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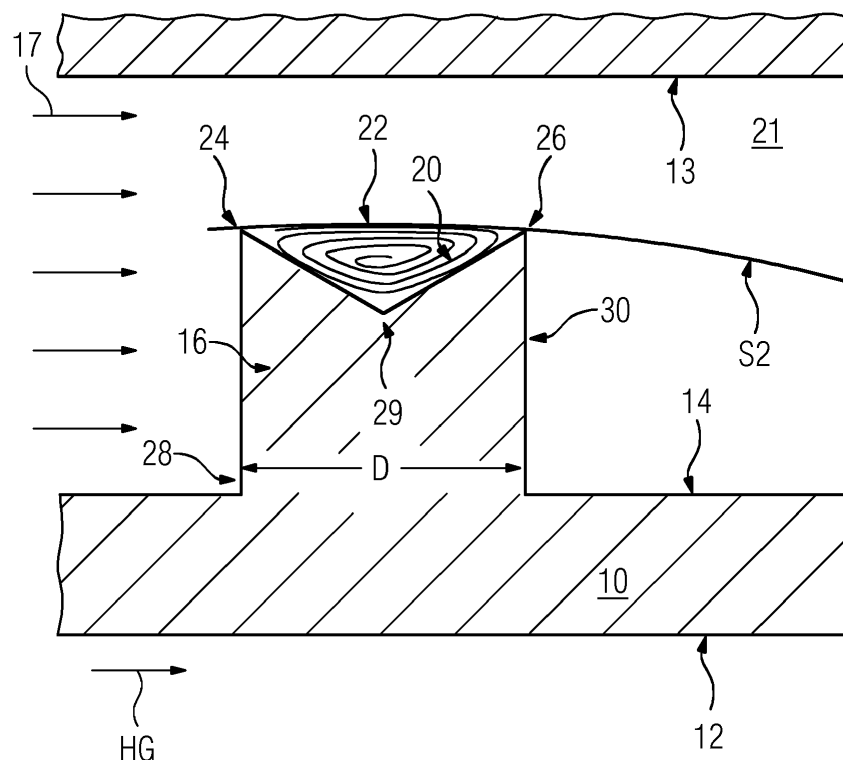
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(54) COOLABLE WALL ELEMENT

(57) The invention relates to a coolable wall element (10) for gas turbines for a hot gas environment, comprising a first surface (12) subjectable to a hot gas and a second surface (14) subjectable to a cooling fluid (17), the first and second surface (12, 14) are arranged opposite to each other, where in the second surface (14) comprises at least one turbulence enhancing element (16)

which projects steplike from the second surface (14) to a free ending top (18) of the turbulence enhancing element (16), the top (18) comprises a top surface (20). To provide a coolable wall element (10) with enhanced cooling properties and fewer blockages inside of a cooling channel, it is proposed that the top surface (20) comprises a depression (22).

FIG 2**EP 3 276 128 A1**

Description

[0001] The invention relates to a coolable wall element for gas turbines, i.e. embodied as turbine blade or turbine vane, etc.

[0002] State-of-the-art internal cooling techniques for temperature loaded blades and vanes use roughened serpentine passages, in which the coolant passes through. Roughness elements, such as pin fins, dimples and most often ribs are usually used to meet the cooling requirements. However, one major problem of the required cooling is the needed coolant flow and the associated pressure drop of the coolant inside the cooling passages, which penalizes the overall efficiency of the gas turbine cycle. Major losses are created by the friction of the used cooling fluid and the blockage of the used turbulators. To date rib-roughened elements have the largest potential among the roughness elements.

[0003] Figure 1 shows a cooling channel 21 bordered by two opposing surfaces 13, 14, wherein from one of these surfaces 13 a rib 15 extends. The mean flow of said cooling fluid 17 around such a rib 15 is also shown. Characteristic for the flow field are the presence of four main vortical structures. On large vortical structure V1 is a large recirculation zone behind the rib 15, a smaller vortical structure V2 is between the rib downstream bottom corner and the large recirculation zone, one recirculation zone V4 in front of the rib 15 and one recirculation zone V3 on top 18 of the rib 15. Such a rib 15 is used as "turbulator" to enhance the turbulent intensity of the flow that promotes the heat transfer inside the cooling channel 21. The largest turbulence production occurs along a shear layer S1 where the shear stresses are very high. The functioning of the shear layer S1 depends on the rib height H as it impacts the size of the recirculation zone V1, where the flow has a low velocity, which increases the shear stress in contact with the high velocity of the mean flow. The vortical structure V3 on the rib top 18 increases the blockage of the rib, however, does not increase the turbulence production as the flow on the rib top 18 reattaches right before 25 the top downward corner 26 of the rib 15.

[0004] Hence, the object of the present invention is to provide a coolable wall element with improved cooling properties, especially with fewer blockages inside of the cooling channel.

[0005] The problem of the invention is solved with a coolable wall element according to the features mentioned in claim 1. Further preferred embodiments are described in the depending claims.

[0006] The invention is based on the knowledge that on the top of the turbulence enhancing element as swirl appears that further blocks the remaining cross section in which the cooling fluid flows. To eliminate this effect of further reduced cross section the turbulence enhancing element comprises at its top surface a depression, preferably in the size, which is appropriate to house the top swirl between the remaining corners (upward and

downward) of the turbulence enhancing element while increasing the not disturbed cross section of the cooling air flow.

[0007] For this reason, a coolable wall element for a hot gas environment comprising a first surface subjectable to hot gas and a second surface subjectable to a cooling fluid, the first and second surfaces are arranged opposite to each other, wherein the second surface comprises at least one turbulence enhancing element, but preferred multiple turbulence enhancing elements, each of which projects steplike from the second surface to a free ending top of the turbulence enhancing element, the respective tops each comprises a top surface having a depression.

[0008] Besides the allocation of a space for housing the top swirl the overall area of the surface of the turbulence enhancing element is increased leading to an enhanced heat transfer.

[0009] Preferable the depression has in cross section a triangular shape or a concave shape. A triangular shape is ease to manufacture while a concave shape of the depression is better equipped to house the top swirl.

[0010] In a further preferred embodiment the top surface is free of a flat section being parallel to a second surface. This give the opportunity to house the swirl at least significantly between the first and second corners of the turbulence enhancing element.

[0011] In a further preferred embodiment the triangular shape is symmetrical. Of course the before mention wall element could be part of a turbine blade, a turbine vane, a ring segment, a combustor wall element or the like.

[0012] In summary the invention relates to a coolable wall element for gas turbines for a hot gas environment, comprising a first surface subjectable to hot gas and a second surface subjectable to a cooling fluid, the first and second surface are arranged opposite to each other, where in the second surface comprises at least one turbulence enhancing element which projects steplike from the second surface to a free ending top of the turbulence enhancing element, the top comprises a surface. To provide a coolable wall element with enhanced cooling properties and fewer blockages inside of a cooling channel, it is proposed that the top surface comprises a depression.

[0013] The invention displayed in the accompanied drawing will be explained in the following description without limiting the scope of the invention. In the drawing and detailed description identical features are numbered with the same identifiers.

[0014] It shows:

Fig. 1 a cross section through a coolable wall element according to the prior art,

Fig. 2 a cross section through a coolable wall element according to a first preferred embodiment and

Fig. 3 a cross section through a coolable wall element according to a second preferred embodiment.

[0015] Fig. 2 shows a not limiting first example of a coolable wall element 10. The wall element 10 could be part of a turbine vane, a turbine blade, a ring segment of the gas turbine or of a combustor wall, etc.

[0016] The coolable wall element comprises a first surface 12 which is subjectable directly or, when covered by a single or multiple layer coating, indirectly to a hot environment. Usually a hot gas HG streams parallel to first surface 12. To achieve a required lifetime of the wall element 10 it has to be cooled down to appropriate wall temperatures. Therefore on the second surface 14, which is arranged opposite of the first surface 12 of the wall, at least one, preferred multiple turbulence enhancing elements 16 are distributed in a regular or irregular pattern. During operation a cooling fluid 17, usually cooling air, flows along the second surface 14, tripping at the location of the turbulence enhancing element 16.

[0017] The displayed turbulence enhancing element 16 could be designed in rib form as trip strip having a longitudinal extension larger than 5 times of the distance D between the front surface 28 and the back surface 30. Usually the height H of the ribs 16 is similar to said distance D. Also, the turbulence enhancing element could have a pin shape (not shown). Then they are known as pedestals.

[0018] The turbulence enhancing element 16 projects out of the plane of the surface 14 in a stepwise manner, i.e. with an angle of 90°. Other angle values are possible, as long as the turbulence enhancing element urges the cooling fluid 17 to trip over them.

[0019] The turbulence enhancing element 16 ends at their free ending top 18. In other words, the turbulence enhancing elements do not merge into a third surface 13, which third surface 13 is arranged opposite of the second surface 14 for establishing there between a cooling channel 21 which cross section is locally restricted at the position of the turbulence enhancing element 16.

[0020] The top 18 comprises a top surface 20. Contrary to the prior art, the top surface 20 is not flat, but comprises a depression 22. The depression 22 is located between an upward located corner 24 of the top 18 and a downward located corner 26 of the top 18

[0021] According to a first example of the invention, displayed in Fig. 2, the depression 22 has a corner 29, which in combination with the first and second corners 24, 26 define a virtual triangle shape. Usually, the depression 22 is as long as the turbulence enhancing element 16 as seen in a direction traverse to the global cooling fluid direction. In other words: the depression 22 extends along the complete longitudinal extension (not shown) of the turbulence enhancing element 16.

[0022] According to a second example of the invention, displayed in Fig. 3, the top surface 20 is concavely shaped between the upward and downward corners 24, 26 for creating said depression 22. Preferred, the shape is of parabolic form, preferred broader than deep.

[0023] The blockage ratio of the turbulence enhancing element 16 remains the same as the rib described in the

prior art, thus creating the same magnitude of shear stresses. A front surface 28 and back surface 30 of the turbulence enhancing element remains straight to keep a larger wetted surface area and as the downstream recirculation zone is needed to create a large magnitude of shear flow.

[0024] The inventive step lies in the shape of the top surface of the turbulence enhancing element, which is shaped as a groove either with corners or with a parabolic profile.

The advantages of the proposed configuration are a reduction of the top recirculation zone and thus a reduction of the pressure drop by decreasing the blocked cooling fluid flow and an increase of the wetted surface area in comparison with a straight top surface.

Claims

1. A coolable wall element (10) for a hot environment comprising a first surface subjectable (12) to a hot gas and an second surface (14) subjectable to a cooling fluid (17), the first and second surfaces (12, 14) are arranged opposite to each other, wherein the second surface (14) comprises at least one turbulence enhancing element (16), which projects steplike from the second surface (14) to a free ending top (18) of the turbulence enhancing element (16), the top (18) comprises a top surface (20), **characterized in that** the top surface (20) comprises a depression.
2. Wall element (10) according to claim 1, wherein the depression (22) has in cross section a triangular or a concave shape.
3. Wall element (10) according to claim 1 or 2, wherein the top surface (20) is free of a flat section being parallel to the second surface (14).
4. Wall element (10) according to claim 2 or 3, wherein the triangular shape is symmetrical.
5. Wall element (10) according to one of the claims 1 to 4, embodied as a turbine blade, turbine vane, a ring segment or combustor wall element.

FIG 2

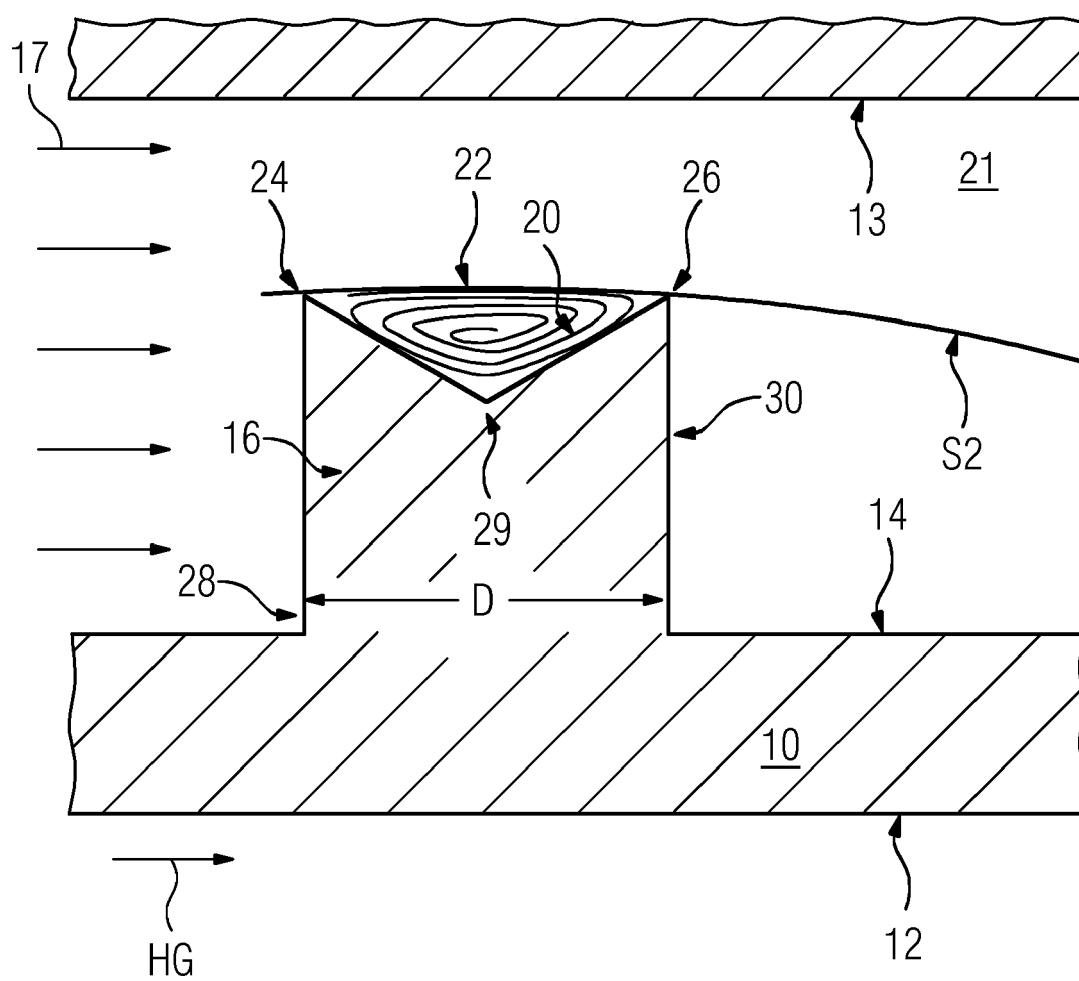
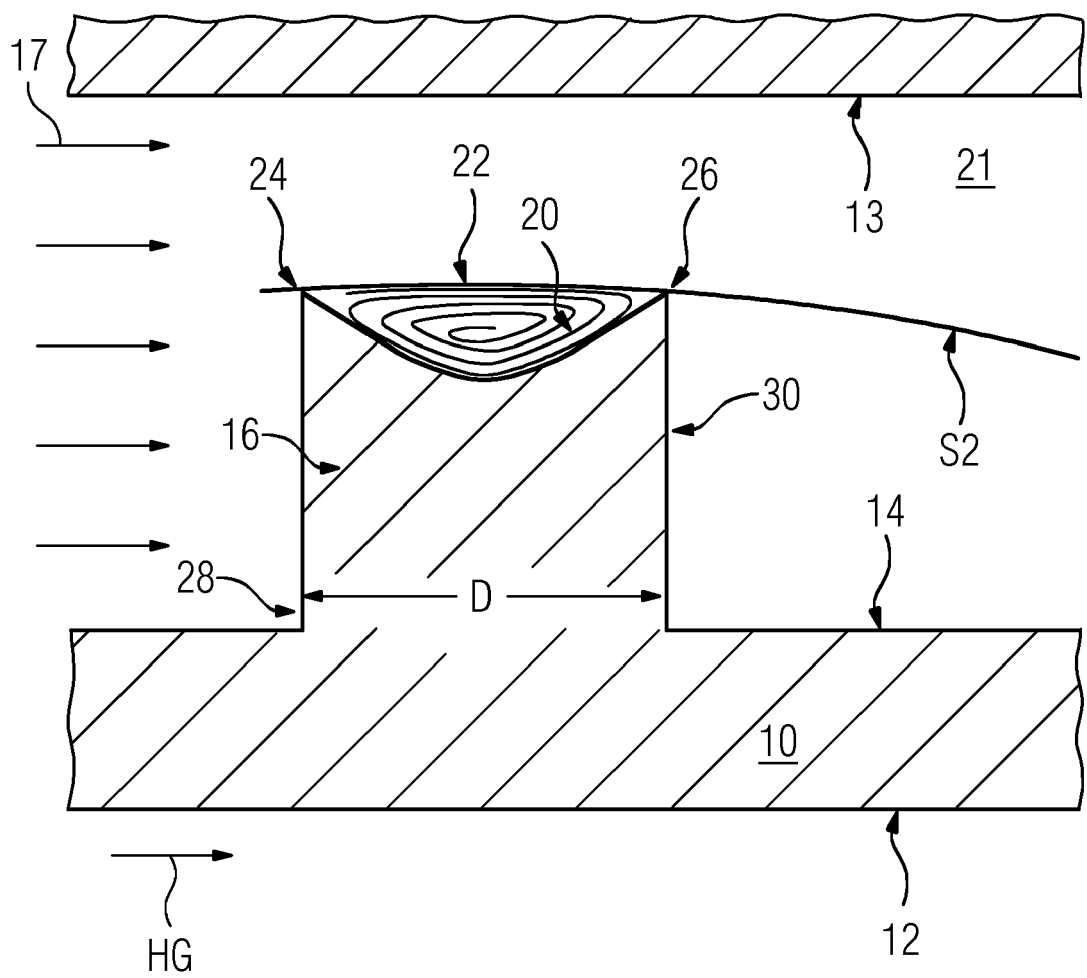


FIG 3





EUROPEAN SEARCH REPORT

Application Number
EP 16 18 0939

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EPO FORM 1503 03.82 (P04C01)

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 2 518 429 A1 (SIEMENS AG [DE]) 31 October 2012 (2012-10-31) * paragraphs [0021], [0028], [0035], [0041], [0042]; figures 1-3 *	1-5	INV. F01D5/18 F01D25/12 F23R3/00
X	EP 1 114 976 A2 (ALSTOM POWER SCHWEIZ AG [CH]) 11 July 2001 (2001-07-11) * paragraph [0016]; figures 1b,2,4a,4b,4d *	1-3,5	
X	WO 2015/050592 A2 (UNITED TECHNOLOGIES CORP [US]) 9 April 2015 (2015-04-09) * paragraphs [0054], [0055]; figures 6-8 *	1-3,5	
X	US 5 538 394 A (INOMATA ASAKO [JP] ET AL) 23 July 1996 (1996-07-23) * column 15, lines 24-38; figures 12,18 *	1,2,4,5	
X	US 2011/033312 A1 (LEE CHING-PANG [US] ET AL) 10 February 2011 (2011-02-10) * paragraphs [0028], [0029]; figures 8,10 *	1,2,5	TECHNICAL FIELDS SEARCHED (IPC)
X	US 5 695 321 A (KERCHER DAVID MAX [US]) 9 December 1997 (1997-12-09) * column 5, line 29 - column 6, line 14; figures 4,5 *	1-3,5	F01D F23R
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 19 December 2016	Examiner Teusch, Reinhold
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2518429 A1	31-10-2012	EP 2518429 A1	31-10-2012
		WO 2012146480 A1	01-11-2012
EP 1114976 A2	11-07-2001	DE 19963374 A1	12-07-2001
		EP 1114976 A2	11-07-2001
		US 2002005274 A1	17-01-2002
WO 2015050592 A2	09-04-2015	EP 3008388 A2	20-04-2016
		US 2016123592 A1	05-05-2016
		WO 2015050592 A2	09-04-2015
US 5538394 A	23-07-1996	DE 69412056 D1	03-09-1998
		DE 69412056 T2	28-01-1999
		DE 69433749 D1	03-06-2004
		DE 69433749 T2	07-10-2004
		EP 0661414 A1	05-07-1995
		EP 0845580 A2	03-06-1998
		JP 3192854 B2	30-07-2001
		JP H07189603 A	28-07-1995
		US 5538394 A	23-07-1996
US 2011033312 A1	10-02-2011	EP 2616642 A1	24-07-2013
		US 2011033312 A1	10-02-2011
		US 2015078898 A1	19-03-2015
		WO 2012036965 A1	22-03-2012
US 5695321 A	09-12-1997	NONE	