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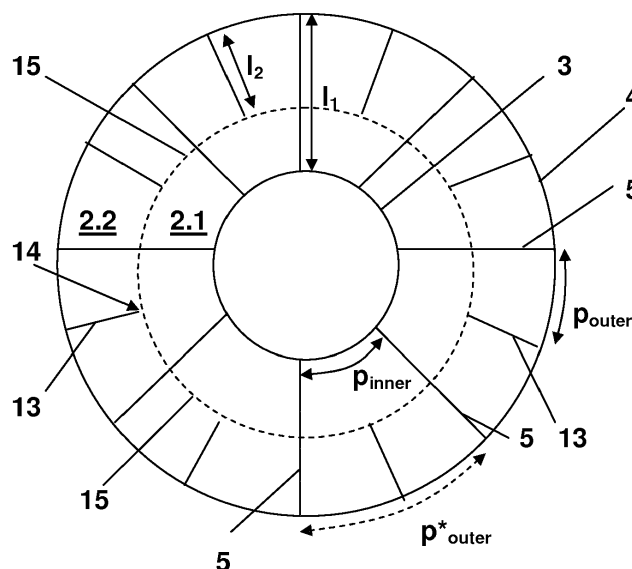
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(54) Swirl generator

(57) The invention refers to a swirl generator (1) for creation a swirling premixed fuel-air mixture for combustion in a gas turbine combustor comprising an annular flow channel (2) bordered by a radially inner (3) and outer channel wall (4) between which a plurality of swirler vanes (5) of a first type are uniformly distributed in a circumferential direction (6) of the annular flow channel (2) each of which is connected radially with the inner and outer channel wall (3, 4) and provides a leading (8) and a trailing edge (9) which are interconnected by a streamlined suction (11) and pressure side (10) wall.

The invention is characterized in that between each

of two adjacent swirler vanes of the first type (5) in the circumferential direction (6) of the annular flow channel (2) one swirler vane of a second type (13) is arranged, and that the swirler vane of the second type (13) is mounted radially one sided at the outer channel wall (4) and extends radially into the annular flow channel (2) in form of a cantilever beam having a leading (8) and a trailing edge (9) which are interconnected by a streamlined suction (11) and pressure side (10) wall which encircle a swirler vane tip (14) being disposed with a radially distance to the radially inner channel wall (3).

**Fig. 1**

Description

Technical Field

[0001] The invention relates to a swirl generator for creation a swirling premixed fuel-air mixture for combustion in a gas turbine combustor comprising an annular flow channel bordered by a radially inner and outer channel wall between which a plurality of swirler vanes of a first type are uniformly distributed in a circumferential direction of the annular flow channel each of which is connected radially with the inner and outer channel wall and provides a leading and a trailing edge which are interconnected by a streamlined suction and pressure side wall.

Background of the Invention

[0002] Swirl generators are well known components of gas turbine combustion systems for mixing fuel and air in a burner for premixed combustion in a subsequent combustion chamber. In modern gas turbines good mixing of fuel and combustion air is a prerequisite for complete combustion with low emissions. A general type of a premix burner is disclosed in EP 321 809 B1 in which the swirl generator consists of hollow part-cone bodies making up a complete body, having tangential air inlet slots and fuel channels for gaseous and liquid fuels. The liquid fuel enters the interior of the burner in shape of a conical column widening in direction of flow which is surrounded by rotating stream of combustion air which flows tangentially into the burner by creating a swirling premixed fuel-air mixture for combustion in a combustor. Ignition of the premixed fuel-air mixture starts at the burner outlet at which the flame is stabilized in the region of the burner outlet by means of a back flow zone.

[0003] Another kind of a swirl generator is disclosed in US 2009/0183511 A1 which is called swozzle design for gas turbine combustor which comprises an annular housing with a radially inner and outer channel wall enclosing an axial annular flow channel in which a plurality of swirler vanes are arranged, each of the swirler vanes is capable of creating a pressure difference in fluid flow through these swirler between a pressure side and a suction side of the swirler vane.

[0004] EP 2 522 911 A1 discloses also an axial swirl generator comprising a multitude of vanes being arranged in an annular housing with limiting radially inner and outer channel walls. Each vane is connected at both sides with the inner and outer channel wall providing a radial length which extends through the whole radial extension of the annular flow channel. The leading edge area of each vane has a profile which is oriented parallel to a main flow direction prevailing at the leading edge position wherein the profiles of the vanes turn from the main flow direction prevailing at the leading edge position to impose a swirl on the flow. To enhance the swirl effect on the flow passing axially through the swirl generator, the trailing edges of each vane provide lobes which contribute to an overall homogeneous mixing of the fuel-air mixture.

[0005] Regardless of the specific configuration of a generic swirl generator the primary function of a swirl generator is the creation of a swirling flow which after expansion in the combustor brakes down and creates reverse flow of hot gases, which ignite the incoming fresh mixture and stabilize the combustion. So the swirl generator contributes significantly to the quality of combustion concerning combustion efficiency, production of low emissions, pressure drop, just to name a few aspects. To comply with all these requirements a fine balance design of all components of the swirl generator is required. It has been recognized that a swirl generator design which is aero dynamical optimized in one special embodiment may lose its efficiency and reliability just by enlarging the design for example by one factor. This will be explained by an example shown in figure 2a which illustrates a schematically axial front view into an annular flow channel 2 of a swirl generator 1. The annular flow channel 2 is bordered by a radially inner channel wall 3 and a radial outer channel wall 4 between which a plurality of swirler vanes 5 are uniformly distributed in circumferential direction 6 of the annular flow channel 2. Each vane 5 is connected radially with the inner and outer channel wall 3, 4 and provides a radial length l_1 which is the radial distance between the inner and outer channel walls 3, 4. Figure 2b additionally shows a schematically profile cross-section 7 of an aero dynamical shaped profile of the swirler vanes 5 arranged within the annular flow channel 2. Each swirler vane 5 provides a leading edge 8 and a trailing edge 9 which are interconnected by a streamlined suction side wall 10 and a pressure side wall 11. The interconnecting line between the leading and trailing edge 8, 9 is called chord 12. It is assumed that each swirler vane 5 is connected both sides along its entire axial extension, i.e. from the leading edge 8 to the trailing edge 9, with the inner and outer channel wall 3, 4.

[0006] The distance between the leading edges 8 of two neighbouring swirler vanes 5 in circumferential direction of the annular flow channel 2 at the radially inner channel wall 3 is called inner pitch p_{inner} and at the radially outer channel wall 4 is called outer pitch p_{outer} .

[0007] A swirl generator 1 which is optimized under aero dynamical aspects provides a so called optimal pitch/chord-ratio at the inner channel wall which however will increase to the outer channel wall depending on the geometry of the flow channel housing to a value far from an optimum. Especially in cases in which the diameter ratio of $D_{\text{outer}}/D_{\text{inner}}$ will be more than two the influence on the pitch/chord ratio between the inner and outer channel wall is not negligible. In such cases annular flow through the swirl generator 1 would redistribute from areas of the flow channel 2 near the inner

diameter with an optimal pitch/chord ratio to areas of the flow channel in the region of the outer diameter with large pitch in which the air flow practically remain axially.

Summary of the Invention

[0008] It is an object of the invention to provide a swirl generator for creation a swirling premixed fuel-air mixture for combustion in a gas turbine combustor comprising an annular flow channel bordered by a radially inner and outer channel wall between which a plurality of swirler vanes of a first type are uniformly distributed in a circumferential direction of the annular flow channel each of which is connected radially with the inner and outer channel wall and provides a leading and a trailing edge which are interconnected by a streamlined suction and pressure side wall, such that negative effects on the flow dynamics and the hereto connected mixing ability may not suffer any disadvantages by enlarging the swirl generator and especially by enlarging the diameter ratio $D_{\text{outer}} / D_{\text{inner}}$ more than 2, preferably more than 3.

[0009] The object is achieved by the sum total of the features of claim 1. The invention can be modified advantageously by the features disclosed in the sub claims as well in the following description especially referring to preferred embodiments.

[0010] The inventive swirl generator for creation a swirling premixed fuel-air mixture for combustion in a gas turbine combustor comprising the feature of the generic part of claim 1 is characterized in said between each of two adjacent swirler vanes of the first type in the circumferential direction of the annular flow channel one swirler vane of a second type is arranged. All the swirler vanes of the second type are mounted radially one sided at the outer channel wall and extends radially into the annular flow channel in form of a cantilever beam having a leading and a trailing edge which are interconnected by a stream lined suction and pressure side wall which encircle a swirler vane tip being disposed with a radially distance to the radially inner channel wall.

[0011] By introducing swirler vanes with a reduced radially length compared to the radially length of the swirler vanes of the first type being connected both sided with the inner and outer channel wall, between the swirler vanes of the first type but only in the outer part of the flow channel, where the pitch starts to be unacceptable large, a modification of the aero dynamical flow through the swirl generator can be reached such that no radially redistribution of airflow from the inner diameter to the outer diameter occurs. With the inventive modification it is possible by optimized adaptation of shape and size of the swirler vanes of the second type to reduce the radial flow velocity at least in the area of the flow channel exit to zero so that no radial mixing takes place.

[0012] In a preferred embodiment the swirler vanes of the first type provide a radially length l_1 which corresponds to the radial distance between the radially inner and outer channel wall and the swirler vanes of the second type provide a radially length l_2 which is basically less than l_1 but preferably half of the size of l_1 or less than half of l_1 .

[0013] Since the swirler vanes of the second type end unilaterally free, the free ending vane tip of each swirler vane of the second type provides a plan surface with corresponds to the profile cross-section oriented orthogonal to the radial extension of the swirler vane of the second type. All the surfaces of the vane tips of the swirler vanes of the second type lies in a common virtually separation plane in form of a cylinder wall which separates the flow channel into two co-axial flow zones virtually. The radially inner flow zone ranging radially from the inner channel wall to the virtually separation plane on which the vane tips of the swirler vanes of the second type lie, and a radially outer flow zone ranging radially from the virtually separation plane to the radially outer channel wall. At least by choosing a radially length of the swirler vanes of the second type an improved possibility is established inventively to generate a velocity profile within said two coaxial flow zones with two different prescribed ideal radial distributions of the swirl exit velocity.

[0014] In a further preferred embodiment in each of the swirler vanes of the first and second type a multitude of fuel nozzles on the suction and/or pressure side wall is arranged to inject fuel into the flow area of the annular flow channel.

[0015] The number and arrangement of the fuel nozzles along the suction and/or pressure side walls of the swirler vanes of the first and second type are chosen with the provision of an optimized fuel-air mixing quality after passing the swirled premixed fuel-air mixture the swirl generator. Especially the fuel injection can be inventively optimized for creation of a defined radial profile of fuel equivalence ratio in a mixing tube following the swirl generator as well at the flame front inside the combustor which follows the swirl generator directly or follows the mixing tube. Due to the different length of the swirler vanes of the first and second type a possibility is given for radial staging which means a controlled variation of equivalence ratio between the inner and outer flow zone of the two coaxial flow zones. Especially it is possible to reach flow behaviour through the swirler generator after steps of aero dynamical optimization such that the radial flow velocity at the virtually border between the two radial flow zones especially at the swirler exit is zero, so that no mixing between the two zones occurs.

Brief Description of the Figures

[0016] The invention shall subsequently be explained in more detail based on exemplary embodiments in conjunction with the drawings. In the drawings

- Fig. 1 shows a schematically axial front view to an inventively embodiment of a swirl generator,
- Fig. 2a, b shows schematically front view of a swirl generator according to the state of the art as well as a typical cross-sectional view of a swirler vane,
- Fig. 3a, b perspective view to the swirler inlet a), and to the swirler exit b),
- Fig. 4a, b front and side view of a swirl generator describing geometrical parameters of the swirler and shows perspective view of swirler vanes of the first and second type with fuel injection nozzles on the pressure side of the vanes,
- Fig. 5 shows a perspective view on two adjacent swirler vanes.

Detailed Description of Exemplary Embodiments

[0017] Figure 1 shows a schematically axial view of an inventive swirl generator 1 providing an annular flow channel 2 bordered by a radially inner channel wall 3 and a radially outer channel wall 4. Between the inner and outer channel wall 3, 4 a plurality of swirler vanes 5 of a first type is uniformly distributed in the circumferential direction 6 of the annular flow channel 2 each of which is connected radially with the inner and outer channel wall 3, 4 and provides a leading and trailing edge 8, 9 which are interconnected by a streamlined suction and pressure side wall 10, 11 which is shown in the before described figure 2b.

[0018] Between each of two adjacent swirler vanes 5 of the first type in the circumferential direction 6 of the annular flow channel 2 one swirler vane 13 of the second type is arranged providing a radially length l_2 which is shorter than the radially length l_1 of the swirler vane 5 of the first type. The swirler vane 13 of the second type is mounted radially one sided at the outer channel wall 4 and extends radially into the annular flow channel 2 in form of a cantilever beam having a swirler vane tip 14 ending freely and facing the radially inner channel wall with a radially distance.

[0019] Since all swirler vanes 13 of the second type have the same radially length l_2 all the swirler vane tips 14 lie in the same virtually separation plane 15 which is illustrated by a dotted line.

[0020] Preferably all the swirler vanes 13 of the second type do have the same aero dynamical shaped profile and chord length like the swirler vanes of the first type but differ in radial length from the swirler vanes 5 of the first type. The aero dynamical profile of the swirler vanes of the first and second type are constant along their radial extension but may differ in other embodiments for purposes of aero dynamical optimization.

[0021] As it can be seen clearly from the schematically sketch of figure 1 the outer pitch p_{outer} , which is the azimuthally distance between two neighbouring vanes 5, 13 of the first and second type is significantly smaller than the outer pitch p^*_{outer} corresponding to the distance between two neighbouring swirler vanes of the first type, see the dotted arrow. Due to the introduction of the swirler vanes of the second type 13 with reduced radially length l_2 between the long vanes 5 only in the radially outer part of the flow channel 2, where the pitch starts to be unacceptably large, the pitch/chord-ratio is reduced significantly and more or less adapted to the pitch/chord-ratio at the inner channel wall.

[0022] The dotted circular line relates to a virtually separation plane 15 along which the axially flow channel 2 is separated into two coaxial flow zones 2.1 and 2.2. The radially inner flow zone 2.1 ranges radially from the inner channel wall 3 to the virtually separation plane 15 along which the swirler vane tips 14 of the swirler vanes of the second type 13 lie. The radially outer flow zone 2.2 ranges radially from the virtually separation plane 15 to the radially outer channel wall 4. The choice of the length l_2 of the swirler vanes 13 of the second kind as well the aero dynamical profiles of all swirler vanes 5, 13 are chosen such that the radial flow velocity at the virtually separation plane 15 between the two flow zones 2.1, 2.2 especially at the swirler exit is zero, so that no mixing between the two flow zones occurs.

[0023] Figure 3a show the perspective view to the swirler inlet and figure 3b shows the perspective view to the swirler exit. Swirler components which are already explained are labelled with the known reference numbers without repeating explanation. The swirler vanes 13 of the second type provide a free ending swirler vane tip 14 which is a plane surface having the contour of the profile cross section of the vane. The radially length l_2 of the swirler vane of the second type 13 is more or less half of the length l_1 of the swirler vanes 5 of the first type but can vary according to shape and size of a swirler embodiment.

[0024] As can be seen from figure 3b all the aero dynamical cross sections 7 of the swirler vanes of the first 5 and second type 14 are identical in shape and size. All the swirler vanes 5, 13 inside the swirl generator 1 create a pressure difference in the fluid flowing through the swirl generator between a pressure side and suction side of each of the swirler vanes to impose a swirl on the flow.

[0025] Figures 4a shows an axially front view into the swirl generator 1. Figure 4b shows a side view on the swirler vane 1. The inventive implementation of additional swirler vanes with a shorter length l_2 between a multitude of swirler vanes 5 with long length l_1 becomes relevant for swirl generators having a geometrical size in which the diameter ratio

$D_{\text{outer}}/D_{\text{inner}}$ is significantly larger than 2, preferably larger than 3.

[0026] In such cases the pitch/chord-ratio will increase to the radially outer region 2.2 significantly. Figure 4a shows the inner pitch p_{inner} and the outer pitch p_{outer} in case of the swirler vanes of the first type with full length l_1 . In case of implemented swirler vanes 13 of the second type the outer pitch p_{outer} is reduced clearly and nearly adapted to the inner pitch p_{inner} . The pitch/chord-ratio between the inner and outer flow region is nearly similar because the length of the chord 12 of the swirler vanes of the first and second type is the same.

[0027] Figure 5 shows a perspective view on two adjacent swirler vanes 5 and 13. At the pressure side 10 of both swirler vanes 5, 13 a multitude of fuel nozzles 16 is arranged linearly along a radial direction with equal distance between two neighbouring fuel nozzles 16. In a preferred embodiment the linearly arrangement of the fuel nozzles 16 of each vane provides a distance d to the leading edge 8 of at least a quarter of the length of the chord 12. Due to the fact that the fuel nozzles 16 are also placed at the swirler vanes 13 of the second type with the reduced length l_2 an increased number of fuel nozzles 16 in the outer part of the annular flow channel is present so that the requirement on the fuel jet penetration depth decreases.

[0028] In a preferred embodiment the swirl generator is part of a premix burner comprising a fuel lance providing a diameter which is adapted to the inner diameter D_{inner} of the radially inner channel wall 3. Further the radially outer channel wall 4 comprises a diameter D_{outer} which corresponds to a diameter of a mixing tube following downstream to that swirl generator which may merge into a combustor of a gas turbine.

List of Reference Numerals

1	Swirl generator
2	Annular flow channel
3	Radially inner channel wall
4	Radially outer channel wall
5	Swirler vane of a first type
6	Circumferential direction of the annular flow channel
7	Aero dynamical shaped profile cross-section
8	Leading edge
9	Trailing edge
10	Pressure side
11	Section side
12	Chord
13	Swirler vane of the second type
14	Swirler vane tip
15	Virtually separation plane
16	Fuel nozzles

Claims

- Swirl generator (1) for creation a swirling premixed fuel-air mixture for combustion in a gas turbine combustor comprising an annular flow channel (2) bordered by a radially inner (3) and outer channel wall (4) between which a plurality of swirler vanes (5) of a first type are uniformly distributed in a circumferential direction (6) of the annular flow channel (2) each of which is connected radially with the inner and outer channel wall (3, 4) and provides a leading (8) and a trailing edge (9) which are interconnected by a streamlined suction (11) and pressure side (10) wall, **characterized in that** between each of two adjacent swirler vanes of the first type (5) in the circumferential direction (6) of the annular flow channel (2) one swirler vane of a second type (13) is arranged, and that the swirler vane of the second type (13) is mounted radially one sided at the outer channel wall (4) and extends radially into the annular flow channel (2) in form of a cantilever beam having a leading (8) and a trailing edge (9) which are interconnected by a streamlined suction (11) and pressure side (10) wall which encircle a swirler vane tip (14) being disposed with a radially distance to the radially inner channel wall (3).
- Swirl generator according to claim 1, **characterized in that** the swirler vanes of the first type (5) provide a radially length l_1 which corresponds to the radial distance between the radially inner and outer channel wall (3, 4) and the swirler vanes of the second type (13) provide a radially length l_2 which is equal to half of l_1 or less than half of l_1 .
- Swirl generator according to claim 1 or 2, **characterized in that** the radially inner channel wall (3) provides a Diameter

D_{inner} and the radially outer channel wall (4) provides a Diameter D_{outer} , which applies to $D_{outer}/D_{inner} \geq 2$.

4. Swirl generator according to one of the claims 1 to 3, **characterized in that** the swirler vanes of the second type (13) are disposed between the swirler vanes of the first type (5) such that the distance of the trailing edges (8) of each of two neighboring swirler vanes of the first (5) and second type (13) in circumferential direction (6) of the annular flow channel (2) at least at the radially outer channel wall (4) is constant.
5. Swirl generator according to one of the claims 1 to 4, **characterized in that** the swirler vanes of the first type (5) have a first aerodynamically shaped profile comprising a first profile cross-section (7) oriented orthogonal to the radial extension of the swirler vane of the first type (5), that the swirler vanes of the second type (13) have a second aerodynamically shaped profile comprising a second profile cross-section (7) oriented orthogonal to the radial extension of the swirler vane of the second type (13), that a chord (12) is assignable to said first and second profile cross-section (7) which corresponds to the connecting line between the leading (8) and trailing edge (9) within said profile cross-section in each case, and that the swirler vanes of the first and second type (5, 13) are arranged such that the swirl effect of both types of swirler vanes on the annular flow passing through the annular channel (2) have the same orientation.
6. Swirl generator according to claim 5, **characterized in that** the swirler vanes of the first and second type (5, 13) have the same aerodynamically shaped profile and chord length.
7. Swirl generator according to claim 5, **characterized in that** the swirler vanes of the first and second type (5, 13) differ in their aerodynamically shaped profiles and/or chord lengths.
8. Swirl generator according to one of the claims 5 to 7, **characterized in that** the swirler vanes of the first and second type (5, 13) are formed and arranged within said flow channel (2) that two co-axial flow zones (2.1, 2.2) are created, a radially inner flow zone (2.1) ranging radially from the inner channel wall (3) to a virtually separation plane (15) on which the vane tips (14) of the swirler vanes of the second type (13) lie, and a radially outer flow zone (2.2) ranging radially from the virtually separation plane (15) to the radially outer channel wall (4).
9. Swirl generator according to claim 8, **characterized in that** number, shape and arrangement of the swirler vanes of the first and second type (5, 13) are such that following ratios are optimized each under aerodynamical aspects pitch / chord (at the radially inner channel wall) and pitch / chord (at the radially outer channel wall), whereby chord: length of a connecting line between the leading edge and trailing edge within a profile cross-section of the swirler vane of the first or second type, and pitch (at the radially inner channel wall):

distance of the trailing edges of two neighboring swirler vanes of the first type in circumferential direction of the annular flow channel at the radially inner channel wall, and

pitch (at the radially outer channel wall):

distance of the trailing edges of each of two neighboring swirler vanes of the first and second type in circumferential direction of the annular flow channel at the radially outer channel wall.
10. Swirl generator according to claim 9, **characterized in that** the aerodynamical aspects are at least one of the following criteria:
 - radial flow velocity at the virtually separation plane at the swirler exit is zero,
 - in each co-axial flow zones a prescribed and controlled equivalence ratio and/or mixture homogeneity in radially and azimuthally direction is assured.
11. Swirl generator according to one of the claims 1 to 10, **characterized in that** each of the swirler vanes of the first and second type (5, 13) provides fuel nozzles (16) on the suction (11) and/or pressure side wall (10).
12. Swirl generator according to claim 11, **characterized in that** a multitude of fuel nozzles (16) are arranged linearly along a radial direction with equal distance between two neighboring fuel nozzles (16) on the suction and/or pressure side wall (10, 11) of the swirler vanes of the first and second type (5, 13), and that linearly arrangement of the fuel nozzles (16) of each vane provides a distance (d) to the leading edge (8) of at least a quarter of the chord length.

13. Swirl generator according to one of the claims 1 to 12, **characterized in that** the swirl generator (1) is part of a premix burner comprising a fuel lance, said fuel lance provides a diameter which is adapted to a diameter (D_{inner}) of the radially inner channel wall (3) and said radially outer channel wall (4) comprises a diameter (D_{outer}) which corresponds to a diameter of a mixing tube following downstream to said swirl generator (1).

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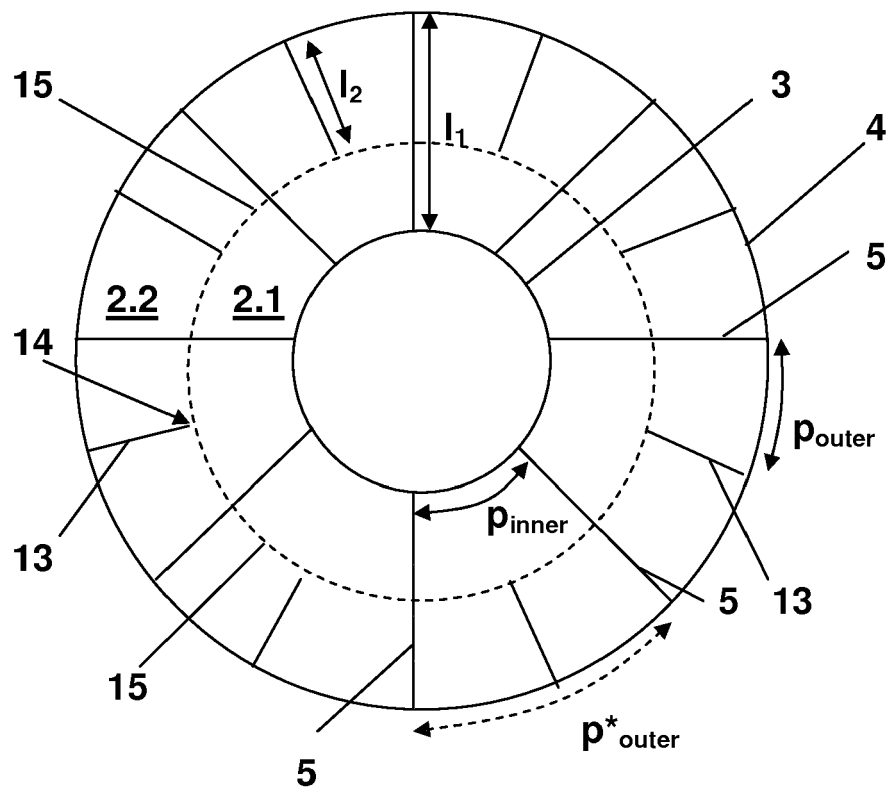


Fig. 1

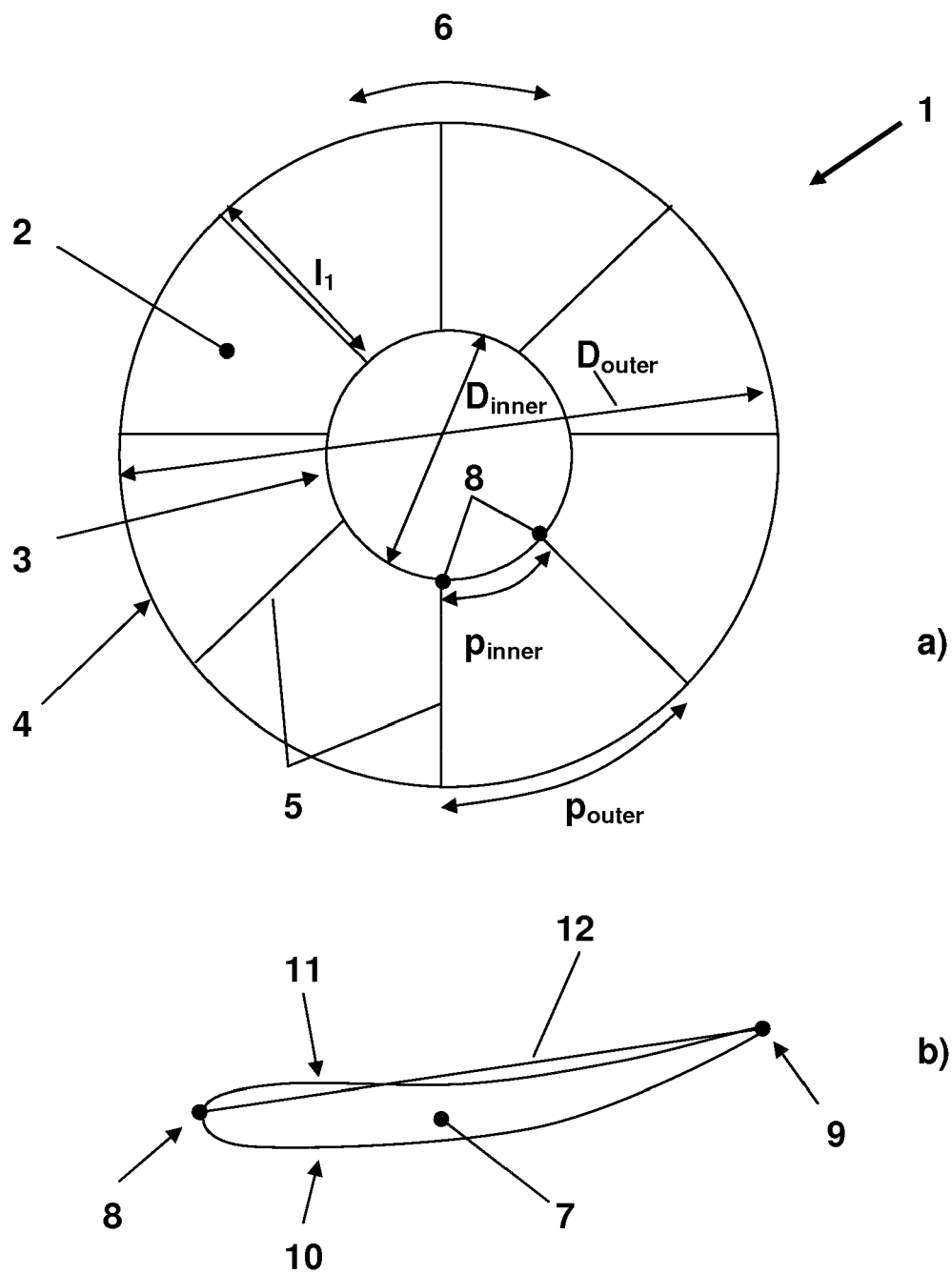


Fig. 2

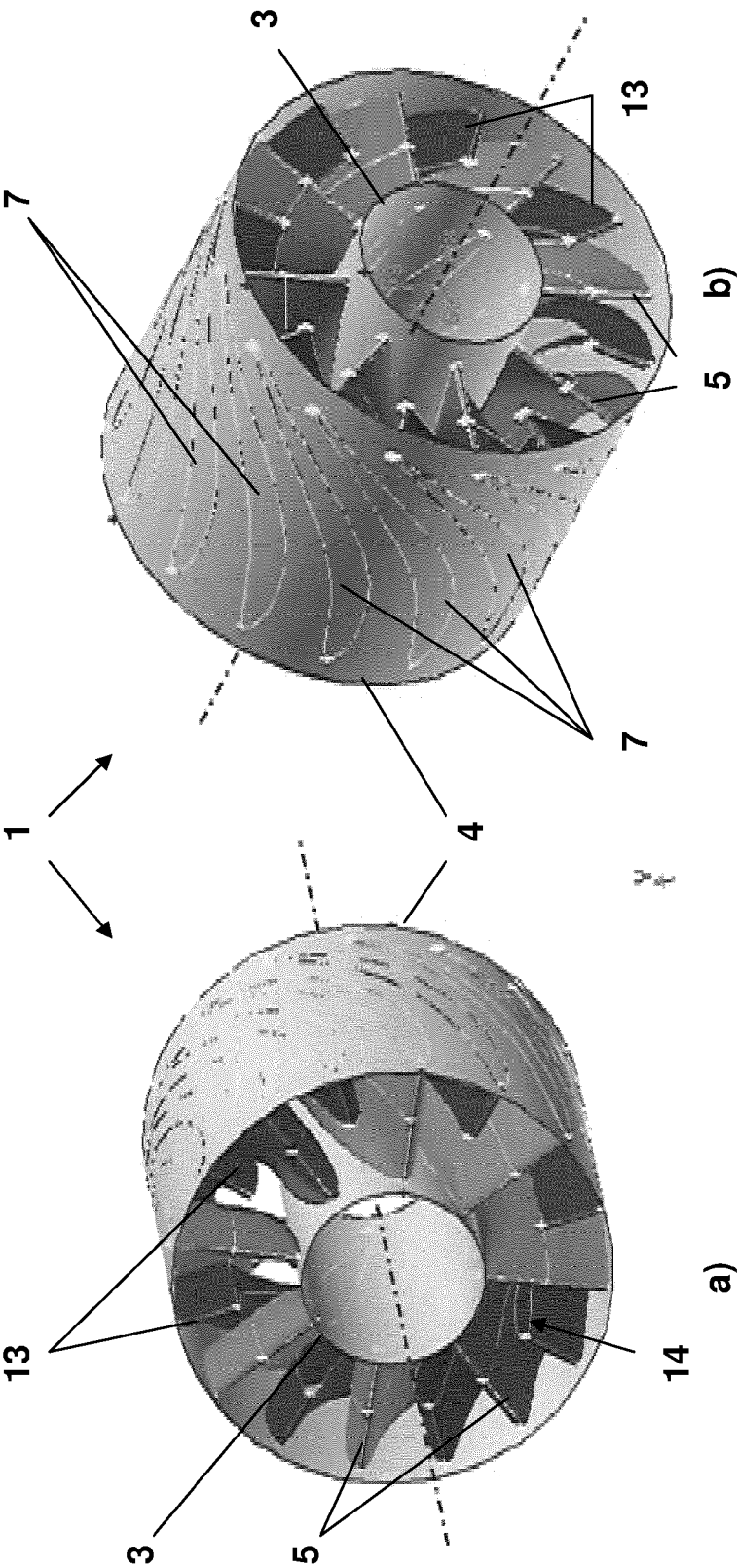


Fig. 3

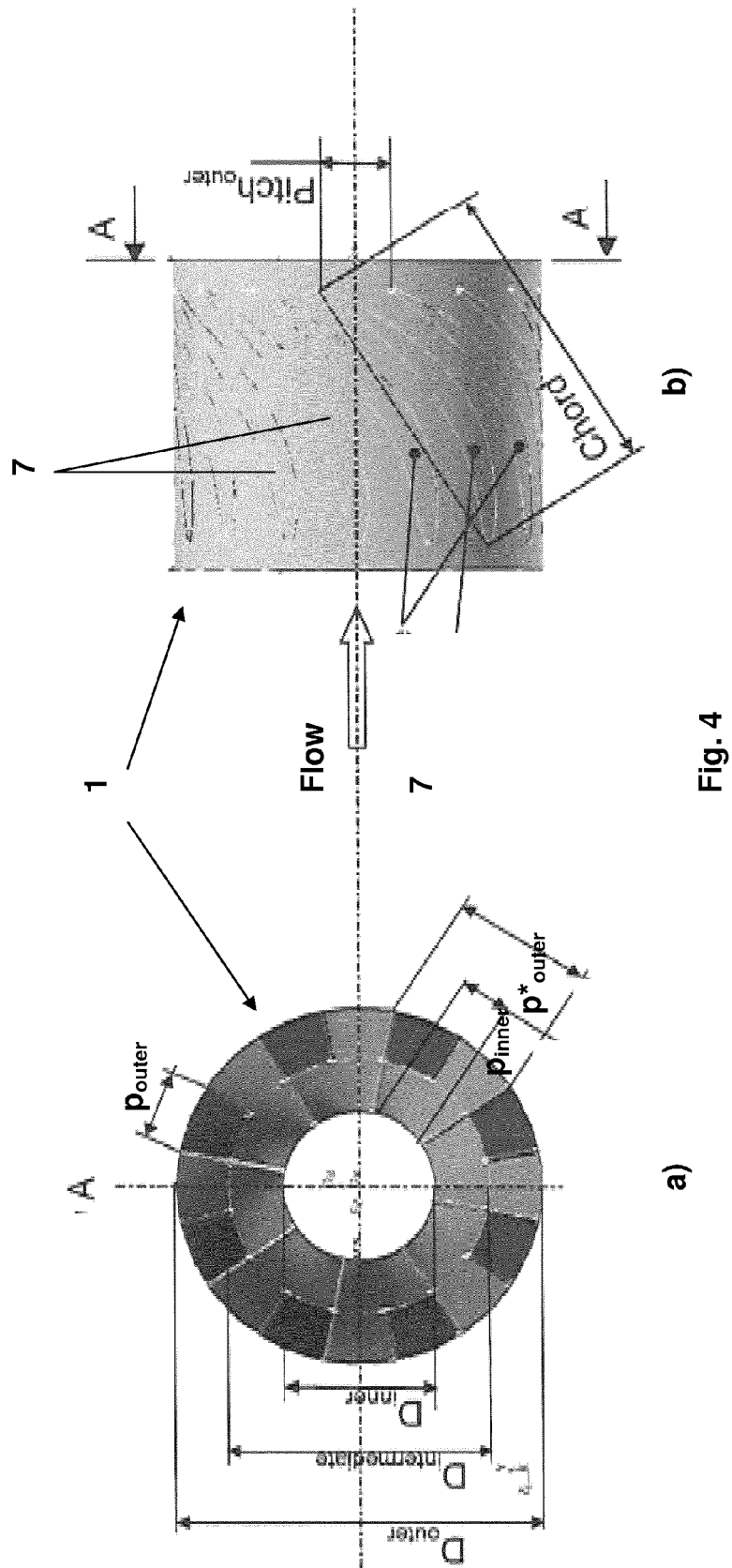


Fig. 4

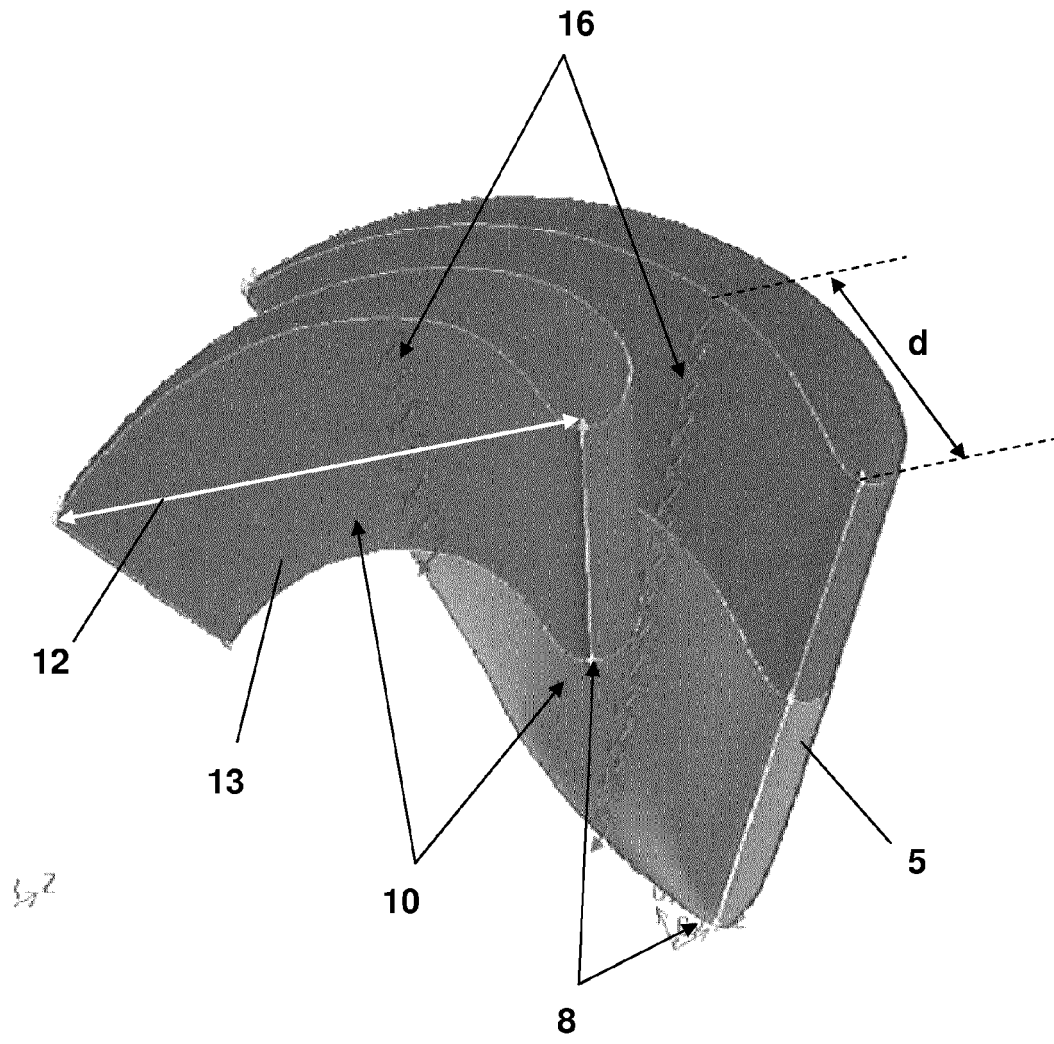


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 13 16 5102

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 2010/095675 A1 (LACY BENJAMIN [US] ET AL) 22 April 2010 (2010-04-22) * page 2, paragraph 21 * * page 2, paragraph 23 - paragraph 28 * * figures 4,7 *	1-13	INV. F23R3/14 F23R3/28 F23C7/00
X	EP 1 096 201 A1 (SIEMENS AG [DE]) 2 May 2001 (2001-05-02) * column 5, paragraph 20 - column 7, paragraph 22 * * figures 2,3 *	1,4,5,7	
A	US 2007/028624 A1 (HSIEH SHIH-YANG [US] ET AL) 8 February 2007 (2007-02-08) * page 6, paragraph 77 - paragraph 79 * * figures 4,5 *	1	
A	US 2011/023494 A1 (BUTLER JESSE BLAIR [US] ET AL) 3 February 2011 (2011-02-03) * page 2, paragraph 28 - page 3, paragraph 31 * * figure 4 *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			F23R F23C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 June 2013	Examiner Gavriliu, Costin
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ON EUROPEAN PATENT APPLICATION NO.**

EP 13 16 5102

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18-06-2013

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2010095675	A1	22-04-2010	CH 699767 A2	30-04-2010
			CN 101725972 A	09-06-2010
			DE 102009026364 A1	22-04-2010
			JP 2010096487 A	30-04-2010
			US 2010095675 A1	22-04-2010

EP 1096201	A1	02-05-2001	CN 1384908 A	11-12-2002
			DE 50007809 D1	21-10-2004
			EP 1096201 A1	02-05-2001
			EP 1224423 A1	24-07-2002
			JP 4567266 B2	20-10-2010
			JP 2003513223 A	08-04-2003
			US 2002174656 A1	28-11-2002
			WO 0133138 A1	10-05-2001

US 2007028624	A1	08-02-2007	NONE	

US 2011023494	A1	03-02-2011	CH 701543 A2	31-01-2011
			CN 101986034 A	16-03-2011
			DE 102010036488 A1	03-02-2011
			JP 2011027405 A	10-02-2011
			US 2011023494 A1	03-02-2011

EPO FORM P0459

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Patent documents cited in the description

- EP 321809 B1 [0002]
- US 20090183511 A1 [0003]
- EP 2522911 A1 [0004]