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CobaltChrome MP1

CobaltChrome MP1 is a cobalt-chrome-molybdenum-based superalloy powder.
This document provides information and data for parts built using CobaltChrome MP1 powder.

Description

Parts built from CobaltChrome MP1 conform to the chemical composition UNS R31538 of high carbon CoCrMo alloy. They are nickel-free (< 0.1 % nickel content) and are characterized by a fine, uniform crystal grain structure. As built CobaltChrome MP1 meets the chemical and mechanical specifications of ISO 5832-4 and ASTM F75 for cast CoCrMo implant alloys, as well as the specifications of ISO 5832-12 and ASTM F1537 for wrought CoCrMo implants alloys except remaining elongation. The remaining elongation can be increased to fulfil even these standards by high temperature stress relieving or hot isostatic pressing (HIP).
Parts made from CobaltChrome MP1 can be machined, spark-eroded, welded, micro shotpeened, polished and coated if required. They are suitable for biomedical applications (note: subject to fulfilment of statutory validation requirements where appropriate), and for parts requiring high mechanical properties in elevated temperatures (500 - 1000 °C) and with good corrosion resistance. Due to the layerwise building method, the parts have a certain anisotropy, which can be reduced or removed by appropriate heat treatment.

Technical data

General process and geometrical data

Typical achievable part accuracy [1]	
- Small parts	approx. ± 20 – 50 µm approx. ± 0.8 – 2 x 10^{-3} inch
- Large parts	approx. ± 50 – 200 µm approx. ± 2 – 8 x 10^{-3} inch
Smallest wall thickness [2]	approx. 0.3 mm approx. 0.012 inch
Surface roughness [3]	
- as build MP1 Surface (20 µm)	Ra 4 - 10 µm; Rz 20 - 40 µm Ra 0.16 – 0.39 x 10-³ inch, Rz 0.79 – 1.57 x 10-³ inch
MP1 Performance (40 µm)	Ra 7 - 10 µm; Rz 35 - 50 µm Ra 0.31 – 0.47 x 10-³ inch, Rz 1.49 – 1.96 x 10-³ inch
MP1 Speed (50 µm)	Ra 8 - 12 µm; Rz 38 - 50 µm Ra 0.31 – 0.47 x 10-³ inch, Rz 1.49 – 1.96 x 10-³ inch
- after polishing	Rz up to < 1 µm Rz up to < 0.04 x 10-³ inch

Volume rate [4] - Parameter set MP1_Surface 1.0 / default job CC20_MP1_020_default.job (20 µm layer thickness)	1.6 mm³/s (5.1 cm³/h) 0.35 in³/h
- Parameter set MP1_Performance 1.0 / default job CC20_MP1_040_default.job (40 µm layer thickness)	3.2 mm³/s (11.5 cm³/h) 0.70 in³/h
- Parameter set MP1_Performance 1.0 for M 280 / 400 W (40 µm layer thickness)	4.2 mm³/s (15.1 cm³/h) 0.92 in³/h
- Parameter set MP1_Speed 1.0 / for M 280 / 400 W (50 µm layer thickness)	5.5 mm³/s (19.8 cm³/h) 1.21 in³/h

[1] Based on users' experience of dimensional accuracy for typical geometries, e.g. ± 20 µm (0.8×10^{-3} inch) when parameters can be optimized for a certain class of parts or ± 50 µm (2×10^{-3} inch) when building a new kind of geometry for the first time. For larger parts the accuracy can be improved by post-process stress relieving at 1150 °C (2100 °F) for 6 hours. Part accuracy is subject to appropriate data preparation and postprocessing.
[2] Mechanical stability is dependent on geometry (wall height etc.) and application
[3] Due to the layerwise building, the surface structure depends strongly on the orientation of the surface, for example sloping and curved surfaces exhibit a stair-step effect. The values also depend on the measurement method used. The values quoted here given an indication of what can be expected for horizontal (up-facing) or vertical surfaces.
[4] Volume rate is a measure of build speed during laser exposure. The total build speed depends on the average volume rate, the recoating time (related to number of layers) and other factors such as DMLS-Start settings.

Physical and chemical properties of the parts	
Material composition	Co (60 - 65 wt-%) Cr (26 - 30 wt-%) Mo (5 - 7 wt-%) Si (≤ 1.0 wt-%) Mn (≤ 1.0 wt-%) Fe (≤ 0.75 wt-%) C (≤ 0.16 wt-%) Ni (≤ 0.10 wt-%)
Relative density	approx. 100 %
Density	approx. 8.3 g/cm³ approx. 0.30 lb/in³

Mechanical properties of the parts		
	As built	Stress relieved [5]
Tensile strength [6]		
- in horizontal direction (XY)	1350 ± 100 MPa 196 ± 15 ksi	1100 ± 100 MPa 160 ± 15 ksi
- in vertical direction (Z)	1200 ± 150 MPa 174 ± 22 ksi	1100 ± 100 MPa 160 ± 15 ksi
Yield strength (Rp 0.2 %) [6]		
- in horizontal direction (XY)	1060 ± 100 MPa 154 ± 15 ksi	600 ± 50 MPa 87 ± 7 ksi
- in vertical direction (Z)	800 ± 100 MPa 116 ± 15 ksi	600 ± 50 MPa 87 ± 7 ksi
Elongation at break [6]		
- in horizontal direction (XY)	(11 ± 3) %	min. 20 %
- in vertical direction (Z)	(24 ± 4) %	min. 20 %
Modulus of elasticity		
- in horizontal direction (XY)	200 ± 20 GPa 29 ± 3 Msi	200 ± 20 GPa 29 ± 3 Msi
- in vertical direction (Z)	190 ± 20 GPa 28 ± 3 Msi	200 ± 20 GPa 29 ± 3 Msi
Hardness [6]	approx. 35 - 45 HRC	
Fatigue strength [7]		
- max. stress to reach 10 million cycles	approx. 560 MPa, 81 ksi	
- max. stress to reach 1 million cycles	approx. 660 MPa, 96 ksi	

[5] High temperature stress relieved, 6 hours at 1150 °C (2100 °F) under inert argon atmosphere
[6] Tensile testing according to ISO 6892-1:2009 (B) Annex D, proportional test pieces, diameter of the neck area 5mm (0.2 inch), original gauge length 25mm (1 inch).
[7] Testing according to ASTM E466:1996, using vertical samples, as built, under 250 MPa (36.3 ksi) stress amplitude and 44 Hz testing frequency
[8] Rockwell C (HRC) hardness measurement according to EN ISO 6508-1 on polished surface. Note that measured hardness can vary significantly depending on how the specimen has been prepared.

Thermal properties of parts	
	As built
Coefficient of thermal expansion	
- over 20 - 500 °C (68 - 932 °F)	typ. 13.6×10^{-6} m/m °C typ. 7.6×10^{-6} in/in °F
- over 500 – 1000 °C (932-1832 °F)	typ. 15.1×10^{-6} m/m °C typ. 8.4×10^{-6} in/in °F
Thermal conductivity (at 20 °C)	
- at 20°C (68°F)	typ. 13 W/m °C typ. 90 Btu in/(h ft² °F)
- at 300 °C (572 °F)	typ. 18 W/m °C typ. 125 Btu in/(h ft² °F)
- at 500 °C (932 °F)	typ. 22 W/m °C typ. 153 Btu in/(h ft² °F)
- at 1000 °C (1832 °F)	typ. 33 W/m °C typ. 229 Btu in/(h ft² °F)
Maximum operating temperature	approx. 1150 °C approx. 2100 °F
Melting range	1350 - 1430 °C 2460 - 2600 °F

Notes

The data are valid for the combinations of powder material, machine and parameter sets referred to on page 1, when used in accordance with the relevant Operating Instructions (including Installation Requirements and Maintenance) and Parameter Sheet. Part properties are measured using defined test procedures. Further details of the test procedures are available on request. Unless otherwise specified, the data refer to the parameter set MP1_Surface 1.0 or the equivalent default job CC20_MP1_020_default.job. The corresponding data for the parameter set MP1_Performance 1.0 or the equivalent default job CC20_MP1_040_default.job are approximately the same except where otherwise specified.
The data correspond to our knowledge and experience at the time of publication. They do not on their own provide a sufficient basis for designing parts. Neither do they provide any agreement or guarantee about the specific properties of a part or the suitability of a part for a specific application. The producer or the purchaser of a part is responsible for checking the properties and the suitability of a part for a particular application. This also applies regarding any rights of protection as well as laws and regulations. The data are subject to change without notice.