Rexnord Automatic Deburring Machine

Operational Readiness Review

Corp 9 Project Group

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Dr. Beale – Comprehensive Design Two – MECH 4250 – Summer 2010

ABSTRACT

A magnetic conveyor design has been chosen and its structural development is complete. This machine will utilize the existing conveyor at Rexnord, and combine it with a system consisting of a magnetic conveyor situated above a rotating carbon steel deburring brush. A part locator sensor will be placed at the beginning of the entrance conveyor. Once a part passes the sensor, it will trigger the deburring system to power on. The system will stay on for a specified amount of time long enough to debur the part, then turn off in order to conserve power. The magnetic conveyor will be adjustable for different part sizes. The magnet at the end of the conveyor will decrease as it reaches the end and the part will drop down onto an exit ramp for storage. An active air system will be situated below the deburring system for automatic clean-up of debris.

As construction of the system ensued, the members of Corp 9 ran many tests on the machine to achieve optimal results. The electrical system, including part sensors, e-stop, and relays have been tested and function properly in coordination with the entire system. The 80/20 frame is assembled and provides excellent stability for the system. After testing, the best results come from positioning the brush at an angle relative to its motion on the magnetic conveyor. There will be marks placed on the legs bracing the magnetic conveyor so that the operator will be able to adjust its height relative to the different sizes of parts being deburred at a given time. The positioning of the magnetic conveyor must be precise in order to achieve a desired finish for different parts. Also, a duct vent has been constructed and implemented with PVC pipe attached to an air compressor. Holes are drilled into the pipe which will direct air down the duct vent and into a debris collection bin.

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INTRODUCTION

Rexnord is a company that has many manufacturing facilities worldwide. The facility here in Auburn, Alabama produces power transmission couplings for a variety of applications including aerospace and military products. The focus of this project is on the T-Hub parts and the removal of machining burs.

During the production process of the T-Hub, the part undergoes a slotting operation. After this operation is complete, burs are left on the bottom and the side. These burs cause problems with the following process in which the part must be placed in a mill and machined. The burs will prevent the part from sitting in the correct orientation within the mill. Currently, the burs are removed by hand. This involves an operator having to take the part and place it in a holding device and then use a pneumatic rotary tool with a sanding disk to remove the burs. With this method, only the burs on the bottom are removed, not on the side, and it takes valuable time away from the operator that could be spent accomplishing other necessary tasks. There is also a safety hazard as the current deburring process produces sparks and a considerable amount of metal dust. See figure 1 below.

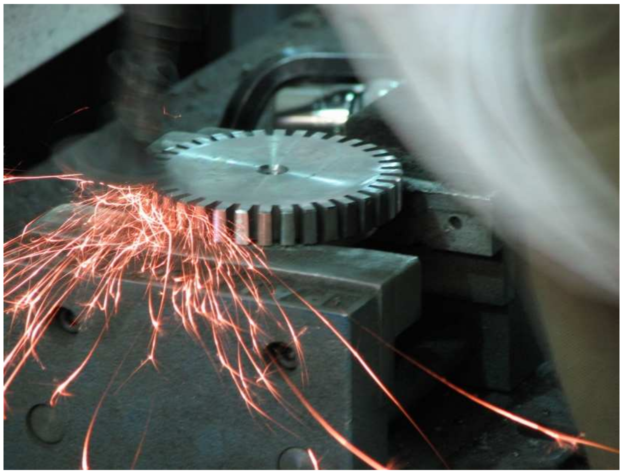


Figure 1 – Current Deburring Method (Manual)

The goal of this project is to produce a deburring machine that will be fully automatic from beginning to end, collect all dust produced by the deburring process, debur both the bottom and the edges of the part, use a spark-less method of deburring, debur all shapes and sizes of specified parts, leave the necessary finish on the part surfaces, and be quickly moved to other cells within the facility. All these requirements must be met while beating the current time it takes to debur the part.

Comments made at the preliminary design review are addressed thoroughly in the following report. Pay special attention to updates made in the concept of operations, product hierarchy, and cost analysis including the bill of materials. A special focus has been put on the cost effectiveness of the machine involving payback periods and revenue increases.

Several comments were made by the sponsor at the final presentation. These comments included issues with safety, reliability, and cost. Please see the following sections of the report that address these issues. For safety, please observe the ConOps and System Engineering sections. For reliability, please see the Validate and Verify section. And for cost, please observe the Bill of Materials.

MISSION OBJECTIVE

Our mission is to:

- Create an automated deburring and transport system while:
    - Reducing production time
    - Improving overall quality of the finished product
    - Improving the efficiency of the waste removal process

ARCHITECTURAL DESIGN AND DEVELOPMENT

Product Hierarchy of Finalized Concept

The total system is known as the Rexnord Deburring Machine. Below that, is the hierarchy of the subsystems and components where, after breaking down the Rexnord Deburring Machine, there are four main subsystems. The first subsystem is the inverted magnetic conveyor that lifts the part from the entrance conveyor and takes it into the brush. The second is the deburring system itself composed of a spinning wire brush. The next, and third, subsystem is the exit ramp where the part is removed from the magnetic conveyor and then slides down the metal ramp where it awaits pick up for the next operation. The fourth subsystem is the cart that will support the shroud and the dust collector that pulls in any dust created by the deburring process.

The components that comprise these subsystems are as follows. The magnetic conveyor possesses the same basic components as a standard conveyor (belt, rollers, motor) except that it also has a magnetic layer underneath the belt. This magnetic will capture the part and translate it through the deburring brush and release it at the exit ramp. Also note that the magnetic conveyor is inverted so the part can be lifted from the top. The components for the deburring system consist of a radial coil brush that is made of steel wire, spacer/adapter shafts, and a roller bearing. This system is powered by an electric motor and will spin at a necessary rpm to achieve the desired finish. The exit ramp is simply made from steel that has been formed into a C-channel shape and turned sideways, and is supported by a basic structure. The cart will consist of the safety shroud and dust collection system. The dust collection subsystem is composed of a circuit of PVC pipe the will lay below the deburring system. This PVC pipe will be charge with air from an attached hose and that air will exit through a series of holes along the inside perimeter. These holes are aimed downward and will push any dust down into a hopper. The safety shroud is composed of a series of pre-fabricated connections that have been assembled to surround the machine entirely. Please observe figure 2 for the visual product hierarchy.

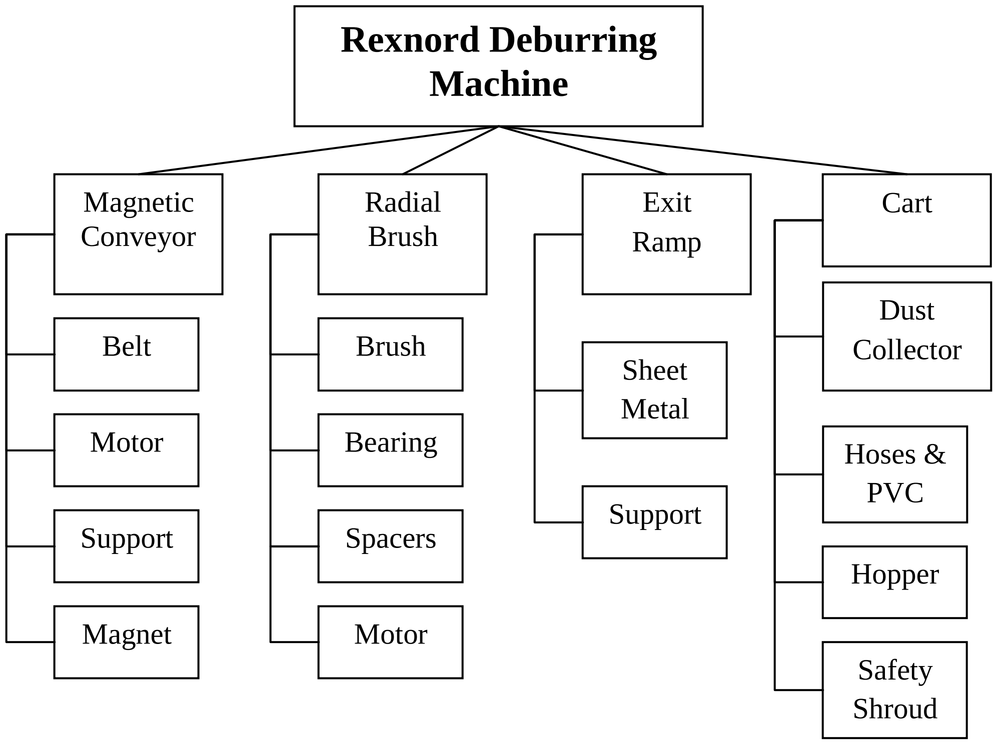


Figure 2 – Product Hierarchy

Bill of Materials

Table 1 below is a bill of materials demonstrating the costs of our selected design.

Table 1 - Bill of Materials

Quantity	Part	Part #/Company	Price ($)
2	Light Sensor	65845K56 / McMaster 65845K57 / McMaster	284.22
1	Timed Relay	2809T41/ McMaster	60.83
1	E-Stop	Idec HW1X / Wolf Automation	32.50
1	Bearing and Mount	6244K56 / McMaster	38.65
1 or 3	Brush Motor	3K771 / Grainger	74.00 each
1	Motor Control	FA206 / Keenzo	28.97
1	Door Switch	65665K13 / McMaster	80.03
1	Magnetic Conveyor	Custom / Bunting Magnetics	4,011.00
1	Duct System	Custom / American HVAC Parts	50.00
1	Exit Ramp	Custom / Metals Depot	38.24
1	Cart	WES101 / Hand Trucks	103.98
4	Linear Bearing	6531 / 80/20 Parts	316.60
3	Double Flange Linear Bearing	6524 / 80/20 Parts	226.05
444	T-Slot Rail	1515 / 80/20 Parts	235.32
96	Double T-Slot Rail	1530 / 80/20 Parts	89.28
2	Lucite/Acrylite Clear Panels	2601 / 80/20 Parts	91.20
16	7 Hole 90 deg Joining Plate	4352 / 80/20 Parts	139.20
16	Bolt Assembly for 4352	3325 / 80/20 Parts	169.44
4	90 deg Inside Corner Connector	3368 / 80/20 Parts	25.20
4	Square Tri Corner Connector	4442 / 80/20 Parts	79.80

4	Bolt Assembly for 4442	3018 / 80/20 Parts	2.52
2	Handles (Natural Finish)	2887 / 80/20 Parts	39.80
2	Bolt Assembly for 2887	3035 / 80/20 Parts	.94
4	Single Flange Bearing Profiles	8531 / 80/20 Parts	18.24
1	Three Sided Cutout	7163 / 80/20 Parts	10.50
1	Four Sided Cutout	7164 / 80/20 Parts	15.75
38	Pre-cuts for 1515 T-slot Rail	7010 / 80/20 Parts	74.10
4	Pre-cuts for 1530 T-slot Rail	7020 / 80/20 Parts	8.20
8	Cut to Length for 8531	7217 / 80/20 Parts	15.60
1	Deburring Brush	Custom / Industrial Brush	362.25
1	Power Inverter/Transformer	Bunting Magnetics	$350.00
		Total Cost	**6,837.09**

COST ANALYSIS OF MACHINE

A major part of this project is to not only improve the finish of the product being created, but also to save money while doing so. This is where cost analysis plays a major role in determining the value this machine will provide. Due to output fluctuations in the company, these values are computed are estimated.

Considering Increase in Productivity Alone

It was noted that Rexnord, on average, creates 2500 parts per month. This translates into about 125 parts per day created. The time to debur one part is 16 seconds, which is equivalent to 2000 seconds per day (or 33.3 minutes) deburring 125 different parts. The cycle time to complete one part is 4 minutes. The 33.3 minutes of extra time the machine will provide can allow for 8.3 more parts to be produced per day. The cost that Rexnord sells each part for is 47 dollars, which translates into 376 dollars more in revenue per day. There are 20 working days per month which is equivalent to 7520 dollars in revenue for merely the 8.3 new parts created each day. A 20 to 30 percent profit margin will translate into somewhere in between 1504 and 2256 dollars per month in profits. Considering profits alone, the machine will be able to pay for itself in the range of 3.03 to 4.54 months.

Considering Burden Rate Alone

The burden rate for the cell was determined to be 35 dollars per hour, which equals .583 dollars per minute saved. It was determined that 33.3 minutes will be saved due to the machine which translates into 19.425 dollars saved per day. With the 20 working days in one month, 389 dollars will be saved per month. The total cost of our machine is 6837.09 dollars, divided by 389 dollars saved per month will come out to 17.58 months till machine payback.

Considering Possible Medical Implications

It is impossible to determine the exact possible savings the machine can have considering the possible medical implications it could avoid. The chance of injury will certainly decrease considering the improved ergonomic conditions it will provide for its workers. Without knowing how much medical check-ups or operations cost, one can only speculate on how much possible savings this machine can have. However, after observing previous cases, one can assume the costs of injury to be in the tens-of-thousands of dollars, not including workers compensation or legal action. Regardless, this machine will be considerably less of a health hazard to its workers and could possibly save an enormous amount of money and inconvenience for Rexnord.

Considering Increase in Productivity and Burden Rate

It was determined that with the additional increase in productivity, Rexnord will bring in 7520 dollars in revenue per month. Also, it was determined that the burden rate analysis will provide 389 dollars per month in savings. If combined, one month will save 7909 dollars. If profit margins are taken into consideration, then the machine will bring in somewhere between 1582 and 2373 dollars per months in profits alone. This translates into the machine paying for itself in profits within 2.88 and 4.32 months.

Requirements:

Rexnord Deburring System

- Debur the various sizes and shapes of the specified parts.
- Leave the necessary finish on the part surface.
- Fully automated from beginning requiring no aid from an operator.
- Automatic collection and removal of dust.
- No sparks must be generated during deburring process.
- Must debur the bottom and sides of each part.
- Must be free to quickly move to other cells.
- Deburring system must meet all OSHA safety and environmental standards for operations.

Subsystem Level Requirements

- ➢ Entrance conveyor must be adjustable for height changes in parts.
- ➢ Magnetic conveyor must be strong enough to support weight of part and hold part steady during the deburring process.
- ➢ Magnetic conveyor must also release part for delivery down the exit ramp.
- ➢ Exit ramp must be large enough to support two of the largest sized parts.
- ➢ Exit ramp must be adjustable for different sized parts.
- ➢ Radial deburring brush must be stiff enough to remove burs but not damage the finish or remove material to the point where the part is out of tolerance.
- ➢ Brush cannot create sparks while deburring.
- ➢ Dust collection system must remove all dust produced by the deburring process and store in a hopper for later removal.

Concept of Operations

The Rexnord Deburring Machine is a fully automated system that requires no aid from any operators. This is accomplished with the following steps. First, the part exits the slotter and slides down the existing ramp onto the existing conveyor. The existing conveyor, which has had its rails adjusted for part diameter, carries the part to the deburring area of the machine. Once there, the part will pass through a light sensor that trips a timed relay to turn on the conveyor and brush motor. The inverted magnetic conveyor will then attract the top of the part and hold it firmly to the conveyor's surface while translating through the deburring system. As the part approaches the end of the magnetic conveyor, the magnetism will decrease until the part releases and slides down the exit ramp for storage.

The conveyor will need to be adjusted for different sized parts. The goal is to lightly skim the bottom of the parts. This results in safe operation and the greatest removal of burs. From testing with these different sizes, it was noticed that smaller parts and larger parts need to be operated under different conditions. The smaller parts have less surface area for the magnet to hold. If these parts enter the brush at a height that is too low, then the possibility of the part dislodging from the power of the rotating brush motor increases. It was noticed that by increasing the speed of the conveyor to 55 percent power and being precise with the height of the magnetic conveyor, that the part will be successfully deburred with no malfunctions. The larger parts have more surface area for the magnetic conveyor to hold and have not resulted in dislodgement from testing. Although if the height of the conveyor is too low, the brush motor will not have enough power to continue rotation and will stall. Height of the magnetic conveyor must be precise and may have to be readjusted several times in order to achieve the desired finish. Through testing, it was concluded that the brush motor can stay at full power for every part size and still produce a desired result. WARNING: It is recommended that when testing parts after adjusting the magnetic conveyor, for employees to keep at least a 20 foot radius free around the machine for safety concerns should a part exit the machine. Please observe figures 3 and 4 below and on the next page for an overview of machine setup and design.

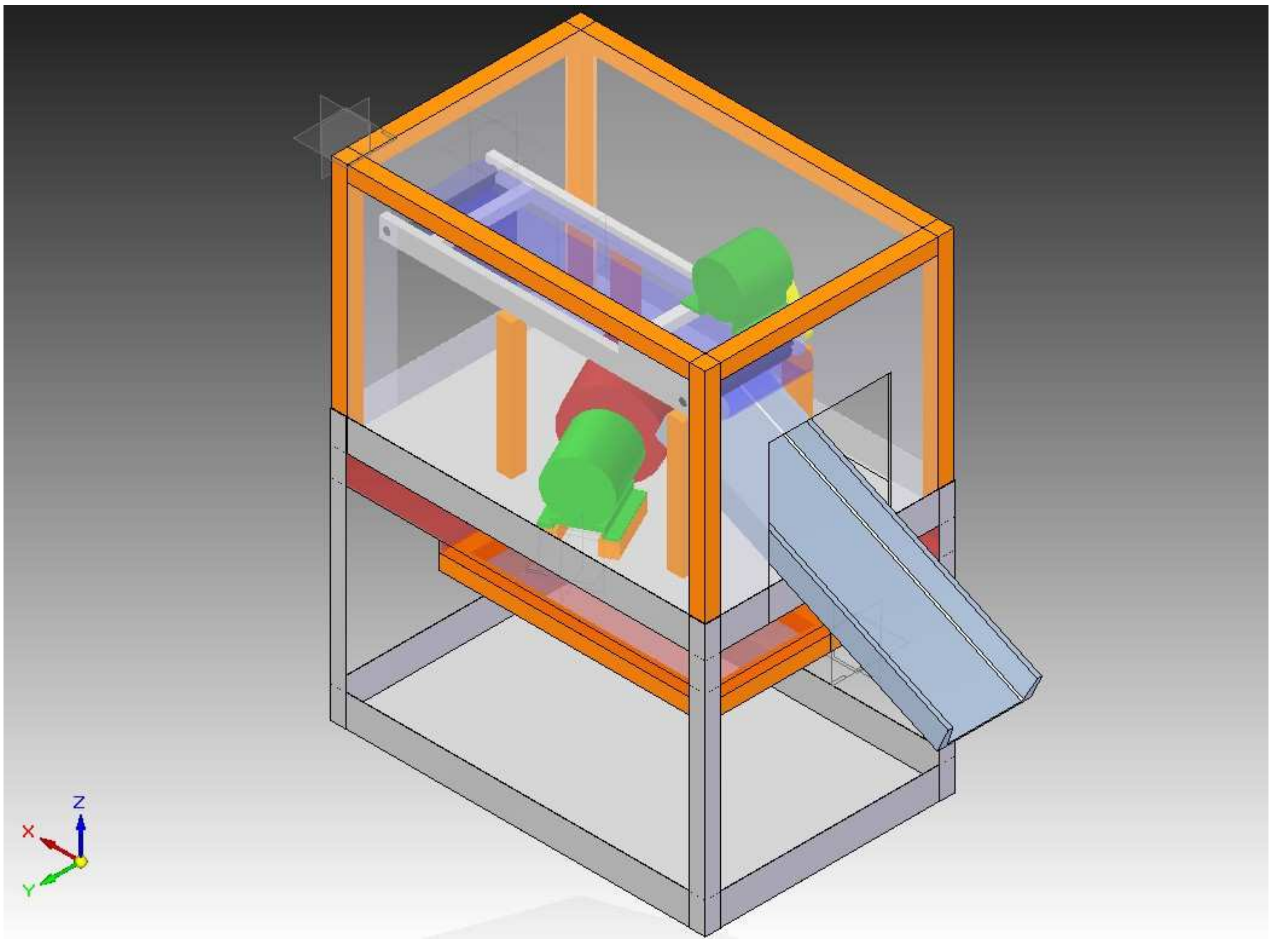


Figure 3 – Isometric view of final assembly

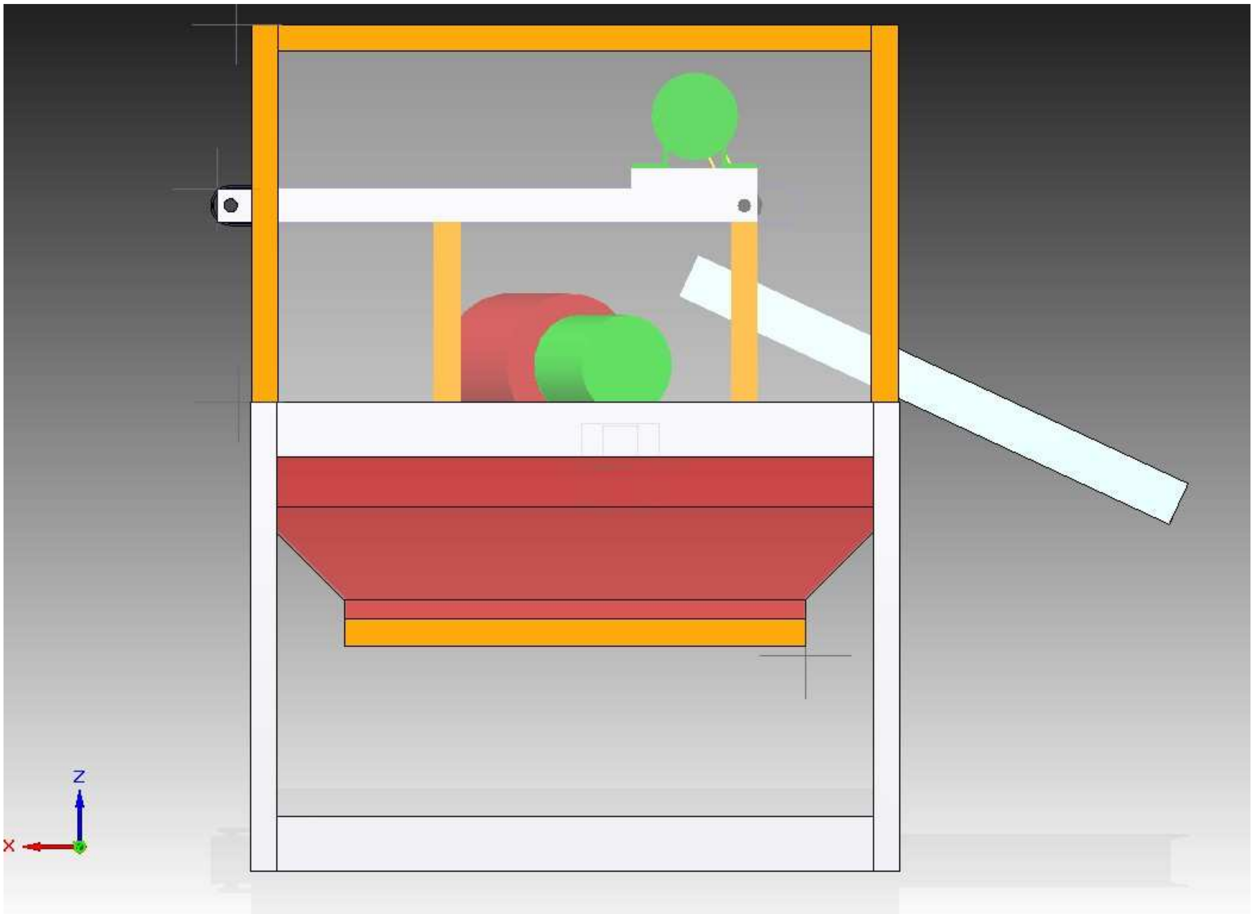


Figure 4 – Side view of final assembly (Green = Motors, Red = Brush)

Next, as the part is being moved by the magnetic conveyor, it sweeps through a rotating brush. This brush is a radial coil wire design and is tubular in shape. The brush is oriented so that it is angled to the path that the part is taking. This brush will remove the burs from the front, bottom, and back of the part.

While the part is deburring, the dust system is removing the dust created by the wire brush. The dust system is connected to the housing and consists of a rectangular shape made of PVC pipe. This will be charged with air at a moderate pressure. A series of holes along the edge will push any dust down into a hopper for later disposal.

After the deburring process is complete, the part will continue to translate along the magnetic conveyor and out to the exit ramp. Here, the magnetic conveyor ends and the part will drop (slightly) onto the exit ramp where the part will slide down and wait for the next operation. The exit ramp has been adjusted for part size and will catch the part from falling too far. Mounted to the exit ramp is another light sensor that will detect if two parts are present. If so, the machine will not start again until at least one part is removed.

The system is designed to run intermittently with each cycle being controlled by the light sensors. Once a cycle is initiated, the conveyor and brush will spin at their set speeds and carry each part automatically through the system and deliver them at the end. However, there are two adjustments that must be made if the machine is moved to a different cell where a different sized part is produced. The first is the centering rails on the existing conveyor. These will have to be adjusted to properly center the part before entering the deburring area. Then, the magnetic conveyor height will also need to be adjusted to meet and dispatch the part properly. If you observe the magnetic conveyor supports, you will see a series of color bands along the sides. These color bands represent the relative location that the conveyor must be located in order to debur the part appropriately. Fine tuning will be needed as these marks are not exact and act only a location to begin testing. Please observe figure 12 in the appendix for the color vs. part size chart and the speeds at which to run them. These adjustments must be made only once prior to startup. Once completed, the machine will need no adjustment until moved to another cell where a different sized part is produced. Located in the later in this report are larger, more detailed CAD drawings of this design.

Validate and Verification

Preliminary tests were done to guide the decision of the process to be used for bur removal. Defective parts were acquired from the manufacturer, and several different tools were used to debur the part, and the results were documented. Now that a final design is decided upon, a more precise mock up of the process will be constructed for further testing and evaluation.

Upon completion of the assembling of the deburring machine, testing was started to establish the correct settings for the machine to be run at to ensure an optimum finished product. Our team decided to test the largest (1080T Hub) and the smallest (1020T Hub) parts to ensure that our machine would be able to handle these parts and develop a base line so as to accordingly learn what adjustments would need to be made to handle all parts in between.

The first part tested was the 1080T Hub. Upon the first test runs, we realized how critically important the height of the conveyor was to overall system performance. If the part was too low as it came into contact with the deburring brush, the brush would encounter resistance which would eventually lead to the motor stalling. Once we found the optimum height, our next variables to test were the conveyor speed and brush speed. We initially tested the 1080T Hub at a conveyor speed of 7% and brush speed of 50%. After one run we noticed that this combination was not adequately deburring to our satisfaction. We then increased the conveyor speed to 10% and the brush speed to maximum power. The slight increase in conveyor speed was due to the fact that we still wanted the part to have as much contact with the brush as we could allow it. The second run of our sample part had much better results, nearly satisfactory. The only problem that existed now was that burs were still on the edges of slots that were parallel with the direction of brush rotation. To overcome this problem we changed the orientation of the brush, instead of being perpendicular with the direction of travel of the conveyor it was now at an angle. This angle change would allow all burs to be completely removed while keeping previous settings unchanged.

Now that we found the optimum settings for the 1080T, we next focused our attention on the much smaller 1020T Hub. Our first attempt used the same conveyor and brush speed settings as was found on the 1080T Hub. We learned that the smaller 1020T would not correctly debur with these speed settings and could be dislodged from the magnetic conveyor. We first raised up the conveyor to 50% power and slowed down the brush speed to 75% power then ran the part again. The results from this kept the part attached to the magnetic conveyor but stalled the brush do to the slow rotational speed. With the brush kept at a slow speed, it kept stalling no matter what the conveyor speed was, so we decided to speed the brush back up to its max speed and run the conveyor at 55% power. This setting kept the part attached and allowed it to get deburred effectively. We then bumped up the power to 60%, but this allowed the part to be dislodged from the conveyor. We ran more tests with the conveyor at 55% power and brush at max power, the part stayed on and was adequately deburred.

From the testing of the largest and smallest parts, we now have a base line of correct settings from which we can apply to the other sized parts that will allow for efficient and safe operation.

Interfaces and ICD

From the time of origin to that of completion, there will be several interfaces within our automated deburring process. The first interface will involve the process where the newly cut part is ejected from the slotter and slides down onto the conveyor. At this point, there are no problems concerning this interface since this process is already a part of the previous system. The next interface will involve the part moving down the conveyor where it will then enter our deburring machine and its magnetic conveyor. The magnetic conveyor will lift the part up onto its moving body and firmly hold it in place. As the part moves along with the conveyor, it will then pass through the rotating deburring brush until the last interface. At this point, the part will reach the end of the magnetic conveyor where it will drop off and slide down to rest at the end of an inclined ramp.

Electrical and Control System

The electrical and control system of this project is a basic relay logic system. The main components include a main power relay, main fuse, connection block, solid-state timing relay, emergency stop, optical sensors, and door access switch. All of these components are housed in a sealed housing that protects them from moisture and dust.

The electrical system is energized when it is hooked up to a 120 volt alternating current system and the main power relay is activated. Should the e-stop or door access switch (both wired in series) be activated, the main power relay will be shut down causing the machine to lose power and also shut down. Once the machine has power, the input devices (two optical line-break sensors, one dark and one light) will detect when a part is approaching the machine. Once the dark line is broken, a signal is sent to a solid-state timing relay that will switch on the brush motor and the magnetic conveyor. Once the timing relay reaches its set limit, it will shut off the motors and wait for another part to approach the machine. Should a certain amount of parts already be stored on the exit ramp of the machine, the “light” optical sensor (wired in series with the “dark” sensor) will be tripped and the machine will not turn on. Please observe the diagram below for more information.

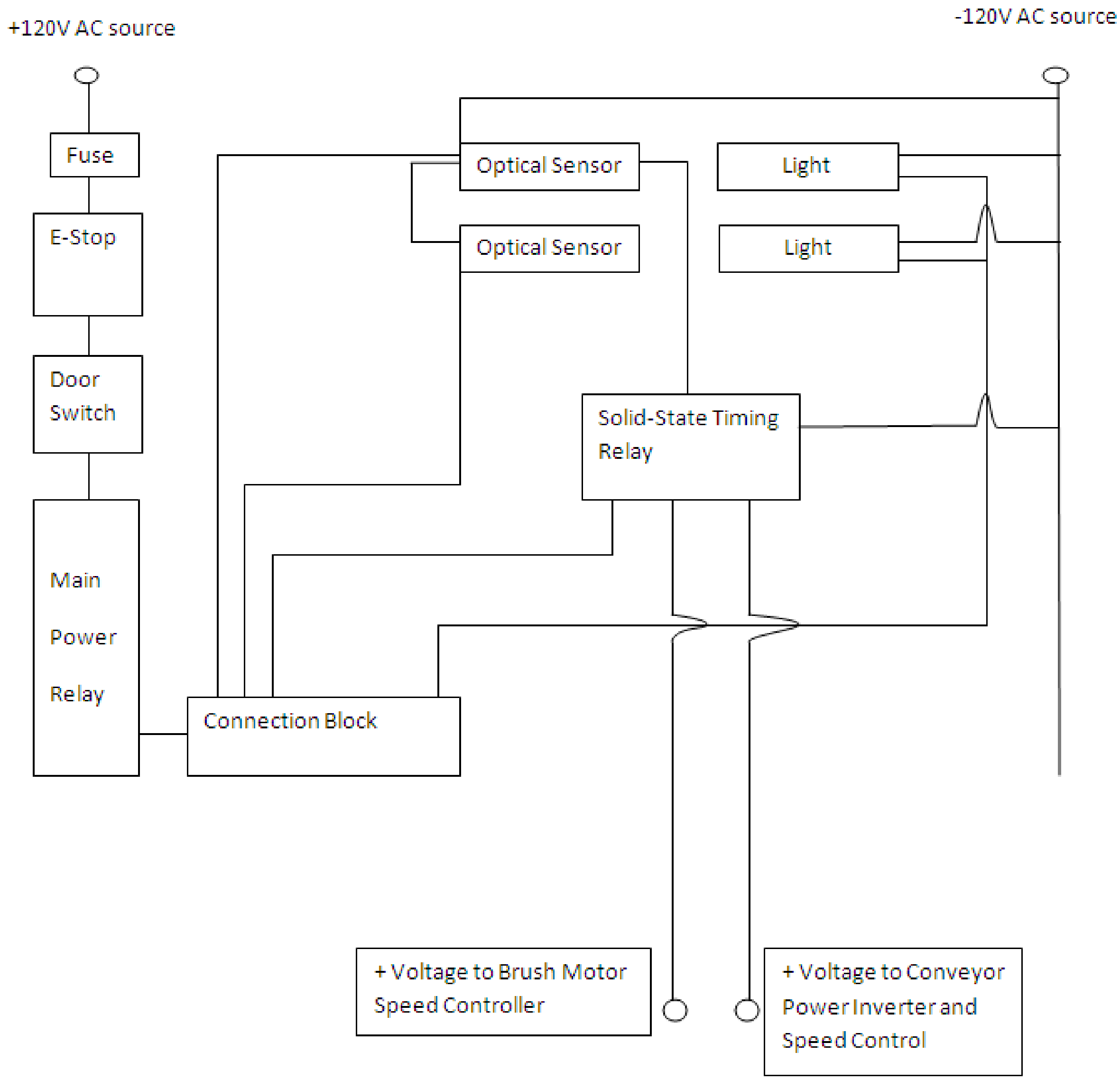


Figure 5 - Electrical Diagram of Control System

Pictures of the final construction have also been included. These pictures demonstrate how the system is connected together and the methods used for proper connections. Please see the next page for figures 6, 7, and 8.

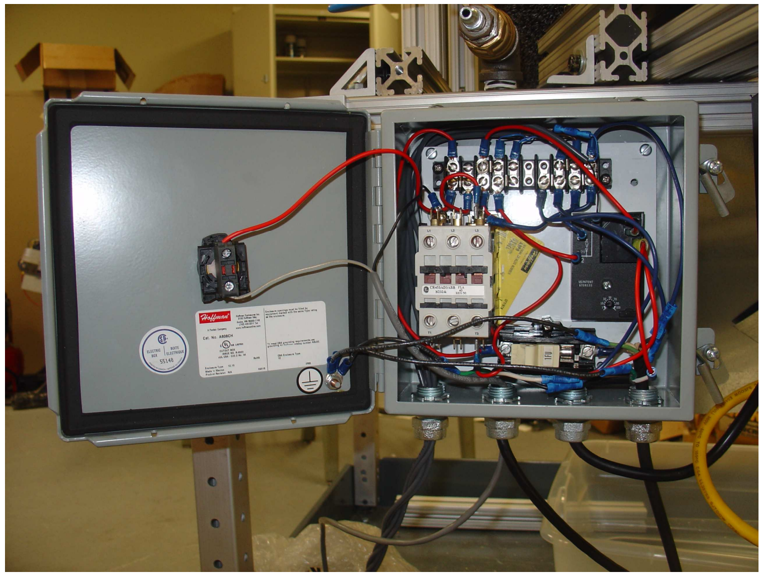


Figure 6 - Electrical Box Internals

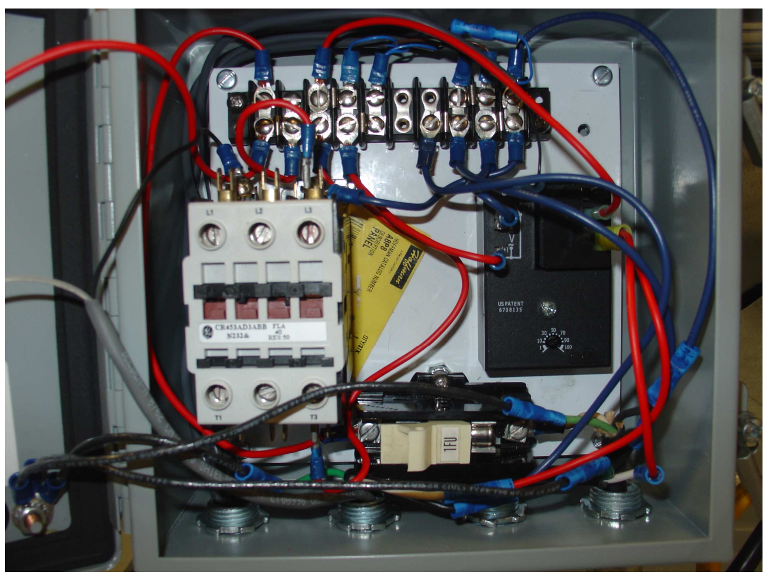


Figure 7 - Relay Logic System

Figure 8 - Optical Sensors and Door Switch

Mission Environment

The mission environment is a general manufacturing atmosphere. Indoors, air conditioned and generally isolated from extreme hot or cold. The only factor that would interfere with the process needed is a space constraint, and mobility of the machine. The company requested that the deburrer be easily moved by one person, as the process before the deburring machine, the slotter, has to be accessible. The access door to change the tooling on the slotter will be located behind the deburrer. In addition to the mobility of the deburring machine, it has to be able to fit in the space available within the cell.

Technical Resource Budget Tracking

- Volume – We have concluded that our design will be 2 feet wide and 4 feet long. The height of the machine will be 5 feet tall. With these dimensions the deburring machine will take up a space of 40 cubic feet.
- Weight – Our design will weigh 314 pounds. The cart being used to hold the entire system has a capacity of 500 pounds. The table below breaks down the weights of the various parts.

Table 2 - Weights of Various Components

Item	Weight (lbs)
Cart	40
Motor	15
Hopper	10
Brush	9
Exit Ramp	30
Mag. Conveyor	110
T-tubing	100
Total	**314**

- Power – The machine will be powered by a standard 120VAC 60 Hz source. This source will power all motors, conveyors, sensors, and the relay. The brush motor itself has ¼ horsepower and operates at 1725 rpm.

Risk Management

Table 3 – Risk Management Evaluation

Rank	Risk Title	Risk Exp	Action	Risk Type	Status
1	Part not deburred sufficiently	Likelihood: Low Consequence: Hi	Research/ Watch	Technical/ Program	Speed adjustment on conveyor and brush motors
2	Part Dislodges	Likelihood: Low Consequence: Hi	Research	Organization	The machine has been analyzed and proper speeds have been determined
3	Brush wear	Likelihood: Low Consequence: Low	Watch	Organization	Brush will need checking and replacement on scheduled intervals
4	Dust collector blocked	Likelihood: Mod Consequence: Low	Watch	Organization	Hopper will need to be emptied on a timely basis for proper maintenance
5	Timing Issue	Likelihood: Low Consequence: Low	Research/ Watch	Technical/ Program	The machine has been timed effectively to maintain pace with the operator and supporting machines.

Configuration Management and Documentation

Please observe the web site for Corp 9 for the documentation and configuration including research photos, test results, presentations, and reports.

SUBSYSTEMS DESIGN ENGINEERING

As the requirements become more and more specific, each subsystem has undergone an evolutionary process since the first conception back in January. Starting in pre-phase A of the engineering design process, each subsystem was thought of as an independent project in itself. From here, the interfaces for each were established and an understanding of the system as a whole was developed. This led into phase A with the concept studies. Part of the goal in this phase was to conduct preliminary tests to help orient the design progress in the correct direction. One experiment conducted was on a series of reject parts from Rexnord. These parts were one of the styles that the machine is required to debur. The test conducted was to see which deburring method was the most effective. Methods such as sanding, grinding, and wire wheel actions were tried yielding some very interesting results.

The results from the preliminary experiment allowed the development to move into phase B of the engineering design process. Here interviews were held with the Rexnord representatives and ideas were suggested and discussed. A single design now could be focused on and evaluated for development.

Starting with the entrance conveyor, the difficult task with this subsystem was to find a way to orient the part correctly. In the previous designs, it had to have the part flip or be picked up, but eventually it was determined that the part only has to be centered and conveyed up to the magnetic conveyor where it can be picked up automatically. There was an already existing solution to this issue. Currently, a conveyor is already used at the needed location and possessed adjustable centering rails. After measurements were taken, it was concluded that the existing conveyor would satisfy the requirements.

For the magnetic conveyor, the initial design was to have an electro magnet activate and then translate the part through the deburring system and then drop the part off. However, a simpler design utilizing the same principles was discovered by using a continuously running magnetic conveyor.

The deburring system was the most challenging to develop. Our preliminary tests helped us to narrow down our options until we decided upon the radial axial brush. This brush will be made of carbon steel and is specifically designed to debur tough, resilient parts.

The exit ramp is a very basic idea that changed very little from the initial concept. At first it was thought that an exit conveyor was needed. But after further evaluation, it was decided that a simple ramp for transport and storage is the best idea for the job.

The air system was a challenging subsystem to tackle. At first it was believed that a passive, or gravity fed idea was suitable. But later requirements indicated that a more aggressive system was needed. That is why an active air is now used to push the dust away from the deburring system and storing it in a hopper for later disposal.

Analysis

The engineering analysis we ran involved simulating the stress on each bristle of the brush. This allows us to see how far we can engage the part into the brush. Assumptions made during these calculations include roe as a function of the change in length of the bristle and that the brush material is homogeneous throughout.

Formulas used for the brush analysis are as follows:

sigma =E*epsilon (1) Hooke's Law

y = sqrt(lo^2-roe^2) (2) Pythagoreans theorem

roe = lo – l (3) Roe Calculation

Figure 9 on the following page is a graph that was generated using MATLAB. The graph is a representation of stress of a bristle versus distance (in inches) into the brush. The very top horizontal line is the maximum stress a bristle can handle before it will break. While the line below that is the maximum stress a bristle can handle before it plastically deforms. From these results, one can conclude that it is best to remain on the ends of the bristles as much as possible as this will reduce brush wear while still giving us a good finish. This will also prevent breakage of the bristles. This graph will allow for the understanding of brush stress and will enable one to adjust distances accordingly to allow for maximum brush force while not having excessive wear and will allow us to better accurately use the machine to its maximum potential. Please refer to the appendix for the MATLAB code that was used as a solution method to determine these results.

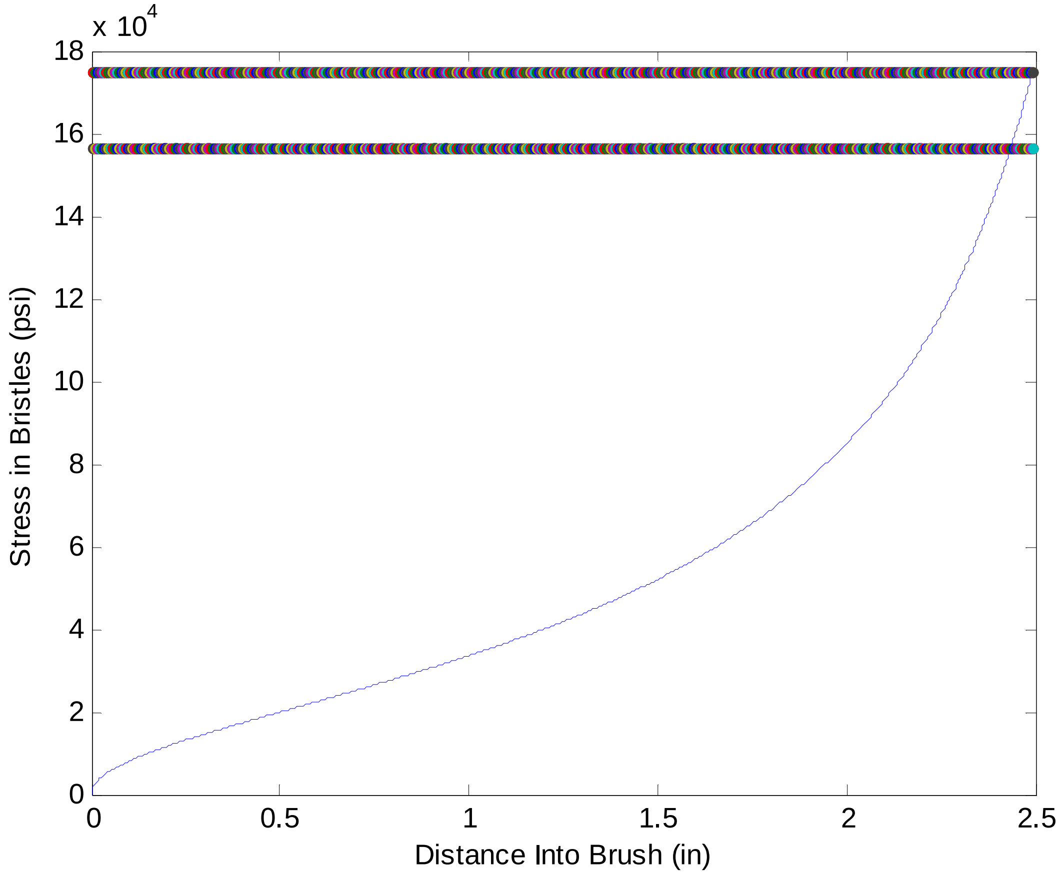
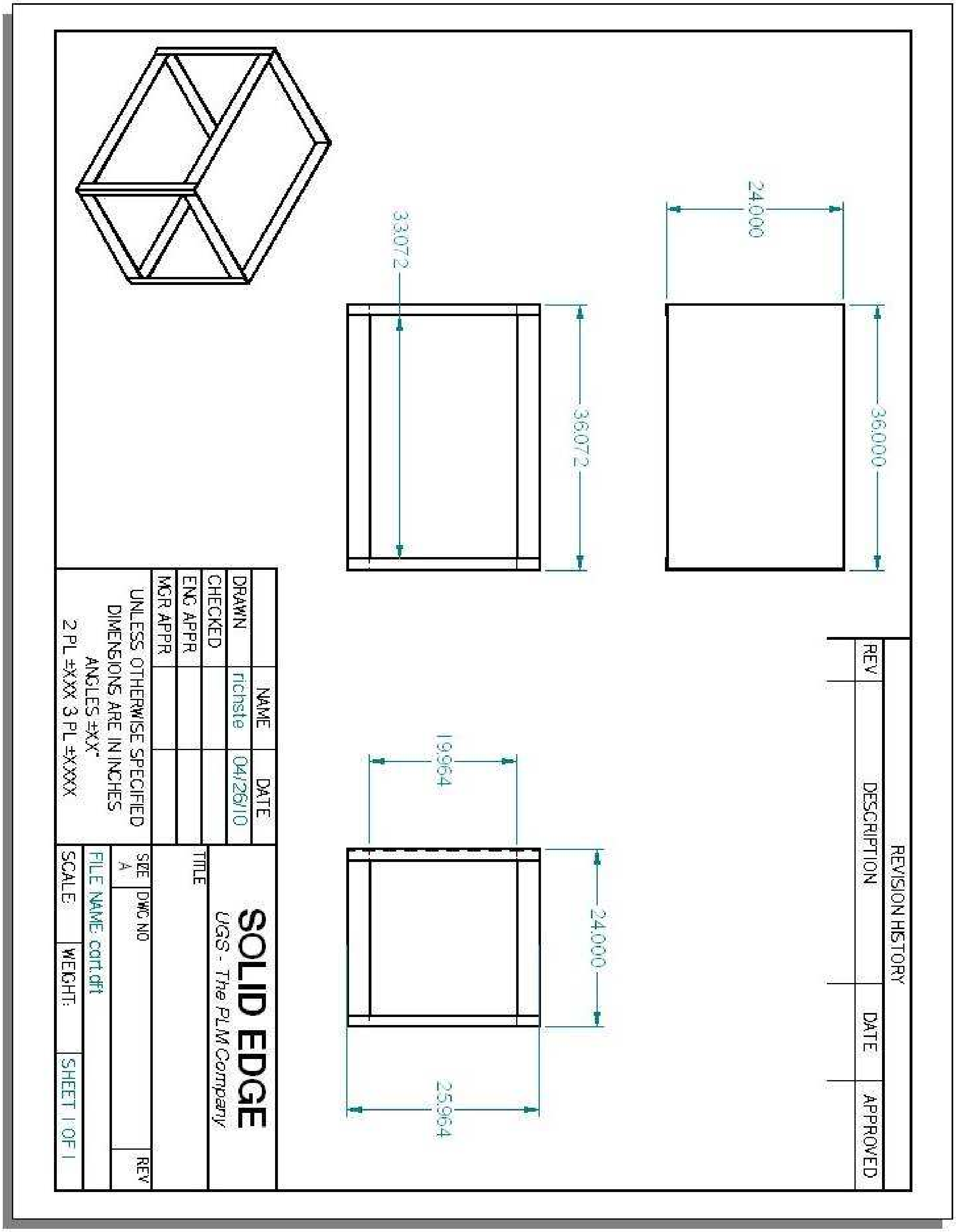
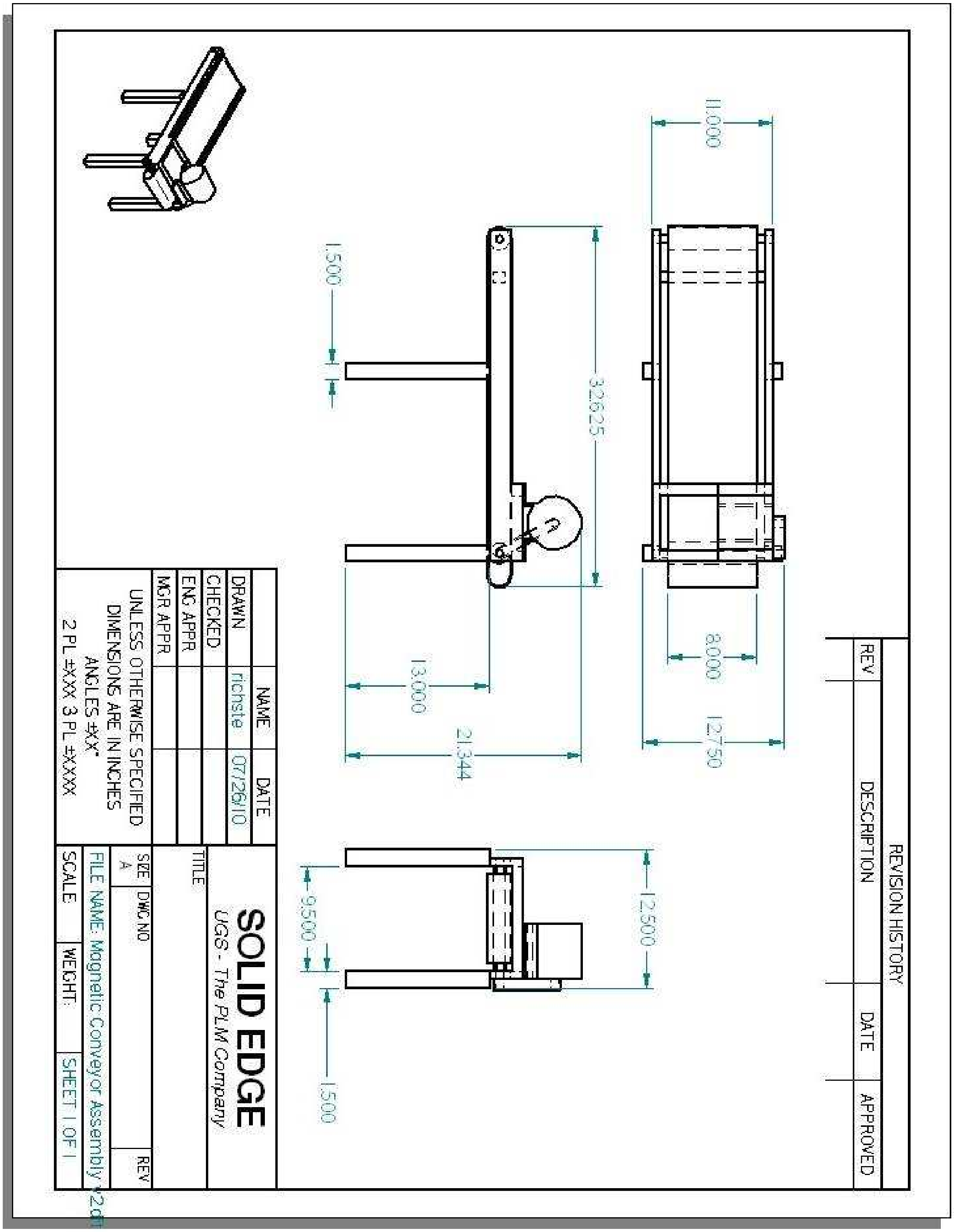


Figure 9 – Brush Stress Analysis

The following is a collection of drawings for the deburring system:





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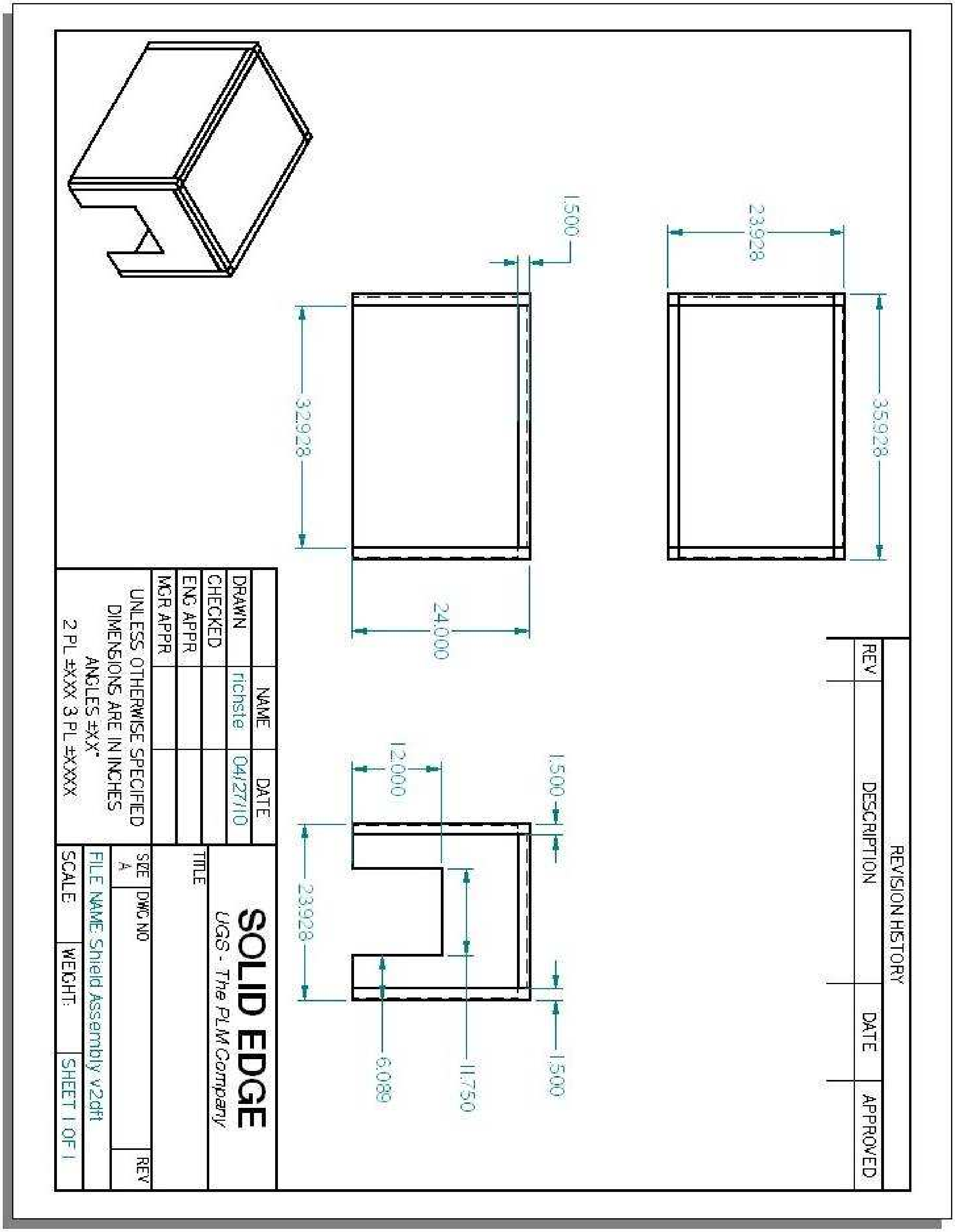
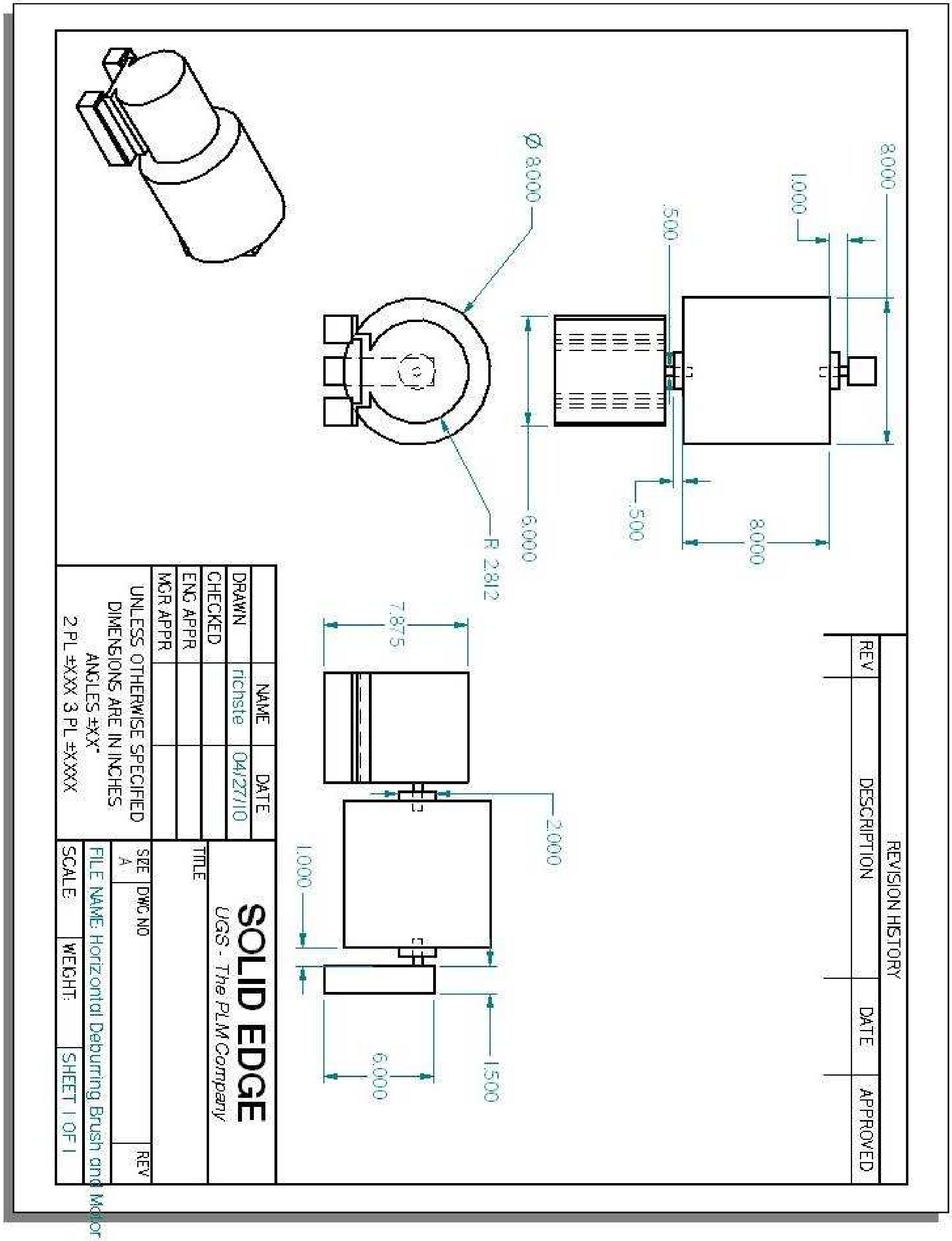
07/26/10
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX
SOLID EDGE
UGS - The PLM Company
TITLE
SIZE
A
DWG NO
REV
FILE NAME: Magnetic Conveyor Assembly 12.dft
SCALE
WEIGHT:
SHEET 1 OF 1


1.500
23.928
32.928
35.928
24.000
12.000
1.500
23.928
6.089
11.750
1.500
REVISION HISTORY
REV
DESCRIPTION
DATE
APPROVED
NAME
DATE
DRAWN
richste
04/27/10
CHECKED
ENG APPR
MGR APPR
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX
SOLID EDGE
UGS - The PLM Company
TITLE
SIZE
A
DWG NO
REV
FILE NAME: Shield Assembly v2dft
SCALE
WEIGHT:
SHEET 1 OF 1


REVISION HISTORY
REV
DESCRIPTION
DATE
APPROVED
Ø 8.000
R 2.812
6.000
.500
.500
1.000
8.000
8.000
7.875
2.000
1.000
1.500
6.000
NAME
DATE
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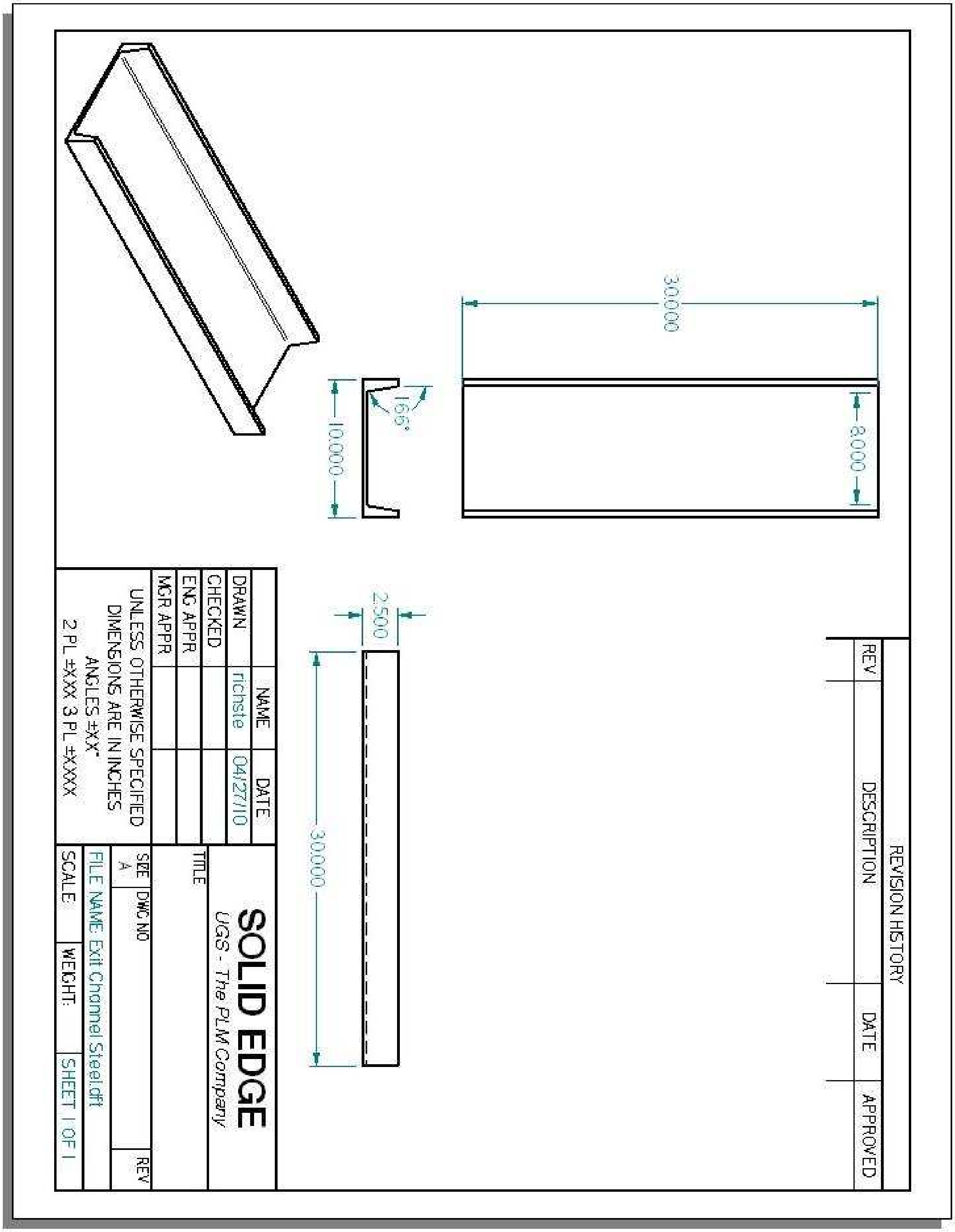
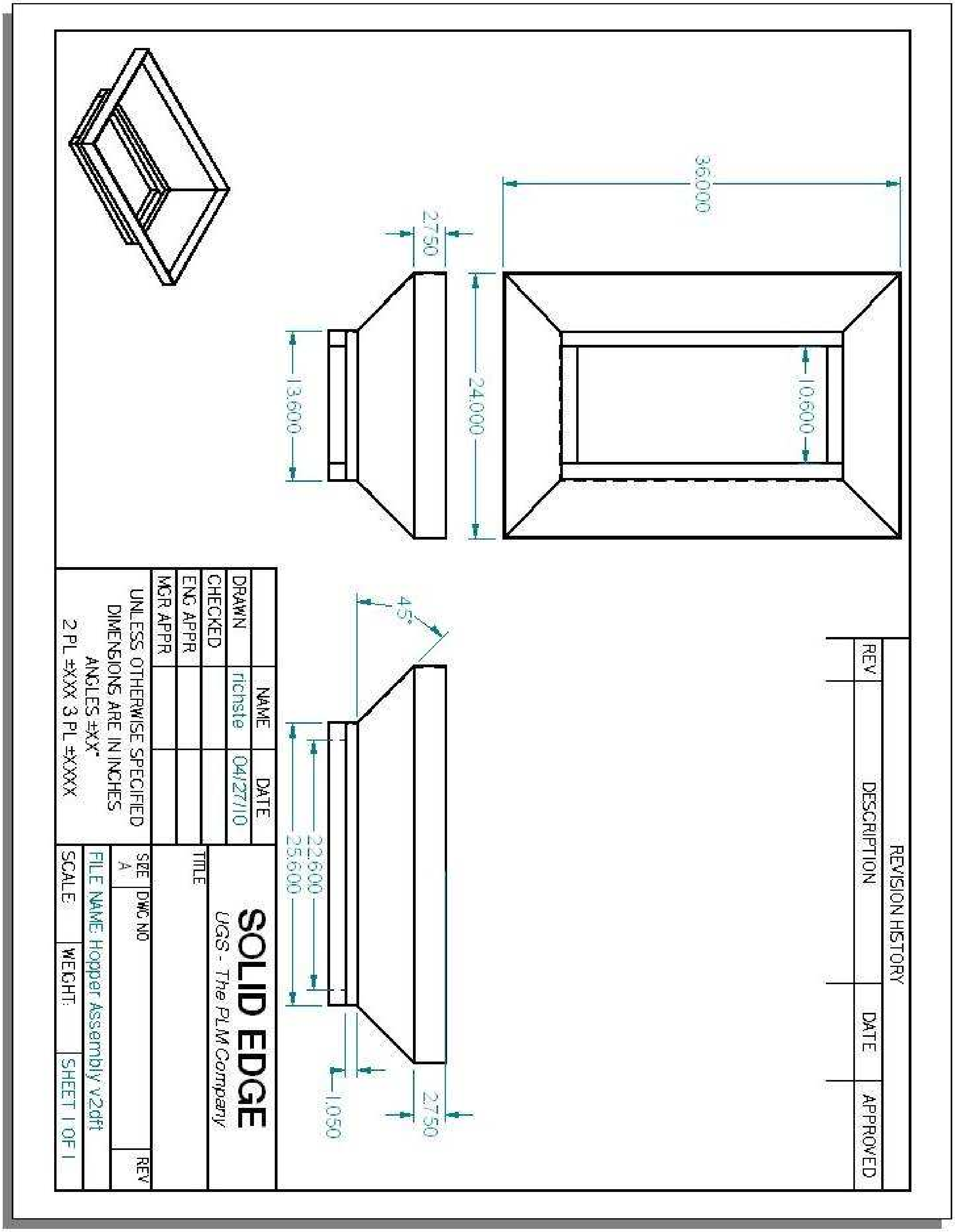
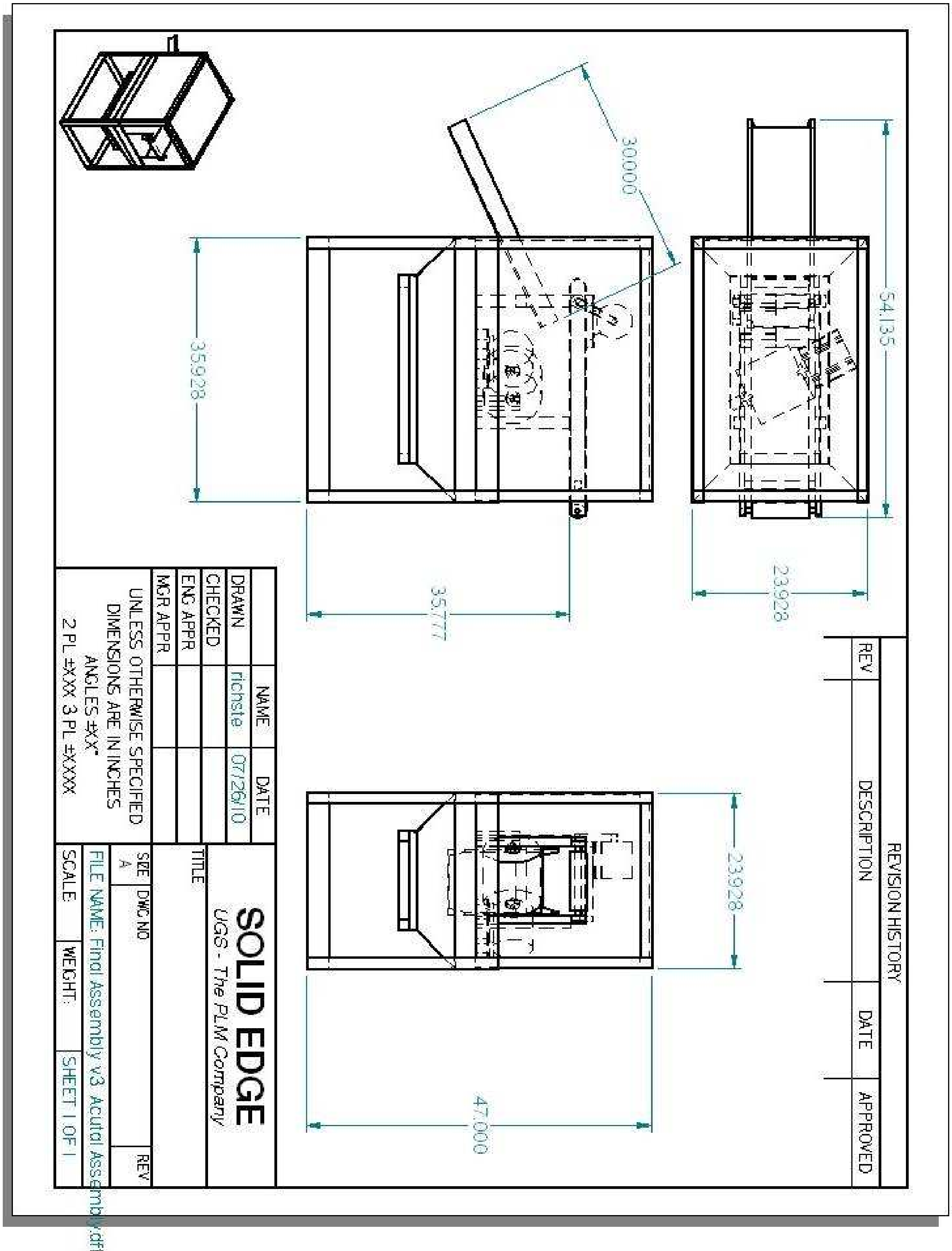
04/27/10
CHECKED
ENG APPR
MGR APPR
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±XX°
2 PL ±XX 3 PL ±XXX
SOLID EDGE
UGS - The PLM Company
TITLE
SIZE
A
DWG NO
REV
FILE NAME: Horizontal Deburring Brush and Motor
SCALE:
WEIGHT:
SHEET 1 OF 1


REVISION HISTORY
REV
DESCRIPTION
DATE
APPROVED
30.000
8.000
10.000
166°
2.500
30.000
NAME
DATE
DRAWN
richste
04/27/10
CHECKED
ENG APPR
MGR APPR
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±XX°
2 PL ±XXX 3 PL ±XXXX
SOLID EDGE
UGS - The PLM Company
TITLE
SIZE A
DWG NO
REV
FILE NAME: Exit Channel Steel.dft
SCALE:
WEIGHT:
SHEET 1 OF 1


36.000
2.750
13.600
24.000
10.600
45°
22.600
25.600
1.050
2.750
REVISION HISTORY
REV
DESCRIPTION
DATE
APPROVED
NAME
DATE
DRAWN
richste
04/27/10
CHECKED
ENG APPR
MGR APPR
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±XX°
2 PL ±XXX 3 PL ±XXXX
SOLID EDGE
UGS - The PLM Company
TITLE
SIZE
A
DWG NO
REV
FILE NAME: Hopper Assembly v2dft
SCALE:
WEIGHT:
SHEET 1 OF 1


30.000
35.928
54.135
35.777
23.928
23.928
47.000
REVISION HISTORY
REV
DESCRIPTION
DATE
APPROVED
NAME
DATE
DRAWN
richste
07/26/10
CHECKED
ENG APPR
MGR APPR
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX
SOLID EDGE
UGS - The PLM Company
TITLE
SIZE
A
DWG NO
REV
FILE NAME: Final Assembly v3 Acutal Assembly.dft
SCALE:
WEIGHT:
SHEET 1 OF 1

PROJECT MANAGEMENT STRUCTURE

Projects are assigned by classification. Figure 10 below demonstrates how each job is distributed to a team member based off their position within the team. For example, if the job at hand involves the web page, Paul Cofield will be assigned this job. If the project requires contact with the sponsor or other outside people, Steven Rich will be assigned the position.

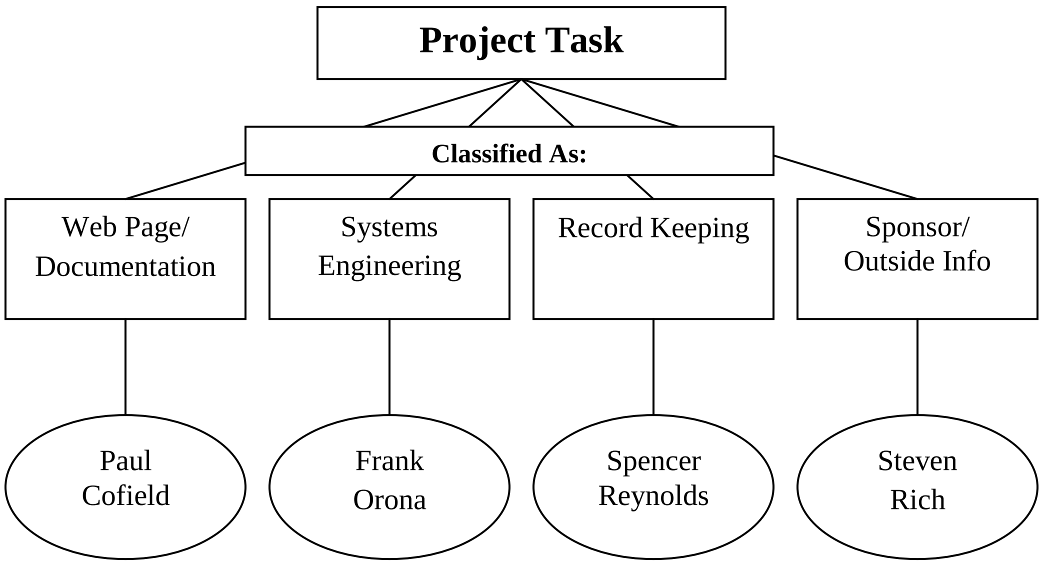


Figure 10 – Management Structure

For the upcoming summer semester, the next tasks will be ordering and receiving the parts and constructing the machine. After this is completed, proper testing of the machine will then take place. The subsystems are currently being broken down into their components where they can be researched and purchased from a manufacturer or retailer. Once every component has been identified, the appropriate measures will be taken to track down, order, and receive the needed parts.

Deliverables for this semester include a built and fully functional deburring system. This will include all test results and demonstrations to sponsors and Dr. Beale. Please observe figure 11 below containing a Gantt chart of our milestones.

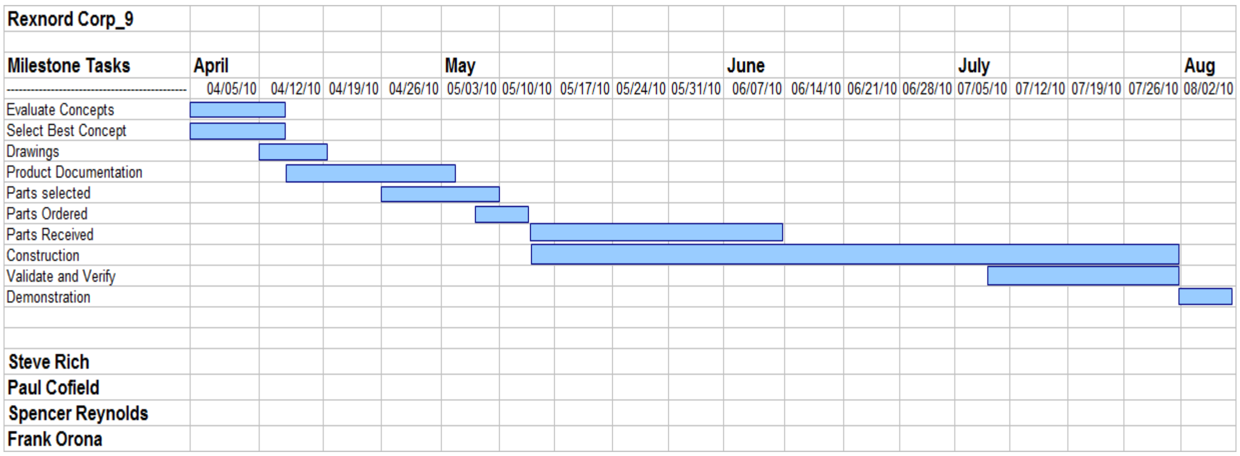


Figure 11 – Gantt Chart for Final Semester

CONCLUSION

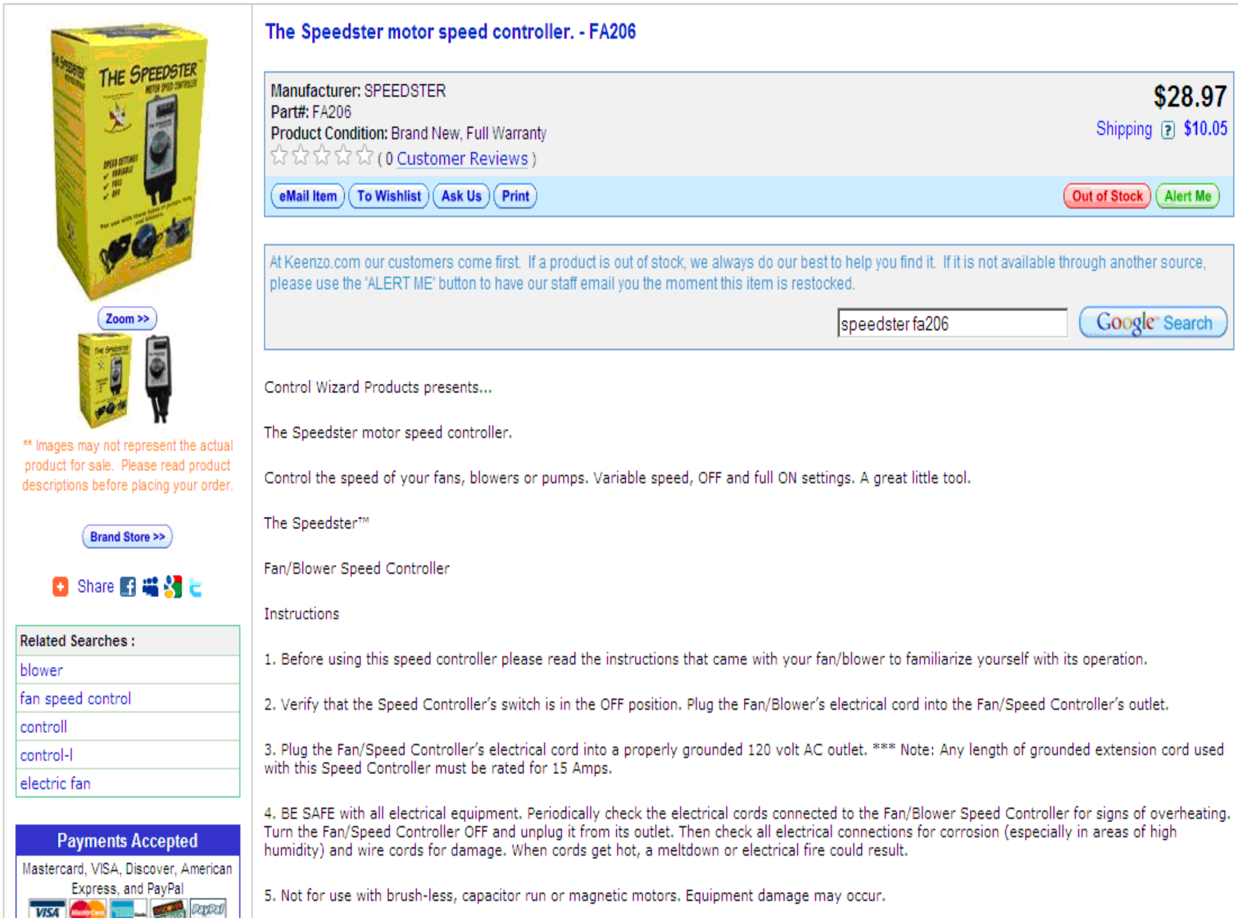
Throughout the development of this project, the main theme kept in mind was "keep it simple". The machine being developed could not exceed a certain level of complexity without reaching extremely high prices and a higher chance that deadlines would not be met. The final result meets all of the promised criteria explained in the contract of deliverables attached, as well as the mission statement presented at the beginning of the project:

- Create an automated deburring and transport system while:
  - Reducing production time
  - Improving overall quality of the finished product
  - Improving the efficiency of the waste removal process

Although this project is complete, there are still several things that could improve this design that could not be done due to time constraints. A smoother, more user friendly adjustment system could be designed, using either an electric motor and sensor to auto adjust the conveyor. Stronger, wider casters, that are more securely fasten to the conveyor cart, could be added. This would help the stability and ease of transport for the deburring system. There are many ways this machine could be adjusted and modified to fit a range of applications, relatively easy.

APPENDIX

Part Specifications:



The Speedster motor speed controller. - FA206

Manufacturer: SPEEDSTER
Part#: FA206
Product Condition: Brand New, Full Warranty
(0 Customer Reviews)

$28.97
Shipping $10.05

eMail Item | To Wishlist | Ask Us | Print | Out of Stock | Alert Me

At Keenzo.com our customers come first. If a product is out of stock, we always do our best to help you find it. If it is not available through another source, please use the 'ALERT ME' button to have our staff email you the moment this item is restocked.

speedster fa206 | Google Search

Control Wizard Products presents...

The Speedster motor speed controller.

Control the speed of your fans, blowers or pumps. Variable speed, OFF and full ON settings. A great little tool.

The Speedster™

Fan/Blower Speed Controller

Instructions

1. Before using this speed controller please read the instructions that came with your fan/blower to familiarize yourself with its operation.

2. Verify that the Speed Controller's switch is in the OFF position. Plug the Fan/Blower's electrical cord into the Fan/Speed Controller's outlet.

3. Plug the Fan/Speed Controller's electrical cord into a properly grounded 120 volt AC outlet. *** Note: Any length of grounded extension cord used with this Speed Controller must be rated for 15 Amps.

4. BE SAFE with all electrical equipment. Periodically check the electrical cords connected to the Fan/Blower Speed Controller for signs of overheating. Turn the Fan/Speed Controller OFF and unplug it from its outlet. Then check all electrical connections for corrosion (especially in areas of high humidity) and wire cords for damage. When cords get hot, a meltdown or electrical fire could result.

5. Not for use with brush-less, capacitor run or magnetic motors. Equipment damage may occur.

Zoom >>

** Images may not represent the actual product for sale. Please read product descriptions before placing your order.

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blower
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The following is the Matlab code for the brush analysis:

```
%Steven Rich
%4/23/10
%Brush Stress Analysis

clear all
clc

%User Inputs

Umax=input('Ultimate tensile strength of material (in psi): ');
Uyield=input('Max tensile yeild strength of material (in psi): ');
E=input('Enter modulus of elasticity of material: ');
lo=input('Enter the length of the bristles: ');

%Calculations
x=1;
l=0;
sigma=0;
while sigma<Uyield
    roe(x)=lo-l;
    y(x)=sqrt(lo^2-roe(x)^2);
    epsilon(x)=y(x)/roe(x);
    sigma(x)=E*epsilon(x); %Hooke's Law
    l=l+.001;
    x=x+1;
end
Max_distance_into_brush_before_yield_is_=l

clear x
clear l
clear roe
clear sigma
clear y
clear epsilon

x=1;
l=0;
sigma=0;
while sigma<Umax
    roe(x)=lo-l;
    y(x)=sqrt(lo^2-roe(x)^2);
    epsilon(x)=y(x)/roe(x);
    sigma(x)=E*epsilon(x); %Hooke's Law
    l=l+.001;
    x=x+1;
end
Max_distance_into_brush_before_break_is_=l

%Graphs
plot(lo-roe,sigma,lo-roe,Uyield,'.',lo-roe,Umax,'.');
xlabel('Distance Into Brush (in)');
ylabel('Stress in Bristles (psi)');
```

PARTS	COLOR BAND	BRUSH SPEED	CONVEYOR SPEED
1020T	**RED**	MAXIMUM	55%
1030T	**RED**	MAXIMUM	55%
1040T	**BLACK**	MAXIMUM	10%
1050T	**PURPLE**	MAXIMUM	10%
1060T	**ORANGE**	MAXIMUM	10%
1070T	**BLUE**	MAXIMUM	10%
1080T	**BROWN**	MAXIMUM	10%

Table 4 – Part sizes, conveyor location, brush and conveyor speed.