

Erasmus+ Programme Key Action 2 Cooperation Partnerships for Higher Education (KA220-HED) Agreement number 2023-1-RO01-KA220-HED-000155412 European Network for Additive Manufacturing in Industrial Design for Ukrainian Contex



SUMMER SCHOOL – hosted by Politehnica Bucharest 8 – 17 July 2024

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Erasmus+ Programme Key Action 2 Cooperation Partnerships for Higher Education (KA220-HED)



Agreement number 2023-1-RO01-KA220-HED-000155412

European Network for Additive Manufacturing in Industrial Design for Ukrainian Context – Acronym AMAZE

INTRODUCTION IN ADDITIVE MANUFACTURING











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- 1. Additive Manufacturing in Industrial Design:
- Generalized globalization
- Strong competition
- Accelerated technological progress
- Generalization of quality systems
- The sophistication of the public (each market segment or niche wants products precisely tailored on its needs, expectations, and desires).













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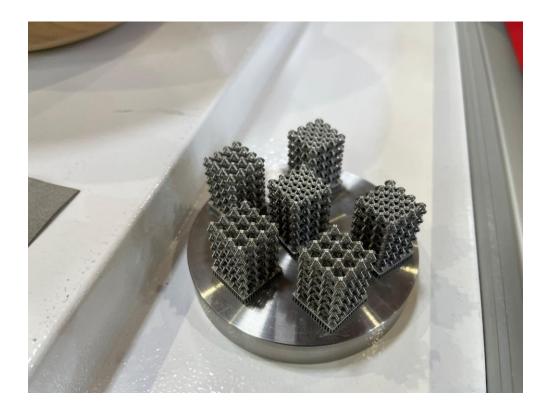


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1. Additive Manufacturing in Industrial Design:















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Туре	Technologies	Materials	
Material jetting	Drop-on-demand or continuous (single- or	Hot-melt materials (wax, thermoplastic, metal alloy),	
	multi-nozzle) particle deposition	dispersed materials (technical ceramics, metals, polymers)	
Material extrusion	Fused Deposition Modeling (FDM) or	Thermoplastics, eutectic metals, edible materials,	
	Fused Filament Fabrication (FFF) and fused	rubbers, modelung clay, plasticine	
	pellet fabrication or fused particle fabrication		
	Robocasting or MIG widing 3D printing or	Metal-binder mixtures such as metal clay, ceramic-	
	Direct Ink Writing (DIW) or extrusion based	binder mixtures (including ceramic clay and ceramic	
	additive manufacturing of metals (EAM) and	slurries), cermet, metal matrix composite, ceramic matr	
	ceramics (EAC)	composite, metal (MIG welding)	
	Additive Friction Stir Deposition (AFSD)	Metal alloys	
	Composite Filament Fabrication (CFF)	Nylon or nylon reinforced with carbon, Kevlar or	
		glass fibers	
Light polymerized	Stereolithography (SLA)	Photopolymer (including preceramic polymers)	
	Digital Light Processing (DLP)	Photopolymer	
	Continuous liquid interface production	Photopolymer + thermally activated chemistry	
	(CLIP)		











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Powder Bed	Powder bed and inkjet head 3D printing (3DP)	Almost any metal alloy, powdered polymers, paster
	Electron Beam Melting (EBM)	Almost any metal alloy including titanium alloys
	Selective Laser Melting (SLM)	Titanium alloys, Co-Cr alloys, Stainless steels,
		aluminium
	Selective Laser Sintering (SLS)	Thermoplastics, metal powders, ceramic powders
	Selective Heat Sintering (SHS)	Thermoplastic powders
	Direct Metal Laser Sintering (DMLS)	Metal alloys
Laminated	Laminated object manufacturing (LOM)	Paper, metal foil, plastic film
	Stratoconception	
Powder fed	Laser Metal Deposition (LMD) or Directed	Metal alloys
	Energy Deposition (DED)	
	Extreme High-speed Laser Cladding (EHLA)	Metal alloys
Wire	Electron Beam Freeform Fabrication	Metal alloys
	(EBF3)	
	Wire-arc additive manufacturing (WAAM)	Metal alloys
Freezing	Rapid Freeze Prototyping (RFP)	Water
3D Bioprinting	3D Bioprinting	STEM cells, biopolimers









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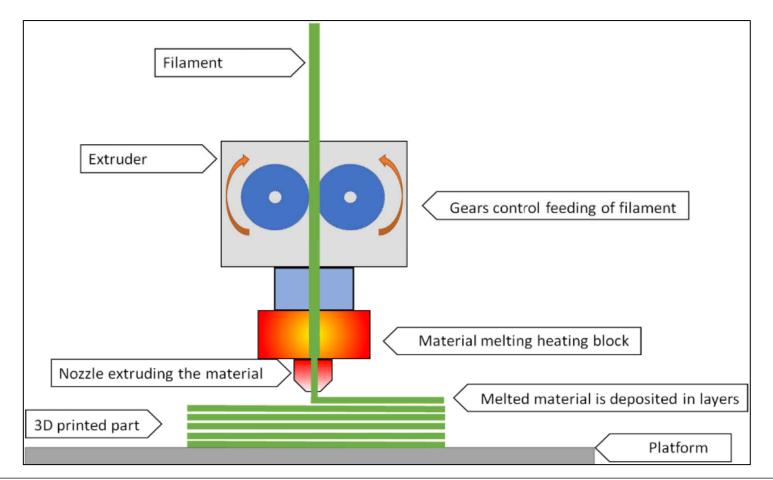


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Fused Deposition Modeling (FDM) principle













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Mechanical properties between the common materials used in FDM technology, PLA, ABS and HIPS

Polymers	н	HIPS ABS			Р	PLA			
rorymers	ov	SD	SEx	ov	SD	SEx	ov	SD	SEx
MFI (g/10 min)	7.5 ± 0.20	0.16	0.11	8.76 ± 0.16	0.13	0.09	13.52 ± 0.11	0.09	0.06
Young's modulus (MPa)	112.5 ± 0.12	0.09	0.06	175 ± 0.11	0.09	0.06	47.9 ± 0.10	0.08	0.05
Yield stress (MPa)	3.44 ± 0.21	0.17	0.12	0.49 ± 0.21	0.17	0.12	0.27 ± 0.16	0.13	0.09
Glass transition temp (°C)	100.41 ± 0.16	0.13	0.09	109.76 ± 0.2	0.16	0.11	62.57 ± 0.21	0.17	0.12
Peak load (N)	80.8 ± 0.11	0.08	0.06	207 ± 0.2	0.16	0.11	282.4 ± 0.20	0.16	0.11
Peak strength (MPa)	4.21 ± 0.16	0.13	0.09	10.78 ± 0.11	0.09	0.06	14.71 ± 0.16	0.13	0.09
Peak elongation (mm)	1.9 ± 0.20	0.16	0.11	4.75 ± 0.16	0.13	0.09	5.13 ± 0.16	0.13	0.09
Percentage elongation at peak (%)	3.0 ± 0.11	0.09	0.06	6.0 ± 0.15	0.12	0.08	$\textbf{7.0} \pm \textbf{0.10}$	0.08	0.05









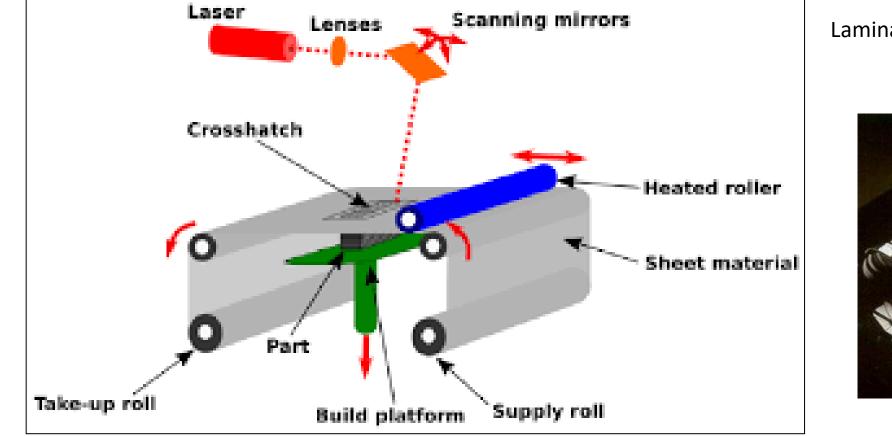


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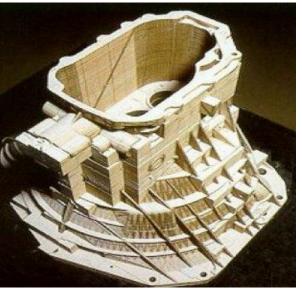
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Laminated Object Manufacturing principle











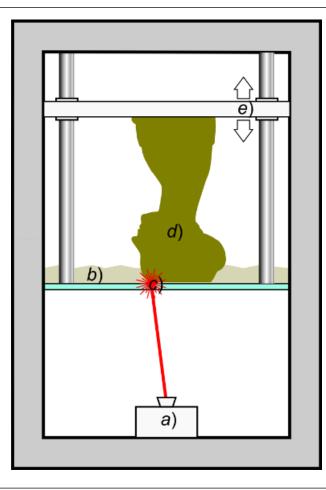


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Stereolithography (SLA) principle





Kretzulescu Palace









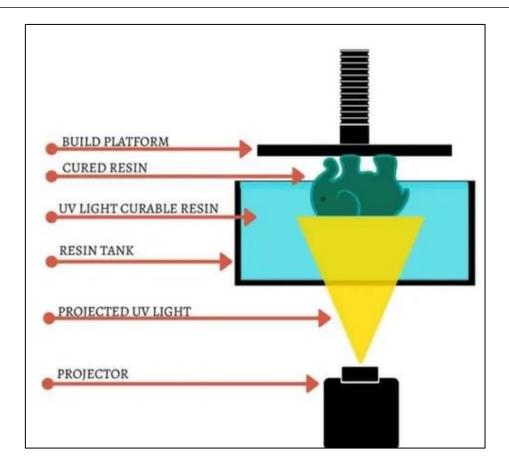


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Digital Light Processing (DLP)













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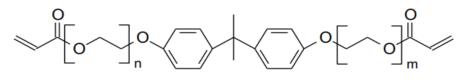
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Mechanical properties of Bisphenol A Ethoxylate Diacrylate

Bisphenol A Ethoxylate Diacrylate





INTRODUCTION

EBECRYL 150 is an ethoxylated bisphenol A diacrylate commonly used as reactive diluent in UV/EB cure applications. EBECRYL 150 can improve the cure response, hardness, and chemical resistance of UV/EB curable coatings and inks while maintaining good adhesion, and without imparting brittleness.

PERFORMANCE HIGHLIGHTS

EBECRYL 150 is characterized by:

- High reactivity
- Moderate viscosity
- High refractive index

UV/EB curable formulated products containing EBECRYL 150 are characterized by:

- Hardness
- Chemical resistance
- Good adhesion
- Improved wetting

The actual properties of UV/EB cured products also depend on the selection of other formulation components such as oligomers, additives and photoinitiators.

SPECIFICATIONS ⁽¹⁾	VALUE
Acid value, mg KOH/g, max.	5
Appearance	Clear liquid
Color, Gardner scale, max.	2
Viscosity, 25°C, cP/mPa·s	1150-1650

TYPICAL PHYSICAL PROPERTIES

Density, g/ml at 25°C	1.14
Flash point, Setaflash, °C	>100
Functionality, theoretical	2
Refractive index (n _D at 20°C)	1.5294
Vapor pressure, mm Hg at 20°C	< 0.01

TYPICAL CURED PROPERTIES⁽²⁾

Tensile strength, psi (MPa)	6300 (43)
Elongation at break, %	9
Young's modulus, psi (MPa)	180000 (1241)
Glass transition temperature, °C ⁽³⁾	41









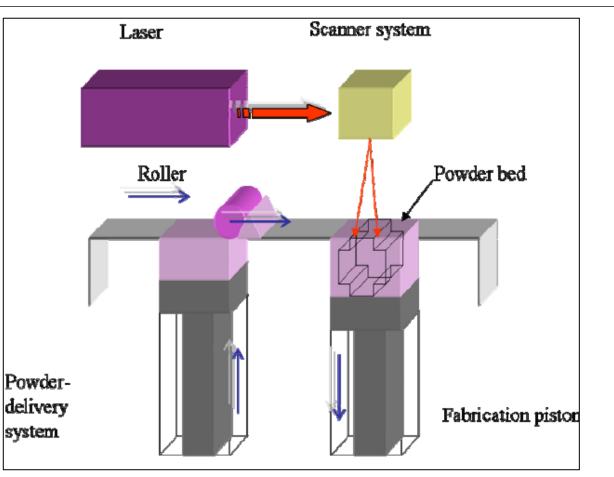


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Principle of Selective Laser Sintering technology



Industrial part with complex forms manufactured by SLS











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Phenix Systems ProX DMP 100 Dental



Analogue dental implants manufactured via DMLS











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Pre-assembled micro-turbojet engine of Inconel 718 manufactured by SLM











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Properties of metallic materials used in SLM technology

Material	Property	Value
Inconel 625	Density	8.44 g/cm ³
	Yield strength	460 MPa
	Modulus	205.8 GPa
	Density	4.43 g/cm ³
TiAl64V	Yield strength	880 MPa
	Modulus	193 GPa
	Density	8 g/cm ³
Stainless steel	Yield strength	205 MPa
	Modulus	193 GPa
	Density	2.67 g/cm ³
AlSi10Mg	Yield strength	240 MPa
-	Modulus	70 GPa











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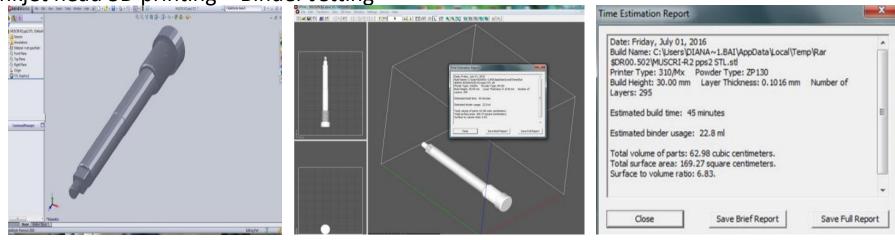
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Powder bed and inkjet head 3D printing – Binder Jetting



ZPrinter310 Plus system



Printing *	MUSCRJ-R2 pps2 STL*	on 30/233003			
E stimate	d Finish Tene d Time Remaining Layer 100 of 246	4 04 PM 23:18 40% Completed	Starting Time Elapsed Tiron Printing Normally	13.34	ncel
-				7	
		-	12		

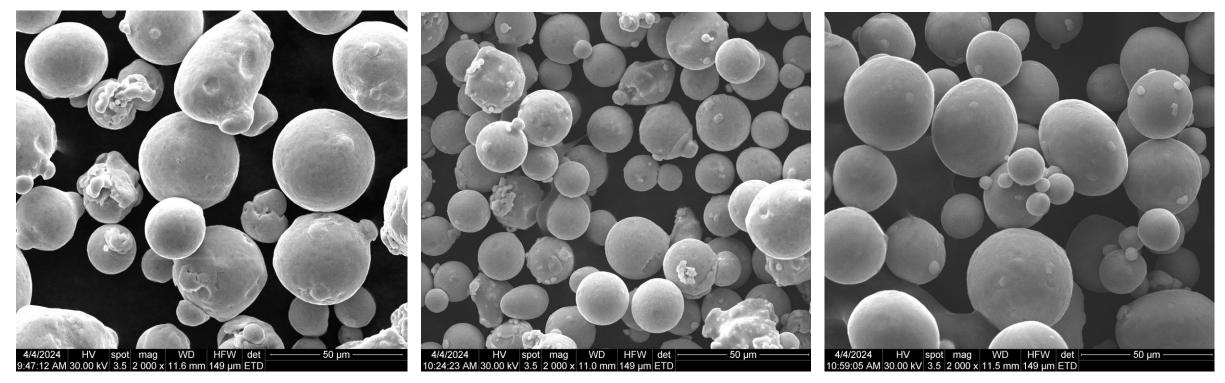




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Metallic powders used in SLM (SELECTIVE LASER MELTING)



718 INCONEL

625 INCONEL









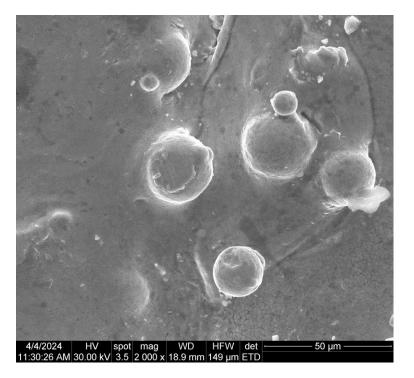
Ti6Al4V



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Sintered parts used in SLM (SELECTIVE LASER MELTING)



 4/4/2024
 HV
 spot
 mag
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 HFW
 det
 1 mm

Ti6Al4V

625 INCONEL







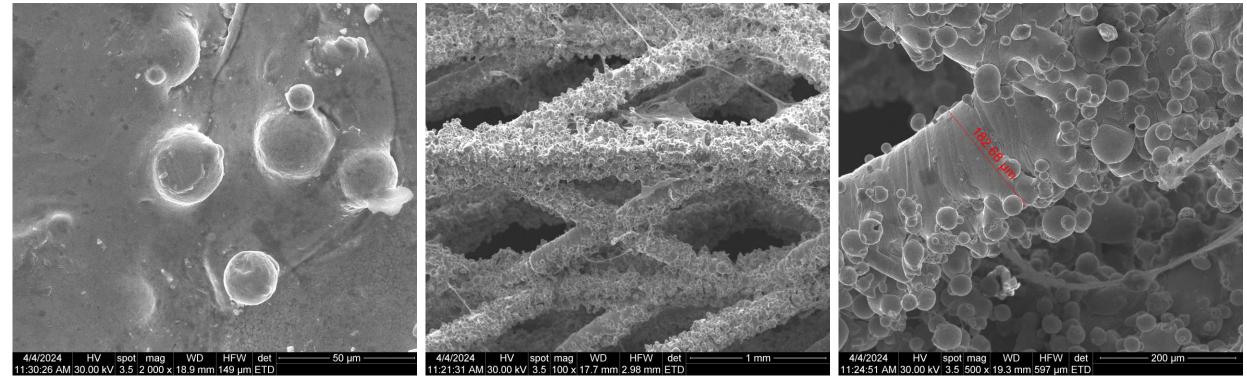




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Sintered parts used in SLM (SELECTIVE LASER MELTING)



625 INCONEL







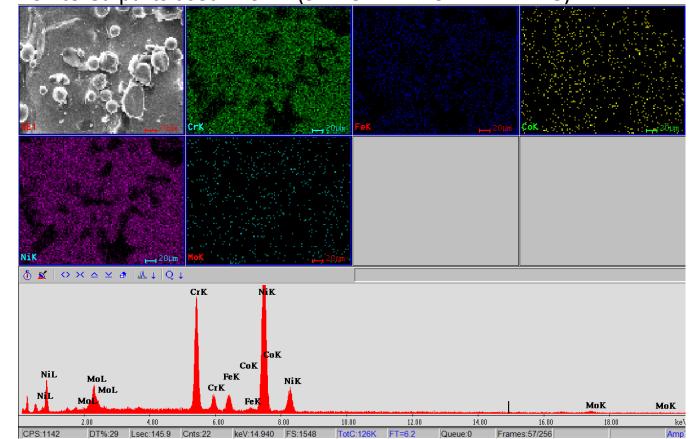


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Sintered parts used in SLM (SELECTIVE LASER MELTING)



625 INCONEL







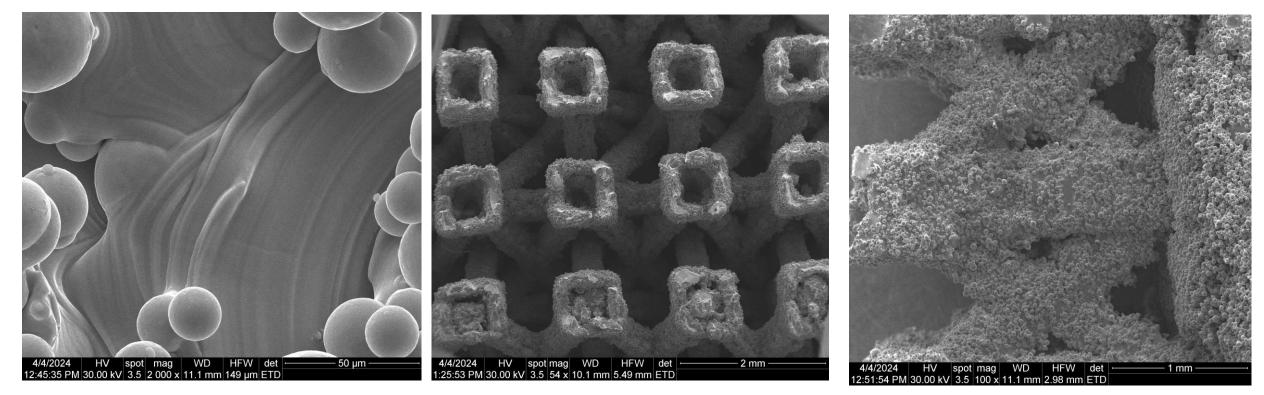




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Sintered parts used in SLM (SELECTIVE LASER MELTING)



Ti6Al4V







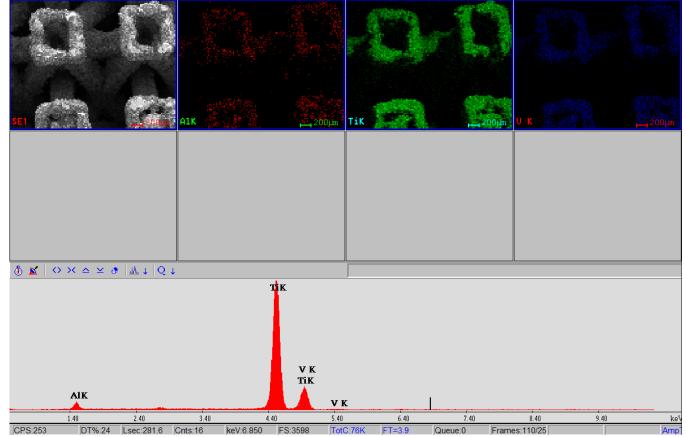




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Sintered parts used in SLM (SELECTIVE LASER MELTING)



Ti6Al4V







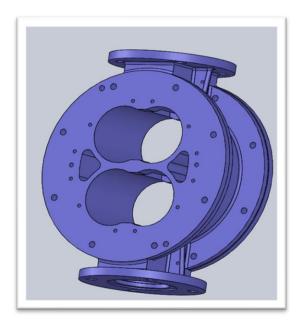




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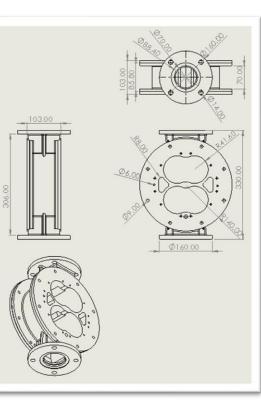


Part 1 – Hydraulic pump body



Hydraulic pump body – SLDPRT

Ti6Al4V





Hydraulic pomp body meshing – STL. file











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Part 1 – Hydraulic pump body

ltimaker Cura		PREPARE PREVIEW	MONITOR			Ľ	Marketplace	Sign ii
Ultimaker S5	Generic PLA AA 0.4	Generic PLA AA 0.4	~	Fine - 0.1mm	20%	Off Off	On On	~
				Print settings				×
				Profiles				
		573		0	Visual	0	Draft	
				Default	Visual	Engineering Fine - 0.1m		~
		1020		- Resolution		Fine - 0.1m	m	
5 🛎 🖪				Print settings				
 Snap Rotation 				Infill (%)	0 20	40 60	80	100
			~ \		Gradual infill			
		Contraction of the		Support				
				Adhesion	•			
							Custor	
							Custon	
A. Object list								
Object list UMS5_corp pompa								
140.0 x 79.9 x 165.0 mm						Slice	e	

Open Ultimaker Cura software and introduce the STL. file of part

Table 1. The mechanical properties of PLA (Polylactic Acid)

Properties	Values	Units
Density	1.25	g/cm3
Poisson's Ratio	0.36	-
Shear Modulus G	2.4	GRa
Melting Temperature	173	20
Glass transition temperature	60	28
Thermal Conductivity	0.13	W/m-K
Extruded Temperature	160-220	28
Heat Resistance	110	2 2
Young's modulus	3.5	GRa
Tensile Strength	61.5	MPa
Compressive Strength	93.8	MPa
Elongation at Break	6	%
Flexural strength	88.8	MPa
Hardness Shore D	85	А
Impact Strength	30.8	kJ/m2
Yield Strength	60	MPa
Standard Tolerance	+/-0.05	mm
Biodegradable	yes	-









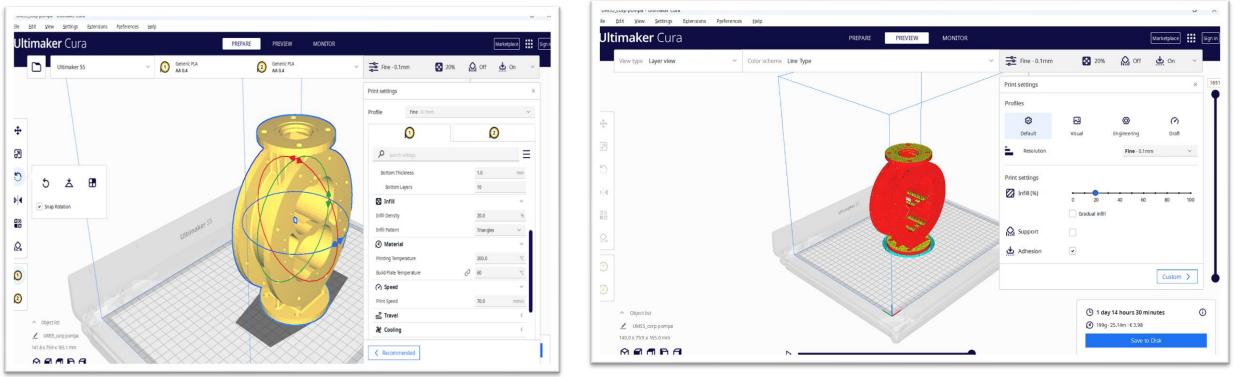


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Part 1 – Hydraulic pump body



Manufacturing parameters for custom Additive Manufacturing Re sciences sciences and sciences and

Recommended manufacturing parameters for the part by the software

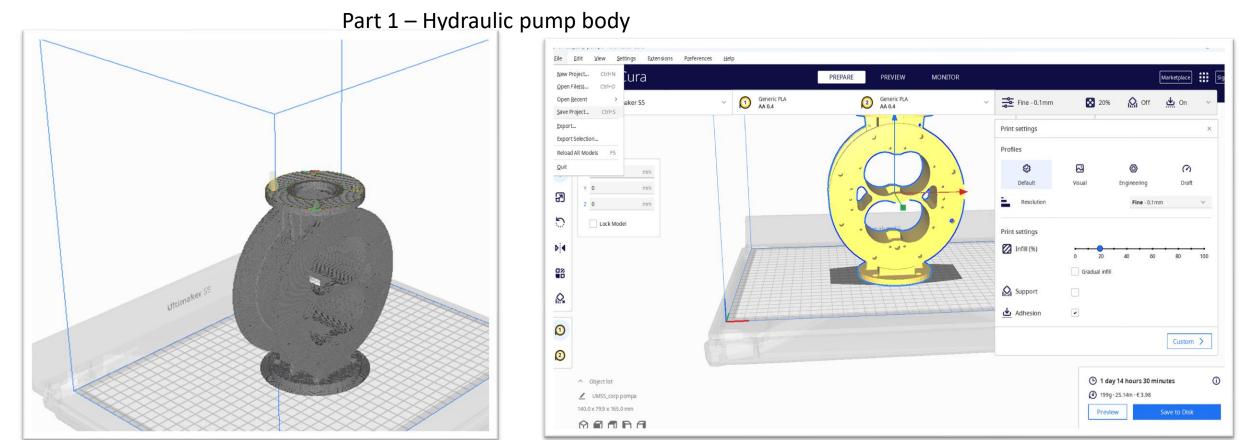




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Preview the manufacturing 3D Printing process

Save Project







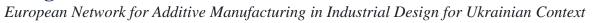






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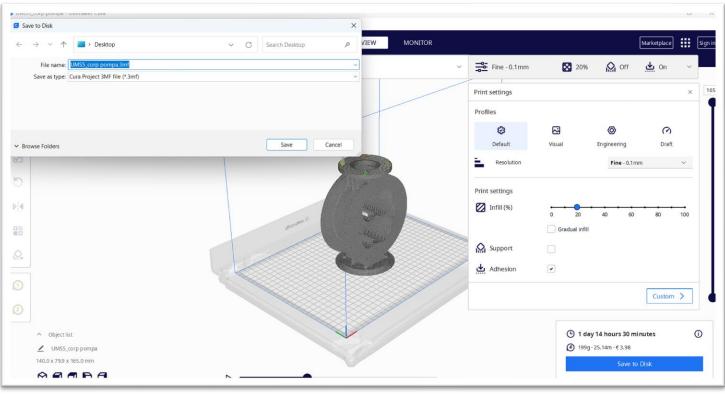
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Part 1 – Hydraulic pump body

Summary - Cura	Project	
P rinter settings Type Printer Name	Ultimaker S5 Ultimaker S5	Up date Ultimaker S5 🛛 🗸
Profile settings Name Intent	Fine	
Material settings		
Name Name	PLA PLA	
Setting visibility		
Mode Visible settings:	Custom 44 out of 609	
		Cancel Open
	Summary- Cu	ura Project



Save Project as 3mf. file









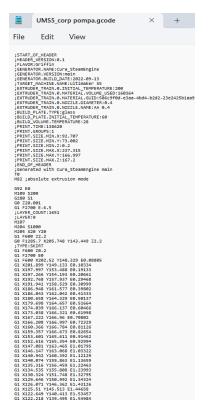


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Part 1 – Hydraulic pump body Edit View Settings Extensions Preferences Save to Disk Marketplace Sign in MONITOR ✓ C Search Desktop Desktop Fine - 0.1mm 20% Off Off 🛃 On File name: UMS5_corp pompa.3mf Save as type: 3MF file (*.3mf) Print settings G-code File (*.gcode Profiles STL File (ASCII) (*.stl) STL File (Binary) (*.stl) Ultimaker Format Package (*.ufp) 0 \$ 4 Rrowse Folders Wavefront OBJ File (*.obj) Defaul Draft 3 Fine - 0.1mm Resolution 5 Lock Model Print settings Þ Infill (%) 40 60 Gradual infil S. Support 0 . 🗄 Adhesion 0 Custom > 2 (1 day 14 hours 30 minutes 0 Object list 199g · 25.14m · € 3.98 UMS5_corp pompa 140.0 x 79.9 x 165.0 mm Preview AAAAA





Different extension for file export

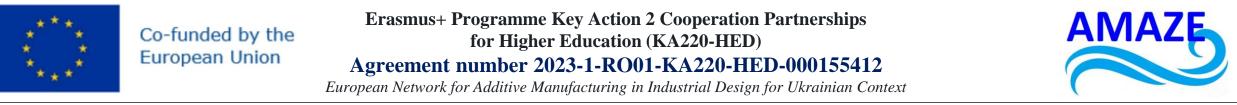
G-code file for hydraulic pomp body



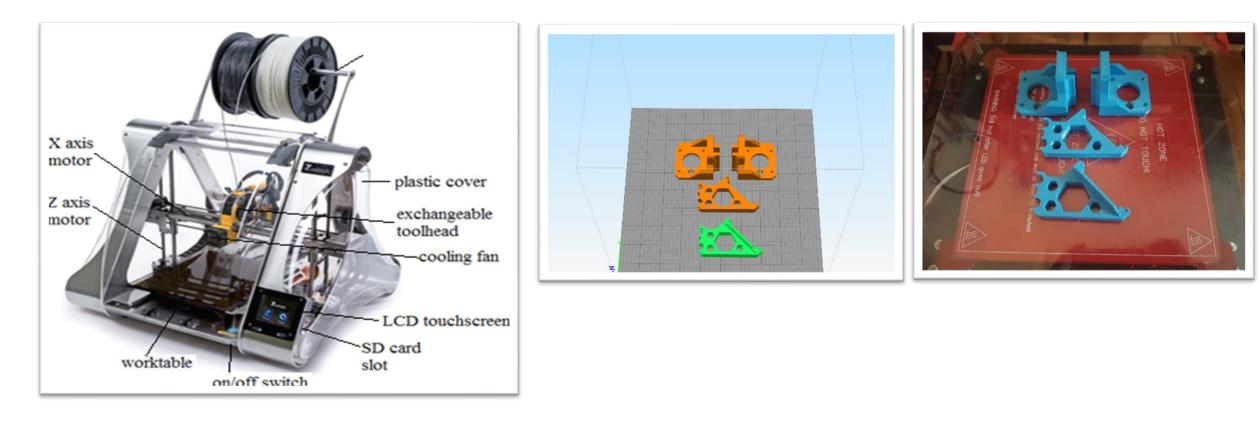








Part 2 - Electronic components used for the manufacture of 3D hybrid printer, type DIY (do it yourself)







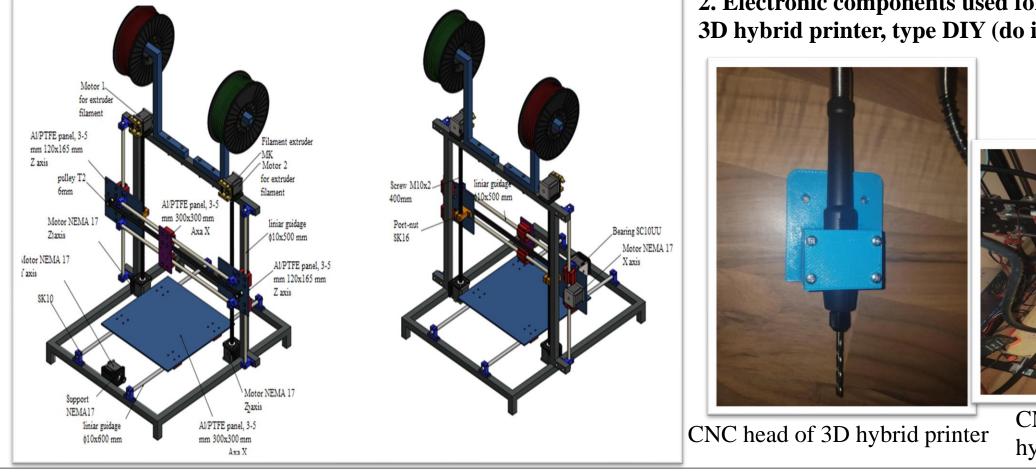




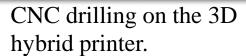


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2. Electronic components used for the manufacture of 3D hybrid printer, type DIY (do it yourself)





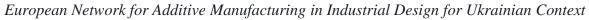




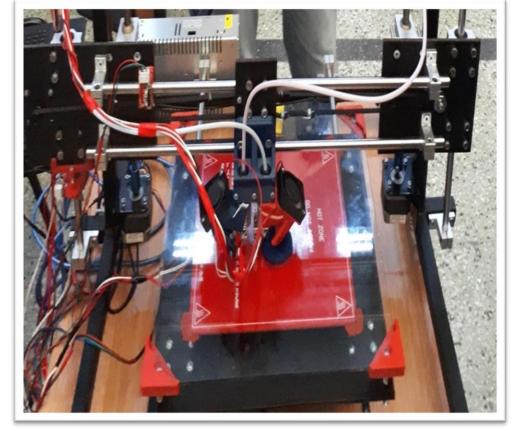




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FDM extruder on the 3D hybrid printer

2. Electronic components used for the manufacture of 3D hybrid printer, type DIY (do it yourself)



CNC head of 3D hybrid printer









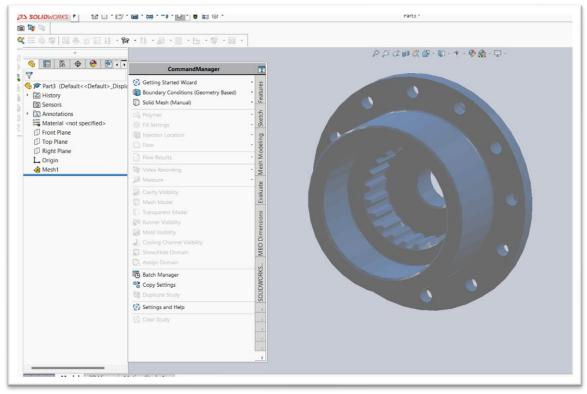


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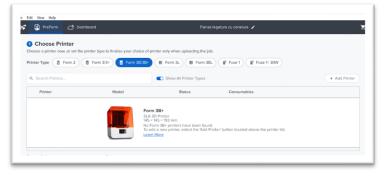


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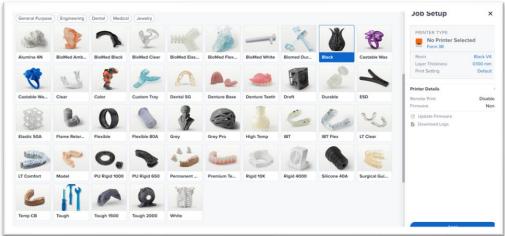
Part 3: Flange.stl file



flange stl. file for printing



Software PreForm, Form 3B+ printer chosen



Photopolymerisable resin and layer thickness chosen









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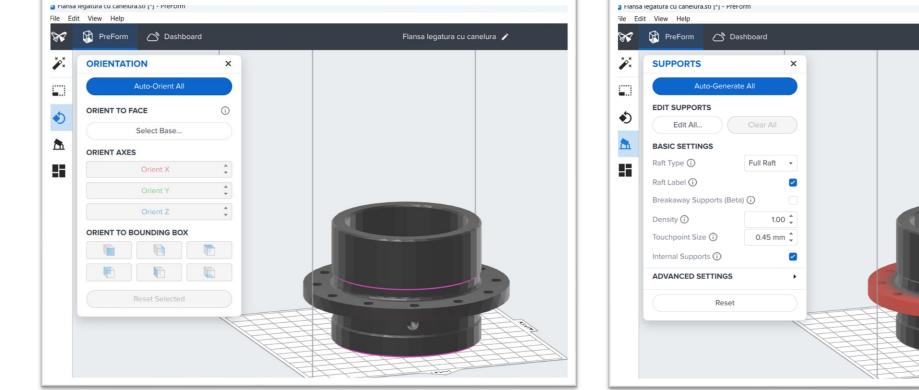


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Part 3: Flange.stl file

Co-funded by the

European Union



Orientation X,Y,Z on the worktable of the part

Supports chosen to sustain the part during the 3D Printing process









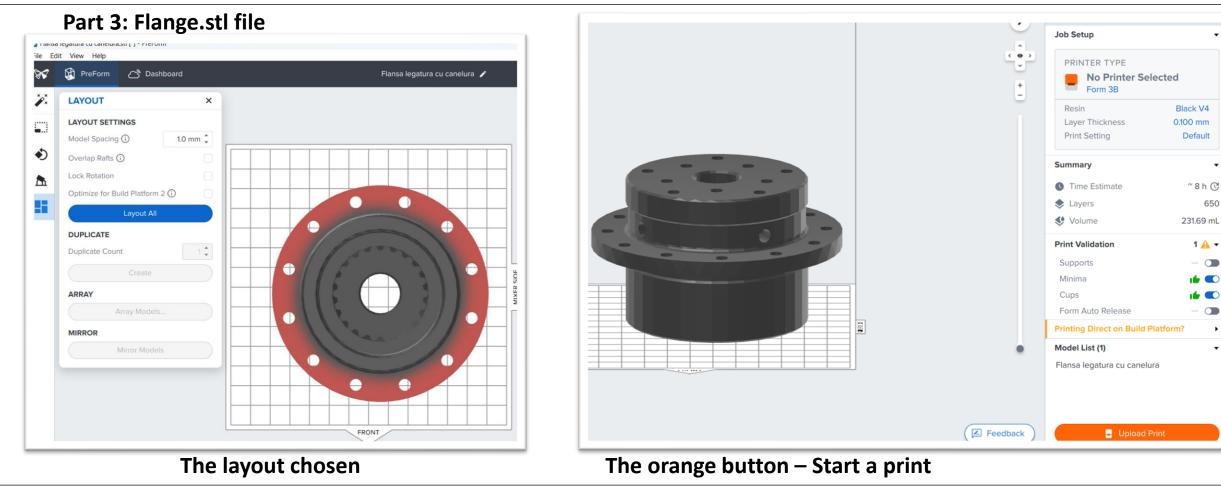
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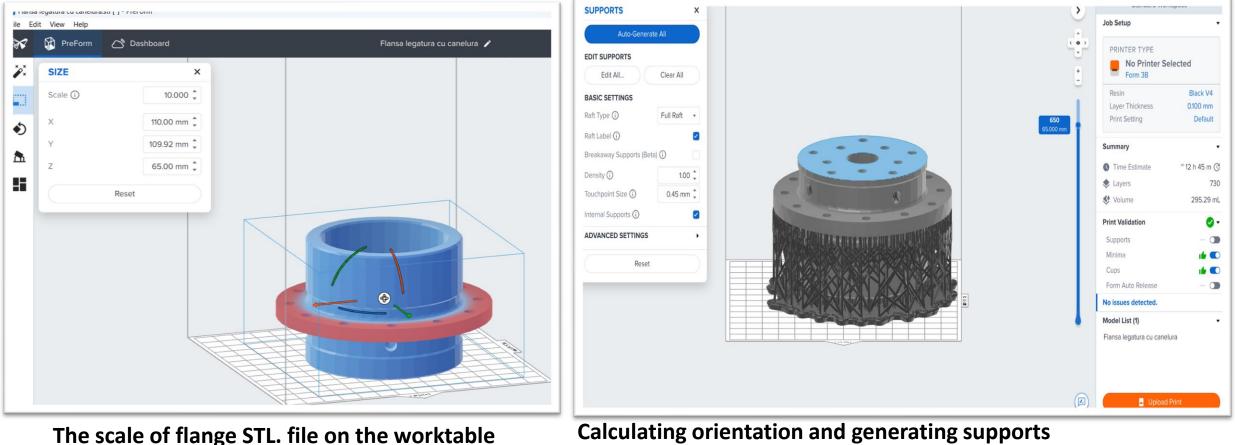


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European Network for Additive Manufacturing in Industrial Design for Ukrainian Context

Part 3: Flange.stl file













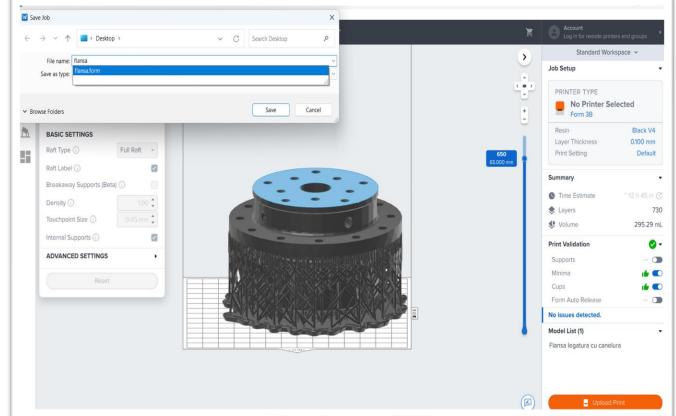
for Higher Education (KA220-HED)

Agreement number 2023-1-RO01-KA220-HED-000155412



European Network for Additive Manufacturing in Industrial Design for Ukrainian Context

Part 3: Flange.stl file Save Job $\leftarrow \rightarrow \vee \uparrow$ > Desktop : PRINTER TYPE File name: flansa Save as type No Printer Selected Form 3B ✓ Browse Folders Resin Black V4 Layer Thickness 0.100 mm A BASIC SETTINGS Default Print Setting Raft Type (i) Raft Label (i) Summary Density (i) Image: Comparison of Compar ~8h 🕑 **403** 40.300 mm Touchpoint Size (i) Layers 650 Internal Supports (i) Volume 😻 231.69 mL ADVANCED SETTINGS **Print Validation** 1 🗛 🔻 Supports - 🕥 1 Minima Cups Form Auto Release - 🔿 Printing Direct on Build Platform? Model List (1)



Save the file as Flange with the extension .FORM

Surface printed at the layer 403











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PRINT		×
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Back	Add to Queue	Print Now

Click on the orange button to print

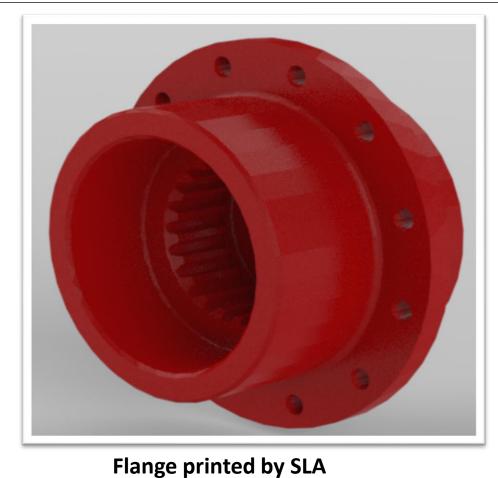












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Thank you!