Oxidation-Resistance of Industrial Carbon and Graphite Grades

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Introduction

Carbon and graphite utilized in oxidizing environments at elevated temperatures suffer a weight-loss which may result in irreversible changes of the dimensional stability and affects also the mechanical properties of the material.

Some preferred fields of application for such parts under operating conditions as described above are continuous casting of non-ferrous metals, pressure-sintering of hard metals or cermets, electric resistance heaters and many soldering or welding operations.

In a previous part of these investigations on oxidation and oxidation-resistance a simple method of determining the weight-loss during oxidation at elevated temperatures was evaluated and described.[1]

Some coating and preferrably impregnating procedures were studied in order to reduce the oxidation rate thus leading to improved performance of the material in the fields of application mentioned above.

Experimental

Figure 1 shows the burn-off at 600 °C as a function of time for a number of grades. The highest values are marked by ungraphitized, resin-bonded or resin-impregnated grades.

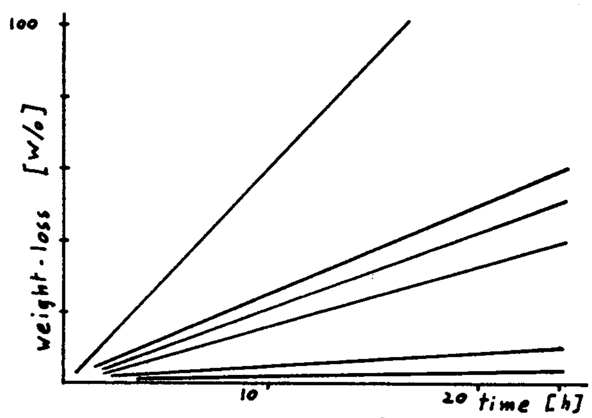

Figure 1. Burn-off at 600 °C as a function of time for several grades.

A second group with lower values of the specific burn-off is formed by a number of grades with a special pore system including various brush grades.

The last two groups contain most of the grades evaluated. Although both are characterized by a relatively low oxidation-rate under test conditions, a marked difference could be observed within this range which is illustrated by figure 2.

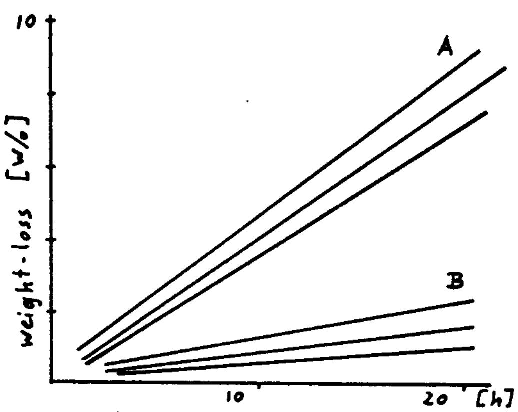

Figure 2. Burn-off at 600 °C as a function of time for two graphite grades with different filler material.

This figure shows the influence of the filler material on the oxidation-resistance. The curves A represent the oxidation-loss for pitch-bonded grades based on a petroleum coke/pitch coke filler.

The curves B give the values for pitch-bonded grades of practically the same composition, but where, prior to this mixing step, the filler material blend was in a first step pitch-bonded, baked and crushed to form a "pre-product" filler.

This type of manufacturing procedure

proves to be very beneficial for the oxidation-resistance of the corresponding grades.
Figure 3 shows the influence of the graphitizing temperature on the specific burn-off of several grades, which normally decreases with increasing temperature and crystalline order.

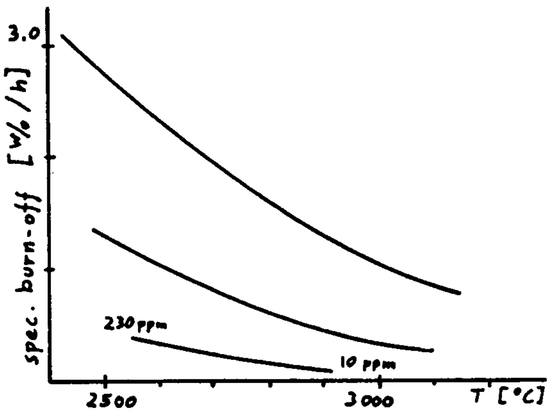

Figure 3. Burn-off-rate at 600 °C as a function of graphitizing temperature and ash content.

This figure also gives an indication of the influence of the ash content on the oxidation.

The effects of inorganic impregnations may be seen from figure 4, where the specific burn-off at 750 °C is plotted versus the concentration of an aqueous solution of a phosphoric acid salt, showing that already at a relatively low impregnation-rate the burn-off reaches a constant

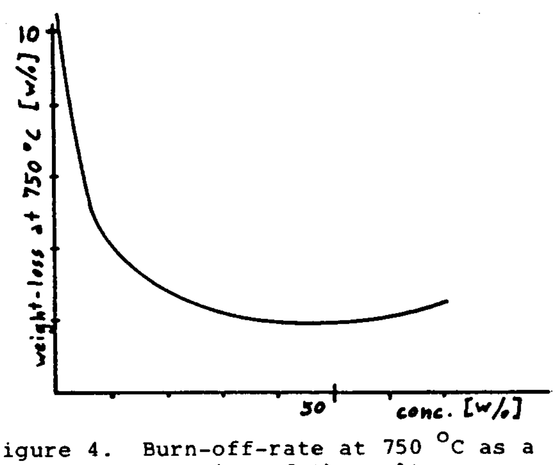

Figure 4. Burn-off-rate at 750 °C as a function of the salt concentration.

level with a slight increase at higher concentrations. This is in good agreement with other observations that too high amounts of metal salts lead to an increase of the oxidation due to catalytic reactions.

In figure 5 the oxidation of graphite crucibles for melting of dental alloys is shown. These crucibles are partially co-

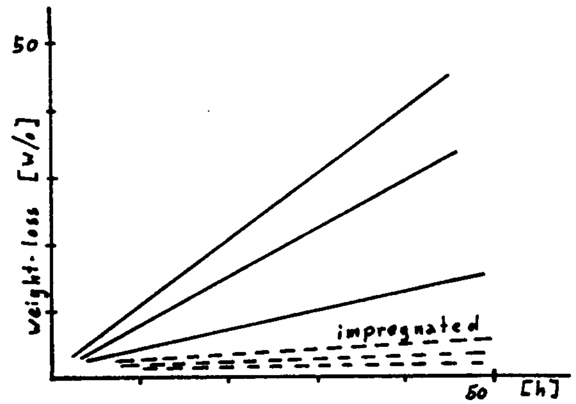

Figure 5. Burn-off at 600 °C as a function of time for several unimpregnated and impregnated grades.

vered by a ceramic tube with an unprotected 5 to 8 mm upper end.
Three different graphite grades were evaluated with two different impregantions both on a phosphate base. Although the three graphites showed a different oxidation behaviour in the unimpregnated state due to their composition and manufacturing technology, after impregnation there were only small differences in their oxidation-resistance to be observed at a very low burn-off level.
Similar results could be obtained in evaluating this impregnation procedure in the field of soldering with high-melting metals and alloys. The operating conditions are very rough since the parts to be joined are heated to the required temperatures exceeding 1000 °C by placing them on resistance-heated graphite plates or stoppers. In order to accelerate the cooling down after joining and thus the production cycle the current is switched off and a stream of cold air is blown against the parts. Depending on the operation mode such an electrode may be already worn after 10 to 12 cycles, but even under these most severe requirements the impregnated electrodes could be brought to a service-time of 50 to 60 cycles.

Summary

The oxidation-resistance of a number of industrial carbon and graphite grades could be considerably improved by impregnation with phosphorus compounds of some metals followed by a heat treatment between 350 and 800 °C.
The improvement of performance and service-time under actual operating conditions is in good agreement with the laboratory test results at 600 or 750 °C so that accordingly already suitable grades can be selected.

References

1. A.E. Kindler, Extd. Abst. 16 th Biennial Conference on Carbon at San Diego, 1983, "Oxidation-Resistance of Carbon and Graphite Grades"