



EML 4551 Senior Design Project Organization

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REQUIREMENT FOR THE DEGREE OF
BACHELOR OF SCIENCE
IN
MECHANICAL ENGINEERING

MATERIAL SELECTION MECHANISM

25% Report

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This B.S. thesis is written in partial fulfillment of the requirements in EML 4551.
The contents represent the opinion of the authors and not the Department of
Mechanical and Materials Engineering.

Ethics Statement and Signatures

The work submitted in this B.S. thesis is solely prepared by a team consisting of Hernando Garcia, Juan Rocha, and Mahdi Mohhamadpour and it is original. Excerpts from others' work have been clearly identified, their work acknowledged within the text and listed in the list of references. All of the engineering drawings, computer programs, formulations, design work, prototype development and testing reported in this document are also original and prepared by the same team of students.

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ABSTRACT

Vinyl Corp, a division of Clark Dietrich Building Systems, has consistently been in the forefront of wall and ceiling accessories, manufacturing and innovation for stucco, plaster, drywall, veneer, and other applications.

In order to maximize material usage, Vinyl Corp recycles 100% of the material expelled from the punching dies; this material undergoes various stages of selection before it is put back for reprocess.

Currently, Vinyl Corp executes the collection and transportation of the material intended for recycling by hand; such procedure is highly ineffective, since it involves hand-picking and transportation of the material through the facility by means of hand-driven cargo carts.

The project to be developed will be designed and planned in partnership with Vinyl Corp. subsequently; the project is to be implemented in their manufacturing facility as an aid in material selection and recycling process.

PROBLEM STATEMENT

Vinyl Corp is in need of optimizing the present undergoing recycling process. As mentioned earlier, the design/project needs to be capable of minimizing the time spent in the sorting and selection of the material, and at the same time keeping the material free of contaminants during this process.

However, within the intended purpose of this particular mechanism, there are several details that one has to keep in mind before coming up with a final design. Such as, the system has to allow the operator to select whether interior or exterior material will be collected, transportation of the material needs to be above head level to maximize walking space through working stations, and energy usage has to be reduced.

Finally, all the knock-outs expelled by the punching dies, need to be further sorted by size, ranging from small pellets to approximately 1cm² flat pieces. Sorted material has to be collected at the end of the process in a common area where recycling will take place.

MOTIVATIONS

Based on the need of the company to improve a current process, an opportunity was presented to take action on this particular task. Approaching this matter as a Senior Design Project would allow the encounter of numerous aspects like: the involvement in a real life situation, the optimization of a current process, the introduction of innovative ideas, and the creation of a new system that takes into account accuracy, safety, and efficiency.

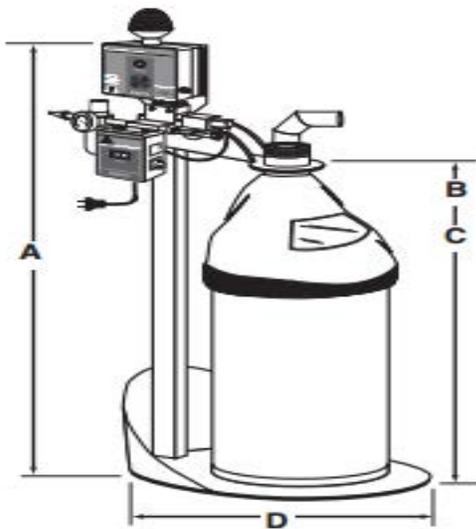
Moreover, it was decided to tackle this project as it offers not only to gain experience, but also to deal with several advanced concepts from different fields of engineering such as: structural analysis, transport phenomena, mechanical design, and computer aided design.

LITERATURE SURVEY

Alternative vacuum systems

1. CAML-EVB evacuation system and compressed air material loaders: This particular systems remove material from granulator bins. These devices are easily controlled with an on/off switch, and they use compressed air to perform the task. Using compressed air, the EVB evacuation system, moves material from the source to a receiving barrel. A fill sensor is added to the system to provide a fill alarm when the receptacle is full, when this happens, the drum can be changed, or the material can be simply removed to another station.

Table 1. EVB evacuation system [2]



MODELS	CAML-EVB
Performance characteristics	
Maximum throughput lb/hr {kg/hr}	700 {318}
Nominal throughput * lb/hr {kg/hr}	500 {227}
Maximum conveying distance ft {m}	20 {6}
Material line size in. {mm}	1.5 {38}
Dimensions inches {mm}	
A - Overall height with alarm option	57 {1448}
B - Maximum height, adjustable arm	46 {1168}
C - Minimum height, adjustable arm	30 {762}
D - Drum stand base diameter	25 {635}
Weight lbs {kg}	
Shipping	130 {59}
Installed	90 {41}
Voltages Total amps	
120V/1 phase/60 hz	1.0
Compressed air requirements	
Typical operating pressure psi {bars}	30 {2.1}
Consumption @ 60 psi #/min {liters/min}	8.25 {233.6}
NPT fitting	3/8 in.

Figure 1. EVB evacuation system Models [2]

2. Material Conveying with Pneumatic Vacuum Systems:

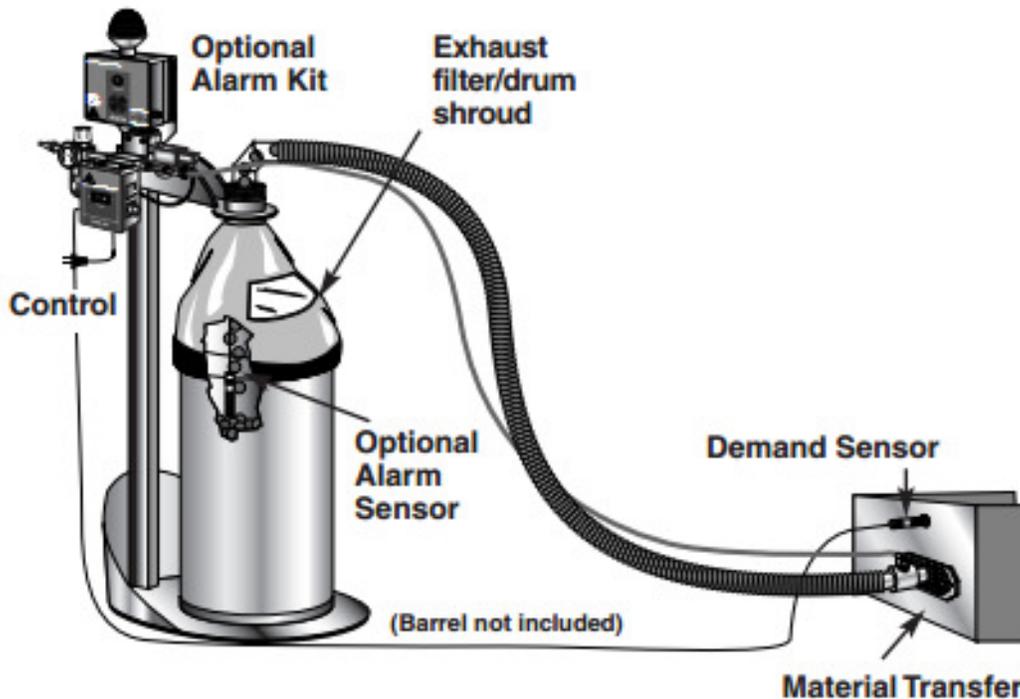


Figure 2. Material conveying with pneumatic vacuum systems [2]

Pneumatic conveying is a very significant operation in the manufacturing of many types of materials such as cement, sugar, salt, sand, oats and plastic pellets. These systems use high pressure air, ranging around 100psi, and reducing the pressures to around 15psi-45psi.

There are two main categories of pneumatic conveying; low- pressure and high-pressure systems. Other terms commonly used referring to low-pressure and high-pressure conveying systems are *Dilute Phase Pneumatic Conveying Systems* and *Dense Phase Systems* respectively. The first system uses air pressure at less than 15psi at the entry location, and exert either a positive or negative pressure to push or pull materials through the line at high volume and velocities. Such low-pressure system can be improved with

the addition of a low-pressure/high velocity blower; the source can be achieved with compressed air. Valve erosion and system piping can be significant issues depending on the nature of the material being conveyed, when operating at high velocities.

The second system, unlike the dilute phase pneumatic conveying systems, utilizes pressure between 15psi, and up to 50psi in the pipe, and uses positive pressure to move materials through the conveying line at low velocities. They are referred as high pressure/low velocity systems and have a low air to material ratio. This conveying technique uses small amounts of air to move larger amounts of solid material through the conveying line. Such process is mainly used when the material being conveyed is abrasive in nature; lower velocities decrease pipe and valve erosion in the system. This system requires a compressed air supply ranging from 35psi to 100psi.

Conveyor augers or screw conveyors

Conveyor augers or screw conveyors are one of the most common ways for material transportation. A screw conveyor or auger conveyor is a mechanism that uses a rotating helical screw blade, usually within a tube, to move liquid or granular materials. They are used in many bulk handling industries. Screw conveyors in modern industry are often used horizontally or at a slight incline as an efficient way to move semi-solid materials, including food waste, wood chips, aggregates, plastic pellets, cereal grains, and many others.



Figure 3. Rigid and Flexible Conveyor augers (screw conveyors) [4]

Filtering Systems

There are different types of filtering systems that exist for material sorting and removal. To filter the material using a screen is the common way. The three common types of screens are:

- Wedge-wire screen
- Square weave screen
- Dutch weave screen

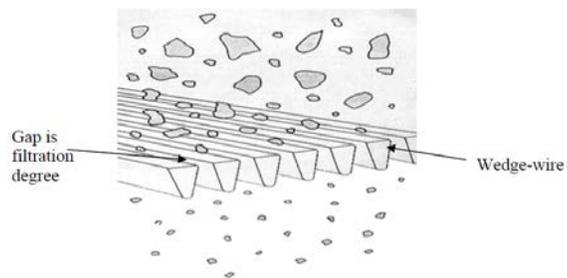


Figure 4. Wedge Wire Screen [5]

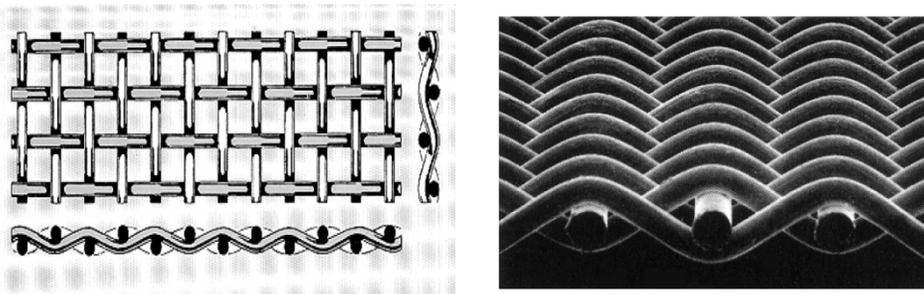


Figure 5. Square weave Screen and Dutch Weave Screen [5]

The filter application is wide around the world. Different industries use these kinds of filtering systems. Among them one can find:

- Wastewater industry
- Automotive industry
- Plastics industry
- Mining industry
- Food industry

In order to choose the appropriate filter one should consider the following important characteristics:

- Durability
- Efficiency
- Smoothness
- Environmental friendliness

PROJECT OBJECTIVES

The major goals for this project are: maximize facility's walking space by being able to design a system that will not only sort the material but also transport it to a recycling station, reduce material contamination by preventing the contact of the material with ground impurities, and finally reduce physical labor performed by the operators by eliminating material removal, sorting, and relocation by hand.

CONCEPTUAL DESIGN

In order to remove the punching die knock-outs (pellets) from collection receptacle, the vacuum system is implemented by using an air conveyor and air compressor. The material is categorized by the Y-valve and transferred for further sorting by size by using rotating drum filter.

Alternative Design

A flat vibrating mesh and rotating drum filter are two considered options for the sorting process.

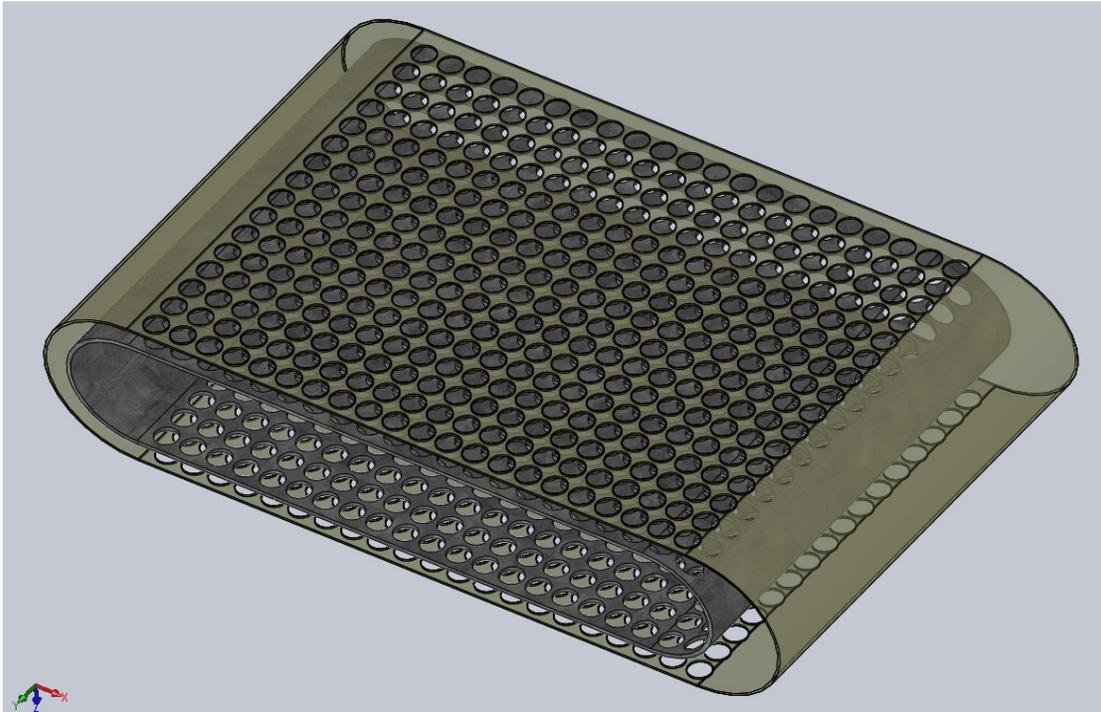


Figure 6. Flat Vibrating Filter

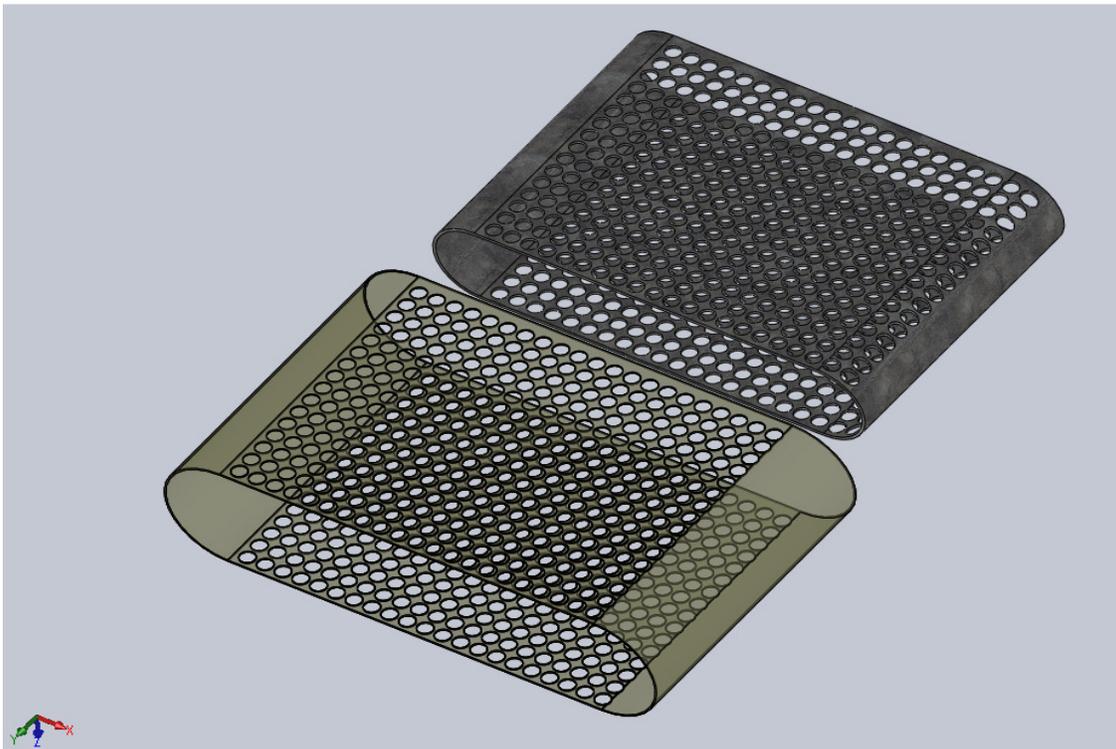


Figure 7. Flat Vibrating Filter Exploded View

PROPOSED DESIGN

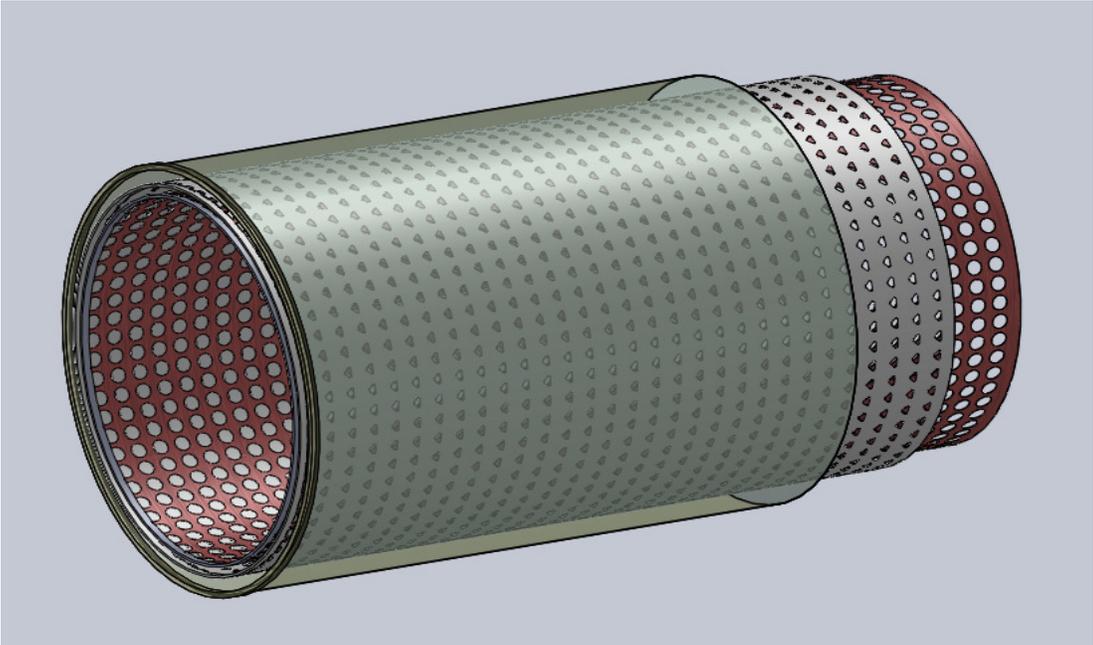


Figure 8. Filter Assembly

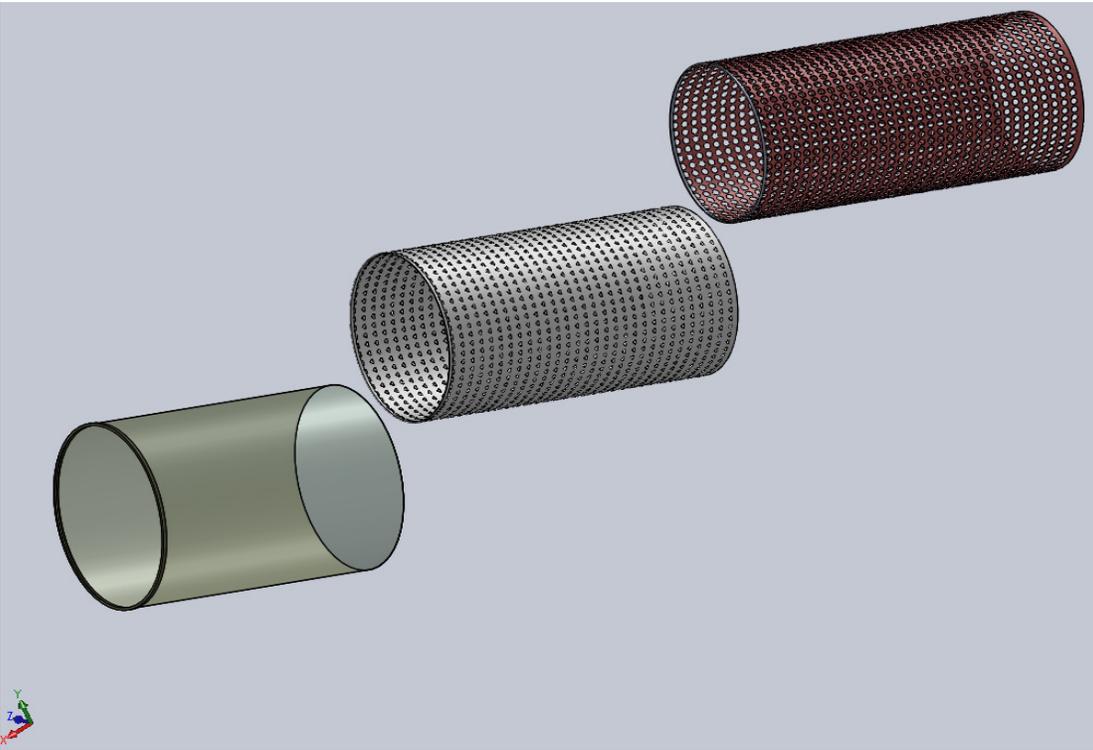


Figure 9. Filtering Exploded view

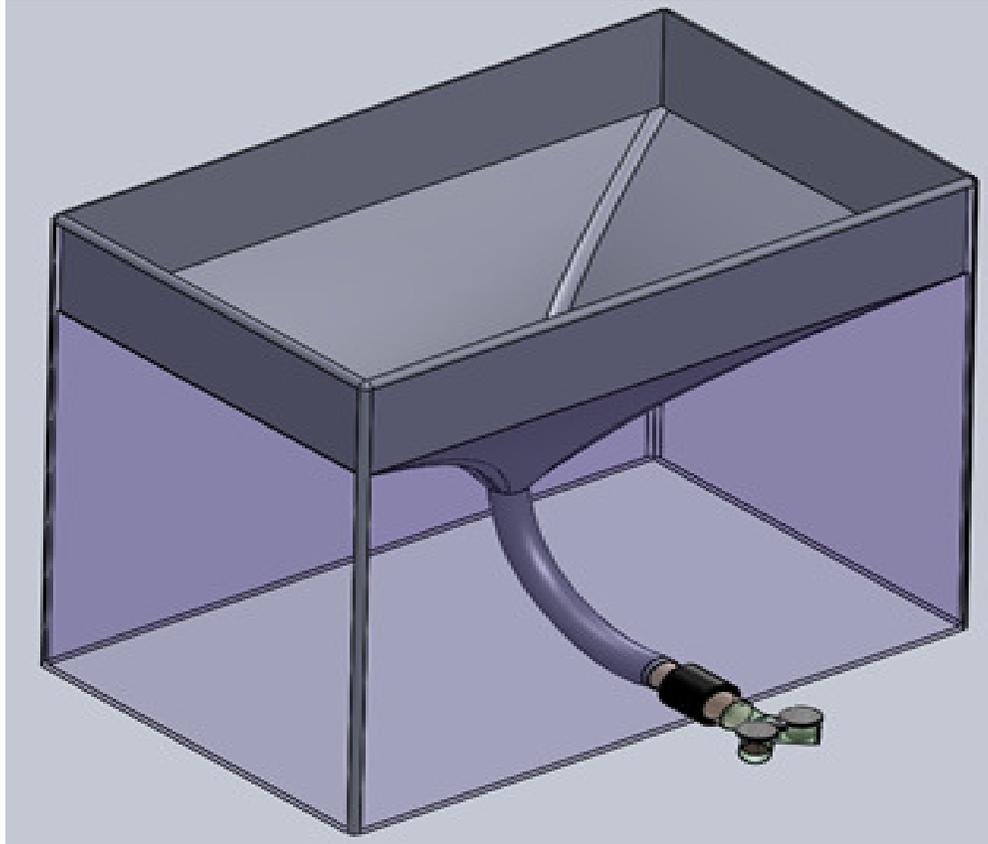


Figure 10. Collection Receptacle

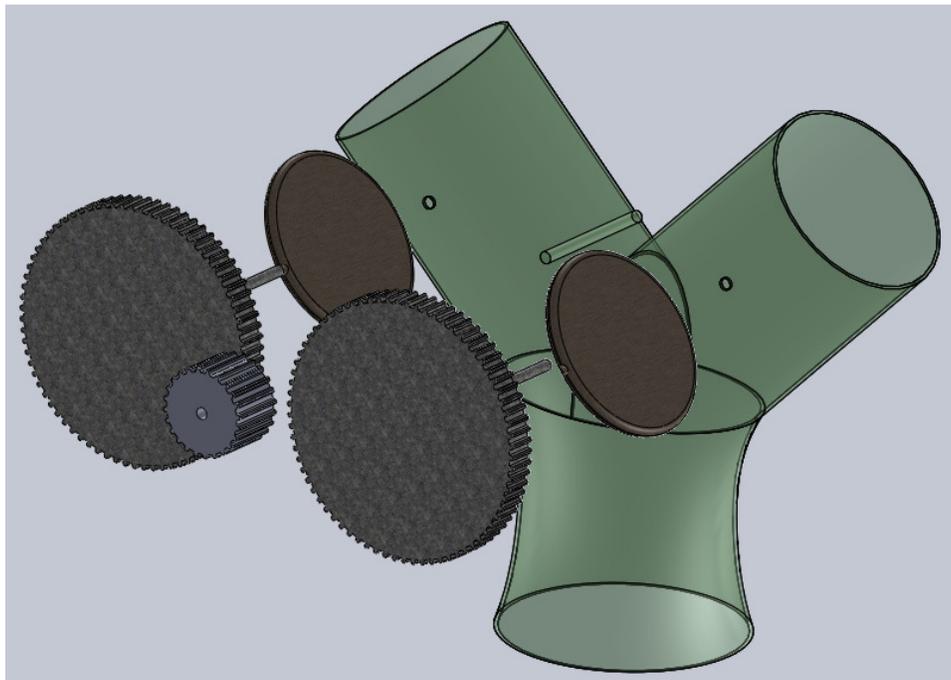


Figure 11. Material Categorizer (Y-Valve)

TIMELINE

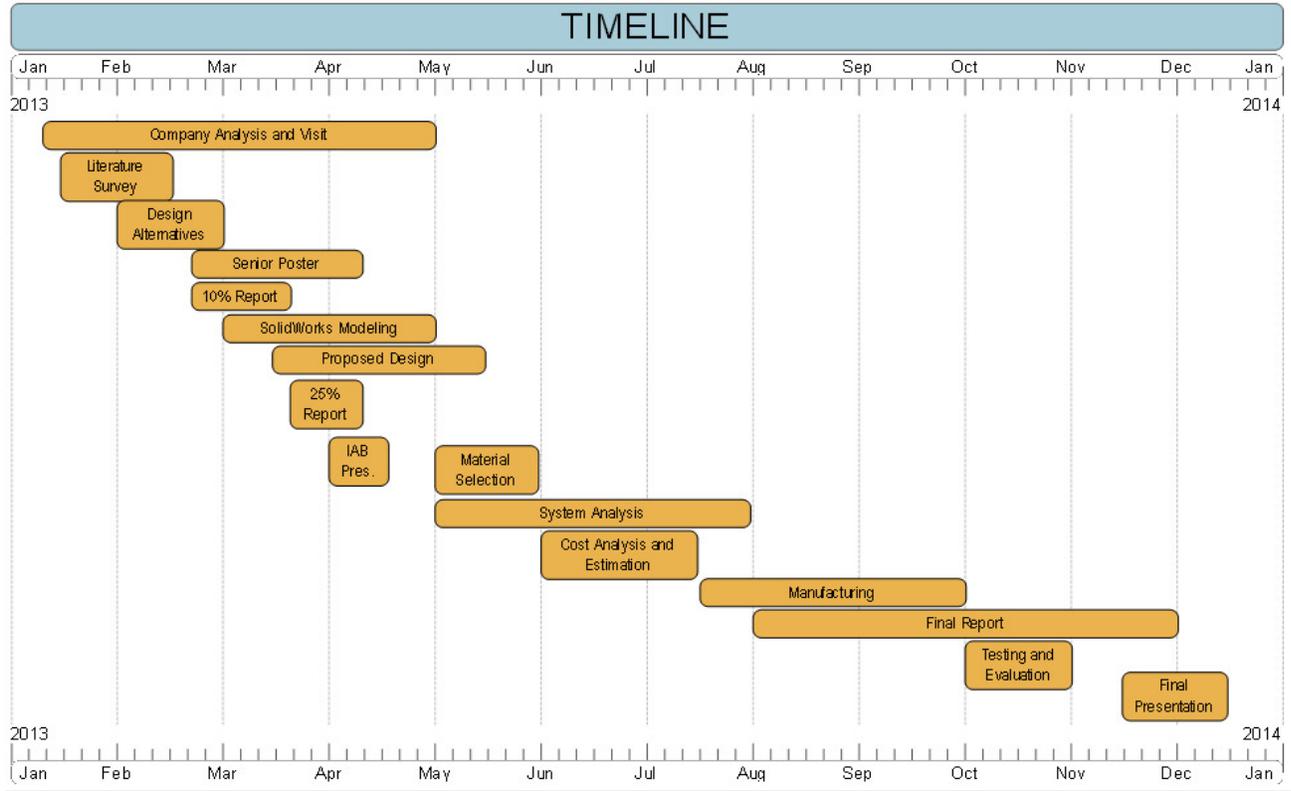


Figure 12. Timeline Chart

Table 2. Responsibilities

	<u>DESIGN</u>	<u>MANUFACTURING</u>	<u>ANALYSIS</u>	<u>REPORTS</u>	<u>PRESENTATION</u>
	02/2013 to 05/2013	07/2013 to 09/2013	05/2013 to 07/2013	02/2013 to 11/2013	04/2013 to 12/2013
JUAN ROCHA					
HERNANDO GARCIA					
MAHDI MOHAMMADPOUR					

ANALYTICAL ANALYSIS

Saving operational costs is one of the main goals of this project. One of the most important features of this design is that it is able to save electricity usage, by being loaded and unloaded as needed. Annual costs of electricity used to power a compressed air system are calculated as follows:

$$\frac{(\text{hp}) * (0.746 \text{ kW/hp}) * (\text{hr/yr}) * (\$/\text{kWh}) * (\% \text{ time}) * (\% \text{ full-load bhp})}{\text{motor efficiency}}$$

Where,

- Horsepower (hp)
- Conversion factor 0.746 kW/hp
- Total operating hours per year (hr/yr)
- Cost per kilowatt-hour (\$/kwh)
- % time fully-loaded or unloaded
- % full-load hp, loaded or unloaded

Divide the product by the motor's efficiency.

MAJOR COMPONENTS

The mechanism consists of five major components:

- Air Compressor
- Air Conveyor
- Pressure Regulator
- Rotating Drum Filter
- Material Categorizer (Y-Valve)



Figure 13. Major Components

The rotating drum filter and selection valve mechanism will be manufactured accordingly from simulation results. Air conveyor parameter has already been determined from experimentation.

Air compressor has a maximum pressure of 125 PSI. Pressure regulator adjusts an operating pressure for the system at 80 PSI.

STRUCTURAL DESIGN

The material selection process is achieved by the flow described (see figure 14)

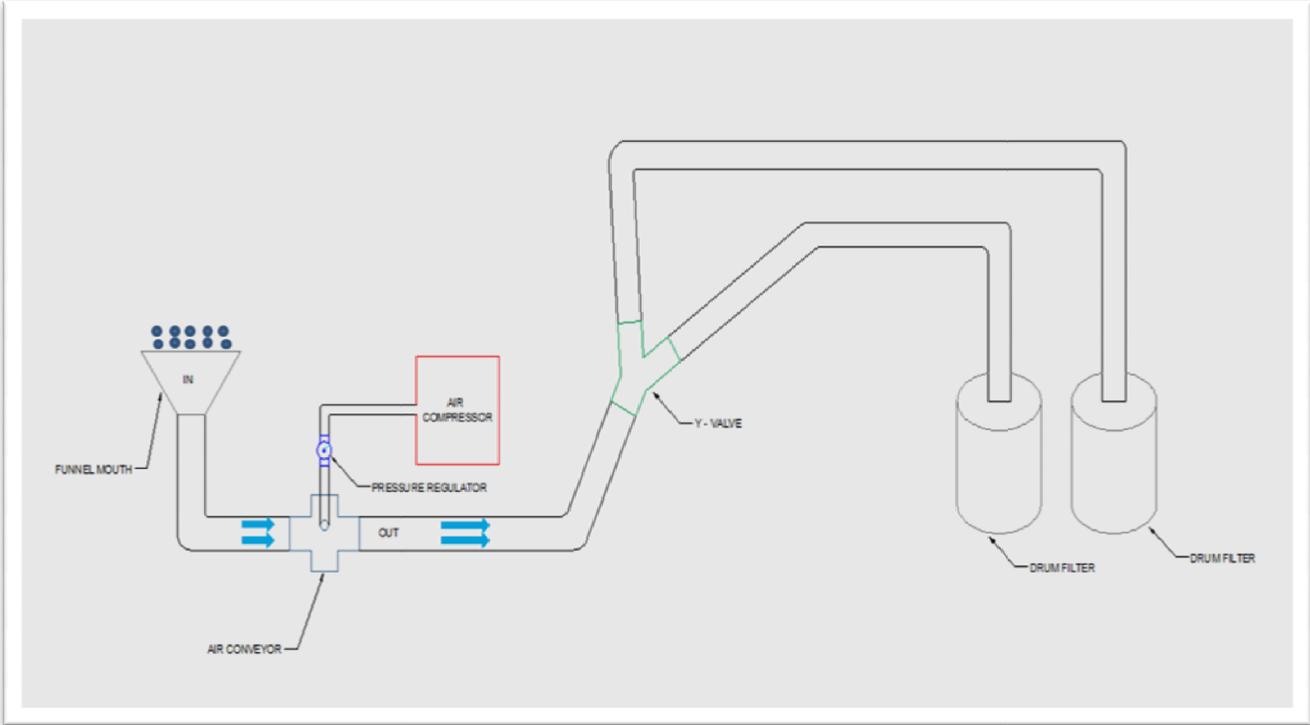


Figure 14. Prototype Concept

COST ANALYSIS

The mechanism has different components include:

- Air Compressor
- Air Conveyor
- Rotating Drum Filter
- Material Categorizer (Y-Valve)
- Piping system

The cost for the project was estimated.

Table 3. Cost Analysis

Component	COST
Air Compressor	\$245
Air Conveyor	\$210
Rotating Drum Filter	\$250
Material Categorizer (Y-Valve)	\$150
Pressure Regulator	\$75
Piping System	\$200
Total	\$1130

Table 4. Human Hours Spent

Responsibilities	Juan Rocha	Hernando Garcia	Mahdi Mohammadpour	Human hours spent
Design Alternatives	5	10	5	20
Proposed Design	10	5	10	25
Analytical Analysis	5	10	5	20
SolidWorks Modeling	10	10	5	25
Prototype Manufacturing	15	15	20	50
Testing	5	10	10	25
Report Preparation	10	10	10	30
			Total Hours	195

PROTOTYPE SYSTEM DESCRIPTION

The following steps represent a synthesis of the procedures describing all the system features. The system is divided into separate stations, in order to achieve the final goal in the recycling process. The process consists of two stages:

1. Material categorization:

Material is gathered in collection receptacle, removed through vacuum by air conveyor, and categorized accordingly by Y-valve (see figure 15).

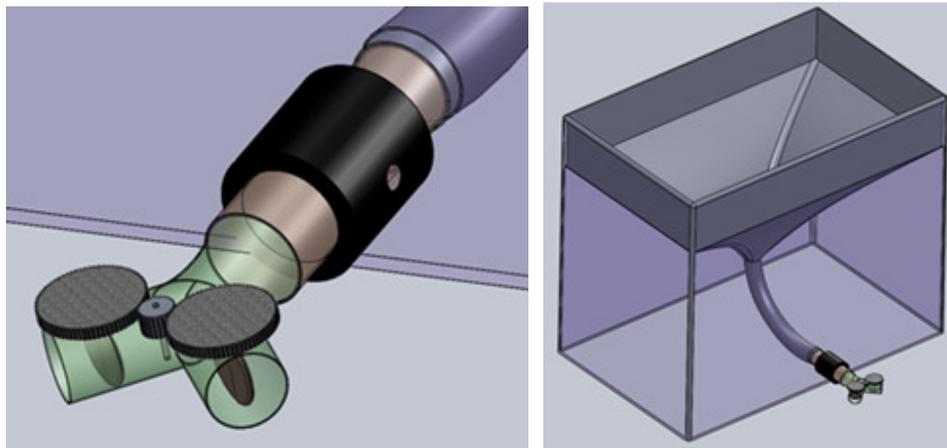


Figure 15. Stage 1

2. Material sorting:

Categorized material goes through a sorting process, executed by rotating drum filter to finalize the material selection process (see figure 16).

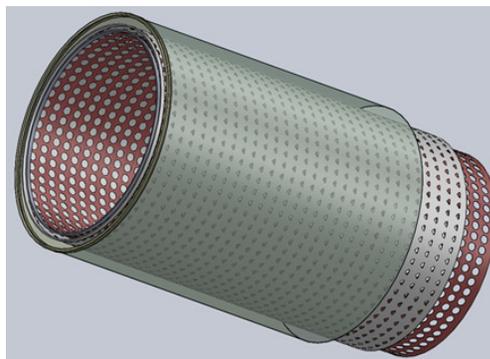


Figure 16. Stage 2

The system consists of four components:

1. Collection receptacle:

It consists of a receptacle located at the initial state with a funnel mouth at the top, in order to collect the incoming material from the die.

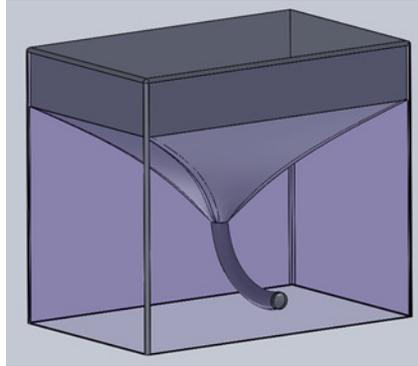


Figure 17. Collection Receptacle

2. Air conveyor:

Is located at the exit point of collection receptacle and in junction with an air compressor, it creates vacuum which, removes material from collection receptacle.



Figure 18. Air Conveyor

3. Material categorizer (Y-valve):

It allows operator to choose the appropriate direction of the material being conveyed (interior/exterior). With a gear ratio of 4:1, the pinion drives the gears in opposite directions; consequently opening one valve, while closing the other one.

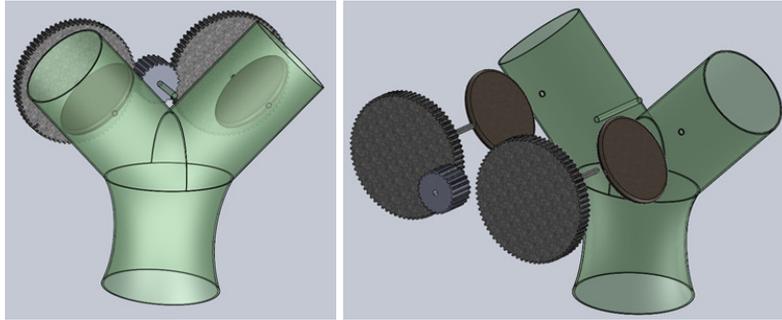


Figure 19. Y-Valve

4. Rotating Drum Filter:

The final station consists in the sorting of the material according to size and shape. Categorized material (interior/exterior) is filtered through a rotating drum with a mesh filter that ranges from larger to smaller size. Filter is positioned in an angle to allow particles to tumble while in motion. Larger particles follow the inner mesh, exiting at location A (See figure 20), while smaller particles fall due to gravity, and exit drum at location B (See figure 20).

The sorting process is done in order to choose whether the material residue (pellets) need to be re-grinded or stored directly as it is for future use. This process is applied for both types of material (interior and exterior).

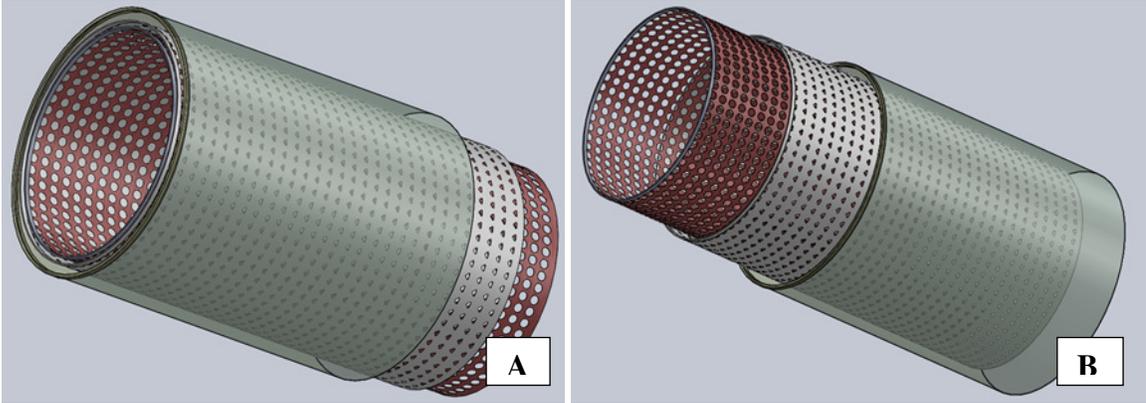


Figure 20. Rotating Drum Filter

PROTOTYPE COST ANALYSIS

The cost analysis for material selection mechanism includes:

- Labor
- Components cost

To evaluate the project, labor has to be considered. Each member has different responsibilities to work on. Based on the estimation, 195 human hours are needed to complete the project. The component costs depend on the material selection, components performances, and size of the items. The major components prices for the system are:

- Air compressor: The maximum pressure cannot exceed 150 PSI. This air compressor has 120 V, 0.8 HP, and 6 Gal Tank. (\$245)

Tech Specs	Additional Information	Compliance & Restrictions	MSDS
Item	Portable Air Compressor		
Type	Electric		
Tank Type	Pancake		
Voltage	120		
Amps AC	10.0		
HP	0.8		
Free Air CFM @ 90 PSI	2.60		
Free Air CFM @ 125 PSI	1.80		
Free Air CFM @ 135 PSI	1.6		
Max. Pressure (PSI)	150		
Tank (Gal.)	6		
(F)NPT Outlet (In.)	1/4		
Unit Weight (Lbs.)	34		
Cylinder	Plated Steel		
Design	Oil Free		
Motor RPM	12,600		
Motor Type	UMC		
Standards	ISO1217		
Length (In.)	18		
Width (In.)	18-3/8		
Height (In.)	15		



Figure 21. Air Compressor [6]

- Clear suction hose for 25 ft. length: (\$73)



STANDARD O.E.M. TYPE SUCTION HOSE CLEAR PVC WITH WHITE HELIX

– FEATURES –

- For powder, pellets, water or light chemicals.
- Specially sized to fit over pipe.
- Suction or Transfer use.
- Smooth Interior prevents material blockage.
- Clear wall allows easy inspection of material flow.
- Temperature Range -10°F to 130°F
- Clockwise spiral (R.H.)



★ ADD ROLL LENGTH TO PART NUMBER!

Hose I.D. Inch	HOSE PART NO. (add length)	Stock Pre-cut Lengths & Prices			Hose O.D. Inch	Max. W.P. @ 68°F P.S.I.	Vacuum Rating @ 68°F In. Hg	Min. Bend Radius Inch	Approx. Weight Lbs./Ft.
		25 ft. Length	50 ft. Length	100 ft. Length Uncut					
1"	★VHSD100_	\$23.25 / \$.93 ft.	\$44.00 / \$.88 ft.	\$84.00 / \$.84 ft.	1-1/4"	50	28	3"	.14
1-1/4"	★VHSD114_	26.00 / 1.04 ft.	49.50 / .99 ft.	93.00 / .93 ft.	1-1/2"	50	28	3"	.31
1-1/2"	★VHSD112_	26.00 / 1.04 ft.	49.00 / .98 ft.	93.00 / .93 ft.	1-7/8"	50	28	3"	.37
1-3/4"	★VHSD175_	32.75 / 1.31 ft.	62.00 / 1.24 ft.	118.00 / 1.18 ft.	2-1/8"	50	28	3-1/2"	.42
2"	★VHSD200_	39.00 / 1.56 ft.	74.00 / 1.48 ft.	140.00 / 1.40 ft.	2-13/32"	45	28	4"	.57
2-3/16"	★VHSD218_	57.25 / 2.29 ft.	109.00 / 2.18 ft.	208.00 / 2.08 ft.	2-9/16"	40	28	4"	.60
2-1/4"	★VHSD225_	52.50 / 2.10 ft.	99.50 / 1.99 ft.	188.00 / 1.88 ft.	2-21/32"	40	28	5"	.63
2-1/2"	★VHSD212_	73.00 / 2.92 ft.	138.50 / 2.77 ft.	265.00 / 2.65 ft.	2-29/32"	40	28	6"	.77
3"	★VHSD300_	98.25 / 3.93 ft.	187.50 / 3.75 ft.	363.00 / 3.63 ft.	3-1/2"	35	28	8"	1.02
3-1/2"	★VHSD350_	143.25 / 5.73 ft.	273.00 / 5.46 ft.	522.00 / 5.22 ft.	4-5/32"	35	28	10"	1.19
4"	★VHSD400_	156.50 / 6.26 ft.	298.50 / 5.97 ft.	570.00 / 5.70 ft.	4-5/8"	35	28	10"	1.64

Figure 22. Suction Hose [7]

- Air conveyor (\$126.35)

Tech Specs	Additional Information	Compliance & Restrictions	MSD
------------	------------------------	---------------------------	-----

Item	Air Conveyor		
Material	Aluminum		
Air Inlet	1/4" NPT		
Hose Size	1"		
Air Consumption	14.7 scfm		
Vacuum	-42 in. H2O		
Pressure Range	20 to 250 psi		
Temp. Rating	275 Degrees F		
Inside Dia.	3/4"		
Outside Dia.	2.13"		
Overall Length	3.88"		



Figure 23. Air Conveyor [8]

- Pressure regulator(\$75.4)

Tech Specs	Additional Information	Compliance & Restrictions	MSDS	Require Accessor
Item	Pneumatic Regulator			
Type	Modular			
NPT	1/2"			
Max. Flow	100 cfm			
Max. Pressure	300 psi			
Max. Temp.	175 Degrees F			
Adjustment Range	5 to 150 psi			
Adjustment Knob	Nonrising Knob			
Gauge Port	1/4" NPT			
Valve Design	Balanced, For Accurate Pressure Control			
Height	6.67"			
Width	3.15"			



Figure 24. Pressure Regulator [9]

PLAN FOR TESTS ON PROTOTYPE

1. Perform all the simulation studies required for our design components. These include:
 - a. Flow analysis on the nozzle and the Y-Valve.
 - b. Flow analysis on the connection hosepipes.
 - c. Stress analysis on the Drum filter crank.
2. Material testing for all our components. This allows for a proper selection of materials taking into account aspects such as cost, strength, and durability.
3. Test efficiency and analyze the specifications of the external (non-built) components in the design in order to make an accurate selection/decision when it comes to purchasing. For example, auger/screw conveyors, motors, and air compressors.
4. Perform tests to analyze the efficiency of our drum filter; the inner cylindrical meshes need to be analyzed once built to see how well the material is being filtered. This particular test is done by using all the range of sizes and shapes of the material residue (pellets).

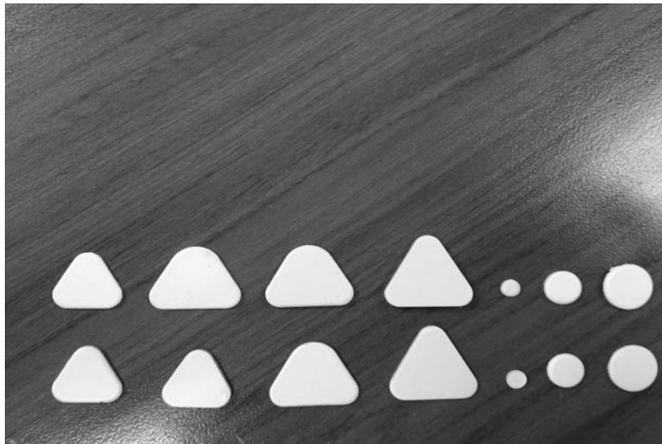


Figure 25. Pellet (Material Residue) Sizes and Shapes

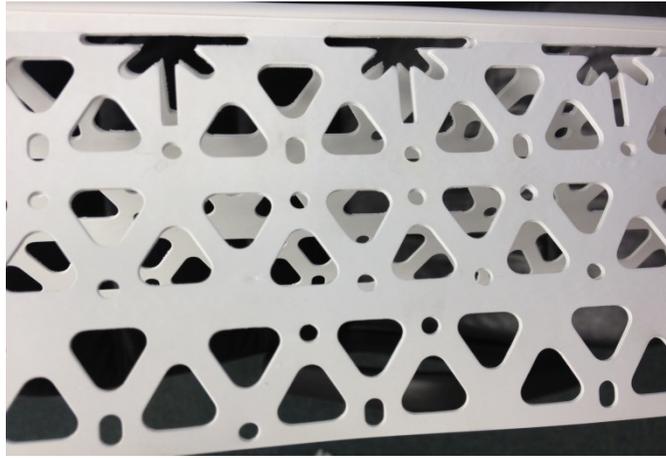


Figure 26. Sample Knockouts Shapes and Sizes

5. Perform a final a final test to determine whether the assembly of all the components is working as desired. Tests should be performed to determine characteristics such as efficiency, smoothness between stages, and quality of the end result; which is to have a properly sorted material for recycling purposes.

CONCLUSION

There is a wide range of screens and filters around the world for different type of usages. For our design the filter is the crucial part. The filtering system makes the project special and unique.

The special screen has to be designed and tested to separate different sizes of plastic parts.

The main achievement through this project will be to implement a unique filtering system, to existing conveying methods for small solid particles.

The main challenge will be to offset the incidence of a difference in height when conveying the material, since this is a main parameter in this design, also to sort different types of materials, having various geometries and shapes.

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9. <http://www.grainger.com/Grainger/SPEEDAIRE-Regulator-4ZM22>

APPENDICES

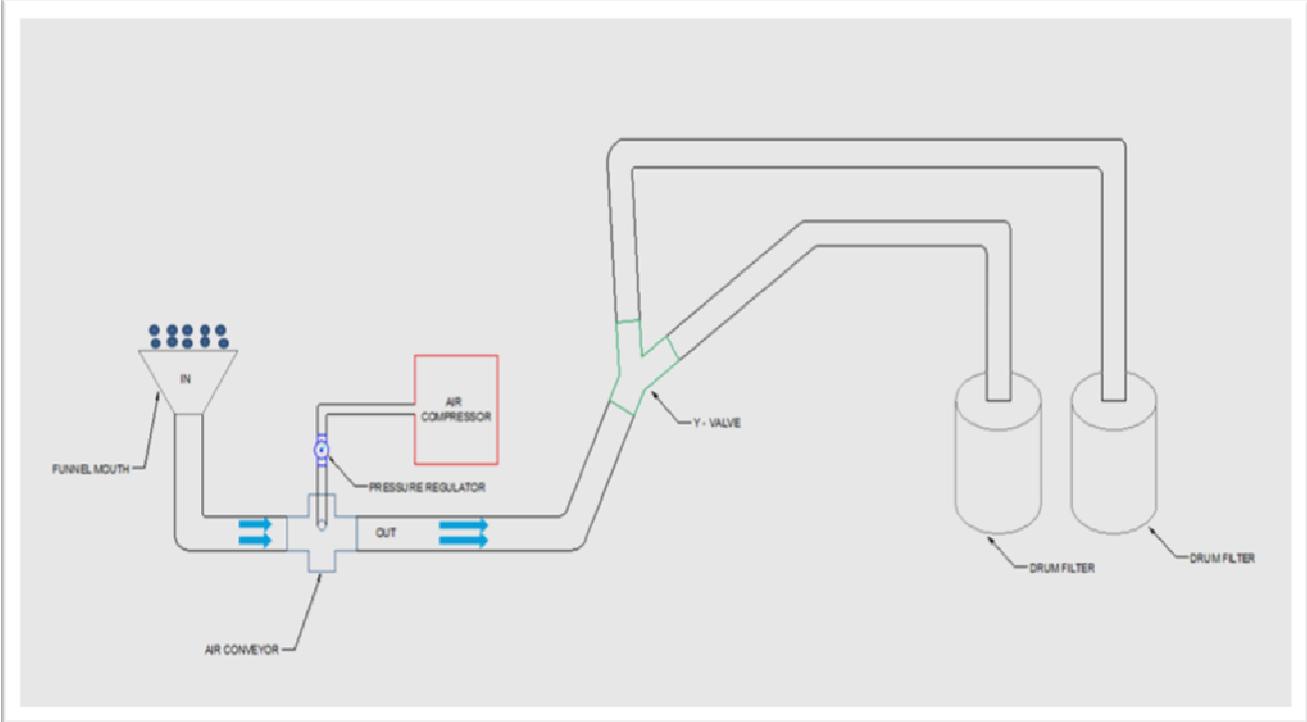


Figure 27. Prototype Concept