Team 501 Targets and Metrics

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Table of Contents

Targets and Metrics 3

Target and Metric Explanations 4

Separates Powder from the Part – Mass 4

Transports Powder to a Container – Mass 4

Hold the Part in the Area – Volume and Force 5

Insulate the User from the powder – Safety Standards 6

Prevents Powder Contamination – Relative Moisture 7

Functionless Targets and Metrics 8

Time to Operate 8

Cost to Operate 9

Size and Footprint 9

Critical Targets and Metrics 10

Target and Metrics Summary 10

Target Catalog 11

References 12

Targets and Metrics

After the functions were determined through functional decomposition, each one had their targets and metrics established. A metric is defined as a method to validate a function, while a target is the specific value used for validation. The targets and metrics will be used to test and validate concepts or prototypes later in the design process. These were found during a group ideation session which started with finding the targets and metrics for each function we had from the functional decomposition. Later in the ideation session, new targets were explored that were necessary but didn't have a respective function. The figure below shows the simple breakdown of targets and metrics derived from the functional decomposition.

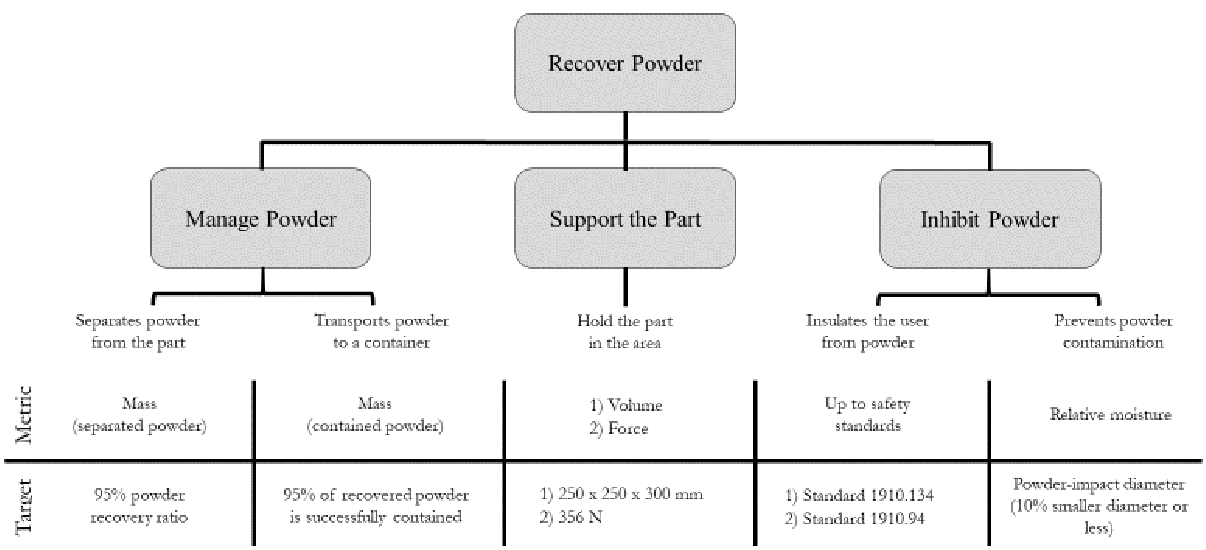

Figure 1. Targets and Metrics for each of the established functions.

Target and Metric Explanations

This section aims to explain the reasoning behind each target and metric. Each explanation will provide a background, derivation, method of validation, and a general discussion. After each has been explained, the information will be tabulated in a catalog later.

Separates Powder from the Part – Mass

Separating the powder is a critical function of the process. Failure to separate the powder from the part defeats the purpose of the product. The metric used to measure the amount of powder recovered from the part will be the mass of the powder. The target is to recover 95% of unused powder in each part compared to the current value of 90% powder recovery provided by our sponsor.

A baseline value will be used for comparison. The baseline will be mass (and calculated percentage) of the recovered powder after a test print using the current powder recovery method. This should be the noted value of 90%. This will then be compared to the same part printed with the new powder recovery method. The mass before and after a recovery step will be noted. Depending where our product will go in the process, the relative steps will be weighed to validate the amount of powder recovered. These masses will be used to measure the percent of powder recovered compared to the used powder.

Transports Powder to a Container – Mass

Transporting the powder to the container is also a critical function. It is critical because the recovered powder must be able to be transported after recovery for later reuse. This requires a containment system, so our product will transport the recovered powder to a container. The metric used to determine the success of this function will be the mass of recovered powder that makes it into the container. The target to reach is containing 95% of the recovered powder. Since the powder particles have a diameter of 10 - 15 microns, successful storage of 100% of the powder is improbable. This is because the small particles can disperse, wedge into crevices, and stick to objects.

To validate this function, our team will record the initial mass of the powder collected, followed by the mass of said powder once transferred into a storage container. The initial mass will be quantified by measuring the mass of the part before and after our product is used. The difference in the before and after masses is the mass of recovered powder. The mass of the contained powder will be found by simply weighing it on a scale.

Hold the Part in the Area – Volume and Force

The function of holding the part in the area is important in making powder recovery more efficient. The metric to measure this is the build volume of the printer. If our product is to hold the part and plate, we must be able to hold any parts within the total build volume of the printer. Therefore, our product must not limit the capabilities of the printer by reducing the maximum print size. The target is determined simply since the printer's maximum print volume dimensions are already known, being 250 mm x 250 mm x 300 mm.

Ensuring this target is met can be accomplished in several ways, one of them being computer simulation. The product can be simulated in a CAD program, where the volume can be created and any conflict in the geometry of the volume with other components will be apparent. Another way to validate this metric would be a physical model. A model of the product can be made, and the dimensions can be measured with a measuring tape to ensure no conflicts occur.

Holding the part in the area will also involve holding the weight of the part, excess powder, build plate, and mounting plate. The product must be able to support all this weight throughout the recovery process. Failure to achieve this would likely be catastrophic. With the metric being mass, the target would need to be the force these components inflict on the product. The target was determined to be the ability of our product to support 356 N of force.

356 N of force was found by assuming that no larger than a fourth of the max build volume would be printed. This same assumption was used to calculate the volume of the powder to be a mass of 36.33 kg. This allows for more than triple the weight when compared to the 11.33 kg typical part mass given by the project sponsor. The metric can be validated in three ways. The first is by applying a 356 N load to a concept or prototype. The other two methods of validation are force analysis and the utilization of a CAD program. The product could be modeled in both methods to ensure it can support the 356 N force.

Insulate the User from the powder – Safety Standards

Insulating the user from the powder is another function of the product. The target associated with this function would be following established safety codes for handling fine powder. Because the safety standards would vary for different concepts, the two most probable safety codes to meet will be covered. The first will be personal air filtration. The second will be utilizing an enclosure. The metric for personal air filtration will be the 1910.134 standard from Occupational Safety and Health Administration (OSHA). The metric for the utilization of an enclosure will be the 1910.94 standard from OSHA.

These metrics were established based on information from our sponsor. He told us that they use a powered air purifying respirator (PAPR) for unenclosed processes, and a sandblasting hood for enclosed processes. Based on the location of our system, we must meet the standards described by OSHA. This makes the data in the safety codes our target.

These targets will be validated by direct comparison to the safety standards. The systems must meet these codes to ensure operator safety and fulfill the function of insulating the user from the powder. These standards will most likely be satisfied by utilizing the equipment that our sponsor already uses in the lab. This equipment is already up to standard, so we can simply utilize them as part of our design to meet this target.

Prevents Powder Contamination – Relative Moisture

Preventing the contamination of powder is a critical function for this project. Moisture is the specific contamination that we must design around. If the powder gets too moist, it can lose the essential properties that allow it to be used for additive manufacturing. The metric to be used for this function is the relative moisture content. The relative moisture will be found by utilizing a simple impact test. This test results in a powder spread that can have its diameter directly measured. The target for this function is for the recovered powder's diameter to be less than 10% smaller than the as-purchased powder.

The specific test that will be done is an impact test. A constant volume, particularly a teaspoon measuring tool, will be used to make two identical powder mounds. One mound would be the recycled powder, and the other would be as-purchased powder. A constant weight, particularly a metal round ball, will be dropped from a constant height on both of the powder mounds. As the metal ball hits the powder, the powder mound will spread on impact. If the recovered powder is contaminated beyond use, its impact powder spread will be different than that of the as-purchased powder. This spread will be directly measured, and if the recovered powder spread is over 10% smaller than the as-purchased spread, it is contaminated.

Functionless Targets and Metrics

There are often functionless metrics that must be considered to measure the success of a project. These are metrics that don't have a specific function they correlate to, but they are still relevant. There are three functionless targets and metrics for this specific project that will be covered now.

Time to Operate

The time that our product needs to operate is important for the efficiency of the system. There is a balance of time required and output for any system. If our product required a week to improve the powder recovery from 90% to 95% it would be exceptionally inefficient. Therefore, a time range is an established metric of this system. The target to meet is 12 hours. The system should be able to operate to its target recovery output in under 12 hours.

This time period was chosen because it loosely correlates to letting the product run overnight. The best example of this is starting the product at 7pm, and then it would be done at 7am the following morning. This is well outside of the general work hours, making it a feasible target. This target will be validated by measuring the required operating time. It is also important to note that this is the largest allowable time for any generated device. A chosen design may not require more than just a few minutes, and that still validated this target.

Cost to Operate

The cost required to operate the device is important for the validity of the design. The cost of running the device should be as low as possible, but it should not exceed the cost of the amount of powder recovered. The target is to not cost more than $95 per 100 grams recovered. This is a function of the amount of powder recovered, but this metric can be validated by keeping this ratio in mind.

The cost to operate the device greatly depends on the chosen design. The way to calculate the cost to run may be related to anything from electricity used to man hours required. Because of this, the method of validation will be simply put as the product should not cost more than $95 per 100 grams it generated to operate. The method to calculate the cost to run will be determined once the concept is selected.

Size and Footprint

The size of the generated product is important for the ergonomics of the system. The product is considered suboptimal if it takes up a large amount of space. Because the size would vary for different concepts, the two most probable size targets will be covered. The first will be outside of an enclosure, and the second will be inside an enclosure. The target for outside will be a footprint no larger than 770 x 1,350 mm and a height no larger than 2,000 mm. The target for inside of an enclosure will be a footprint no larger than 1,210 x 730 mm and a height no larger than 940 mm.

These dimensions were found by comparing the future product to the size of a sandblasting cabinet used currently. If the product is designed to fit inside of the sandblaster, it must be physically smaller than the working volume. That is how the dimensions for inside the enclosure were found. If the product is designed to fit outside of an enclosure, it shouldn't be larger than the size of the sandblasting cabinet. This was determined because adding an object similar in size to the sandblasting cabinet would be feasible for this lab environment. This is how the dimensions for outside of the enclosure were found.

Critical Targets and Metrics

The critical targets and metrics directly correspond to the critical functions generated from our functional decomposition. The targets for the three most important functions are the critical targets of this project. The ranking of the functions was done using a cross-reference table. This table can be seen in the functional decomposition section. The three most critical targets are those relating to the contamination, separation, and transportation of the powder.

Target and Metrics Summary

The targets and metrics were generated to identify methods to validate each function. These were found by considering the ways to test if the function's purpose is met and researching a proper value for validation. Three functionless targets were also found that are needed to quantify the cost, time, and size of the product. These targets and metrics will be used to aid in concept selection in the future. The tools needed for validation are a measuring tape, scale, stopwatch, and a CAD program. A catalog of each target can be found on the following page. This catalog includes all the discussed targets, metrics, and their method of validation. The functions that are bolded correspond to the critical functions, and therefore the critical targets as well.

Target Catalog

Target Catalog			
Functions	Metrics	Targets	Method of Validation
Hold the Part in the Area	Volume	250 x 250 x 300 mm	Dimensioning (via measuring device) and CAD
	Force	356 N	Physical weight, Force Calculations, and CAD
Separates Powder	**Mass of Separated Powder**	**95% recovered powder**	**Mass of separated powder compared to a baseline of previous methods**
Transports Powder to Container	**Mass of Contained Powder**	**95% transferred powder**	**Mass of contained powder compared to mass of separated powder**
Insulates User from Powder	Up to safety standards	PAPR Codes/Airtight Enclosures	Compare data to OSHA standards
Prevent Contamination of Powder	**Relative moisture**	**10% difference in recovered powder spread**	**Powder impact test to compare recovered powder to as-received powder**
Functionless	Time to operate	12 hours	Measure the time needed for the powder recovery system to operate
Functionless	Cost to operate	$95 per 100 g recovered	Cost to operate the product
Functionless	Overall Size/Footprint	Outside Enclosure: 770 x 1,350 mm footprint and 2,000 mm height	Dimensioning (via measuring device) and CAD
		Inside Enclosure: 1,210 x 730 mm footprint and 940 mm height	Dimensioning (via measuring device) and CAD

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