**NASA TECH BRIEF**

*Lewis Research Center*



# Advanced Alloy Design Technique - - High Temperature Cobalt Base Superalloy

An advanced alloy design technique has been developed for creating alloys that will have an extended life in service at high temperature (1162°C (2125°F)) and intermediate temperatures (650°-871°C (1200°-1600°F)). The process, in essence, is to stabilize the microstructure of the alloy by designing it so that the compound identified with embrittlement is eliminated or minimized. The alloy is designed to a calculated value of the average electron-vacancy concentration of the residual matrix after the initial phases (contributing to embrittlement) have formed. The key to the design is that the critical value of the average electron vacancy can be determined by a few simple experiments.

The effectiveness of this alloy design process was demonstrated by formulating a microstructurally stable, high temperature-strength cobalt-base superalloy. A cobalt alloy system (weight % 25 W – 3 Cr – 0.5 Zr – 1 Ti – 0.5 C – balance Co) resulting from previous NASA research was chosen as the starting material. This alloy had excellent high temperature strength but showed embrittlement after exposure in the 650° to 980°C (1200°–1800°F) temperature range as a result of the precipitation of an intermetallic compound $Co_3W$. Applying the novel alloy design process, which related the amount of $Co_3W$ (embrittling phase) to alloy composition by means of the average electron vacancy concentration, resulted in a new high temperature cobalt alloy of the following composition in weight percent, 17.5 W – 3 Cr – 5 Ni – 5 Fe – 0.37 Zr – 0.75 Ti – 3 Re – 0.5 C – balance Co. This new cobalt superalloy has the desired high temperature strength properties of the base alloy and is significantly less subject to embrittlement, thus having a longer service life.

This alloy design process provides a guide to more directly develop alloys having the desired physical and mechanical properties necessary to maintain a stable microstructure over their entire usable temperature range. This process has potential for significantly reducing the cost of alloy development by reducing the number of experimental alloy heats and by permitting the prediction of desired alloy properties in advance of actual formulation.

The alloy design process is currently being used to develop both nickel and cobalt-base superalloys for various high-temperature applications. The specific new cobalt alloy developed by this process and described above has applicability to advanced turbine engine stator vanes and other structural applications requiring high strength up to approximately 1150°C (2100°F), for example, heat treating furnaces.

## Notes:

1. This new high temperature cobalt-base alloy has an average stress rupture life at 1162°C (2125°F) and $27.6 \times 10^6$ N/m$^2$ (4000 psi) in an inert atmosphere of more than 2000 hours. Its incipient melting point is between 1357°C (2475°F) and 1371°C (2500°F).
2. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA TN-D-6147 (N71-18515), Modification of High Temperature Cobalt-Tungsten Alloys for Improved Stability
3. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10514

## Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive

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or exclusive license for its commercial development should be addressed to:

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