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(54) **AN AEROFOIL AND A METHOD FOR CONSTRUCTION THEREOF**

TRAGFLÄCHE UND KONSTRUKTIONSVERFAHREN DAFÜR

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Description

[0001] The present invention relates to an aerofoil and a method for construction of the aerofoil.

[0002] An aerofoil is generally used as a vane and/or a blade in a turbomachine such as a gas turbine or a steam turbine for power generation. The turbomachine operates for extensive periods of time, and during its operation the aerofoil comes into contact with very high temperature gases (in excess of 1000°C), i.e. the working fluid in the turbomachine. Therewith the temperature of the external surface of the aerofoil increases tremendously. Exposure of the aerofoil to the tremendously high operating temperatures for such extensive periods of time leads to a reduction of the operational life span of the aerofoil. Thus, the aerofoil needs to be cooled during its operation for increasing its operational life span.

[0003] Impingement cooling is a popular technique that is employed for cooling an aerofoil. In impingement cooling, a coolant fluid is bombarded at high pressure onto certain regions (hot spots) on the aerofoil that require cooling. This requires the coolant fluid to be provided with high pressure for producing the impingement, which requires the employment of additional means to increase the coolant fluid pressure. Therefore, the current impingement cooling technique is expensive as well as not efficient for cooling the aerofoil.

[0004] US5704763 discloses an airfoil with a subdivided cooling passageway including arrangements for creating turbulences of a cooling fluid directed through the passageway. The turbulences improve the cooling efficiency.

[0005] US 5 738 493 discloses a turbulator for a rotor blade.

[0006] US7722327 proposes an alternative technique for cooling an aerofoil, and recites a multiple vortex cooling circuit for a thin aerofoil, wherein a wall of the aerofoil is constructed with a plurality of individual vortex cooling channels that are connected to a leading edge cooling air supply channel. This is however a very expensive solution, because it advocates an intricate aerofoil structure, thereby increasing the complexity of construction of the aerofoil.

The objective of the present invention is to propose a simpler and an enhanced design of an aerofoil for improving the efficiency of cooling the aerofoil.

[0007] The above objective is achieved by an aerofoil according to claim 1 and a method for construction of the aerofoil according to claim 10.

[0008] The underlying objective of the present invention is to propose a design for an aerofoil such that the cooling of the aerofoil, especially during the operation of the aerofoil, is enhanced. Herein, the aerofoil according to the present invention comprises an outer wall, an inner wall, and a cooling channel located between the aforementioned walls. The cooling channel is purported to guide a coolant fluid during the operation of the aerofoil. The inner wall comprises a protrusion, which extends

from a surface of the inner wall and into the cooling channel. This protrusion is arranged and profiled so as to direct at least a part of the coolant fluid, which is flowing through the cooling channel and especially over the protrusion, to impinge the coolant fluid on to a first region of the outer wall. Furthermore, the outer wall comprises a protrusion, which extends from a surface of the outer wall and into the cooling channel. The protrusion on the outer wall is also arranged and profiled so as to direct at least a part of the coolant fluid, which is flowing through the cooling channel and especially over the protrusion on the outer wall, to impinge the coolant fluid on to a second region of the inner wall.

[0009] The protrusion aids in directing the coolant fluid for producing an impingement of the coolant fluid on the outer wall.

[0010] The impingement of the coolant fluid on the outer wall purports to transfer more the heat from the outer wall on to the coolant fluid, especially compared to the conventional technique of convection cooling. Additionally, by providing a protrusion, the effective surface area of the wall is increased, thereby enhancing the transfer of heat from the outer wall to the coolant fluid. Therewith, it is possible to redirect the coolant fluid impinging on the outer wall back on to the inner wall during the circulation of the coolant fluid inside the cooling channel, thereby preparing the coolant fluid to be directed again on to the outer wall to cause an impingement of the coolant fluid on a different location on the outer wall.

[0011] Thereby an enhanced cooling of the outer wall is achieved, especially the cooling of the first region.

[0012] According to an embodiment of the invention disclosed herein, the protrusion on the inner wall extends both in a direction of flow of the coolant fluid and in a direction towards the outer wall.

[0013] According to another embodiment of the invention disclosed herein, the protrusion comprises an ascending portion, a descending portion and a peak, when perceived in an overall direction of flow of the coolant fluid. The ascending portion ascends in a direction towards the outer wall, whereas the descending portion descends in a direction towards the inner wall. The peak is located between the ascending portion and the descending portion. Additionally, an absolute value of a gradient of the descending portion is greater than an absolute value of a gradient of the ascending portion.

[0014] This profile of the protrusion according to the preceding embodiments is advantageous in smoothly directing the coolant fluid on to the first region on the outer wall. The gradient of the ascending portion smoothly guides the coolant fluid along the ascending portion in a manner for increasing the efficacy of the impingement of the coolant fluid on to the first portion of the outer wall. Therewith, both efficacious impingements as well as an unobstructed circulation of the coolant fluid in the cooling channel are achieved.

[0015] According to yet another embodiment of the invention disclosed herein, the location of the protrusion in

the aerofoil is such that it is proximal to a leading edge of the aerofoil. The leading edge of the aerofoil undergoes more heating than the trailing edge of the aerofoil during the operation of the aerofoil. Therefore, by dint of the protrusion being located closer to the leading edge, the protrusion purports to cool down the part of the aerofoil that undergoes more heating, thereby increasing the operational life span of the aerofoil.

[0016] According to yet another embodiment of the invention disclosed herein, the protrusion on the outer wall extends both in a direction of flow of the coolant fluid and in a direction towards the inner wall.

[0017] According to yet another embodiment of the invention disclosed herein, the protrusion on the outer wall also comprises an ascending portion, a descending portion and a peak, when perceived in an overall direction of flow of the coolant fluid. The ascending portion ascends in a direction towards the inner wall, whereas the descending portion descends in a direction towards the outer wall. The peak is located between the ascending portion and the descending portion. Additionally, an absolute value of a gradient of the descending portion is greater than an absolute value of a gradient of the ascending portion.

[0018] This profile of the protrusion on the outer wall that is in accordance with any of the preceding embodiments is advantageous in smoothly directing the coolant fluid impinging on to the first region on the outer wall back to the second region on the inner wall. The gradient of the ascending portion smoothly guides the coolant fluid along the ascending portion in a manner for increasing the efficacy of the impingement of the coolant fluid on to the second portion of the inner wall. Therewith, both efficacious impingements as well as an unobstructed circulation of the coolant fluid in the cooling channel are achieved. Furthermore, this is beneficial in causing a series of impingements of the coolant channel on the outer wall, thereby aiding in increasing the efficiency of cooling the outer wall.

[0019] According to yet another embodiment of the invention disclosed herein, when perceived in the overall direction of flow of the coolant fluid, the location of the protrusion on the outer wall and the location of the protrusion on the inner wall such that the part of coolant fluid that is directed towards the first region by the protrusion on the inner wall impinges on the ascending portion of the protrusion on the outer wall. Therewith, it is possible to cause a more efficient and a smoother flow path of the coolant fluid in the cooling channel.

[0020] According to yet another embodiment of the invention disclosed herein, when perceived in the overall direction of flow of the coolant fluid, the peak of the protrusion on the inner wall and the peak of the protrusion on the outer wall are offset to one another. Therewith, it enhances the smoothness of the flow as well as the efficacy of the series impingements of the coolant fluid between the walls of the aerofoil.

[0021] According to yet another embodiment of the in-

vention disclosed herein, the location of the protrusion on the outer wall is such that it is proximal to the leading edge of the aerofoil. Therewith, it benefits the cooling of the parts of the aerofoil located proximal to the leading edge, because the leading edge of the aerofoil undergoes maximum heating during the operation of the aerofoil. This purports to increase the operational life span of the aerofoil.

[0022] In a method for construction of the aerofoil according to any of the aforementioned embodiments, the outer wall and the inner wall are arranged such that the cooling channel separates the outer wall and the inner wall. The protrusion on the inner wall is provided such that the protrusion (70) on the inner wall extends from the surface of the inner wall and into the cooling channel. Furthermore, the protrusion on the outer wall is provided such that the protrusion on the outer wall extends from the surface of the outer wall and into the cooling channel. Therewith, it is possible to directing at least a part of the coolant fluid flowing through the cooling channel and also over the protrusion on the outer wall for impinging the on to a second region of the inner wall.

[0023] Therewith, it is beneficial in directing the coolant fluid for producing an impingement of the coolant fluid on the first region on the outer wall.

[0024] The aforementioned and other embodiments of the invention related to an aerofoil and a method for cooling thereof will now be addressed with reference to the accompanying drawings of the present invention. The illustrated embodiments are intended to illustrate, but not to limit the invention. The accompanying drawings contain the following figures, in which like numbers refer to like parts, throughout the description and drawings.

[0025] The figures illustrate in a schematic manner further examples of the embodiments of the invention, in which:

FIG 1 depicts a cross-sectional view of an aerofoil according to an embodiment of the present invention,

FIG 2 depicts an enlarged cross-sectional view of a section of the aerofoil referred to in FIG 1, and

FIG 3 depicts a flowchart of a method for construction of the aerofoil referred to in FIG 1.

[0026] FIG 1 depicts a cross-sectional view of an aerofoil 10 in accordance with one or more embodiments of the invention described herein. The aerofoil 10 can be a vane or a blade of a turbomachine (not depicted), such as a gas turbine or a steam turbine that is employed for power generation.

[0027] The aerofoil 10 comprises a first wall 20, a second wall 30, and a cooling channel 40. The cooling channel 40 is located between the first wall 20 and the second wall 30, and the cooling channel 40 facilitates the cooling of first wall 20 of the aerofoil 10. The first wall 20 is an

outer wall and the second wall 30 is an inner wall of the aerofoil 10, wherein the outer wall 20 surrounds the inner wall 30. Furthermore, the cooling channel 40 separates the inner wall 30 and the outer wall 20. In accordance with an exemplary aspect, the cooling channel 40 can preferably surround the entire extent of the inner wall 30. However in the exemplary aerofoil described herein, the inner wall 30 is a core of the aerofoil 10.

[0028] During the operation of the turbomachine, the outer wall 20 is exposed to hot gases 50 thereby resulting in the heating of the outer wall 20, which subsequently increases the temperature of the outer wall 20. A coolant fluid 60, which is dispensed into the cooling channel 40, flows through the cooling channel 40. The dispensation of the coolant fluid 60 into the cooling channel 40 of the aerofoil 10 is however a well-known technique and is not covered herein for the purpose of brevity.

[0029] While the coolant fluid 60 passes through the cooling channel 40, the coolant fluid 60 is in thermal contact with both the outer wall 20 and the inner wall 30. The inner wall 30 is relatively cooler than the outer wall 20. The interaction between the coolant fluid 60 and the outer wall 20 results in a substantial transfer of heat from the outer wall 20 to the coolant fluid 60, thereby resulting in the cooling of the outer wall 20. The majority of heat would be removed from the aerofoil 10 together with the coolant fluid 60 as described below. Moreover, since the coolant fluid 60 is in contact with the outer wall 20 as well as the inner wall 30, the cooling channel 40 is capable of transferring a marginal amount of heat onto the inner wall 40. However, the majority of the heat transferred from the outer wall 20 onto the coolant fluid 60 is still retained in the coolant fluid 60. Therewith, the cooling the outer wall 20 is achieved in accordance with the aforementioned manner.

[0030] The coolant fluid 60 can be dispensed into the cooling channel 40 using any of the well-known techniques, for example, by means of a coolant fluid supply (not depicted) operably coupled to an inlet hole 45 provided on a base or a root (not depicted) of the aerofoil 10. Thereafter the coolant fluid 60 flows through the cooling channel 40, and the coolant fluid 60 finally exits thorough an exit hole 165 that is generally located in the trailing edge 160 of the aerofoil 10. The coolant fluid 60 thereby circulates inside the cooling channel 40 by entering into the aerofoil 10 through the inlet hole 45 and by exiting through the exit hole 165. Herewith, the majority of heat is transported out of the aerofoil 10 by means of circulating the coolant fluid 60 in the cooling channel 40 of the aerofoil 10.

[0031] With reference to the exemplary aerofoil 10 depicted in FIG 1, in the upper half 110 of the aerofoil 10, which is both above the camber line 100 and proximal to the suction side 130 of the aerofoil 10, the coolant fluid 60 generally flows towards the leading edge 150 of the aerofoil 10. On the other hand, in the lower half 120 of the aerofoil 10, which is both below the camber line 100 and proximal to the pressure side 140 of the aerofoil 10,

the coolant fluid 60 generally flows towards the trailing edge 160 of the aerofoil 10.

[0032] To increase the efficiency of the transfer of heat between the outer wall 20 and the coolant fluid 60 for cooling the outer wall 20, a portion 35 of the inner wall 30 comprises a plurality of protrusions 70,75. The protrusions 70,75 on the inner wall 30 are preferably integral to the inner wall 30. Herein, each of the protrusions 70,75 on the inner wall 30 extends from a surface 37 on the inner wall 30 into the cooling channel 40 and generally in a direction towards the outer wall 20. These protrusions 70,75 on the inner wall influence the course of the coolant fluid 60 flowing in the cooling channel 40. Each of the protrusions 70,75 on the inner wall 30 is arranged and profiled such that the coolant fluid 60 is directed towards an opposing first region 64 on the outer wall 20, in order to impinge the coolant fluid 60 on that first region 64 on the outer wall 20. An impingement cooling effect on the opposing first region 64 is therewith achieved since the coolant fluid 60 is provided with increased pressure on the first region 64. This impingement of the coolant fluid 60 on the first region 64 herein results in an enhanced transfer of heat from the first region 64 on the outer wall 20 on to the coolant fluid 60. The portion 35 of the inner wall 30 comprising the protrusions 70,75 is preferably located proximal to the leading edge 150 of the aerofoil 10 because of the significant heating experienced at the leading edge 150 of the aerofoil 10.

[0033] Similarly, a portion 25 of the outer wall 20 also comprises a plurality of protrusions 80,85, wherein each of the protrusions 80,85 on the outer wall 20 extends from a surface 27 on the outer wall 20 into the cooling channel 40 and generally in a direction towards the inner wall 30. The protrusions 80,85 on the outer wall 20 are preferably integral to the outer wall 20. Each of the protrusions 80,85 on the outer wall 20 is arranged and profiled such that at least a part of the coolant fluid 60 that impinges on the first region 64 on the outer wall 20 is directed towards an opposing second region 66 on the inner wall 30, thereby producing an impingement cooling effect on the second region 66 on the inner wall 30, therewith resulting in a marginal transfer of heat from the coolant fluid 60 to the inner wall 30. However, the majority of the heat is still retained in the coolant fluid 60.

[0034] Herein, it is preferred that the inner wall 30 and the outer wall 20 comprise a respective plurality of protrusions 70,75,80,85, such that several corresponding first regions 64 and second regions 66 are present on the outer wall 20 and the inner wall 30 onto which the coolant fluid would be directed to achieve impingement cooling effect on the first regions 64 and second regions 66.

[0035] Herein, with the arrangement of the plurality of protrusions 70,75,80,85 both on the inner wall 30 and the outer wall 20, the impinged coolant fluid is repeatedly redirected between the outer wall 20 and the inner wall 30 in an overall flow direction of the coolant fluid 60 in the cooling channel 40. For example, if the first protrusion

70,75 is located on the inner wall 30 as viewed in the overall flow direction, the coolant fluid 60 is directed to impinge on the first region 64 on the outer wall 20. Thereafter, the coolant fluid 60 is redirected towards the opposing second region 66 on the inner wall 30 for further impingement of the coolant fluid 60 on the inner wall 30. Thereafter, the coolant fluid 60 will be again redirected towards the first region 64 of the outer wall, and so on. Especially, this series of impingements of the coolant fluid 60 on the outer wall 20 of the aerofoil 10 result in enhancing the efficiency of cooling of the aerofoil 10. Furthermore, this portion 25 of the outer wall 20 comprising the protrusions 70,75 is again preferably located proximal to the leading edge 150 of the aerofoil 10.

[0036] In the upper half 110 of the aerofoil 10, the overall direction of flow of the coolant fluid 60 in the cooling channel 40 of the exemplary aerofoil 10 depicted herein is in a direction preferably from the trailing edge towards the leading edge 150. However, the local direction of the flow of the coolant fluid 60 is determined by the profile of each of the protrusions 70,75,80,85 over which the coolant fluid 60 flows.

[0037] An exemplary section 65 of the aerofoil 10 depicting the hereinabove mentioned portions 25,35 of the outer wall 20 and the inner wall 30 and the cooling channel 40, which is present between the portions 25,35 and the walls 20,30, is elucidated with reference to FIG 2. The series of impingements of the coolant fluid 60 on the outer wall 20 of the section 65 takes place due to the coolant fluid 60 flow over the protrusions 70,75 on the inner wall 30 of the section 65. Similarly, the series of impingements of the coolant fluid 60 on the inner wall 30 of the section 65 takes place due to the coolant fluid 60 flow over the protrusions 80,85 on the outer wall 20 of the section 65. The geometry of the protrusions 70, 75, the flow of the coolant fluid 60, and the manner in which the protrusions 70,75 direct the coolant fluid 60 to cause impingements of the coolant fluid 60 on the first regions 64 and the second regions 66 of the respective outer wall 20 and the inner wall 30 for cooling the outer wall 20 will be explained in the following paragraphs.

[0038] FIG 2 depicts an enlarged cross-sectional view of the aforementioned exemplary section 65 comprising the portion 25 of the outer wall 20 and the portion 35 of the inner wall 30 of the aerofoil 10.

[0039] The exemplary section 65 depicted herein is located in the upper half 110 of the aerofoil 10 and is furthermore proximal to the leading edge 150 of the aerofoil 10 when compared to the trailing edge 160 of the aerofoil 10. The overall direction of the flow of the coolant fluid 60 in the cooling channel 40 comprised in the depicted section 65 is in the direction from the trailing edge 160 towards the leading edge 150.

[0040] For the purpose of elucidation of the exemplary section 65, two exemplary protrusions 80,85 on the portion 25 of the outer wall 20 and two exemplary protrusions 70,75 on the portion 35 of the inner wall 30 of the aerofoil 10 are considered. When viewed along the overall direc-

tion of the flow of the coolant fluid 60 in the section 65, each of the aforementioned protrusions 70,75,80,85 comprises the following:

1. an ascending portion 170,
2. a peak 175, and
3. a descending portion 180.

[0041] When viewed along the overall direction of the flow of the coolant fluid 60, the ascending portions 170 of the respective protrusions 70,75 on the inner wall 30 extends from the surface 37 on the inner wall 30 and ascends in the direction towards the outer wall 20, whereas the ascending portion 170 of the protrusion 80,85 on the outer wall 20 extends from the surface 27 on the outer wall 20 and ascends in the direction towards the inner wall 30. The ascending portion 170 is preferably both continuous and smooth, and each of the ascending portions 170 of each of the protrusions 70,75,80,85 end at the respective peak 175 of the respective protrusions 70,75,80,85. The coolant fluid 60 flowing over the ascending portion 170 of each of the protrusions 80,85 is directed towards the ascending portion 170 of the opposing protrusion 70,75 on the opposite wall 30. Subsequently, this results in the impingement of the coolant fluid 60 on the opposing second region 64 of the opposite wall 20, thereby leading to an enhanced transfer of heat between the coolant fluid 60 and the opposite wall 20.

[0042] Additionally the flow of the coolant fluid 60 over the ascending portion 170 of the protrusion 70,75 results in accelerating the coolant fluid 60. Therewith the velocity of the coolant fluid 60 is increased. A higher impact upon the impingement of the coolant fluid 60 on the ascending portion 170 of the protrusion 80,85 on the opposing wall 20 is achieved, which enhances the transfer of heat from the wall 20 to the coolant fluid 60.

[0043] When viewed along the overall direction of the flow of the coolant fluid 60, the descending portion 180 of the protrusion 70,75 on the inner wall 30 descends from the respective peak 175 and in the direction towards the inner wall 30 itself, whereas the descending portion 180 of the protrusion 80,85 on the outer wall 20 descends from the respective peak 175 and in the direction towards the outer wall 20 itself. Herein, the absolute values of the respective gradients of the descending portions 180 of each of the respective protrusions 70,75,80,85 are preferably greater than the absolute values of the gradients of the ascending portions 170 of each of the respective protrusions 70,75,80,85, i.e. the ascending portion 170 ascends gradually and the descending portion 180 descends abruptly.

[0044] The profile of the ascending portion 170 may be linear, logarithmic, exponential, quadratic, and the like. Similarly, the profile of the descending portion 180 may be linear, logarithmic, exponential, quadratic, and the like. However, the profiles of all the protrusions 70,75,80,85 are essentially the same.

[0045] The peak 175 of each of the protrusions

70,75,80,85 lies between the respective ascending portion 170 and the respective descending portion 180 of the protrusion 70,75,80,85. The gradient of the protrusion 70,75,80,85 is zero at its peak 175. The local flow direction of the coolant fluid 60 constantly changes as the coolant fluid flows along the ascending portions 170 of the respective protrusions 70,75,80,85. The local flow at the peak 175 of the respective protrusions 70,75,80,85 is in the direction towards the respective opposing region 64,66 of the opposing wall 20,30, whereon the coolant fluid 60 impinges.

[0046] The flow of the coolant fluid 60 over the protrusions 70,75,80,85 may also create vortices of the coolant fluid 60 flow depending on the profiles of the respective protrusions 70,75,80,85. Herein the usually laminar flow of the coolant fluid 60 is converted into a turbulent flow, akin to a turbulator effect, thereby resulting in better transfer of heat between the coolant fluid 60 and the inner wall 30 and outer wall 20 of the aerofoil 10.

[0047] The overall direction of the flow of the coolant fluid 60 is represented herein by a tangent 'X' 190, which is tangential to the portion 25 of the outer wall 20 that is comprised in the section 65. The peaks 175 of the protrusions 70,75,80,85 depicted in the section 65 are projected on to the tangent 'X' 190 by dropping perpendiculars from the peaks 175 on to the tangent 'X' 190, thereby resulting in the positions X_1 , X_2 , X_3 and X_4 of the peaks 175 on the tangent 'X'. Therein X_1 and X_3 are the positions of the peaks 175 of the respective exemplary protrusions 80,85 on the outer wall 20, and wherein X_2 and X_4 are the positions of the peaks 175 of the respective exemplary protrusions 70, 75 on the inner wall 30.

[0048] The respective protrusions 70,75,80,85 on any of the walls 20,30 are preferably and substantially equidistant from one another, i.e. the distance between the neighbouring peaks 175 of the respective protrusions 70,75,80,85 are substantially equal when viewed along the overall direction of flow of the coolant fluid 60. For example, the distance between the peaks X_1 and X_3 175 of the protrusions 80,85 will be identical to the distance between any two neighbouring peaks 175 of the respective protrusions 80,85 on the outer wall 20 of the aerofoil 10. Herein, it may be noted that the distance between the protrusions 70,75 on the inner wall 30 may differ slightly when compared to the distance between the protrusions 80,85 on the outer wall 20. This can be attributed to the slightly different curvatures and radii of the inner wall 30 and the outer wall 20. Also, the distances between the protrusions 70,75 on the inner wall 30 may vary slightly due to the variation in curvature of the inner wall 30, and the same reason is also valid for the outer wall 20. However, the distances between the respective protrusions 70,75,80,85 of the respective walls 20,30 are substantially equal when considered section wise.

[0049] Furthermore, the protrusions 70,75 on one wall 30 and the protrusions 80,85 on the opposing wall 20 are offset, i.e. they are not directly opposite from one another, when viewed along the overall direction of flow of the

coolant fluid 60. I.e. a peak 175 of a protrusion 80,85 on the outer wall 20 and a peak 175 of a protrusion 70,75 on the inner wall 30 are preferably not directly opposite to one another. For example, X_1 and X_2 are not directly opposite to one another and the same applies to X_3 and X_4 . Additionally, the peak X_2 is located in between peaks X_1 and X_3 when viewed along the tangent 'X' 190, preferably midway of peaks X_1 and X_3 . Similarly, the peak X_3 is located in between peaks X_2 and X_4 when viewed along the tangent 'X' 190, preferably midway of peaks X_2 and X_4 .

[0050] The locations of the protrusions 80,85 on the outer wall 20 relative to the locations of the protrusions 70,75 on the inner wall 30 are such that the first and second regions 64,66 onto which the coolant fluid 60 impinges are each located between the peaks 175 of the respective protrusions 70,75,80,85 of the respective outer and inner walls 30, 20. I.e. the first regions 64 on the outer wall 20 are located between the peaks X_1 and X_3 170 of the protrusions 80,85 of the outer wall 20, whereas the second regions 66 on the inner wall 30 are located between the peaks X_2 and X_4 170 of the protrusions 70,75 of the inner wall 30.

[0051] Herein, the individual locations of the protrusions 70,75,80,85 are meant to be the individual positions of the protrusions 70,75,80,85 in the overall direction of the flow of the coolant fluid 60.

[0052] Preferably, the first and second regions 64,66 onto which the coolant fluid 60 impinges are the respective protrusions 70,75,80,85 of the opposing walls 20,30. Especially, the first region 64 and the second region 66 are the ascending portions 170 of the respective protrusions 70,75,80,85. The coolant fluid 60 ascends along the ascending portion 170 of a protrusion 70 and the direction of the coolant fluid flow changes at the peak 175 of the protrusion 70,75,80,85. Thereafter the coolant fluid 60 is directed towards the ascending portion 170 of the opposing protrusion 80 on the opposite wall 30, whereon it impinges thereby leading to a transfer of heat from the opposite wall 20 to the coolant fluid 60. Therewith, the aforementioned first regions 64 and the second regions 66 can be the respective ascending portions of the respective protrusions 70,75,80,85. Herein, the impingement of the coolant fluid 60 on the outer wall 30 leads to the transfer of heat from the outer wall 20 to the coolant fluid 60, whereas the impingement of the coolant fluid 60 and the inner wall 30 leads to the transfer of heat from the coolant fluid 60 to the inner wall 30. The bulk of transfer of heat always occurs at the ascending portion 170 of the protrusion 70,75,80,85 upon the impingement of the coolant fluid 60 on the protrusion 70,75,80,85.

[0053] Herein the protrusions 70,75,80,85 may be provided on the outer wall 20 and the inner wall 30 by means of precision casting, laser sintering, electrical discharge machining, et cetera.

[0054] FIG 3 depicts a flowchart of a method for construction of the aerofoil 10.

[0055] In a step 200, the inner wall 30 and the outer

wall 20 of the aerofoil 10 are arranged opposing one another. The arrangement of the walls 20,30 is such that the aforementioned cooling channel 40 is formed between the inner wall 30 and the outer wall 20, wherein the cooling channel 40 separates the inner wall 30 and the outer wall 20.

In a step 210, the inner wall 30 is provided with protrusions 70,75. The protrusions 70,75 on the inner wall 30 extend from the surface 37 and also into the cooling channel 40 and in the direction towards the outer wall 20. Additionally, the outer wall 20 is also provided with the protrusions 80,85. The protrusions 80,85 on the outer wall 20 also extend both from the surface 27 and also into the cooling channel 40 and in the direction towards the inner wall 30. The arrangement of the inner wall 30 and the outer wall 20 is such that the peaks 175 of the protrusions 70,75 of the inner wall 30 and the peaks 175 of the protrusions 80,85 of the outer wall 20 are offset with respect to each other in the direction of flow of the coolant fluid 60.

[0056] Herein the protrusions 70,75 on a certain wall 30 may be provided at certain predefined locations depending on the regions 64 on the opposing wall 20 wherein the coolant fluid 60 is to be precisely impinged, in order to cool the regions 64 on the opposing wall. These regions 64 may be hotspots on the outer wall 20, which undergo intense heating upon the exposure of the aerofoil 10 to the hot gases 50. These hotspots primarily occur at the leading edge 150 of the aerofoil 10. Herewith the flow of the coolant fluid 60 over the protrusions 70,75,80,85 on the inner wall 30 is precisely directed to cause impingements of the coolant fluid on the hotspots.

[0057] Thereafter the coolant fluid 60 may be dispensed in the cooling channel 40. The course of the coolant fluid 60 in the cooling channel 40 is herein influenced by the profiles of the protrusions 70,75 on the inner wall 30 and the protrusions 80,85 on the outer wall 20.

[0058] The coolant fluid 60 that flows over any of the protrusions 70,75 on the inner wall 30 is directed towards the outer wall 20, thereby leading to impingement of the coolant fluid 60 on the region 64 of the outer wall 20. The impingement of the coolant fluid 60 on the outer wall 20 leads to a transfer of heat from the outer wall 20 to the coolant fluid 60. Therewith, cooling of the outer wall 20 is achieved. Similarly, the coolant fluid 60 that flows over any of the protrusions 80,85 on the outer wall 20 is directed towards the inner wall 30, thereby leading to impingement of the coolant fluid 60 on the region 66 of the inner wall 30. The impingement of the coolant fluid 60 on the inner wall 30 leads to a transfer of heat from the coolant fluid 60 to the inner wall 30. Therewith, the coolant fluid 60 is cooled in order to be redirected again on to the outer wall 20 for further cooling of the outer wall 20.

[0059] Though the invention has been described herein with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various examples of the disclosed embodiments, as well as alternate embodiments of the invention, will become ap-

parent to persons skilled in the art upon reference to the description of the invention.

5 Claims

1. An aerofoil (10) for a turbomachine comprising:

- an outer wall (20) and an inner wall (30), and
- a cooling channel (40) located between the outer wall (20) and the inner wall (30) for guiding a coolant fluid (60) during operation of the aerofoil (10),

wherein the inner wall (30) comprises a protrusion (70) extending from a surface (37) of the inner wall (30) into the cooling channel (40),

wherein the protrusion (70) on the inner wall (30) is arranged and profiled such that the protrusion (70) on the inner wall (30) directs at least a part of the coolant fluid (60), when the coolant fluid (60) is flowing through the cooling channel (40) and over the protrusion (70) on the inner wall (30), for impinging the coolant fluid (60) on to a first region (64) of the outer wall (20),

characterized in that

- the outer wall (20) further comprises a protrusion (80), wherein the protrusion (80) on the outer wall (20) extends from a surface (27) of the outer wall (20) into the cooling channel (40), and

wherein the protrusion (80) on the outer wall (20) is arranged and profiled such that the protrusion (80) on the outer wall (20) directs at least a part of the coolant fluid (60), when the coolant fluid (60) is flowing through the cooling channel (40) and over the protrusion (80) on the outer wall (20), for impinging on to a second region (66) of the inner wall (30).

2. The aerofoil (10) according to claim 1, wherein the protrusion (70) on the inner wall (30) extends both in a direction of flow of the coolant fluid (60) and in a direction towards the outer wall (20).

3. The aerofoil (10) according to claim 1 or 2, wherein in an overall direction of flow of the coolant fluid (60), the protrusion (70) on the inner wall (30) comprises:

- an ascending portion (170) ascending in a direction towards the outer wall (20),
- a descending portion (180) descending in a direction towards the inner wall (30), and
- a peak (175) located between the ascending portion (170) and the descending portion (180),

wherein an absolute value of a gradient of the descending portion (180) is greater than an absolute

value of a gradient of the ascending portion (170).

4. The aerofoil (10) according to any of the claims 1 to 3, wherein the protrusion (70) on the inner wall (30) is located proximal to a leading edge (150) of the aerofoil (10) compared to a trailing edge (160) of the aerofoil (10). 5

5. The aerofoil (10) according to claim 1, wherein the protrusion (80) on the outer wall (20) extends both in the direction of flow of the coolant fluid (60) and in a direction towards the inner wall (30). 10

6. The aerofoil (10) according to claim 1 or 5, wherein in the overall direction of flow of the coolant fluid (60), the protrusion (80) on the outer wall (20) comprises: 15
 - an ascending portion (170) ascending in a direction towards the inner wall (30),
 - a descending portion (180) descending in a direction towards the outer wall (20), and
 - a peak (175) located between the ascending portion (170) and the descending portion (180), 20

wherein for the protrusion (80) on the outer wall (20), an absolute value of a gradient of the descending portion (180) is greater than an absolute value of a gradient of the ascending portion (170). 25

7. The aerofoil (10) according to claim 6, wherein the protrusion (80) on the outer wall (20) and the protrusion (70) on the inner wall (30) are located in the overall direction of flow of the coolant fluid (60) such that the part of coolant fluid (60) that is directed towards the first region (64) of the outer wall (20) by the protrusion (70) on the inner wall (80) impinges on the ascending portion (170) of the protrusion (80) on the outer wall (20). 30
35

8. The aerofoil (10) according to claim 6 or 7, wherein in the overall direction of flow of the coolant fluid (60), the peak (175) of the protrusion (80) on the inner wall (30) and the peak (170) of the protrusion (70) on the outer wall (20) are offset to one another. 40

9. The aerofoil (10) according to claim 8, wherein the protrusion (80) on the outer wall (20) is located proximal to the leading edge (150) of the aerofoil (10). 45

10. A method for construction of an aerofoil (10) for a turbomachine, wherein the aerofoil (10) comprises: 50
 - an outer wall (20) and an inner wall (30), and
 - a cooling channel (40) located between the outer wall (20) and the inner wall (30) such that the cooling channel (40) separates the outer wall (20) and the inner wall (30) for guiding a coolant fluid during operation of the aerofoil, wherein the 55

inner wall (30) comprises a protrusion (70) for directing at least a part of the coolant fluid (60), when the coolant fluid (60) is flowing through the cooling channel (40), for impinging the coolant fluid (60) on a first region (64) of the outer wall (20),

wherein the protrusion (70) on the inner wall (30) extends from a surface (37) of the inner wall (30) into the cooling channel (40), wherein the outer wall (20) further comprises a protrusion (80), and wherein the protrusion (80) on the outer wall (20) extends from a surface (27) of the outer wall (20) into the cooling channel (40), the method comprising:

- a step (200) of arranging the outer wall (20) and the inner wall (30) such that the cooling channel separates the outer wall (20) and the inner wall (30),

characterized in that

- a step (210) of providing the protrusion (70) on the inner wall (30) such that the protrusion (70) on the inner wall (30) extends from the surface (37) of the inner wall (30) into the cooling channel (40), and providing the protrusion (80) on the outer wall (20) such that the protrusion (80) on the outer wall (20) extends from the surface (27) of the outer wall (20) into the cooling channel (40) for directing at least a part of the coolant fluid (60), when the coolant fluid (60) is flowing through the cooling channel (40) and over the protrusion (80) on the outer wall (20), for impinging on to a second region (66) of the inner wall (30).

Patentansprüche

1. Schaufelprofil (10) für eine Turbomaschine mit:

- einer Außenwand (20) und einer Innenwand (30) und
- einem zwischen der Außenwand (20) und der Innenwand (30) liegenden Kühlkanal (40) zum Leiten eines Kühlfluids (60) beim Einsatz des Schaufelprofils (10),

wobei die Innenwand (30) einen Vorsprung (70) umfasst, der von einer Fläche (37) der Innenwand (30) aus in den Kühlkanal (40) hinein verläuft, wobei der Vorsprung (70) an der Innenwand (30) so angeordnet und profiliert ist, dass er zumindest einen Teil des Kühlfluids (60), wenn dieses durch den Kühlkanal (40) und über den Vorsprung (70) an der In-

nenwand (30) strömt, so lenkt,
dass das Kühlfluid (60) an eine erste Region (64)
der Außenwand (20) prallt,
dadurch gekennzeichnet, dass

- die Außenwand (20) ferner einen Vorsprung
(80) umfasst, wobei der Vorsprung (80) an der
Außenwand (20) von einer Fläche (27) der Au-
ßenwand (20) aus in den Kühlkanal (40) hinein
verläuft und

wobei der Vorsprung (80) an der Außenwand (20)
so angeordnet und profiliert ist, dass er zumindest
einen Teil des Kühlfluids (60), wenn dieses durch
den Kühlkanal (40) und über den Vorsprung (80) an
der Außenwand (20) strömt, so lenkt, dass es an
eine zweite Region (66) der Innenwand (30) prallt.

2. Schaufelprofil (10) nach Anspruch 1, bei dem der
Vorsprung (70) an der Innenwand (30) sowohl in
Strömungsrichtung des Kühlfluids (60) als auch in
Richtung zur Außenwand (20) hin verläuft.

3. Schaufelprofil (10) nach Anspruch 1 oder 2, bei dem
der Vorsprung (70) an der Innenwand (30) in einer
allgemeinen Strömungsrichtung des Kühlfluids (60)
Folgendes umfasst:

- einen ansteigenden Abschnitt (170), der in
Richtung zur Außenwand (20) hin ansteigt,
- einen abfallenden Abschnitt (180), der in Rich-
tung zur Innenwand (30) hin abfällt, und
- eine Spitze (175), die sich zwischen dem an-
steigenden Abschnitt (170) und dem abfallen-
den Abschnitt (180) befindet, wobei ein Abso-
lutwert eines Gradienten des abfallenden Ab-
schnitts (180) größer ist als ein Absolutwert ei-
nes Gradienten des ansteigenden Abschnitts
(170).

4. Schaufelprofil (10) nach einem der Ansprüche 1 bis
3, bei dem sich der Vorsprung (70) an der Innenwand
(30) im Vergleich zu einer Hinterkante (160) des
Schaufelprofils (10) in der Nähe einer Vorderkante
(150) des Schaufelprofils (10) befindet.

5. Schaufelprofil (10) nach Anspruch 1, bei dem der
Vorsprung (80) an der Außenwand (20) sowohl in
Strömungsrichtung des Kühlfluids (60) als auch in
Richtung zur Innenwand (30) hin verläuft.

6. Schaufelprofil (10) nach Anspruch 1 oder 5, bei dem
der Vorsprung (80) an der Außenwand (20) in der
allgemeinen Strömungsrichtung des Kühlfluids (60)
Folgendes umfasst:

- einen ansteigenden Abschnitt (170), der in
Richtung zur Innenwand (30) hin ansteigt,

- einen abfallenden Abschnitt (180), der in Rich-
tung zur Außenwand (20) hin abfällt, und
- eine Spitze (175), die sich zwischen dem an-
steigenden Abschnitt (170) und dem abfallen-
den Abschnitt (180) befindet, wobei ein Abso-
lutwert eines Gradienten des abfallenden Ab-
schnitts (180) für den Vorsprung (80) an der Au-
ßenwand (20) größer ist als ein Absolutwert ei-
nes Gradienten des ansteigenden Abschnitts
(170).

7. Schaufelprofil (10) nach Anspruch 6, bei dem sich
der Vorsprung (80) an der Außenwand (20) und der
Vorsprung (70) an der Innenwand (30) in der allge-
meinen Strömungsrichtung des Kühlfluids (60) be-
finden, so dass der Teil des Kühlfluids (60), der von
dem Vorsprung (70) an der Innenwand (80) zu der
ersten Region (64) der Außenwand (20) gelenkt
wird, an den ansteigenden Abschnitt (170) des Vor-
sprungs (80) an der Außenwand (20) prallt.

8. Schaufelprofil (10) nach Anspruch 6 oder 7, bei dem
die Spitze (175) des Vorsprungs (80) an der Innen-
wand (30) und die Spitze (170) des Vorsprungs (70)
an der Außenwand (20) in der allgemeinen Strö-
mungsrichtung des Kühlfluids (60) zueinander ver-
setzt sind.

9. Schaufelprofil (10) nach Anspruch 8, bei dem sich
der Vorsprung (80) an der Außenwand (20) in der
Nähe der Vorderkante (150) des Schaufelprofils (10)
befindet.

10. Verfahren zum Konstruieren eines Schaufelprofils
(10) für eine Turbomaschine, wobei das Schaufel-
profil (10) Folgendes umfasst:

- eine Außenwand (20) und eine Innenwand (30)
und
- einen Kühlkanal (40) zum Leiten eines Kühl-
fluids beim Einsatz des Schaufelprofils, der so
zwischen der Außenwand (20) und der Innen-
wand (30) liegt, dass er die Außenwand (20) und
die Innenwand (30) trennt,

wobei die Innenwand (30) einen Vorsprung (70) um-
fasst, der, wenn das Kühlfluid (60) durch den Kühl-
kanal (40) strömt, zumindest einen Teil des Kühlflu-
ids (60) so lenkt, dass das Kühlfluid (60) an eine
erste Region (64) der Außenwand (20) prallt,
wobei der Vorsprung (70) an der Innenwand (30)
von einer Fläche (37) der Innenwand (30) aus in den
Kühlkanal (40) hinein verläuft,
wobei die Außenwand (20) ferner einen Vorsprung
(80) umfasst und
wobei der Vorsprung (80) an der Außenwand (20)
von einer Fläche (27) der Außenwand (20) aus in
den Kühlkanal (40) hinein verläuft,

wobei das Verfahren Folgendes umfasst:

- einen Schritt (200) des derartigen Anordnens der Außenwand (20) und der Innenwand (30), dass der Kühlkanal die Außenwand (20) und die Innenwand (30) trennt,

gekennzeichnet durch

- einen Schritt (210) des derartigen Bereitstellens des Vorsprungs (70) an der Innenwand (30), dass dieser von der Fläche (37) der Innenwand (30) aus in den Kühlkanal (40) hinein verläuft, und des derartigen Bereitstellens des Vorsprungs (80) an der Außenwand (20), dass dieser von der Fläche (27) der Außenwand (20) aus in den Kühlkanal (40) hinein verläuft, so dass, wenn das Kühlfluid (60) **durch** den Kühlkanal (40) und über den Vorsprung (80) an der Außenwand (20) strömt, zumindest ein Teil des Kühlfluids (60) so gelenkt wird, dass es an eine zweite Region (66) der Innenwand (30) prallt.

Revendications

1. Un profil aérodynamique (10) pour un moteur à turbines comprenant :

- une paroi extérieure (20) et une paroi intérieure (30), et
- un canal de refroidissement (40) situé entre la paroi extérieure (20) et la paroi intérieure (30) destiné au guidage d'un fluide réfrigérant (60) au cours du fonctionnement du profil aérodynamique (10),

dans lequel la paroi intérieure (30) comprend une saillie (70) s'étendant à partir d'une surface (37) de la paroi intérieure (30) dans le canal de refroidissement (40),

dans lequel la saillie (70) sur la paroi intérieure (30) est agencée et profilée de sorte que la saillie (70) sur la paroi intérieure (30) dirige au moins une partie du fluide réfrigérant (60) lorsque le fluide réfrigérant (60) s'écoule au travers du canal de refroidissement (40) et par dessus la saillie (70) sur la paroi intérieure (30), de façon à appliquer le fluide réfrigérant (60) sur une première zone (64) de la paroi extérieure (20),

caractérisé en ce que

- la paroi extérieure (20) comprend en outre une saillie (80), dans lequel la saillie (80) sur la paroi extérieure (20) s'étend à partir d'une surface (27) de la paroi extérieure (20) dans le canal de refroidissement (40), et

dans lequel la saillie (80) sur la paroi extérieure (20) est agencée et profilée de sorte que la saillie (80) sur la paroi extérieure (20) dirige au moins une partie du fluide réfrigérant (60) lorsque le fluide réfrigérant (60) s'écoule au travers du canal de refroidissement (40) et par dessus la saillie (80) sur la paroi extérieure (20), de façon à venir s'appliquer sur une deuxième zone (66) de la paroi intérieure (30).

2. Le profil aérodynamique (10) selon la revendication 1, dans lequel la saillie (70) sur la paroi intérieure (30) s'étend à la fois dans une direction d'écoulement du fluide réfrigérant (60) et dans une direction vers la paroi extérieure (20).

3. Le profil aérodynamique (10) selon la revendication 1 ou 2, dans lequel, dans une direction globale d'écoulement du fluide réfrigérant (60), la saillie (70) sur la paroi intérieure (30) comprend :

- une partie ascendante (170) montant dans une direction vers la paroi extérieure (20),
- une partie descendante (180) descendant dans une direction vers la paroi intérieure (30), et
- un pic (175) situé entre la partie ascendante (170) et la partie descendante (180),

dans lequel une valeur absolue d'un gradient de la partie descendante (180) est supérieure à une valeur absolue d'un gradient de la partie ascendante (170).

4. Le profil aérodynamique (10) selon l'une quelconque des revendications 1 à 3, dans lequel la saillie (70) sur la paroi intérieure (30) se situe proche d'un bord d'attaque (150) du profil aérodynamique (10) en comparaison d'un bord de fuite (160) du profil aérodynamique (10).

5. Le profil aérodynamique (10) selon la revendication 1, dans lequel la saillie (80) sur la paroi extérieure (20) s'étend à la fois dans la direction d'écoulement du fluide réfrigérant (60) et dans une direction vers la paroi intérieure (30).

6. Le profil aérodynamique (10) selon la revendication 1 ou 5, dans lequel, dans la direction globale d'écoulement du fluide réfrigérant (60), la saillie (80) sur la paroi extérieure (20) comprend :

- une partie ascendante (170) montant dans une direction vers la paroi intérieure (30),
- une partie descendante (180) descendant dans une direction vers la paroi extérieure (20), et
- un pic (175) situé entre la partie ascendante (170) et la partie descendante (180),

dans lequel, pour la saillie (80) sur la paroi extérieure (20), une valeur absolue d'un gradient de la partie descendante (180) est supérieure à une valeur absolue d'un gradient de la partie ascendante (170).

7. Le profil aérodynamique (10) selon la revendication 6, dans lequel la saillie (80) sur la paroi extérieure (20) et la saillie (70) sur la paroi intérieure (30) sont situées dans la direction globale d'écoulement du fluide réfrigérant (60) de sorte que la partie de fluide réfrigérant (60) qui est dirigée vers la première zone (64) de la paroi extérieure (20) par la saillie (70) sur la paroi intérieure (80) vienne s'appliquer sur la partie ascendante (170) de la saillie (80) sur la paroi extérieure (20). 5
8. Le profil aérodynamique (10) selon la revendication 6 ou 7, dans lequel, dans la direction globale d'écoulement du fluide réfrigérant (60), le pic (175) de la saillie (80) sur la paroi intérieure (30) et le pic (170) de la saillie (70) sur la paroi extérieure (20) sont décalés l'un par rapport à l'autre. 10
9. Le profil aérodynamique (10) selon la revendication 8, dans lequel la saillie (80) sur la paroi extérieure (20) se situe proche du bord d'attaque (150) du profil aérodynamique (10). 15
10. Un procédé de construction d'un profil aérodynamique (10) pour un moteur à turbines, dans lequel le profil aérodynamique (10) comprend . 20

- une paroi extérieure (20) et une paroi intérieure (30), et
- un canal de refroidissement (40) situé entre la paroi extérieure (20) et la paroi intérieure (30) de sorte que le canal de refroidissement (40) sépare la paroi extérieure (20) de la paroi intérieure (30) de façon à guider un fluide réfrigérant au cours du fonctionnement du profil aérodynamique, 25

dans lequel la paroi intérieure (30) comprend une saillie (70) destinée à diriger au moins une partie du fluide réfrigérant (60) lorsque le fluide réfrigérant (60) s'écoule au travers du canal de refroidissement (40) de façon à appliquer le fluide réfrigérant (60) sur une première zone (64) de la paroi extérieure (20), dans lequel la saillie (70) sur la paroi intérieure (30) s'étend à partir d'une surface (37) de la paroi intérieure (30) dans le canal de refroidissement (40), dans lequel la paroi extérieure (20) comprend en outre une saillie (80), et dans lequel la saillie (80) sur la paroi extérieure (20) s'étend à partir d'une surface (27) de la paroi extérieure (20) dans le canal de refroidissement (40), le procédé comprenant . 30

- une étape (200) d'agencement de la paroi ex- 35

térieure (20) et de la paroi intérieure (30) de sorte que le canal de refroidissement sépare la paroi extérieure (20) de la paroi intérieure (30),

caractérisé par

- une étape (210) de fourniture de la saillie (70) sur la paroi intérieure (30) de sorte que la saillie (70) sur la paroi intérieure (30) s'étende à partir de la surface (37) de la paroi intérieure (30) dans le canal de refroidissement (40), et de fourniture de la saillie (80) sur la paroi extérieure (20) de sorte que la saillie (80) sur la paroi extérieure (20) s'étende à partir de la surface (27) de la paroi extérieure (20) dans le canal de refroidissement (40) de façon à diriger au moins une partie du fluide réfrigérant (60) lorsque le fluide réfrigérant (60) s'écoule au travers du canal de refroidissement (40) et par dessus la saillie (80) sur la paroi extérieure (20), de façon à venir s'appliquer sur une deuxième zone (66) de la paroi intérieure (30). 40

FIG 1

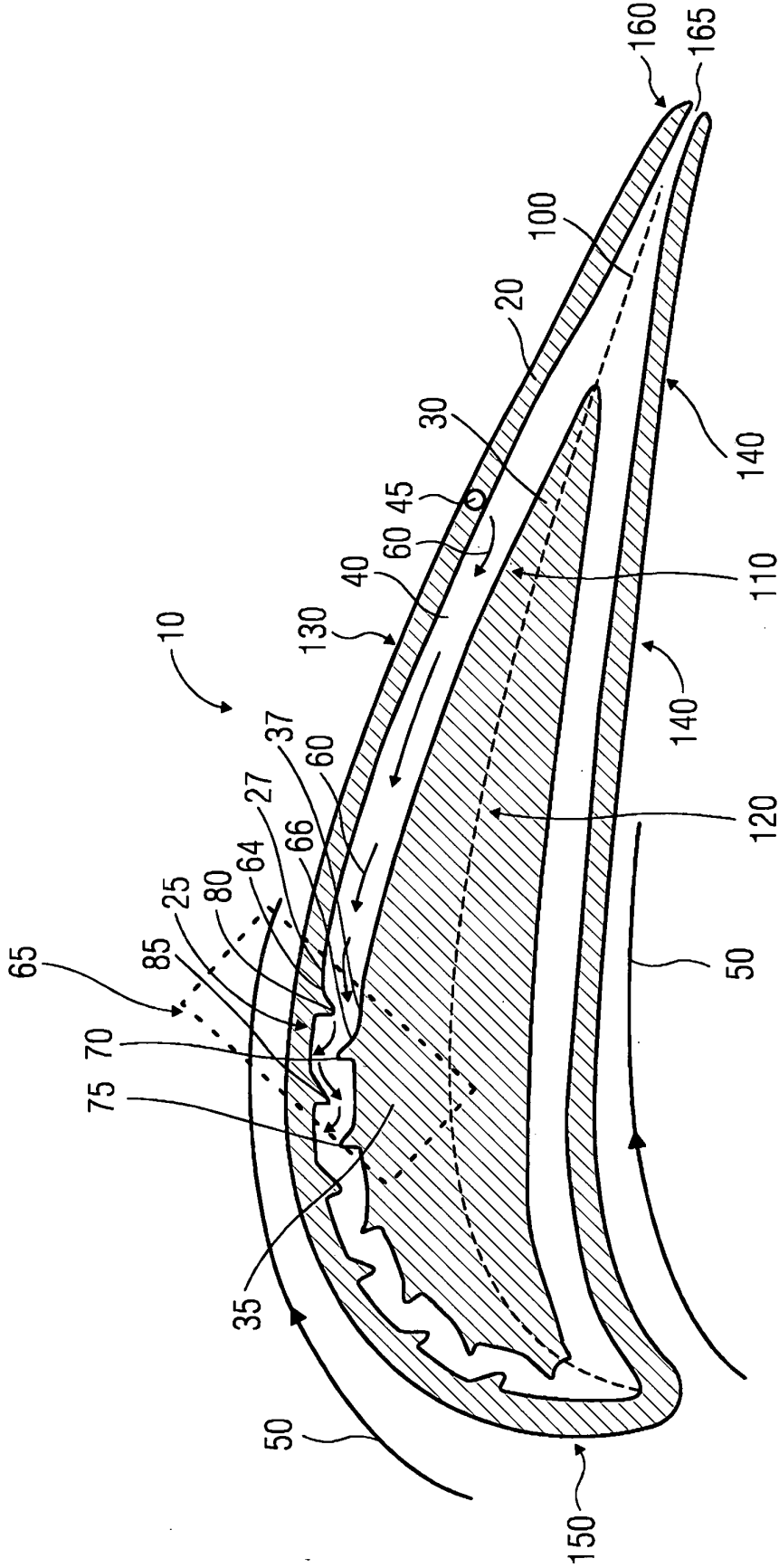


FIG 2

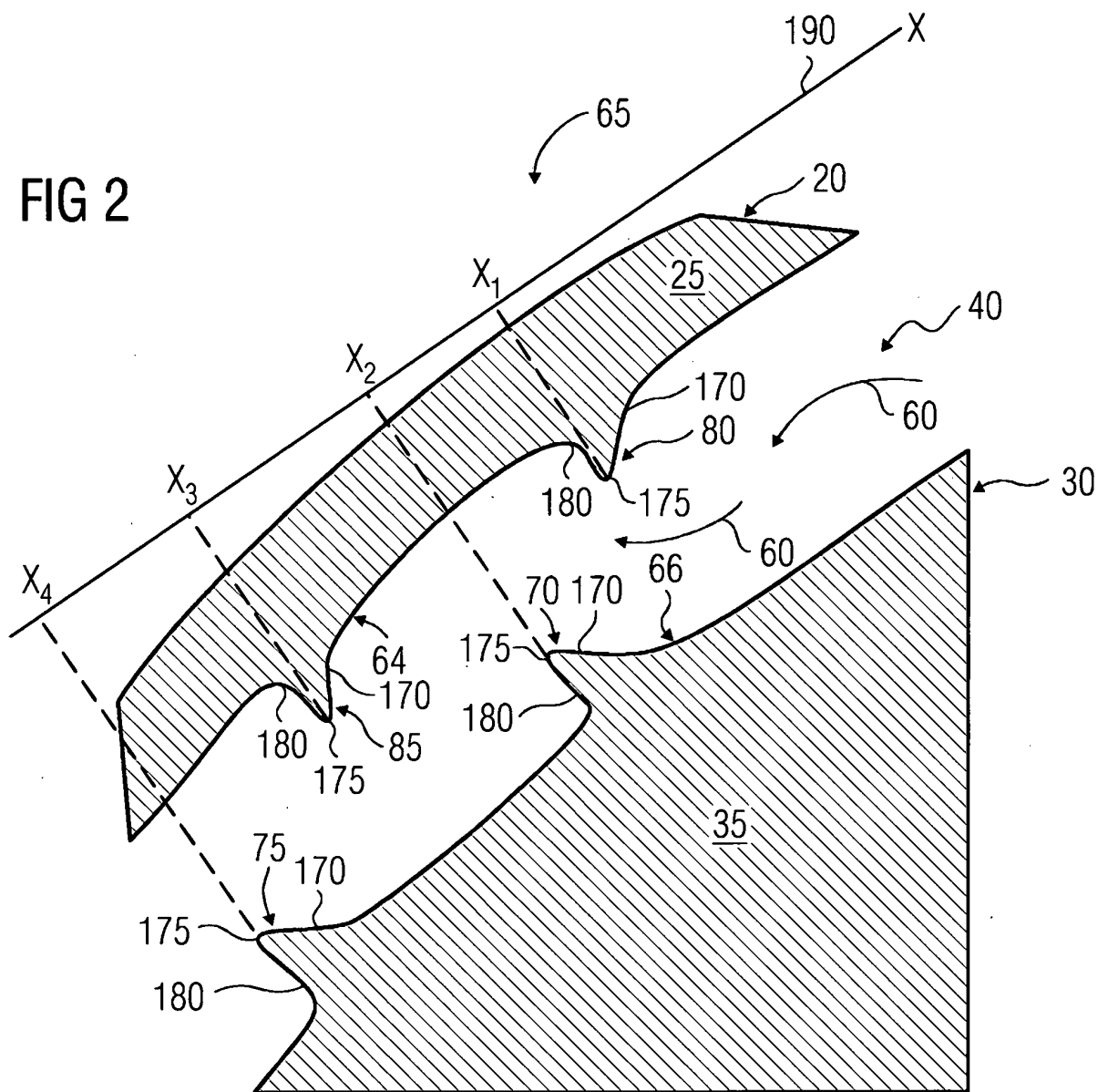
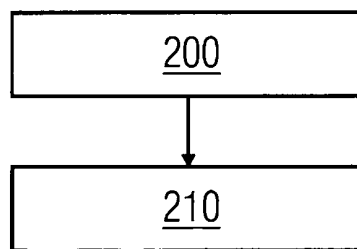


FIG 3



REFERENCES CITED IN THE DESCRIPTION

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