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NASA TECH BRIEF

Lewis Research Center

REFRACTORY INSERTS USED TO FORM COOLING PASSAGES IN CAST SUPERALLOY TURBINE VANES

The Problem:

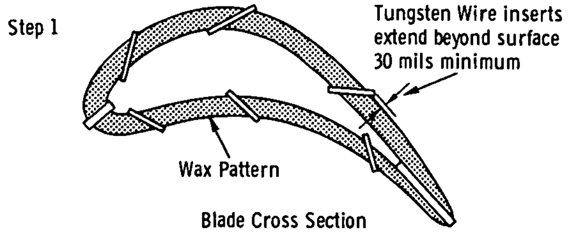
Better cooling performance will be required for higher temperature (1811 to 2478 K (2800 to 4000°F)) environments of future gas turbine engines. Air cooled components, blades and vanes will require numerous and more complicated internal configurations for cooling. An economical technique had to be developed for manufacturing these complicated parts.

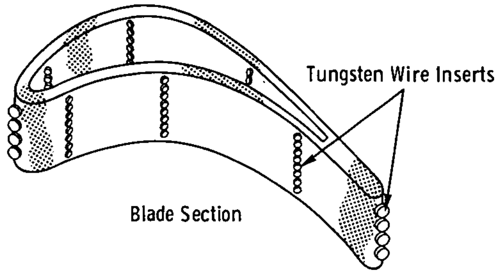
The Solution:

A process for casting blades and vanes using tungsten insert cores to form the coolant passages. After casting, the cores are reduced to tungsten oxide during sublimation with oxygen at an elevated temperature (1033 K (1400°F)). The tungsten oxide is leached out of the coolant passages with a molten salt solution (sodium and potassium nitrite and nitrate). Tungsten is used for the core material because of its high melting temperature (3700 K (6200°F)), its high stiffness modulous at the blade casting temperature, and its characteristic of subliming rapidly at elevated temperatures in the presence of oxygen.

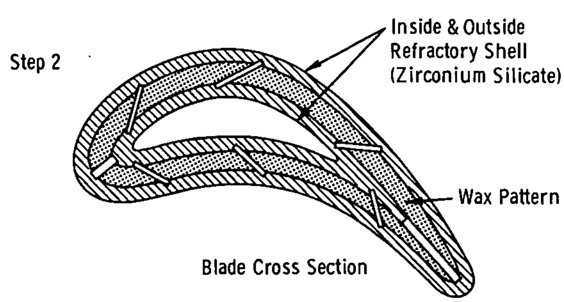
How It's Done:

1. Tungsten inserts are placed in desired locations in the hollow wax blade pattern. The tungsten inserts may be coated with an aluminum oxide (Al_2O_3) to minimize the diffusion rate of one metal into the other during the casting process.



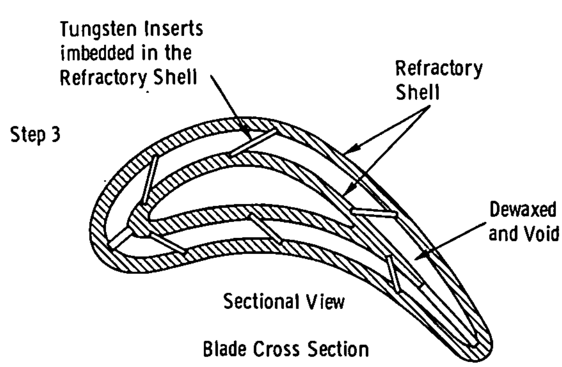


2. The wax pattern is coated with a refractory material (zirconium silicate). The thickness of the coating depends on the size of the part to be cast; i.e., the coating must be thick enough to form a shell to contain the molten metal during vacuum casting.



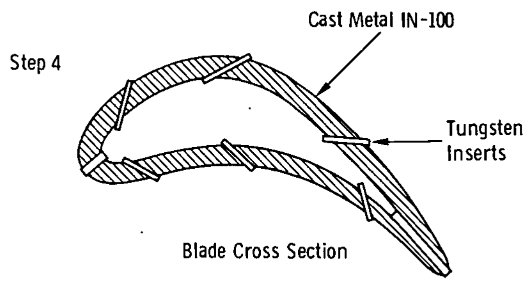
3. (a) The refractory coated wax pattern (shell mold) is dewaxed in an autoclave at 426 K (307°F).

(b) The dewaxed shell mold is then fired in either a vacuum furnace, hydrogen furnace, or an Argon furnace for a period of one hour at 1255 K (1800°F).



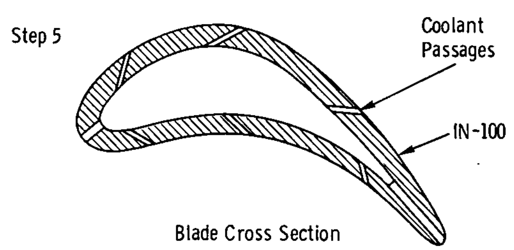
(continued overleaf)

4. The shell mold is heated to approximately 1366 K (2000°F) in a vacuum casting furnace before the molten metal is poured into it. The blades were cast from a superalloy (chromium nickel) at 1922 K (3000°F).



5. (a) The mold is removed from the blade, and the blade is placed in an atmospheric furnace for a period of one hour at 1033 K (1400°F) to cause the tungsten insert cores to sublime into an oxide.

(b) The tungsten oxide is leached out with a molten salt solution (sodium fluoride) at 589 K (600°F) for a period of two hours.



Blades cast by this process have contained coolant passages of various sizes from 6 to 30 mils (0.006 to 0.030 inch) in diameter. The internal cooling passages were oriented at approximately 45° to the shell surfaces.

Notes:

1. This process can be used in producing blades for single blade cascade research test facilities or can be adapted for mass production. The element that makes this process useful for research is the ease with which changes in cooling passage patterns and sizes can be made to the same blade geometry. This casting technique requires no post-process machining or heat treating as do conventional drilling processes.
2. No additional documentation is available. Specific questions, however, may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10013

Patent Status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

NASA Patent Counsel
Mail Stop 500-113
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(LEW-11169)