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EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC MECHATRONIC SYSTEMS - EMERALD

Intellectual Output_O2: EMERALD e-toolkit manual for digital learning in producing biomimetic mechatronic systems

Toolkit 4 Materials

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EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC MECHATRONIC SYSTEMS - EMERALD

EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC MECHATRONIC SYSTEMS

E-toolkit – New materials used

for the developed biomimetic mechatronic systems

	Envences actively for 2D anisting of biomimatic
	European network for 5D printing of biomimetic
Project Title	mechatronic systems
	21-COP-0019
Output	IO2 - EMERALD e-toolkit manual for digital learning in
Output	producing biomimetic manufacturing method
Madula	Database used for the smart (intelligent) materials
Module	properties
Date of Delivery	January 2023
Authors	Diana BĂILĂ, PUB
Version	FINAL VARIANT, *27.01.2023*

https://project-emerald.eu

Total Materia used for determination of the materials properties

1. Quick search for alloys	3.
2. Advanced research for alloys	8.
3. Algorithms used for identification the unknown metals	.15.
4. Advanced research for polymers, ceramics and composite materials	.18.
5. Conclusions	.23.

ferences











Total Materia used for determination of the materials properties.

Total Materia is the world's most comprehensive materials database, having more than 20,000,000 property records for over 450,000 metallic and non-metallic materials presented in 26 languages.

This database is world class quality, service and support, being trusted in over 160 countries, the smallest companies to global industry leaders all receive our complete specialist technical support.



Fig.1. Total Materia database









Total Materia used for determination of the materials properties.

Total Materia database help solve diverse engineering challenges from the simplest to the

complex, being used in: medicine industry, aerospace industry, energy industry, automotive

industry, machinery industry, engineering industry, diversified. By example, for the alloy Ti6Al4 V, we want to know the chemical composition and the

mechanical properties, and we click on Advanced Search, as in the Figure 2.

	Advanced Search	SmartComp	Suppliers	Extended Range	Standard List	Order Now
Advanced	Search					
Designation, Sta	ndard					
Material		Standard Numb	er	Submit	Clear	
Group of Materials		Standard Desc	iption			
- All	~					
Country/Standard						
- / Approval	~					
— Full Text Search						
Search for						
		,				
		"				

Fig.2. Advanced Search











In the figure 3, it is presented the choice of the standard in function of the country and group of materials.

It was choosing the alloy Ti6Al4V, making part of Titanium materials and was choose European Union standard, as in Figure 3. It must specify the material type, as example Bulk Materials, in Figure 4.

The World's Most	Comprehensive METALS Data	hann			The select cangings	Stibboul C Log ora
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Designation, Sta Material	ndard	Standard Numbe	pr	Submit	Clear	
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Designation, Sta Material Tr6Al4V Group of Materials - Titanium	ndard	Standard Number	ption	Submit	Clear	
Designation, Sta Material Tr6AHV Group of Materials - Titanium Country/Standard	ndard	Standard Number	ption	Submit	Clear	

Fig.3. European Union standard choice



Fig.4. Material type









In figure 5, it is specifying the material group and in this case, nonferrous alloys and European standard choice, as in figure 6.

When we give a quick search, as in figure 7, are presented different Ti6Al4V producers from different countries and using different standards.

	European emerit e
Q Search	EU
	Finland
Ferrous Alloys	SFS
Polymers	France
Ceramics	AFCEN
Composites	AFNOR NF
Fibers	
Cements	
Honeycombs	
Foams	Germany
Wood	DIN

	Lini Iotal Materia				Metric	Imperial Units	e Inna Biela	English -	Logout
	TOTAL SEAMCH	ELLENDED RANKE		COMMITANCS BINATISAE	(A)	EXACULTER (C)	(P) TRACKER		
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If you Result	u would like to view more possible mat t(s) found: 21 MATERIAL	tches for your search, please <u>clic</u> STANDARD	ck here.	COUNTRY	/ PRODUCER		CLASSI	PRATION	HILLICA 4- Followall I
If you Result Result	u would like to view more possible mat tisi found: 21 MATERIAL MIM-TIGA14V-600	tches for your search, please <u>clic</u> standard Afnor NF	ck here.	COUNTRY	/ PRODUCER		CLASS! Ferrous	FECATION Alloys / Sintered pr	ninian (- nameni n
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Fig.7. Different Ti6Al4V producers







The results it is the mechanical properties of the alloy Ti6Al4V, conforming of FR AFNOR NF standard, as in figure 8 and figure 9.

In figure 9, the database gives us all information about the mechanical properties of the alloy Ti6Al4V in function of the temperature used in the process where it is used this material.

In figure 10, the database shows us the chemical composition of the alloy Ti6Al4V.

1IM-Ti6Al4V-600) ☆		=+ 🖪 🖈
Country/Standard France / AFNOR NF Material group Ferrous Alloys / Sinte	red powdered metals		
MECHANICAL PROPERTIES	IN PHYSICAL PROPERTIES	CROSS REFERENCING	TRACKER
Yield Strength, Rp0.2 ≥ 600 MPa Tensile Strength ≥ 800 MPa Congetion, A ≥ 3 %	Density 4.2 kg/dm ²	20 0 0 Alt official Other	Last update 2019-08 Composition

Fig.8. Ti6Al4V standard Fr AFNOR NF-Mechanical properties



Fig.9. Mechanical properties Ti6Al4V at the temperature between 0-30°C

SELECTED REPEREN	VCE				
EN 150 22068: 2	014/Sintered-restal injec	tion-modded enterials	Specifications		
GERENA	VALE	6927	NOTE	CAS WARRED	CREDICAL KNOP MARE REALS CONFLICT MEMORAL
AL	5.0 - 7.0			3425.39.3	
c	163			2440-44-0	
н	104			7725-37-0.37778-88-0	
0	153	-16		2702-04-5-27739-08-2	
Other total	12.0	-16			
П			sations.	2642-32-6	sized
v	3.0 - 5.0	. 64		2550,62,2	United

Fig.10. Chemical composition of Ti6Al4V





2. Total Materia database – Advanced Research for alloys

In the case of Advanced Research, by example for the Ti6Al4V, producer Vday Additive Manufacturing Technology Co., it is given the classification of different Ti alloys producers, as in figure 11.

In the figure 12, are presented the mechanical properties of Ti6Al4V used in Additive Manufacturing, for different temperature domains.

	000 found: 3/64			Ø
×.	HATERIAL	STANDARD	COUNTRY / PRODUCER	CLASSIFICATION
	TIGAI4V	PROPRIETARY	Vdey Additive Manufacturing Technology Co., Lto:; 3T Additive Ma	Notlerrous Alloys / Titania 30 Materiais
z	TI-6AI-4V	APNOB MP	Plance	noeferrous Alloys / Titari
3	TI-6AI-4V	48	Australia	Nonferrous Alloys / Titani
¢.,	TI-6Al-4V	ADRO	Romania	nueferrous Alloys / Titar
5	TI-6AI-4V	8.5	United Kingdom	Nonlerroux Alloys / Titer
5	TI-6AI-4V	805	Dulgeria	Norferrous Alloys / Titari
7	TI-6AI-4V	CSN	Casch Republic	Nonfertoux Alloys / Titar
1	TI-6AI-4V	DEV	Gennany	Nonferrous Alloys / Titan
	Ti-6Al-4V	EN	European Unice	Nonferrous Alloys / Titan
10	TI-6AI-4V	OB	china	spelerous plots / titer



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Fig.12. Mechanical properties of Ti6Al4V used in Additive Manufacturing





2. Total Materia database – Advanced Research for alloys

The chemical composition of Ti6Al4V used in Additive Manufacturing is given in the figure 13. In the figure 14, the physical properties of Ti6Al4V used in Additive Manufacturing, for different temperature domains.

ILT LILITELS					
T Additive Monufa	cturing Ltd. Product Data Sheets / Available	at: www.3t-am.com, visited 2019			
Arcam All, Product I	Data Sheets / Available at: www.arcam.com	, visited 2016			
Digital Metal, Produ	ct Data Sheeta / Available at! www.digitalm	etal.tech, visited 2021			
Heraeus Additive Pr	enuflecturing GmbH, Product Data Sheets / J	Available st: www.heraeus.com, visit	ed 2020		
Maltio, Product Data	a Sheets / Available at: https://meltic3id.com	n/, visited 2022			
) Shanghai Research:	Institute of Material, Product Data Sheet / A	weilable att www.arim.com.cn. visite	d 2022		
SELECTED REFEREN	Œ				
31 M2010/VE Martun	acturing city, Product Data Shoets / W	variable al. www.sr-amccom, vis	1000 2019		
CRITERIA	wate	UNET	NUTE	CAS NUMBER	CRITICAL RAW MATERIALS CONFLICT MIMERIALS
CRITERIA Al	19410F 5.59-5.75	UNET %	NOTE	CAS MUMBER 7429-92-5	CRETICAL RAW MATERIALS CONFLICT MIMERALS
carreata Al C	194102 5.50 - 6.75 5.00	UNIT SS SS	NOTE	CAS MUMIER 2420-52-5 7540-54-5	CETTLOAL DRW MATERIALS CONFLICT MINERALS
carreata Al C Ee	wuur 5.50 - 6.75 4 0.50 4 0.3	UNIT TS TS TS	NUTE .	CAL KUMER 7459-55.5 7440-54.5 7448-54.5	CERTICAL RAW MATERIALS COPULAT MINERALS
oriteria Al C E E E E E E	98000 5.50 - 5.73 9.050 #0.3 #0.915	UMET TS TS TS TS TS	NOTE	CAS MUMER 7425-95-6 7460-94-6 2428-95-6 1438-76-8	CETTICK: BRW MATERIALS COPPLET MINERALS
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Carreata Alí C Ese H N Q Zí	9404 6.089-6.79 6.08 6.03 6.055 6.05 6.02	0467 55 55 55 55 55	NUT .	CATHOMER 2828-894 2828-894 2828-894 2828-894 2828-894 2828-894 2828-894 2869-284 2869-284	CETTOR INFORMATIONS CONTRACT MINERALS CONTRACT MINERALS CONTRACT MINERALS CONTRACT C

Fig.13. Chemical composition of Ti6Al4V used in Additive Manufacturing

TEMPERATURE	PROPER	TY / VALUE
□ > 300°C	MODULUS OF ELASTICITY	100 — 124 GPa
□ 100-300°C	DENSITY	≥ 2.5 kg/dm²
30-100°C	COEFFICIENT OF THERMAL EXPANSION (CTE)	7.6 - 7.9 10 ⁻⁶ /°C
< 0°C	MELTING TEMPERATURE	1600 - 1750 °C
•		

Fig.14. Physical properties of Ti6Al4V used in Additive Manufacturing





2. Total Materia database – Advanced Research for alloys

The database gives us details concerning the heat treatment used for the alloy Ti6Al4V used in Additive Manufacturing.

rcam AB, Product Data Sheets / Available at: www.arcam.com, visited 2015	Hot Isostatic Pressing (HIP) at 920°C for 120 minutes, 100 MPa.
T Additive Manufacturing Ltd, Product Data Sheets / Available at: www.3t- m.com, visited 2019	Stress relieved at 800°C for 2 hours in a vacuum furnace with specimens on build plate
feltio, Product Data Sheets / Available at: https://meltio3d.com/, visited 2022	Strass Relief - Hear up to 750°C in 2 h - Hold at 730°C during 2 h - Cool down to Ambient 1° in 1 h 50 min

Fig.15. Heat treatment used for the alloy Ti6Al4V used in Additive Manufacturing

	As powdered;	Spherical Shape	and a few satellites; SEM	image
GENERAL INF	ORMATION			
As powdered				
Microstructure		Spherical Shape and a	ew satellites	
Comment		SEM image		
10 µm	Microstructure	Detector = SE2 EHT = 10.00 KV WD = 8 mm		
	1/2		2/2	

Fig.16. Metallography details for Ti6Al4V powders used in Additive Manufacturing



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2. Total Materia database – Advanced Research for alloys

C	Joints One state of the second	See. are Secol in the table below.		anasanatana a
-	MATERIAL	STANDARD	COUNTRY / PRODUCTS	COUPHALENCE CATEGORY
3	YTAW 640 E	13	Kares	Composition 100%
2	AB-1	sat	United States	Other sources
1	8 265 Grade 5	ASTH	United States	Other sources
4	B 265 Grade TI-6AI-4V	ASTM	United States	Other acurces
	ERTI-5	405	Limited States	Other sources
6	5 Tİ 6402	CNUTEM	Austria	Other sources
7	S Ti 6402	Ngts	Beigum	Other sources
	S TI 6402	820	Bulgaria	Other sources
	5 Tİ 6402	C5V	Cosch Republic	Other sources
30	5 TI 6402	EN	European Union	Other sources

Fig.19. Different variants similar alloy of Ti, used in welding and in brazing



Fig.20. Stress strain diagram for Ti6Al4V used in Electron Beam Melting (EBM)



Fig.21. Fatigue data given for Ti6Al4V used in Electron Beam Melting (EBM)

PROPERTIES					
=+ Add property					
Mechanical Properties	>	Brinell Hardness (HB)	Elongation, A (%)	Reduction of Area (%)	
Physical Properties		Rockwell Hardness (HR)	Tensile Strength (MPa)	Vickers Hardness (HV)	
Chemical Composition 💮		Vield Strength, Rp0.2 (MPa)			

Fig.22. Equivalents finder

b









3. Total Materia database – Search algorithms used for identification the unknown metallic materials

For the chemical composition Co 54,31 %, Cr 23,08 %, Mo 11,12 %, W 7,85 %, Si 3,35 % and Mn, Fe < 0,1, using the algorithms of the Total Materia database, it will identify the material with this chemical composition.

Ivanced Search - Add criteria			
eneral Information			
hemical Composition (%)	Saloct	с. С	
echanical Properties			
tysinal Properties			
pecial Search			

Fig.26. Algorithms used for identification the unknown materials

General Information					
Chemical Composition (%)	Si	slect			
Mechanical Properties	Co:	50	-	55	Not Allowed
Physical Properties					
Special Search	Cr:	20	-	24	Not Allowed (
	Mo:	10	-	12	Not Allowed
	w:	5	-	10	Not Allowed
	si:	2	-	4	Not Allowed 🌒
	Mn:	0	-	1	Not Allowed
	Fe:	0	-	1	Not Allowed

Fig.27. Chemical composition selection





4. Total Materia database – polymers, ceramics and composite materials

Total Materia database is used too for the polymers (Fig.31), ceramics and composite materials.

The database given 125 results of PLA types, as in the figure 32.

		Quick Search	Advanced Searc	ch Standard list	Material Discovery	
ΞO	PLA					SEARCH C
12	Туре	✓ Polyme	rs X V	Standard	♥ Producer	

Fig.31. Total Materia database for the polymers

Resul	(t)) found: 125			ALL TO MATCHING LIGT BUILDER + + YORK
₹ţ	MATERIAL	STANDARD	COUNTRY / PRODUCER	CLASSIFICATION
1	PLA	GENEROC		Polymens / Plastics, thermoplasts / Biopolymens (CA, CAB, PLA) / PLJ 3D Materials
2	PLA++	PROPRIETARY	Breathe-30P	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA) / PLA 3D Materials
3	PLA Crystal Clear	PROPRIETARY	Filamentum	Polymens / Plastics, thermoplasts / Biopolymens (CA, CAB, PLA) / PL 30 Materials
4	PLA Extrafill	PROPRIETARY	Filanestum	Polymens / Plastics, thermoplasts / Biopolymens (CA, CAB, PLA) / PLI 30 Materials
5	PLA Filament	PROPRIETARY	Filament PM	Polymens / Plastics, thermoplasts / Biopolymens (CA, CAB, PLA) / PLI 30 Materials
6	PLA Plus ProSpeed	PROPRIETARY	Rose 30	Polymens / Plastics, thermoplasts / Biopolymens (CA, CAB, PLA) / PLJ 30 Materials
7	PLA Premium Filament	PROPRIETARY	Airwalf 30	Polymens / Plastics, thermoplasts / Biopolymens (CA, CAB, PLA) / PLJ 30 Materials
8	PLA Prografen color	PROPRIETARY	Advanced Graphene Products	Polymers / Plastics, thermoplasts / Biopolymers (CA, CAB, PLA) / PLJ 3D Materials

Fig.32. 125 results of PLA types existing on the database









4. Total Materia database – polymers, ceramics and composite materials

In figure 33, are presented the mechanical properties of PLA crystal clear.

Database give us the manufacturing processes of PLA crystal clear, such as 3D Printing and temperature used in the manufacturing processes, as in figure 34.

Manufacturing Processes				
PROPERTY VALUE UNIT				
3D printing machine settings Reference: Fillamentum, Product Data Sheets / Av	ailable at: www.fillamentum.com, visited 2021			
Heated Bed Temperature 50 - 60				
Printing Temperature 210-230 °C				
Reference for the selected material and condition 1 Fillamentum, Product Data Sheets / Available at: www.	fillamentum.com, visited 2021			



Fig.33. Mechanical properties of PLA crystal clear

Fig.34. Manufacturing processes of PLA crystal clear









5. Conclusions

In the last years, the materials developed very much, appeared different news materials with very interesting properties realized by different world companies, that can be used in Additive Manufacturing and in other manufacturing domain to realize medical parts or for industrial domain and grace to this database, all materials developed are introduced in this platform, giving us the possibility to choose, the chemical composition, the mechanical properties, or using the search algorithms, finding the unknown material, in function of the chemical or mechanical properties.

The implications of the present research would be interesting for the manufacture by Additive Manufacturing different medical parts, using different materials using the database Total Materia, or others to know the mechanical and chemical properties that are very important to establish the manufacturing parameters and manufacturing systems and tools.







