**Multidisciplinary Senior Design Project**

**GE 497**

**College of Engineering**

**Valparaiso University**

**Valparaiso, Indiana**



**Finalized Test Plan**

**for**

**Filament Recycling**

**Filament Recycling Squad**

**Date: March, 22 2020**

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| Prepared by: | **Filament Recycling Squad** |  |
| Concurrence: | Professor Blood | Initials: |
| Approved (Customer): | Adam Johnson | Initials: |
| Approved (Team Leader): | Connor Cassaro | Initials: CC |

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**Honor Code Statement**

I have neither given or received, nor have I tolerated other’s use of unauthorized aid.

Connor Cassaro Munib Rashad

Connor Cassaro Munib Rashad

Nicole Pomeroy Jon Bayert

Nicole Pomeroy Jon Bayert

Alec Rich  *Paul Oscar Benbow*

Alec Rich Oscar Benbow

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# TEST PROGRAM

## PROGRAM OBJECTIVE

This test program will verify that the Filament Recycler either satisfies or fails to satisfy its design requirements as identified in Appendix A.

## SCOPE OF EFFORT

The article to be tested is the extrusion machine for filament recycling. There are 15 requirements that will be tested through 5 different tests as laid out in Section 2.

## ADMINISTRATION

* Obtain the shredded plastic from Adam. (Oscar)
* Secure a location for testing. (Munib)
* Acquire correct testing equipment. (Alec and Jon)

# TEST SUPPORT REQUIREMENTS

The five tests discussed below will verify if the filament recycler meets the thirteen system design requirements that are stated in the SDRD. These 5 tests are: Filament Test (1), Dimension Test (2), UI Test (3), External Test (4) and Powerloss Test (5).

## FILAMENT TEST

* + 1. Design Requirements Tested
       1. SDRD 3.1 The barrel nozzle shall maintain a temperature accuracy of ± 2.5 degrees Celsius from the set value.
       2. SDRD 3.2 The output filament diameter shall be 1.75 ± 0.05 mm.
       3. SDRD 3.3 The filament shall be extruded onto a nominally 1 kg spool.
       4. SDRD 3.5 The system shall be capable of extrusion at a rate of at least 0.2 kg per hour.
    2. Description of Test
       1. The goal is to test the normal functioning of the machine. At the First the hopper should be filled and the recycler should be turned on. We will run the system for 1 hour. Every 10 minutes barrel nozzle temperature reading will be taken using a thermocouple and will be compared with the expected value. Using a micrometer, diameter of the output filament will be measured every 10 minutes as well and will be compared to the expected diameter of 1.75 ± 0.05 mm. Also confirm that the measured diameter is the same as the in house diameter sensor. Weight of the spool will be measured every 10 minutes and from the weight extrusion rate will be calculated and compared to the desired rate of 0.2 kg per hour.
    3. Resources Required
       1. Mechanical Requirements
          1. A thermocouple is required to measure up to 180 degrees. This will be used to test the barrel temperature.
          2. Micrometer is needed to measure the diameter of the output filament.
          3. Recycled Filaments will be mixed in hopper, melted and extruded in the barrel inorder to produce new usable filament.
          4. Virgin Filament will be mixed in hopper, melted and extruded in the barrel inorder to produce new usable filament.
       2. Video Requirements
          1. A video camera to record the demonstration.
    4. Justification
       1. SDRD 3.1 This test will show that the barrel nozzle will remain within 2.5 degrees Celsius by measuring the temperature over the length of the test.
       2. SDRD 3.2 This test will observe the diameter of the output filament and record the average. This will show if the diameter is between 1.75 ± 0.05 mm.
       3. SDRD 3.3 This test will show that the recycler can be loaded with a nominally 1 kg spool.
       4. SDRD 3.5 This test will record the rate of output to show that the system is capable of extrusion at a rate of at least 0.2 kg per hour.
       5. SDRD 2.2 This test will show that the inhouse sensor that was designed is functioning correctly.

## DIMENSION TEST

* + 1. Design Requirements Tested
       1. SDRD 2.1 The system shall fit in a cuboid with dimensions of 82 inches by 50 inches by 46 inches.
       2. SDRD 3.4 The system shall accept shredded plastic with no dimension exceeding 7 mm.
       3. SDRD 4.4 Any opening of the system shall comply with Table O-10 of OSHA 29 CFR 1910.217(c)(2)(i)(a) and 1910.217(c)(2)(i)(b).
    2. Description of Test
       1. The system’s length, width, and height will be recorded at the points where the measurements are greatest and compared to the dimensions given. Additionally, a guard-opening scale will be attempted to be inserted into hazardous areas of the system to ensure compliance with OSHA standards. Furthermore, we will attempt to process plastic chips with dimensions averaging 7mm.
    3. Resources Required
       1. Mechanical Requirements
          1. Shredded plastic to ensure that the system can properly handle plastic measuring 7mm in any dimension.
          2. Tape measure to measure the dimensions of the system.
          3. Guard-Opening Scale to ensure that objects cannot be inserted into the system’s hazardous areas.
    4. Justification
       1. SDRD 2.1 This test shall prove that the system does not exceed the given specifications.
       2. SDRD 3.4 The test shall prove that objects with certain dimensions will not be able to come into contact with hazardous parts of the system.
       3. SDRD 4.4 The test shall prove that the system can accept plastic with dimensions up to 7mm.

## UI TEST

* + 1. Design Requirements Tested
       1. SDRD 5.2 The system shall allow for manual temperature control between 130 and 180 degrees Celsius.
       2. SDRD 5.3 The system shall allow for manual flow rate control between 0.1 kg and 0.2 kg per hour.
       3. SDRD 5.4 The system shall display the current temperatures of the nozzle.
    2. Description of Test
       1. The user interface(s) will be able to allow the user to change the recycler’s active temperature freely between 130 and 180 degrees celsius with the temperature value correctly displayed. There will also be an option for the user to control the speed from 0.1kg of plastic per hour to at least 0.2kg per hour.
    3. Resources Required
       1. Mechanical Requirements
          1. Thermocouple probe to measure temperatures of the barrel to check accuracy of user inputs.
          2. Tape Measure to record changes in length of extruded filament.
          3. Time recording device to put length changes in terms of time.
    4. Justification
       1. SDRD 5.2 is tested and verified based on the readings of a thermocouple probe on the heated barrel over an extended period of time.
       2. SDRD 5.3 is tested and verified by measuring the rate at which filament is extruded at different motor speeds.
       3. SDRD 5.4 is tested and verified by the value associated with the user interface matching the thermocouple probe and the desired temperature.

## EXTERNAL TEST

* + 1. Design Requirements Tested
       1. SDRD 4.3. The system shall be built such that external surfaces that can be touched will not exceed temperatures of 49 degrees Celsius.
       2. SDRD 1.1 The system shall be able to use an input between 95-125 VAC or 195-255 VAC at 60Hz.
    2. Description of Test
       1. The system will be connected to a nominally 110 VAC outlet and turned on to see if it is powered. The system will then be connected to a nominally 220VAC outlet and turned on to see if it is powered. Once powered on the system will be turned on to the highest temperature possible and left to reach full temperature for 30 minutes. Once at full temperature a thermocouple probe will be moved throughout the system to verify that all surfaces within reach are less than 49 degrees Celsius.

* + 1. Resources Required
       1. Mechanical Requirements
          1. Thermocouple probe to be used to measure temperatures of the system.
       2. Electrical Requirements
          1. Nominally 110 VAC outlet to power system.
          2. Nominally 220 VAC outlet to power system.
          3. Nominal 220 VAC power cord to plug it in.
    2. Justification
       1. SDRD 1.1 is tested and verified by powering the system off of nominally 110 and 220 VAC to ensure that the extruder can be operated off of both so that the user can plug it in at any location.
       2. SDRD 4.3 is tested and verified by ensuring that the temperature of any surface that can be touched by an operator will be at a temperature that will not cause burns.

## POWER LOSS TEST

* + 1. Design Requirements Tested
       1. SDRD 4.1 The system shall cut off power within 1 second of using the emergency stop.
       2. SDRD 4.2 The system’s mechanical components shall stop within 5 seconds of using the emergency stop.
       3. SDRD 5.1 The system shall maintain storage specified settings even after power loss.
    2. Description of Test
       1. The system shall be run so that it has been outputting filament for at least 3 minutes and the power will be cut off via the emergency stop as well as a simulated power outage by unplugging the machine. Once this is done the power cut off time will be measured for the electronic system, the mechanical system will also be tested by recording the time it takes the moving parts to stop. Then turn the system back on and check for the stored data for temperature control as well as the extrusion speed.
    3. Resources Required.
       1. Mechanical Requirements
          1. Stopwatch to measure stoppage time.
       2. Electrical Requirements
          1. LED for power loss indication.
       3. Video Requirements
          1. Video camera to review stoppage times.
    4. Justification
       1. SDRD 4.1 is tested and verified by the timing of the LED light going off. The timing of the light going off being recorded in the same view as the emergency stop button and power cord being used with give us the amount of time it takes for the system to cut off power
       2. SDRD 4.2 is tested and verified by the timing of the moving parts coming to a complete stop. The time it takes to come to a stop will be recorded with the moving parts in the same view of the stopwatch and the button and power cord being used.
       3. SDRD 5.1 is tested and verified by the system losing power and needing to be turned back on and used again. When the power is cut to the system for the other requirements the system will be turned back on to be tested again and doing so the stored settings will be referenced.

# SUPPORTING INFORMATION

## REFERENCED DOCUMENTS

1910.217 - Mechanical power presses. (n.d.). Retrieved August 27, 2020, from https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.217

OSHA Compliant Guard-Opening Scale, Measuring Device. (2020, February 03). Retrieved August 27, 2020, from https://www.rockfordsystems.com/product/osha-guard-opening-scale/

## SYMBOLS AND ABBREVIATIONS

PLA - Polylactic acid is a filament used for 3d printer

SDRD - System Design Requirements Document

VAC - Volts of Alternating Current

UI - User Interface

# DISTRIBUTION

(Original) Team Leader  
(1) Advisor