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Fundamentals of High Temperature Corrosion

Catastrophic Oxidation in the Presence of Liquid Eutectics

GOAL

The goal of the exercise is to become familiar with the procedure and consequences of catastrophic corrosion using copper oxidation in the presence of V_2O_5 as an example

INTRODUCTION

The term catastrophic corrosion should be understood as rapid deterioration of metallic material at elevated temperatures associated with especially poor protective properties of scales or the formation of liquid or gas oxidation products. Catastrophic corrosion can be most often found in combustion gas environments containing ashes. In such conditions, aside from oxide scale formation on metals, metallic material corrosion can also take place due to their reaction with aggressive ash components. The catastrophic corrosion process starts with a certain incubation period, after which very rapid material deterioration of construction material. Among the most aggressive ash components with differing aggressiveness are vanadium compounds, sulfates and alkali metal chlorides. In general, catastrophic corrosion takes place in the presence of compounds, such as, e.g., V_2O_5, Na_2O, K_2O, SO_2, SO_3, Cl. Other ash components do not accelerate corrosion and can even significantly limit the process (e.g. CaO and MgO). Chemical reactions that proceed in combustion gases containing ashes are interrelated, which means that the corrosion mechanism and kinetics are very complex. Up to now, a general theory has not been developed that describes the material deterioration processes, which take place in such complex environments. As a consequence, protecting materials in these conditions is very difficult.

PERFORMING THE EXERCISE

Pour a small amount of vanadium oxide powder into a crucible while being especially careful of the hazardous nature of this compound to your health. Grind and purify a small piece of copper from organic impurities. After drying the sample, put the copper plate into the crucible so that only a part (around one-half) of the sample is in contact with the previously inserted powder. Carefully place crucibles with a copper sample and V_2O_5 powder into an electrical resistance furnace, then head the furnace to 620ºC at a rate of 10ºC/min. Keep the sample at the previously mentioned temperature for a period of time selected by the laboratory instructor (from 15 min. to 1 h). After that, turn of the furnace, wait until it cools down completely, take out the copper sample and observe the deterioration caused by corrosion. Pay special attention to the differences between the sample surface in contact with air and the surface in contact with V_2O_5.

Observations

With the help of a stereoscopic and metallographic microscope carry out observations on the surface and cross-section of the oxidized sample. On the basis of these microscopic observations of the previously prepared metallographic cross-section describe sample morphology and interpret the result of the previously carried out experiment. Pay special attention to the part of the sample that remained in direct contact with V_2O_5. Compare the morphologies of scales formed on copper oxidized in air and in the presence of V_2O_5. Propose an explanation for the catastrophic corrosion mechanism that takes place in the presence of vanadium (V) oxide.

Literature

1. S. Mrowec, T. Werber, Modern Scaling-Resistant Materials, Warsaw 1982.