材料详情表
Materialdatenblatt
Material Data Sheet

工具钢 1.2709 / A646 / M300 [1]

概述

工具钢以及不锈钢制成的零件以高硬度和优秀的延展性著称。一般来说，合金材料的性能可以通过改变合金的构成成分来进行相当准确的调整。这意味着即便是耐蚀不锈钢如316L（1.4404）也可以通过SLM的工艺来处理。耐蚀不锈钢主要被应用于医疗、汽车工业以及航空航天工程等领域，工具钢则主要应用于工具、模具的制造方面。工具钢的成层结构让它可以应用于集成冷却管道。工具钢和不锈钢具备的良好机械特性使它们可以应用于强应力的场合；通过表面硬化处理或凭借其本身优秀的耐磨损性能可将磨耗控制在最低限度。钢材可以在较高的工作温度下使用，可减少对工具的磨损。

General

Components made from tool or stainless steels are known for great hardness with a high ductility. Through selective application of alloying components, the material properties can be precisely adjusted. This means that even corrosion-resistant steel alloys like 316L (1.4404) can be treated using the SLM process. Applications for corrosion resistant alloys are found in medical technologies, the automotive industry as well as in aerospace engineering. Tool steel is mainly used to produce tools and molds, and its layered structure enables components to be fitted with integrated cooling canals. The good mechanical characteristic values of tool and stainless steel make it suitable for use in places that are exposed to heavy strain, because its high resistance to wear and tear or surface hardening keep abrasion to a minimum. Steel can also be used at high operating temperatures which reduces the amount of wear and tear on the tools.

材料结构

经过SLM工艺处理的钢合金零件展现出各向同性、近乎无孔的结构，因此其机械特性可以参考概述中对于工具钢和不锈钢的性能描述。同时，如有对零件性能的特殊要求，也可以通过硬化、热处理或热等静压（HIP）等后处理来实现。

Material Structure

Following the SLM-process, steel components exhibit a homogeneous, nearly poreless texture, whereby the mechanical characteristic values lie within the range of the material specifications. Through subsequent post treatment, such as hardening, heat treatment or hot isostatic pressing (HIP), the components' properties can be adapted to meet specific requirements. In the SLM process with 1.2709 theoretical build-up rates of 10,4 cm³/h (layer thickness 30 µm), 13,0 cm³/h (layer thickness 40 µm), and 15,6 cm³/h (layer thickness 50 µm) are achieved.

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物理/化学 性质
Physical and Chemical Properties

材料密度 *Material Density*	8,042 g/cm³		
20 °C时的导热性系数 Thermal Conductivity at 20 °C	14,2 W/mK		
打印零件密度 *Build Part Density[2]*	层厚 *Layer Thickness*	30 µm[3] ≈ 99,5 %	40 µm[4] ≈ 99,5 %	50 µm[5] ≈ 99 %

化学成分 (wt%)[6]
Chemical Composition (wt%)[6]

Element *Element*	**Min.** *Min.*	**Max.** *Max.*
Fe	Balance	Balance
Ni	18,00	19,00
Co	8,50	9,50
Mo	4,70	5,20
Ti	0,50	0,80
Al	0,05	0,15
Mn	-	0,10
Si	-	0,10
P	-	0,01
S	-	0,01
C	-	0,03

颗粒大小分布（范围） *Particle Size Distribution[6]*	10 – 45 µm *10 – 45 µm*
晶粒形状[7] *Grain Shape[7]*	球状 *Spherical*

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机械特性
Mechanical Data

层厚 30 µm[3] *Layer Thickness 30 µm[3]*			打印件 *As-built*	经后处理件[11] *After Heat Treatment[11]*
拉伸强度[8] *Tensile Strength[8]*	R_m [MPa]	Horizontal	1149 ± 25	1789 ± 355
		Vertical	1017 ± 178	1440 ± 329
		Diagonal	1050 ± 148	1717 ± 520
屈服强度[8] *Yield Strength[8]*	R_e [MPa]	Horizontal	992 ± 32	1955 ± 62
		Vertical	975 ± 31	1980 ± 0
		Diagonal	890 ± 45	2066 ± 8
断裂伸长率[8] *Elongation at Break[8]*	A [%]	Horizontal	9 ± 3	3 ± 1
		Vertical	6 ± 3	-
		Diagonal	12 ± 0	-
断面收缩率[8] *Contraction at Fracture[8]*	Z [%]	Horizontal	28 ± 18	5 ± 0
		Vertical	34 ± 5	-
		Diagonal	50 ± 6	-
弹性模量[8] *Young's modulus[8]*	E [GPa]	Horizontal	182 ± 42	192 ± 23
		Vertical	179 ± 42	155 ± 15
		Diagonal	205 ± 38	187 ± 9
维氏硬度[9] *Vickers Hardness[9]*	[HV10]		354 ± 8	-
平均粗糙度[10] *Mean Roughness Index[10]*	R_a [µm]		7 ± 1	-
平均表面粗糙度[10] *Average Surface Roughness[10]*	R_z [µm]		46 ± 5	-

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机械特性
Mechanical Data

层厚 40 µm[4] *Layer Thickness 40 µm[4]*			打印件 *As-built*	经后处理件[11] *After Heat Treatment[11]*
拉伸强度[8] *Tensile Strength[8]*	R_m [MPa]	Horizontal	1176 ± 19	1680 ± 272
		Vertical	1151 ± 26	1946 ± 109
		Diagonal	1160 ± 11	1688 ± 11
屈服强度[8] *Yield Strength[8]*	R_e [MPa]	Horizontal	975 ± 54	1822 ± 207
		Vertical	1002 ± 33	1876 ± 170
		Diagonal	1010 ± 40	2059 ± 40
断裂伸长率[8] *Elongation at Break[8]*	A [%]	Horizontal	13 ± 1	3 ± 2
		Vertical	11 ± 4	4 ± 2
		Diagonal	12 ± 1	4 ± 1
断面收缩率[8] *Contraction at Fracture[8]*	Z [%]	Horizontal	53 ± 7	16 ± 3
		Vertical	57 ± 3	11 ± 3
		Diagonal	54 ± 2	10 ± 2
弹性模量[8] *Young's modulus[8]*	E [GPa]	Horizontal	132 ± 12	144 ± 11
		Vertical	110 ± 9	159 ± 9
		Diagonal	101 ± 9	158 ± 18
维氏硬度[9] *Vickers Hardness[9]*	[HV10]		344 ± 14	-
平均粗糙度[10] *Mean Roughness Index[10]*	R_a [µm]		7 ± 1	-
平均表面粗糙度[10] *Average Surface Roughness[10]*	R_z [µm]		52 ± 9	-

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机械特性
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层厚 50 µm[5] *Layer Thickness 50 µm[5]*			打印件 *As-built*	经后处理件[11] *After Heat Treatment[11]*
拉伸强度[8] *Tensile Strength[8]*	R_m [MPa]	Horizontal	1125 ± 42	1205 ± 517
		Vertical	967 ± 167	1814 ± 241
		Diagonal	1135 ± 29	1784 ± 313
屈服强度[8] *Yield Strength[8]*	R_e [MPa]	Horizontal	970 ± 28	1799 ± 5
		Vertical	894 ± 58	1803 ± 88
		Diagonal	987 ± 15	1920 ± 12
断裂伸长率[8] *Elongation at Break[8]*	A [%]	Horizontal	8 ± 3	5 ± 0
		Vertical	7 ± 3	4 ± 1
		Diagonal	11 ± 1	3 ± 1
断面收缩率[8] *Contraction at Fracture[8]*	Z [%]	Horizontal	26 ± 20	7 ± 0
		Vertical	30 ± 17	11 ± 2
		Diagonal	44 ± 2	10 ± 0
弹性模量[8] *Young's modulus[8]*	E [GPa]	Horizontal	125 ± 26	116 ± 28
		Vertical	111 ± 10	165 ± 7
		Diagonal	113 ± 8	125 ± 5
维氏硬度[9] *Vickers Hardness[9]*	[HV10]		373 ± 2	
平均粗糙度[10] *Mean Roughness Index[10]*	R_a [µm]		9 ± 1	-
平均表面粗糙度[10] *Average Surface Roughness[10]*	R_z [µm]		67 ± 5	-

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本表中的测试性能与机械特性的粉末是由SLM Solutions测试及销售的，测试是在使用SLM Solutions提供的参数和机器的情况下，根据适当的操作指令（包括机器状况和维护）进行的。零件的性能是严格实验的结果，如需了解更多细节可以与SLM Solutions沟通询问。
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The properties and mechanical characteristics apply to powder that is tested and sold by SLM Solutions, and that has been processed on SLM Solutions machines using the original SLM Solutions parameters in compliance with the applicable operating instructions (including installation conditions and maintenance). The part properties are determined on the basis of specified procedures. More details about the procedures used by SLM Solutions are available upon request.
The specifications correspond to the most recent knowledge and experience available to us at the time of publication and do not themselves form a sufficient basis for component design. Certain properties of products or parts or the suitability of products or parts for specific applications are not guaranteed. The manufacturer of the products or parts is responsible for the qualified verification of the properties and their suitability for specific applications. The manufacturer of the products or parts is responsible for protecting any third-party proprietary rights as well as existing laws and regulations.

SLM Solutions Group AG
Materialentwicklung / Material Development
Lübeck, den 08.02.2017

[1] Material gemäß ASTM A646 / *Material according to ASTM A646.*

[2] Optische Dichtebestimmung mittels Lichtmikroskopie. / *Optical density determination by light microscopy.*

[3] Materialdatei / *Material data file:* 1.2709_SLM_MBP2.2_30_FS_Stripes_T100_400W_V5103

[4] Materialdatei / *Material data file:* 1.2709_SLM_MBP2.2_40_Stripes_T100_400W_V5101

[5] Materialdatei / *Material data file:* 1.2709_SLM_MBP2.2_50_Stripes_T100_400W_V5103

[6] Bzgl. pulverförmigen Ausgangsmaterial. / *With respect to powder material.*

[7] Gemäß DIN EN ISO 3252. / *According DIN EN ISO 3252.*

[8] Zugprüfung gemäß ISO 6892-1: 2009 B (DIN 50125 – B6x30); Ausrichtung: 0° und 90°; Wärmebehandlung: keine; Prüfmaschine: Zwick 1484; Lastbereich: 200 kN; Prüfgeschwindigkeit 0,008 1/s; Prüftemperatur: Raumtemperatur; Prüflabor: EWIS GmbH. Die Proben sind vor dem Zugversuch abgedreht worden. / *Tensile test according to ISO 6892-1: 2009 B (DIN 50125 – B6x30); Orientation: 0° und 90°; Heat treatment: None; Testing machine: Zwick 1484; Load range: 200 kN; Testing speed: 0,008 1/s; Testing temperature: room temperature; Test laboratory: EWIS GmbH. Test samples were turned before Tensile test.*

[9] Härteprüfung gemäß DIN EN ISO 6507-1. / *Hardness testing according to DIN EN ISO 6507-1.*

[10] Rauheitsmessung gemäß DIN EN ISO 4288: 1998; λc = 0,8 mm. / *Roughness Measurement according to DIN EN ISO 4288: 1998; λc = 0,8 mm.*

[11] Wärmebehandlung: Auslagern bei 500°C, 6h; Abkühlung an Luft / Heat Treatment: Aging: 500°C, 6h; Cooling in air.

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