Protecting tubes for use under extreme stresses

General notes

Demands on protecting tubes

The demands on temperature measuring devices for use in industry increase with the requirement that temperatures should be measured continuously, exactly and reliably even in critical fields. Modern high-performance materials have opened up new applications at the extremities of temperature measurement. It used to be possible to serve a number of branches of industry only unsatisfactorily or not at all where the life and reliability of thermometers were concerned.

Extensive know-how is necessary for the design of thermometers which will

- measure temperatures under abrasive stresses such as frequently appear in processes in mechanical and thermal manufacturing technology
- measure temperatures under corrosive and thermal conditions, such as have to be considered in metal smelting, salt baths and glass smelting
- measure temperatures for processes of the food industry or pharmaceutical industry with high requirements as to surface cleanliness, elimination of certain species of bacteria and toxic-free process management
- measure temperatures in the corrosive hot-gas atmospheres of smoke desulphurization plants during wet and dry operation, in exhaust systems of vehicles and of plants for the incineration of communal and industrial refuse.

Materials

The choice of materials for protecting tubes has a considerable influence on the life of the temperature measurement devices. The following material groups are important for improved protecting-tube design:

heat and creep-resistant or corrosion resistant metals:

- super alloys (especially nickel and cobalt based)
- MCRALY's
- ODS alloys produced by powder metallurgy

ceramic high-performance materials:

- nitrides (e. g. silicon nitride, aluminium nitride, boron nitride)
- borides (e. g. zircon boride)
- carbides (e. g. silicon-infiltrated silicon carbide)
- oxides (e. g. zirconium dioxide, pure corundum)

plastics with exceptional properties:

- homopolymers, copolymers and chemically modified natural materials (especially PTFE, E/CTFE, PA, PC, PE, PP, PI, PFA)
- synthetic rubber (especially ABR, PBR)

Coatings

The range of these types of modern material has been extended not only by the introduction of modern technology in protecting-tube production and use but also by new coating techniques on cheap base materials. Modification of surfaces to the needs of industry is facilitated by the usual techniques of dipping and painting but also by the following special coating techniques:

- plasma spraying (atmospheric, inert or vacuum)
- diffusion coating
- laser separation PVD/CVD techniques
- sintering techniques (especially for plastics)

The selection of base and coating is determined by the stress conditions predicted.

Application

Metallic and non-metallic hard coatings on metallic base materials are suited to flowing mixtures of hot gases with solids and mixtures of fluids and solids with abrasive conditions but preferably not beyond a maximum of 500°C. It is the limited compatibility of both thermal expansion coefficients which leads to this restriction.

The application of metallic coating alloys can be achieved in hot-gas corrosive atmospheres up to 1200°.

In blast furnaces and other smelting baths it is preferable to use monolithic ceramics (e. g. silicon nitride or aluminium nitride in molten aluminium) or metals (e.g. DVS platinum in molten glass).

Nickel based alloys with high corrosion resistance and super alloys have been successfully used for thermometer protecting tubes in the wet and dry processes of smoke desulphurization plants. ODS-alloys are establishing themselves for high-temperature application in cement plants, exhaust systems and refuse incineration plants. Where required for financial reasons, it is possible to fall back on cheap alternatives such as super alloys or monolithic ceramics.

The life of the protecting-tube material chosen in any particular case is influenced by the actual stress conditions: temperature, chemical composition of the medium being measured , mechanical loads. Thus it is advisable to determine the stress conditions expected before making any practical decision about which material to use so that the best combination of advantageous features can be found for the intended application.