Nylon-Coat Process Final Report

Prepared for: Micropulse, Incorporated and Professor Barry Dupen

Prepared by: Matthew Amberg, Jacob Beard, and Branden Lagassie

Spring 2016

Table of contents

Purpose:

The purpose of the project was to find a way to remove Nylon from holes in brackets that have gone through a Nylon coating process. The initial idea was to design and fabricate a plug that would be placed in the holes before the bracket went through the Nylon coating process. After some preliminary testing the conclusion was made that the plug would not be a viable option due to the time required to remove the plug, the cost of producing the plug, and a multitude of other reasons. The next option was to design and fabricate a pneumatic clamp fixture that would be able to hold various sized brackets in order to remove Nylon from the holes during a post drilling operation.

Background

Brackets made of Aluminum and Stainless Steel are components of many of the delivery systems that Micropulse designs and manufactures. At this time, Micropulse outsources these brackets to another company to apply a coating of Nylon-11 (tradename Rilsan) to the parts. This company runs the parts through a furnace, heating them to 640^{o}F. The parts are then lowered manually into a fluidized bed of Nylon powder and hung on a conveyor to cool.

The Nylon coating is evenly applied to every surface of the parts; including the holes which will be used to mount the brackets to the case or tray assembly. These holes come back from the coating operation undersize with the Nylon on the inner diameter of the mounting holes. Currently, the out-sourced manufacturer drills the Nylon out of the holes for a small fee.

Micropulse is in the final stages of setting up its own fluidized-bed Nylon dipping operation. This means that the removal of material from the mounting holes will also fall to Micropulse.

First Approach: Plug

The first approach was to use a plug that would be placed in the holes before the bracket went through the Nylon coating process. This was proposed to increase safety, because the Nylon entered the holes and was then removed during a post drilling operation. During this post drilling operation an operator would hold the bracket in there hand and then bring the bracket up to a moving drill bit to remove the Nylon. The plug would have eliminated the need for the post drilling process.

a. Design of the plug

   All of the holes in the brackets were the same size, so the design was fairly simple to come up with. An image of the design can be seen in Figure 1.

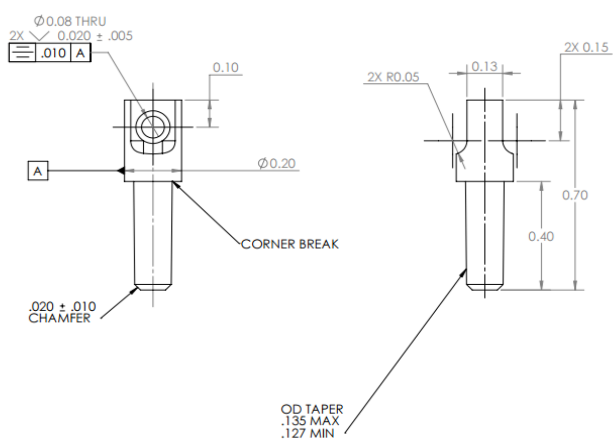


Figure 1

b. Material type and fabrication of the plug

The decision was made to use 17-4 stainless steel, because it was readily available in house at Micropulse and it could withstand being heated up to 640 degrees Fahrenheit [1]. The plug was machined in house at Micropulse using a CNC lathe and a CNC mill. The finished plug can be seen in figure 2.

Figure 2

Testing of Plug

Once the plug was designed and machined, a test run was done using the plug to see if it would prevent the Nylon from enetering the holes. After running the test, the bracket and plug were inspected. The plug was successful in preventing the Nylon from entering the bracket's hole, but created a multitude of additional issues. The additional issues are listed and described below.

a. Plug removal

The plug was very difficult to remove from the bracket because the Nylon coating adhered to both the plug and the bracket. It took close to 10 minutes to remove just one plug.

b. Cost of plugs

The quantity of plugs that would be needed would be cost prohibitive because the plugs can only be used once.

c. Integrity and finish of Nylon coat

The plug affected the finish of the Nylon coating by causing pitting near where the plug was inserted. We thought that the plug affected the cooling rate of the bracket after it comes out of the post heating oven. The thought was the plug was acting as a fin and causeing the Nylon and bracket near the the plug to cool too rapidly. After doing some calculations which can be seen later in this report, we found that the plug only increased the heat transfer by 3.5% [2]. We did not feel that this small increase in heat transfer would have that great of an effect on the Nylon finish, so we were not able to determine why the pin was causeing the the Nylon to pit.

First Approach Conclusion

After performing this test and finding the unexpected issues that arose with using the plug. We decided as a team that using a plug to prevent the Nylon from entering the bracket's holes was not a viable option. After discussions and brain storming meetings, we decided that instead of removing the post drilling process completely, we were going to create an air powered clamp to hold the brackets during the post drilling operation making it safer and reducing the risk of serious injury.

Second Approach: Pneumatic Clamp Fixture

After realizing that the plug was no longer a viable option we proposed a new idea for a clamp that would hold the brackets during the post drilling operation. By creating an air powered clamp to hold the brackets during the drilling operation it eliminated the need for the operator to hold the bracket while the Nylon is being removed from the holes. This will make the post drilling operation much safer and reduce the risk of a serious injury occurring.

The clamp fixture presented us with many challenges, from choosing a design and finding the correct components to selecting the right type of material to use to build the assembly. The first challenge encountered was creating a design that could hold brackets of different shapes and sizes, while still being compact enough so the operator could easily move the clamp fixture. The next challenge was finding the correct pneumatic cylinder and control valve to purchase for the clamp fixture. An additional challenge encountered was trying to find the correct material to build the body, movable jaw, and jaw face insert out of. In order to insure that the clamp fixture was durable enough to withstand the forces that it was going to be encountering.

Design of Clamp Fixture

The design was the first thing that needed to be completed. We knew that the operator would be moving the clamp fixture multiple times for a single bracket in order to move from hole to hole. This meant that the most important aspect was to keep the clamp fixture small and light enough so it could easily be moved from hole to hole. We also knew that the clamp fixture would be using a pneumatic cylinder to move one of the jaw faces back and forth. In order to complete the design we needed to know the size and type of cylinder that was going to be used. After some research a double acting Original Line® air cylinder was found and purchased [3]. Once the right cylinder was decided upon a control valve needed to be found to control the cylinder. After looking at multiple types of valves we chose to use a Jupiter Pneumatic 1/4 inch, 5-way, 2-position control [4]. Once the cylinder and control valve were chosen the design was completed.

Components of Clamp Fixture

Figures 3 through 6 are the main components that make up the body of the clamp fixture.

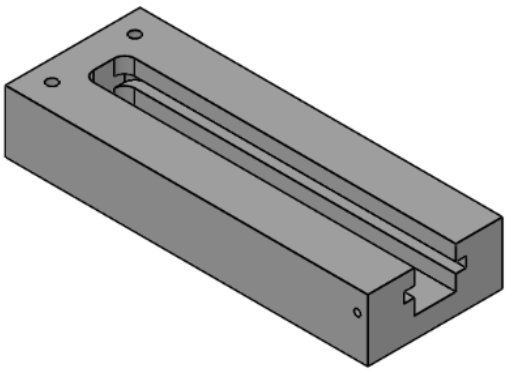


Figure 3: Base of clamp

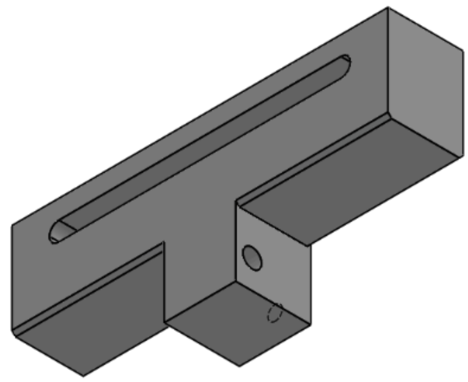


Figure 4: Movable jaw

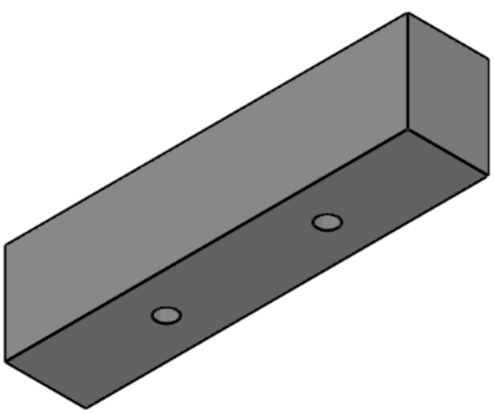


Figure 5: Stationary jaw

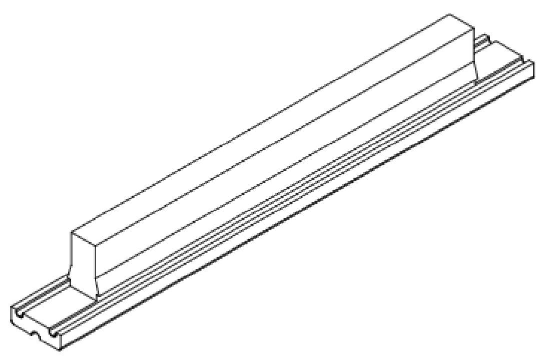


Figure 6: Silicone jaw insert

An exploded image of the entire clamp assembly can be seen in figure 7. Table 1 shows a list of the components that make up the clamp assembly

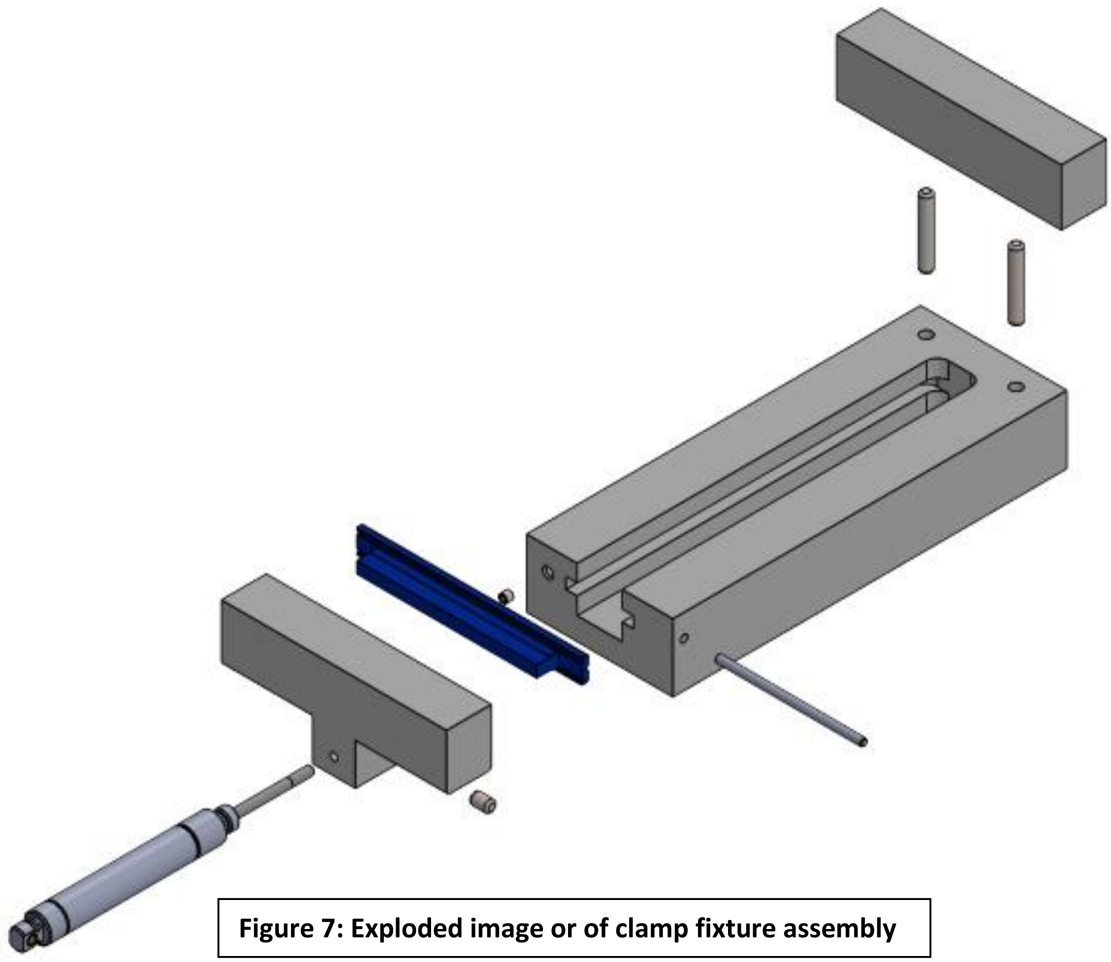


Figure 7: Exploded image or of clamp fixture assembly

DESCRIPTION	QTY.
Clamp Base	1
Fixed Jaw	1
Movable Jaw	1
Silicone Insert	1
Air Cylinder	1
Cross Pin	1
Set Screw	1
Track Pins	2
Fixed Jaw Pins	2

Table 1: list of components used in clamp fixture assembly

Pneumatic Components

a. Control valve

The control valve that was used is a Jupiter Pneumatic 1/4 inch, 5-way, 2-position control valve with a manual lever [4]. The control valve can be seen in figure8. A 5-way, 2-position control valve was chosen because we wanted to reduce the amount of times the operator had to press the lever per bracket being drilled. With this valve we were able to get it down to 2 times per bracket. One to open the clamp to put the bracket in place, and one to remove the bracket after it has been drilled.

Figure 8: 5-way, 2-position control valve [4]

b. Regulator

The regulator that was used is a Norgren ½" NPT pressure regulator with a 0-160 psi gauge. The regulator can be seen in figure 9. This regulator was used because it was readily available at Micropulse. We knew that a range of 0-160 psi was going to be fine because the line pressure at Micropulse is ran at 110 psi.

Figure 9: Regulator

c. Cylinder

The cylinder that was chosen is a double acting Original Line® air cylinder. The cylinder has a bore size of 9/16" with a 2" stroke and a pressure rating of 250 PSI [3]. This cylinder was chosen because it was compact and met all the requirements needed for what it was going to be used for. The cylinder can be seen in figures 10 and 11.

Figure 10: Bimba air cylinder

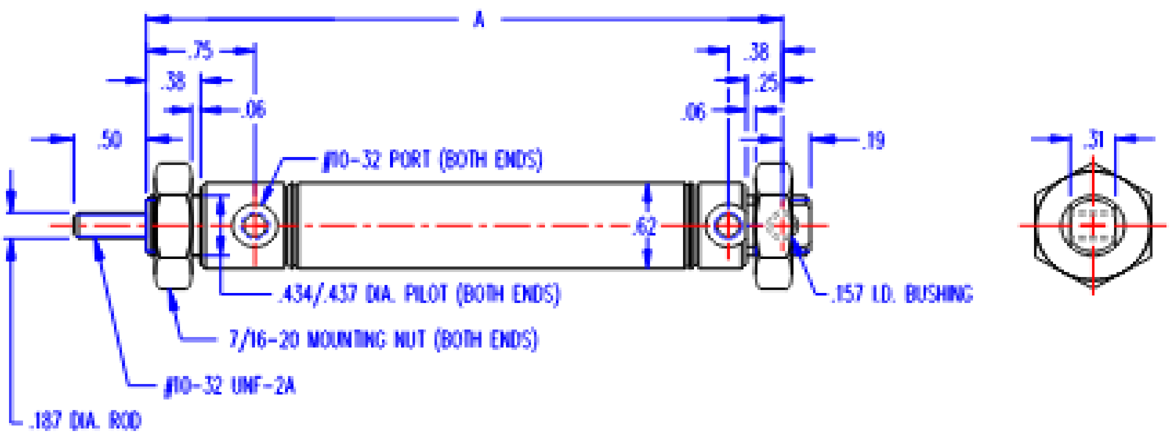


Figure 11: Dimensions of air cylinder [3]

Material Type

The material used for the clamp fixture needed to be strong, but light weight as well. Knowing that some type of plastic would be the best choice for many of the components, it was decided to use Tecapro MT. The body, fixed jaw, and movable jaw were all made out of Tecapro MT. Tecapro MT was chosen because it was readily available at Micropulse and this material had the properties needed to withstand the forces that will be applied to it. Tecapro MT is a homopolymer polypropylene based material, mechanical properties of Tecapro MT can be seen in table 2 [5]. The Jaw face was made out of Silicone. Silicone was chosen because it was also readily available at Micropulse, and it is a softer polymer that would deform before damaging the brackets that are going to be clamped.

	Properties	Condition	Value		Test Method
Mechanical	Tensile strength at yield	@ 73°F	5,076	psi	ASTM D 638
	Elongation at break	@ 73°F	12	%	ASTM D 638
	Flexural strength	@ 73°F	7,830	psi	ASTM D 790
	Modulus of elasticity (flexural test)	@ 73°F	210,000	psi	ASTM D 790
	Compression strength	1% Sec, @ 73°F	2320	psi	ASTM D 695
	Compression modulus		232,000	psi	ASTM D 695
	Impact strength (Izod)	@ 73°F	0.899	ft-lbs/in	ASTM D 256

Table 2: Mechanical properties of Tecapro MT [5]

Fabrication

Once the material was chosen, fabrication of the components could begin. The base, fixed jaw and movable jaw were all machined using a manual mill. The silicone bracket was cut on a water jet. Images of these components after being machined can be seen in figures 12, 13 and 14.

Figure 12: Body of clamp

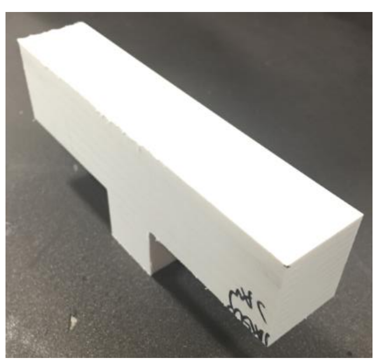


Figure 13: Movable jaw

Figure 14: Silicone Jaw insert

Completed Assembly

An image of the final assembly as well as an image of the whole system can be seen in figures 15 and 16.

Figure 15: Clamp fixture assembly

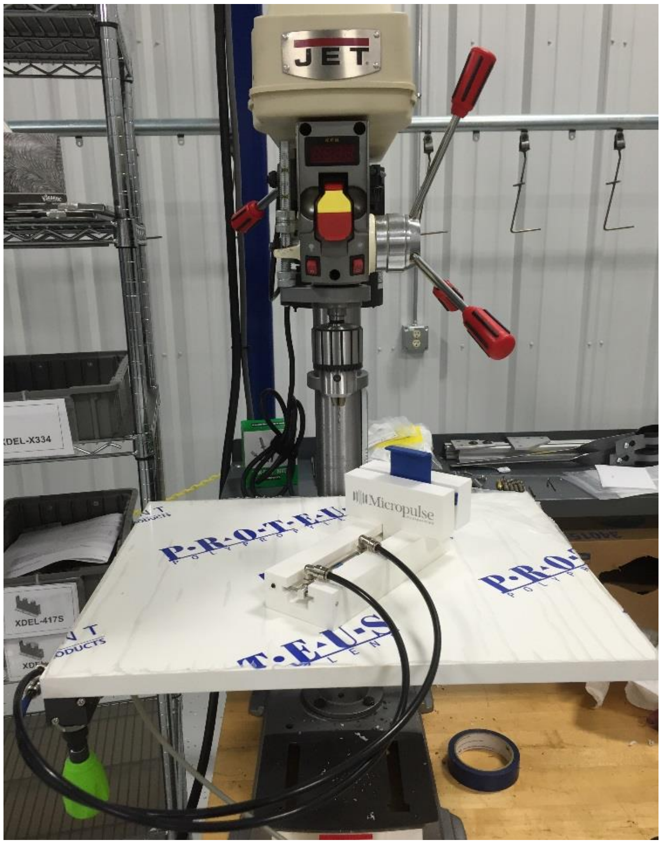


Figure 16: Entire system of pneumatic clamp fixture

Circuit Diagrams

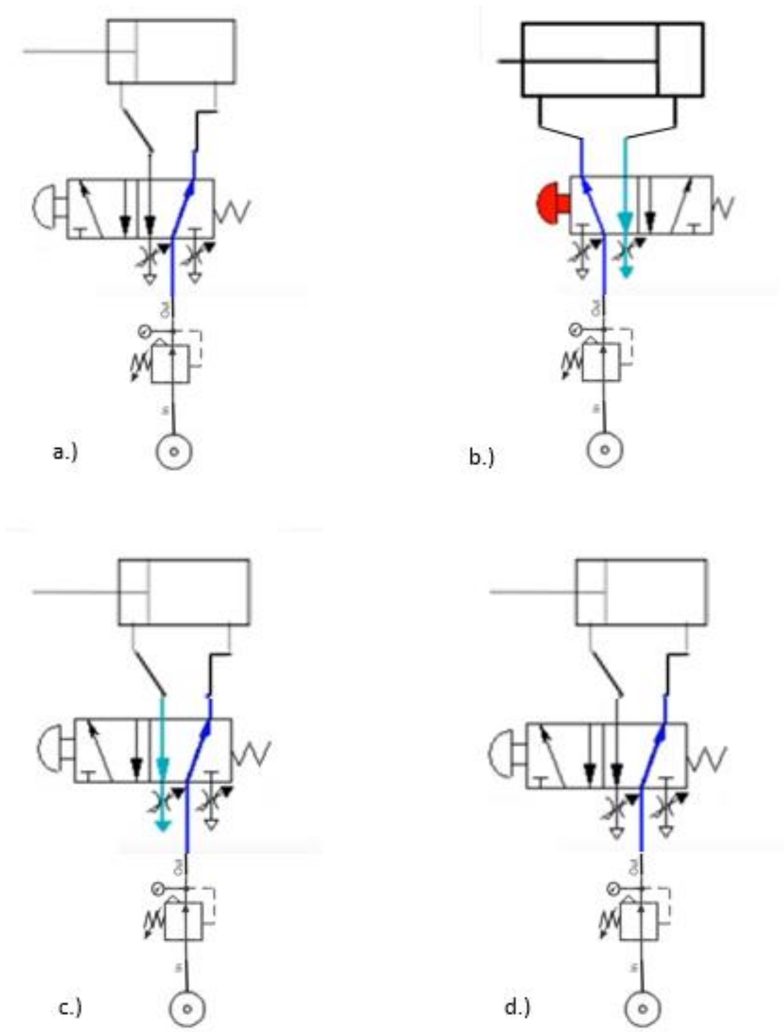


Figure 17: Circuit diagram

Figure 17 shows the four stages that out pneumatic system will go through. Figure 17a shows the system at its initial stage with the piston extended meaning that the clamp is closed. Once the operator pulls the lever air begins to pump into the cylinder at one end and let's air exhaust out of the other end, retracting the piston resulting in the clamp opening up, this can be seen in figure 17b. Once the operator lets off of the lever the air flow will switch directions, the piston will begin extend back out closing the clamp this is shown in figure 17c. Figure 17d shows the system back at its original state with the piston extended.

Finite Element Analysis (FEA)

$$\textbf{\textit{Pin Cross Sectional Area (Bearing Stress)}}\text{:}^{[6]}$$

$$A = Length * Diameter$$

$$A = 3.25\ in * .157\ in$$

$$A = .510\ in^2$$

$$\textbf{\textit{Maximum Force on Block}}\text{:}^{[6]}$$

$$F_{max} = P_{max} * A$$

$$F_{max} = 127.98\ \frac{lb}{in^2} * .510\ in^2$$

$$F_{max} = 65.26\ lbs$$

The pressure value of 128 psi was used because it was merely the maximum rated pressure for the control valve. Since it was a test for the normal stress in the Z direction (direction of arrows), we used the most extreme values.

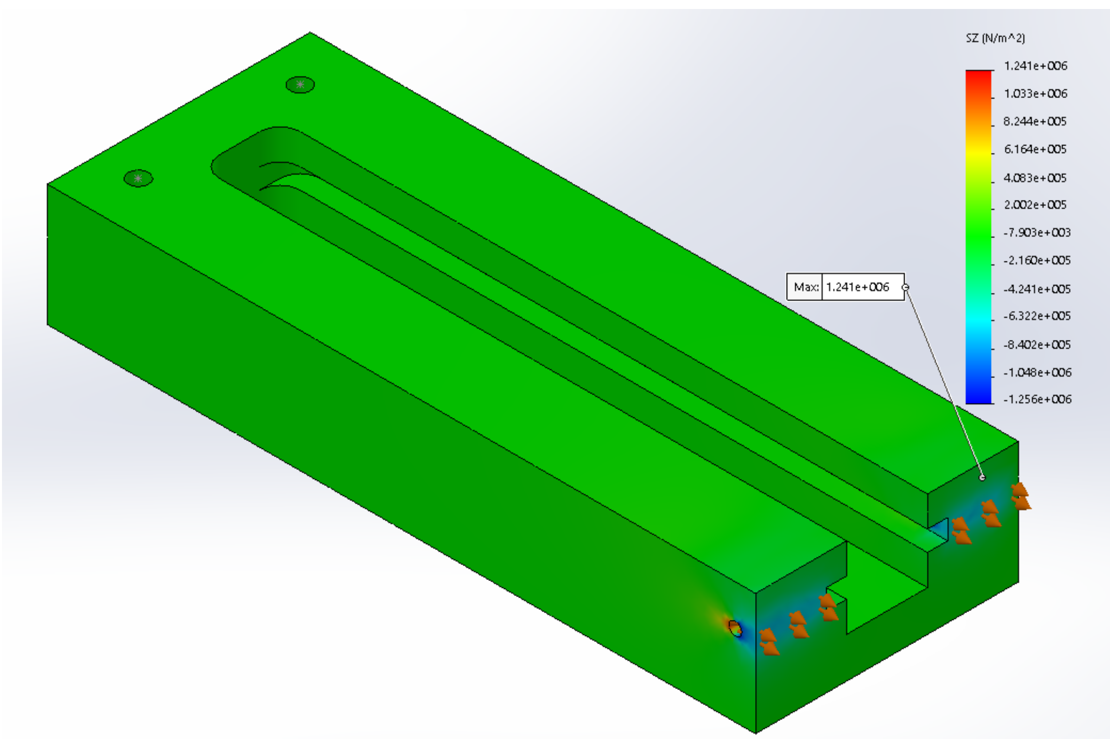


Figure 18: FEA for normal stress in Z (direction of arrows)

Finite element analysis of the fixture base determined the maximum normal stress that the block will experience in the Z direction to be 1.241e6 N/m^2 (seen in the brightest red around the pin hole).

Calculations

<u>ADDITIONAL HEAT TRANSFER ON ACCOUNT OF PLUG</u>

<u>Given:</u>

A_1 = Area of part alone
A_2 = Area of part with plug
h = 25 W/m^2K (table 16-5, Fundamentals of thermal-fluid sciences, 4^{th}, cengel)
T_1 = Temp just out of furnace
T_∞ = Temp of air a distance from part

<u>Task:</u>

Determine whether the application of the plug could cause additional and problematic heat transfer.

<u>Convection Heat Transfer: Part without Plug</u>

$$Q_1 = hA_1(T_1 - T_\infty)$$

$$Q_1 = 25\ \frac{W}{m^2K}(0.006985m^2)(611K - 294K)$$

$$Q_1 = 55.36\ W$$

<u>Convection Heat Transfer: Part with Plug</u>

$$Q_2 = hA_2(T_1 - T_\infty)$$

$$Q_2 = 25\ \frac{W}{m^2K}(.0002611m^2 + (.006985\ m^2 - .00001555m^2)(611K - 294K)$$

$$Q_2 = 57.30\ W$$

<u>Percent Change in Q with Plug</u>

$$\Delta Q = 100\left(\frac{(Q_2 - Q_1)}{Q_1}\right)$$

$$\Delta Q = 100\left(\frac{(57.30\ W - 55.36\ W)}{55.36\ W}\right)$$

$$\Delta Q = +\ 3.5\%\ with\ plug$$

<u>Conclusion:</u>

This change in heat transfer presents a reasonable level of risk. We can confidently proceed with this method without expecting a significant change in part temperature on account of the plug being in the part. The part will be out of the furnace for approximately one second prior to Nylon application. Nylon melts at 186 ^oC. During this time, it is unlikely that there will be sufficient heat transfer to drop the part temperature below the critical point.

AXIAL SHEAR STRESS IN THREADS

The movable jaw has been tapped with a 10-32 thread in order for us to be able to connect the air cylinder's piston to the movable jaw [7]. One of our areas of concern was whether or not the threads could withstand the shear stress's that would be applied to them.

Given:

10-32 UNF threads http://www.barnhillbolt.com/page/specs/InternalThreadsClass2B100.htm

Thread length, L_e = .380 in

Shear Strength, τ = 19.44 ksi

$F = \tau A_n$

$$A_n = \pi\, n\, L_e D_{s\,MIN}\left(\frac{1}{2n} + 0.57735(D_{s\,MIN} - E_{n\,MAX})\right)$$

$D_{s\,MIN}$= Minimum major diameter of external thread

$E_{n\,MAX}$=Maximum pitch diameter of internal thread

$$A_t = 0.7854\left(D - \frac{0.9743}{n}\right)^2$$

Task:

Calculate the force at which the Tecapro will fail in the threaded region.

Solve for Internal Shear Area

$$A_n = \pi\, n\, L_e D_{s\,MIN}\left(\frac{1}{2n} + 0.57735(D_{s\,MIN} - E_{n\,MAX})\right)$$

$$A_n = \pi\, 32\,(.380\, in)(.190\, in)\left(\frac{1}{2(32)} + 0.57735(.190\, in - .1736\, in)\right)$$

$$A_n = 0.182\, in$$

Solve for Shear Strength

$$F_s = \tau\, A_n$$

$$F_s = 19.44\, ksi * 0.182\, in$$

$$F_s = 3.54\, kip$$

$$F_s = 3{,}540\, lb$$

Conclusion:

Since our calculated F_{max} is significantly less than F_s, it is reasonable to expect that the threads in the Tecapro will not fail in shear.

TIME TO CLOSE CLAMP

The following calculation shows the time it takes to close the clamp when different air pressures are used in the cylinder.

Given:

Valve coefficient of velocity, C_v = .976 (from manufacturer)

Cyliner bore dia = 9/16 in

Cylinder stroke = 2 in

P_{max} = 100 psi (limited by regulator output)

Task:

Calculate time required to close clamp at a variety of air pressures.

$$V_c = A * Stroke$$

$$V_c = \frac{\pi D^2}{4} * Stroke$$

$$V_c = \frac{\pi\left(9/16\ in\right)^2}{4} * 2\ in$$

$$\underline{V_c = 0.497\ in^3}$$

$$t = \frac{V_c * A * C_f}{C_v * 29}$$

Time, s	Inlet P, psi	Comp. Factor, Cf	"A" Constant
0.003	10	1.6	0.102
0.003	30	3	0.055
0.003	50	4.4	0.043

As shown, the clamp will close extremely quickly regardless of inlet pressure. This is good from a time-saving standpoint. This could cause issues with operator safety and life of the fixture. In order to combat this, we would recommend using a valve with a smaller C_v and the addition of speed flow control valves on the inlet lines to the cylinder. This will control the speed of the cylinder independent of the inlet pressure.

These times are unverifiable given the equipment available to us. We do not have a stop watch with the necessary resolution, or the technology or reflexes capable of indicating the cycle of the clamp.

Test Results

To test the clamp fixture we ran the system at different operating pressures starting at 10 psi increasing at 10 psi increments until we reached 70 psi. The results of the tests and a comparison of our theoretical values to out experimental values can be seen in table 3

Bore Area (9/16)	**Pressure, psi**	**Force, Theoretical, lb**	**Force, Experimental, lb**	**Difference, Absolute**	**Difference, Percent**
0.2485	10	INOPERABLE	INOPERABLE	N/A	N/A
	20	5.0	2.2	2.8	55.74%
	30	7.5	3.6	3.9	51.71%
	40	9.9	5.1	4.8	48.69%
	50	12.4	6.9	5.5	44.47%
	60	14.9	8.9	6.0	40.31%
	70	17.4	10.7	6.7	38.49%

Table 3: Theoretical vs. experimental values for force applied

Experimental values were collected using a load tester. Pressure was increased incrementally and three samples collected at each pressure. The results were averaged and compared against calculated values.

Sources of error; in order of greatest contribution:

1. Load was not tested coaxially with the force vector of the air cylinder. This was intentional and this deviation was expected. Though this produces a moment about the intersection point of the air cylinder and movable jaw, this is a test that is representative of the function of the clamp.
2. Possible inconsistency in the placement of the load tester; could have been at slightly different distances from the vertical plane that intersects the central axis of the cylinder.
3. Possible difference between P_{Actual} and $P_{Expected}$. Given the low resolution of the gauge on the regulator, the P_{Actual} could easily be set ± 2psi from $P_{Expected}$.

Overall the clamp met our expectations of being able to hold the brackets securely while being drilled, while at the same time not damaging the brackets. Many of the managers at Micropulse are very pleased with the final product. They plan to implement the clamp into the Nylon process, and it will be used in production.

Costs

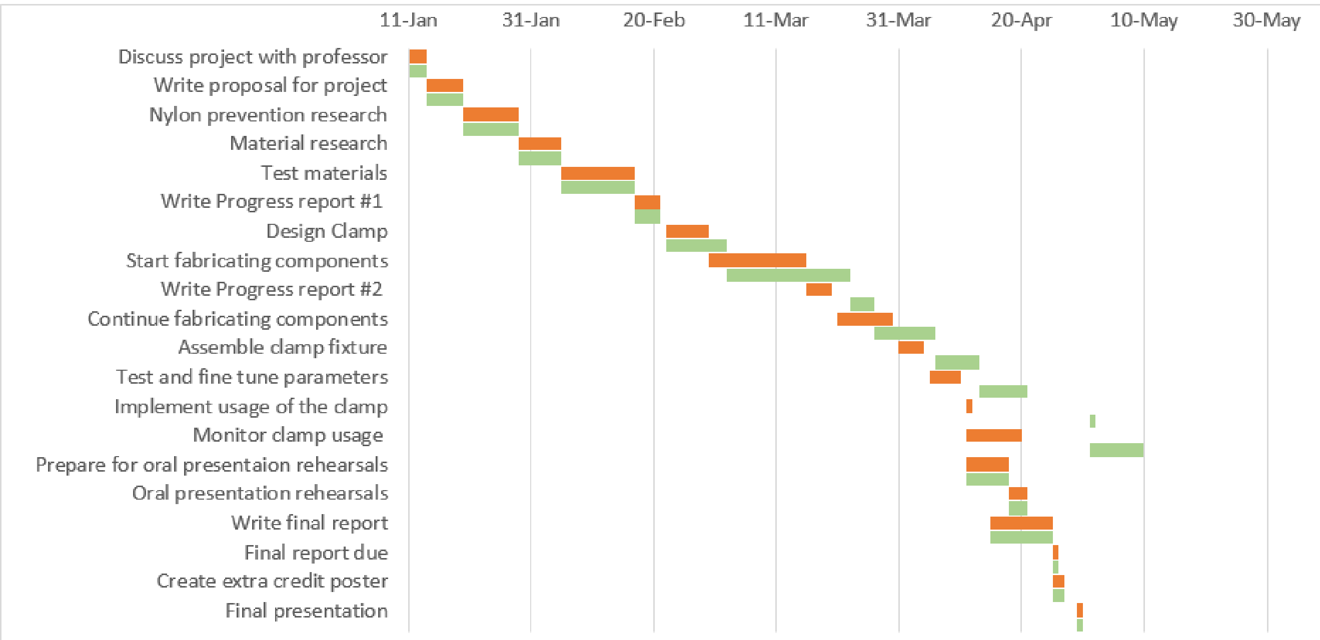
The project was funded by Micropulse. All or the labor was done by our group members, and all fabrication was done in house at Micropulse. It took a total of 52 hours to design and fabricate the clamp fixture. Many of the components were already in house or were previously purchased for a different project. We tried to use as many parts that were on hand at Micropulse as possible to keep cost down. Table 4 shows the costs of various components that were used in the clamp fixture.

Component	Cost
Drill press	$400
Air Cylinder[3]	$27
5/2 Control Valve[4]	$42
Air Lines (100 ft)	$11
Pneumatic Connectors	$20
Regulator[8]	$105
¼ - in Dowel Pins	$2
Tecapro Mat'l	$150
TOTAL	$757

Table 4: Cost of components used in clamp fixture assembly

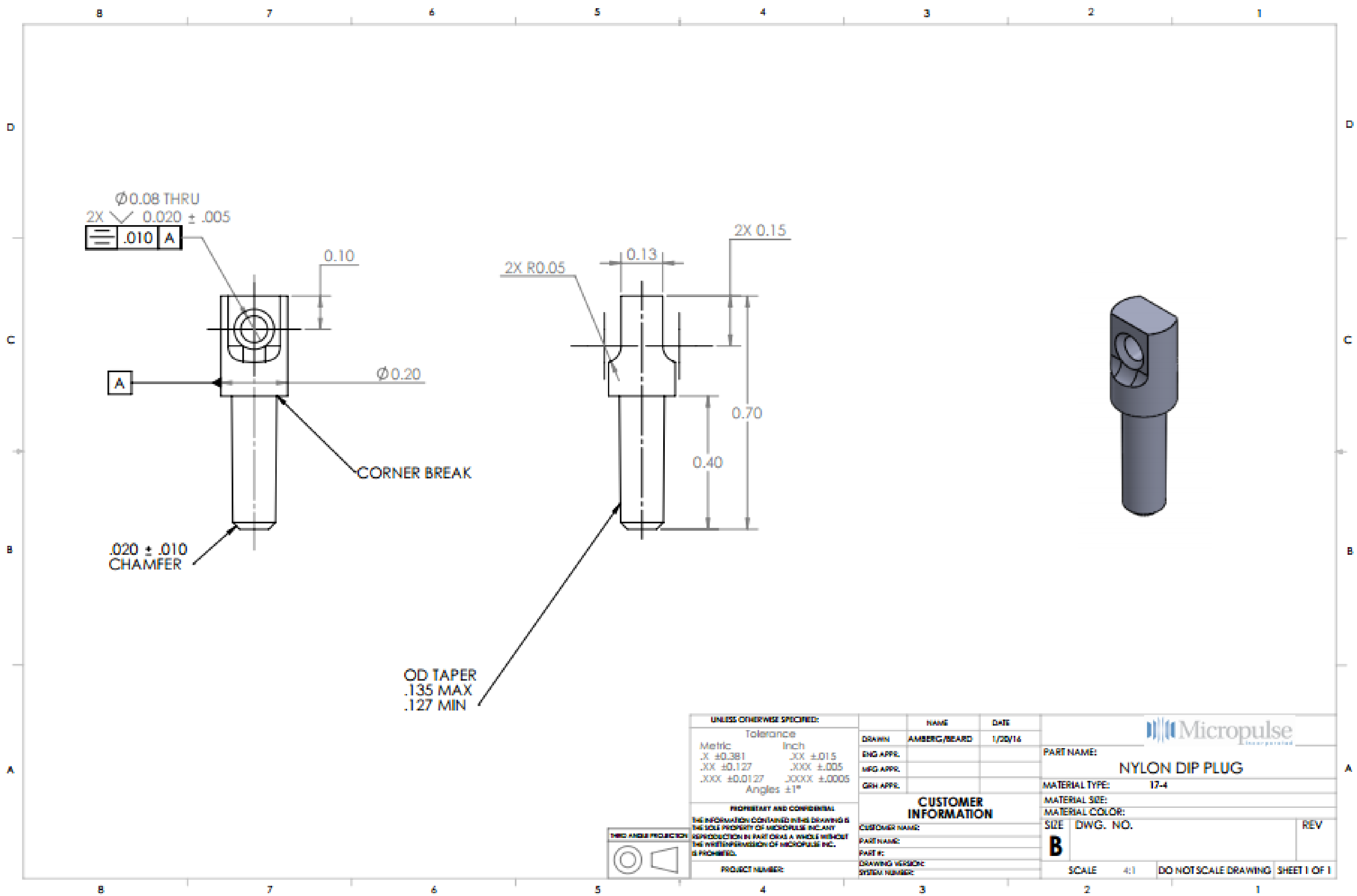
Timeline

Below is a Gantt chart that shows the original timeline of the project versus the actual timeline of the project. The original timeline is represented by the orange bars and the actual timeline is represented by the green bars.

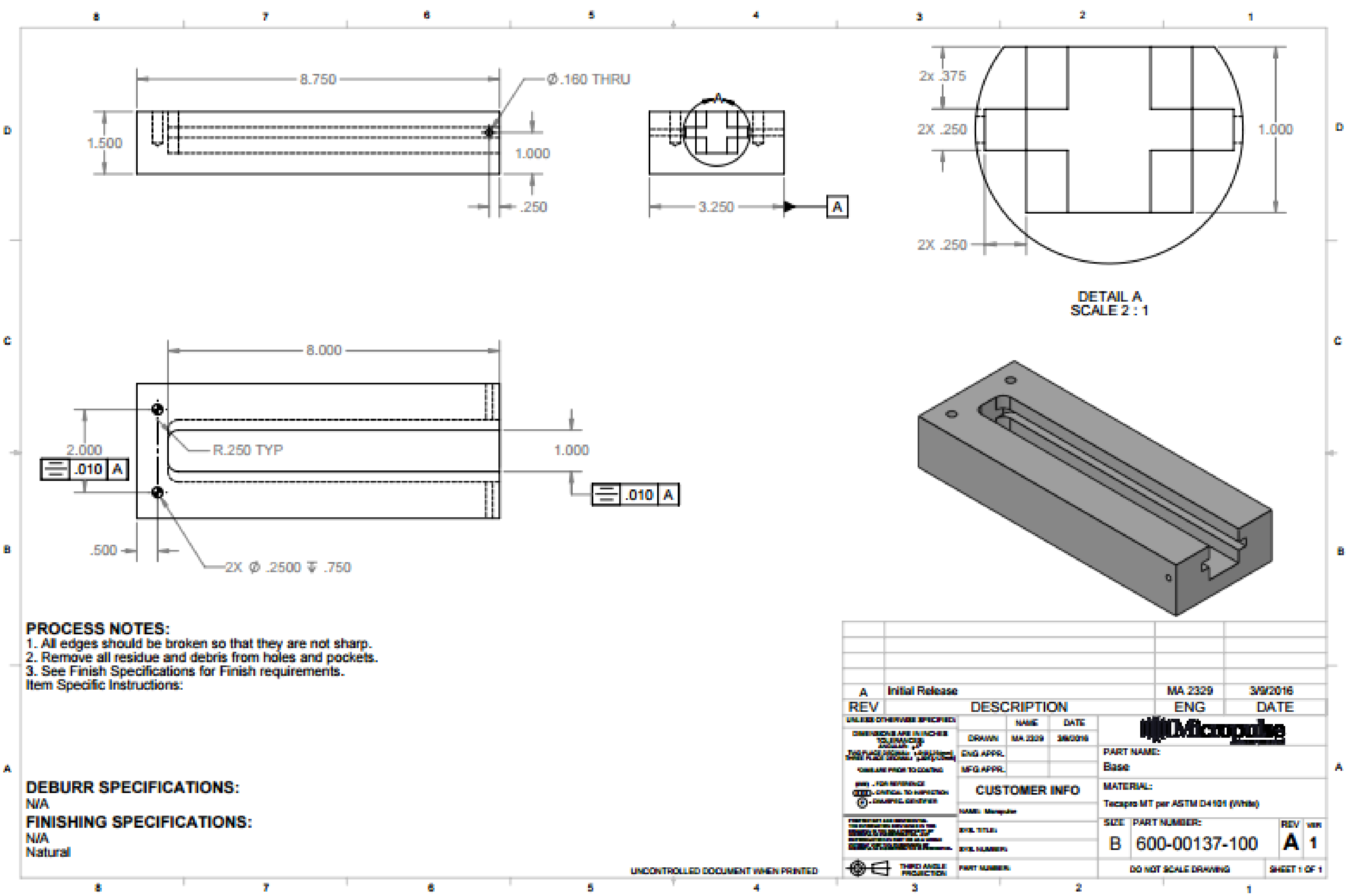


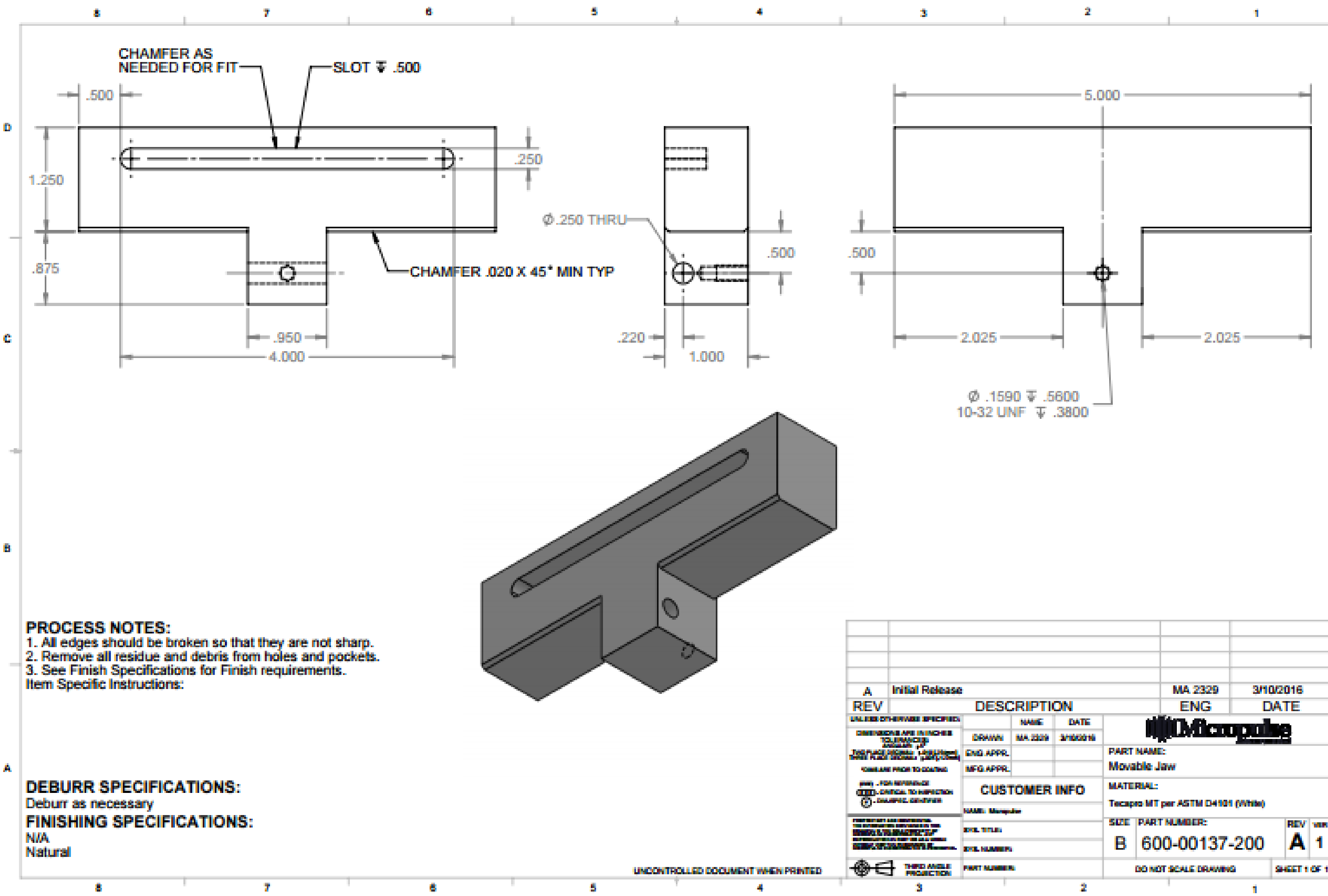
Conclusion

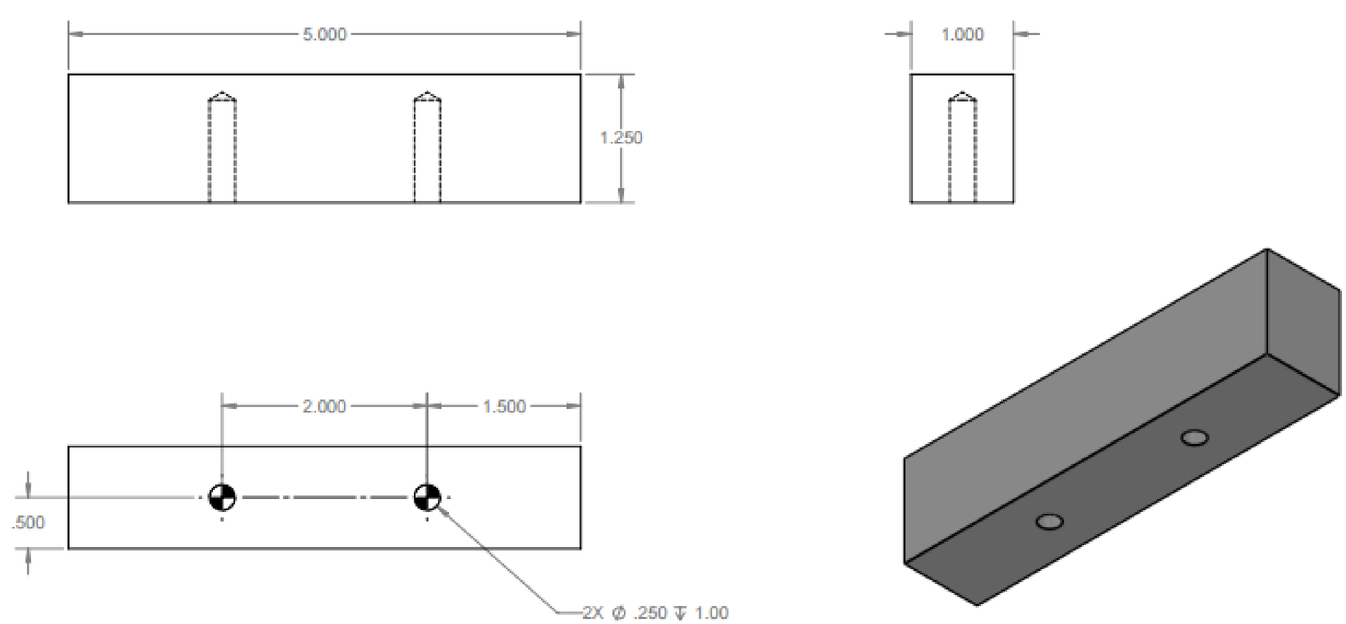
With Micropulse being in the final stages of setting up its own fluidized-bed Nylon dipping operation. The need for a way to remove the Nylon from the holes had risen but the current process for removing the Nylon is very dangerous. Our initial idea of using a plug did not work out in the long run, but that failure pushed our team to advise a new and safer way of removing the Nylon. Through that failure, arose the idea of a pneumatic clamp fixture, which turned out to be the solution. The pneumatic clamp fixture has made the post drilling process much safer for the operator. Overall the whole project was a success. The clamp fixture functions as it was supposed to and is able to firmly grip the brackets during the post drilling operation without damaging them. Micropulse was very pleased with the design and fabrication of the clamp and plan on implementing its use when they start running production full time.



Ø0.08 THRU
2X ⌵ 0.020 ± .005
.010 A
0.10
A
Ø0.20
CORNER BREAK
.020 ± .010
CHAMFER
2X R0.05
0.13
2X 0.15
0.70
0.40
OD TAPER
.135 MAX
.127 MIN
UNLESS OTHERWISE SPECIFIED:
Tolerance
Metric
.X ±0.381
.XX ±0.127
.XXX ±0.0127
Inch
.XX ±.015
.XXX ±.005
.XXXX ±.0005
Angles ±1°
PROPRIETARY AND CONFIDENTIAL
NAME
DATE
DRAWN
AMBERG/BEARD
1/20/16
ENG APPR.
MFG APPR.
GRH APPR.
CUSTOMER INFORMATION
CUSTOMER NAME:
PART NAME:
PART #:
DRAWING VERSION:
SYSTEM NUMBER:
PROJECT NUMBER:
Micropulse
PART NAME:
NYLON DIP PLUG
MATERIAL TYPE:
17-4
MATERIAL SIZE:
MATERIAL COLOR:
SIZE
DWG. NO.
REV
B
SCALE
4:1
DO NOT SCALE DRAWING
SHEET 1 OF 1


8.750
Ø.160 THRU
1.500
1.000
.250
3.250
A
2x .375
2X .250
2X .250
1.000
DETAIL A
SCALE 2 : 1
8.000
2.000
.010 A
R.250 TYP
1.000
.010 A
.500
2X Ø .2500 ↧ .750
PROCESS NOTES:
1. All edges should be broken so that they are not sharp.
2. Remove all residue and debris from holes and pockets.
3. See Finish Specifications for Finish requirements.
Item Specific Instructions:
DEBURR SPECIFICATIONS:
N/A
FINISHING SPECIFICATIONS:
N/A
Natural
UNCONTROLLED DOCUMENT WHEN PRINTED
A Initial Release MA 2329 3/9/2016
REV DESCRIPTION ENG DATE
NAME DATE
DRAWN MA 2329 3/9/2016
ENG APPR.
MFG APPR.
CUSTOMER INFO
PART NAME:
Base
MATERIAL:
Tecapro MT per ASTM D4181 (White)
SIZE PART NUMBER: REV
B 600-00137-100 A 1
THIRD ANGLE PROJECTION
DO NOT SCALE DRAWING
SHEET 1 OF 1


CHAMFER AS NEEDED FOR FIT
SLOT ↧ .500
.500
1.250
.875
.250
.950
4.000
Ø .250 THRU
CHAMFER .020 X 45° MIN TYP
.500
.220
1.000
5.000
.500
2.025
2.025
Ø .1590 ↧ .5600
10-32 UNF ↧ .3800
PROCESS NOTES:
1. All edges should be broken so that they are not sharp.
2. Remove all residue and debris from holes and pockets.
3. See Finish Specifications for Finish requirements.
Item Specific Instructions:
DEBURR SPECIFICATIONS:
Deburr as necessary
FINISHING SPECIFICATIONS:
N/A
Natural
UNCONTROLLED DOCUMENT WHEN PRINTED
A
Initial Release
MA 2329
3/10/2016
REV
DESCRIPTION
ENG
DATE
NAME
DATE
DRAWN
ENG APPR.
MFG APPR.
CUSTOMER INFO
PART NAME:
Movable Jaw
MATERIAL:
Tecapro MT per ASTM D4101 (White)
SIZE
PART NUMBER:
REV
B
600-00137-200
A
1
DO NOT SCALE DRAWING
SHEET 1 OF 1
THIRD ANGLE PROJECTION
PART NUMBER:



PROCESS NOTES:
1. All edges should be broken so that they are not sharp.
2. Remove all residue and debris from holes and pockets.
3. See Finish Specifications for Finish requirements.
Item Specific Instructions:

DEBURR SPECIFICATIONS:
Deburr as necessary

FINISHING SPECIFICATIONS:
N/A
Natural

UNCONTROLLED DOCUMENT WHEN PRINTED

REV	DESCRIPTION	ENG	DATE
A	Initial Release	MA 2329	3/10/2016

	NAME	DATE
DRAWN	MA 2329	3/10/2016
ENG APPR.		
MFG APPR.		

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES

CUSTOMER INFO
NAME: Micropulse
SYS. TITLE:
SYS. NUMBER:
PART NUMBER:

THIRD ANGLE PROJECTION

Micropulse

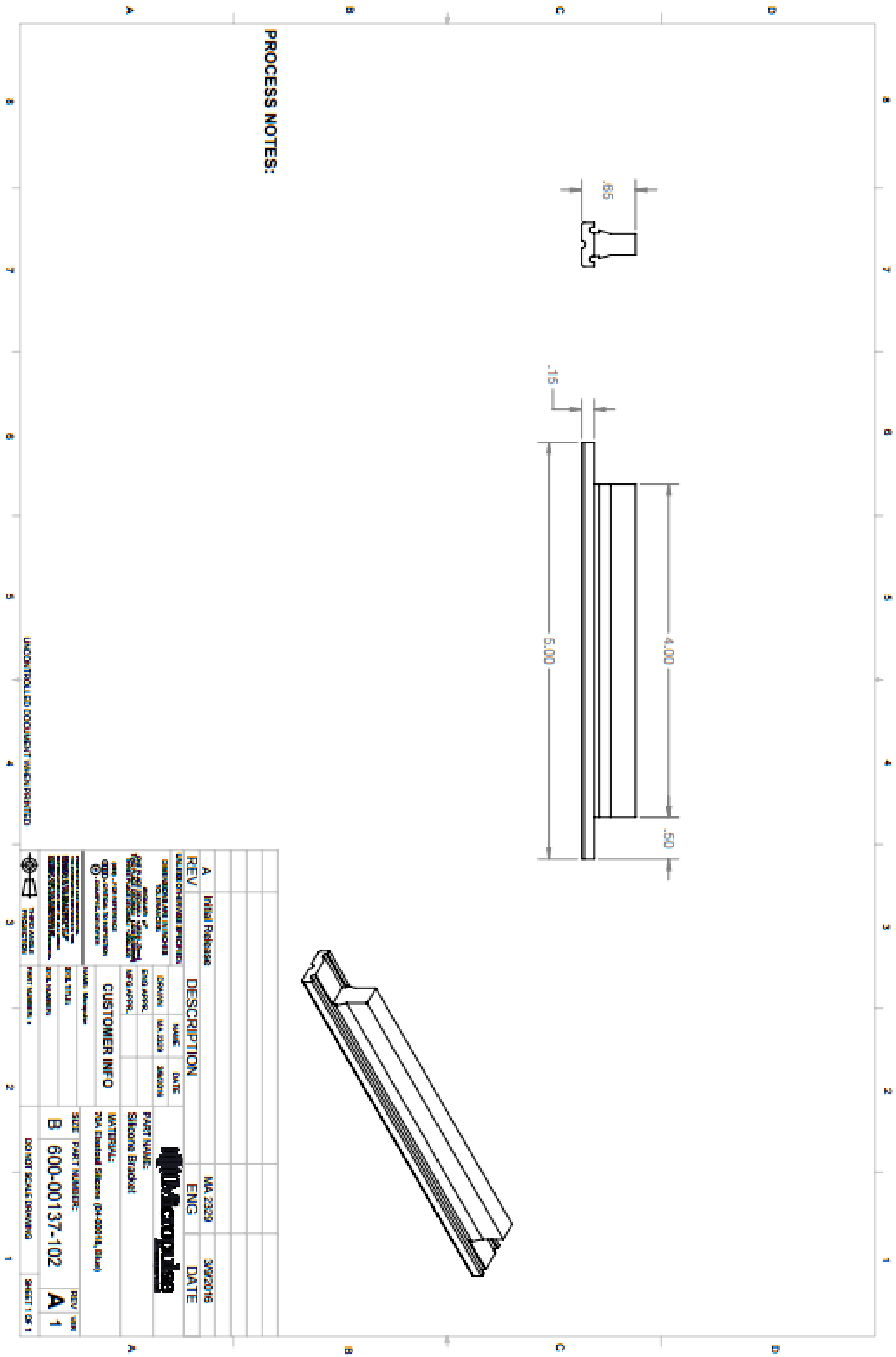
PART NAME:
Fixed Jaw

MATERIAL:
Tecapro MT per ASTM D4101 (White)

SIZE	PART NUMBER:	REV	VER
B	600-00137-101	A	1

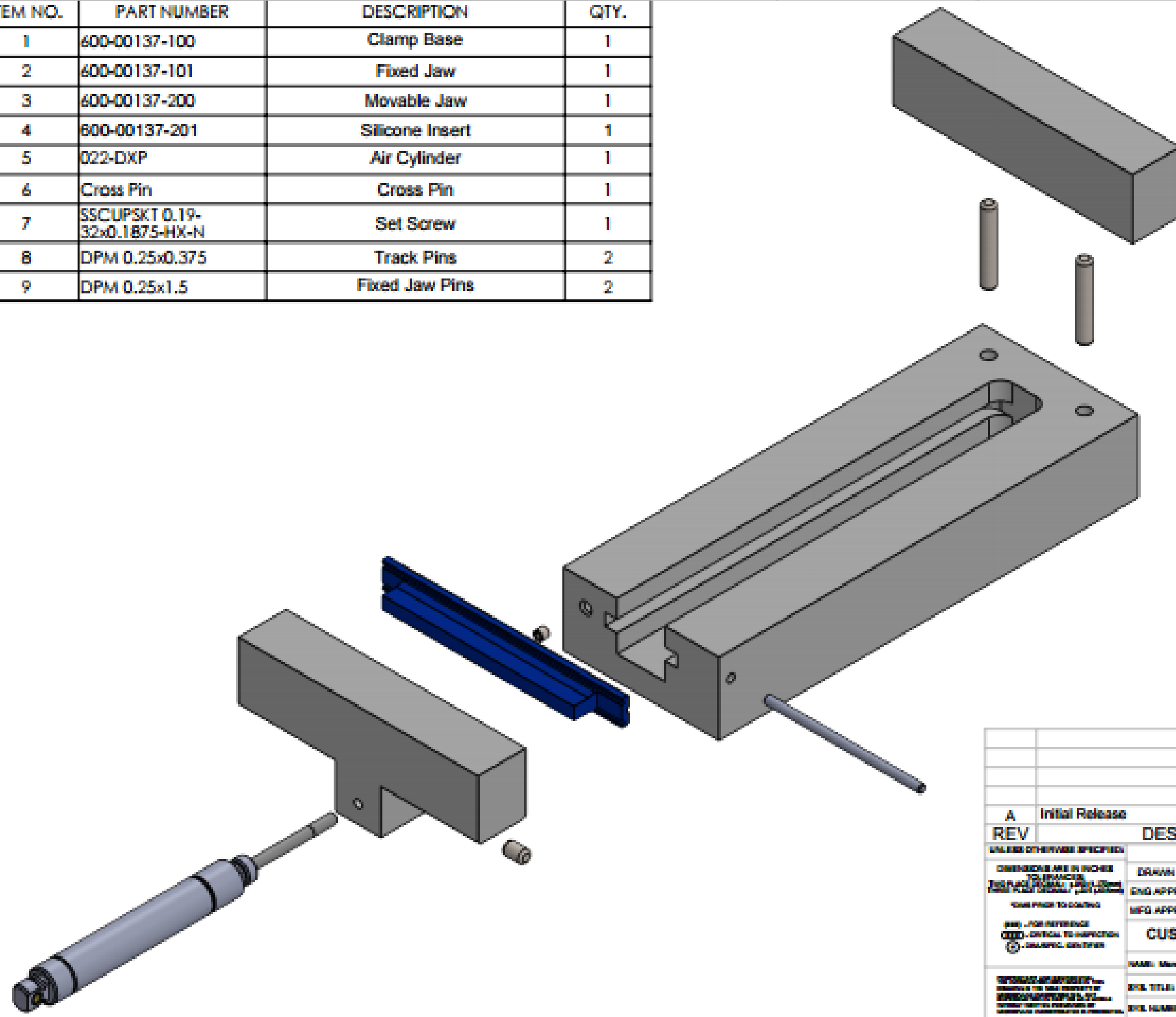
DO NOT SCALE DRAWING

SHEET 1 OF 1



PROCESS NOTES:
.65
.15
5.00
4.00
.50
A
Initial Release
REV
DESCRIPTION
MA 2329
3/9/2016
ENG
DATE
CUSTOMER INFO
PART NAME:
Silicone Bracket
MATERIAL:
SIZE
PART NUMBER:
B
600-00137-102
REV
A
1
UNCONTROLLED DOCUMENT WHEN PRINTED
DO NOT SCALE DRAWING
SHEET 1 OF 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	600-00137-100	Clamp Base	1
2	600-00137-101	Fixed Jaw	1
3	600-00137-200	Movable Jaw	1
4	600-00137-201	Silicone Insert	1
5	022-DXP	Air Cylinder	1
6	Cross Pin	Cross Pin	1
7	SSCUPSKT 0.19-32x0.1875-HX-N	Set Screw	1
8	DPM 0.25x0.375	Track Pins	2
9	DPM 0.25x1.5	Fixed Jaw Pins	2



UNCONTROLLED DOCUMENT WHEN PRINTED

REV	DESCRIPTION	ENG	DATE
A	Initial Release	MA 2329	4/21/2016

DRAWN MA 2329 4/21/2016

ENG APPR.

MFG APPR.

CUSTOMER INFO

Micropulse

ASSEMBLY

PART NAME: Pneumatic Clamp

SIZE B PART NUMBER: 600-00137 REV A 1

DO NOT SCALE DRAWING SHEET 1 OF 1

THIRD ANGLE PROJECTION

Bibliography

[1]"17-4 Stainless Steel Properties | KVA Stainless", *Kvastainless.com*, 2016. [Online]. Available: http://www.kvastainless.com/17-4.html. [Accessed: 25- Apr- 2016].

[2]Y. Çengel and R. Turner, *Fundamentals of thermal-fluid sciences*. Boston: McGraw-Hill, 2001.

[3]"Original Line® Air Cylinder - Bimba Manufacturing", *Bimba.com*, 2016. [Online]. Available: http://www.bimba.com/en/Products-and-Cad/Actuators/Inch/Round-Line/Non-Repairable/Original-Line-Cylinder/?searchRef=yes&pn=022-DXP. [Accessed: 25- Apr- 2016].

[4]"1/4 Inch NPT Manual Mechanical Valve 78261054 - MSC", *Mscdirect.com*, 2016. [Online]. Available: http://www.mscdirect.com/product/details/78261054?rItem=78261054. [Accessed: 25- Apr- 2016].

[5]"Ensinger", *Ensinger-inc.com*, 2016. [Online]. Available: http://www.ensinger-inc.com/products.cfm?page=product&product=tecapro+mt+(medical+grade). [Accessed: 25- Apr- 2016].

[6]b. dupen, *Applied strength of materials for engineering technology*, 4th ed. 2013.

[7]"Internal Threads, Class 2B", *Barnhillbolt.com*, 2016. [Online]. Available: http://www.barnhillbolt.com/page/specs/InternalThreadsClass2B100.htm. [Accessed: 25- Apr- 2016].

[9]"Amflo 1/2" NPT Pressure Regulator Model 4135 0-160 PSI Gauge - Motion Constrained Surplus", *Motion Constrained Surplus*, 2016. [Online]. Available: https://surplus.motionconstrained.com/shop/pneumatic-valves/amflo-12-npt-pressure-regulator-modek-4135-0-160-psi-gauge/?gclid=CLP8lN2YnswCFQEGaQodSd0Nbg. [Accessed: 25- Apr- 2016].