BAKER INDUSTRIES

Cobalt-Chrome MP1

MATERIAL DATA SHEET

Parts made from Cobalt-Chrome MP1 can be machined, spark-eroded, welded, micro shot-peened, polished and coated if required. They are suitable for biomedical applications (note: subject to fulfillment 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 layer-wise building method, the parts have a certain anisotropy, which can be reduced or removed by appropriate heat treatment

General process data

Typical achievable part accuracy [1] [2] *- small parts*	approx. ± 20 – 50 µm approx. ± 0.8 – 2 x 10^{-3} inch
Typical achievable part accuracy [1] [2] *- large parts*	approx. ± 50 – 200 µm approx. ± 2 – 8 x 10^{-3} inch
Minimum wall thickness [1] [3]	approx. 0.3 mm approx. 0.012 inch
Surface roughness [3] , as built: *- 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 0.28 - 0.39 x 10-^{3} inch Rz 1.37 – 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 < 1µm 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 / 400W (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

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Physical & Chemical properties of parts

Material composition	Co (60 - 65 wt-%)	Si (≤ 1.0 wt-%)	C (≤ 0.16 wt-%)
	Cr (26 - 30 wt-%)	Mn (≤ 1.0 wt-%)	Ni (≤ 0.10 wt-%)
	Mo (5 - 7 wt-%)	Fe (≤ 0.75 wt-%)	
Relative density	approx. 100 %		
Density	approx. 8.3 g/cm^3 approx. 0.30 lb/in^3		

Mechanical properties of parts T 20 °C (68 °F) - as built

	Horizontal Axis (XY)	*Vertical Axis (Z)*
Tensile Strength [6]	1350 ± 100 MPa 196 ± 15 ksi	1200 ± 150 MPa 174 ± 22 ksi
Yield strength (Rp 0.2 %) [6]	1060 ± 100 MPa 154 ± 15 ksi	800 ± 100 MPa 116 ± 15 ksi
Modulus of elasticity	200 ± 20 GPa 29 ± 3 Msi	190 ± 20 GPa 128 ± 3 Msi
Elongation at break [6]	(11± 3) %	(24 ± 4) %
Fatigue life [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	
Hardness [8]	approx. 35 - 45 HRC	

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Mechanical properties of parts T 20 °C (68 °F) - stress relieved[5]

	Horizontal Axis (XY)	*Vertical Axis (Z)*
Tensile Strength [6]	1100 ± 100 MPa 160 ± 15 ksi	1100 ± 100 MPa 160 ± 15 ksi
Yield strength (Rp 0.2 %) [6]	600 ± 50 MPa 87 ± 7 ksi	600 ± 50 MPa 87 ± 7 ksi
Modulus of elasticity	200 ± 20 GPa 29 ± 3 Msi	200 ± 20 GPa 29 ± 3 Msi
Elongation at break [6]	min. 20 %	min. 20 %
Fatigue life [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	
Hardness [8]	approx. 35 - 45 HRC	

Thermal properties of parts - as built

Coefficient of thermal expansion - *over 20 - 500 °C (68 - 932 °F)*	typ. 13.6 x 10^{-6} m/m °C typ. 7.6 x 10^{-6} in/in °F
- *over 500 – 1000 °C (932 - 1832 °F)*	typ. 15.1 x 10^{-6} m/m °C typ. 8.4 x 10^{-6} in/in °F
Thermal conductivity - *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

[1] Based on users' experience of dimensional accuracy for typical geometries, e.g. ± 20 µm (0.8 x 10 $^{-3}$ inch) when parameters can be optimized for a certain class of parts or ± 50 µm (2 x 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 post-processing, in accordance with EOS training.

[2] Mechanical stability is dependent on geometry (wall height etc.) and application.

[3] Due to the layer-wise 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 re-coating time (related to number of layers) and other factors such as DMLS-Start settings.

[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.