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(54) Cooling configuration, corresponding stator heat shield, blade, and vane for a gas turbine

(57) Cooling configuration for a gas turbine T-junction (100) joining a first wall (1) and a second wall (2), the second wall (2) requiring cooling because it is subjected to hot gas on one side (3), the cooling configuration comprising an impingement sheet (4) having a plurality of holes (40) through which an air flow (400) is blown, and comprising a plurality of reinforcing ribs (5) defining a plurality of cavities (7) between them, such that the air flow (400) impacts into said cavities (7). The wall thickness of the second wall (2) can be locally reduced in the vicinity of its junction to the first wall (1) and the wall thickness of the first wall (1) can also be locally reduced in the vicinity to its junction to the second wall (2). Corressonding stator heat shield, blade, and vane are also provided.

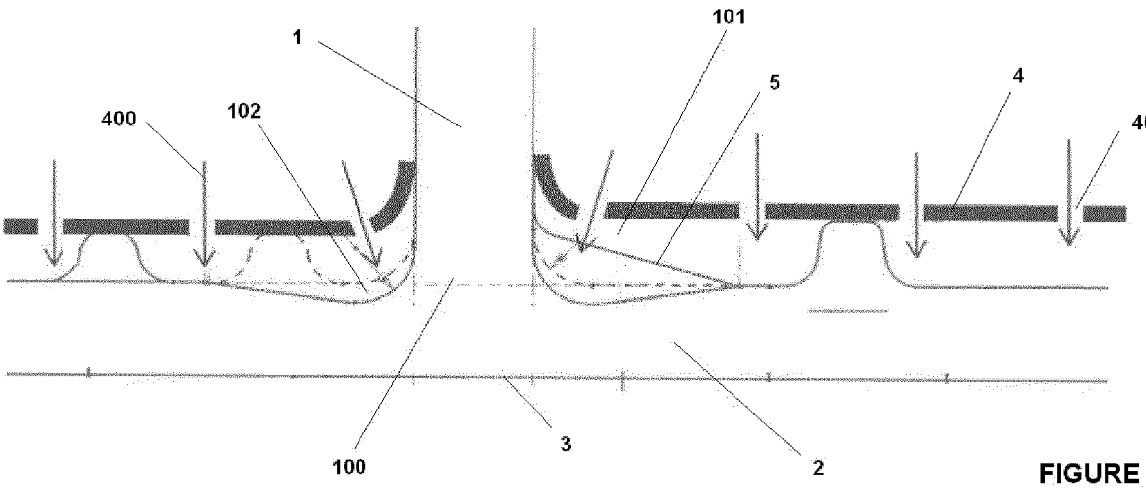

FIGURE 4

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an impingement cooling configuration for T-junctions between a first wall and a second wall, the second wall requiring cooling because it is subjected to high temperatures on one side, particularly in gas turbine applications, the configuration of the invention improving heat transfer and providing a longer lifetime of the cited T-junctions.

BACKGROUND

[0002] Components of gas turbines are subjected to very high temperature and pressure conditions, and sometimes also to a high vibration environment, which limit the lifetime of the mentioned components. For example, the blades of gas turbines are often the limiting component of gas turbines, as they are subjected to very strenuous environments inside the gas turbine, facing high temperatures, high stresses and potentially high vibration environments, which can lead to the blade failures.

[0003] Therefore, the components that are particularly subjected to harsh conditions in gas turbines are made of high strength materials to withstand these conditions.

[0004] Another solution, aside from the use of better materials, is to cool these components, thus decreasing their operating temperature, typically by convection cooling, passing cooling air through passages internal to the components to be cooled, so that heat is transferred by conduction first, and then by convection into the air flowing inside of the components.

[0005] A variation of convection cooling is impingement cooling that works by hitting the inner surface of the component that has to be cooled with high velocity air that passes typically through an impingement sheet, allowing more heat to be transferred than regular convection cooling does. Impingement cooling is often used in certain areas of the gas turbine, typically subjected to very strong conditions, such as T-junctions between a web and an airfoil. However, these T-junctions cannot be properly cooled even if using this known solution of impingement cooling, as cooling is effected mainly by heat conduction through the web part, such that temperature hot spots at T-junctions subjected to a high temperature and not being properly cooled are created, causing increased stresses and reduced lifetime of these parts.

[0006] It is known in the state of the art, as per the document *"Heat transfer characteristics of an integrated cooling configuration for ultra-high temperature turbine blades: experimental and numerical investigations",* a cooling configuration designed for an ultra-high temperature turbine nozzle, integrating impingement cooling and pin cooling devices for the enhancement of the effective area for the impingement cooling. However, this configuration still has hot spots having a high temperature and not having been properly cooled at T-junction parts, thus having a more limited lifetime.

[0007] Also known in the art is "Heat transfer to a row of impinging jets in consideration of optimization", using impingement cooling in gas turbines, in order to enhance heat transfer. However, hot spots at T-junctions still exist, limiting the lifetime of the components.

[0008] US Patent 6,139,269 discloses a convectively cooled turbine blade having two distinct cooling air passage systems in order to improve heat transfer; however, T-junctions between the web and the airfoil still have hot spots with higher temperature, limiting lifetime of the parts.

[0009] It is known, as per document US 7,220,103 B2, a configuration of a gas turbine engine blade having a large fillet with thin wall and impingement rib to improve airflow, such that cooling air flows through the impinging holes in the rib and impinge on the rear surface of the fillet. This configuration is not however intended at dealing with the hot spots created at T-junctions, where heat transfer is kept low and the lifetime is drastically reduced.

[0010] The present invention is intended to solve the above-mentioned disadvantages and limitations in the prior art, as it will be further explained.

SUMMARY OF THE INVENTION

[0011] The present invention relates to an impingement cooling configuration for T-junctions between a first wall, for example a web or a hook, and a second wall, for example an airfoil, the second wall requiring cooling because it is subjected to high temperatures on one side, typically subjected to hot gas, particularly in gas turbines. The cooling configuration of the invention improves heat transfer and provides a longer lifetime of the cited T-junctions.

[0012] The configuration of the invention comprises a plurality of longitudinally spaced reinforcing ribs, located at least on one of the areas where the first wall and the second wall are joined. According to another embodiment, these reinforcing ribs can be located on both areas where the first wall and the second wall are joined. An impingement sheet with a plurality of impingement holes is located over the T-junction, on the side of the first wall (opposite to the side facing the high temperatures typically from hot gas), such that cooling air is blown through the impingement holes in the impingement sheet. With this configuration, the cooling air blown impacts into the cavities generated between the longitudinally spaced ribs into the T-junction.

[0013] According to another preferred embodiment, the wall thickness in both junction areas where the first wall and the second wall are joined forming a junction having a cross-section with a T-shape, is reduced longitudinally, all along the second wall. Another possible embodiment of the invention contemplates the reduction of the thickness in both junction areas where the first wall and the second wall are joined forming a junction having a cross-section with a T-shape, longitudinally, all along the second wall, and vertically, all along the first wall. These embodiments improve even more heat transfer of the T-junctions, therefore providing even longer lifetime for them. With these configurations, the cooling air blown impacts reduced wall thickness areas in the T-junction, impacting into the cavities with reduced thickness generated between the longitudinally spaced in the T-junction.

[0014] With the configurations described above, the T-junction areas formed between the first wall and the second wall are provided with improved heat transfer, thus allowing a longer lifetime of these parts.

BRIEF DESCRIPTION OF DRAWINGS

[0015] The foregoing objects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description when taken in conjunction with the accompanying drawings, wherein.

Figure 1 shows a typical impingement cooling configuration used in T-junctions, according to the known prior art.

Figure 2 shows the temperature distribution in a typical impingement cooling configuration for T-junctions according to the known prior art, as shown in Figure 1, compared to the temperature distribution of a cooling configuration used in T-junctions according to the present invention.

Figures 3a and 3b show detailed views of the impingement cooling configuration for T-junctions between a first wall (e.g. web or hook) and a second wall subjected to hot gas requiring cooling, according to the present invention.

Figure 4 shows a detailed cross-section view of the impingement cooling configuration for T-junctions between a first wall (e.g. web or hook) and a second wall (e.g. airfoil)subjected to hot gas, according to the present invention.

Figure 5 shows a typical configuration of T-junctions in a gas turbine vane where the cooling configuration according to the invention can be used.

Figure 6 shows a typical configuration of T-junctions in a gas turbine blade where the cooling configuration according to the invention can be used.

DETAILED DESCRIPTION OF THE INVENTION

[0016] The present invention discloses an impingement cooling configuration for a T-junction 100 between a first wall 1 (e.g. web) and a second wall 2 (e.g. airfoil), the second wall 2 requiring cooling as it is subjected to high temperatures on one side. The cooling configuration of the invention is particularly used in gas turbines, and the side of the second wall 2 requiring cooling is a hot gas surface 3. The cooling configuration of the invention improves heat transfer and provides a longer lifetime of the cited T-junction 100.

[0017] According to the known prior art, shown in Figure 1, cooling of both first 101 and second 102 areas of the T-junction 100 is made by means of an air flow 400 passing through a plurality of holes 40 in an impingement sheet 4. However, cooling of the first and second areas 101 and 102 of the T-junction 100 is not properly done, such that hot spots 6 appear, as shown in Figure 2.

[0018] As it can be seen in Figures 3a and 3b, the joint of a first wall 1 and a second wall 2 forms a T-junction 100 having two areas, a first area 101 and a second area 102, located opposite the hot gas surface 3.

[0019] The configuration of the invention comprises a plurality of longitudinally spaced reinforcing ribs 5, located at least on one of the first area 101 or the second area 102, these plurality of longitudinally spaced reinforcing ribs 5 being preferably located on both first area 101 and second area 102. An impingement sheet 4 with a plurality of impingement holes 40 is located over the T-junction 100, on the side opposite to the side facing the hot gas (hot gas surface 3), such that a cooling air flow 400 is blown through the impingement holes 40 in the impingement sheet 4. With this configuration, the cooling air flow 400 impinges into the cavities 7 generated between the longitudinally spaced ribs 5 on the first area 101, on the second area 102 or on both areas, 101 and 102. Therefore, into the cavities 7 created between the T-junction 100 and the reinforcing ribs 5, the impingement cooling air flow 400 is much better utilized because the cooling surface area is increased.

[0020] According to another embodiment, the configuration of the invention shown in Figures 3a, 3b and 4, reduces the wall thickness in both junction first and second areas 101 and 102, compared to the wall thickness in the prior art configuration shown in Figure 1. The wall thickness is reduced longitudinally, preferably all along the second wall 2, as shown in Figure 4. According to another embodiment of the invention, the wall thickness can be reduced longitudinally, all along the second wall 2, and also vertically, all along the first wall 1. With this configuration, the cooling air flow 400 impinges on a reduced wall thickness area (101, 102) of the T-junction 100, impinging into the cavities 7 generated between the longitudinally spaced ribs 5, first wall 1 and second wall 2. Therefore, the impingement cooling air flow 400 is much better utilized in both the first area 101 and the second area 102 thanks to the plurality of cavities 7, as the cooling surface area is increased. According to the invention, the reinforcing ribs 5 recover some of the stiffness sacrificed by the wall thickness reduction.

[0021] With the configuration of the invention, using the same cooling air flow 400 consumption, the temperature hot spot 8 at the middle of the web 1 is significantly reduced (in special cases even more than 30°C), as shown in the graph of Figure 2. Furthermore, this configuration allows lifetime at the T-junction 100 to be increased by around 50%, compared to its lifetime in the prior art, as shown in Figure 1.

[0022] Although the configuration of the T-junction 100 of the present invention has been described with reference to stator heat shields in a gas turbine, as shown in Figures 3a and 3b, the configuration of the invention can be applied to any T-junction design, for example to gas turbine vanes (shown in Figure 5) or to gas turbine blades (shown in Figure 6).

[0023] Although the present invention has been fully described in connection with preferred embodiments, it is evident that modifications may be introduced within the scope thereof, not considering this as limited by these embodiments, but by the contents of the following claims.

1	First wall
2	Second wall
3	Hot gas surface
4	Impingement sheet
5	Reinforcing ribs
6	Hot spot
7	Cavities
8	Reduced hot spot
400	Air flow
40	Impingement holes
100	T-junction
101	First area T-junction
102	Second area T-junction

Claims

1. Cooling configuration for a gas turbine T-junction (100) joining a first wall (1) and a second wall (2), the second wall (2) requiring cooling because it is subjected to hot gas on one side (3), the cooling configuration comprising an impingement sheet (4) having a plurality of holes (40) through which an air flow (400) is blown and being **characterized in that** it comprises a plurality of reinforcing ribs (5) defining a plurality of cavities (7) between them, such that the air flow (400) impacts into said cavities (7).

2. Cooling configuration according to claim 1 **characterized in that** the plurality of reinforcing ribs (5) is spaced a similar distance between each other, therefore defining equidistant cavities (7).

3. Cooling configuration according to any of claims 1-2 **characterized in that** the T-junction (100) comprises a first area (101) where the plurality of reinforcing ribs (5) are located, longitudinally.

4. Cooling configuration according to any of claims 1-2 **characterized in that** the T-junction (100) comprises a second area (102) where the plurality of reinforcing ribs (5) are located, longitudinally.

5. Cooling configuration according to any of claims 1-2 **characterized in that** the T-junction (100) comprises a first area (101) and a second area (102), the plurality of reinforcing ribs (5) being located longitudinally in both the first area (102) and the second area (102).

6. Cooling configuration according to claim 5, **characterized in that** the first area (101) and the second area (102) of the T-junction (100) are located opposite to the side facing the hot gas surface (3) in the gas turbine.

7. Cooling configuration according to any of the previous claims, **characterized in that** the wall thickness of the second wall (2) is locally reduced in the vicinity of its junction to the first wall (1).

8. Cooling configuration according to claim 7, **characterized in that** the wall thickness of the first wall (1) is also locally reduced in the vicinity to its junction to the second wall (2).

9. Gas turbine stator heat shield comprising a cooling configuration according to any of claims 1-8.

10. Gas turbine blade comprising a cooling configuration according to any of claims 1-8.

11. Gas turbine vane comprising a cooling configuration according to any of claims 1-8.

12. Gas turbine stator heat shield comprising a cooling configuration according to any of claims 1-8.

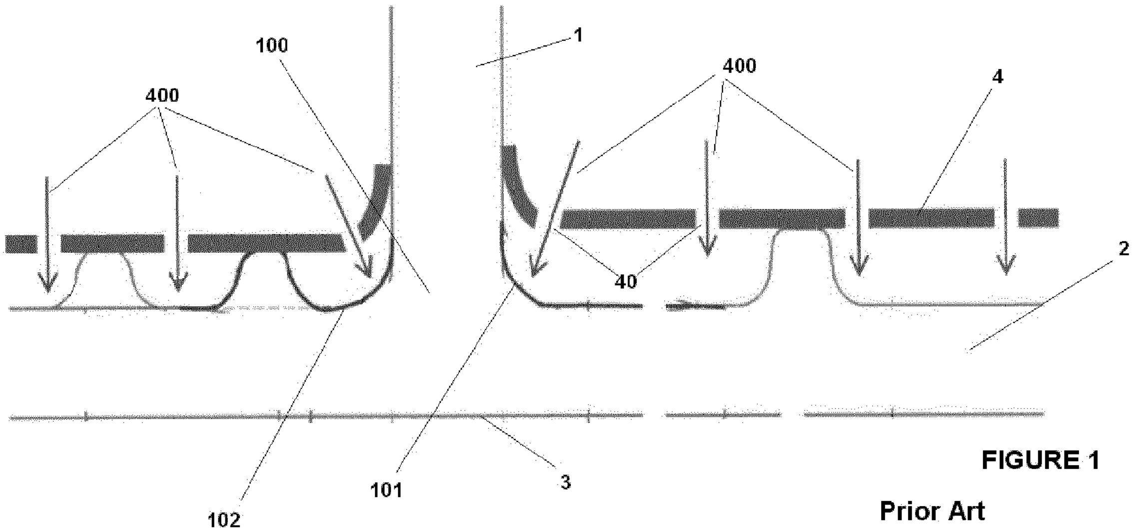

FIGURE 1

Prior Art

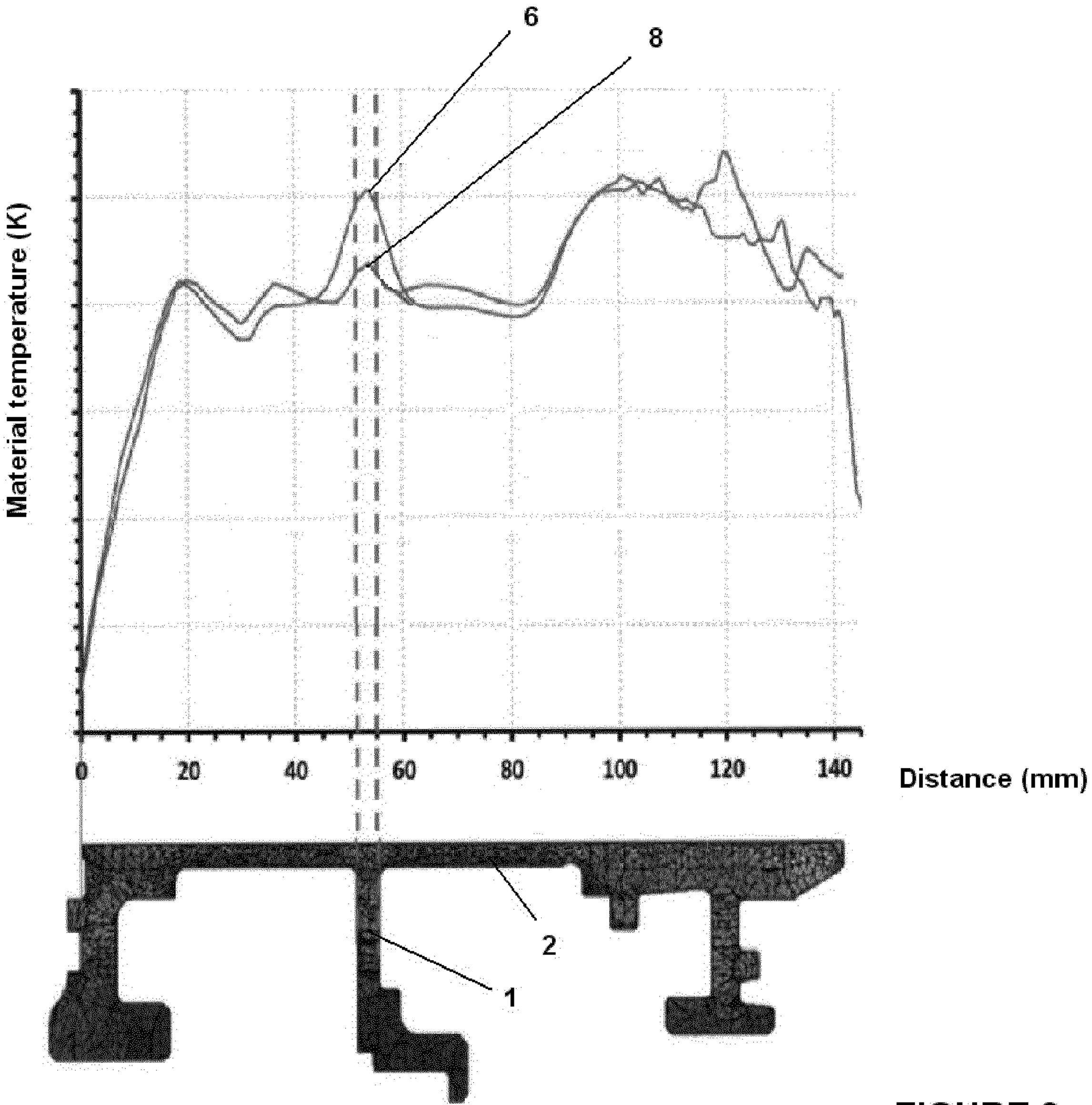
6
8
Material temperature (K)
0
20
40
60
80
100
120
140
Distance (mm)
2
1

FIGURE 2

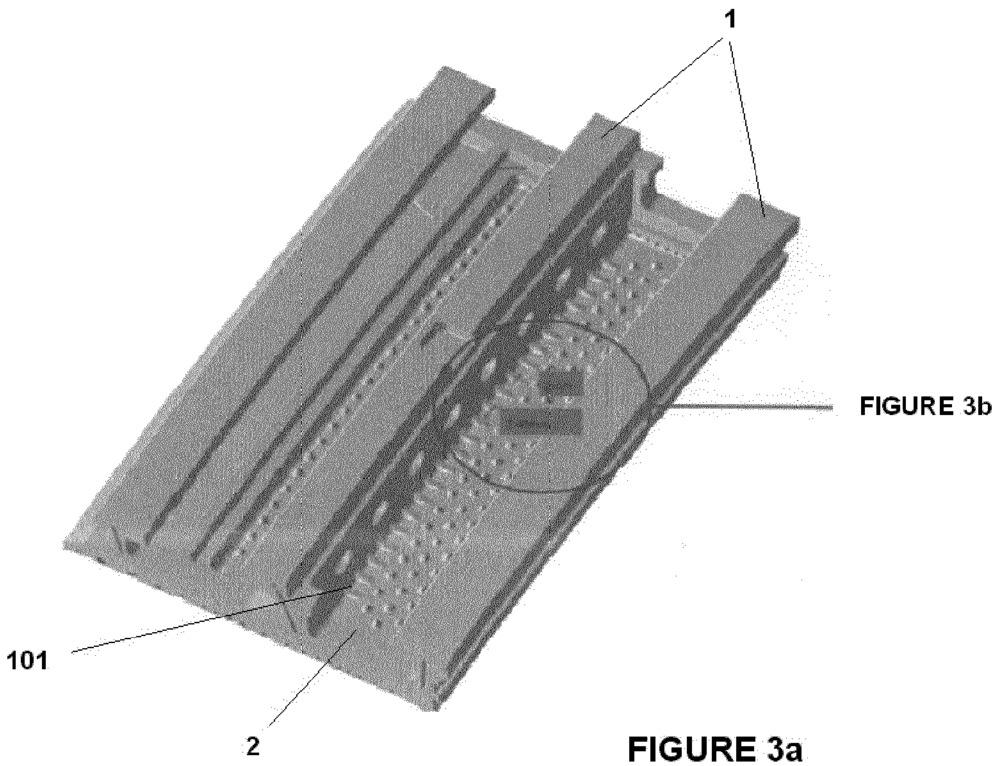

FIGURE 3a

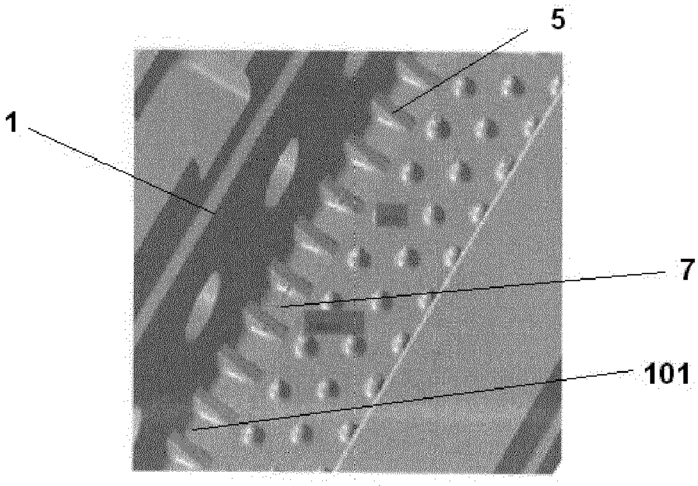

FIGURE 3b

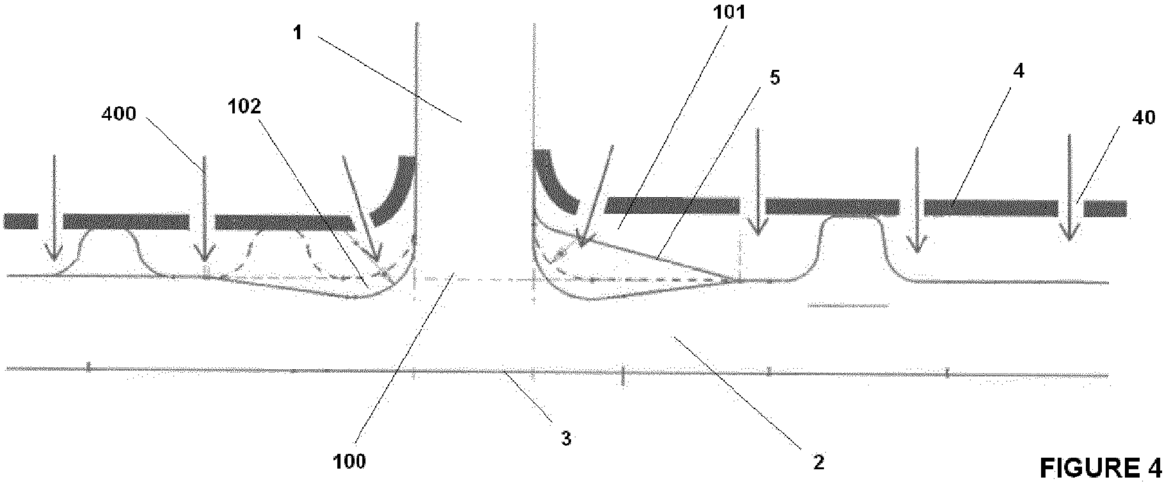

FIGURE 4

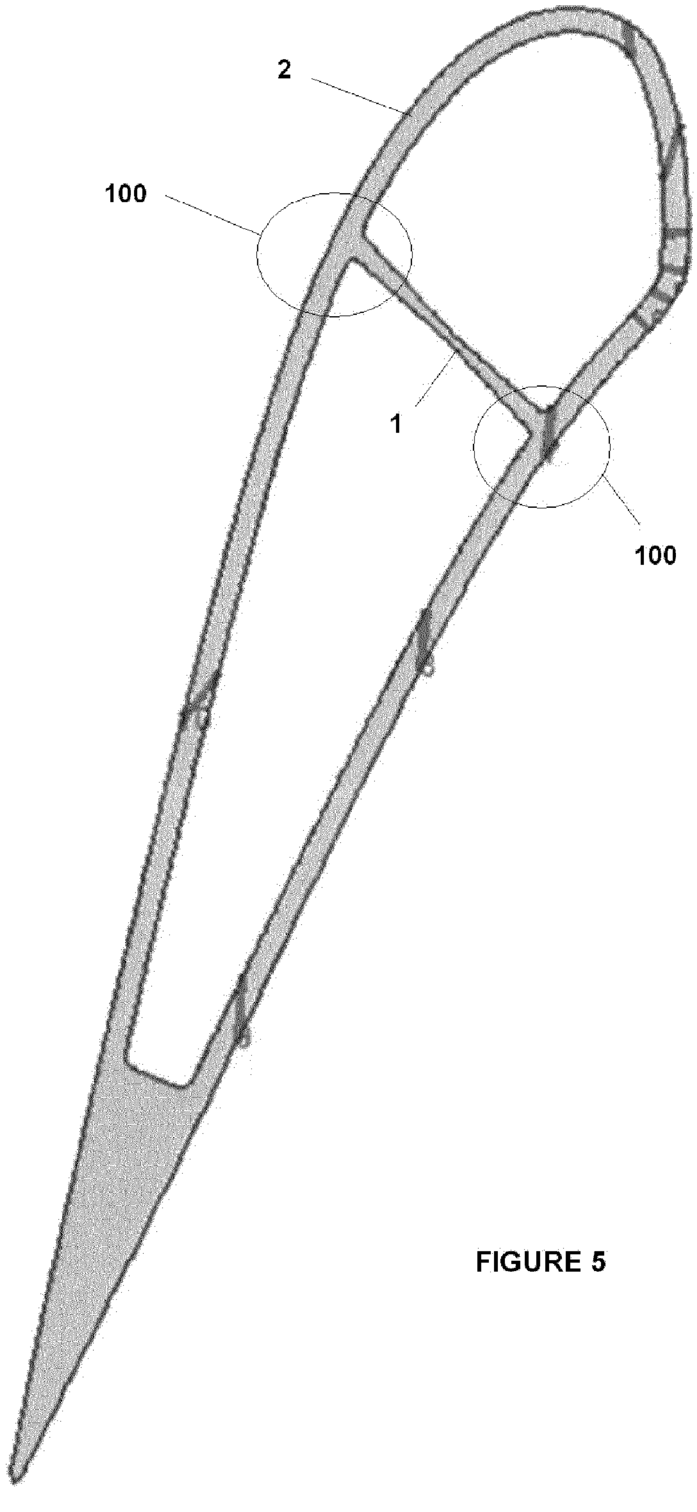

FIGURE 5

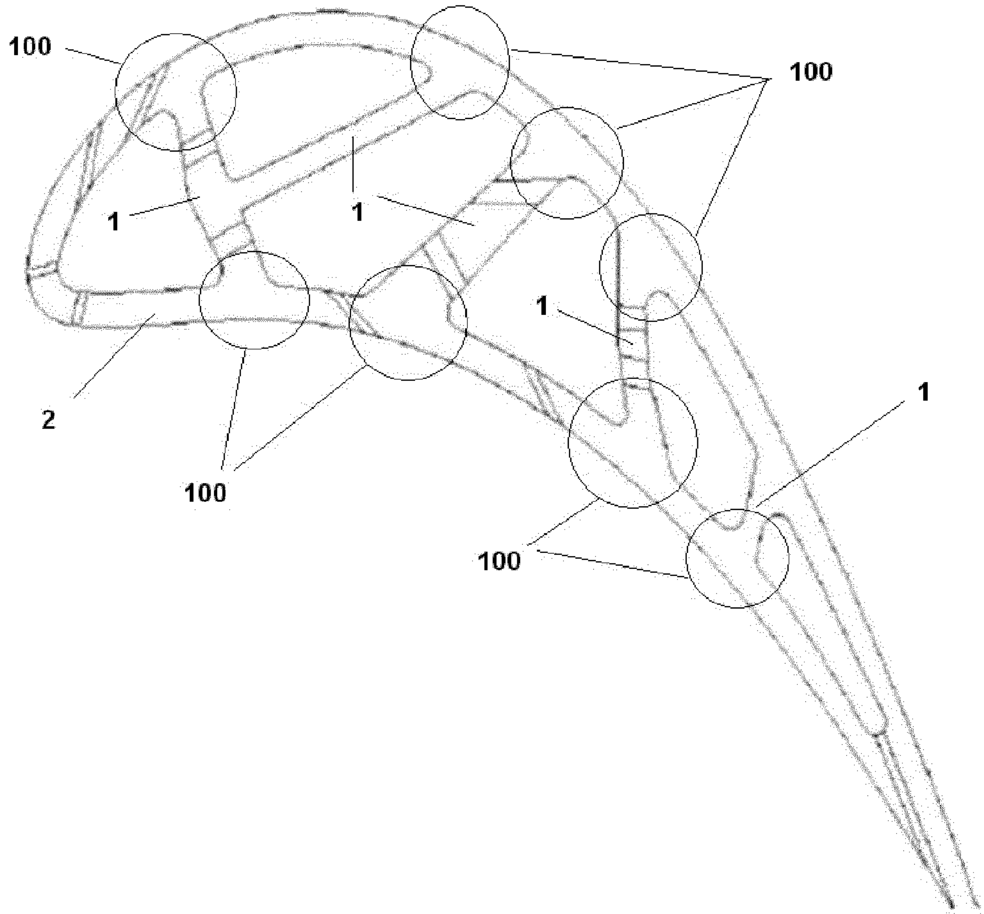

FIGURE 6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 0882

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 June 2013	Lutoschkin, Eugen

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	3 June 2013	Lutoschkin, Eugen

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