A Comprehensive Investigation into a Nickel-Base Superalloy From Prealloyed Powders

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A detailed investigation covering several years into the factors affecting the production and properties of sintered nickel-base heat-resisting alloys is described. Particular attention has been paid to the relationships between composition and creep strength. The role of boron and zirconium in sintered alloys is discussed in relation to the effects upon grain size. A method of producing powders from vacuum-melted alloys has been developed. The properties of specimens produced by sintering these powders are compared with those made also from air-/argon-melted powders. The elevated temperature, tensile, creep, fatigue and thermal shock properties of the best sintered alloys are compared with data for commercially available wrought and cast alloys. It is shown that the best sintered alloys are equal to the best vacuum-melted wrought alloys. However, the creep properties of the best nickel-base vacuum-cast alloys are still superior.

INTRODUCTION

The development of high creep-strength nickel and cobalt-base alloys for gas-turbine aeroengines has occupied a prominent position in metallurgical research during the past twenty years. This concentrated effort had its origin in the marked increase in working efficiency which is obtained when the operating temperature of a gas turbine is raised.

For many years, there was considerable controversy over the relative merits of wrought and cast materials for the rotor blades of gas-turbine aeroengines. These blades are subjected to complex creep stresses, principally resulting from the bending stress imposed by the gas pressure, and the tensile stresses due to the centrifugal force developed. Moreover, the roots of these blades are subject to fatigue, while in addition thermal shock, impact, corrosion and oxidation conditions appertain. In advanced aeroengines, some of these conditions have to be withstood when the blades are operating at about 0.8 T_m (where T_m is the melting point of the alloy). Naturally, to withstand these conditions, only the very highest-quality materials are used, and in modern turbines all highly stressed parts are made from vacuum-melted alloys.

There is little doubt that the majority of designers would prefer to use alloys which have been hot-worked, rather than to use them in the cast state. The preference for wrought alloys arises from the knowledge that these offer a more reliable combination of strength, toughness, and fatigue properties. While this generalization seems to be applicable in superalloys, there is no doubt that much higher creep strengths have been attained in cast alloys. Since it is creep strength which influences maximum permissible engine temperature, many engineers have accepted cast alloys with their lower toughnesses and fatigue strengths. Nevertheless, it is probably