P11553 Improved Powder Spreader for ProMetal

Test Plans & Test Results

Table of contents

P11553 Improved Powder Spreader for ProMetal
Preliminary Test Plan

1. MSD I: PRELIMINARY TEST PLAN

Introduction and Overview

1.1.1. Project Background

Project P11553 is a Senior Design activity to design, build, and test three dimensional printing (3DP) of metal powder. A system will be designed to print powder on a twelve inch by eighteen inch surface up to six inches deep.

1.1.2. Project Testing Overview

There will be at a minimum two spreader heads tested. Both a counter-rotating roller and doctor blade will be compared with distributed powder spreading and lumped powder spreading. Each printed part will be tested against desired specifications from ProMetal's sandcasting tolerances.

System interfaces will also be tested to ensure full functionality.

Sub-Systems/ Functions/ Features

Major Sub-Systems/ Features/ Function
1. Frame (Rigid Support)
2. Chassis (Build Box)
3. Carriage (Spreader System)
4. Motion Control (Controllers and Motors)
5. Binder Application
6. Printed Parts

Approval: Team, Guide

	Name	Signature	Date
Team Members	Carlos Bu		
	Mathew Rebisz		
	Christopher Rukas		
	Nick Shields		
	Jay Wheaton		
Guide	Dr. Cormier		

Test Strategy

1.1.3. Product Specifications and Pass/Fail Criteria

See **Attachment 1**.

Test Equipment

- Digital Microscope
- Tape Measure
- Calipers
- Stop Watch
- Manila Envelope
- Multimeter
- Profilometer
- Graduated Cylinder

Definitions, Important Terminology, Key Words

- Frame – Main support for 3-D Printer. Provides z axis travel. Main platform for holding layers of powder.
- Chassis – Build box. Moves along z axis travel and provides x axis travel for carriage.
- Carriage – Moves along chassis and provides y axis travel for sprayer. Also carries various powder spreading tools (i.e. counter-rotating roller, doctor blade, tamper).
- Trough – Carries ProMetal powder.
- Sprayer – Atomizer for binder solution. Provides application method for binder.

2. MSD II WEEKS 2-3: FINAL TEST PLAN

Introduction: This test plan is used as a guideline for the ProMetal 3DP produced by team P11553 to verify that components and systems meet the specifications as defined in MSD 1.

Data Collection Plan

2.1.1. Test Template

See **Attachment 2**.

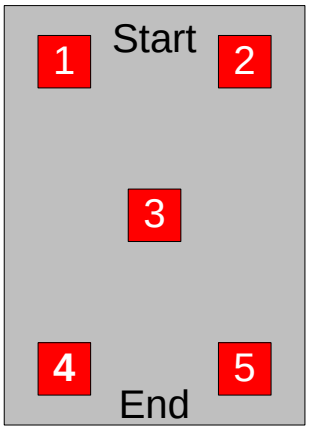
2.1.2. Data Collection Structure

Update list of tests to be performed (indicate test # and name, test description and so on).

2.1.3. Sampling Techniques

2.1.3.1. Printing Sampling Technique

Five (5) blocks will be printed. These will be located in the four corners of the printable area with a fifth block in the center. Their dimensions will be one inch wide, one inch long, and a quarter of an inch deep. As seen in the photo the five blocks will be printed in the red areas. This will be important when recording data.



2.1.3.2. Spreader Head Technique

Two spreader heads will be tested. A counter rotating roller and a doctor blade.

"How" to measure and any setup needed?

2.1.4. Sample Size

Each spreader head will be tested once. The data collected from the digital microscope will be analyzed on three different locations per surface.

2.1.5. Reporting Problems; Corrective Action

Test Procedure, timeline

Each subsystem interacts with other subsystems in the 3DP. Portions of testing may be completed before the system is fully assembled.

2.1.6. Frame

All tests pertaining to the frame will be completed by Nick Shields upon construction of the system.

2.1.7. Chassis

All tests pertaining to the chassis will be completed by Nick Shields upon construction of the system.

2.1.8. Carriage

All tests pertaining to the chassis will be completed by Jay Wheaton upon construction of the system.

2.1.9. Trough

All tests pertaining to the trough will be completed by Jay Wheaton upon construction of the system.

2.1.10. Sprayer

All tests pertaining to the binder application will be completed by Matt Rebisz upon construction of the system.

2.1.11. Controller

All tests pertaining to the controller and motors will be completed by Chris Rukas upon construction of the system.

2.1.12. Printed Parts

All tests pertaining to printed parts will be completed by Carlos Bu after construction of the system.

3. MSD II – WKS 3-10 DESIGN VERIFICATION

Test Results

Test results are to be entered here.

Logistics

All testing shall be recorded on the provided test plan, initialed, and dated. A full copy of this test plan will be kept with the 3DP. Formal write-ups will be performed in this document and uploaded to Edge and Google Docs as changes occur.

Analysis of Data – Design Summary

Analysis of data to be entered here.

Conclusion or Design Summary

Can you explain why a particular function doesn't work? Conclusions are reported or summarized (i.e. significance with confidence, pass/fail, etc.) as applicable.

3.1.1. Lab Demo with your Guide and Faculty Consultants

Perform each of the specifications and features.

3.1.2. Meeting with Sponsor

See Customer Acceptance above. Field Demonstration. Deliver the project. Demonstrate to the Sponsor. Customer needs met / not met.

Attachment 1

Crit. #	Description	Critical Value	Nominal Value	Units
Frame				
1.1	The frame provides a vertical path of travel.	90	$\pm$ 1	Degrees
1.2	The frame provides a set length of travel	6	+ 1	Inches
1.3	The frame does not fail under loading	True	True	Boolean
Chassis				
2.1	The chassis moves vertically while loaded with powder	True	True	Boolean
2.2	The chassis provides a horizontal path of travel.	0	$\pm$ 1	Degrees
2.3	Z axis resolution	60	< 100	µm
2.4	Chassis velocity (z axis)			in/s
2.5	The chassis does not fail under loading	True	True	Boolean
Carriage				
3.1	The carriage moves while loaded with powder	True	True	Boolean
3.2	Carriage velocity (x axis)			in/s
Trough				
4.1	The trough door opens	True	True	Boolean
4.2	Powder falls through trough door opening	True	True	Boolean
Sprayer				
5.1	The sprayer shall travel in the y axis along the carriage.	True	True	Boolean
5.2	The sprayer shall supply uninterrupted binder for a full pass across the printed surface	18	$\pm$ 2	Inches
5.3	The sprayer shall supply an evenly distributed spray pattern.			
5.4	Sprayer travel velocity (y axis)			in/s
5.5	Sprayer flow rate			$\frac{cm^3}{s}$
Controller				
6.1	The microcontroller is programmable	True	True	Boolean
6.2	All motors respond to programming	True	True	Boolean
Printed Parts				
7.1	Powder density variation in x-y plane	1	< 5	%
7.2	Powder density variation along z axis	1	< 5	%
7.3	Surface roughness	50	< 100	µm

Note:

1. Any tests missing nominal values are desired for informational purposes and are not required by customer needs or engineering specifications.
2. X axis is lengthwise. Y axis is widthwise. Z axis is normal to X and Y axis.

Attachment 2

Frame

Test #	Description	Value	Units	Pass / Fail	Initials	Test Date
1.1	The frame provides a vertical path of travel.		Degrees			
1.1.1	Pillar 1 is vertical		Degrees			
1.1.2	Pillar 2 is vertical		Degrees			
1.1.3	Pillar 3 is vertical		Degrees			
1.1.4	Pillar 4 is vertical		Degrees			
1.2	The frame provides a set length of travel		Inches			
1.2.1	Pillar 1 provides a set length of travel		Inches			
1.2.2	Pillar 2 provides a set length of travel		Inches			
1.2.3	Pillar 3 provides a set length of travel		Inches			
1.2.4	Pillar 4 provides a set length of travel		Inches			
1.3	The frame does not fail under loading		Boolean			

Chassis

Test #	Description	Value	Units	Pass / Fail	Initials	Test Date
2.1	The chassis moves vertically while loaded with powder		Boolean			
2.2	The chassis provides a horizontal path of travel.		Degrees			
2.3	Z axis resolution		µm			
2.4	Chassis velocity (z axis)		in/s			
2.5	The chassis does not fail under loading		Boolean			

Carriage

Test #	Description	Value	Units	Pass / Fail	Initials	Test Date
3.1	The carriage moves while loaded with powder		Boolean			
3.2	Carriage velocity (x axis)		in/s			
3.1	The carriage moves while loaded with powder		Boolean			

Trough

Test #	Description	Value	Units	Pass / Fail	Initials	Test Date
4.1	The trough door opens		Boolean			
4.2	Powder falls through trough door opening		Boolean			

Attachment 2

Sprayer

Test #	Description	Value	Units	Pass / Fail	Initials	Test Date
5.1	The sprayer shall travel in the y axis along the carriage.		Boolean			
5.2	The sprayer shall supply uninterrupted binder for a full pass across the printed surface		Inches			
5.3	The sprayer shall supply an evenly distributed spray pattern.					
5.4	Sprayer travel velocity (y axis)		cm/s			
5.5	Sprayer flow rate		$\frac{cm^3}{s}$			

Controller

Test #	Description	Value	Units	Pass / Fail	Initials	Test Date
6.1	The microcontroller is programmable		Boolean			
6.2	All motors respond to programming		Boolean			
6.2.1	Y axis motor responds to programming		Boolean			
6.2.2	Z axis motor responds to programming		Boolean			
6.2.3	X axis motor responds to programming		Boolean			
6.2.4	Roller motor responds to programming		Boolean			
6.2.5	Solenoid responds to programming		Boolean			
6.2.6	Syringe motor responds to programming		Boolean			

Printed Parts

Test #	Description	Value	Units	Pass / Fail	Initials	Test Date
7.1	Powder density variation in x-y plane		%			
7.2	Powder density variation along z axis		%			
7.3	Surface roughness		µm			

Attachment 3

Printed parts

Block Number	Spreading Head	Surface Roughness	Particle Count	Density	Initials	Test Date
1	Counter-Rotating Roller					
1	Counter-Rotating Roller					
1	Counter-Rotating Roller					
2	Counter-Rotating Roller					
2	Counter-Rotating Roller					
2	Counter-Rotating Roller					
3	Counter-Rotating Roller					
3	Counter-Rotating Roller					
3	Counter-Rotating Roller					
4	Counter-Rotating Roller					
4	Counter-Rotating Roller					
4	Counter-Rotating Roller					
5	Counter-Rotating Roller					
5	Counter-Rotating Roller					
5	Counter-Rotating Roller					

Block Number	Spreading Head	Surface Roughness	Particle Count	Density	Initials	Test Date
1	Doctor Blade					
1	Doctor Blade					
1	Doctor Blade					
2	Doctor Blade					
2	Doctor Blade					
2	Doctor Blade					
3	Doctor Blade					
3	Doctor Blade					
3	Doctor Blade					
4	Doctor Blade					
4	Doctor Blade					
4	Doctor Blade					
5	Doctor Blade					
5	Doctor Blade					
5	Doctor Blade					