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(71) Applicant: **ABB Turbo Systems AG**
5400 Baden (CH)

(72) Inventor: **Fischer, Magnus**
8049 Zürich (CH)

(74) Representative: **Zimmermann & Partner Patentanwälte mbB**
Postfach 330 920
80069 München (DE)

(54) GAS TURBINE WITH A CLEANING DEVICE HAVING PARTICULAR INJECTORS

(57) A cleaning device (10) for a turbine is described. The cleaning device (10) includes an injector main body (11) for injecting cleaning liquid into a flow channel of the turbine. The injector main body (11) includes a main flow channel (12). The main flow channel (12) is connected to one or more first flow channels (121) of respective one or more first injectors (13). At least one of the one or more first flow channels (121) includes a curved channel portion (125).

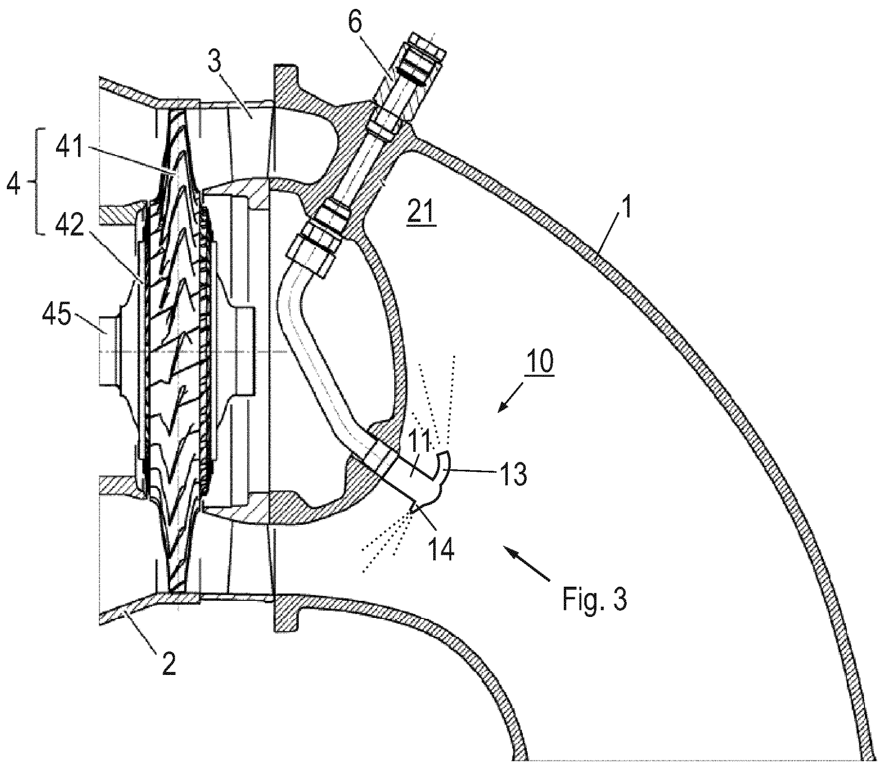

Fig. 2

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Description

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to cleaning devices for turbines, particularly exhaust gas turbines or power turbines. Additionally, embodiments of the present disclosure relate to turbines, e.g. exhaust gas turbines or power turbines with such a cleaning device. Further embodiments of the present disclosure relate to exhaust gas turbochargers with an exhaust gas turbine with such a cleaning device.

BACKGROUND

[0002] Exhaust gas turbines are used in exhaust gas turbochargers for charging internal combustion engines or as power turbines for converting the energy contained in the exhaust gases of internal combustion engines into mechanical or electrical energy.

[0003] Depending on the actual operating situation of the internal combustion engine and the composition of the fuels used to drive the internal combustion engine, typically fouling of the turbine stage, i.e. the turbine blades on the impeller and the guide vanes of the nozzle ring, as well as of the various turbine housing parts, occur in the exhaust gas turbine. Typically, fouling includes deposition of exhaust gas particles. Such dirt deposits can lead to a decrease in turbine efficiency in the region of the nozzle ring. Further, as a result, there may be an increase in the exhaust gas temperatures in the combustion chamber, whereby both the internal combustion engine and the turbocharger can be thermally overstressed. In particular, damage or even destruction of the outlet valves can occur in the internal combustion engine.

[0004] For example, if a dirt layer is deposited on the nozzle ring and on the turbine blades of a turbocharger connected to an internal combustion engine, an increase in the turbocharger rotational speed and consequently in the boost pressure and the cylinder pressure is to be expected. As a result, in addition to the increased thermal load both components of the internal combustion engine and the turbocharger are also subjected to higher mechanical loads, which may lead to destruction of the affected components.

[0005] Further, with irregular distribution of such a dirt layer on the circumference of the blades of the turbine wheel, an increase in the imbalance of the rotor may occur, whereby the bearings of the rotating parts can be damaged. If there are dirt deposits on the turbine housing at the outer contour of the flow channel extending radially outside the turbine blades, contact can occur during operation due to the reduced radial clearance between turbine blades and turbine housing, which can damage the turbine blades.

[0006] Therefore, in view of the above, the nozzle ring, turbine blades and affected areas of the turbine housing must be regularly cleaned during operation.

[0007] In the state of the art, for cleaning exhaust gas turbines of heavy fuel-operated internal combustion engines from contaminants during operation typically water is used as a cleaning agent, which is injected via one or more nozzles upstream of the turbine stage in the exhaust stream. It is to be noted that a cleaning effect can only be achieved in the areas of the exhaust gas turbine which can be wetted by the cleaning agent. Accordingly, for a good cleaning performance, a homogeneous distribution of the cleaning agent in the circular or annular surface at the entrance to the turbine stage must be realized.

[0008] In the context of turbine cleaning systems for exhaust gas turbines there are several challenges and to a certain extent opposing targets have to be met. For instance, the cleaning agent distribution on the nozzle ring has to be homogenously spread over the whole circumference. An uneven distribution could lead to uneven contraction of the turbine casing and in turn to rubbing contact with the blade tips resulting in wear. Further, the amount of cleaning agent impinging on walls of the hot gas path has to be minimized. Applying cleaning agent, e.g. water, to hot surfaces typically provokes thermal stresses which can lead to cracks and failure.

[0009] Accordingly, there is a continuing demand for cleaning devices for interior cleaning of turbines, which at least partially overcome the problems of the state of the art and provide for an improved cleaning performance.

SUMMARY

[0010] In light of the above, a cleaning device for a turbine according to the independent claim is provided. Further aspects, advantages, and features are apparent from the dependent claims, the description, and the accompanying drawings.

[0011] According to an aspect of the present disclosure, a cleaning device for a turbine is provided. The cleaning device includes an injector main body for injecting cleaning liquid into a flow channel of the turbine. The injector main body includes a main flow channel. The main flow channel is connected to one or more first flow channels of respective one or more first injectors. At least one of the one or more first flow channels includes a curved channel portion.

[0012] Accordingly, the cleaning device of the present disclosure is improved compared to conventional cleaning devices. In particular, the cleaning device of the present disclosure beneficially provides for an improved cleaning liquid distribution resulting in a better cleaning performance. Further, the cleaning device of the present disclosure is improved with respect to homogenously spreading the cleaning liquid, e.g. water, on a nozzle ring of a turbine.

[0013] According to a further aspect of the present disclosure, a turbine, including a cleaning device according to any of the embodiments described herein is provided.

For instance, the turbine can be an exhaust gas turbine or a power turbine. Accordingly, beneficially an improved turbine, particularly an improved exhaust gas turbine or a power turbine, can be provided.

[0014] According to another aspect, an exhaust gas turbocharger including an exhaust gas turbine with a cleaning device according to any of the embodiments described herein is provided. Accordingly, an improved exhaust gas turbocharger can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

Fig. 1 shows a schematic sectional view of a turbine housing of an exhaust gas turbine with a cleaning device according to the prior art;

Fig. 2 shows a schematic sectional view of a turbine housing of an exhaust gas turbine with a cleaning device according to embodiments described herein;

Fig. 3 shows a front view of a cleaning device according to embodiments described herein; and

Fig. 4 shows a sectional view along line A-A indicated in Fig. 3 of a cleaning device according to embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0016] Reference will now be made in detail to the various embodiments, one or more examples of which are illustrated in each figure. Each example is provided by way of explanation and is not meant as a limitation. For example, features illustrated or described as part of one embodiment can be used on or in conjunction with any other embodiment to yield yet a further embodiment. It is intended that the present disclosure includes such modifications and variations.

[0017] Within the following description of the drawings, the same reference numbers refer to the same or to similar components. Generally, only the differences with respect to the individual embodiments are described. Unless specified otherwise, the description of a part or aspect in one embodiment can apply to a corresponding part or aspect in another embodiment as well.

[0018] With exemplary reference to Fig. 1, a cleaning device 50 according to the prior art is described.

[0019] In particular Fig. 1 shows a schematic sectional view along the turbine axis of a section of an axial turbine according to the prior art. The gas inlet casing 1 includes an outer and an inner housing wall, wherein the inner housing wall is configured in a calotte shape with a hollow interior space and which serves as a cover of the hub body 42 of the turbine wheel 4 opposite the flow channel. The turbine wheel is provided in the gas outlet housing 2.

[0020] During operation of the exhaust gas turbine, the hot exhaust gas discharged from the internal combustion engine is first directed into the gas inlet casing 1 of the exhaust gas turbine providing an exhaust gas flow having an approximately circular cross section. The effect of the inner housing wall is a conversion into an annular exhaust gas flow with a stagnation point streamline impinging the inner housing wall in a substantially perpendicular direction. The annular exhaust gas flow is guided to the turbine blades 41. The nozzle ring 3 arranged upstream of the turbine blades 41 has the task of optimally aligning the exhaust gases with the turbine blades 41 of the turbine wheel 4. Upstream of the nozzle ring 3, the cleaning device 50 extending from the inner housing wall of the gas inlet housing into the flow channel 21 is provided.

[0021] In particular, the cleaning device 50 includes a nozzle body 5 which projects in the region of the stagnation point streamline from the inner housing wall into the flow channel 21. The nozzle body includes a plurality of nozzle openings 51, 52 for injecting a cleaning liquid into the flow channel 21.

[0022] In particular, the nozzle openings 51 and 52 are subdivided into two groups of nozzle openings. The first group of the nozzle openings 52 is arranged downstream of a throttle point 53. The second group of the nozzle openings 51 is arranged upstream of the throttle point 53. Due to the throttle point 53, two different pressure levels may be realized for the cleaning fluid. In particular, the first group of the nozzle openings 52 can be configured for injecting the cleaning liquid at lower pressure than the second group of the nozzle openings 51 upstream from the throttle 53. The different pressure conditions at the first and second nozzle openings 52 have the effect that different amounts of cleaning fluid with different injection velocities can be injected into the flow channel 21 through the nozzle openings 51, 52.

[0023] With exemplary reference to Figs. 2 to 4, a cleaning device 10 for a turbine according to the present disclosure is described. According to embodiments which can be combined with other embodiments described herein, the cleaning device 10 includes an injector main body 11 for injecting cleaning liquid into a flow channel of the turbine. As exemplarily shown in Fig. 4, the injector main body 11 includes a main flow channel 12. For instance, as exemplarily shown in Fig. 2, the injector main body 11 can be mounted to the inlet casing 1 (calotte) of the turbine. The main flow channel 12 is connected to one or more first flow channels 121 of respective one or more first injectors 13. For instance, the one or more first injectors 13 can be low pressure injectors. At least one of the one or more first flow channels 121 includes a curved channel portion 125, as exemplarily shown in Fig. 4.

[0024] It is to be understood that the curved channel portion 125 can include a bending in one, two or three dimensions. In other words, the curved channel portion 125 can be bent in the x-direction and/or the y-direction and/or the z-direction. Further, in the case that two or more first injectors 13 are provided, the respective curved channel portions 125 of the respective first flow channels 121 can be different. Accordingly, it is to be understood that the one or more first flow channels 121 can be individually bent in one, two or three dimensions, e.g. by respective curved channel portions. Although not explicitly shown, it is to be understood that the one or more first flow channels 121 may include two or more curved channel portions.

[0025] Accordingly, compared to the state of the art, the cleaning device of the present disclosure beneficially provides for a cleaning device design with an improved cleaning liquid distribution resulting in a better cleaning performance. In particular, the cleaning device according to embodiments described herein is improved with respect to homogenously spreading the cleaning liquid.

[0026] With exemplary reference to Figs. 2 to 4, according to embodiments which can be combined with other embodiments described herein, the main flow channel 12 can be connected to one or more second flow channels 122 of respective one or more second injectors 14. For instance, the one or more second injectors 13 can be high pressure injectors. In particular, the one or more second injectors can be directly connected to the main flow channel, such that the one or more second injectors can be directly fed through a plenum.

[0027] From Figs. 2 to 4 it is to be understood that, typically the cleaning liquid, e.g. water, enters the cleaning device at the entrance of the main flow channel of the of the injector main body, in particular at a high pressure level. Subsequently, the cleaning liquid is further distributed by the one or more first injectors 13 and/or the one or more second injectors 14 to the respective injection openings from which the cleaning liquid is injected into the flow channel 21 of the turbine. As a non-limiting example, Fig. 3 shows a design of the cleaning device having six low pressure injectors 13 and five high pressure injectors 14, of which three high pressure injectors 14 can be seen in the perspective of Fig. 3. However, it is to understood that the cleaning device may include various numbers low pressure injectors and/or high pressure injectors.

[0028] Accordingly, the cleaning device as described herein can be configured for providing cleaning liquid jets of different pressure levels. In particular, in order to ensure the required high cleaning liquid penetration for cleaning the nozzle ring, e.g. in certain areas of the gas stream upstream of the nozzle ring, the cleaning device as described herein is beneficially configured for providing high pressure jets of cleaning liquid to the nozzle ring. Additionally, the cleaning device is configured for providing low pressure jets of cleaning liquid to areas where low pressure injection is beneficial for obtaining good cleaning results.

[0029] As exemplarily shown in Fig. 4, according to embodiments which can be combined with other embodiments described herein, the one or more first flow channels 121 end in respective one or more first injection openings 131. At least one of the respective one or more first injection openings 131 provide for an injection direction 102 deviating from a main flow direction 101 in the main flow channel 12 by an deviation angle α of $\alpha \geq 15°$. For instance, the deviation angle α can be selected from the group consisting of $\alpha \geq 25°$, $\alpha \geq 35°$, $\alpha \geq 45°$, $\alpha \geq 45°$, $\alpha \geq 55°$, $\alpha \geq 65°$, $\alpha \geq 75°$, $\alpha \geq 85°$, $\alpha \geq 95°$, $\alpha \geq 105°$; $\alpha \geq 115°$, and $\alpha \geq 125°$.

[0030] According to embodiments which can be combined with other embodiments described herein, two or more of the first injection openings 131 may provide for different, i.e. individual, injection directions. In other words, at least one first injection opening 131 may be configured for providing an injection direction deviating from the main flow direction in the main flow channel 12 by a deviation angle α_1 while at least one other first injection opening 131 may be configured for providing a different deviation angle α_2. Accordingly, it is to be understood, that two or more first injection openings may be configured for providing individual injection directions.

[0031] According to embodiments which can be combined with other embodiments described herein, the flow cross-section of the first injection openings 131 may individually be designed. In other words, at least two flow cross-sections of the respective first injection openings 131 may have a different flow cross-section, respectively.

[0032] According to embodiments which can be combined with other embodiments described herein, the cross-section of the one or more first flow channels 121 can be circular or elliptical or completely free. In particular, at least one of the one or more first flow channels 121 includes an interior freeform surface.

[0033] A freeform surface can be understood as a surface which does not have radial dimensions, unlike regular surfaces such as planes, cylinders or conic surfaces. For instance, freeform surfaces can be given by an array of control point and a mathematical model defining the way the surface is created. In particular, based on the mathematical model free form surfaces can be divided in interpolation free form surfaces and approximation free form surfaces. In the case of interpolation free form surfaces, the surface is passing through predefined control points. Approximation free form surfaces can include (non) rational bézier surfaces, and (non) rational (non) uniform b-spline surfaces.

[0034] According to embodiments which can be combined with other embodiments described herein, at least one of the one or more first flow channels 121 is connected with the main flow channel 12 via an orifice 15. Typically, the cross-section of the orifice 15 is smaller than a flow cross-section of the at least one first flow channel 121. Accordingly, the respective orifice 15 at the entrance of the one or more first flow channels 121 can be configured to reduce the cleaning liquid pressure level to an intended level. The respective orifices can individually be designed with respect to the flow cross-sectional area and/or with respect to the cross-sectional shape, e.g. circular, elliptical, free form or any other suitable shape.

[0035] As exemplarily shown in Fig. 4, according to embodiments which can be combined with other embodiments described herein, at least one of the one or more first flow channels 121 includes a guide vane 16. In particular, the guide vane 16 may be provided in the curved channel portion 125 of the one or more first flow channels 121. Providing guide vanes in the one or more first flow channels can be beneficial for improving flow guidance or even ensuring optimal flow guidance in the first flow channels. Additionally or alternatively, other flow features such as ribs or dimples can be provided in at least one of the one or more first flow channels 121 for flow guidance optimization.

[0036] With exemplary reference to Fig. 4, according to embodiments which can be combined with other embodiments described herein, at least one of the one or more second flow channels 122 includes a conical section 123 having an enlarged flow cross-section at the connection with the main flow channel 12. Accordingly, flow guidance into the one or more second flow channels 122 can be improved.

[0037] Further, as exemplarily shown in Fig. 4, according to embodiments which can be combined with other embodiments described herein, at least one of the one or more second flow channels includes a cylindrical section 124 ending in a second injection opening 132. Accordingly, the one or more second flow channels 122 end in respective one or more second injection openings 132. The one or more second pressure injection openings 132 may also be referred to a as high pressure injection openings. For instance, the cylindrical section 124 may have a length to diameter ratio L/D of $1 \leq L/D \leq 4$, particularly $2 \leq L/D \leq 3$, e.g. $L/D = 2.5 \pm 0.25$. Providing the one or more second flow channels with a cylindrical section can be beneficial for ensuring an optimal spray profile.

[0038] With exemplary reference to Fig. 4, according to embodiments which can be combined with other embodiments described herein, at least one inlet section of the one or more second flow channels 122 may include a guide vane 16. In particular, the guide vane 16 may be provided at an inlet section of the conical section 123 of the one or more second flow channels 122. Providing guide vanes at the inlet section of the one or more second flow channels 122 can be beneficial for improving flow guidance or even ensuring optimal flow guidance at the entrance of the second flow channels. Additionally or alternatively, other flow features such as ribs or dimples can be provided at the entrance of or inside at least one of the one or more second flow channels 122 for flow guidance optimization.

[0039] According to embodiments which can be combined with other embodiments described herein, at least one of the one or more second flow channels 122 may include an interior freeform surface.

[0040] As exemplarily shown in Fig. 4, according to embodiments which can be combined with other embodiments described herein, at least one of the respective one or more second injection openings 132 provide for an injection direction 103 deviating from a main flow direction 101 in the main flow channel 12 by a deviation angle β of $\beta \geq 15°$. For instance, the deviation angle β can be selected from the group consisting of $\beta \geq 25°$, $\beta \geq 35°$, $\beta \geq 45°$, $\beta \geq 45°$, $\beta \geq 55°$, $\beta \geq 65°$, $\beta \geq 75°$, $\beta \geq 85°$, $\beta \geq 95°$, $\beta \geq 105°$; $\beta \geq 115°$, and $\beta \geq 125°$.

[0041] According to embodiments which can be combined with other embodiments described herein, two or more of the second injection openings 132 may provide for different, i.e. individual, injection directions. In other words, at least one second injection opening 132 may be configured for providing an injection direction deviating from the main flow direction in the main flow channel 12 by a deviation angle β_1 while at least one other second injection opening 132 may be configured for providing a different deviation angle β_2. Accordingly, it is to be understood, that two or more second injection openings may be configured for providing individual injection directions.

[0042] According to embodiments which can be combined with other embodiments described herein, the flow cross-section of the second injection openings 132 may individually be designed. In other words, at least two flow cross-sections of the respective second injection openings 132 may have a different flow cross-section, respectively.

[0043] According to embodiments which can be combined with other embodiments described herein, the one or more first flow channels 121 include a number $N_1 \geq 2$ of first flow channels 121. For instance, the number N_1 of first flow channels 121 can be selected from the group consisting of: $N_1=2$, $N_1=3$, $N_1=4$, $N_1=5$, $N_1=6$, $N_1=7$, $N_1=8$, $N_1=9$, $N_1=10$ and $N_1>10$. Further, it is to be understood that the number N1 of first flow channels can be selected from the group consisting of: $N_1 \geq 2$, $N_1 \geq 3$, $N_1 \geq 4$, $N_1 \geq 5$, $N_1 \geq 6$, $N_1 \geq 7$, $N_1 \geq 8$, $N_1 \geq 9$, and $N_1 \geq 10$.

[0044] According to embodiments which can be combined with other embodiments described herein, the number N_1 of first flow channels 121 can include individually designed interior freeform surfaces.

[0045] According to embodiments which can be combined with other embodiments described herein, the number N_1 of first flow channels 121 are connected with the main flow channel 12 via a respective number of orifices 15. In particular, at least two of the orifices 15 have a different flow cross-section. In particular, the orifices 15 may be designed individually to provide for an individual pressure drop and an individual water flow rate.

[0046] According to embodiments which can be combined with other embodiments described herein, the one or more second flow channels 122 include a number N_2

of second flow channels selected from the group consisting of: N_2=2, N_2=3, N_2=4, N_2=5, N_2=6, N_2=7, N_2=8, N_2=9, N_2=10 and N_2>10. Further, it is to be understood that the number N_2 of second flow channels can be $N_2 \geq 2$, $N_2 \geq 3$, $N_2 \geq 4$, $N_2 \geq 5$, $N_2 \geq 6$, $N_2 \geq 7$, $N_2 \geq 8$, $N_2 \geq 9$, and $N_2 \geq 10$.

[0047] As exemplarily shown in Figs. 2 to 4, according to embodiments which can be combined with other embodiments described herein, the one or more second flow channels 122 can be shorter than the one or more first flow channels 121. Alternatively, the one or more second flow channels 122 can be longer than the one or more first flow channels 121 or of equal length.

[0048] According to embodiments which can be combined with other embodiments described herein, the cleaning device is at least partially produced by additive manufacturing. In particular, employing additive manufacturing has the advantage that complex or extraordinary design features, e.g. free form shapes and surfaces, can be produced in an easy and cost-efficient manner. Further, additive manufacturing can be beneficial for producing the cleaning device with individually designed injectors, e.g. injectors having individually designed flow channels including individual free form geometries, particularly individual interior freeform surfaces.

[0049] In particular, the cleaning device as described herein can be designed and manufactured by combining enhanced methodologies in CFD (computational fluid dynamics) design with the benefits of additive manufacturing. Free form shapes of the individual channels which distribute the cleaning liquid to the injection openings allow for optimal flow guidance, reduce recirculation zones and provide for an intact and optimal flow profile at the injection openings of the jet of cleaning liquid in the turbine casing.

[0050] More specifically, the cleaning device as described herein can be designed with a closed-loop process between CFD simulation and CAD (computer-aided design) tools, which helps to optimize the flow- and injections characteristics of the cleaning device. For instance, with the CFD simulation the cleaning liquid distribution on the turbine casing and nozzle ring can be assessed and the pressure drop of the individual channels inside the cleaning device can be calculated. With this information at hand, the geometry can be changed and then re-assessed with CFD. Accordingly, after several design loops an optimal geometry of the cleaning device can be determined.

[0051] According to embodiments which can be combined with other embodiments described herein, at least one element of the cleaning device selected form the group consisting of: at least one of the one or more first injectors 13, particularly the one or more first flow channels 121; at least one of the one or more second injectors 14, particularly the one or more second flow channels 122; and the injector main body 11, particularly the main flow channel 12; can be produced by additive manufacturing.

[0052] Further, it is to be understood that the cleaning device may also at least partially be produced by conventional machining techniques, such as drilling, milling, welding or others. For instance, the cleaning device may include at least one element or component produced by additive manufacturing, e.g. the one or more first flow channels 121, whereas the remaining elements or components of the cleaning device can be produced by conventional machining techniques.

[0053] In view of the embodiments described herein, it is to be understood that compared to the state of the art an improved cleaning device for turbines, particularly for exhaust gas turbines or a power turbines, is provided. In particular, embodiments of the present disclosure beneficially provide for an improved cleaning liquid distribution resulting in a better cleaning performance. Further, embodiments of the present disclosure are improved with respect to homogenously spreading the cleaning liquid, e.g. water, on a nozzle ring of a turbine. Further, embodiments of the present disclosure are beneficially configured for providing cleaning liquid jets of different pressure levels. In particular, in order to ensure the required high cleaning liquid penetration for cleaning the nozzle ring, e.g. in certain areas of the gas stream upstream of the nozzle ring, embodiments of the present disclosure are beneficially configured for providing high pressure jets of cleaning liquid to the nozzle ring. Additionally, embodiments of the present disclosure are beneficially configured for providing low pressure jets of cleaning liquid to areas where low pressure injection is beneficial for obtaining good cleaning results.

[0054] According to a further aspect of the present disclosure, a turbine is provided. In particular, the turbine of the present disclosure, e.g. an exhaust gas turbine or a power turbine, includes a cleaning device according to any of the embodiments described herein is provided. Accordingly, compared to conventional turbines, the embodiments of the turbine as described herein provide for a turbine which can be cleaned more effectively.

[0055] According to another aspect, an exhaust gas turbocharger is provided. In particular, exhaust gas turbocharger of the present disclosure includes an exhaust gas turbine with a cleaning device according to any of the embodiments described herein is provided. Accordingly, compared to conventional, exhaust gas turbochargers, the embodiments of the exhaust gas turbine as described herein can be cleaned more effectively.

[0056] While the foregoing is directed to embodiments, other and further embodiments may be devised without departing from the basic scope, and the scope is determined by the claims that follow.

REFERENCE NUMBERS

[0057]

1	gas inlet casing
2	gas outlet casing
3	nozzle ring

4 turbine wheel
41 turbine blades
42 hub body of the turbine wheel
45 turbine shaft
50 prior art cleaning device
5 nozzle body of prior art cleaning device
51 high-pressure nozzle openings
52 low-pressure nozzle openings
53 throttle point (constriction)
6 feed line for supplying cleaning fluid
10 cleaning device
101 main flow direction
102 injection direction of low pressure injectors
103 injection direction of high pressure injectors
11 injector main body
12 main flow channel
121 one or more first flow channels
122 one or more second flow channels
123 conical section
124 cylindrical section
125 curved channel portion
13 one or more first injectors
131 first injection openings
132 second injection openings
14 one or more second injectors
15 orifice
16 guide vane
21 flow channel of turbine
α deviation angle of injection direction of low pressure injectors with respect to main flow direction
β deviation angle of injection direction of high pressure injectors with respect to main flow direction
L length of cylindrical section
D diameter of cylindrical section
N_1 number of first flow channels
N_2 number of second flow channels

Claims

1. A cleaning device (10) for a turbine, comprising an injector main body (11) for injecting cleaning liquid into a flow channel of the turbine, the injector main body (11) comprising a main flow channel (12), the main flow channel (12) being connected to one or more first flow channels (121) of respective one or more first injectors (13), wherein at least one of the one or more first flow channels (121) comprises a curved channel portion (125).

2. The cleaning device (10) according to claim 1, wherein the one or more first flow channels (121) end in respective one or more first injection openings (131), wherein at least one of the respective one or more first injection openings (131) provide for an injection direction (102) deviating from a main flow direction (101) in the main flow channel (12) by an deviation angle α of $\alpha \geq 15°$.

3. The cleaning device (10) according to claim 1 or 2, wherein at least one of the one or more first flow channels (121) comprises an interior freeform surface.

4. The cleaning device (10) according to any of claims 1 to 3, wherein at least one of the one or more first flow channels (121) is connected with the main flow channel (12) via an orifice (15), wherein a flow cross-section of the orifice (15) is smaller than a flow cross-section of the at least one first flow channel (121).

5. The cleaning device (10) according to any of claims 1 to 4, wherein at least one of the one or more first flow channels (121) comprises a guide vane (16).

6. The cleaning device (10) according to any of claims 1 to 4, the main flow channel (12) being connected to one or more second flow channels (122) of respective one or more second injectors (14).

7. The cleaning device (10) according to claim 6, wherein at least one of the one or more second flow channels (122) comprises a conical section (123) having an enlarged flow cross-section at the connection with the main flow channel (12).

8. The cleaning device (10) according to claim 6 or 7, wherein at least one of the one or more second flow channels (122) comprises a cylindrical section (124) ending in a second injection opening (132).

9. The cleaning device (10) according to claim 8, wherein the cylindrical section (124) has a length to diameter ratio L/D of $1 \leq L/D \leq 4$, particularly $2 \leq L/D \leq 3$, particularly $L/D = 2.5 \pm 0.25$.

10. The cleaning device (10) according to any of claims 1 to 9, wherein the one or more first flow channels (121) comprise a number N_1 of first flow channels (121) being $N_1 > 2$, and the number N_1 of first flow channels (121) comprising individually designed interior freeform surfaces.

11. The cleaning device (10) according to any of claims 1 to 10, wherein the one or more first flow channels (121) comprise a number N_1 of first flow channels (121) being $N_1 > 2$, wherein the number N_1 of first flow channels (121) are connected with the main flow channel (12) via a respective number of orifices (15), wherein at least two of the orifices (15) have a different flow cross-section.

12. The cleaning device (10) according to any of claims 1 to 11, wherein the one or more first flow channels (121) comprise a number N_1 of first flow channels (121) being selected from the group consisting of: N_1=2, N_1=3, N_1=4, N_1=5, N_1=6, N_1=7, N_1=8, N_1=9,

N_1=10 and N_1>10.

13. The cleaning device (10) according to any of claims 6 to 12, wherein at least one inlet section of the one or more second flow channels (122) comprises a guide vane (16).

14. The cleaning device (10) according to any of claims 6 to 13, wherein a number N_2 of second flow channels (122) being selected from the group consisting of: N_2=2, N_2=3, N_2=4, N_2=5, N_2=6, N_2=7, N_2=8, N_2=9, N_2=10 and N_2>10.

15. The cleaning device (10) according to any of claims 1 to 13, wherein the cleaning device is at least partially produced by additive manufacturing.

16. A turbine, particularly an exhaust gas turbine or a power turbine, comprising a cleaning device according to one of claims 1 to 14.

17. An exhaust gas turbocharger, comprising an exhaust gas turbine with a cleaning device according to one of claims 1 to 14.

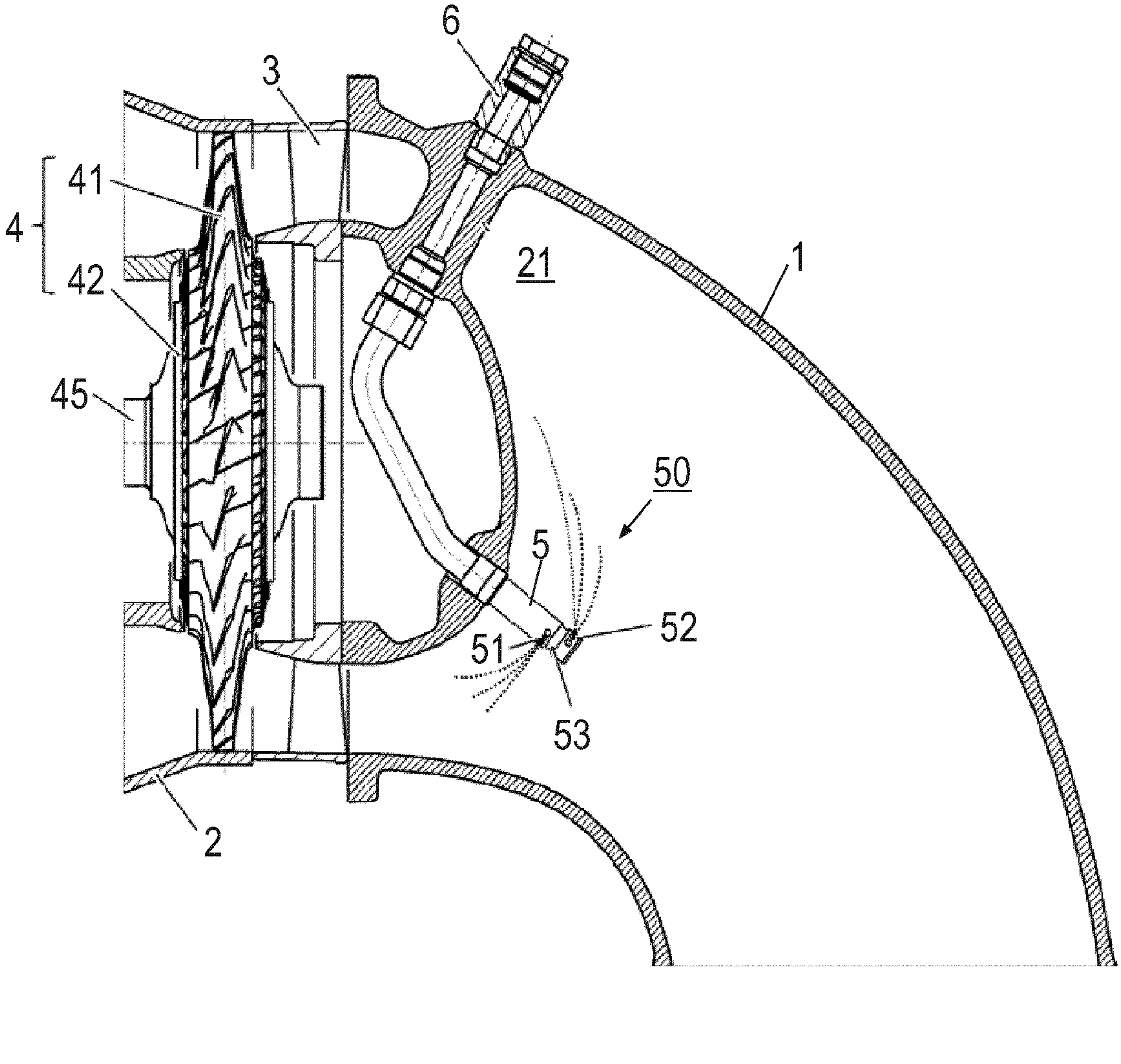


Fig. 1 (prior art)

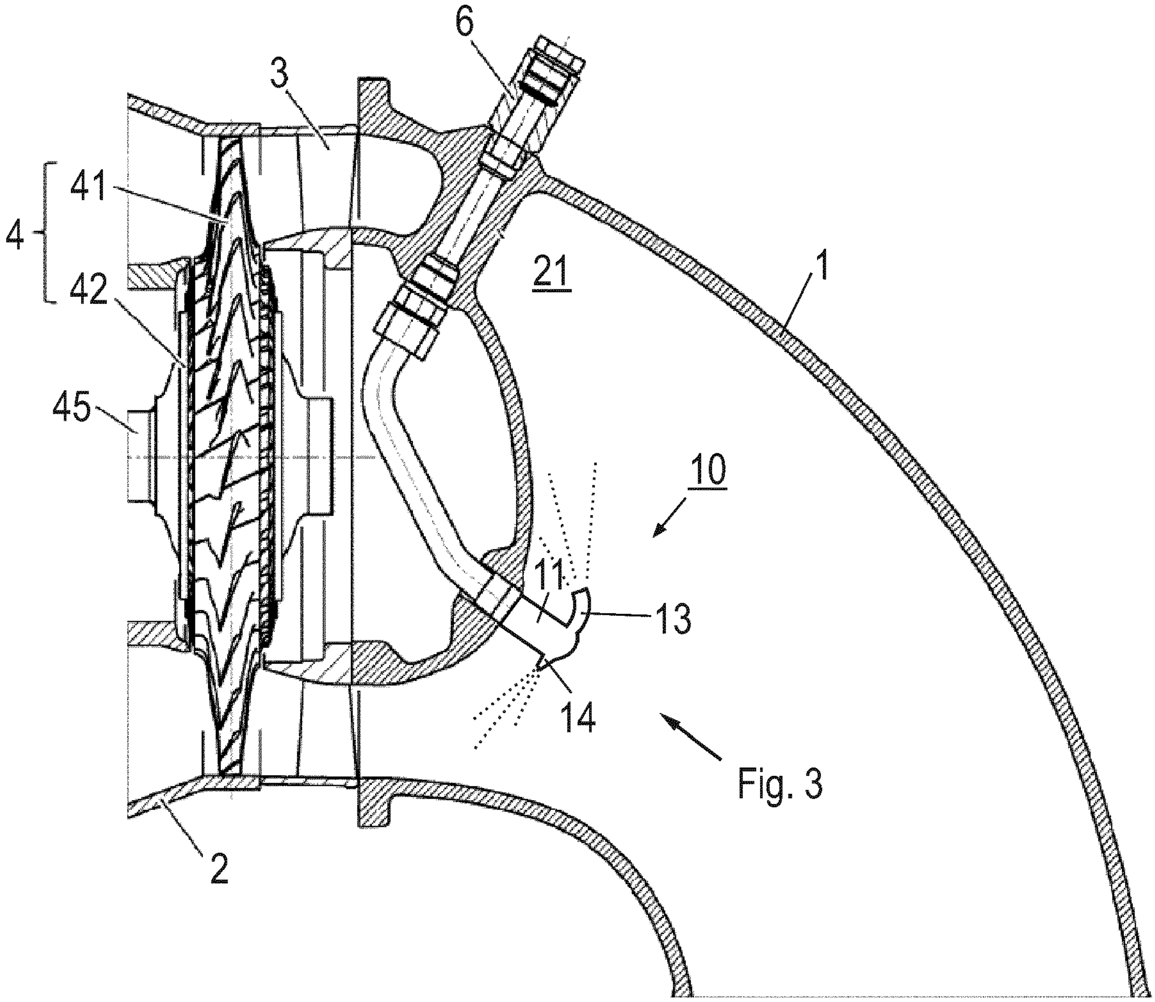
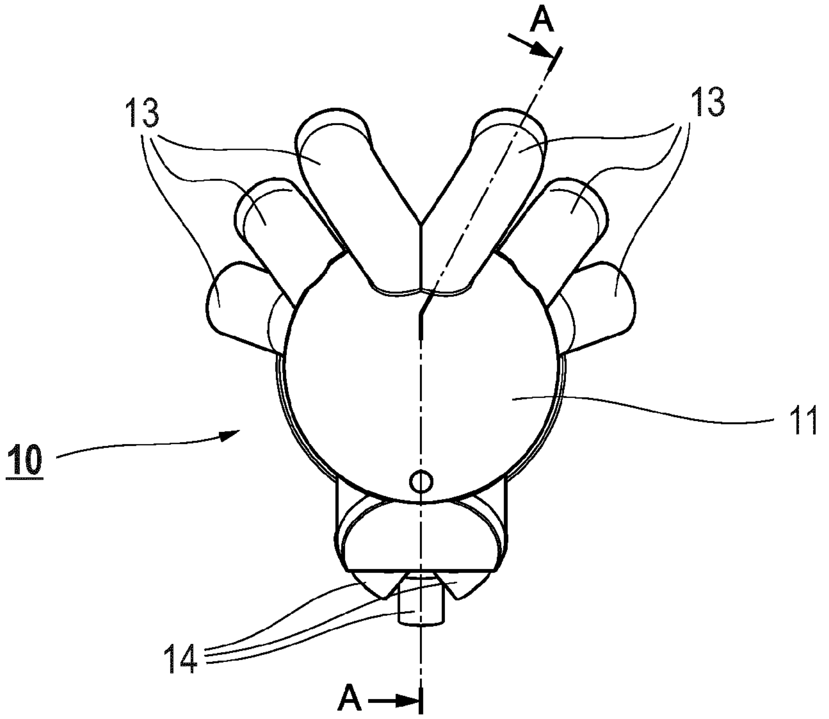


Fig. 2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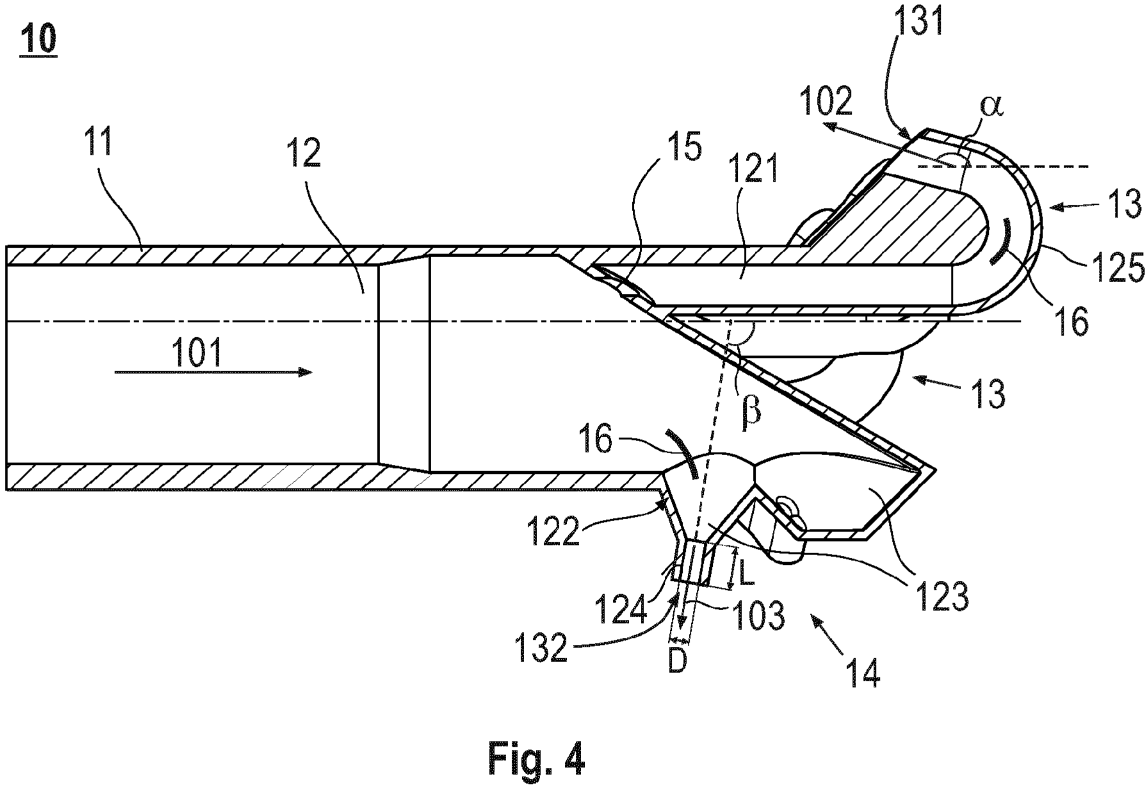
A

Fig. 3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14

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 18 21 2563

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	10 April 2019	Rolé, Florian

CATEGORY OF CITED DOCUMENTS

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