COOLING FLOW CONTROL MEMBERS FOR TURBOMACHINE BUCKETS AND METHOD

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ABSTRACT

A turbomachine bucket includes a base portion having a first end that extends to a second end, and an airfoil portion extending from the first end of the base portion. The airfoil portion includes a first end section that extends to a tip section. A plurality of cooling channels extend through the turbomachine bucket from the first end of the base portion to the tip portion, and a cooling flow control member is arranged in one of the plurality of cooling channels. The cooling flow control member creates at least a partial flow restriction in the one of the plurality of cooling channels to modify cooling flow passing through the turbomachine bucket.
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BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to the art of turbomachines and, more particularly to cooling flow control members for turbomachine buckets.

[0002] Turbomachines typically include a compressor portion operationally linked to a turbine portion. Turbomachines also include a combustor that receives fuel and air which is mixed and combusted to form a high energy fluid or hot gases. The hot gases are directed into a hot gas path toward turbine blades or buckets. The turbine buckets convert thermal energy from the hot gases to mechanical, rotational energy that provides power to, for example, generators, pumps etc. During operation, compressor discharge air is passed through the turbine buckets to provide cooling that may extend an overall operational life of turbine portion components.

[0003] Typically, the compressor discharge air is passed into a turbine rotor that supports a plurality of turbine buckets. The compressor discharge air passes through the turbine rotor into each of the plurality of buckets to provide internal cooling. The compressor discharge air enters each of the turbine bucket through a dovetail member, and passes through an airfoil portion before exiting toward a shroud member mounted to a housing of the turbine portion. While effective at providing cooling, diverting compressor discharge air into the buckets reduces an overall operational efficiency of the turbomachine.

BRIEF DESCRIPTION OF THE INVENTION

[0004] According to one aspect of the exemplary embodiment, a turbomachine bucket includes a base portion having a first end that extends to a second end, and an airfoil portion extending from the first end of the base portion. The airfoil portion includes a first end section that extends to a tip section. A plurality of cooling channels extend through the turbomachine bucket from the first end of the base portion to the tip portion, and a cooling flow control member is arranged in one of the plurality of cooling channels. The cooling flow control member creates at least a partial flow restriction in the one of the plurality of cooling channels to modify cooling flow passing through the turbomachine bucket.

[0007] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

[0008] The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0010] FIG. 1 is a partial cross-sectional view of a turbomachine including a bucket provided with a cooling flow control member in accordance with an exemplary embodiment;

[0011] FIG. 2 is a perspective view of a turbine bucket including cooling flow channels in accordance with an exemplary embodiment;

[0012] FIG. 3 is a elevational view of a base portion of the turbine bucket of FIG. 2;

[0013] FIG. 4 is a plan view of a portion of a cooling flow channel of the turbine bucket of FIG. 2;

[0014] FIG. 5 is a plan view of a cooling flow control member in accordance with one aspect of the exemplary embodiment;

[0015] FIG. 6 is a cross sectional view of the cooling flow control member of FIG. 5;

[0016] FIG. 7 is a plan view of a cooling flow control member in accordance with another aspect of the exemplary embodiment;

[0017] FIG. 8 is a plan view of the cooling flow control member illustrated in FIG. 7 positioned in the cooling flow channel of FIG. 4;

[0018] FIG. 9 is a cross-sectional view of the cooling flow control member of FIG. 7; and

[0019] FIG. 10 is a cross-sectional view of a cooling flow control member in accordance with yet another aspect of the exemplary embodiment.

[0020] The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0021] With reference to FIG. 1, a turbomachine in accordance with an exemplary embodiment is indicated generally at 2. Turbomachine 2 includes a housing 4 that surrounds a compressor portion 6 operatively connected to a turbine portion 8. Compressor portion 6 includes a plurality of rotor or wheel members, three of which are indicated at 20-22. Each wheel member 20-22 is operatively connected to corresponding pluralities of vanes or buckets 23-25 that establish various stages of compressor portion 6. Similarly, turbine portion 8 includes a plurality of rotor or wheel members, three of which are indicated at 26-28. Each wheel member 26-28 is operatively connected to corresponding pluralities of vanes or buckets 31-33 that establish various stages of turbine section 8.

[0021] With this arrangement, hot combustion gases 35 flowing from a combustor (not shown) enter a hot gas path 38 and flow into turbine portion 8. Hot combustion gases 35 flow
across vanes 31-33 of turbine portion 8 developing mechanical energy. A cooling flow 40 is passed from compressor portion 6 through wheel members 26-28. Each bucket 31-33 receives a corresponding portion 42-44 of cooling flow 40. With this arrangement, the cooling flow 40 lowers a temperature of corresponding ones of buckets 31-33 before passing to a turbine stator (not separately labeled) supported relative to housing 4. As each bucket 31-33 includes similar structure, a detailed description will be made to FIGS. 2-4 in describing bucket 31 with an understanding that buckets 32 and 33 are similarly formed. Of course, it should be understood that while including similar structure, buckets 31-33 may have different dimensions, and airfoil profiles depending upon a particular design of turbine portion 8.

[0022] Bucket 31 includes a bucket body 54 having a base portion 56 and an airfoil portion 58. Base portion 56 includes a first or dovetail end 61 that extends to a second end 62 through an intermediate portion 63. Airfoil portion 58 includes a first end section 68 that extends from second end 62 of base portion 56 to a second or tip end section 69 through an intermediate section 70. Bucket 31 includes a plurality of cooling channels, one of which is indicated at 80, that extend from dovetail end 61 of base portion 56 to tip end section 69 of airfoil portion 58 within bucket body 54. As best shown in FIG. 4, each cooling channel 80 includes a first cooling channel section 83 that extends within base portion 56 and a second cooling channel section 84 that extends within airfoil portion 58. First cooling channel section 83 includes a first diameter and second cooling channel section 84 includes a second diameter that is smaller than the first diameter. First cooling channel section 83 includes an inlet end 85 that extends to a second end 86 through an intermediate section 87.

[0023] In accordance with the exemplary embodiment, bucket 31 includes a cooling flow control members 90 arranged within select ones of cooling channels 80. As best shown in FIGS. 5-6, cooling flow control member 90 includes a first end portion 95 that extends to a second end portion 96 through an intermediate portion 97. In the exemplary embodiment shown, cooling flow control member includes a solid cross-section 98 that forms a plug 99 that inhibits cooling flow through cooling channel 80. Although only a single cooling flow control member 90 is shown, it should be understood that additional cooling flow control members could be arranged in others of cooling channels 80. In order to install cooling flow control member 90, bucket 31 is removed from rotor wheel 26 to expose inlet end 85 of cooling channels 80. Once exposed, the one or more cooling flow control members 90 may be inserted to completely block cooling flow passing through the corresponding cooling channel. By inserting one or more cooling flow control members 90 in select ones of cooling channels 80, an amount of compressor air passing through bucket 31 is reduced. While reducing the amount of cooling air flowing through bucket 31 may lead to increased temperatures, additional compressor flow is made available for combustion thereby enhancing an overall efficiency of turbomachine 2. However, if over time additional cooling is desired, one or more cooling flow control members previously inserted into corresponding cooling channels 80 may be removed to enhance cooling flow to bucket 31.

[0024] FIGS. 7-9 illustrate a cooling flow control member 104 in accordance with another aspect of the exemplary embodiment. Cooling flow control member 104 includes a first end portion 106 that extends to a second end portion 107 through an intermediate portion 108. Cooling flow control member 104 includes a passage 110 that extend between first and second end portions 106 and 107. Passage 110 creates a flow restriction within the corresponding one of cooling channels 80. In the exemplary embodiment shown, passage 110 includes a tapered profile 113 having a circular cross-section 115. By restricting cooling air passing though cooling channel(s) 80, additional compressor flow is directed to other portions of turbomachine 2 to enhance operability. FIG. 10 illustrates a cooling flow control member 119 having a passage 121 including a non-circular cross-section 123. The non-circular cross-section provides another restriction to the cooling flow passing through cooling channel(s) 80.

[0025] At this point it should be understood that the cooling flow control member in accordance with the exemplary embodiment provides either a complete or partial blockage to cooling flow passing through one or more cooling channels in a turbomachine bucket. It should also be understood that while shown inserted into a base portion of the bucket, the cooling flow control member may be placed at any portion in either the base portion or the airfoil portion. It should be further evident that while shown in connection with a turbine bucket, the cooling flow control member may also be employed in a compressor bucket and/or in stationary turbine or compressor vanes.

[0026] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

1. A turbomachine bucket comprising:
   a. a base portion including a first end that extends to a second end;
   b. an airfoil portion extending from the first end of the base portion, the airfoil portion including a first end section that extends to a tip section;
   c. a plurality of cooling channels extending through the turbomachine bucket from the first end of the base portion to the tip portion; and
   d. a cooling flow control member arranged in one of the plurality of cooling channels, the cooling flow control member creating at least a partial flow restriction in the one of the plurality of cooling channels to modify cooling flow passing through the turbomachine bucket.
2. The turbomachine bucket according to claim 1, wherein the cooling flow control member comprises a plug that completely block cooling flow passing through the one of the plurality of cooling channels.
3. The turbomachine bucket according to claim 1, wherein the cooling flow control member includes a first end portion that extends to a second end portion, and a passage that extends between the first and second end portions.
4. The turbomachine bucket according to claim 3, wherein the passage includes a tapered profile.
5. The turbomachine bucket according to claim 3, wherein the passage includes a circular cross-section.
6. The turbomachine bucket according to claim 3, wherein the passage includes a non-circular cross-section.

7. The turbomachine bucket according to claim 1, wherein each of the plurality of cooling channels includes a first cooling channel section having a first diameter and a second cooling channel section having a second diameter, the second diameter being smaller than the first diameter, the first cooling channel section being arranged in the base portion and the second cooling channel section being arranged in the airfoil portion.

8. The turbomachine bucket according to claim 7, wherein the cooling flow control member is arranged in the first section of the plurality of cooling channels.

9. The turbomachine bucket according to claim 1, wherein the cooling flow control member is arranged at the first end of the base portion.

10. The turbomachine bucket according to claim 9, wherein the turbomachine bucket comprises a turbine bucket.

11. A method of controlling cooling flow passing through a plurality of cooling passages formed in a turbomachine bucket, the method comprising:
   exposing the plurality of cooling passages formed in the turbomachine bucket;
   inserting a cooling flow control member into at least one of the cooling passages; and
   controlling a cooling fluid flow passing through the turbomachine bucket with the cooling flow control member.

12. The method of claim 11, wherein controlling the cooling fluid flow comprises completely blocking cooling fluid flow through the at least one of the plurality of cooling passages.

13. The method of claim 12, wherein completely blocking cooling fluid flow comprises preventing cooling fluid from entering the one of the plurality of cooling flow passages.

14. The method of claim 11, wherein controlling fluid flow comprises partially blocking the one of the plurality of cooling passages with the cooling flow control member.

15. The method of claim 14, wherein partially blocking the one of the plurality of cooling passages comprises passing the cooling flow through an orifice formed in the cooling flow control member.

16. The method of claim 11, further comprising: removing the cooling flow control member from the one of the plurality of cooling passages without damaging the turbomachine bucket.

17. A turbomachine comprising:
a compressor portion;
a turbine portion; and
a turbomachine bucket arranged in one of the compressor portion and the turbine portion, the turbomachine bucket comprising:
a base portion including a first end that extend to a second end;
an airfoil portion extending from the first end of the base portion, the airfoil portion including a first end section that extends to a tip section;
a plurality of cooling channels extending through the turbomachine bucket from the first end of the base portion to the tip portion; and
a cooling flow control member arranged in one of the plurality of cooling channels, the cooling flow control member creating at least a partial flow restriction in the one of the plurality of cooling channels to modify cooling flow passing through the turbomachine bucket.

18. The turbomachine according to claim 17, wherein the cooling flow control member comprises a plug that completely block cooling flow from passing into the one of the plurality of cooling channels.

19. The turbomachine according to claim 17, wherein the cooling flow control member includes a first end portion that extends to a second end portion, and a passage that extends between the first and second end portions.

20. The turbomachine according to claim 19, wherein the passage includes a tapered profile.