



ADDITIVE MANUFACTURING KINETIC METALLIZATION™

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ITSC 2015 Presentation

Session — Engineering, Protection and Repair of Aircraft Structural Parts 3

SOLID-STATE ADDITIVE MANUFACTURING (SAM)

Kinetic Metallization™ (KM)

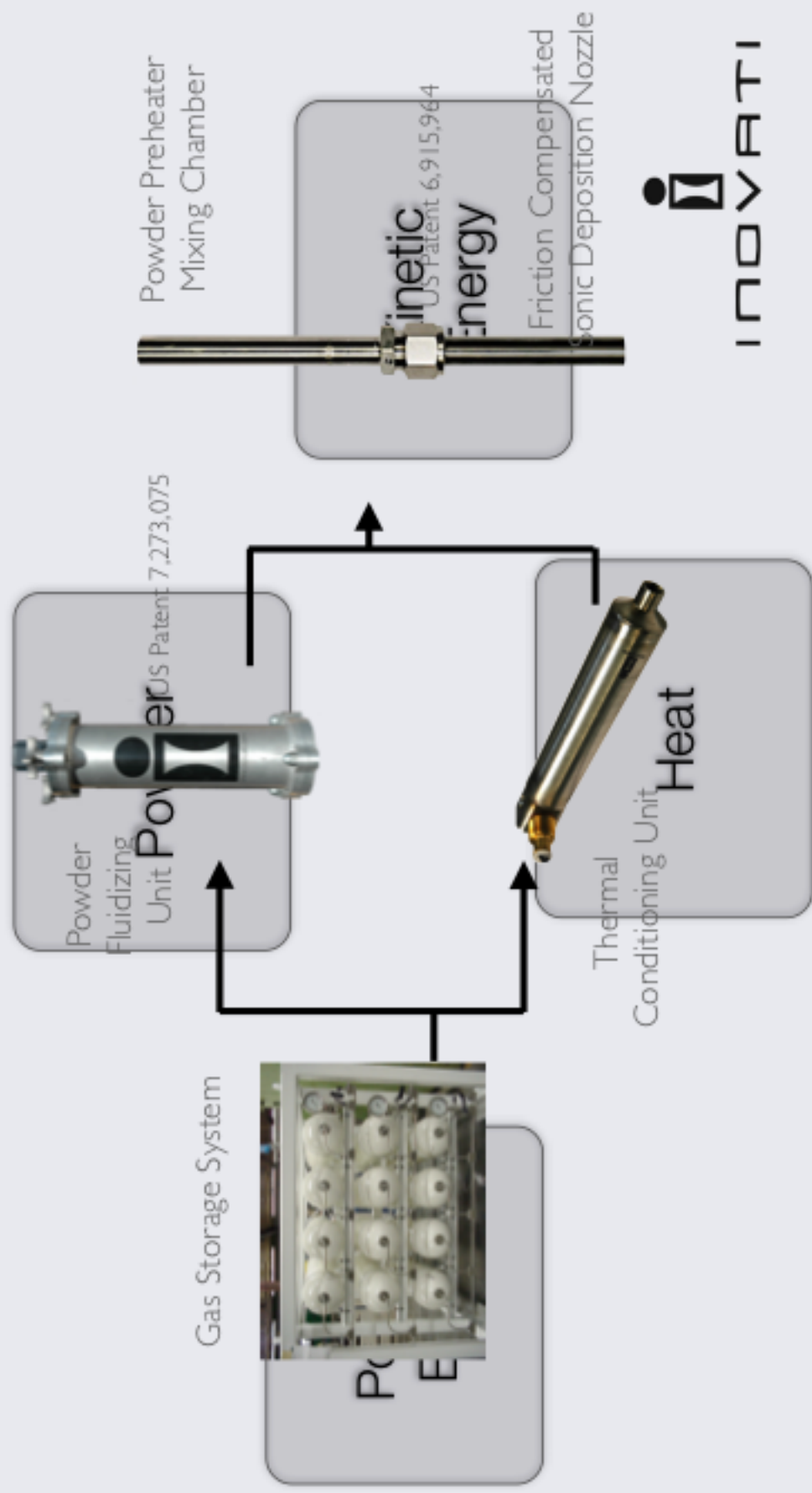


AM COMPARISON TABLE

ADDITIVE MFG.	SLS AM	KM-SAM
PROCESS	Liquid	Solid-state
THERMAL EFFECTS	Deformation Stress	Minimal
MATERIAL STRUCTURE	Non-homogenous	Homogenous
ALLOY CONSITUENTS	De-alloy	Alloy preserved
NEAR NET FINISH	Rough	Smooth
EQUIPMENT COST	High	Low

KINETIC METALLIZATION™

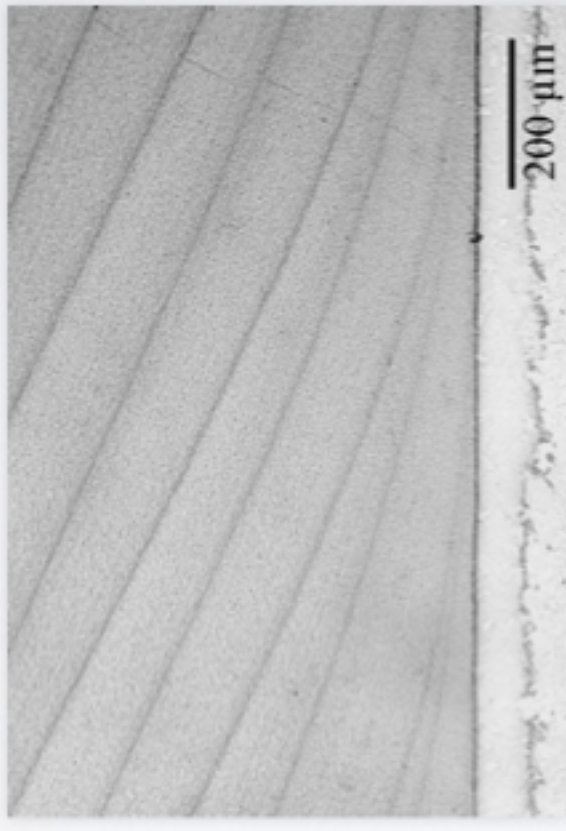
PROCESS



- Impact Consolidation Process
- Feed-stock: fine powder,
- Accelerant: inert light gas
- Solid-state Consolidation
- No Melting
- No Liquid Chemicals



- Environmentally Innocuous
- No Particle release
- No Chromate formation
- No Hazardous Gas Emission
- Enhanced worker safety

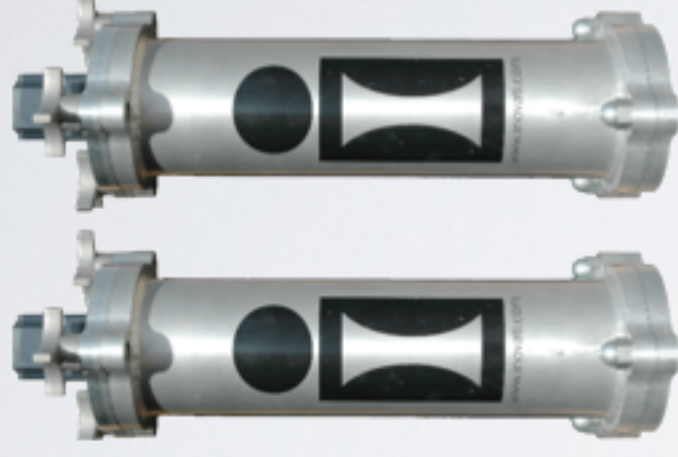





KM-PCS EQUIPMENT INOVATI

POWDER FLUIDIZING UNITS

- Patented Brush-Sieve Design
- Light-weight pressure vessel
- Powder/ Gas flow rate independent
- Powder Size: 500nm - 50 μ m
- Feed Rate: 0-100g/min
- Large Capacity - 4 hour run time



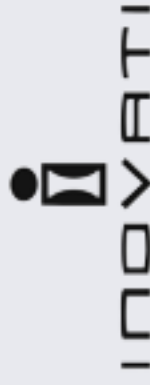
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PROCESS SETUP



General <input checked="" type="checkbox"/>		Customer Customer	Project Project	Task Task	Run Comment Comment
Nozzle <input checked="" type="checkbox"/>		Nozzle Type Straight	Serial Number 12345	Throat Diameter 0.0590	Nozzle Comment Comment
Substrate <input checked="" type="checkbox"/>		Material Group Other	Alloy Alloy	Surface Prep None	Surface Roughness (Ra) 100.00 uin
		Thickness 0.125 in	Bond Coat Bond Coat		Preheat Temperature 0 Deg F
Powder 1 <input checked="" type="checkbox"/>		Material Group Other	Alloy Alloy	Powder ID Powder ID	Drying Method None
PFU 1		Sieve 100	Set Point 50	Measured Feed Rate 30.0 g/min	Powder Comment Comment
Gas <input checked="" type="checkbox"/>		H ₂ H ₂	Temperature 1400 F	Pressure 70 psi	Operator Name Operator
		N ₂ N ₂			Log File Description Description
					Log Operator
					60 Second Powder Preview

INOYATI KINETIC METALLIZATION
PRODUCTION COATING SYSTEM

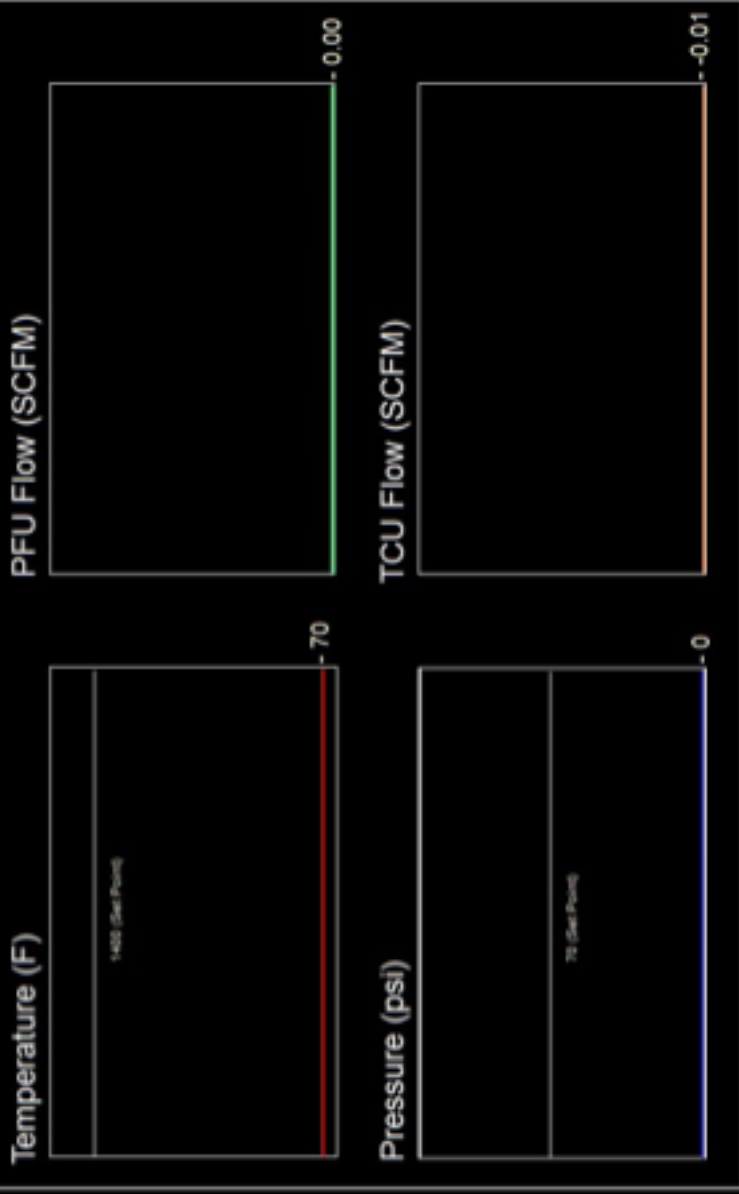


PROCESS MONITOR



System Status

- Inlet Pressure: ■ 1.40
- Thermocouple: ■
- Door: ■
- PFU 1: ■
- PFU 2: ■



Start

Run Timer



KINETIC METALLIZATION
PRODUCTION COATING SYSTEM



MOTION SETUP



Motion Mode

Handheld

Raster

Gear Shaft

Radar Dome

Door: ■

Raster Parameters

Substrate Thickness	0.25 _{in}		Standoff	0.50 _{in}	
Width	13.00 _{in}		Step Size	0.020 _{in}	
Length	13.00 _{in}		Surface Speed	35.00 _{in/s}	
Layers	1		Strokes	1	

Add excess to length for robot accel/decel (default = no)

Motion Preview

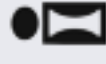


Clear Robot

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KINETIC METALLIZATION

PRODUCTION COATING SYSTEM



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KM QUALITY REPORT



Run Details

Operator	Inovate	Customer	INOVATI
Date	1/16/15	Project	WC-Co Demo
Time	12:36:03	Task	Sample Coopool

Substrate

Material Group	Steel	Coat	none
Alloy	4150	Preheat Temp	0
Surface Prep	A0203 Grt Blast	Thickness (in)	0.04
Surface Roughness	124		
Substrate Comment	3" W x 4" L x 0.40"		

Powder 1

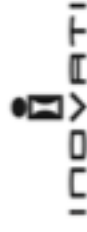
Material Group	Tungsten	Drying Method	None
Alloy	KM118-10-10	Preblend?	No
Powder ID	0104-67	Set Point (%)	35
Sieve	35	Feed Rate (g/min)	30
Powder 1 Comment			

Powder 2

Material Group		Drying Method	
Alloy		Preblend?	
Powder ID		Set Point (%)	0
Sieve		Feed Rate (g/min)	0
Powder 2 Comment			

Nozzle

Type	Straight	Serial Number	1501
Throat Diameter (in)	0.059		
Nozzle Comment			



Gas

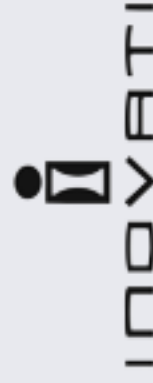
TCU Gas	He
TCU Gas	He

Spray Parameters

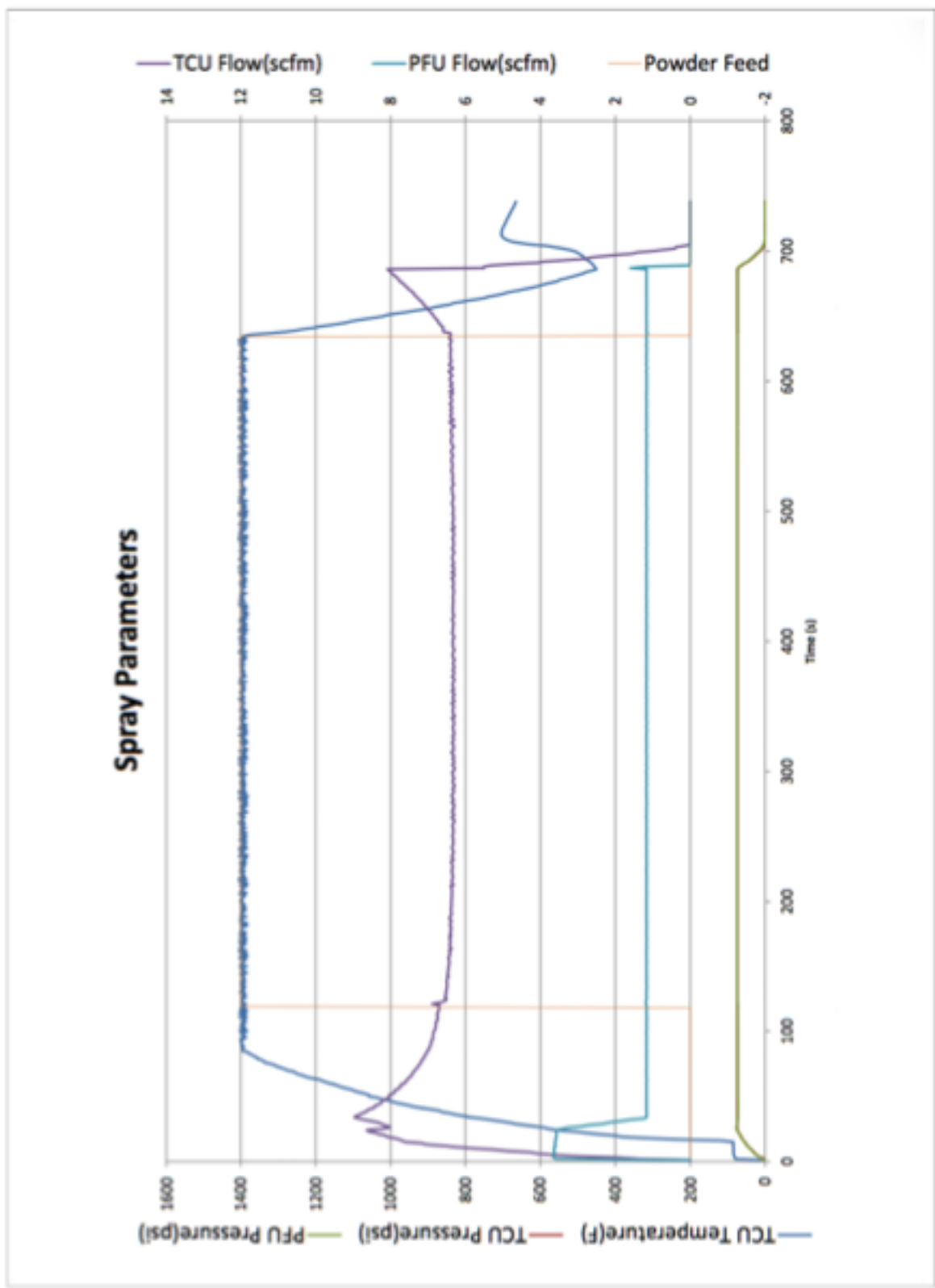
	Units	Set Point	Min	Max	Average	Standard Deviation
Temperature	F	1600	1585.00	1603.00	1,594.46	5.36
Pressure	psig	75	73.77	74.26	73.93	0.07
TCU Flow	SCFM		3.69	6.64	5.87	0.14
TCU Flow	SCFM		1.16	1.18	1.16	0.00
TCU Motor 1	%	35	0.00	35.00	34.69	0.60
TCU Motor 2	%	0	0.00	0.00	0.00	0.00

Robot Parameters

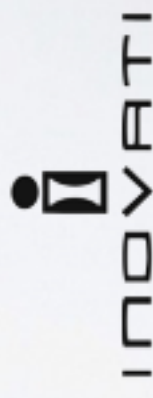
	Units	Set Point
Length	in	4.2
Width	in	1
Substrate Thickness	in	2.02
Standoff	in	0.43
Speed	In/sec	5
Step Size	in	0.01
Strokes		1
Layers		1
Turn Table Rotation Speed	rpm	0



Spray Parameters

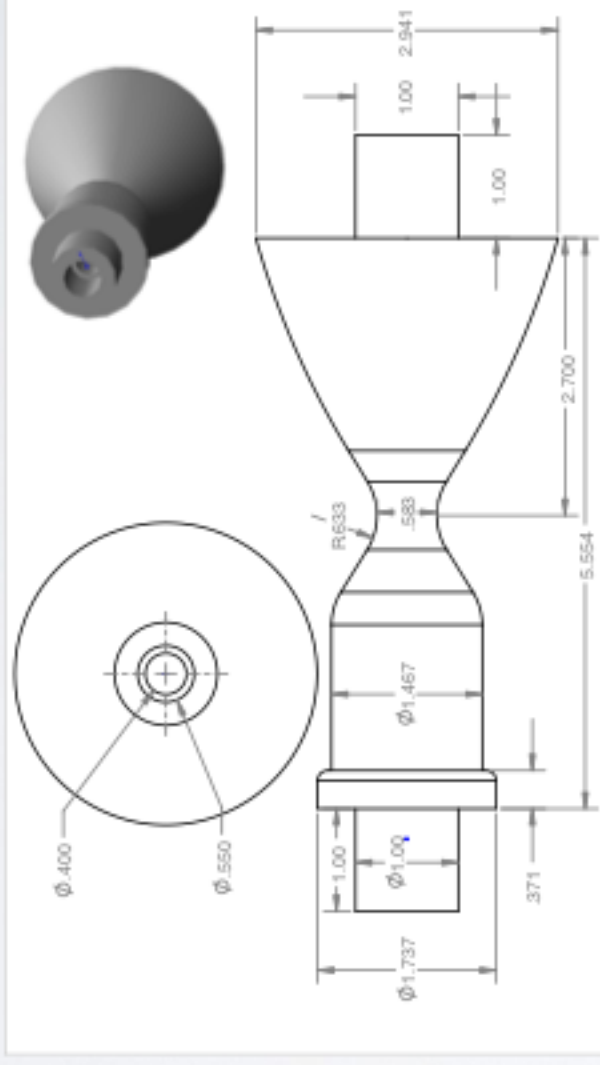


KM-SAM OF DAC THRUSTERS



SLS OF DAC MANDREL

- SLS Process
- Rotationally symmetric
- Nylon material
- Cu flash coated



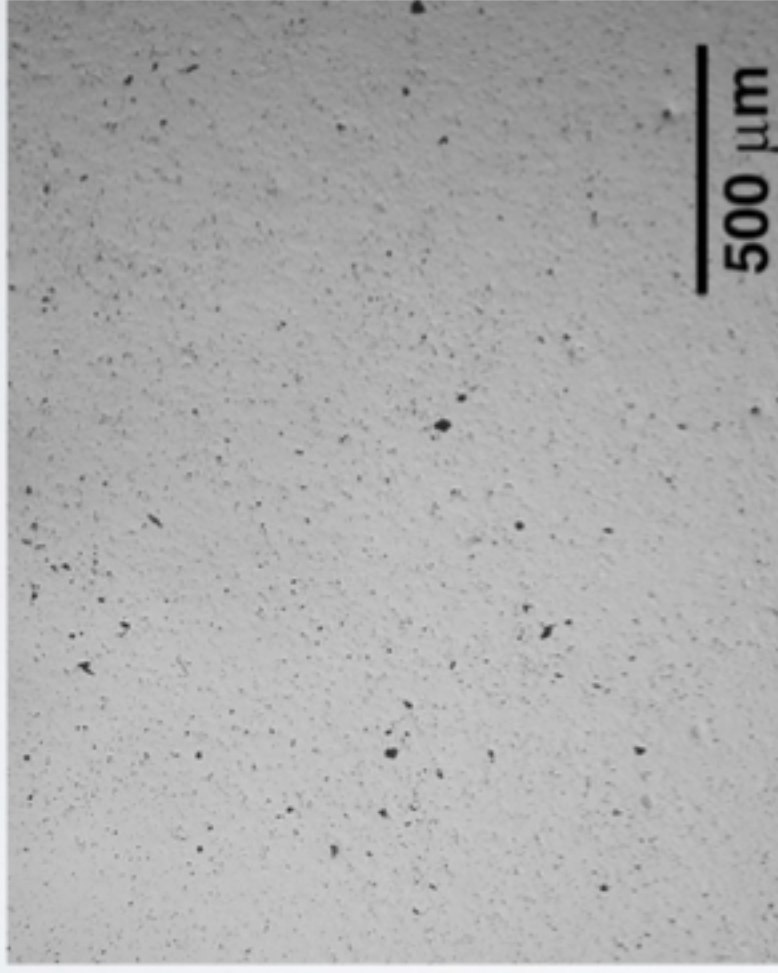
DAC AM MANDREL

- SLS Process
- Nylon mandrel
- Cu flash
- KM SAM
- C-103 (Nb-Alloy)



MATERIAL PROCESSING

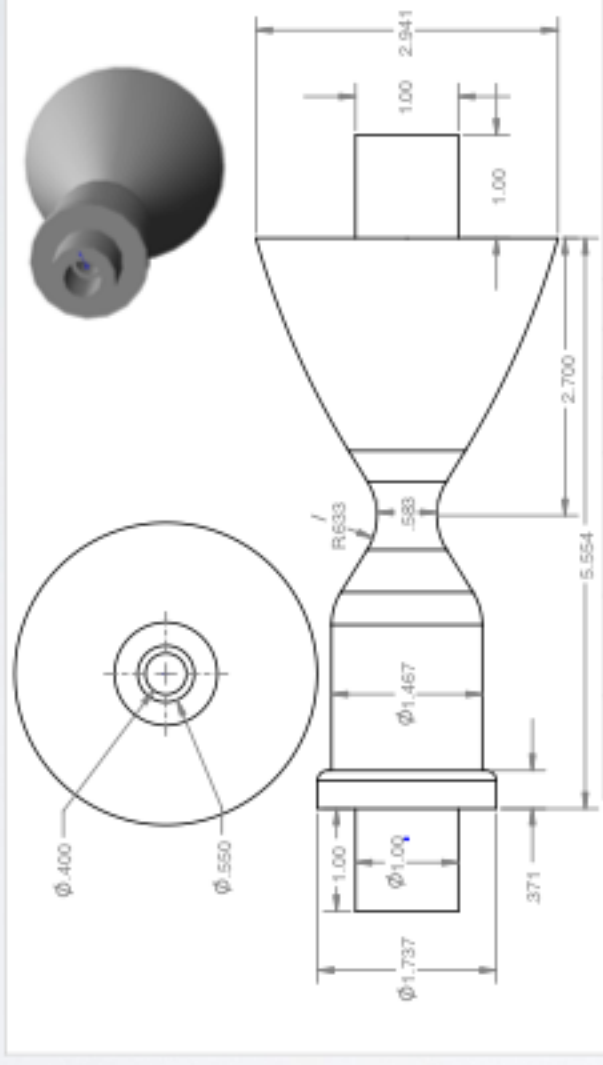
- KM-SAM of Nb (C-103)
- Chemically etch mandrel
- Heat treat @ 1800 F
- Hoop Stress Testing
- Performed at 1500 °C
- 90% wrought property (UTS 8600 psi @ 1500 °C)



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CAD DRAWING OF DAC

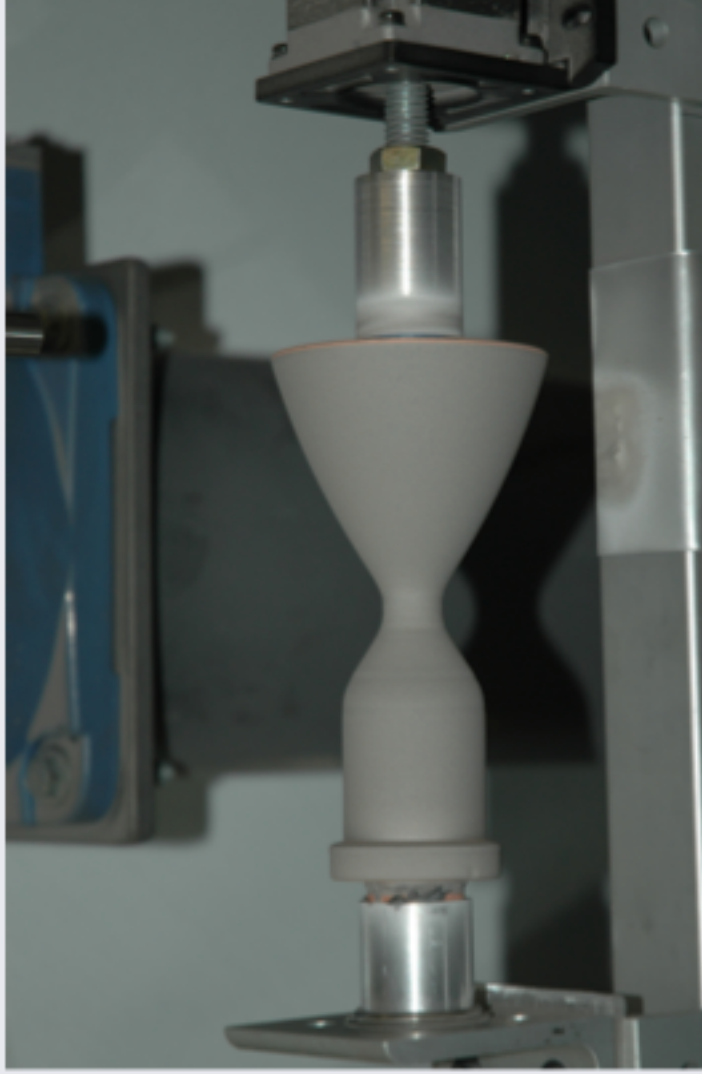
- Import to Robot Code
- Direct digital AM
- KM-Gun Motion
- Spray \perp to Contour
- AM part thickness





DDM ROBOT MOTION


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KM SAM OF C-103


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DIMENSIONAL REPAIR

KM-SAM with Handheld KM Gun  INOVATI

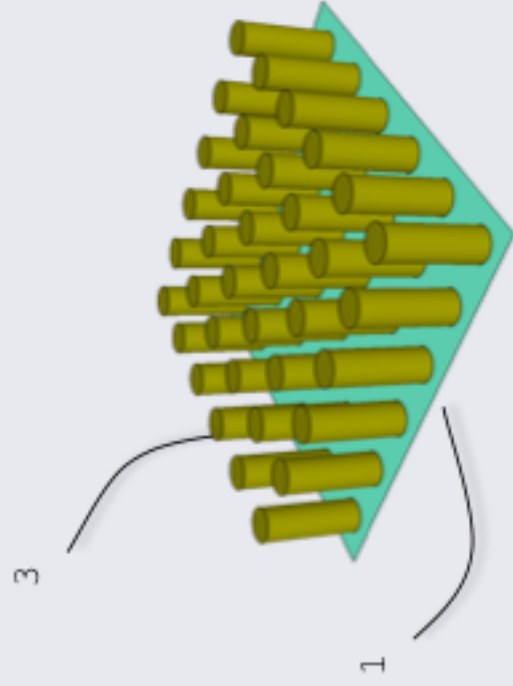
NEW AM CONCEPT

Tomo-laminated Anisotropic
Manufacturing™ (TAM)



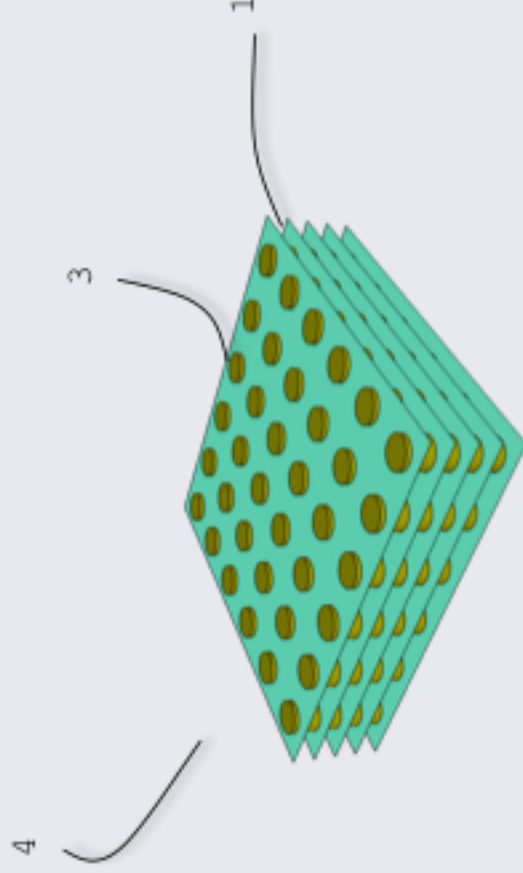

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Manufacturing* (TAM™)



- ❖ Laminated sheets
- ❖ Reinforced structures

*Inovati Patent Pending



- ❖ 3-D multi-facet objects
- ❖ Anisotropic strengthening



KM-SAM CONCLUSIONS

- KM offers solid-state alternative for AM
- Readily adaptable for rotational systematic components
- Enables method for adding surface features to components
- More development required for engineering material properties
- Recent emphasis on KM-SAM is gaining acceptance





VISIT BOOTH 1064
KM-SAM Process & Equipment