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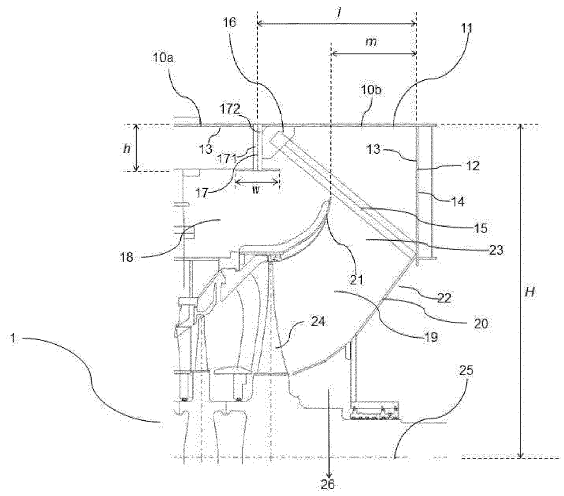
(54) **EXHAUST CASING FOR A LOW PRESSURE STEAM TURBINE SYSTEM**

(57) The present invention relates to the exhaust casing (10) for a low pressure steam turbine system comprising an upper wall (11) and a side wall (12), an inner surface (13) and an outer surface (14), a plurality of casing reinforcement elements (15), and a guiding rib (17), wherein the guiding rib (17) is attached to the inner surface (13) of the upper wall (11) of the exhaust casing (10) and extending radially inwards, and wherein each of the casing reinforcement elements (15) is fastened to the guiding rib (17).

The guiding rib serves as a guide for a steam moving in the substantially vertically upward direction to be turned in 180 degrees in order to flow downwards to the outlet of the exhaust system. The guiding rib further serves as a fastening element for fastening the reinforcement elements to the upper wall of the exhaust casing and may also serve as a connecting element between casing blocks. The steam flow efficiency is improved with this configuration, because it reduces the number of elements within the inner space of the exhaust casing. Thus, collisions of the steam passing through the system with said elements are reduced as well. Consequently, turbulent velocities of the steam are balanced and pressure losses caused by the collisions are reduced. As a result, the efficiency of the exhaust system and the overall performance of the turbine are improved.

Fig. 1



EP 3 299 592 A1

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Description

Technical Field

[0001] The present invention relates to an exhaust casing for a low pressure steam turbine system, and to a configuration of the guiding rib and reinforcement elements within an inner space of the exhaust casing, which allows to reduce the pressure losses and to increase the steam flow efficiency.

Background Art

[0002] A steam passing through a steam turbine is guided through an exhaust system to a condenser to be condensed and brought back into the system. A conventional exhaust system comprises an annular diffuser, comprising an inner and an outer flow guide, through which the steam passed through the turbine stage is discharged radially outward. A conventional exhaust system may be oriented vertically or horizontally, typically a vertical orientation is provided. A conventional diffuser has a guiding channel, divided by a horizontal plane into an upper and a lower guiding channel. The steam exiting the diffuser through the lower guiding channel moves substantially radially downwards and merely continues in this direction through the outlet towards the condenser. The steam exiting the diffuser through the upper guiding channel is, however, moving in a substantially vertically upward direction and has to be turned by 180 degrees in order to flow downwards to the outlet of the exhaust system. In order to do that, the steam is directed by collisions with guiding blocks at the apex of the diffuser within an inner space of the exhaust system. Apart from the guiding blocks, the steam collides with the casing itself and any other elements positioned within said inner space of the exhaust casing. The other elements may be various connecting elements, e.g. connecting elements for connecting individual blocks of a casing or fastening ribs for fastening reinforcement elements within the exhaust system. Consequently, vortices are formed within the exhaust casing in the upper part of the diffuser outlet and the steam flow undergoes large pressure losses, which undesirably affects the efficiency of the exhaust system and the overall performance of the turbine.

[0003] For large steam turbines, the exhaust casing may be built up of several blocks, which have to be connected together. In the current practice, the blocks may be connected e.g. by connecting element or elements similar to the guiding ribs, but separate from the actual guiding rib. Such a configuration increases the number of elements present within the inner space of exhaust casing, which in turn increases steam collisions and pressure losses. Further, the exhaust casing must be reinforced, because a vacuum has to be provided inside the exhaust casing. The reinforcement is usually provided by a plurality of reinforcement elements, often in a form of tubes or plates, which need to be fastened to the casing. The current practice is that each of the reinforcement elements is fastened to a separate fastening rib. Thus, there are as many fastening ribs as reinforcing elements. The fastening ribs are positioned perpendicularly to the guiding rib, i.e. parallel to the longitudinal axis of the steam turbine system. Such a configuration extremely increases the number of elements present within the inner space of exhaust casing, which in turn increases steam collisions and pressure losses.

[0004] The disadvantage of the above-mentioned configurations is that they affect the efficiency of the exhaust system, because with so many elements, the steam is forced not only to collide with the guiding rib, but also with all the other elements. These collisions contribute to formation of vortices, leading to large pressure losses in the steam flow. As mentioned above, these pressure losses affect the efficiency of the exhaust system and the overall performance of the turbine in an undesirable manner.

Disclosure of the Invention

[0005] The aim of this invention is to provide a configuration of the guiding rib and the reinforcement elements within the inner space of the exhaust casing, which allows to reduce the pressure losses and to increase the steam flow efficiency.

[0006] The present invention provides an exhaust casing for a low pressure steam turbine system comprising an upper wall and a side wall, an inner surface and an outer surface, a plurality of casing reinforcement elements, and a guiding rib, wherein the guiding rib is attached to the upper wall of the exhaust casing extending radially inwards, and wherein one or more of the reinforcement elements are fastened to the guiding rib. The steam flow efficiency is improved with this configuration, because it reduces the number of elements within the inner space of the exhaust casing. Thus, collisions of the steam passing through the system with said elements are reduced as well. Consequently, turbulent velocities of the steam are balanced and pressure losses caused by the collisions are reduced. As a result, the efficiency of the exhaust system and the overall performance of the turbine are improved. On top of that, vibrations of the system caused by the turbulent steam flow are reduced, which increases the durability of the individual elements present in the system. The present invention further relates to a low pressure steam turbine system comprising the exhaust casing as described above.

[0007] A low pressure steam turbine system comprises a low pressure steam turbine, a diffuser, and an exhaust casing covering the exhaust system. The diffuser may be a conventional diffuser, which is positioned directly behind the last row of blades of the steam turbine. The diffuser forms part of the exhaust system of the steam turbine system and comprises an exhaust guiding channel, formed by an inner guide and an outer guide, the outer guide being the one which is distant from a side wall of the exhaust casing. Once the steam has passed the last row of blades of the steam turbine, it is directed through the guiding channel and its outlet into the inner space of the exhaust system surrounded by the exhaust casing. The exhaust system leads the steam into the condenser, heat exchanger, or into an industrial process using the steam.

[0008] The steam turbine system may be divided into an upper part and a lower part, determined by the horizontal plane containing the longitudinal axis of the system. Further, the steam turbine system is usually symmetric about the vertical plane containing its transversal axis and may be also divided into a first half and a second half, determined by the vertical plane containing the transversal axis of the system. The exhaust casing as described in the following is provided in the first half of the upper part, covering at least part of the steam turbine and creating the inner space of the exhaust casing in the first half of the upper part of the system. In the lower part of the exhaust system corresponding to the lower part of the steam turbine (the lower part being below the horizontal plane of the longitudinal axis), the steam flows from the lower outlet of the diffuser directly into the outlet of the exhaust system; thus, there is no need to guide the steam and no vortices are formed in this part. The steam turbine system may comprise at least one exhaust casing as described in the following, preferably two exhaust casings, the two exhaust casings being mutually symmetric about the vertical plane containing the transversal axis. The two exhaust casings may then cover the whole low pressure steam turbine system.

[0009] In one embodiment of the invention, the steam turbine system may be one flow direction low pressure steam turbine with radial steam exhaust with only one low pressure steam turbine exhaust system and one exhaust casing.

[0010] The exhaust casing of the exhaust system may have a substantially cylindrical shape. The cylindrical shape is preferred for steam turbine systems with vertically oriented exhaust outlet.

[0011] In one embodiment of the invention, the exhaust casing of the steam turbine system may have another shape, preferably rectangular. A combination of a cylindrical and rectangular exhaust casing may be preferred for the steam turbine systems with horizontally oriented exhaust outlet.

[0012] The casing of the exhaust system may comprise one or more blocks. Preferably, the casing comprises two blocks - a first block and a second block, but it may also comprise more than two blocks. Configuration with more blocks may be preferred especially for large steam turbines.

[0013] The exhaust casing comprises an upper wall and a side wall, both having an inner surface and an outer surface. The exhaust casing may be made of creep-resistant materials, such as metals, e.g. of steel or steel alloys.

[0014] A vacuum needs to be provided in the inner space of the exhaust casing (typically a pressure of about 0.5 bar or less is used, preferably a pressure of about 0.1 bar or less is used); therefore the exhaust casing needs to be reinforced. The reinforcement is provided by a plurality of reinforcement elements, positioned within the inner space of the exhaust casing. The reinforcement elements are preferably positioned between the upper wall and the side wall of the exhaust casing. The reinforcement elements may be positioned between the upper wall and the connection between the side wall and the inner flow guide of the diffuser or between the upper wall and the inner flow guide of the diffuser. The reinforcement elements may have any suitable form, preferably a form of tubes or plates. An angle between the reinforcement element and the upper wall may be between 20 and 60 degrees, preferably between 30 and 50 degrees. The number of reinforcement elements should preferably be reduced as much as possible with respect to the reinforcement needs. The optimal number of reinforcement elements falls within a range of 5-15, preferably 7-10. They may preferably be made of the same material as the casing of the exhaust system, e.g. of steel or steel alloys.

[0015] Furthermore, guiding rib is located in the inner space created by the exhaust casing. The guiding rib is attached to the upper wall of the exhaust casing and oriented perpendicularly to the longitudinal axis of the system. The guiding rib extends from the inner surface of the upper wall radially inwards into the inner space of the exhaust system. Preferably, the guiding rib extends from the horizontal plane of the longitudinal axis of the system and follows the cylindrical shape of the upper wall of the exhaust casing.

[0016] In cross-section, the guiding rib may have an I-shape or a T-shape. The guiding rib may be formed of one single plate, or it may comprise more identical plates, preferably two - the first plate and the second plate. The T-shaped guiding rib preferably contains two identical L-shaped plates. The T-shaped guiding rib may also comprise an additional plate perpendicular to the plate or plates of the I-shaped guiding rib. The plates may be made of the same material as the exhaust casing, e.g. steel or steel alloys and may then be connected together by bolts and/or welding. There is no difference between the I-shaped guiding rib and the T-shaped guiding rib in terms of the improvement of the steam flow. In terms of construction, the I-shaped guiding rib is easier to manufacture. The T-shaped guiding rib on the other hand has an advantage that it is easier to weld.

[0017] The height h of the guiding rib is given with respect to the height H between the horizontal plane of the longitudinal axis and the highest point of the upper wall. The height h of the guiding rib may be in the range of $0.05*H$ and $0.15*H$, preferably $0.14*H$, more preferably about $0.1*H$. The reduction of pressure losses is higher within this height range in comparison to heights outside this range. The reduction of pressure losses is maximized for $h=0.1*H$. The same height range may be applied to both the I-shaped and the T-shaped guiding ribs. The width w of the T-shaped guiding rib is preferably equal to or less than 1.4*h, more preferably equal to or less than 1.2*h and even more preferably equal to or less than 1.0*h.

[0018] The guiding rib serves as a guide for the steam exiting the outlet of the diffuser in the substantially vertically upward direction to be turned in 180 degrees in order to flow downwards to the outlet of the exhaust system. In order to improve the steam flow to reduce the pressure losses caused by the formation of vortices, the guiding rib may be positioned in a specific position with respect to the exhaust outlet of the diffuser, or at a distance l from the side wall of the exhaust casing, respectively. The position or the distance l, respectively, may be determined based on the distance m between the end point of the outer guide of the guiding channel and the inner surface of the side wall of the exhaust casing. The optimal position may be at the distance l, which may be between 1.2*m and 1.9*m, more preferably, between 1.3*m and 1.7*m, even more preferably between 1.4*m and 1.6*m, and even more preferably at l=1.5*m from the inner surface of the side wall of the exhaust casing, wherein the parameter m is defined as described above. The reduction of pressure losses is higher within this range in comparison to the cases when the guiding rib is positioned outside this range. The reduction of pressure losses is maximized for the desirable position at l=1.5*m. The same position range may be applied to both the I-shaped and the T-shaped guiding ribs.

[0019] The guiding rib further provides the reinforcement for the exhaust casing of the steam turbine system. The guiding rib itself provides the reinforcement for the exhaust casing. Furthermore, the guiding rib serves as a fastening element for fastening the reinforcement elements to the upper wall of the exhaust casing, such that no separate fastening ribs are needed. The reinforcement elements are fastened to the guiding rib. They may be fastened directly to the guiding rib, or an abutment element may be provided in order to fasten the reinforcement element to the guiding rib. The abutment element may have any suitable shape and size. The height of the abutment element should preferably be equal to or less than the height h of the guiding rib, in order not to introduce further obstacles for the flowing steam. The width of the abutment element should preferably be equal to or less than the height of the abutment element. One single abutment element may be provided along the guiding rib, or, preferably, separate abutment elements may be provided for each of the reinforcement elements. The reinforcement elements are fastened to the guiding rib or to the abutment elements by any suitable means known in the art, e.g. by bolts and/or welding, preferably by both bolts and welding, in order to ensure a solid connection.

[0020] In one embodiment, the reinforcing elements may penetrate the guiding rib and may be attached to the upper wall at the side of the guiding rib that is distant from the side wall. In such a case, the guiding rib and the penetrating reinforcement elements are fastened to each other, e.g. by welding. In order to fasten the reinforcement elements to the upper wall, a separate abutment elements are needed, however, the size of those separate abutment elements may be reduced, because the welded connections of the reinforcement elements with the guiding rib provide additional fixation.

[0021] In any case, such a configuration, in which the guiding rib provides a fastening element for the reinforcing elements, is advantageous, because there is no need for separate fastening elements. Thus, the number of elements within the inner space of the exhaust casing is reduced, which in turn leads to reduction of steam collisions with these elements within said inner space and to reduction of the pressure losses within the exhaust system.

[0022] The guiding rib may be attached to the upper wall in one of the following ways: a single plate of the guiding rib may be attached to the inner surface of the upper wall or a single plate of the guiding rib may be used as a connecting element to connect the individual blocks of the exhaust casing. Alternatively, the first plate may be attached to the first block of the exhaust casing and the second plate may be attached to the second block of the exhaust casing. The connections between the rib and the casing blocks may be provided by any suitable means known in the art, e.g. by bolts and/or welding, preferably by both bolts and welding, in order to ensure a secure and sealed connection. Such a configuration, in which the guiding rib provides also a connection of the casing blocks, is advantageous, because there is no need for a separate connecting element for connecting the individual blocks of the casing. Thus, the number of elements within the inner space of the exhaust casing is reduced, which in turn leads to reduction of steam collisions with these elements within said inner space and to reduction of the pressure losses within the exhaust system. The guiding rib serves as a guide for a steam moving in the substantially vertically upward direction to be turned by 180 degrees in order to flow downwards to the outlet of the exhaust system. The guiding rib further serves as a reinforcing element and as a fastening element for fastening the reinforcement elements to the upper wall of the exhaust casing and may also serve as a connecting element between casing blocks. If the reinforcement elements are fastened to the guiding rib, directly or through the abutment element/elements, no further ribs or fastening elements are required. Similarly, if the casing blocks are connected by the guiding rib directly, no further connecting element is required. Thus, any of the above-mentioned configurations, whether applied separately or in combination, allows for improvement of the steam flow efficiency, because it reduces the number of elements within the inner space of the exhaust casing. Thus, collisions of the steam passing through the system with said elements are reduced as well. Consequently, turbulent velocities of the steam are balanced and pressure losses caused by the collisions are reduced. As a result, the efficiency of the exhaust system and the overall performance of the turbine are improved. On top of that, vibrations of the system caused by the turbulent steam flow are reduced, which increases the durability of the individual elements present in the system.

Brief description of figures

[0023]

Fig. 1 shows a vertical cross-section of the first half of the upper part of the steam turbine system, showing the exhaust system with the exhaust casing.

Fig. 2 shows the 3D model of the two connected exhaust casings, providing the cover of the whole steam turbine system.

Fig. 3 shows a dependency of a normalized loss coefficient on the position of the guiding rib from the inner surface of the side wall.

Examples

[0024] The present invention is further illustrated by way of example of preferred embodiments of the exhaust casing for the low pressure steam turbine system, described in the following with references to the attached figures. The examples should not be construed as limiting the claimed scope.

[0025] A low pressure steam turbine system of Fig. 1 comprises a low pressure steam turbine 1, a diffuser 22, and an exhaust casing 10 covering the exhaust system. The diffuser 22 may be a conventional diffuser, which is positioned directly behind the last row of blades 24 of the steam turbine 1. The diffuser 22 comprises an exhaust guiding channel 19, formed by an inner guide 20 and an outer guide 21. Once the steam has passed the last row of blades 24 of the steam turbine 1, it is directed through the guiding channel 19 and its outlet 23 into the inner space 18 of the exhaust system surrounded by the exhaust casing 10.

[0026] The exhaust casing 10 is provided in the first half of the upper part of the steam turbine system, which is the part above the horizontal plane containing the longitudinal axis 25 of the system, covering at least part of the steam turbine 1 and creating the inner space 18 of the exhaust casing 10 in the upper part of the system, into which the steam exits from the outlet 23 of the diffuser 22 and where it is to be turned 180 degrees towards the outlet 26 in the lower part of the steam turbine system below the horizontal plane of the longitudinal axis.

[0027] The exhaust casing 10 of the exhaust system has a substantially cylindrical shape and comprises an upper wall 11 and a side wall 12. The casing 10 of the exhaust system has an inner surface 13 and an outer surface 14. The exhaust casing 10 may be made of creep-resistant materials, such as metals, e.g. of steel or steel alloys.

[0028] The reinforcement of the exhaust casing 10 is provided by the guiding rib 17 itself and by a plurality of reinforcement elements 15, which are preferably positioned between the upper wall 11 and place of connection of the inner flow guide 20 to the side wall 12 of the exhaust casing 10. The reinforcement elements 15 may have a form of tubes or plates, preferably tubes. The optimal number of reinforcement elements 15 is from 5 to 15, preferably 7 to 10; in the provided example, eleven reinforcement elements is provided. They may preferably be made of the same material as the casing 10 of the exhaust system, e.g. of steel or steel alloys.

[0029] The guiding rib 17 is attached to the upper wall 11 of the exhaust casing 10 and oriented perpendicularly to the longitudinal axis 25 of the system. It extends from the inner surface 13 of the upper wall 11 radially inwards into the inner space 18 of the exhaust casing. The guiding rib 17 extends from the horizontal plane of the longitudinal axis 25 of the system and follows the cylindrical shape of the upper wall 11 of the exhaust casing 10, which can be seen in the 3D model of Fig. 2.

[0030] An embodiment with the T-shaped guiding rib 17 is shown in Fig. 1, but the T-shaped rib may be replaced by an I-shaped rib. Preferably, the T-shaped guiding rib 17 comprises two identical plates - the first plate 171 and the second plate 172. The plates may be made of the same material as the exhaust casing, e.g. steel or steel alloys and may then be connected together by bolts and/or welding.

[0031] The *height h* of the guiding rib 17 is given with respect to the height H between the horizontal plane of the longitudinal axis 25 and the highest point of the upper wall 11. The height h of the guiding rib 17 may be in the range of $0.05*H$ and $0.15*H$, preferably $0.14*H$, more preferably $0.1*H$. In the shown example, the height of the guiding rib 17 is $0.1*H$. The same height range may be applied to both the I-shaped and the T-shaped guiding ribs 17. The width w of the T-shaped guiding rib 17 is preferably equal to or less than $1.4*h$, more preferably equal to or less than $1.2*h$ and even more preferably equal to or less than $1.0*h$.

[0032] The guiding rib 17 may be positioned in a specific position with respect to the exhaust outlet 23 of the diffuser 22. The specific position is at the distance l, which may be between $1.2*m$ and $1.9*m$, more preferably, between $1.3*m$ and $1.7*m$, even more preferably between $1.4*m$ and $1.6*m$, and even more preferably at $l=1.5*m$ from the inner surface 13 of the side wall 12 of the exhaust casing 10, wherein the parameter m is defined as the distance between the end point of the outer guide 21 of the guiding channel 19 and the inner surface 13 of the side wall 12 of the exhaust casing 10. The above-mentioned position range is based on measurements of a loss coefficient of the steam flow (representing the pressure losses of the steam flow) for various positions various positions of the guiding rib 17. The results of the measurements may be seen in Fig. 3, in which the dependency of the loss coefficient normalized according to its highest value on the position of the guiding rib 17 from the inner surface 13 of the side wall 12 is shown. According to these measurements, the pressure losses for the guiding rib 17 positioned between 1.2*m and 1.9*m are relatively low compared to losses measured outside this range.

[0033] The guiding rib 17 serves as a fastening element for fastening the reinforcement elements 15 to the upper wall 11 of the exhaust casing 10. The reinforcement elements 15 may be fastened directly to the guiding rib 17, or, as can be seen in Fig.1, an abutment element 16 may be provided in order to fasten the reinforcement element 15 to the guiding rib 17. The abutment element 16 may have any suitable shape and size. The height of the abutment element 16 is preferably equal to or less than the height h of the guiding rib 17. The width of the abutment element 16 is preferably equal to or less than the height of the abutment element 16. One single abutment element 16 may be provided along the guiding rib (not shown), or, preferably, separate abutment elements 16 may be provided for each of the reinforcement elements 15. The reinforcement elements 15 are fastened to the guiding rib 17 or to the abutment elements 15 aby any suitable means known in the art, e.g. by bolts and/or welding, preferably by both bolts and welding, in order to ensure a solid connection.

[0034] In one embodiment, the reinforcing elements 15 may penetrate the guiding rib 17 and may be attached to the upper wall 11 at the side of the guiding rib 17, which is distant from the side wall 12.

[0035] In a preferred embodiment, the casing 10 of the exhaust system may comprise one or more blocks. Preferably, it comprises two blocks - a first block 10a and a second block 10b. As can be seen in Fig. 1, the first block 10a and the second block 10b may be connected together. Preferably, the first plate 171 of the guiding rib 17 may be attached to the first block 10a of the exhaust casing 10 and the second plate 172 may be attached to the second block 10b of the exhaust casing 10. The connections between the rib 17 and the casing blocks 10a, 10b may be provided by any suitable means known in the art, e.g. by bolts and/or welding, preferably by both bolts and welding, in order to ensure a secure and sealed connection.

[0036] Finally, the 3D model in Fig. 2 shows a preferred embodiment of the low pressure steam turbine system with two connected exhaust casings.

Claims

1. An exhaust casing (10) for a low pressure steam turbine system comprising
an upper wall (11) and a side wall (12),
an inner surface (13) and an outer surface (14),
a plurality of reinforcement elements (15), and
a guiding rib (17), the guiding rib (17) attached to the upper wall (11) of the exhaust casing (10) and extending radially inwards, **characterized in that**
at least one of the reinforcement elements (15) is fastened to the guiding rib (17).

2. The exhaust casing (10) according to claim 1, wherein
the guiding rib (17) is positioned at a distance ranging between 1.2*m and 1.9*m from the inner surface (13) of the side wall (12) of the turbine casing (10), wherein the parameter m is defined as a distance of an end point of an outer guide (21) of a diffuser (22) of the steam turbine system from the inner surface (13) of the side wall (12).

3. The exhaust casing (10) according to any one of the preceding claims, wherein
the height of the guiding rib (17) lies within the range of 0.05*H to 0.15*H, wherein H is the height of the steam turbine system between the horizontal plane of the longitudinal axis (25) and the highest point of the upper wall (11).

4. The exhaust casing (10) according to any one of the preceding claims, wherein
the guiding rib (17) has an I-shape and comprises at least one plate, or the guiding rib (17) has a T-shape and comprises at least two plates perpendicular to each other.

5. The exhaust casing (10) according to any one of the preceding claims, wherein
each of the casing reinforcement elements (15) is fastened to the guiding rib (17) through a separate abutment element (16).

6. The exhaust casing (10) according to claim 5, wherein
the height of each of the separate abutment elements (16) is equal to or less then the height h of the guiding rib (17) and wherein a width of each of the separate abutment elements (16) is equal to or less then the height of the separate abutment element (16).

7. The exhaust casing (10) according to any one of the claims 1 to 4, wherein
at least one of the reinforcement elements (15) penetrates the guiding rib (17) and is fastened to the upper wall (11) at the side of the guiding rib (17), which is distant from the side wall (12) of the exhaust casing (10).

8. The exhaust casing (10) according to any one of the preceding claims further comprising at least two casing blocks (10a, 10b), wherein
the first plate (171) of the guiding rib (17) is attached to the first block (10a) of the exhaust casing (10) and the second plate (172) of the guiding rib (17) is at-

tached to the second block (10b) of the exhaust casing (10).

9. A steam turbine system comprising at least one exhaust casing (10) according to any one of the preceding claims.

Fig. 1

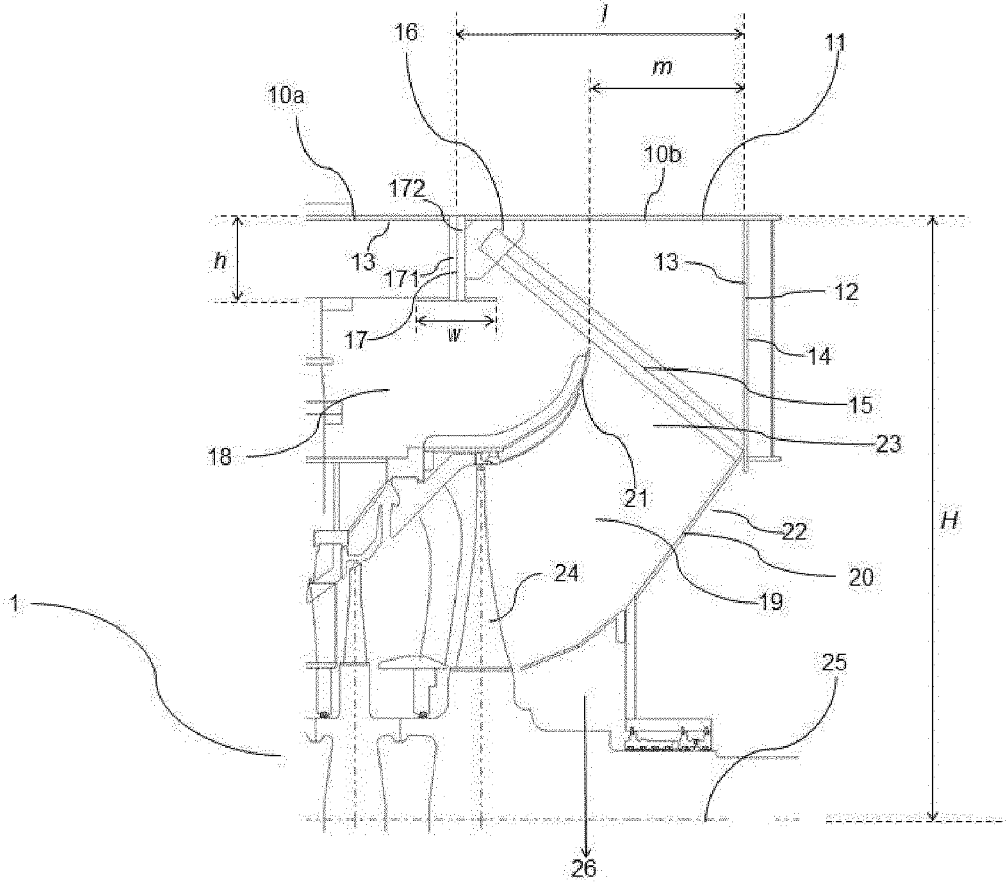
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Fig. 2

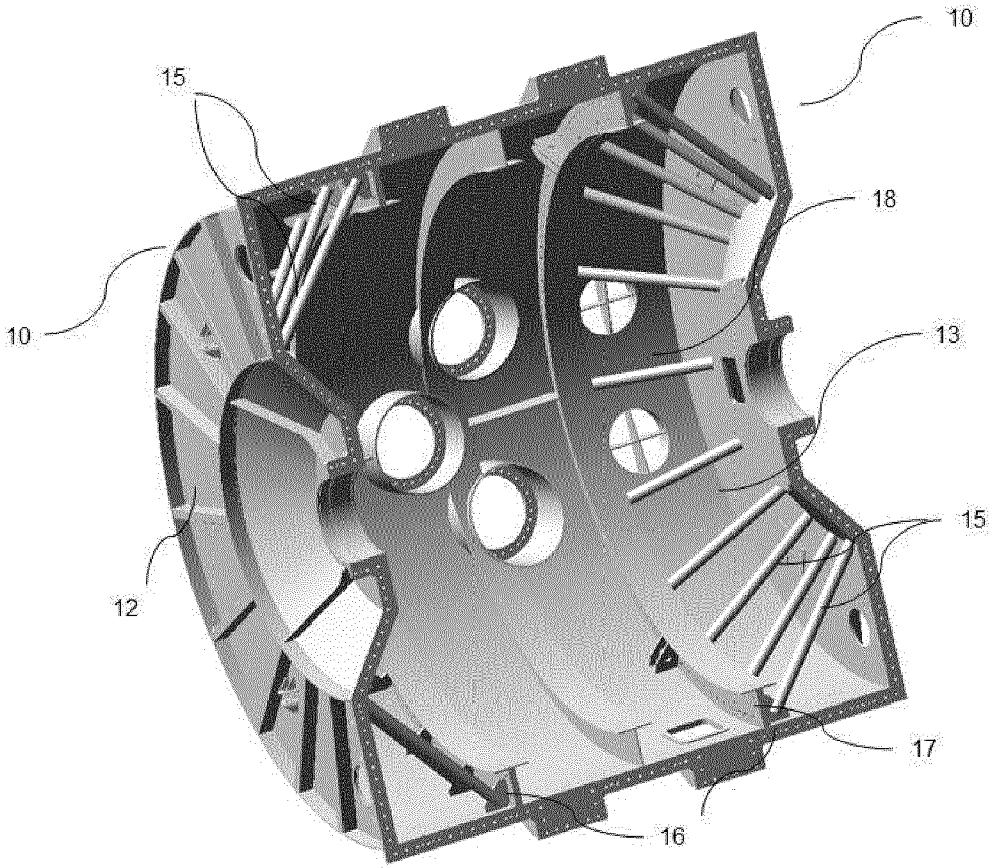
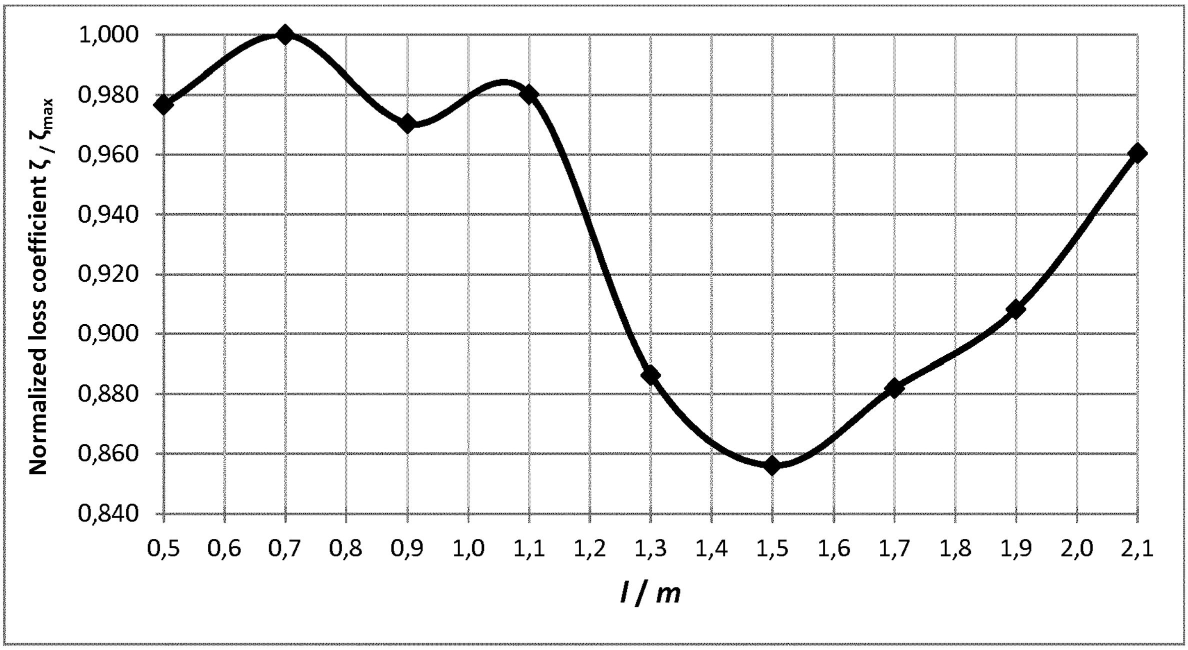


Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 9912

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/207595 A1 (ROGE JULIEN [FR] ET AL) 16 August 2012 (2012-08-16) * paragraph [0030] - paragraph [0031]; claims 1-3, 6, 9; figures 2, 4 * * paragraph [0034] * -----	1-9	INV. F01D25/30 F01D25/28
X	US 5 203 674 A (VINCIGUERRA COSTANTINO [IT]) 20 April 1993 (1993-04-20) * column 5, line 8 - column 5, line 27 * -----	1-6,9	
X	US 4 863 341 A (GROENENDAA J C; GROENENDAAL J C) 5 September 1989 (1989-09-05) * column 3, line 27 - column 3, line 41 * -----	1-4,9	
X	US 4 764 084 A (PARKER DAVID M [US] ET AL) 16 August 1988 (1988-08-16) * figure 1 * -----	1	
A	US 5 024 579 A (GROENENDAAL JR JOHN C [US] ET AL) 18 June 1991 (1991-06-18) -----	1	TECHNICAL FIELDS SEARCHED (IPC)
A	EP 2 666 975 A1 (MITSUBISHI HEAVY IND LTD [JP]) 27 November 2013 (2013-11-27) -----	1	F01D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	26 January 2017	Alaguero, Daniel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 18 9912

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