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(54) **Casting of metal articles using
disintegrable cores**

(57) The process embodies the use of
a core made from material comprising
dicalcium silicate. Dicalcium silicate
undergoes various phase changes

during heating and cooling one of
which, the β to γ transformation, is
accompanied by a large volume
increase. By using this feature casting
cores may be produced which
disintegrate during cooling of the
solidified metal.

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SPECIFICATION

Casting of metal articles

This invention relates to the casting of metal articles, particularly articles having internal passages and/or cavities.

It is well-known to use shaped cores in the production of castings having internal passages or other hollow portions, the molten metal being poured around a core which is removed after solidification of the casting. Cores may be conveniently produced in a granular material, such as sand which is compacted before use, or they may be moulded from ceramic materials which will withstand the heat of the casting process. Granular cores can often be readily removed by mechanical means as can some ceramic cores though recourse is frequently made to 'leaching' in which the core material is removed by the action of suitable chemical agent such as for example, sodium hydroxide solution.

In certain circumstances the removal of cores by mechanical means or by leaching is unsuitable or undesirable, for example where a core of complex shape is required and the chemicals employed are likely to have unwanted effects on the metal of the finished article.

The present invention provides a core which will disintegrate as the result of controlled heat treatment.

A casting process according to the invention includes the steps of producing a core comprising dicalcium silicate, forming a casting around the core and disintegrating the core during cooling of the casting.

The common phases of dicalcium silicate ($2\text{CaO} \cdot \text{SiO}_2$) are:

α — hexagonal, density 3.07 g/cc, stable above 1430°C.

α^1 — orthorhombic, density 3.31 g/cc, stable on heating through 900°—1447°C and on cooling through 1447 to 675°C.

β — monoclinic, density 3.28 g/cc, a metastable phase between 675—400°C, capable of being preserved at room temperature under certain conditions.

γ — orthorhombic, density 2.97 g/cc. The room temperature stable phase formed by inversion of β to γ at 400°C to a fine powder.

According to a feature of the invention, a core formed of dicalcium silicate may first be sintered in the temperature range in which the high temperature hexagonal phase is stable and then cooled rapidly so as to avoid the β to γ phase change. This initial heating of the core ensures that sintering takes place in the temperature range for which the high temperature hexagonal phase (α phase) is stable, i.e. above nominally 1430°C.

The sintering temperature will be chosen to be at least as high as the subsequent metal casting temperature so as to obviate any further significant sintering of the core and so promote dimensional stability. The rapid cooling is preferably effected by air quenching at room temperature. This avoids the β to γ phase change

which, as indicated above, begins to occur at 400°C and as shown in the density difference, is accompanied by a large volume change and consequent disintegration. The core resulting from the initial sintering operation and rapid cooling is stable and can be stored until required for use. The rapid cooling of sintered cores prevents the β to γ phase change because of insufficient thermal energy being available for the reaction which is of a nucleation and growth type rather than a crystalline shear type transformation.

Disintegration of the core after casting may then be effected by cooling the casting very slowly e.g. over several hours, so as to allow the core sufficient time to undergo the β to γ phase change.

Advantageously the calcium disilicate is not pure. Indeed, according to an important feature of the invention the dicalcium silicate may include a stabilizer for stabilizing the β phase thereof and to facilitate sintering. Typical stabilizers include oxides of chromium, sodium oxide, molybdenum trioxide, and boric oxide.

The behaviour of material thus stabilized is markedly influenced by the thermal treatment, in particular dusting (disintegration) is enhanced the higher the holding temperature during sintering (provided fusion does not occur), the longer the time of holding, and the slower the cooling rate.

Stabilization is also advantageous in enabling storage of cores until required for use. According to another feature of the invention a destabilizer may then be introduced to override the stabilizer and promote dusting. Iron and nickel in elemental or compound forms may be used as destabilizers. Thus after a batch of cores has been produced and stored, one selected for use may be heated in contact with pellets of iron, ferric nitrate, iron oxide, nickel, nickel oxide, or by heat soaking in a ferrous solution. The particular advantage to the use of a destabilizer is that slow cooling of the casting, which may not be desirable from the point of view of the structure of the casting, may not be required.

It has been found that destabilisation and consequent dusting on cooling is most effectively initiated by surface contact with certain metals. Most notably, nickel, iron and cobalt are effective in promoting destabilisation. This fact is most useful in the production of gas turbine engine components since the majority of such components are cast from alloys based on nickel, cobalt or iron.

The 'dusting' associated with the β to γ transformation of dicalcium silicate is well-known, and has been utilised as a means of producing self-disintegrating portland cement clinker (Kapolyi et al. USP 3770469) but this material is not known to have been previously employed for the manufacture of cores as part of casting processes. In general however this is an undesirable phenomenon since it can lead to unwanted effects e.g. bricks are liable to fall apart if dicalcium silicate is present in them.

Cores produced in accordance with the

invention are particularly suitable for advanced casting processes such as are for instance used in the production of gas turbine blades. They can be easily fabricated to quite complex shapes, have adequate strength to permit all necessary manipulation together with minimum dimensional change and a capability of withstanding casting temperatures with negligible core/metal interaction. They have adequate thermal shock and impact resistance and are readily removable after solidification and cooling of the blade due to the dusting phenomenon.

In one example of a casting process according to the invention a gas turbine blade core is moulded from dicalcium silicate powder ($2\text{CaO} \cdot \text{SiO}_2$) having 0.5% chromium oxide (Cr_2O_3) powder mixed therein and sintered at a temperature of 1500°C for several hours followed by rapid air quenching to room temperature. The core is next assembled in a casting mould which was heated to 1500°C and a nickel based superalloy at a temperature of 1500°C introduced. The mould with casting and core is allowed to cool to a temperature just below 1430°C in a manner inducing unidirectional solidification of the blade. This was followed by slow cooling in the casting furnace to room temperature during which time the furnace controls are manipulated to slow the normal rate of cooling. On completion of the cooling process, the core will have disintegrated to a fine powder which can readily be removed from the casting. A washing operation such as, for example, flushing out the internal passages with high pressure water to assist in removing the dust and those particles adhering to the channel walls may prove advantageous.

In another example a core is moulded from dicalcium silicate containing 0.2 weight percent chromium oxide and sintered for 2 hours at 1450°C followed by air quenching. The remainder of the casting process is as described in the first

example above.

CLAIMS

- 45 1. A casting process for metallic articles comprises the steps of producing a core comprising dicalcium silicate, pouring metal around the core, the core subsequently disintegrating during cooling of the solidified
- 50 metal.
2. A method of producing a core for a casting process comprises shaping the core from material comprising dicalcium silicate, sintering in the temperature range in which the high temperature
- 55 hexagonal phase is stable and cooling the sintered core at a rate such as to avoid the β to γ phase change.
3. A method of producing a core for a casting process according to claim 2 and where the
- 60 sintering temperature of the core is at least the pouring temperature of the metal to be cast.
4. A method of producing a core for a casting process according to claim 2 or claim 3 and where cooling of the sintered core is effected by air
- 65 quenching.
5. A core for a casting process according to claim 1 and wherein the core includes a β phase stabilising material.
6. A casting process according to claim 1 or
- 70 claim 5 and wherein the cast metal includes iron and/or nickel.
7. A casting process according to any one of claims 1, 5 or 6 and where disintegration of the core is promoted by slow cooling of the casting.
- 75 8. A casting process according to claim 5 and wherein the β phase stabiliser comprises one or more of the materials selected from the group oxides of chromium, sodium oxide, molybdenum trioxide and boric oxide.
- 80 9. A casting process according to claim 1 and wherein the metallic article cast is a component for a gas turbine engine.