VIEWS ON COMPOUND MATERIALS

TOMAS THORVALDSSON
General Manager, Product R&D, AB Sandvik Steel, S-811 81 Sandviken, Sweden

Introduction

The development and use of metallic materials have two different driving forces; either the possibility to produce a less expensive material by replacing parts of an expensive alloy with a less costly structural material or the need to combine different and contradictory material properties that cannot be met in one single alloy. This paper will be considering the latter subject only.

Typical applications requiring compound materials are in energy producing systems of high efficiency and with improved environmental control. Examples are found in black liquor recovery boilers and super-heaters, in coal gasification plants and in waste incinerators. The fuels used impose severe corrosion from sulphur, chlorine or molten deposits, why stainless steels are required. The hot water or steam used in the heat exchanger system give risk to stress corrosion cracking, why a structural carbon steel is suitable. To meet these conflicting requirements compound material can be used, Figure 1.

In chemical processes, e. g. urea production, it can be advantageous to use a combination of zirconium and stainless steel in the most corrosion sensitive parts.

In nuclear reactors cladding tubes in compound material are now being used. Here zirconium is used due to its low cross section for thermal neutrons. While pure zirconium can be good for the fuel side corrosion the water side corrosion has other material requirements. In addition, the structural strength may need a third element, so up to three different layers of zirconium alloys can be required.

For car exhaust systems using catalytic converters a different approach is used. In order to have good mechanical and structural strength stainless steel is used as a monolith material while an alumina oxide layer is grown in situ in order to provide alumina whiskers for surface area enlargement. The oxide layer is then used as host material for the active elements platinum and rhodium.

Fig. 1 - Coextruded tubes.

Production

Different production methods have successfully been used, like rolling, co-extrusion, spray forming, explosive bonding or in situ material transformations. The type of production method must be balanced against technical requirement, amount of material and overall economy.

Material properties

The design of compound systems requires considerable care. While it is easy to establish what material combinations that are most desirable from the user's point of view, nature does not permit all combinations without severe restrictions. Since most compound materials are either produced or used at high temperatures, sufficient thermodynamic balance must be maintained. Both experimental and theoretical techniques must be used for a successful selection of

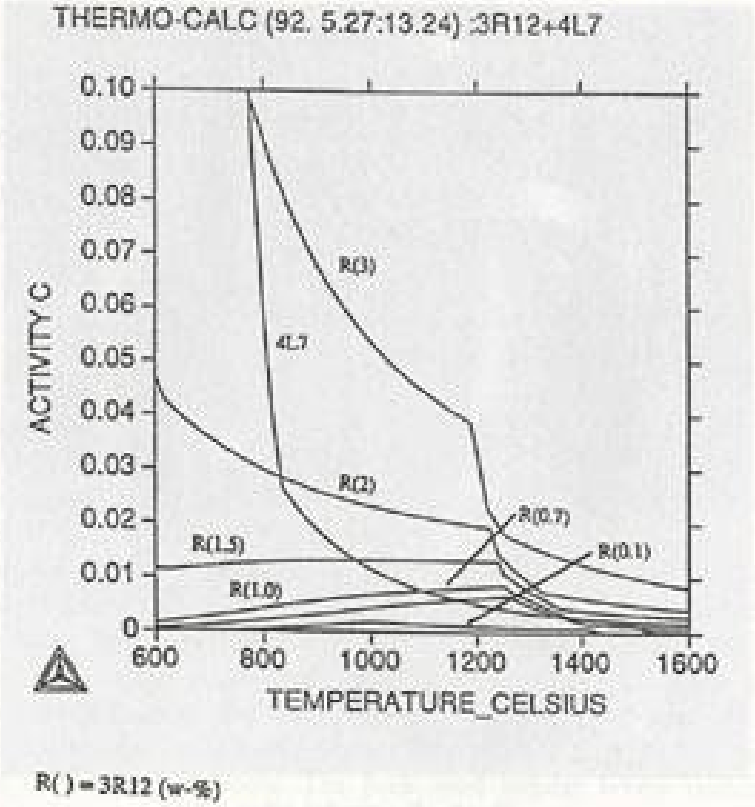

Fig. 2 - Calculation of C-activity in coextruded material.

material combinations. Thermodynamic calculations from first principles have proven to be important tools for compound design, Figure 2. Special care must also be taken regarding overall corrosion resistance, maximum service temperature, structure stability, heat transfer, thermal expansion, thermal cycling, welding, bending etc.

It should also be noted that by using compound material specific physical properties can be changed in an advantageous way. For example, by using a ferritic/austenitic steel compound material instead of a pure austenitic material better thermal diffusivity, thermal expansion and heat transfer can be obtained, thereby increasing efficiency and improving performance in a heat exchanger system.

Conclusions

Compound material is successfully used in many applications today. With improving theoretical and experimental methods more material combinations can be used. This is important in order to aid tomorrow's increasing demands on various applications, including increased energy production and environmental control.