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(54) **Turbine engine component comprising a leading edge airfoil-to-platform fillet cooling tube**

(57) A turbine engine component (10) includes an airfoil portion having a leading edge (18), a platform (14), a leading edge airfoil to platform fillet (16), and a cooling tube (30) located within said fillet (16). The cooling tube

(30) has a flared entrance (31) end and a flared exit end (33).

The invention also extends to a core used to form the turbine engine component.

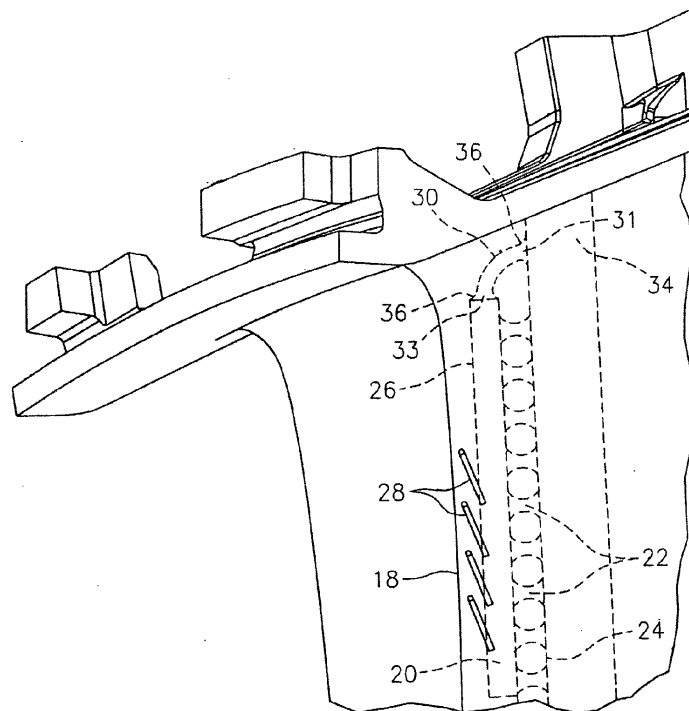


FIG. 2

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Description

STATEMENT OF GOVERNMENT INTEREST

[0001] The subject matter described herein was made with government support under Contract No. N00019-02-C-3003 awarded by the Department of the Navy. The government of the United States of America may have rights to the subject matter described herein.

BACKGROUND

[0002] The present disclosure relates to a cooling tube in the vicinity of the leading edge of a turbine engine component at the outer diameter airfoil-to-platform fillet and a casting core for forming same.

[0003] Vanes can be subjected to severe heating conditions in the region of the fillet which extends from the leading edge of the airfoil to the platform. Increased metal temperatures in this region can lead to thermal strains and reduced part life.

[0004] The prior technology for forming impingement cavities in vanes has not incorporated features that adequately cool the airfoil-to-platform fillet radius.

SUMMARY

[0005] Accordingly, it is desirable to reduce metal temperatures in the leading edge outer diameter airfoil-to-platform fillet so as to reduce thermal strains and increase part life. Described herein is a way to cool this region using convective cooling.

[0006] In accordance with the present disclosure, there is provided a turbine engine component which broadly comprises an airfoil portion having a leading edge, a platform, a leading edge airfoil to platform fillet, and a cooling tube located within said fillet, which cooling tube has a flared entrance end and a flared exit end.

[0007] Further in accordance with the present disclosure, there is provided a core for forming part of a turbine engine component, which core broadly comprises a first portion for forming an internal cavity within an airfoil portion of said component, a second portion for forming a leading edge boxcar in a leading edge of said airfoil portion, and a third portion for forming a cooling tube which extends between said leading edge boxcar and said internal cavity, which third portion has a flared entrance end and a flared exit end.

[0008] Other details of the leading edge airfoil-to-platform fillet cooling tube are set forth in the following detailed description and the following drawings wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a schematic illustration of a turbine vane

having a leading edge airfoil-to-platform fillet;

Fig. 2 is a schematic illustration of a turbine vane having a fillet cooling tube in accordance with the present invention;

Fig. 3 is a schematic illustration of a core used to form the fillet cooling tube of Fig. 2;

Fig. 4 is a sectional view taken along lines 4-4 in Fig. 3; and

Fig. 5 is a sectional view taken along lines 5-5 in Fig. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0010] Fig. 1 illustrates a turbine engine component 10, in particular a turbine vane. The component 10 has an airfoil portion 12 and a platform 14. The airfoil portion 12 is joined to the platform 14 by an outer diameter fillet 16 at the leading edge 18 of the airfoil portion 12. In previous designs, the outer diameter fillet 16 was uncooled due to geometry constraints of the impingement cavity, preventing impingement heat transfer from occurring and also preventing film holes from being drilled through the fillet. As described herein, a new design feature has been developed that provides convective heat transfer to the outer diameter fillet 16.

[0011] Fig. 2 illustrates a cooling configuration for the turbine engine component 10 which is comprised of three separate impingement cavities 20, also known as boxcars. In order to achieve a desirable oxidation life for the leading edge 18, crossover holes 22 in the impingement rib 24 are designed to maximize heat transfer at the nose 26 of the leading edge 18. Film cooling holes 28 are drilled into the leading edge impingement cavity as an additional means for cooling the airfoil portion 12.

[0012] The new design feature comprises a fillet cooling tube 30. The cooling tube 30 connects the outer diameter of the leading edge boxcar 20 to the leading edge feed cavity 34. The cross sectional area of the cooling tube 30 is to be between 25% and 100% of the cross sectional area of the impingement cavity/boxcar 20 to ensure adequate coolant velocity in the cooling tube. The ends 31 and 33 of the cooling tube 30 flare out at a blend radius 36 at the junction to the boxcar 20 and the feed cavity 34. This bellmouth shape at the entrance and exit ends 31 and 33 of the tube 30 helps to minimize pressure losses of the cooling air through the cooling tube 30.

[0013] The cross-sectional shape of the cooling tube 30 is dependent on the cross-sectional shape of the boxcar 20 to which it is connected. Since cooling holes are drilled into the outer diameter leading edge boxcar 20, a pressure ratio exists across the fillet cooling tube 30, allowing cooling air to travel from the feed cavity 34 to the leading edge boxcar 30. The cooling air convectively cools the airfoil-to-platform fillet 16, reducing metal temperature and increasing part life.

[0014] By adding an additional flow path for cooling air, additional internal cooling is achieved in a critical re-

gion.

[0015] Referring now to Figs. 3 to 5, there is shown a core 60 which may be used to form the leading edge boxcar(s) 20, the cavity 34 internal to the airfoil portion, and the cooling tube 30. The core 60 may be formed from a ceramic material. As can be seen from Fig. 3, the core has a first portion 62 which forms the interior cavity 34, a leading edge portion 64 which forms the leading edge boxcar 20, a plurality of shaped portions 66 which form the cross-over holes, and an arcuate portion 68 which forms the fillet cooling tube. As can be seen from Fig. 3, the portion 68 has two bellmouth shaped end portions 70 and 72 which form the entrance and exit ends of the fillet cooling tube 30.

[0016] The fillet cooling tube 30 described herein will provide convective heat transfer in the outer diameter leading edge airfoil-to-platform fillet 16, reducing metal temperatures.

[0017] The impingement cavity 20 to which the fillet cooling tube is connected needs film holes 28 or other cooling features that promote a positive pressure ratio from the feed cavity 34 to the impingement cavity 20.

[0018] As noted above, the ends 31 and 33 of the fillet cooling tube 30 are flared at the junction to the boxcar 20 and the feed cavity 34 to minimize cooling flow pressure losses as cooling air moves through the tube 30. The blend radius of the flare is determined by the specific shape of the boxcar support tube.

[0019] The cross-sectional shape of the fillet cooling tube 30 is dependent on the cross-sectional shape of the impingement cavity (boxcar) it is connecting to. The cross sectional shape of the tube 30 may be circular, elliptical, triangular, or square.

[0020] There has been provided herein a leading edge airfoil-to-platform fillet cooling tube. While the cooling tube has been described in the context of a specific embodiment thereof, other unforeseen alternatives, modifications, or variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations as fall within the broad scope of the appended claims.

Claims

1. A turbine engine component (10) comprising:
 - an airfoil portion (12) having a leading edge (18);
 - a platform (14);
 - a leading edge airfoil to platform fillet (16); and
 - a cooling tube (30) located within said fillet (16), said cooling tube having a flared entrance end (31) and a flared exit end (33).
2. The turbine engine component of claim 1, wherein said entrance end (31) and said exit end (33) are each bellmouth shaped.

3. The turbine engine component of claim 1 or claim 2, wherein said leading edge (18) of said airfoil portion (12) includes a leading edge boxcar (20) and an interior portion of said airfoil portion includes a cavity (34) through which cooling air flows.
4. The turbine engine component of claim 3, further comprising a plurality of cross-over holes (22) for allowing cooling fluid to flow from said cavity (34) to said boxcar (20).
5. The turbine engine component of claim 3 or claim 4, wherein said boxcar (20) has a plurality of cooling film holes (28).
6. The turbine engine component of any preceding claim, wherein said tube (30) has a cross-sectional area which is between 25% and 100% of a cross-sectional area of said boxcar (20).
7. The turbine engine component of any preceding claim, wherein said tube (30) has a cross-sectional area which is between 50% and 100% of a cross-sectional area of said boxcar (20).
8. The turbine engine component of any preceding claim, wherein said tube (30) has a cross-sectional shape selected from the group consisting of circular, elliptical, triangular, and square.
9. The turbine engine component of any preceding claim, wherein said cooling tube (30) meets said leading edge boxcar (20) at an end of said leading edge boxcar (20).
10. A core (60) for forming part of a turbine engine component (10), said core comprising:
 - a first portion (62) for forming an internal cavity (34) within an airfoil portion of said component (10);
 - a second portion (64) for forming a leading edge boxcar (20) in a leading edge of said airfoil portion;
 - a third portion (68) for forming a cooling tube (30) which extends between said leading edge boxcar (20) and said internal cavity (34); and
 - said third portion (68) having a flared entrance end (70) and a flared exit end (72).
11. The core according to claim 10, wherein said core (60) is formed from a ceramic material.
12. The core according to claim 10 or claim 11, wherein said core (60) has at least one fourth portion (66) adapted to form at least one cross-over hole (22) between said leading edge boxcar (20) and said cavity (34).

13. The core according to any of claims 10 to 12, wherein said entrance end (70) and said exit end (72) are each bellmouthed shaped.

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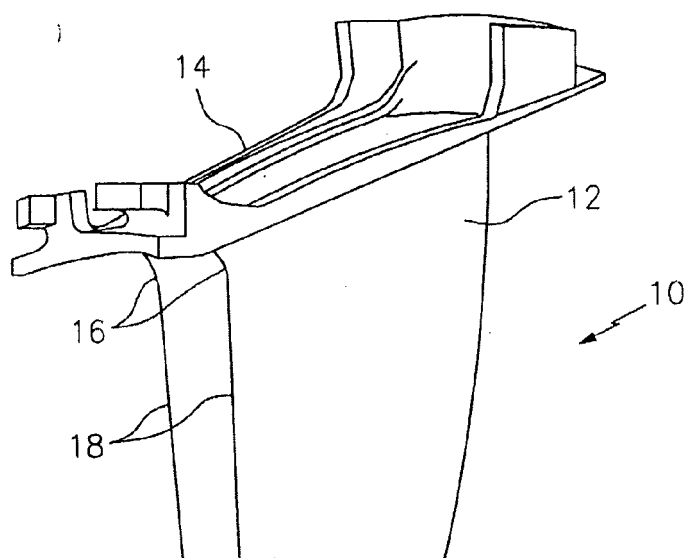


FIG. 1

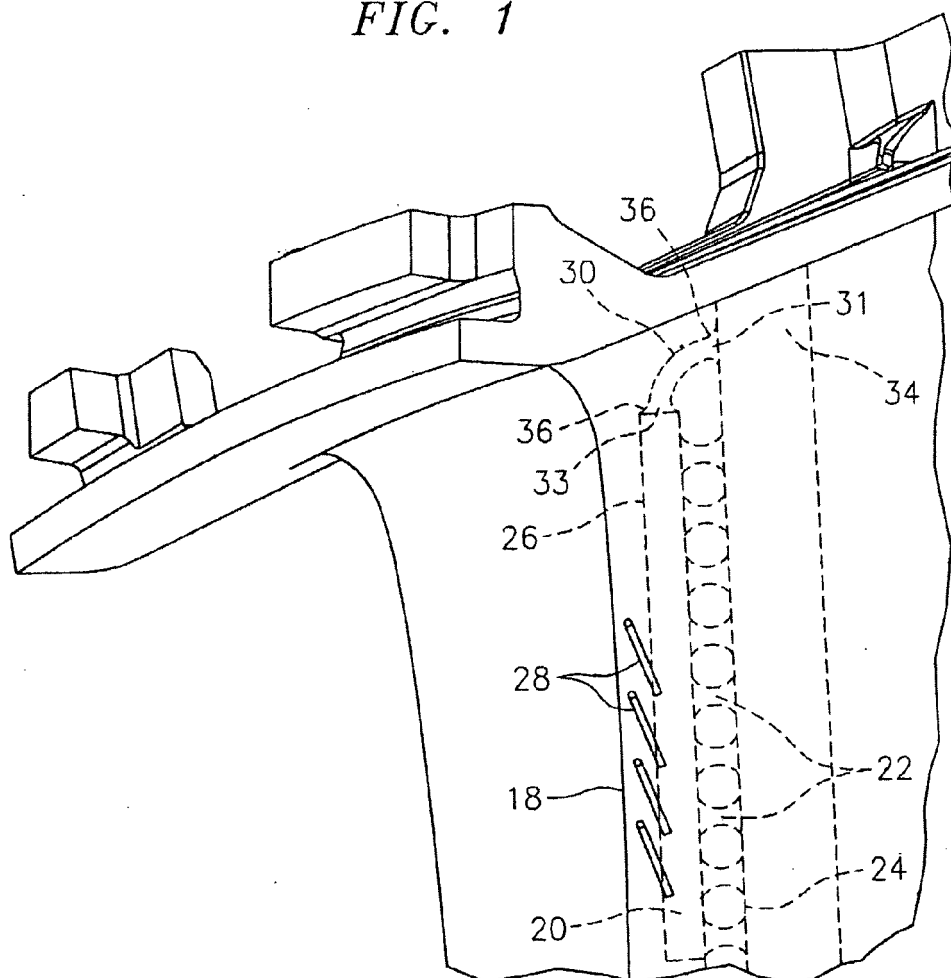


FIG. 2

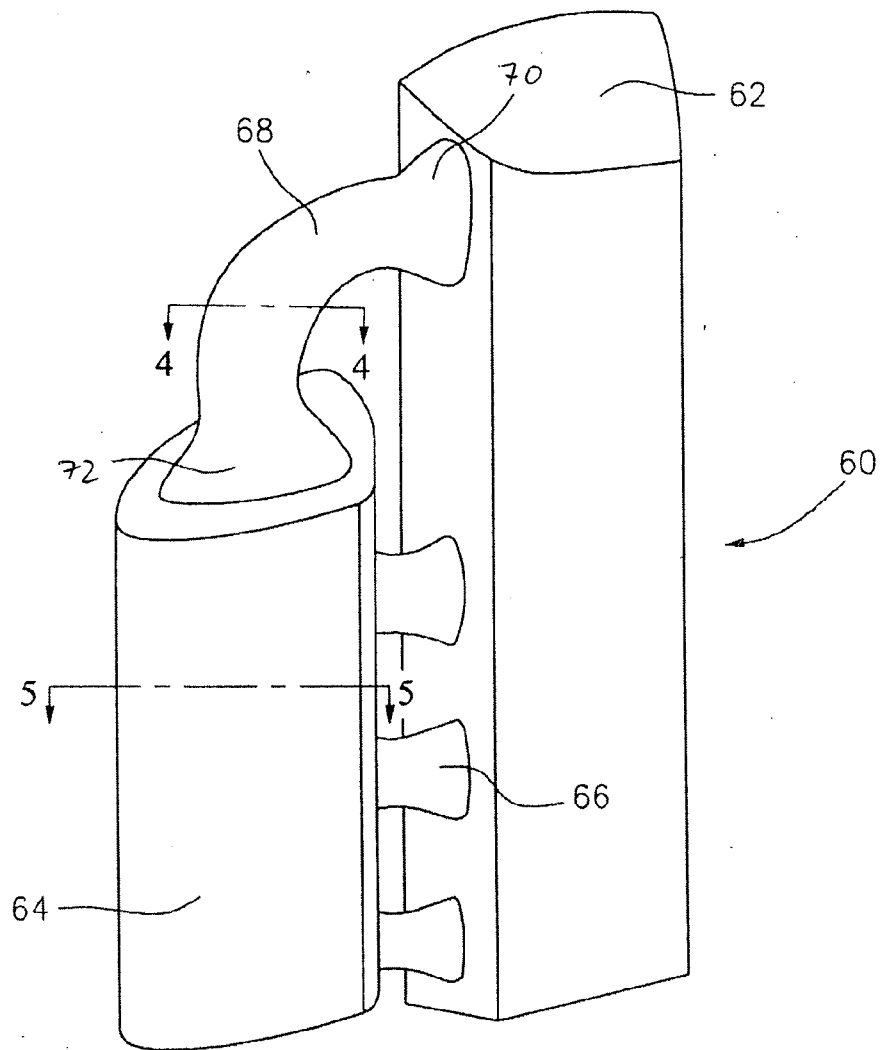


FIG. 3

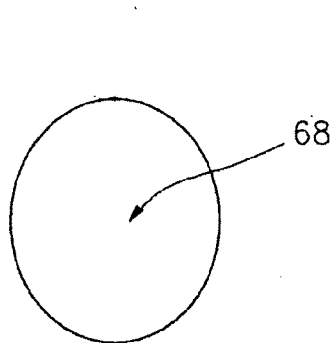


FIG. 4

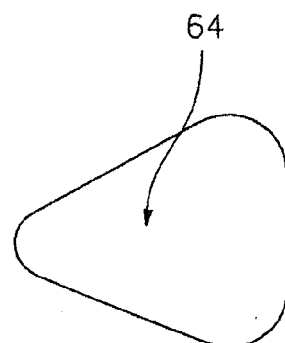


FIG. 5