Where innovation delivers performance™

Technical Information

FK07

Performance Colors & Glass

Inoculants for Investment Casting

Often, a great strain is put on metallic work pieces say turbine blades. The fatigue strength of the material plays an important role for the durability of the components.

The fatigue strength of e.g. polycrystalline turbine blades produced in the vacuum cast process is strongly influenced by the microstructure of the alloy after solidification. Compared to a coarse grain structure, a fine- grained microstructure shows improved fatigue strength.

Therefore the Original Equipment Manufacturers (OEM) of aero-engine and stationary gas turbines have specified the grain size of the investment cast turbine blades and nozzle guide vanes within very tight limits. Usually, the grains should be smaller than 2 to 6 mm. Chill and elongated grains with an aspect ratio larger than three are not accepted.

But investment casting is not only used by the aeronautical and automotive industry. Various other industries are also large users of castings produced by this process.

The product spectrum ranges from long lasting turbine blades, turbo chargers, parts for high-vacuum pumps, and medical implants to golf clubs.

How it works

The cast product grain size is determined by energetic methods (mould temperature, metal pouring temperature), mechanical treatment (vibration, sonification) as well as the application of nucleation agents.

Nucleation agents can be high melting point oxides, borides and nitrides. For nickel and cobalt based alloys, the addition of cobalt containing oxides proved to be the best. The fine-grained structure is related to a redox reaction between the melt and the inoculant. With cobalt aluminate $CoAl_2O_4$ for example, the oxide is reduced and metallic cobalt is formed. This reaction is initiated by the oxygen affinity of the alloying elements say Ti, Al, and Cr.

The lost-wax process

After the production of wax models, these are covered with a $CoAl_2O_4$ containing coating. This coating normally consists of ca. 5% $CoAl_2O_4$, binders (latex), zircon, silica, dispersing agents, defoamers, and in case of longer shelf-times also preserving agents. This is followed by several other ceramic coatings until the desired thickness is achieved. After dewaxing the model with hot air, it is filled with super alloy in a vacuum kiln. The final step is a mechanical treatment of the finished material.

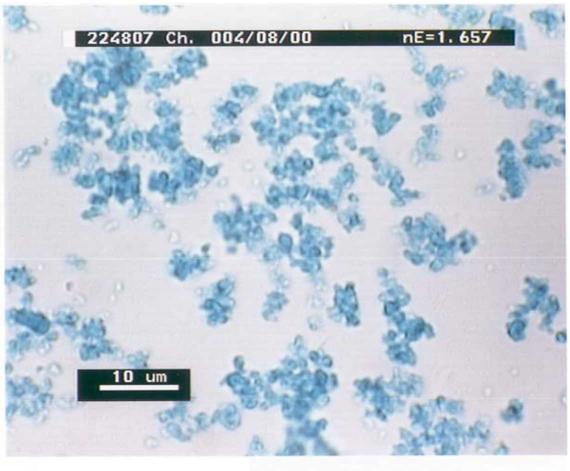
The quality of the $CoAl_2O_4$ coating has a fundamental significance for the surface of the casted product. It is very important to keep to the following parameters:

- maintain the pH value >9
- avoid too intense mixers (danger of gel formation)
- ensure constant control and correction of the rheology and the solids concentration
- store in a frost-protected location

Advantages

Cobalt aluminate ($CoAl_2O_4$) is the most frequently used inoculant in the investment casting process of superalloys. Besides this, also cobalt oxide (Co_3O_4) and cobalt silicate (Co_2SiO_4) are used. Although all these cobalt containing compounds work as nucleation agents, cobalt aluminate proved to be the most effective. In relation to the cobalt content, the needed quantities when using $CoAl_2O_4$ are lower compared to Co_2SiO_4 or Co_3O_4. Several other advantages are:

- constant, optimized grain size distribution (fine grains – small particle size distribution, Co_3O_4 has coarser grains and often inhomogenities)
- good dispersability in the slurry
- very low content of impurities (Ag, Bi, Pb)
- excellent cost-effectiveness due to only 33% cobalt content vs. 40% or more in cobalt oxide or cobalt silicate
- phase purity.



Microscopic picture of our product 224 807.

Table 1: Specification of our product 224 807

Metal content	Specification	Method
Co	33 ± 1 %	X-ray fluorescence analysis
Pb Bi Ag	< 60 ppm < 2 ppm < 5 ppm	leaching 1 g of sample with 10 ml HNO_3 + 10 ml H_2O + 5 ml HF for 1 h at 60 °C, analysis by AAS or ICP
Particle Size Distribution	**Specification**	**Method**
d_{10} d_{50} d_{90}	– 1.5 ± 0.5 µm < 6 µm	Device: Cilas 1064; Dispersion: 0.5 g powder + 0.5 ml dispersion agent/water (1:1)
Mineralogical Characterization (X-ray Diffraction)		
Phase	**Empirical Formula**	**Content (wt-%)**
Spinel	$CoAl_2O_4$	> 99
Corundum	Al_2O_3	< 1
Spinel	Co_3O_4	< 1

Our Service

Extensive research has proved that our cobalt aluminate meets the high demands of the industry. As the only supplier in central Europe, we developed our material in close Co-operation with one major manufacturer of investment cast turbine blades. Since several years, our product is successfully used.

Although our cobalt aluminate has the advantage of a cobalt content as low as 33%, we can also offer customized material with a higher or lower cobalt content.

Ferro - your partner for innovative products.