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NASA TECH BRIEF

The Columbium-Hydrogen System and Hydrogen Embrittlement of Columbium

Columbium and columbium alloys have desirable properties which make them quite attractive for industrial application, especially where high heat fluxes and high temperatures are encountered. In these applications, it is usually more efficient to use a cooling fluid, such as hydrogen, which has excellent heat-transfer characteristics, than to rely on methods which employ ablative materials and porous walls. However, it is well known that columbium and columbium alloys can be severely embrittled by hydrogen, particularly at low cooling temperatures; under certain conditions, fragmentation may even occur.

A thorough investigation of the available literature was undertaken and laboratory efforts were conducted to provide a comprehensive treatise on the columbium-hydrogen system and the effects of hydrogen on the mechanical properties of columbium.

Laboratory methods were developed to charge columbium specimens uniformly with hydrogen and to measure accurately the hydrogen content by a procedure which involved the removal of hydrogen from flowing argon at 2000°F.

The columbium-hydrogen phase diagram that included a miscibility gap and an eutectoid transformation, was determined for two different columbium purity levels. A peritectoid transformation was postulated at the hydrogen-rich end of the diagram. The effects of hydrogen content on the ductile-to-transition temperature, deduced from slow strain-rate tensile test data, were determined for temperatures between 200° and 600°F. Brittle fracture occured at 700° and 800°F for specimens containing large amounts of hydrogen. The strength and ductility of columbium was found essentially to be independent of hydrogen content.

Note:

Requests for further information may be directed to:
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No patent action is contemplated by NASA.

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