Arcam **EBM** systems

Arcam ASTM F75 CoCr

Arcam EBM
A GE Additive Company

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General characteristics

Arcam ASTM F75 CoCr is a non-magnetic Cobalt Chrome alloy exhibiting high temperature capability, strength, corrosion resistance, wear resistance as well as excellent biocompatibility. CoCr alloys are widely used within the orthopedics, aerospace, power generation and the dental fields.

Within orthopedics, CoCr alloys are typically used where high stiffness or a highly polished and extremely wear-resistant material is required for articulating surfaces. CoCr alloys are commonly used for applications such as knee implants, metal-on-metal hip joints and dental prosthetics. In all examples the components are heavily loaded and subject to both wear and fatigue.

CoCr alloys also play an important role for the performance of aero- and land-based gas turbines. CoCr is routinely used for demanding applications such as fuel nozzles in aero engines and guide vanes for industrial gas turbines.

CoCr has been used in demanding applications for as long as investment casting has been available as an industrial process. Arcam's Electron Beam Melting (EBM®) technology is a cost-efficient alternative to investment casting for production of CoCr parts with complex geometries.

The EBM process for Arcam ASTM F75 CoCr

In the Arcam Q10plus system the CoCr process runs at a powder bed temperature of ~850°C using a layer thickness of 70 µm. The chosen layer thickness enables both high build speed and high resolution, allowing cost-efficient production of press fit implants with advanced trabecular structures. The elevated powder bed temperature eliminates the need for stress-relieving and allows the building of parts in multiple layers in the Z-direction which further increases productivity.

EBM parts built with Arcam ASTM F75 CoCr requires hot isostatic pressing (HIP) but no heat treatment for homogenization or stress relieving. Parts built from Arcam ASTM F75 CoCr exhibit high strength, corrosion resistance and excellent wear resistance high strength, corrosion resistance, wear resistance and excellent biocompatibility which makes the alloy suitable for use in orthopedic and dental implants. In particular, it may be used for components requiring a highly polished, mirror-like finish such as femoral knee components, tibial trays, femoral stems and spinal disks.

Femoral knee components and tibia trays manufactured with Electron Beam Melting (EBM).

Powder characteristics

The Arcam ASTM F75 CoCr alloy powder for EBM is a spherical powder with low internal porosity and few satellites produced by gas atomization. The chemical composition complies with the ASTM F75 standard specification. The particle size distribution is 45–100 microns which ensures safe handling of the powder.

Material properties

CoCr built with the Arcam EBM technology fulfills the ASTM F75 standard with regards to both chemical composition as well as mechanical properties. The material demonstrates excellent strength and ductility.

Chemical Composition of Arcam ASTM F75 CoCr alloy powder

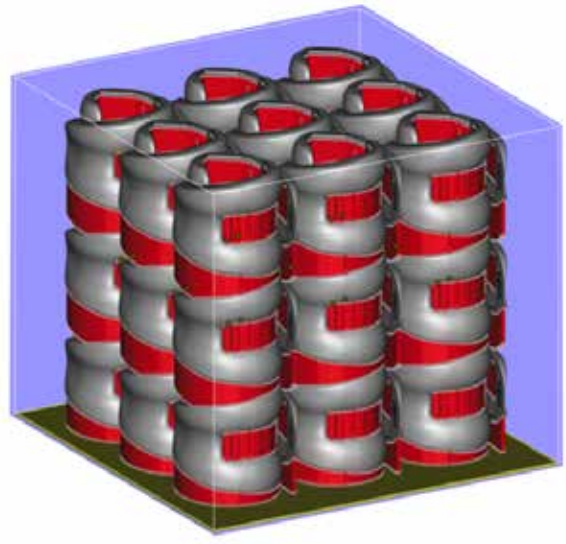
	Arcam ASTM F75*	ASTM F75 requirements
Aluminium, Al	<0,01%	<0,1%
Bor, B	<0,01%	<0,01%
Carbon, C	<0,020%	<0,35%
Cobalt, Co	Balance	Balance
Chromium, Cr	27-30%	27–30%
Iron, Fe	0,17%	<0,75%
Manganese, Mn	<1%	<1%
Molybdenum, Mo	5-7%	5–7%
Nitrogen, N	<0,05%	<0,25%
Nickel, Ni	<0,2%	<0,5%
Phosphorous, P	<0,02%	<0,02%
Sulphur, S	<0,01%	<0,01%
Silicone, Si	<0,1%	<1%
Titanium, Ti	<0,01%	<0,1%
Tungsten, W	<0,2%	<0,2%

*Typical

Chemical Composition of as-EBM material

	Arcam ASTM F75*	ASTM F75 requirements
Aluminium, Al	<0,01%	<0,1%
Bor, B	<0,01%	<0,01%
Carbon, C	<0,010%	<0,35%
Cobalt, Co	Balance	Balance
Chromium, Cr	27,7%	27–30%
Iron, Fe	0,17%	<0,75%
Manganese, Mn	0,56%	<1%
Molybdenum, Mo	5,68%	5–7%
Nitrogen, N	0,031%	<0,25%
Nickel, Ni	0,07%	<0,5%
Phosphorous, P	<0,005%	<0,02%
Sulphur, S	<0,003%	<0,01%
Silicone, Si	0,31%	<1%
Titanium, Ti	<0,01%	<0,1%
Tungsten, W	<0,01%	<0,2%

*Typical



High productivity of the Q10plus build tray highlighting a stacked CoCr femoral knee build.

Mechanical Properties

	Arcam ASTM F75 CoCr	ASTM F75 requirements
Tensile Strength, Ultimate	1050 (±13) MPa 152’000 (±2’000) psi	655 MPa 95’000 psi
Tensile Strength, Yield	600 (±13) Mpa 87’000 (±2’000) psi	450 MPa 65’000 psi
Elongation at Break	20% (±3%)	>8%
Reduction of Area	20% (±2%)	>8%

Post Processing

Following support structure and powder removal, it is recommended that the parts undergo hot isostatic pressing (HIP) with the following parameters:

— 1200 °C
— 1000 bar argon
— 240 minutes
— Free cooling rate

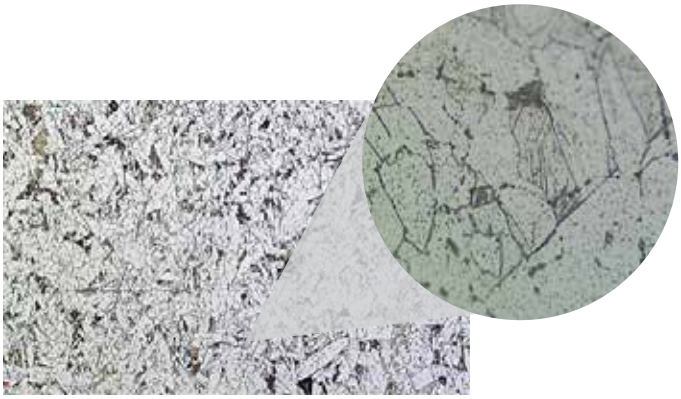
Machining

Parts produced using the Arcam EBM process demonstrate excellent machineability using any conventional machining process.

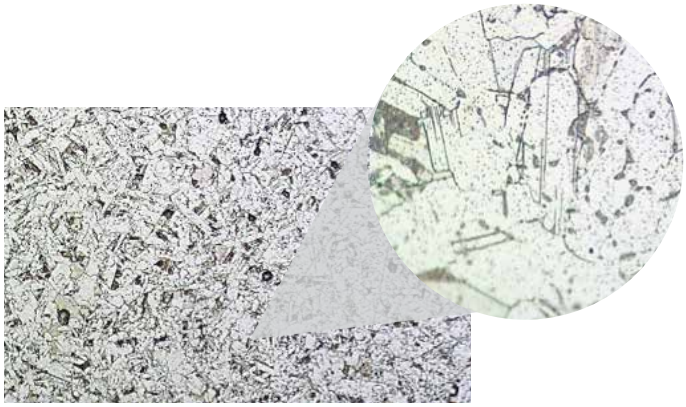
The EBM built material allow polishing to mirror-like finish for use as articulating surfaces in knee implants or other applications requiring superior surface finish.

Microstructure

Manufacturing CoCr parts with EBM results in fully dense parts without weld lines in the material before or after HIP treatment. The images show the typical microstructure after HIP treatment with different magnification. There is no porosity in both the horizontal and vertical cross sections.



Horizontal cross section at 50x and 500x magnification



Vertical cross section at 50x and 500x magnification

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Arcam provides cost-efficient Additive Manufacturing solutions for production of metal components. Arcam's EBM® technology offers freedom in design combined with excellent material properties and high productivity. Arcam is an innovative partner for manufacturing in the orthopedic implant and aerospace industries, where we deliver customer value through our competence and solution orientation.