HOT CORROSION PHENOMENA IN GAS TURBINES.

I. INTRODUCTION

While constant evidence of the gas turbine's superior performance is provided by the many aircraft and industrial turbines in service today, industry is trying to improve its durability, reliability and economy.

Hot corrosion, including oxidation sulfidation, and attack by lead, and vanadium is of prime concern to designer. However, sulfidation is probably the biggest problem facing the turbine industry today. While sulfidation does not interfere with turbine performance, except in the most advanced stages, it does limit the operating temperature time relationship of turbine blade materials.

In early gas turbines, sulfidation of superalloys was not a problem because operating temperatures were very low.

The first case of hot corrosion problem was reported in 1950 in a land based turbine, where low grade of fuel, crude and residual oils led to severe effects caused by vanadium pentoxide and sodium sulfate (1).

This type of problem was not encountered with destillate (high grade) fuel which have only trace amounts of vanadium and sodium and relatively small amounts of sulfur 0,4 percent maximum and 0,12 percent average for JP 5. However, evidence of hot corrosion was reported in a petrol boat application in 1959 and then sporodic cases occurred in aircraft applications. It has increased in frequency and is now considered as a major problem. This coincided with an increase in the number of marine applications, higher temperatures and with the introduction of higher strength nickel base alloy which generally have relatively low chromium contents.

Visually, in hot corrosion the components look cracked, swollen and or spalled. Fig. 1 and 2 illustrate an affected Inco 713 nozzle guide vane. There is a deep subsurface penetration of oxides which have often a striated appearance in some zones. At the interface of the oxides and the base matrix there are numerous small grey globular particules. It is evident that these corrosion products are formed by a complex mechanism. This fact induced difficulties to predict the behavior of the superalloys in service conditions. The work performed on the mechanism and on the corrosion resistance of the superalloys have shown that sulfur, sea salts, the different impurities and the temperature have interdependent effects which vary with the nature of the alloy.

Two methods are usual to increase the hot corrosion resistance of the superalloys. The first is the modification of the chemical composition with the addition of elements which are susceptible to improve the characteristics of hot corrosion resistance of the base alloys.

The second method is the protection of the alloy by coating. This paper concerns principally works performed to increase the corrosion resistance of the base alloys by the addition of alloying elements.

To evaluate the hot corrosion resistance of the superalloys some tests are usual. First there is the oxidation tests at high temperature and in air. Then the sulfidation tests in atmospheres containing H_2S, $S0_2 + 0_2$ or in pure H_2S and finally the hot corrosion tests in polluted combustion gases.

In the past, only the corrosion resistance of industrial alloys has been evaluated. Among these it can be mentioned a great number of nickel base alloys such as Udimet 500, Udimet 700, Inconel SM 200 and any cobalt base alloys such as WI 52 and X 40. Nevertheless in recent works attemps were made to determine the influence of the different elements of the alloys on the hot corrosion resistance.