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(54) HEAT RECOVERY OR WORK RECOVERY SYSTEM, EJECTOR THEREFOR AND FLUID MIXING METHOD

(57) An ejector (80) for a heat recovery or work recovery system, a heat recovery or work recovery system, and a method of mixing fluids in a heat recovery or work recovery system are provided by the present disclosure. The ejector includes: a high-pressure fluid passage (1) including a high-pressure fluid inlet (11) and a high-pressure fluid nozzle (12); a suction fluid passage (2) including a suction fluid inlet (21) and a suction chamber (22) surrounding the high-pressure fluid nozzle; a mixing chamber (3) in fluid communication with the high-pressure fluid passage and the suction fluid passage respectively; and a diffusion chamber (4) downstream of the mixing chamber; wherein a front end of an outer wall of the high-pressure fluid nozzle has an arc-shaped rounded portion. The ejector according to the embodiment of the present disclosure has improved efficiency.

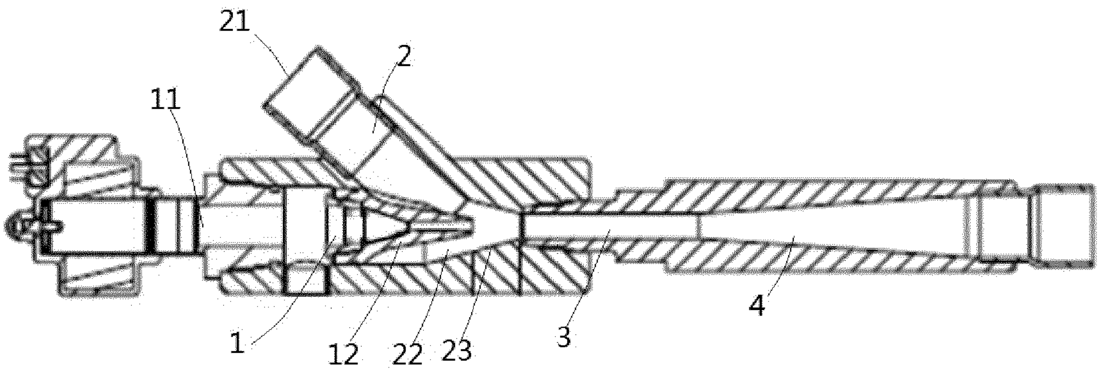

Fig.2

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Description

FIELD OF THE INVENTION

[0001] The present disclosure relates to the field of heat recovery or work recovery systems. More specifically, the present disclosure relates to an ejector for a heat recovery or work recovery system, a heat recovery or work recovery system, and a method of mixing fluids in a heat recovery or work recovery system.

BACKGROUND OF THE INVENTION

[0002] In commercial heat recovery or work recovery systems, especially systems that require a large pressure differential, an ejector is used to improve efficiency. The ejector for example pressurizes a suction fluid by means of a high-pressure fluid and supplies mixed fluids to a compressor inlet, thereby increasing the pressure of fluid at the compressor inlet, reducing the requirements on the capacity of the compressor and improving the efficiency of the system.

[0003] The ejector usually includes a high-pressure fluid nozzle to convert the high-pressure fluid into a high-momentum fluid. The suction fluid is suctioned in with the high-momentum fluid and mixed with the high-momentum fluid in a mixing chamber, then diffuses in a diffusion chamber to increase the pressure of the fluid and is subsequently supplied to for example a compressor. If vortices are formed in the ejector, a loss of fluid energy will be caused and the efficiency of the ejector will be reduced.

SUMMARY OF THE INVENTION

[0004] An object of the present disclosure is to solve or at least alleviate the problems existing in the related art.

[0005] In a first aspect there is provided an ejector for a heat recovery or work recovery system, the ejector comprising: a high-pressure fluid passage including a high-pressure fluid inlet and a high-pressure fluid nozzle; a suction fluid passage including a suction fluid inlet and a suction chamber surrounding the high-pressure fluid nozzle; a mixing chamber in fluid communication with the high-pressure fluid passage and the suction fluid passage respectively; and a diffusion chamber downstream of the mixing chamber; wherein a front end of an outer wall of the high-pressure fluid nozzle has an arc-shaped rounded portion.

[0006] Optionally, the outer wall of the high-pressure fluid nozzle has a cone-shaped section on a front side, and the arc-shaped rounded portion starts from a position at 75% to 98% of a total length of the cone-shaped section of the outer wall of the high-pressure fluid nozzle, and ends at a position at 100% of the total length of the cone-shaped section of the outer wall.

[0007] Optionally, a thickness of a frontmost side of the outer wall of the high-pressure fluid nozzle is less than 1mm.

[0008] Optionally, the outer wall of the high-pressure fluid nozzle includes a mounting portion, a concave arc-shaped section on a front side of the mounting portion, and the cone-shaped section on a front side of the concave arc-shaped section, the arc-shaped rounded portion is located at a frontmost side of the cone-shaped section, and an interior of the high-pressure fluid nozzle includes a constricted section, a throat portion, a diffusion section and a high-pressure fluid outlet in sequence.

[0009] Optionally, the arc-shaped rounded portion at the front end of the high-pressure fluid nozzle is formed by a rounding process after cutting, wherein the rounding process is for example performed by laser cutting or mechanical grinding.

[0010] In a second aspect there is provided a heat recovery or work recovery system including the ejector according to the first aspect, wherein the ejector may include any/all of the optional features discussed above.

[0011] In a third aspect there is provided a method of mixing fluids, the method including: passing a first fluid through a high-pressure fluid nozzle in a high-pressure fluid passage; suctioning a second fluid via a suction fluid passage by means of a kinetic energy of the first fluid, the suction fluid passage including a suction chamber surrounding the high-pressure fluid nozzle; mixing the first fluid and the second fluid in a mixing chamber; and diffusing the mixed fluid in a diffusion chamber; wherein the method further includes forming an arc-shaped rounded portion at a front end of an outer wall of the high-pressure fluid nozzle to reduce a flow energy loss of the second fluid therethrough.

[0012] Optionally, the method may include forming the arc-shaped rounded portion at the front end of the high-pressure fluid nozzle by a rounding process after cutting, wherein the rounding process is for example performed by laser cutting or mechanical grinding.

[0013] Optionally, the outer wall of the high-pressure fluid nozzle may have a cone-shaped section on a front side, and the method may include: starting the arc-shaped rounded portion from a position at 75% to 98% of a total length of the cone-shaped section of the outer wall of the high-pressure fluid nozzle, and ending the arc-shaped rounded portion at a position at 100% of the total length of the cone-shaped section of the outer wall.

[0014] Optionally, the method may include forming a frontmost side of the outer wall of the high-pressure fluid nozzle to have a thickness of less than 1mm.

[0015] The device and method according to the present invention can improve the efficiency of the ejector and a system to which the ejector is applied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Certain embodiments of the present disclosure will now be described in greater detail by way of example only and with reference to the accompanying drawings.

It can be easily understood by those skilled in the art that the drawings are merely used for illustration, and are not intended to limit the scope of the invention as set out in the appended claims. In addition, like parts are denoted by like numerals in the drawings, wherein:

FIG. 1 shows a schematic view of a work recovery system;

FIG. 2 shows a schematic structural view of an ejector;

FIG. 3 shows a perspective view of an ejector nozzle;

FIG. 4 shows a sectional view of an ejector nozzle;

FIG. 5 shows a sectional view of an ejector nozzle; and

FIG. 6 shows a schematic flow simulation of two kinds of ejector nozzles.

DETAILED DESCRIPTION OF THE EMBODIMENT(S) OF THE INVENTION

[0017] Referring to FIG. 1, a work recovery system to which an ejector according to an embodiment of the present disclosure is applied will be described. An example will be used in which the work recovery system is a refrigeration device. The work recovery system may include a compressor 83, an outlet of the compressor 83 is connected to an inlet of a condenser 82 downstream thereof, and an outlet of the condenser 82 is connected to a high-pressure fluid inlet 11 of an ejector 80. On the other hand, a fluid outlet 43 of the ejector 80 is connected to a separator 84. A fluid exiting from the fluid outlet 43 of the ejector 80 is separated in the separator, wherein a gas phase returns to an inlet of the compressor 83, and a liquid phase passes through a valve 85 and an evaporator 86 and then arrives at a suction fluid inlet 21 of the ejector 80. In the illustrated embodiment, the ejector 80 is used in the work recovery system as shown in FIG. 1. In an alternative embodiment, the ejector 80 may also be applied to other types of more complicated work recovery systems. In addition, the ejector 80 may also be applied to a heat recovery system, such as a heat recovery system including a generator. In the illustrated embodiment, the work recovery system includes only one ejector, and in alternative embodiments, the system may include a plurality of ejectors. Therefore, the ejector according to various embodiments can be applied to various types of heat recovery or work recovery systems.

[0018] With continued reference to FIG. 2, a sectional view of the ejector is shown. The ejector includes: a high-pressure fluid passage 1 including a high-pressure fluid inlet 11 and a high-pressure fluid nozzle 12; a suction fluid passage 2 including a suction fluid inlet 21 and a suction chamber 22 surrounding the high-pressure fluid nozzle 12; a mixing chamber 3 in fluid communication with the high-pressure fluid passage 1 and the suction fluid passage 2 respectively; and a diffusion chamber 4 downstream of the mixing chamber 3. In the illustrated embodiment, a high-pressure fluid outlet of the high-pressure fluid nozzle 12 in the high-pressure fluid passage 1 is aligned with the mixing chamber 3, and the connection between the suction chamber 22 and the mixing chamber has a tapered transition section 23. In the illustrated embodiment, the mixing chamber 3 has a substantially uniform cross-sectional area, and the diffusion chamber 4 has a gradually increasing cross-sectional area. The working principle of the ejector is generally described as follows: a high-pressure fluid is converted into a high-momentum fluid when passing through the high-pressure fluid nozzle, the suction fluid is suctioned into the mixing chamber with the high-momentum fluid and mixed with the high-momentum fluid in the mixing chamber, and then diffuses in the diffusion chamber to recover the pressure of the fluid, which is then supplied to an apparatus such as a compressor.

[0019] With continued reference to FIG. 3, a perspective view of the high-pressure fluid nozzle is shown. The high-pressure fluid nozzle 12 may for example include: a mounting portion 121 for fixing into the ejector, wherein the mounting portion 121 is for example cylindrical and has a snap-in slot, a front side of the mounting portion 121 is a concave arc-shaped section 122, a front side of the concave arc-shaped section 122 is a cone-shaped section 123, and a frontmost side 124 of the cone-shaped section 123 has an arc-shaped rounded portion 129 (see FIG. 5).

[0020] With continued reference to FIG. 4, a sectional view of the high-pressure fluid nozzle is shown. The interior of the high-pressure fluid nozzle may include a constricted section 125, a throat portion 126, a diffusion section 127, and a high-pressure fluid outlet 128. The high-pressure fluid outlet 128 is located radially inward of the frontmost side 124 of the cone-shaped section 123. As shown in FIG. 4, the frontmost side 124 of a conventional nozzle is formed with an obtuse-angle portion by cutting, and the obtuse-angle portion will cause vortices to be generated when the suction fluid passes through, thereby causing energy loss of the fluid. In addition, a wall thickness T at the frontmost side 124 of the high-pressure fluid nozzle formed by cutting is generally greater than 1mm. With continued reference to FIG. 5, the high-pressure fluid nozzle according to an embodiment of the present disclosure is shown, which has an arc-shaped rounded portion 129 at the frontmost side 124, that is, a portion 130 of the high-pressure fluid nozzle at the frontmost side of the frontmost side 124 is removed so that a smooth transition is formed there without having an obtuse angle. In some embodiments, the arc-shaped rounded portion 129 may be formed by a rounding process after cutting, for example, by laser cutting or mechanical grinding. In some embodiments, the frontmost side of the outer wall of the high-pressure fluid nozzle has a thickness of less than 1mm, which is obviously smaller than that of a conventional high-pressure fluid nozzle. In some embodiments, the outer wall of the high-pressure fluid nozzle has a cone-shaped section on the front side (points A to B in FIG. 5), and the arc-shaped rounded portion starts from a position at 75% to 98% of a total length of the cone-shaped section of the outer wall of the high-pressure fluid nozzle (marked with C), and ends at a position at 100% of the total length of the cone-shaped section of the outer wall (point B); in other words, a length L_1 from the starting point A of the cone-shaped section to the starting point C of the arc-shaped rounded portion accounts for 75% to 98% of the total length $L_1 + L_2$ (from A to B) of the cone-shaped section. In some embodiments, the length L_2 of the arc-shaped rounded portion accounts for at least 2%, or at least 5%, or at least 10%, or at least 15% of the total length $L_1 + L_2$ of the cone-shaped section. In some embodiments, the length L_2 of the arc-shaped rounded portion accounts for at most 25%, or at most 15%, or at most 10% of the total length $L_1 + L_2$ of the cone-shaped section.

[0021] With continued reference to FIG. 6, fluid simulation diagrams when the front side of the high-pressure nozzle is rounded (right) and not rounded (left) are shown respectively. It can be seen from FIG. 6 that vortices (as shown in the block) of the fluid on the front side of the high-pressure nozzle are significantly reduced after the rounding process. After calculation and analysis, if the front side of the high-pressure nozzle is rounded, the efficiency of the ejector can be increased by 1%, which can effectively improve the efficiency of the entire heat recovery or work recovery system. Therefore, according to another aspect, a heat recovery or work recovery system is provided, which includes the ejector according to various embodiments.

[0022] In another aspect, a method of mixing fluids is provided, which includes: passing a first fluid through a high-pressure fluid nozzle in a high-pressure fluid passage; suctioning a second fluid via a suction fluid passage by means of a kinetic energy of the first fluid, the suction fluid passage including a suction chamber surrounding the high-pressure fluid nozzle; mixing the first fluid and the second fluid in a mixing chamber; and diffusing the mixed fluid in a diffusion chamber; wherein the method further includes forming an arc-shaped rounded portion at a front end of an outer wall of the high-pressure fluid nozzle to reduce a flow energy loss of the second fluid therethrough. This method can effectively reduce the vortices of the fluid in the ejector at the front end of the high-pressure fluid nozzle, thereby reducing the flow energy loss there and improving the efficiency of the ejector.

[0023] In some embodiments, the method includes forming the arc-shaped rounded portion at the front end of the high-pressure fluid nozzle by a rounding process after cutting, for example by mechanical grinding or laser cutting. In some embodiments, the outer wall of the high-pressure fluid nozzle has a cone-shaped section on a front side, and the method includes: starting the arc-shaped rounded portion from a position at 75% to 98% of a total length of the cone-shaped section of the outer wall of the high-pressure fluid nozzle, and ending the arc-shaped rounded portion at a position at 100% of the total length of the cone-shaped section of the outer wall. In some embodiments, the method includes forming a frontmost side of the outer wall of the high-pressure fluid nozzle to have a thickness of less than 1mm. Through calculation and analysis, by rounding the front side of the high-pressure nozzle by the method according to the embodiment of the present disclosure, the efficiency of the ejector can be improved by about 1%, for example.

[0024] The specific embodiments described above are merely for describing the principle of the present invention more clearly, and various components are clearly illustrated or depicted to make it easier to understand the principle of the present invention. Those skilled in the art can readily make various modifications or changes to the present disclosure without departing from the scope of the present invention as set out in the appended claims. Therefore, it should be understood that these modifications or changes should be included within the scope of protection of the present invention.

Claims

1. An ejector (80) for a heat recovery or work recovery system, comprising:

    a high-pressure fluid passage (1) comprising a high-pressure fluid inlet (11) and a high-pressure fluid nozzle (12);
    a suction fluid passage (2) comprising a suction fluid inlet (21) and a suction chamber (22) surrounding the high-pressure fluid nozzle;
    a mixing chamber (3) in fluid communication with the high-pressure fluid passage and the suction fluid passage respectively; and
    a diffusion chamber (4) downstream of the mixing chamber;
    wherein a front end of an outer wall of the high-pressure fluid nozzle has an arc-shaped rounded portion (129).

2. The ejector for a heat recovery or work recovery system according to claim 1, wherein the outer wall of the high-pressure fluid nozzle (12) has a cone-shaped section (123) on a front side, and the arc-shaped rounded portion (129) starts from a position at 75% to 98% of a total length of the cone-shaped section of the outer wall of the high-pressure fluid nozzle, and ends at a position at 100% of the total length of the cone-shaped section of the outer wall.

3. The ejector for a heat recovery or work recovery system according to claim 1 or 2, wherein a thickness of a frontmost side (124) of the outer wall of the high-

pressure fluid nozzle (12) is less than 1mm.

4. The ejector for a heat recovery or work recovery system according to claim 2, wherein the outer wall of the high-pressure fluid nozzle (12) comprises a mounting portion (121), a concave arc-shaped section (122) on a front side of the mounting portion, and the cone-shaped section (123) on a front side of the concave arc-shaped section, the arc-shaped rounded portion (129) is located at a frontmost side (124) of the cone-shaped section, and an interior of the high-pressure fluid nozzle comprises a constricted section (125), a throat portion (126), a diffusion section (127) and a high-pressure fluid outlet (128) in sequence.

5. The ejector for a heat recovery or work recovery system according to claim 1 or 2, wherein the arc-shaped rounded portion (129) at the front end of the high-pressure fluid nozzle (12) is formed by a rounding process after cutting, and the rounding process is for example performed by laser cutting or mechanical grinding.

6. A heat recovery or work recovery system, comprising the ejector according to any one of claims 1 to 5.

7. A method of mixing fluids, comprising:

   passing a first fluid through a high-pressure fluid nozzle (12) in a high-pressure fluid passage (1);
   suctioning a second fluid via a suction fluid passage (2) by means of a kinetic energy of the first fluid, the suction fluid passage comprising a suction chamber (22) surrounding the high-pressure fluid nozzle;
   mixing the first fluid and the second fluid in a mixing chamber (3); and
   diffusing the mixed fluid in a diffusion chamber (4);
   wherein an arc-shaped rounded portion (129) is formed at a front end of an outer wall of the high-pressure fluid nozzle (12) to reduce a flow energy loss of the second fluid therethrough.

8. The method according to claim 7, wherein the method comprises forming the arc-shaped rounded portion (129) at the front end of the high-pressure fluid nozzle (12) by a rounding process after cutting, and the rounding process is for example performed by laser cutting or mechanical grinding.

9. The method according to claim 7 or 8, wherein the outer wall of the high-pressure fluid nozzle (12) has a cone-shaped section (123) on a front side, and the method comprises: starting the arc-shaped rounded portion (129) from a position at 75% to 98% of a total length of the cone-shaped section of the outer wall of the high-pressure fluid nozzle, and ending the arc-shaped rounded portion at a position at 100% of the total length of the cone-shaped section of the outer wall.

10. The method according to claim 7 or 8, wherein the method comprises forming a frontmost side (124) of the outer wall of the high-pressure fluid nozzle (12) to have a thickness of less than 1mm.

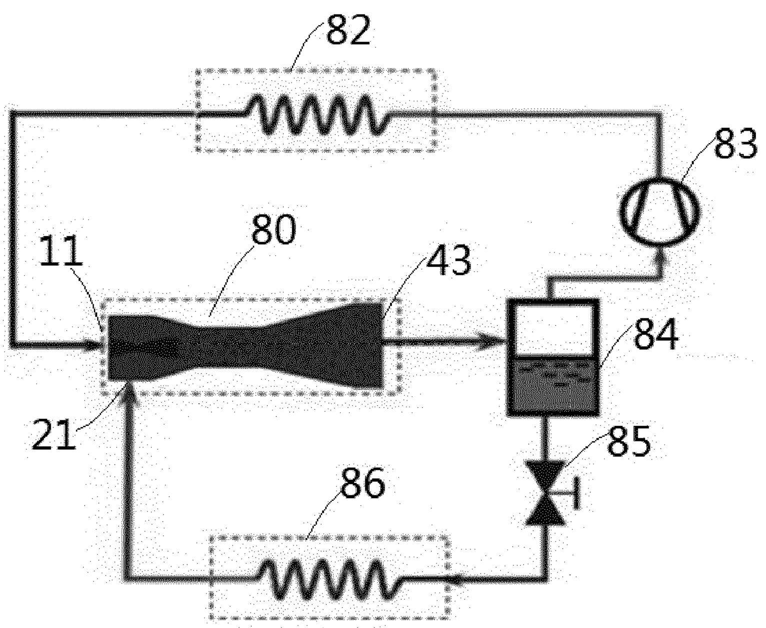

Fig.1

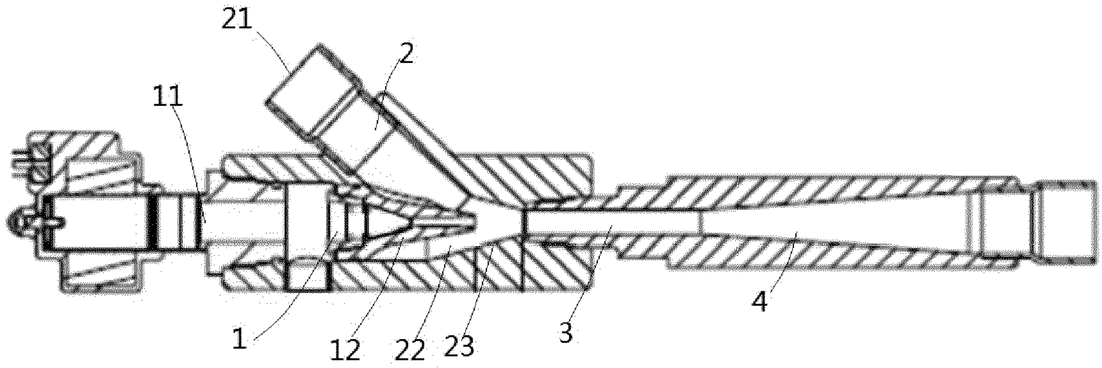

Fig.2

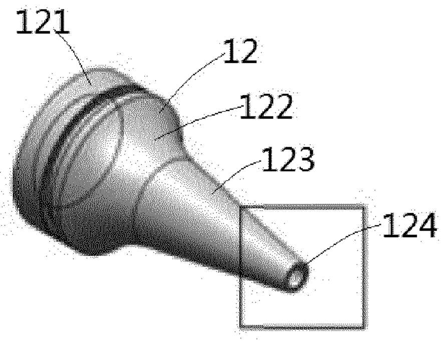

Fig.3

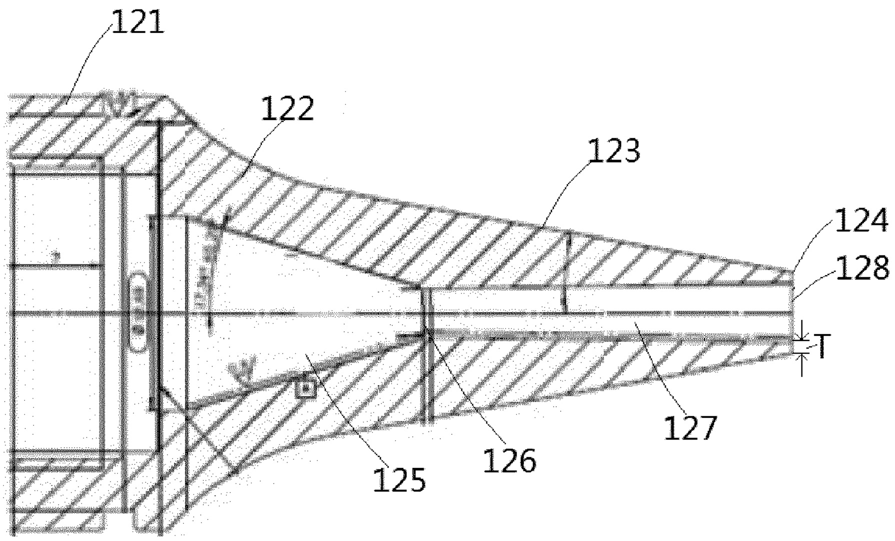

Fig.4

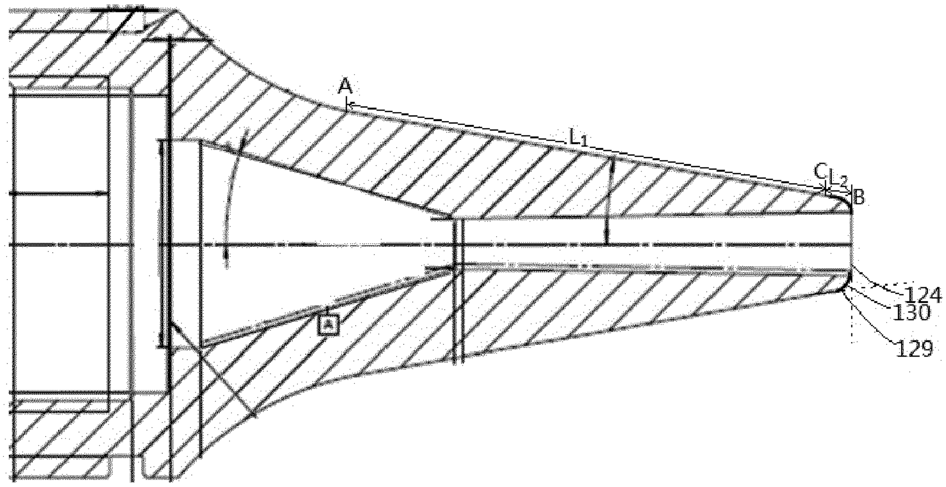

Fig.5

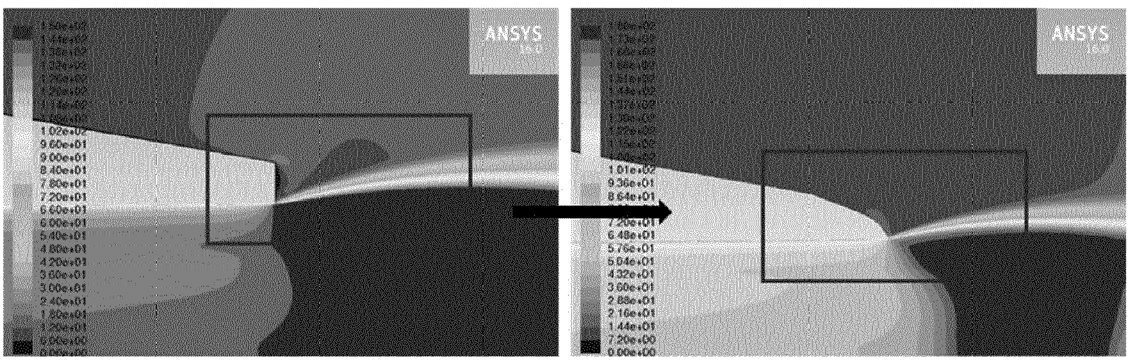

Fig.6

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EUROPEAN SEARCH REPORT

Application Number
EP 20 21 4609

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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
The Hague	26 May 2021	Krasenbrink, B

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 21 4609

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