EXPERIMENTAL INVESTIGATION OF BLANCHING EFFECTS OF TYPICAL LIQUID ROCKET ENGINE COMBUSTION CHAMBER WALL MATERIALS

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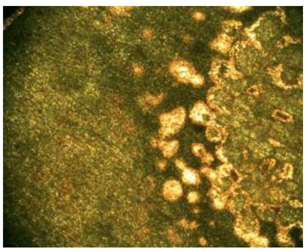
Conditions in combustion chambers of liquid rocket engines are severe, especially for the inner liner of the chamber wall. The copper alloys used in the thin inner liner of the chamber wall ensure an efficient cooling. However, concentration fluctuations of the propellants such as H2 and O2 on the surface of the inner liner of the chamber wall can lead to a damage of the alloys, especially if the wall is not permanently protected by H2. This phenomenon is known as Blanching, which is a quick cyclic exposition to oxidizing and reductive gas concentrations, leading to a physical-chemical reduction of the width of the wall, even up to fracture. CNES and DLR support this study dedicated to a better understanding of Blanching, optimizing the reliability of engines. Ogbuji [1] showed that copper alloys can - depending on their composition - provide a protection to oxidation and reduction. As copper is mandatory because of its high thermal conductivity, some metallic elements are usually added in order to maximize the mechanical and chemical resistance of the alloy. For example, an addition of Chromium is used for mechanical resistance and also has some chemicals interests. The present document will show the differences of the behavior between three copper basis alloys (OFHC copper and two Copper-Chromium alloys) under oxidation-reduction cycles at 750°C. This experimental investigation aims at assessing blanching in the range of real liquid rocket engines combustion chambers conditions.

The performed tests consisted in oxidizing and reducing of samples in a Thermo Gravimetric Analyzer (TGA) during 40 cycles under controlled atmospheres at 750°C, and 600°C, 750°C or 900°C for CuCrNb. Oxidation is obtained by industrial quality air (O2+N2), and reduction by CO as low safety risk replacements for the O2+H2 atmosphere in the engine. Oxidation phases last 2 minutes and reduction phases last 6 minutes. Attention was focused on a complete reduction of the formed copper oxides. The shortest cycle time allows for the most accurate blanching assessment. On the contrary, the longest cycle time allows for the most accurate damage assessment of the redox behavior. Differences of the behavior were observed between OFHC and copper-chromium alloys mainly in the evolution of the weight after each oxidation-reduction cycle. These differences may be caused by the growth of secondary copper oxides, which are not reduced during the reduction phases [2]. Oxide layers have been identified. Exploitation of these data and differences may lead to a principal understanding of the behavior of the chamber wall material during blanching, and helps to determine oxidation and reduction law parameters. RAMAN and SEM analyses confirm the presence of secondary copper oxide layers below the reduced copper on the surface of the sample ($CuCrO_2$ or $CrNbO_4$).



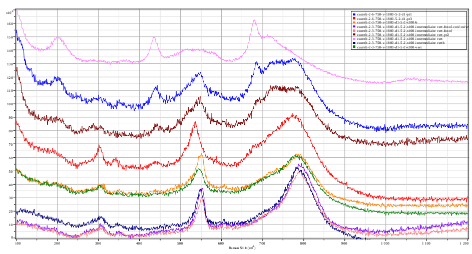


Figure 1: Secondary oxide layer in CuCrNb (left) and RAMAN Spectrum for different zones (right).

REFERENCES:

[1] Ogbuji, L., 2005. A table-top technique for assessing the blanching resistance of Cu alloys. *Oxidation of metals,* 63(5-6), pp. 383-399

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