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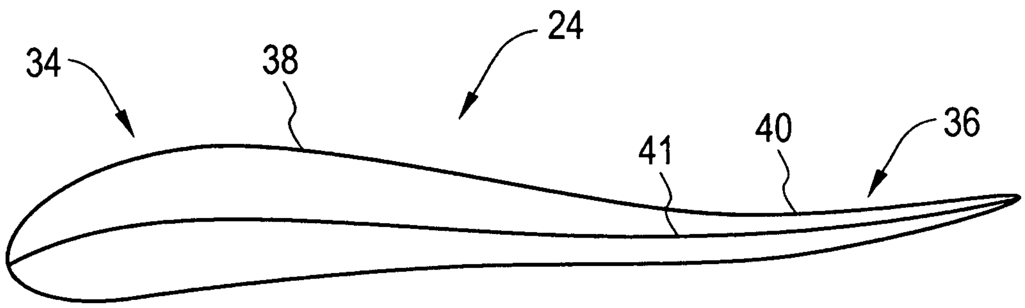
(54) **Inlet guide vane and compressor**

(57) The present invention relates to an axial compressor (20) and an inlet guide vane (24) for use with Axial compressor (20), wherein Axial compressor (20) comprises a plurality of inlet guide vanes (24), each inlet guide vane (24) comprising a first camber (38) at a leading section (34) and a second camber (40) at a trailing section (36), said second camber (40) having a curvature opposite to that of said first camber (38).

FIG 3



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Description

[0001] The present invention relates to an inlet guide vane for use with a compressor, prefereably an axial compressor, said inlet guide vane is defined by a blades profile, said profile being defined by a camber line and a thickness distribution. Further the invention relates to a compressor comprising the above inlet guide vane.

[0002] Some axial compressors have adjustable inlet guide vanes to control a flow angle to a first rotor stage of the axial compressor. The flow is controlled by turning or staggering the inlet guide vanes.

[0003] Conventional inlet guide vanes produce little flow turning at zero stagger angles as the inlet guide vanes have little camber. As a result, a flow incidence on the conventional inlet guide vane is large at high stagger angles leading to flow separation with high losses and breakdown of a flow angle distribution.

[0004] FIG 1 illustrates an inlet guide vane structure currently in use. In general the blade's profile geometry is defined by a camber line 18 and a thickness distribution along the camber line 18, which defines by means of a mathematical function the distance between the camber line 18 and the blade's surface. The thickness distribution defines thicknesses of the profile perpendicular to the camber line, wherein the camber line intersects these thicknesses in their respective central point. A blade's profile is exactly defined by the camber line and the thickness distribution. Normally a thickness distribution begins with 0, has an intermediate maximum and ends with 0, wherein the location of the maximum along the camber line often is varied to obtain optimal efficiency. The incidence is defined as the angle of the flow direction to a tangent at the camber line at the leading edge of the profile and depends on the profile's geometry and the stagger angle. A higher incidence normally increases turbulence and pressure losses.

[0005] The inlet guide vane 10 comprises a leading section 12 and a trailing section 14. The inlet guide vane 10 comprises a small amount of bending and thus produces little flow turning at zero stagger angles, which is illustrated as a constant bending of the profile's surface 16. The surface 16 extends from the leading section 12 to the trailing section 14. From the camber line 18, it may be noticed that the surface 16 provides a curvature which is small in amount. As a result, the flow incidence is large at high stagger angles leading to flow separation with high loses and breakdown of the flow angle separation.

[0006] Blade profiles always comprise a pressure side and a suction side. During operation the pressure side faces higher static pressures than the suction side according to the direction of the flow entering the stage of blades. The average bending of a blade's profile, respectively the camber line 18, normally is concave at the pressure side. The example in figure 1 shows the pressure side of the profile facing downwards.

[0007] It is an object of the invention to increase the efficiency of the axial compressor by preventing flow separation, and thus, reducing losses and maintaining the flow angle distribution.

[0008] The above object is achieved by an axial compressor according to claim 1.

[0009] Hereinafter 'camber' always refers to the bending of the camber line.

[0010] The first camber at the leading edge reduces flow separation at high stagger angles and thereby, increasing the efficiency of the compressor by reducing losses and maintaining the flow angle distribution. The second camber turns the flow back to the desired exit angle as the flow was provided a turn by the first camber. This enables in retrofitting the inlet guide vane to existing axial compressors and thus, eliminating the requirement of redesigning and replacing the compressor stages downstream of the inlet guide vanes.

[0011] According to another embodiment, the first camber is designed such that a flow incidence is reduced. Designing the first camber to reduce the flow incidence enables reducing the flow separation.

[0012] According to yet another embodiment, the second camber is designed such that a desired exit flow angle is achieved.

[0013] According to yet another embodiment, the first camber at the leading section and said second camber at said trailing section provides an S shape to said inlet guide vane.

[0014] Another embodiment includes an inlet guide vane for use with an axial compressor, said inlet guide vane comprising a first camber at a leading section and a second camber at a trailing section, said second camber having a curvature opposite to that of said first camber.

[0015] The present invention is further described hereinafter with reference to illustrated embodiments shown in the accompanying drawings, in which:

FIG 1 illustrates an inlet guide vane structure currently in use,

FIG 2 illustrates a partial sectional view of an exemplary axial compressor according to an embodiment herein,

FIG 3 illustrates an inlet guide vane profile according to an embodiment herein, and

FIG 4 shows a graphical comparison of performances of an inlet guide vane of constant camber and an inlet guide vane according to the invention.

[0016] Various embodiments are described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments. It may be evident that such embodiments may be practiced without these specific details.

[0017] FIG 2 is a partial sectional view of an exemplary axial compressor according to an embodiment herein. The compressor 20 comprises a housing 22 to which inlet guide vanes 24 and a plurality of stator rows 26 are attached. A hub 28 having attached therein a plurality of rotor rows 30 is attached to a shaft 32. The shaft 32 and the hub 28 with the rotor rows 30 rotate about an axis of the shaft 32.

[0018] FIG 3 illustrates an inlet guide vane profile 24 according to an embodiment herein. The inlet guide vane 24 comprises a leading section 34 and a trailing section 36. A camber line 41 depicts the mean of the amount of camber provided to the inlet guide vane 24. The leading section 34 comprises a camber 38 designed such that a flow incidence is reduced at high stagger angles. The trailing section 36 comprises a camber 40 having a curvature opposite to that of the camber 38. From the camber line 41, it can be observed that the curvature of the camber 40 of the trailing section 36 is opposite to that of the camber 38 of the leading section 34.

[0019] The camber 38 is designed such that the amount of curvature provided by the camber 38 is large and therefore, a gradual turn is provided to the incident flow. This prevents flow separation until higher stagger angles.

[0020] Due to the gradual turn provided to the flow by the camber 38, the inlet flow angle is turned more than a desired exit flow angle. The exit flow angle is the angle at which a gas, usually air, exits the inlet guide vane 24. To turn the flow back to the desired exit flow angle, the trailing section 36 comprises a camber 40 having a curvature opposite to that of the camber 38. The flow is turned back to the desired exit flow angle in order to maintain the exit conditions at par with the standard inlet guide vanes. This eliminates the requirement of redesigning and replacing the compressor stages downstream of the inlet guide vanes.

[0021] Typically, the camber 38 at the leading section 34 and the camber 40 at the trailing section 36 provide an S shape to the inlet guide vane 24.

[0022] FIG 4 shows a graphical comparison of performances of an inlet guide vane of constant camber (hereinafter referred as "standard IGV") and an inlet guide vane according to the invention (hereinafter referred as "S-shaped IGV"). The graphical comparison shown is total pressure loss in percentage versus stagger angle in degrees. Plots are shown for a standard IGV and an S-shaped IGV. From the plot 42, it can be seen that the percentage of pressure loss increase for the standard IGV from a stagger angle of 15 degrees and reaches to 2 percent at the stagger angle of 30 degrees. From, the plot 44, it can be seen that the percentage of pressure loss for the S-shaped IGV remains constant till the stagger angle is 35 degrees and reaches to 0.8 percent at the stagger angle of 40 degrees. Therefore, the S-shaped IGV prevents pressure loss and also flow separation until higher stagger angles are reached.

[0023] The embodiments described herein enable reducing the flow incidence at high stagger angles and flow separation. This provides an increase in the efficiency as the flow angle distribution is maintained. Additionally, as the flow is turned back to the desired exit flow angle, redesigning and replacing of the compressor stages downstream of the inlet guide vane is avoided. Moreover, an increase in efficiency and output of a compressor may be increased by retrofitting the inlet guide vane described herein to a compressor.

[0024] While this invention has been described in detail with reference to certain preferred embodiments, it should be appreciated that the present invention is not limited to those precise embodiments. Rather, in view of the present disclosure which describes the current best mode for practicing the invention, many modifications and variations would present themselves, to those of skill in the art without departing from the scope and spirit of this invention. The scope of the invention is, therefore, indicated by the following claims rather than by the foregoing description. All changes, modifications, and variations coming within the meaning and range of equivalency of the claims are to be considered within their scope.

Claims

1. Inlet guide vane (24) for use with a compressor (20), prefereably an axial compressor (20), said inlet guide vane (24) is defined by a blades profile, said profile being defined by a camber line (18) and a thickness distribution,
characterized in that
the camber line (18) comprises a first camber (38) at a leading section (34) and a second camber (40) at a trailing section (36), said second camber (40) having a curvature opposite to that of said first camber (38).

2. Inlet guide vane to claim 1, wherein said first camber (38) is designed such that a flow incidence is reduced.

3. Inlet guide vane (24) according to claim 1, wherein said inlet guide (24) vane is provided with means for a pivotable connection to at least one adjoining part, wherein a rotation axis extends along a longitudinal direction of the inlet guide vane (24) perpendicular to the blade's profiles.

4. Inlet guide vane (24) according to claim 1, 2 or 3, wherein said second camber (40) is designed such that a desired exit flow angle is achieved.

5. Inlet guide vane (24) according to any preceding claim, wherein said first camber (38) at said leading section (34) and said second camber (40) at said trailing section (36) provides an S shape to said inlet guide vane (24).

6. Inlet guide vane (24) according to any of the preceding claims, wherein the blade's profile comprises a pressure side and a suction side, which pressure side of the camber line (18) has a concave shape at the leading section (34) and a convex shape at the trailing section (36).

7. Axial compressor (20) comprising a plurality of inlet guide vanes (24) according to any of the preceding claims.

FIG 1

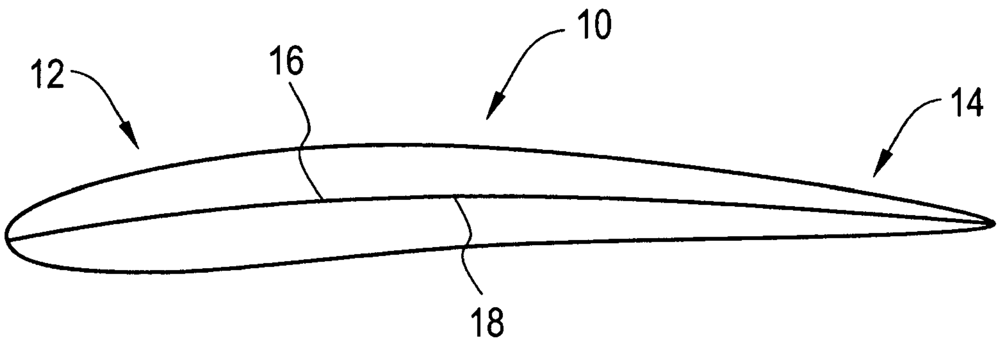


FIG 2

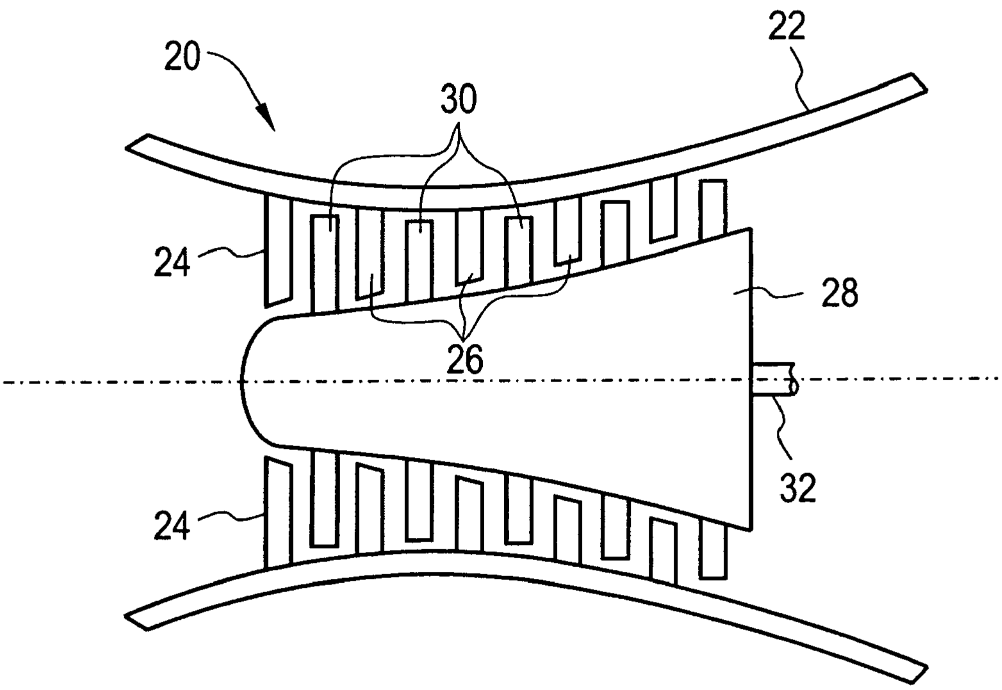


FIG 3

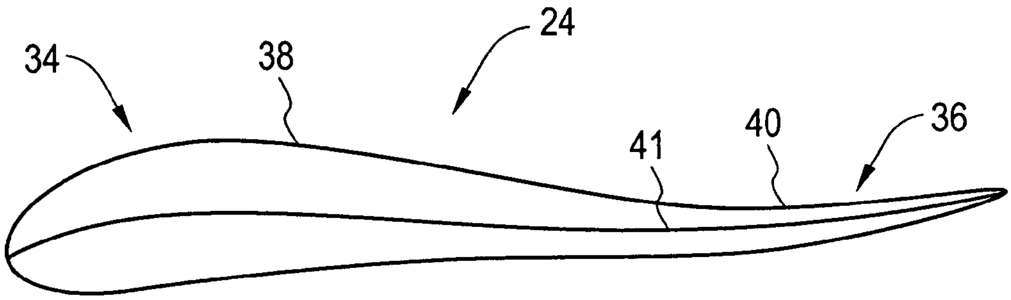
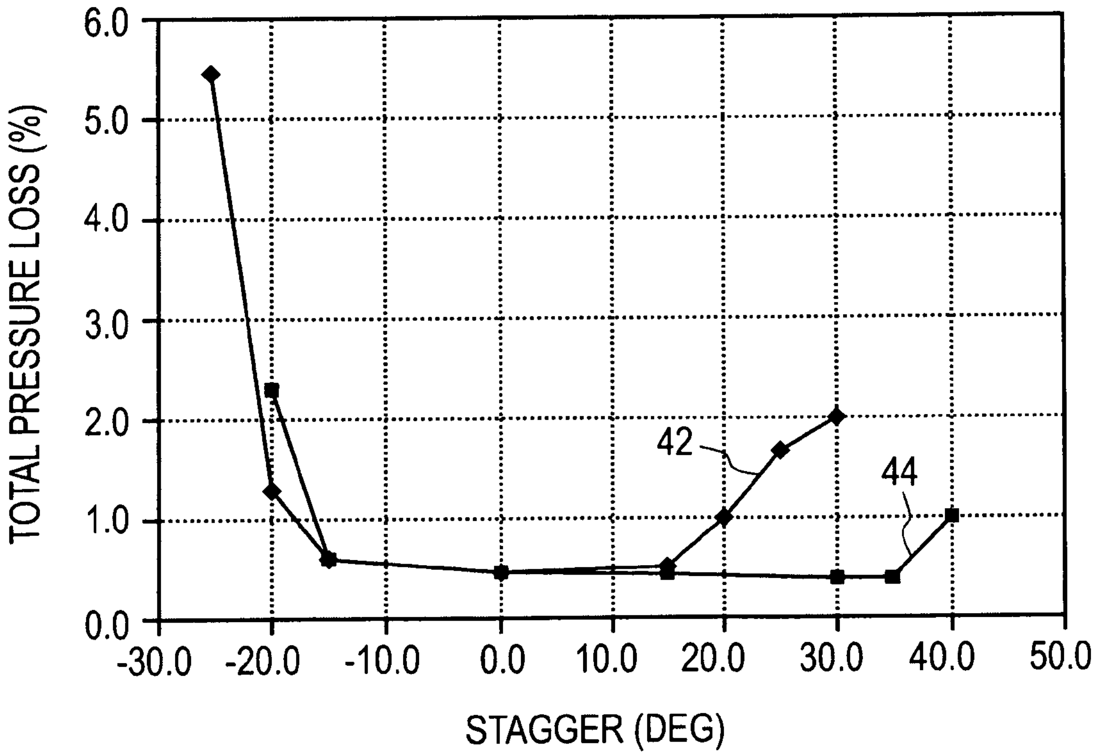

24
34
38
41
40
36

FIG 4


6.0
5.0
4.0
3.0
2.0
1.0
0.0
TOTAL PRESSURE LOSS (%)
42
44
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
STAGGER (DEG)

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EUROPEAN SEARCH REPORT

Application Number
EP 09 00 5326

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	EP 1 340 894 A (GEN ELECTRIC [US]) 3 September 2003 (2003-09-03) * abstract * * paragraphs [0009], [0010], [0014], [0015], [0017], [0019] - [0021] * * figures 1-4 *	1-7	INV. F01D5/14 F01D9/04 F01D17/16
X	US 5 472 314 A (DELONGE JEAN-CLAUDE L [FR] ET AL) 5 December 1995 (1995-12-05) * abstract * * column 3, line 44 - line 48 * * column 4, line 9 - line 34 * * figures 1a,2 *	1-7	
X	EP 1 674 664 A (UNITED TECHNOLOGIES CORP [US]) 28 June 2006 (2006-06-28) * abstract * * paragraphs [0014], [0017], [0019], [0022] * * figures 1-4 *	1,2,4-7	
X	US 2003/129056 A1 (KUNO NAOKI [JP] ET AL) 10 July 2003 (2003-07-10) * abstract * * paragraphs [0023], [0030], [0032], [0033] * * figures 1-3 *	1,2,4-7	TECHNICAL FIELDS SEARCHED (IPC) F01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 September 2009	Mielimonka, Ingo

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CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 00 5326

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