

⑫

EUROPEAN PATENT APPLICATION

⑮ Application number: **88202172.8**

⑤① Int. Cl.⁴: **B22C 1/10**

⑰ Date of filing: **03.10.88**

⑳ Priority: **07.10.87 GB 8723582**

㉑ Date of publication of application:
12.04.89 Bulletin 89/15

㉒ Designated Contracting States:
CH DE FR IT LI

㉓ Applicant: **AE TURBINE COMPONENTS LIMITED**
Victoria Avenue
Yeadon Leeds LS19 7AY(GB)

Applicant: **THE UNIVERSITY OF LEEDS**

Leeds, LS2 9JT(GB)

㉔ Inventor: **Hamilton, Duncan Havelock**
6 Boston Avenue
Kirkstall Leeds, LS5 3DL(GB)
Inventor: **Roberts, Edward Wilford**
8 Parklands
Bramhope Leeds(GB)

㉕ Representative: **Hadfield, Robert Franklin et al**
Bowdon House PO Box 20 Ashburton Road
West Trafford Park
Manchester M17 1RA(GB)

⑤④ **Foundry core material.**

⑤⑦ Silica cores are described particularly though not exclusively for use in the manufacture of precision cast components. The cores are dimensionally stable and resistant to distortion at temperatures exceeding 1500 °C. The silica cores contain ions selected from the group comprising titanium, zirconium, phosphorus, vanadium, chromium, molybdenum and tungsten. A preferred material is titania. The cores may contain between 0.05 and 10 wt% of titania to promote devitrification.

EP 0 311 203 A2

Foundry Core Material

The present invention relates to ceramic materials for use in ceramic cores particularly, though not exclusively for use in the manufacture of precision cast components.

Components such as blades and nozzle guide vanes, for example, for gas turbine engines frequently have complex shaped hollow internal passages for cooling purposes. Such passages allow the component to operate at much higher gas inlet temperature than would otherwise be the case. The passages are generally formed by the use of leachable ceramic cores cast in situ during a vacuum precision casting process.

Such cores have generally comprised silica-based materials. The high temperature strength of a core depends on the devitrification of vitreous silica to the crystalline phase, cristobalite. Heretofore this has generally been accomplished by alkali metal ions such as sodium, for example, added to the silica glass as catalysts in minor additions. Although alkali metal ions do promote devitrification of silica they also lower the high temperature strength of the core by lowering the melting temperature of the bond.

In recent years gas turbine components having metallic grain structures comprising either columnar grains, produced by a directional solidification process (DS), or a single crystal (SC) have gained increased prominence. This is due to the higher stresses and temperatures which may be withstood by components having such structures.

Both types of component are made by an essentially similar process wherein any cores used have to withstand temperatures exceeding 1500°C , sometimes for several hours. The result of this may be extensive plastic deformation of the core which tends to deform under its own weight and deflect when metal is poured into the mould in which the core is located.

Outer dimensional tolerances for precision cast gas turbine components are stringent, also the position, size and orientation etc. of cored passages within the components are subject to equally stringent tolerances.

It is an object of the present invention to provide a material for cores which will devitrify without the presence of alkali metal ions and not suffer from distortion at high temperatures.

According to one aspect of the present invention a core material for foundry use comprises silica having therein ions selected from the group comprising titanium, zirconium, phosphorous, vanadium, chromium, molybdenum and tungsten.

The ions may be added in the form of a finely divided oxide powder, or as a compound containing the element, preferably an organic compound which is miscible with the binder used during core manufacture. An organic compound miscible with the binder allows homogeneous dispersal throughout the mixture.

Where the element is added as the oxide the addition may lie in the range from 0.05 to 10wt%.

A preferred addition is titania.

A preferred range of titania may be 0.1 to 5wt%.

A more preferred range of titania may be 0.1 to 2.5wt%.

Preferably the silica is of purity greater than 99.5%.

According to a second aspect of the present invention a method of making a core for foundry use comprises the steps of mixing silica with material containing ions selected from the group comprising titanium, zirconium, phosphorous, vanadium, chromium, molybdenum and tungsten and organic binder material, moulding a desired core shape, heating to remove the organic binder and then firing in excess of 1180°C .

Preferably the firing temperature is in excess of 1200°C .

The content of organic binder material may be in the range of 15 to 40wt% of the mixture.

After firing it is preferred that less than 50% of the silica has transformed to cristobalite, further devitrification continuing during mould preheat so that at casting the cristobalite content approaches 100%.

Titania may be added as titania or as a titanium compound which decomposes to the oxide during processing.

In order that the invention may be more fully understood examples will now be described by way of illustration only.

A series of core material compositions were made by mixing fused silica with 0.1wt%, 0.25wt%, 1.0wt% and 2.5wt% titania of substantially submicron particle size. These compositions were pressed into pellets and fired at temperatures from 1150°C to 1300°C . The extent of devitrification was then assessed by means of thermal expansion measurements. The results showed that titania over the whole range of concentrations tested promoted devitrification when fired at and above 1200°C . The extent of crystallisation

increased with firing temperature, soak time at temperature and with increasing concentration of titania.

Further material was made of a single composition containing 1wt% titania in the mix to give 1.3wt% in the fired material. The mix comprised 68.50wt% fused silica, 1wt% titania and the balance being an organic binder based in polyethylene glycol. The mix was made in a Z-blade mixer. The organic components were mixed dry with the titania and then the Z-blade mixer heated until the organic components were molten. Mixing of the molten components and titania was continued for 1 hour and then the silica added in portions. When all the silica had been added mixing continued for 2 hours, the heaters were then switched off and the material granulated in situ. This material was designated mix L69.

A mix was made of a normal production core material containing sodium ions. This material was designated mix 52.

Test bars of mixes L69 and 52 were injection moulded and heated slowly to a temperature of 700 °C to drive off the organic binder materials.

Some of the mix 52 bars were dipped in ethyl silicate solution prior to firing in order to fill some of the porosity in the material. The dipped material was designated A52.

All three types of material were then fired under similar conditions at 1150 °C for 5 hours. Test bars of each of the compositions were then placed from ambient into the hot zone of a Modulus of Rupture (MOR) testing apparatus which had been allowed to stabilise at 1450 °C, and soaked for periods of 30 minutes and 60 minutes. After the completion of each soak period the bars were loaded to failure at 55 N/min to failure. After testing physical measurements of porosity and density were made (see Table).

Physical and Mechanical Properties of Compositions No. 52, A52, L69 tested at 1450 °C.							
Mix No.	Test No.	Soak Time/ min.	Bulk Density/ g cm ⁻³	Apparent Solid Density/ g cm ⁻³	Apparent Porosity /%	MOR / MPa	Deflection at Failure / mm
52	*AMB	AMB	1.453	2.21	34.1	7.5	0.34
	T129	30	1.483	2.27	34.7	6.4	0.80
	T128	60	1.467	2.27	35.4	7.2	0.72
A52	*AMB	AMB	1.579	2.21	28.6	14.1	0.33
	T135	30	1.580	2.26	30.1	11.2	0.80
	T134	60	1.598	2.27	29.6	12.4	0.67
L69	*T120	AMB	1.431	2.17	34.1	11.0	0.36
	T132	30	1.673	2.28	26.6	37.8	0.52
	T131	60	1.680	2.31	27.3	39.8	0.58

*As fired bars tested at ambient temperature.

Referring now to the Table and where Mix 52 as fired has a bulk density of 1.45 g/cm³, porosity of 34.1% and a MOR of 7.5 MPa. The effect of dipping in ethyl silicate prior to firing is to increase the bulk density to 1.58 g/cm³ with a decrease in porosity to 28.6% and a consequent doubling of MOR. The L69 bars as fired have a bulk density of 1.43 g/cm³, a porosity of 34.1% and a MOR of 11.0 MPa. The deflection at failure for all compositions is similar at 0.35mm.

It may be seen that the L69 material soaked for 30 and 60 minutes at 1450 °C has achieved MOR values of 37.8 and 39.8 MPa. The level of crystallisation of mix 52 and A52 materials is comparable to the L69 material but the MOR values are greatly reduced at averages of 6.8 and 11.8 MPa respectively.

Claims

1. A core material for foundry use, the material comprising silica characterised by having therein ions selected from the group comprising titanium, zirconium, phosphorus, vanadium, chromium, molybdenum and tungsten.

2. A core material according to Claim 1 characterised in that the ions are present in the form of an oxide.

3. A core material according to Claim 2 characterised in that the oxide is titania.

4. A core material according to Claim 2 or Claim 3 characterised in that the oxide content is from 0.05 to 10.0 wt%.

5. A core material according to Claim 4 characterised in that the oxide content is from 0.1 to 5.0 wt%.

6. A core material according to Claim 4 characterised in that the oxide content is from 0.1 to 2.5 wt%.
7. A method of making a core for foundry use, the method being characterised by comprising the steps of mixing silica with material containing ions selected from the group comprising titanium, zirconium, phosphorus, vanadium, chromium, molybdenum, tungsten and organic binder material, moulding a desired
5 core shape, heating to remove the organic binder and then firing in excess of 1180 ° C.
8. A method according to Claim 7 characterised in that the firing temperature is in excess of 1200 ° C.
9. A method according to either Claim 7 or Claim 8 characterised in that the ions are added in the form of a finely divided oxide.
10. A method according to either Claim 7 or Claim 8 characterised in that the ions are added as an
10 organic compound.
11. A method according to Claim 10 characterised in that the organic compound is miscible with the organic binder material.
12. A method according to Claim 9 characterised in that the oxide is titania.
13. A method according to Claim 12 characterised in that the titania content of the mixture is from 0.05
15 to 10.0 wt%.
14. A method according to Claim 13 characterised in that the titania content of the mixture is from 0.1 to 5.0wt%.
15. A method according to Claim 13 characterised in that the titania content of the mixture is from 0.1 to 2.5wt%.
- 20 16. A method according to any one of Claims 7 to 15 characterised in that the core is held at temperature for up to 60 minutes prior to casting of metal around the core.

25

30

35

40

45

50

55