IPFW MET SENIOR DESIGN PROJECT

Final Report

DIRECTED DIE LUBRICANT SPRAYER

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4/27/15

Submitted To-

Dr. Dupen, MET 494 Professor

Purpose

For our senior project we consulted one of our team member's employers, AccuGear Fort Wayne. Their company both forges and machines differential gears for American Axel Motors. AccuGear presented us with an issue with their lubricant sprayers on their 1000 ton AIDA forging presses. Currently these sprayers lubricate the form punches for a short linear motion across the face of the form punches. This doesn't allow for much lubricant to adhere to the surface of the form punch. AccuGear Fort Wayne has challenged our team to come up with a way to improve the lubricant system within these presses.

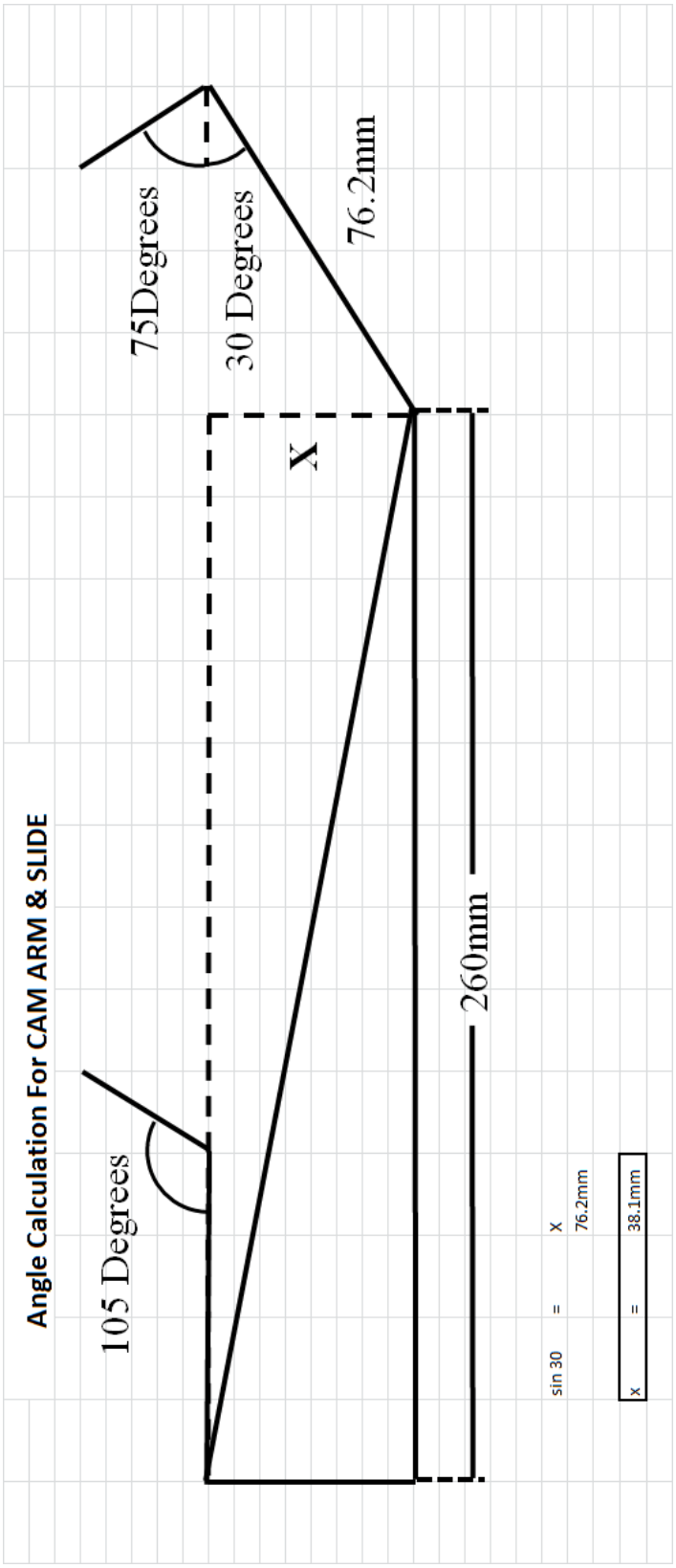
Function

The importance of the form die lubrication is to prevent tool wear from prematurely breaking the tool. This also affects the costs AccuGear has on tooling. The intention of improving the lubrication system is to increase tool life on form punches which is a high use and high cost driving wear tool at AccuGear. Our project solution is required to increase the duration of the lubricant being applied to the form punches. After implementation of our device we will monitor the effects of our new system to track any improvements that occur with tool life as well as estimate cost savings.

Initial Performance Specifications

The final project solution is expected to apply a coating of lubricant to the form punch for a full duration during the placement of parts in the ready position before being pressed to its near-net finish shape and repeat. This is to be accomplished through any design our teams decides on however, it has been requested by AccuGear to accomplish this through a mechanical solution. AccuGear would like for us to avoid us from using PLC or any complex electrical components in completing this project. Ideally, AccuGear would like for our design to be easily duplicated to the remaining 1000 ton and two 630 ton presses in their facility as well but they are not requiring our team to perform the duplication. The final project solution will not be able to be transported to the campus for the final presentation since it will be fixed to the press at AccuGear. If the prototype model is constructed it may be brought in, otherwise we will show a video or digital model.

Calculations



Nozzle Selection

-Given Criteria

- The pressure given in the air/ lubricant line reads 50psi (gage)\
- The flow rate of the system is 0.5gal/min

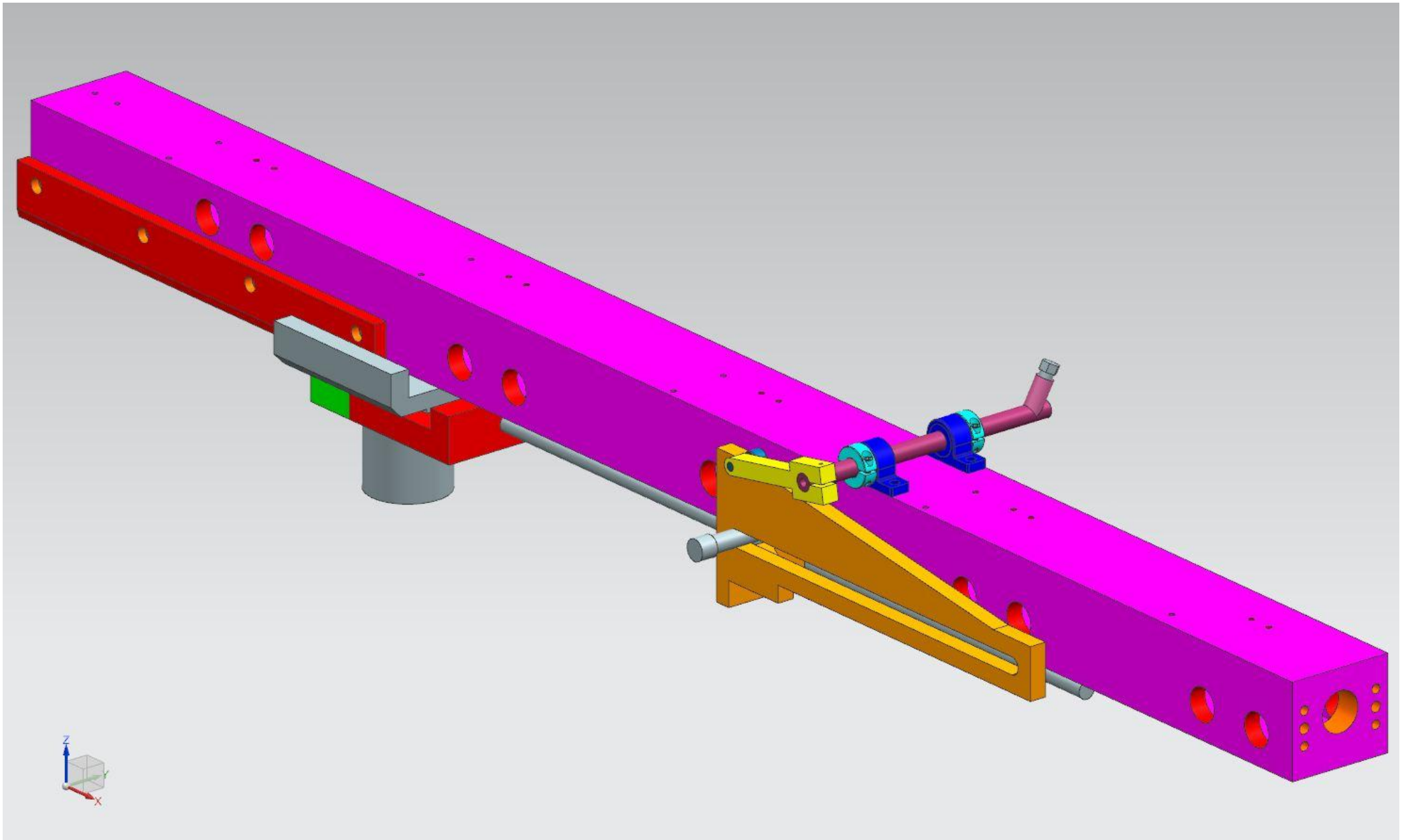
With the given data we were able to determine a nozzle that would fit its criteria well. We looked at McMaster Carr for the majority of the components we needed for our design so this is where we ended up buying the nozzle. In order to save money we decided to go with the brass version of the nozzle.

Full Cone Spray Nozzle

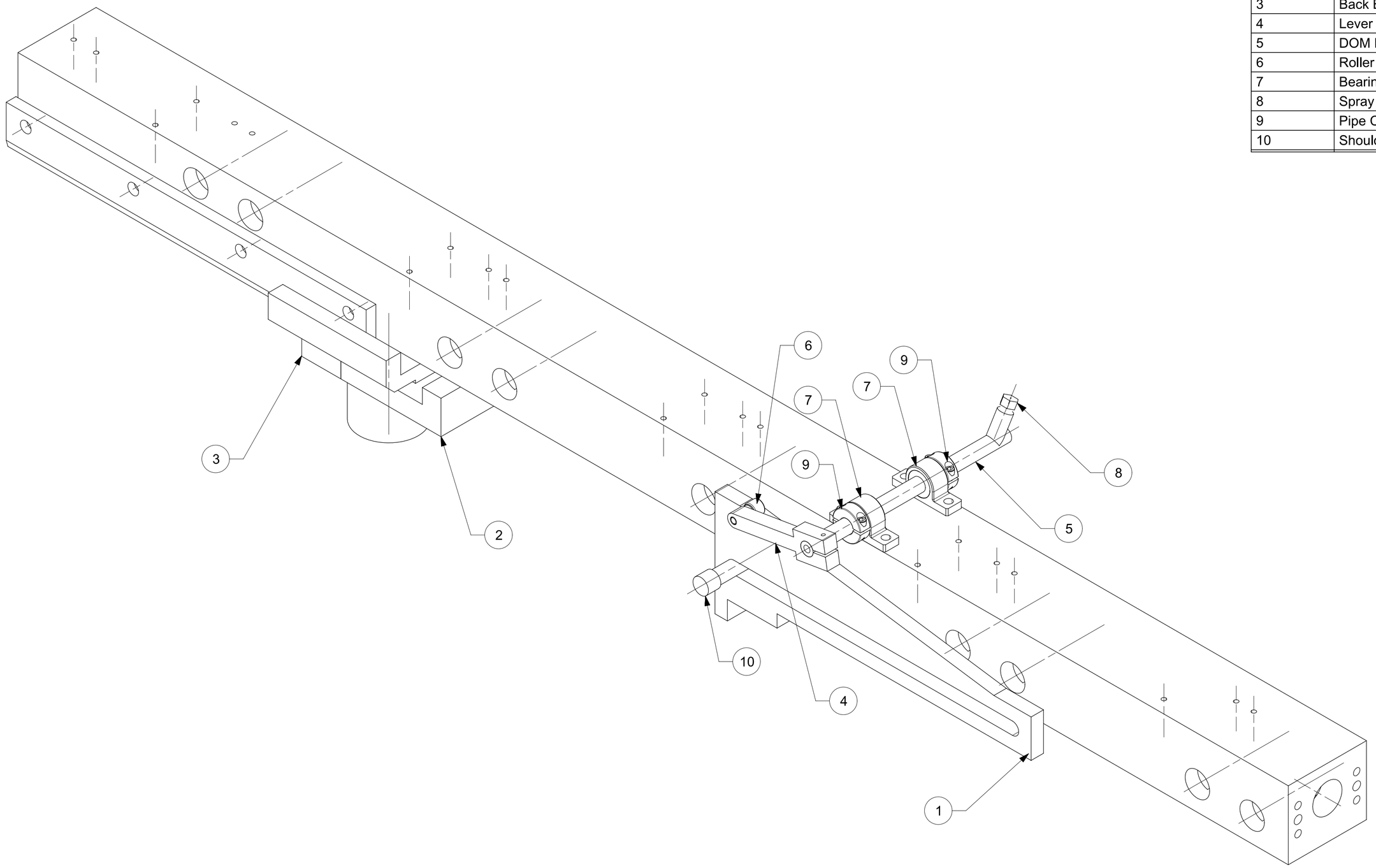
Brass, 1/8" NPT Connection, 0.7 gpm @ 40 PSI

Male

Material	Brass
Pipe Size	1/8"
Flow Rate, gpm	
20 psi	0.5
40 psi	0.7
100 psi	1.1
400 psi	2.2
Spray Angle	90°
Orifice Diameter	0.07"
Male	
Overall Width (Hex Size)	7/16"
Overall Length	7/8"
Female	
Overall Width (Hex Size)	9/16"
Overall Length	1 1/8"
NPT Connection	Male
Additional Specifications	Full Cone Spray Nozzles


Z
Y
X

Part #	Description
1	Slide
2	Front Bracket
3	Back Bracket
4	Lever Arm
5	DOM Pipe
6	Roller
7	Bearing
8	Spray Nozzle
9	Pipe Clamp
10	Shoulder Bolt



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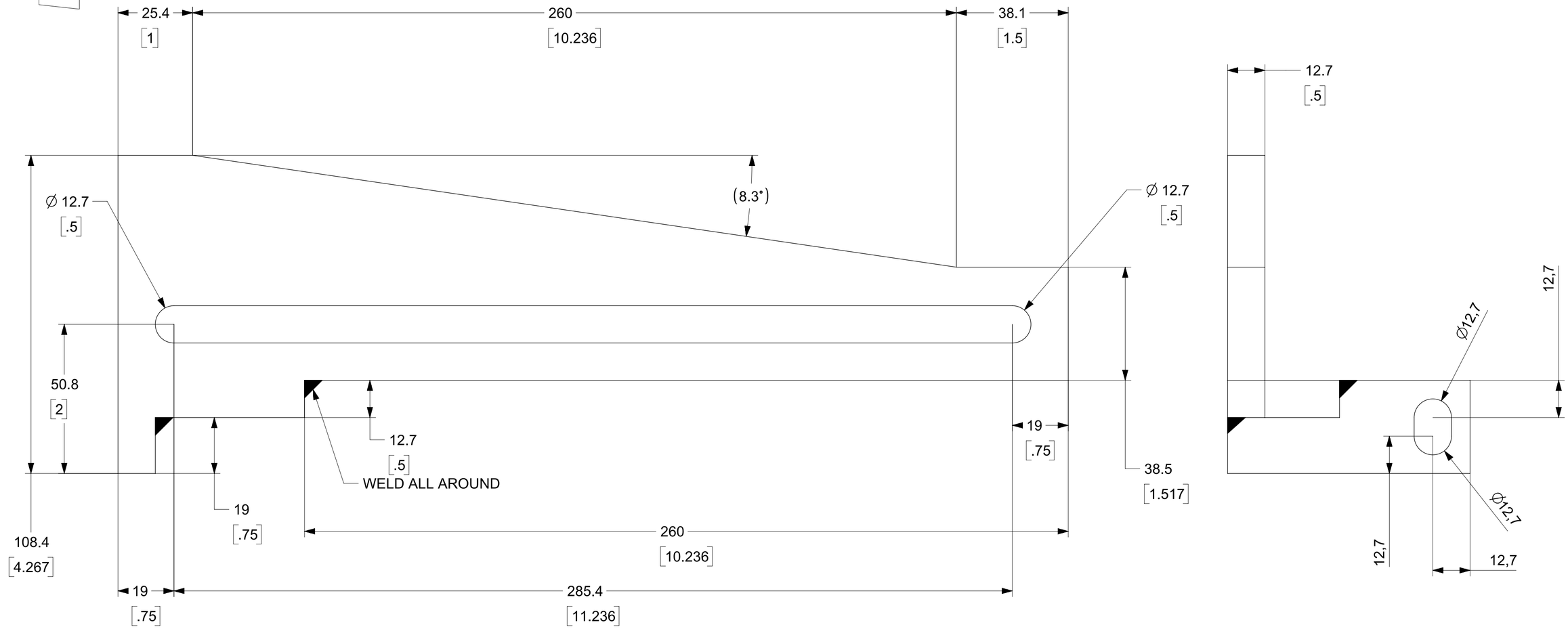

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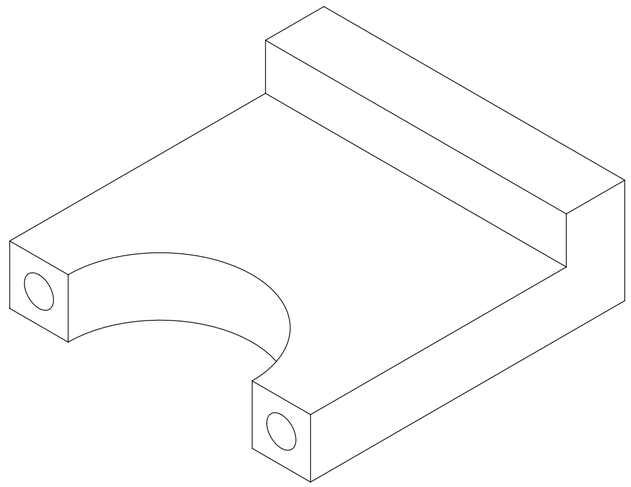

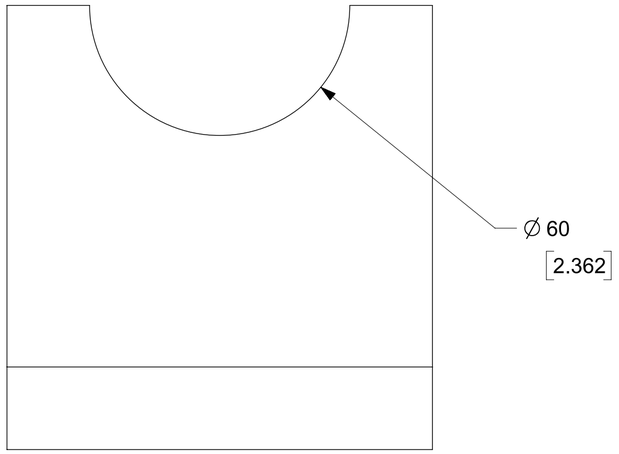

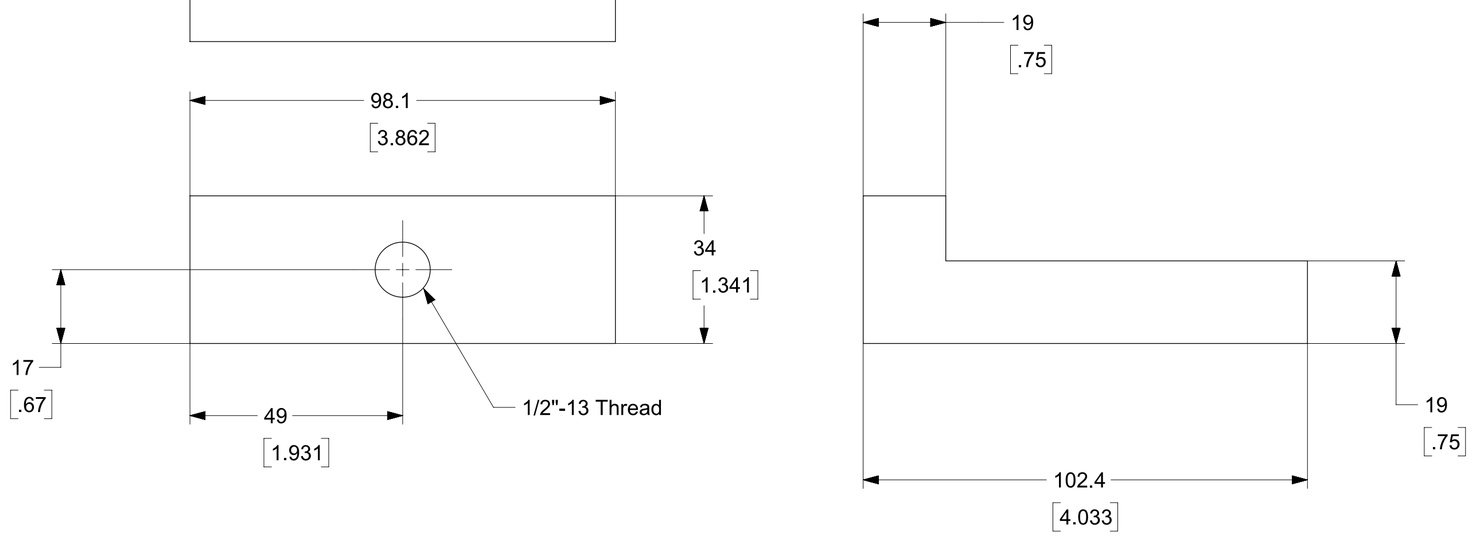

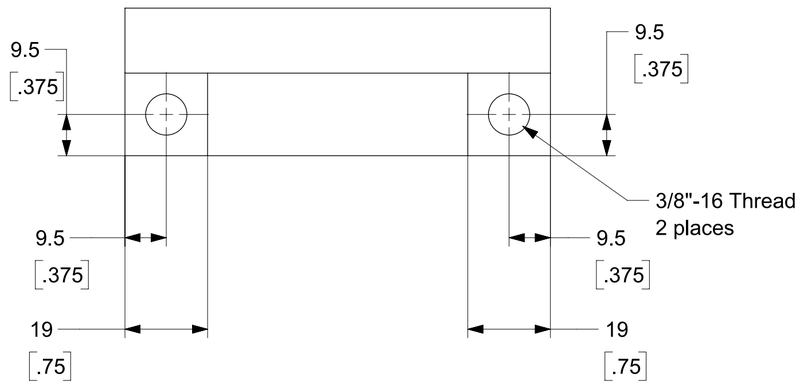

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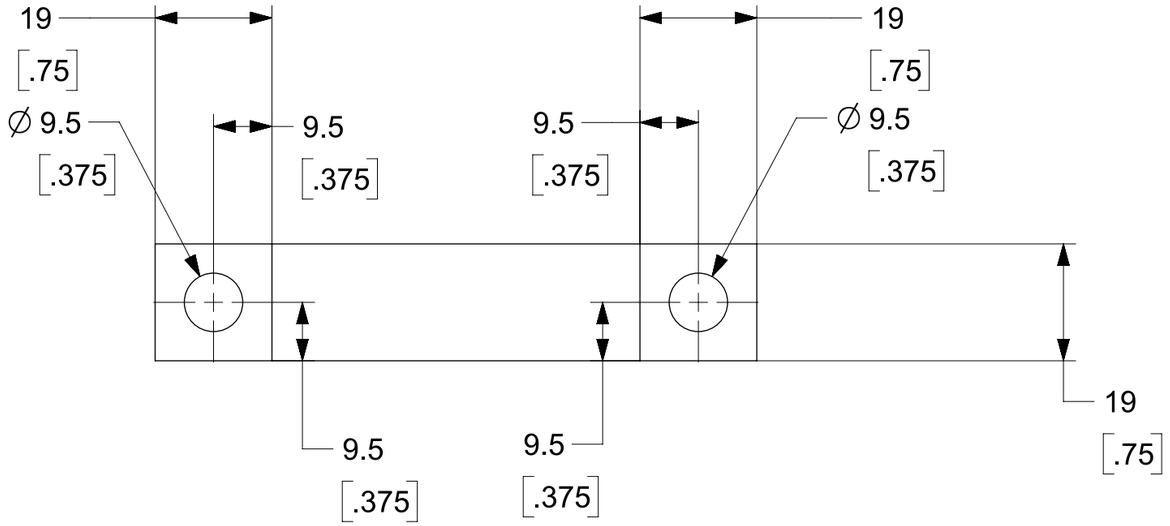

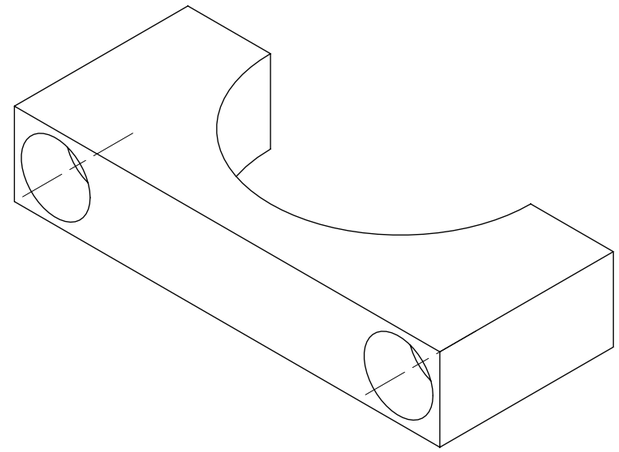

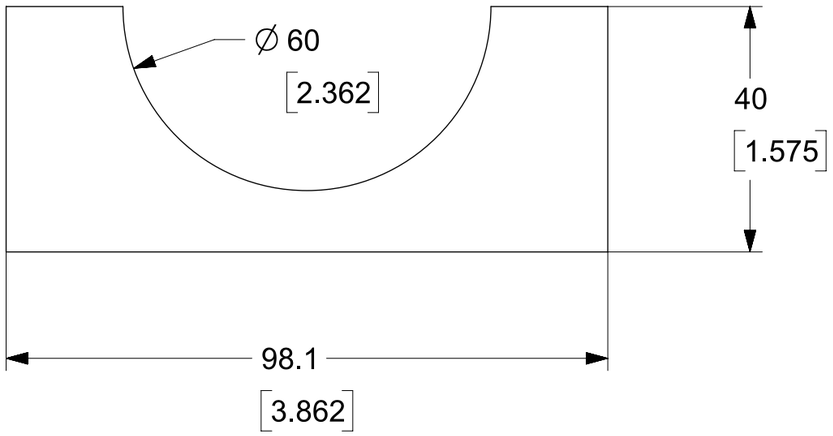

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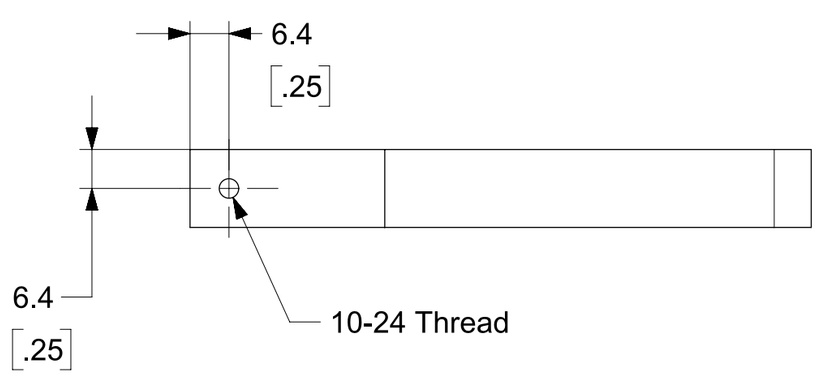

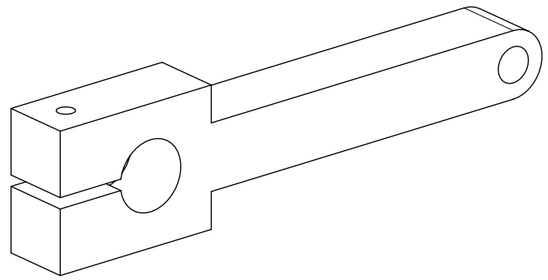

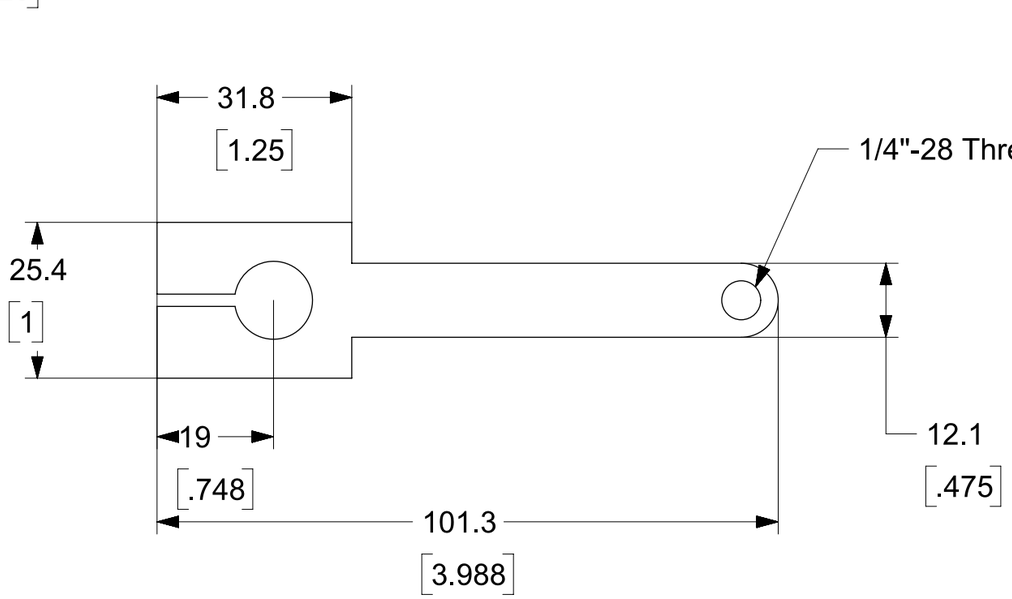

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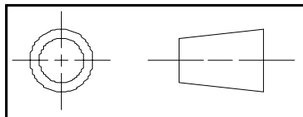
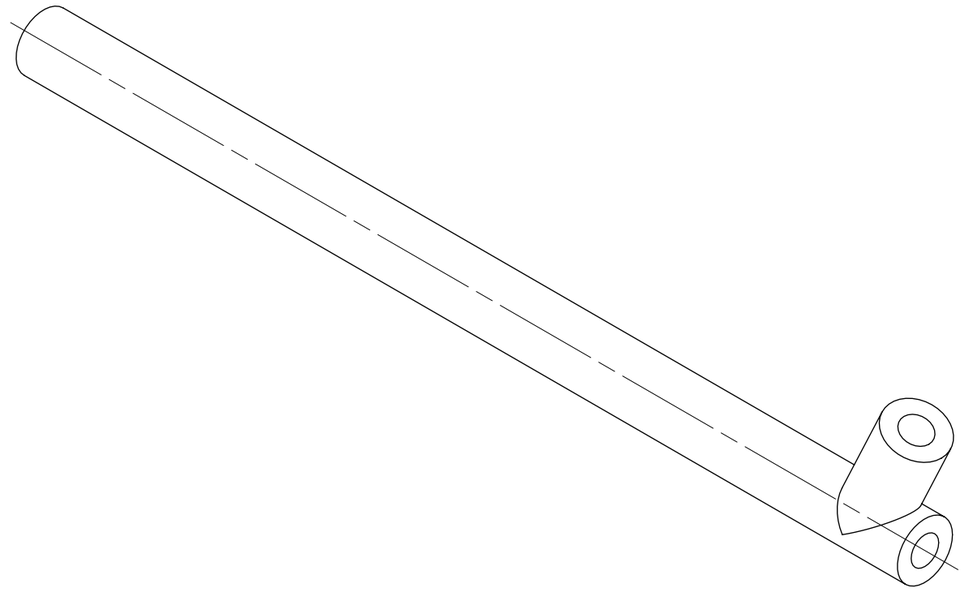
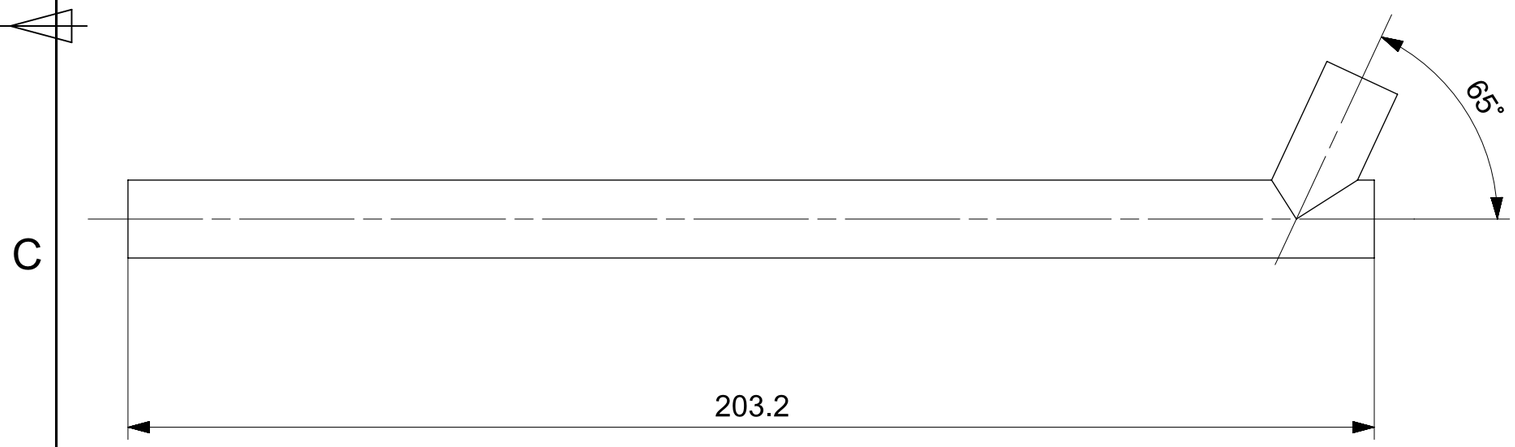
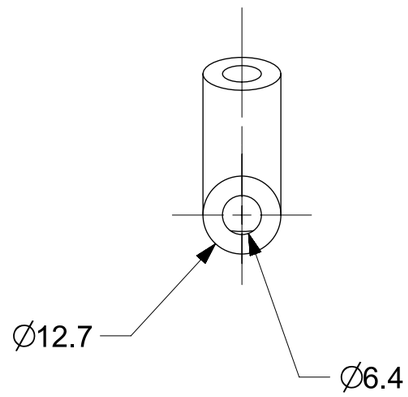
SCALE 1:1 | SHEET 1 OF 1









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SIZE	DRG NO.	SHEET REV
A3	DOM 1-2 IN Pipefor print	A

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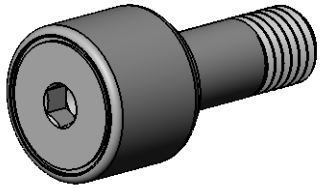
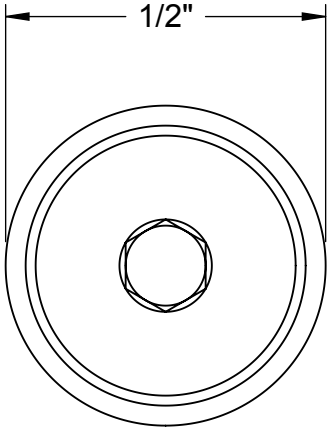
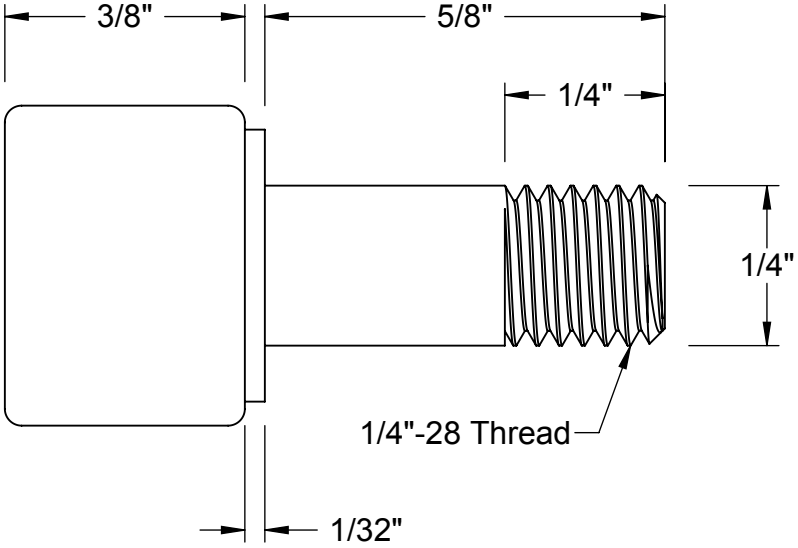
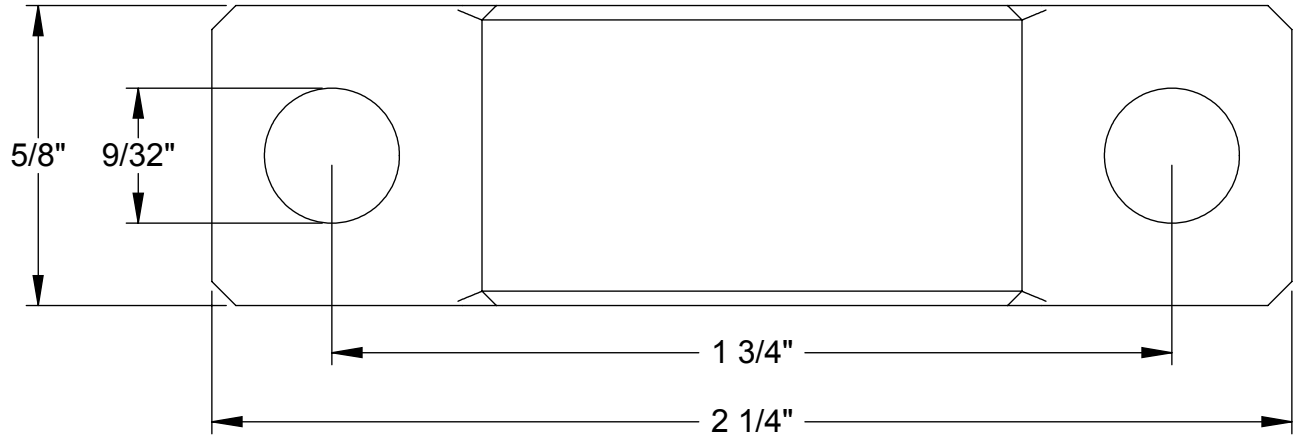
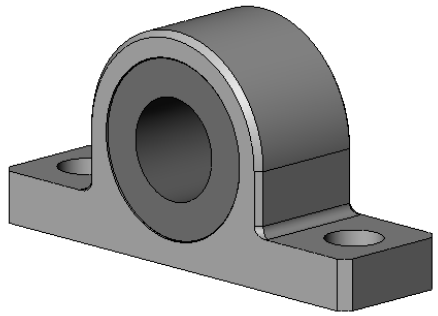


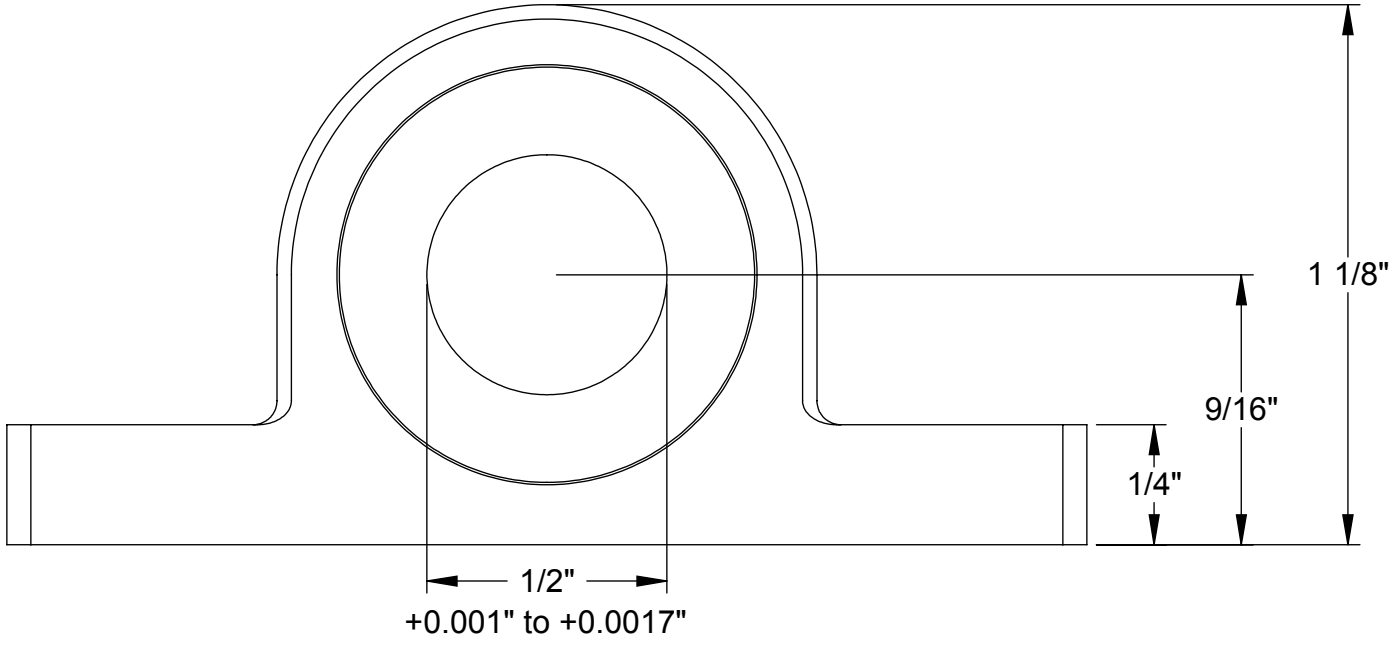




McMASTER-CARR® CAD http://www.mcmaster.com	PART NUMBER **1470T11**
	Long-Life Track Roller with Oversized Stud







McMASTER-CARR® CAD

http://www.mcmaster.com

PART NUMBER **5912K4**

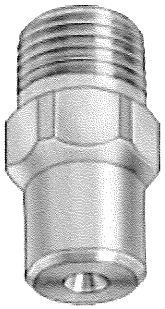
Aluminum Base-Mounted Bronze Bearing

McMASTER-CARR® OVER 555,000 PRODUCTS
(330) 995-5500
(330) 995-9600 (fax)
cle.sales@mcmaster.com
Text 76947

Full Cone Spray Nozzle

Brass, 1/8" NPT Connection, 0.7 gpm @ 40 PSI

In stock
1-9 Each $9.63
10 or more $8.64
32885K13



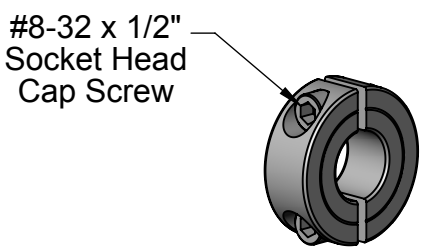
Male

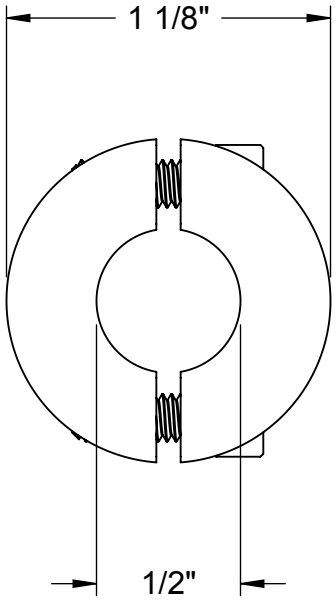
Material	Brass
Pipe Size	1/8"
Flow Rate, gpm	
20 psi	0.5
40 psi	0.7
100 psi	1.1
400 psi	2.2
Spray Angle	90°
Orifice Diameter	0.07"
Male	
Overall Width (Hex Size)	7/16"
Overall Length	7/8"
Female	
Overall Width (Hex Size)	9/16"
Overall Length	1 1/8"
NPT Connection	Male
Additional Specifications	Full Cone Spray Nozzles

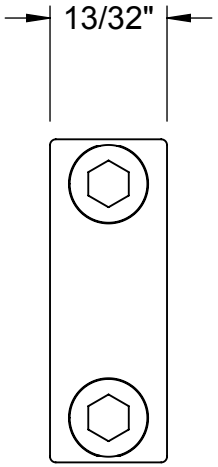
An excellent choice for cooling as well as dust- and foam-control applications. They provide a uniform distribution of droplets.

Spray nozzle fittings and manifolds are also available.

The full cone spray pattern and low flow rates of these nozzles make them good for distributing fluids, cooling, washing, and rinsing. Maximum pressure is 400 psi. Brass nozzles have a maximum temperature of 450° F.





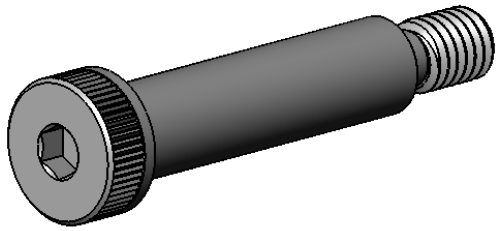


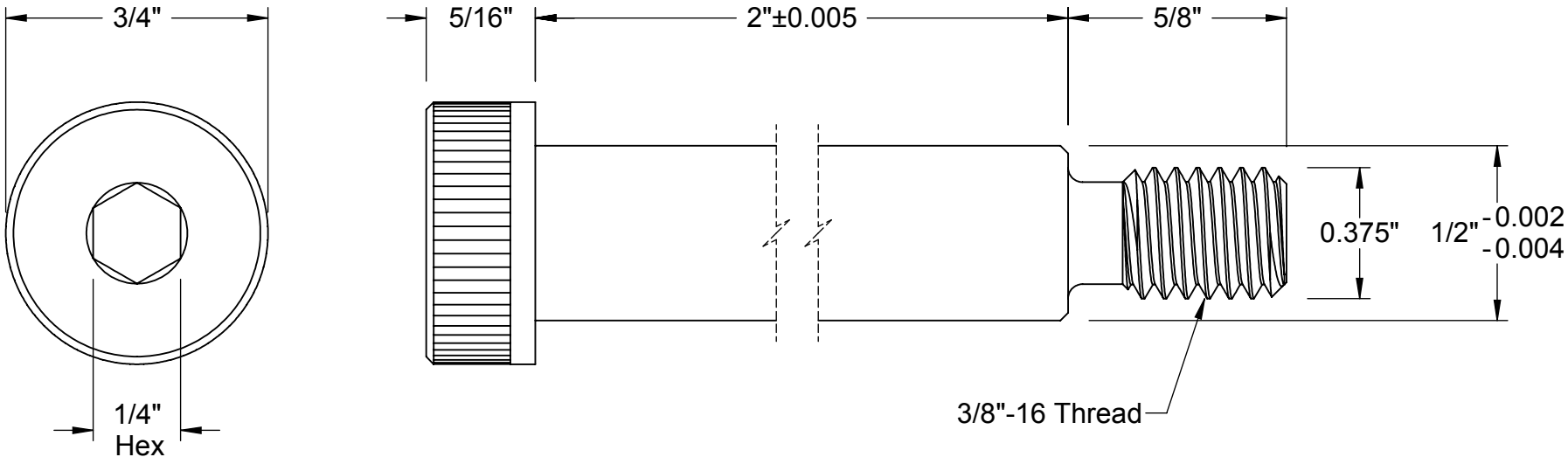
McMASTER-CARR® CAD

http://www.mcmaster.com

PART NUMBER **6436K14**

Two-Piece
Clamp-On Shaft Collar

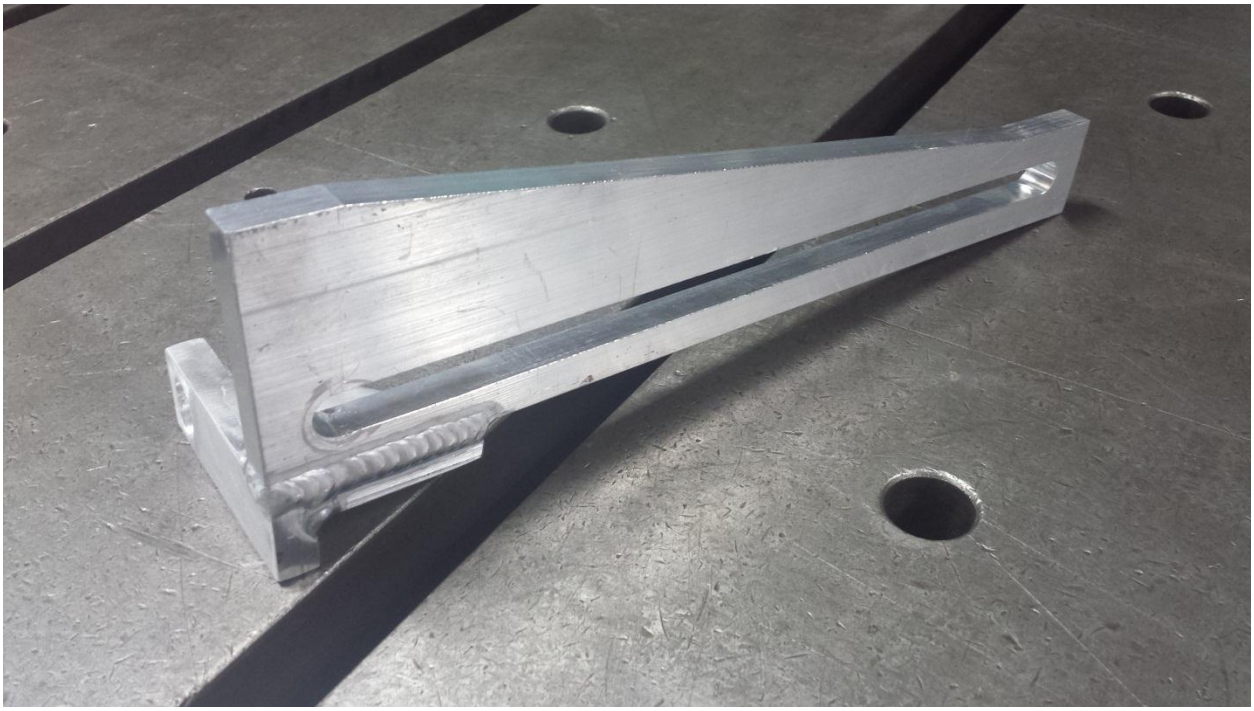




McMASTER-CARR® CAD	PART NUMBER 97345A720
http://www.mcmaster.com	Shoulder Screw

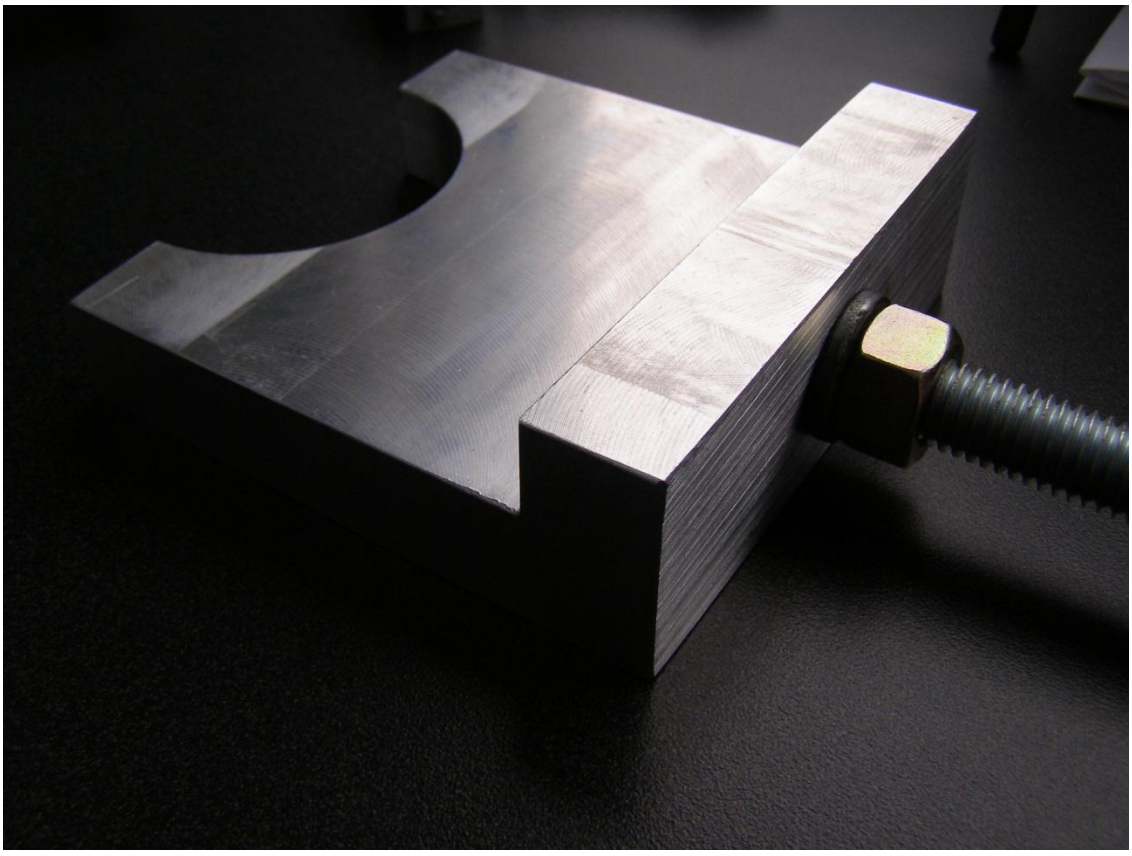
Component Pictures of Completed Parts

CAM Slide

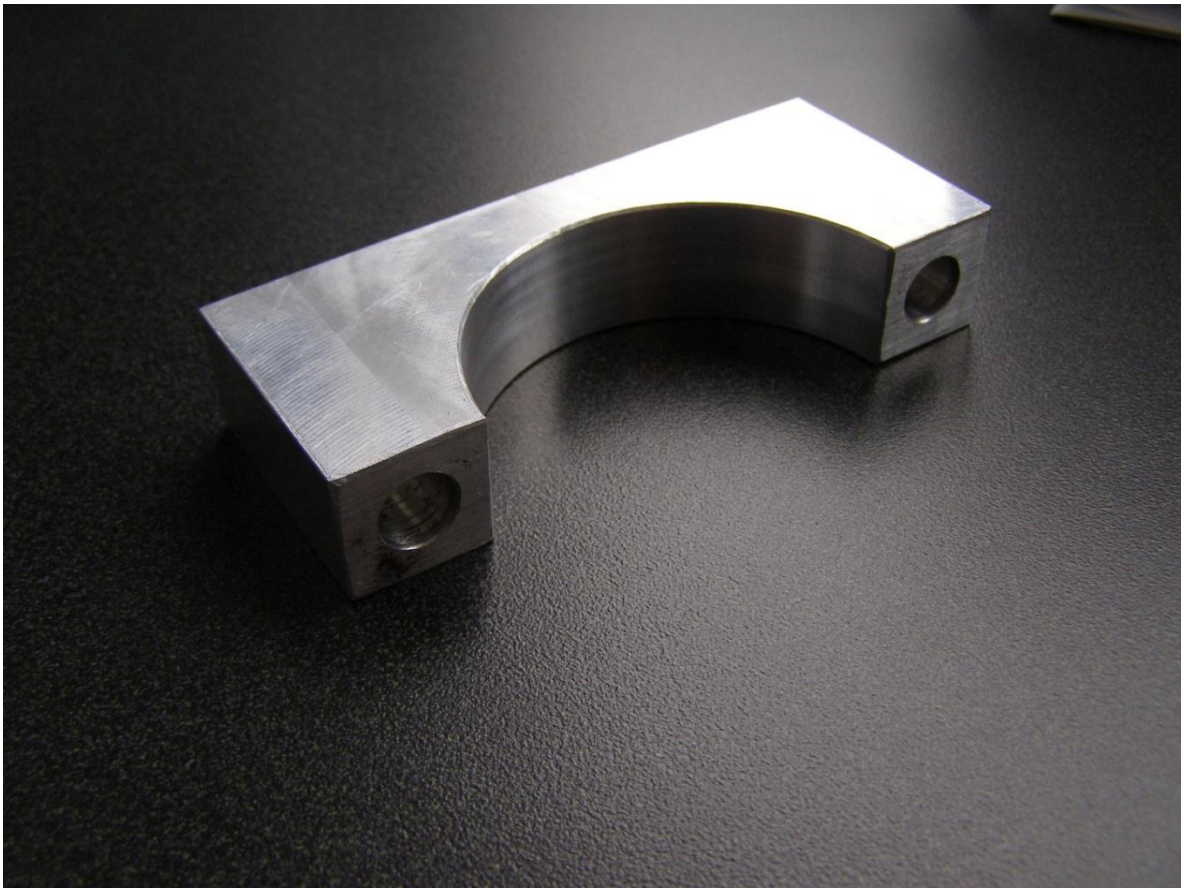


Lever Arm

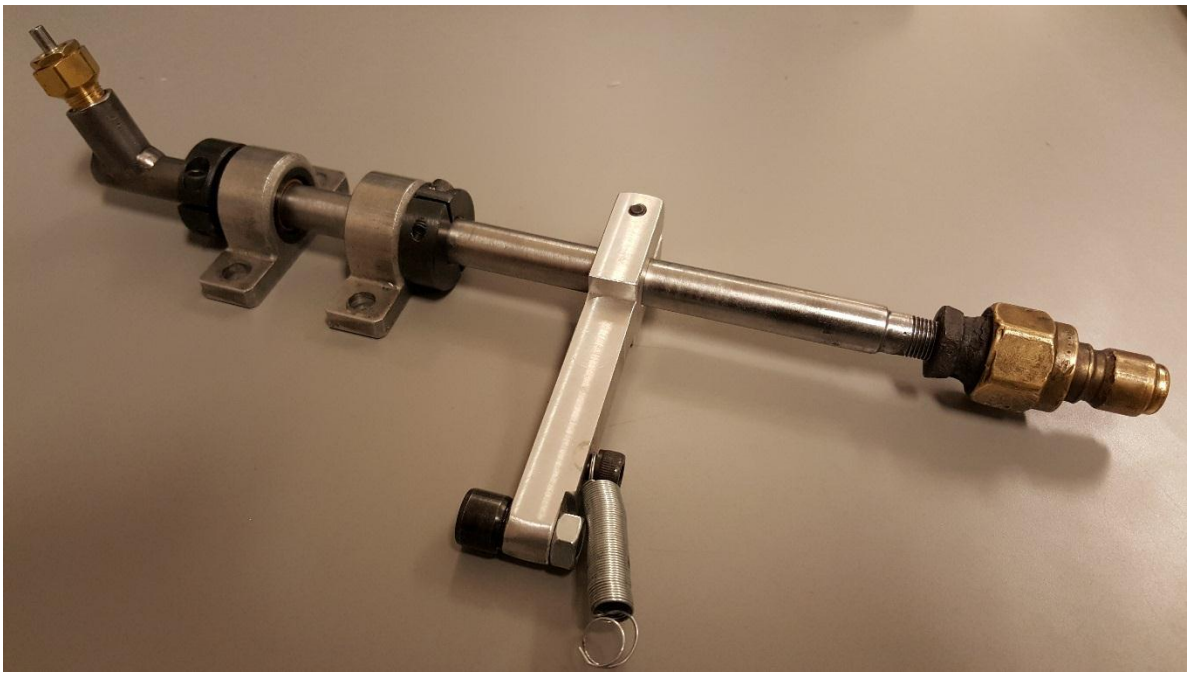
Front Bracket (Clamp)



Back Bracket (Clamp)



Sprayer Assembly (DOM Tubing)



Fabrication Procedure

Cylinder Clamp

- First we saw cut the billet to the needed length. Following that we proceeded to the Haas CNC. Using a CAM software we programmed the part using the 3D model. Once machining was complete in the Haas we cut the clamp in the band saw in the middle of the bore to officially make it a clamp. Lastly we drilled and tapped the holes in the knee mill on the ends and the clamp was complete.

Cam Slide

- For the cam slide we rough cut the shape of the main body on the band saw out of a piece of flat stock aluminum. From here we went to the knee mill and finish milled the contour as well as milled the slot. Once the main body was done we made the gusset and tab and welded everything together.

Sprayer Tube

- For the sprayer tube we started with cutting a piece of DOM tubing to length. We plug welded one end and welded a pipe close nipple on the other. From here we used the knee mill to drill a hole in the plugged end to 65 degrees. Once the hole was drilled we welded a pipe coupling center over the hole and matching the angle.

Lever Arm

- For the lever arm we simply used a CAM software to program the part. Once the code was wrote we placed a piece of billet aluminum that was close to size in the Haas CNC and finish machined the part.

Transfer Bar

For the transfer bar we used our prints from the 3D model to get our hole locations and from there we drilled and tapped the holes in the transfer bar

Test Procedure & Results

For our design we only made a rotating sprayer for the front side of the forging press. We wanted to confirm that our design would be successful before making an identical system that would be mounted on the back side of the press.

For our test procedure we started first on a dry run to work out any kinks in our system. We wanted to make sure that our design would hold up and run smoothly during a cycle simulating a production but without running any parts until we were comfortable that there would be no issues during an official run. For the simulation we had an operator run the system for 100 cycles verifying that the sprayer would coat the form punch as we intended. We also wanted to confirm it would hold together without loosening our clamp fixture.

The test had a few hiccups at first. We had the bearing bolted on slightly crooked not allowing the DOM Tubing to move and one of the clamp bolts was slightly loose. We adjusted the bearing and put a locking washer on the clamp and had no further issues for another dry run of 100 parts.

For the actual production run we decided to go with a part that used one of the more expensive form punches used at AccuGear for their PNF-654 forging at the request of the Production Manager Clint Thompson. This was setup for a 15000 piece run that would last for around 8 shifts of work. We started on 4/22/15 at the beginning of first shift and ended half way through second shift on 4/25/15. During the run the operators had to tighten the clamp that held the CAM slide in place once every 3-4 hrs. This was the only major complaint given during the run. The system held together and made it through the whole production run as planned.

The form punches are determined to be bad when a part doesn't pass an AGMA report (American Gear Manufacturers Association). Once this report shows bad when inspecting a gear the punch is deemed bad even if there are to cracks formed in the punch or die. In the case where the punch isn't cracked but is still shown bad on the report there is root wear in the punch. Root wear is the mal-forming of the gear tooth surface typically when the punch either melts slightly through a long period of use. This is the major failure mode of the punch if a good run has taken place. Cracks in the punch indicate a system or setup failure during the run. For our tests we only had slightly prolonged root wear occur.

The Standard tool life for the PNF-654 Form Punch is set for 5000 parts in the system at AccuGear. Typically they are under this amount ranging from 4500-5000 depending on the run and any issues that take place. For our run we were fortunate to not come upon many major issues in the setup that could cause fatal errors. We had 3 tests on the punches with our new sprayer and the results are shown below along with cost and tool life anaylsis.

Tool Life Standard (parts)	Test Punch #1 (parts)	Test punch #2 (parts)	Test Punch #3 (parts)	Ave (parts)
5000	5047	5098	5051	5065

Year Production (parts)	Punches/Year Std Tool Life	Punches/Year w/ New Sprayer	Tool Life Savings
625000	125	123.4	1.29%

PNF-654 Form Punch	Approx. Savings (2 Punches)
$2,350	$4,700

Overall Cost

-Cost for Components Purchased at McMaster Carr & Metals Supermarket

Item	Qty	Cost	Accum. Cost
Long-Life Track Roller W/ Oversized Stud, 1/2"dia X 3/8" W Roller, Hex, Unsealed	1	$23.20	$23.20
Full Cone Spray Nozzle, Brass, 1/8" NPT Male, 0.7 gpm @ 40 PSI, 60 Degree Angle	1	$9.63	$9.63
High-Pressure Black Steel Threaded Pipe Fittings 1/4" Coupling	1	$2.19	$2.19
Self-lubricating Alum-mounted Bronze Bearing, Base Mounted, For 1/2" Shaft Dia, 2-1/4"l	2	$11.11	$22.22
Two-piece Clamp-on Shaft Collar, For 1/2" Diameter, Black-oxide Steel	2	$3.56	$7.12
1/2" OD and 1/4" ID Cold Rolled DOM Tubing (2ft)	1	$5.96	$5.96
1.5in by 4in by 2ft 6061 Aluminum Block	1	$55.67	$55.67
10ft 1/2 threaded rod	1	$10.86	$10.86
Total Cost:			$136.85

-Estimated Labor Costs

- 8 hour time frame
- Ave. $65/hr. for labor costs (quoted by Diversified Metal Specialties)

Given the quoted labor, AccuGear stated that they would more than likely build this on their own in house.

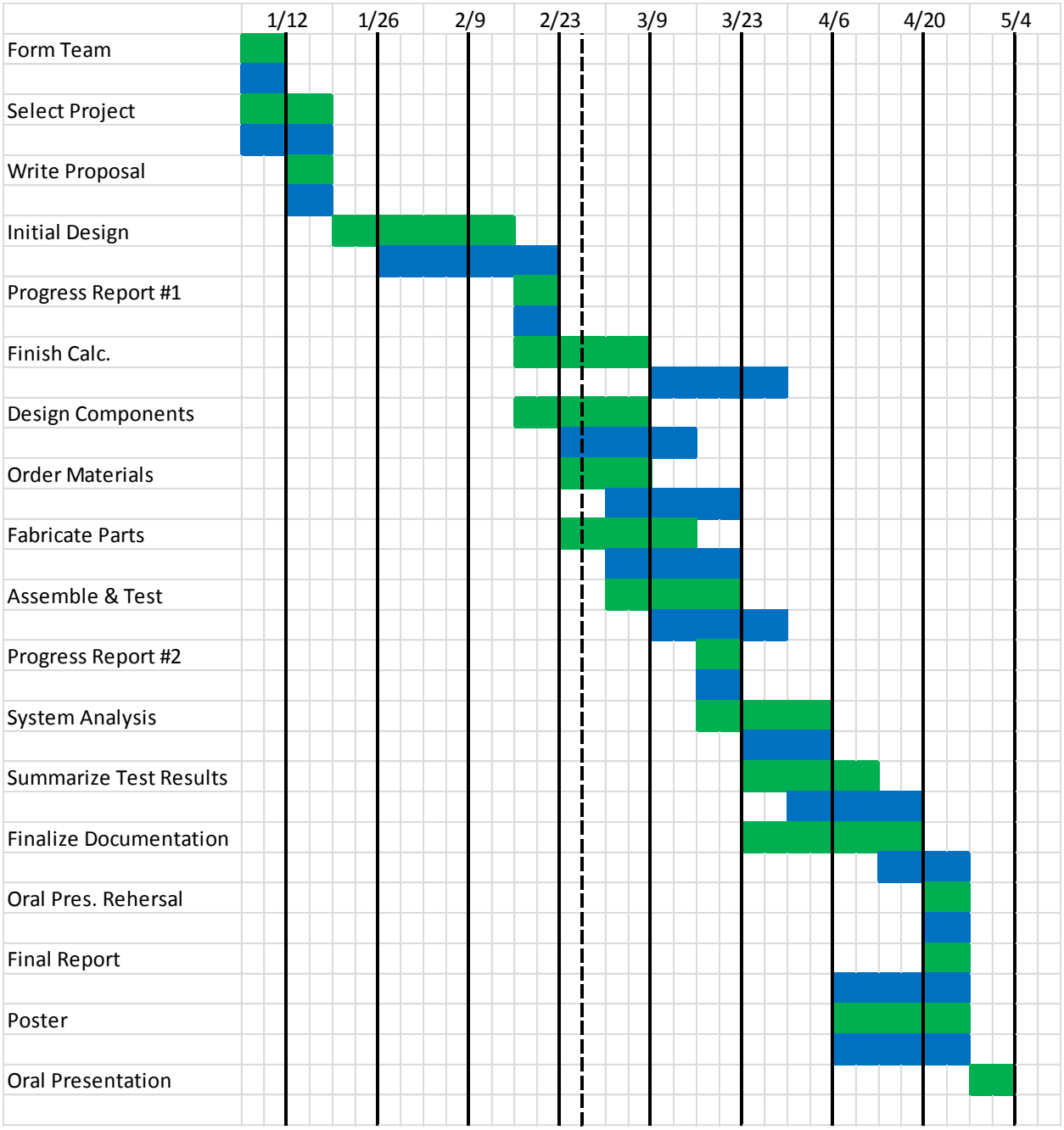
Conclusion

With our completed design we were able to meet the given specifications from AccuGear to help correct their issue with their forging presses. We created a simple mechanical system that used the existing transfer motion of the incoming material to finished product in order to run our CAM system mechanism. This allowed us to avoid using PLC's or other electronic devices as recommended by AccuGear's Engineering Manager Ram Anantha. Our CAM system allowed us to cover the Form Punch in lubricant for nearly 100% of the transfer from the original which covered close to 40% in the stationary nozzle position. With the material costs involved AccuGear was pleased with the design based on our results. This system will allow AccuGear to further improve their tool life on all jobs other than the one we tested on in this project.

Bibliography

Cengel, Y. A., Cimbala, J. M. & Turner, R. H. (2012). Fundamentals of Thermal-Fluid Sciences, Forth Edition. Singapore: McGraw-Hill Education

Gantt Chart



Planned

Actual