Pat. No. 6,761,538 B2, said moving blades being pressed against the known hammer-shaped latching with the aid of a tubular spring element that is slitted both longitudinally and transversely.

[0004] A further type of fastening of moving blades in a compressor to a rotor disk is known from U.S. Pat. No. 2,753,149. To prevent movement of the moving blade in a compressor along its axial groove, a double-headed bolt connection is provided between the base of the axial groove and the underside of the blade root. So as to nevertheless allow slight movement of the moving blade in a compressor in the retaining groove, the bolt sits in its receptacle with a small amount of play. During operation however, the blades tend to clatter in constructions of this type, particularly when the compressor is started, and this generates wear.

[0005] In addition, a fastening assembly is known from U.S. Pat. No. 4,836,749, in which a shaft made of a super-elastic material is used to bias a moving blade. The shaft, which is intrinsically hollow, is filled with a material that melts at a low temperature and with an electric heating element. The heat generated by the current flow then leads to radial expansions of the shaft, thus generating pressure. This assembly is complex, however, susceptible to failure and associated with operational costs.

SUMMARY OF INVENTION

[0006] The object of the present invention is to disclose an alternative fastening assembly for blades of turbomachines having axial flow. A further object of the invention is to provide a corresponding production method.

[0007] The fastening assembly according to the invention for blades of turbomachines having axial flow comprises a blade support with a central axis and a lateral surface concentric therewith, in which retaining grooves distributed along the periphery and extending axially are provided, and comprises blades, of which the blade roots are inserted into these retaining grooves, wherein each retaining groove has a groove base, which is located opposite an underside of the respective blade root, and in each case has a resilient tensioning element, which is arranged between each groove base and the opposed underside and is supported in a biased manner at the respective underside and at the respective groove base, wherein, in each of the undersides of the blades, a channel is provided, in which the respective tensioning element rests flat, that is to say along its longitudinal extent. A suitable channel for guidance of the tensioning element is preferably also arranged in the groove base.

[0008] The invention is based on the knowledge that the blade can be pressed into the retaining groove in an improved manner if a channel is provided at least in the underside of the blade root, the tensioning element resting over its entire length in said channel with a positive fit. The blade is thus pressed in uniformly over the length of the latching region of the undercut, which is not the case in the closest prior art. At the same time, increased process quality is achieved when the blade is assembled in the retaining groove, since individual adaptation of blades is not necessary in order to press in and fix said blades.

[0009] If a channel is provided both in the underside of the blade root and in the groove base, these channels can be produced particularly easily with the aid of the methods below. In accordance with the first method, the blades and the blade support are produced inclusive of all retaining grooves. A blade is then inserted into its respective retaining groove. The blade is then fixed temporarily in the retaining groove. The two mutually opposed channels are then produced in pairs, that is to say at the same time, by means of a single drilling process. The bore runs along the underside/groove base plane and cuts into the blade foot and into the blade support at a respective halfway point. The tensioning element is then inserted into the bore. The temporary fixing is preferably released again either before or after the insertion of the tensioning element. Both channels can be produced at the same time in a relatively simple manner and without excessive effort with the aid of this first method according to the invention. Since both channels are produced in just one drilling process, a very high precision of the positioning of both channels can be assumed, which results in a particularly reliable fit of the spring element in the corresponding channels. This results in the fact that the blades can be pressed into their retaining groove against the undercuts with predefined tensioning forces, in particular over the entire length of the undercuts.

[0010] A second method according to the invention comprises the following steps: the blade support is first produced, but without the respective retaining grooves. The blade support is then drilled, wherein the bores are each placed in such a way that merely part of the material surrounding the respective bore is removed subsequently during production of one of the retaining grooves. The retaining grooves are then produced in the blade support, wherein, in each case, merely part of the material surrounding the respective bore is removed during this process, such that the rest of the material surrounding the respective bore forms the groove-base channel Blades are then inserted, each having underside channels already provided, and the tensioning element is inserted into the space defined by the mutually opposed channels.

[0011] This production method has the advantage that the channel arranged in the blade support can be produced beforehand in a relatively simple manner and without particular effort, in particular if the longitudinal directions of the channel and retaining groove are different.

[0012] Advantageous embodiments are disclosed in the dependent claims.

[0013] In accordance with a first advantageous embodiment, both channels extend parallel to the longitudinal extension of the retaining groove. Alternatively, the channels may extend at an incline to the longitudinal extension of the retaining groove. In particular, the latter variant has the advantage that a positive fit between the blade root and the groove is produced with the aid of the tensioning element due to the mutually inclined direction of displacement of the moving blades (along the retaining groove) and the tensioning element (along the channel), and is simultaneously used to provide axial security against displacement of the blades along the retaining groove. The tensioning element thus simultaneously performs the function of an axial displacement safeguard. At the same time, the shear forces acting from the blades onto the tensioning elements prevent said tensioning elements from being released from the channels.

[0014] The longitudinal extension of the retaining grooves is expediently inclined with respect to the central axis and the channels expediently extend parallel to the central axis.

[0015] To enable relatively simple assembly of the blades and the tensioning element, the groove-base channel discharges into at least one of the two end faces of the blade support, which border the lateral surface. In addition or alternatively, the underside channel discharges into at least one of the two end faces of the blade root, which border the underside. Lateral accessibility of the channels can accordingly be assumed for assembly of the tensioning element, which is preferably designed as a tensioning pin.

[0016] Should the channels extend parallel to the longitudinal extension of the retaining groove, the end-face opening of one or more channels is plugged to secure the tensioning element against loss.

[0017] The proposed fastening assembly can be used both for rotating and static systems. In rotating systems, the blade is formed as a moving blade with axial roots and the blade support is formed as a rotor element, wherein at least part of the radially outer lateral surface of the rotor element forms the respective lateral surface of the blade support comprising the corresponding retaining grooves. In static systems, each blade is formed as a guide blade with axial roots and the blade support is formed as an annular guide blade support element, wherein at least part of the radially inner lateral surface of the guide blade support forms the respective lateral surface of the blade support.

[0018] Of course, the fastening assembly described above is used for all blades of a blade ring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The invention will be explained in greater detail hereinafter on the basis of a drawing, in which:

[0020] FIG. **1** shows the perspective view of a root of a blade for the fastening assembly according to the invention,

[0021] FIG. **2** shows a perspective illustration of a portion of the fastening assembly according to the invention with a retaining groove and a blade fitted therein;

[0022] FIG. **3** shows a sectional view through a blade support of a fastening assembly,

[0023] FIG. **4** shows a blade according to a second embodiment, and

[0024] FIG. **5** shows a blade support according to a second embodiment, suitable for receiving the blade illustrated in FIG. **4**.

DETAILED DESCRIPTION OF INVENTION

[0025] FIG. **1** shows a perspective illustration of a blade **10** formed as a compressor blade. The compressor blade comprises a blade face **12**, illustrated merely in part, to which a blade root **14** adjoins. The blade root **14** has a dovetail-shaped outer contour so as to be held with a positive fit in a blade support (not illustrated in FIG. **1**). In this case, the blade root **14** has an underside **16**, in which a channel **18** is arranged. The channel **18** will also be referred to hereinafter as an underside channel **18**. The underside channel **18** extends over the entire longitudinal extension of the blade root **14**, such that it ends at the end faces of the blade root **14** contoured in a dovetail-shaped manner. The channel **18** is U-shaped in this case, that is to say groove-shaped with a semi-circular basic contour, and is of such a depth that it can almost, but not fully, receive a tensioning element formed as a tensioning pin (not illustrated). It is thus possible, with the aid of the tensioning pin, to fasten the blade **10** in a biased manner in a retaining groove that does not have a channel at the base thereof.

[0026] FIG. **2** shows a perspective illustration of a blade support **20** of a fastening assembly **8**. A retaining groove **22** is provided in the blade support **20** and has a contour corresponding to the blade foot **14** of the blade **10**. Merely in the region of the underside channel **18**, the contour of the retaining groove **22** does not correspond to the blade root, but is different therefrom. A groove-base channel **26** is provided in the base **24** of the retaining groove **22**. The blade **10** illustrated in FIG. **2** differs from the blade **10** illustrated in FIG. **1** in that the channel **18** is not U-shaped, but is merely approximately semi-circular. The openings of both channels **18**, **26** point toward one another. Viewed in cross section, both channels **18**, **26** form an approximately circular contour. They also always lie against one another along their longitudinal extension and are thus suitable for receiving a tensioning element **28**, which is generally formed as a tensioning pin.

[0027] With the aid of the tensioning pin **28** arranged in the channels **18**, **26**, the supporting flanks **30** arranged on the blade root **14** are each pressed against a flank **32** of the retaining groove **22** forming an undercut, whereby the blade **10** is held radially as intended. Both channels **18**, **26** extend over the entire axial extension of the retaining groove **22**, such that the tensioning element **28** can be inserted at the end face (FIG. **3**). It should be noted that the tensioning element **28** is only shown schematically in FIG. **3**, in which the cross section of said tensioning element is illustrated rotated through 90°.

[0028] In accordance with an alternative fastening assembly **8**, of which the blade support **20** is illustrated schematically in FIG. **5** and the blade root **14** is illustrated schematically in FIG. **4**, the channels **18**, **26** extend transversely, that is to say at an incline, to the longitudinal extension of the retaining groove **22**. As a result, the underside channel **18** now does not discharge at the end face of the blade root **14**, but at the supporting flank (FIG. **4**). Furthermore, the groove-base channel **26** now does not discharge in the region of the contour of the retaining groove **22**, but outside said region, in the form of a bore opening. This is illustrated in FIG. **5**. In FIG. **5**, the discharge **34** of the groove-base channel **26** is outside the discharge **38** of the retaining groove **22**. In particular in the latter embodiment of the fastening assembly **8**, it is advantageous if, before the retaining groove **22** is produced, a bore is introduced into the blade support **20** at the point at which the groove-base channel **26** is to remain later. Since the groove-base channel **26** and retaining groove **22** are oriented in a mutually inclined manner at this point, the groove-base channel **26** arranged in the retaining groove **22** can only be produced using conventional methods in a particularly complex manner once said retaining groove has been produced.

[0029] In the assembled state, the longitudinal displacement of the blade **10** along the retaining groove **22** is prevented, since the tensioning element **28** rests with a positive fit in the bore or channel **26** and also engages in the underside channel **18** in the blade root **14**. Due to the different directions of displacement of the blade **10** (along the retaining groove **22**) and of the tensioning element **28** (along the channels **18**, **26**), the blade **10** is simultaneously secured against displacement along the retaining groove **22** with insertion of the tensioning element.

[0030] On the whole, a fastening assembly **8** for blades **10** of turbomachines having axial flow, preferably compressors, is disclosed by the invention, said assembly comprising a blade support **20** with a lateral surface, in which retaining grooves **22** distributed along the periphery are provided and in which blades **10** are inserted, wherein a resilient tensioning element **28** is provided between each groove base **24** and the opposed underside **16** of the respective blade root **14** and is supported in a biased state at the respective groove base **24**, wherein a channel **18**, **26**, in which the tensioning element **28** rests, is provided both in the groove base **24** and in the underside **16**.

1-14. (canceled)

15. A fastening assembly for blades of turbomachines having axial flow, the fastening assembly comprising:

a blade support with a central axis and a lateral surface concentric therewith, the blade support including a plurality of retaining grooves distributed along the periphery of the blade support, each of the plurality of retaining grooves comprising a groove base;

a plurality of blades each comprising a blade root and an underside, which includes a underside channel in which a resilient tensioning element rests along in the longitudinal extent, the underside located opposite of the blade root; and

wherein for each of the plurality of blades, the respective blade is inserted into the retaining groove of one of the plurality of retaining groves such that the respective groove base is located opposite the underside of the respective blade root, and such that the resilient tensioning element is arranged between each groove base and the opposed underside of the respective blade root and the respective resilient tensioning element is supported in a biased manner at the respective underside and at the respective groove base.

16. The fastening assembly as claimed in claim **15**,

wherein each of the plurality of grooves includes a groove channel in the groove base arranged opposite the respective underside channel such that the grove channel and the underside channel form a pair of channels.

17. The fastening assembly as claimed in claim **16**,

wherein the pair of channels extend parallel to the longitudinal extension of the retaining groove.

18. The fastening assembly as claimed in claim **16**,

wherein the pair of channels extend at an incline to the longitudinal extension of the retaining groove.

19. The fastening assembly as claimed in claim **18**,

wherein the longitudinal extension the retaining groove in the pair of channels is inclined with respect to the central axis, and

wherein the pair of channels extend parallel to the central axis.

20. The fastening assembly as claimed in one of claims **16**,

wherein the groove channel in the pair of channels discharges into at least one of the two end faces of the blade support, which border the lateral surface, and/or

wherein the underside channel in the pair of channels discharges into at least one of the two end faces of the blade root, which border the underside.

21. The fastening assembly as claimed in one of claims **16**,

wherein the pair of channels form a substantially circular recess.

22. The fastening assembly as claimed in claim **16**,

wherein each tensioning element is formed as a tensioning pin, of which the axial length is approximately equal to the length the respective channel groove-base and/or the respective underside channel.

23. The fastening assembly as claimed in one claim **16**,

wherein each tensioning element is plugged to secure against loss.

24. The fastening assembly as claimed in claim **16**,

wherein each blade is formed as a moving blade and the blade support is formed as a rotor element, and

wherein at least part of the radially outer lateral surface of the rotor element forms the respective lateral surface of the blade support.

25. The fastening assembly as claimed in claim **15**,

wherein each blade is formed as a guide blade and the blade support is formed as an annular guide blade support, and

wherein at least part of the radially inner lateral surface of the guide blade support forms the respective lateral surface of the blade support.

26. A method for producing a fastening assembly as claimed in claim **1**, the method comprising:

producing the blades and the blade support inclusive of all retaining grooves;

inserting a blade into one of the retaining grooves;

temporarily fixing the blade in the retaining groove;

producing two mutually opposed channels in pairs via a drilling process along an underside/groove base plane; and

inserting the tensioning element into the bore.

27. The method as claimed in claim **12**,

wherein the temporary fixing is released before the inserting of the tensioning element.

28. The method as claimed in claim **12**,

wherein the temporary fixing is released after the inserting of the tensioning element.

29. A method for producing a fastening assembly as claimed in claim **15**, comprising:

producing the blade support without retaining grooves;

drilling the blade support, wherein the bores are each placed in such a way that merely part of the material surrounding the bore is removed when one of the retaining grooves is produced,

producing the retaining grooves, wherein, in each case, merely part of the material surrounding the respective bore is removed during this process, such that the rest of the material surrounding the respective bore forms the groove channel;

inserting blades, each having an underside channel already provided; and

inserting the tensioning element into the space defined by the mutually opposed channels.

* * * * *