

SELF-RELEASING GRAPPLING HOOK (SRGH)

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by

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ACKNOWLEDGEMENTS

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	II
TABLE OF CONTENTS	II
LIST OF FIGURES	III
LIST OF TABLES	III
ABSTRACT	IV
INTRODUCTION	1
BACKGROUND	1
EXISTING DESIGN ITERATIONS	3
FOLDABLE GRAPPLING HOOKS	3
POCKET GRAPPLING HOOK	4
MIL GRABBERS	5
CUSTOMER FEEDBACK, FEATURES, AND OBJECTIVES	6
SURVEY ANALYSIS	6
PRODUCT FEATURES AND OBJECTIVES	8
CONCEPT SENERATION AND SELECTION	9
CALCULATIONS	14
ASSEMBLY DESIGN	21
TESTING	23
SCHEDULE AND BUDGET	27
CONCLUSION	29
REFERENCES	30
APPENDIX A – RESEARCH	1
APPENDIX B – SURVEY AND QFD	1
APPENDIX C - PRODUCT OBJECTIVES AND SCHEDULE	1
APPENDIX D - BUDGET	1

LIST OF FIGURES

Figure 1 : A soldier loading the hook.	1
Figure 2 : MR Grappling Hook.....	1
Figure 3 : Retractable Grappling Hook.....	3
Figure 4 : Pocket Grappling Hook	4
Figure 5 : Mil Grabbers.....	5
Figure 6 : Design sketches v1	9
Figure 7 : Design sketches v2	10
Figure 8 : Expanding the idea of the collar and spring release	11
Figure 9 : Close up of the top right design concept.	11
Figure 10 : Sketch of the reset spring cylinder and design of assembly.	12
Figure 11 : Design of the reset cylinder.....	12
Figure 12 : Final design of assembly	13
Figure 13 : 600lbs. load on the furthest point	14
Figure 14 : 600 lbs. load stress over the fluke.	15
Figure 15 : 600 lbs. alloy steel.....	15
Figure 16 : Upward force of 600 lbs.	16
Figure 17 : Stress point 1.	16
Figure 18 : Release collar tooth.	17
Figure 19 : 600 lbs. load with a larger corner radius of 0.25”	17
Figure 20 : Closer look of the 0.25” radius.....	18
Figure 21 : Release collar tooth.	18
Figure 22 : 600 lbs. pre-existing fluke design.....	19
Figure 23 : 600 lbs. existing fluke design	20
Figure 24 : 600 lbs. existing fluke design, corner.....	20
Figure 25 : Release Collar and Reset Cylinder.....	21
Figure 26 : Dog-ear and Release Body’s slots for the flukes	21
Figure 27 : Complete assembly of Flukes.....	22
Figure 28 : Locked position.	23
Figure 29 : Released position.....	23
Figure 30 : S.R.G.H. Locked.	24
Figure 31 : S.R.G.H. Released.....	24
Figure 32 : Water testing.....	25
Figure 33 : Item retrieval testing.....	25
Figure 34 : S.R.G.H. submerged and ensnared.....	26
Figure 31 : S.R.G.H. submerged and freed.....	26

LIST OF TABLES

Table 1 - Survey responses in order of importance.....	6
Table 2 - Engineering characteristics.....	7
Table 2 : Key Milestone Dates	27
Table 3 : Preliminary Budget	27
Table 5 : Actual Bill	28

ABSTRACT

A grappling hook is an anchor with multiple hooks (claws, flukes), attached to a rope; it is thrown, dropped, sunk, projected, or fastened directly by hand to where at least one hook may catch and hold. Generally, grappling hooks are used to temporarily secure one end of a rope. They may also be used to dredge for submerged objects. Historically, grappling hooks were used in naval warfare to catch ship rigging so that it could be boarded.

A common design has a central shaft with a hole ("eye") at the shaft base to attach the rope, and typically three equally spaced hooks at the end, arranged that at least one is likely to catch on some protrusion of the target. Most grappling hooks are thrown by hand, but some used in rescue work are propelled by a mortar or a rocket. Some modern designs feature folding hooks to resist unwanted attachment or for transportation.

The Self-Releasing Grappling Hook (SRGH) has all of the features stated above with the addition of a mechanical release. The function of the release is that the operator can retrieve the hook from an entangled situation.

In water rescue, multiple grappling hooks are typically used to retrieve a submerged body. During the rescue operation it is common to encounter submerged debris. During retrieval the fixed flukes can become entangled which makes the hook irretrievable. This is the only method that is currently used. It is expensive, wasteful and time consuming because a second hook will be used while the ensnared hook is lost.

However, the SRGH concept is primarily designed for such conditions. This design allows the release mechanism to release itself. Therefore cost and rescue time is kept to a minimum. This is crucial when dealing with water rescue cases.

The SRGH is cast to a target area, using the pull line to drag the hook. When the SRGH is ensnared, the operator exerts a quick jerk on the secondary (release) cable. The release cable pulls back on the release collar which unlocks the flukes. The freed flukes now become loose and able to release from whatever they are attached. Once released, the flukes can be reset by the operator. Resetting the flukes back to the locked position allows for continued operation. This operation is repeated until the operator retrieves the desired target.

INTRODUCTION

BACKGROUND

A grappling hook is an anchor with multiple hooks (claws, flukes, arms, tines), attached to a rope. The hook is thrown, dropped, sunk, projected, or fastened directly by hand to where at least one hook can catch and hold. Figure 1 shows a soldier deploying a grappling hook.



Figure 1 : A soldier loading the hook.

Generally, grappling hooks are used to temporarily secure one end of a rope. They may also be used to dredge for submerged objects. (1)

Historically, grappling hooks were used in naval warfare to catch the ship's rigging so that it could be boarded. A common design has a central shaft with a hole ("eye") at the shaft base to attach the rope, and three equally spaced hooks at the end, arranged that at least one is likely to catch on some protrusion of the target.

Some modern designs feature folding hooks to resist unwanted attachment. See Figure 2.



Figure 2 : MR Grappling Hook.

The Collapsible Grappling Hook has been tested to exceed military specifications & deploys in 1 second, has independent/simultaneous blade access and includes a tactical swivel. (2)

Most grappling hooks are thrown by hand, but some used in rescue work are propelled by mortar or a rocket. Grappling hooks are used by combat engineers breaching tactical obstacles. The grappling hook is launched in front of an obstacle and dragged backwards to detonate trip-wire-fused land mines, and can be hooked on wire obstacles and pulled to set off booby traps on the wire. Two tools are available for this purpose; the rifle-launched grapnel, a single-use grappling hook placed on the end of an M4/M16 rifle, or the crossbow launched version. A grapple can clear up to 99 percent of the trip-wires in a single pass. (2)

Grappling hooks have many uses, including gaining entry or providing exit from buildings. For climbing and descending, the user places or tosses the grappling hook onto a roof, through a window or anywhere that catches and secures itself to give the necessary support. The other end of the hook is attached to a rope, which the user climbs or fastens to an item that is to be raised or lowered. (4)

This lead to sacrificing the hook, which caused hooks to be cut, lost and forgotten. This can become expensive investment, when hooks are seen going for \$600.00 on the market. (3)

Talking with Dwayne Haskell, a veteran and POW, about grappling hooks used in the service, and if any changes could be done, what would improve on the idea. This later honed the scope to a self-releasing grappling hook. The one thing that all grappling hooks don't have is a means of retrieving the hook, once entangled. (3)

Taking the newly shaped idea to the Burlington Ky, Fire department. The Firefighters and their use of grappling hooks opened the idea of water rescue. (5) Using a grappling hook to drag a body of water to retrieve whatever is needed in the water.

Offering the idea of a releasing grappling hook to aid in water rescue, the Firefighters all agreed that using a grappling hook with a releasing mechanism is greatly wanted in this type of application.

Thus a water rescue, self-releasing grappling hook became the main design.

EXISTING DESIGN ITERATIONS

FOLDABLE GRAPPLING HOOKS

Designed by the Army Natick Soldier Center by soldiers for soldiers. The Capewell Retractable Grappling Hook (Fig 3) is the ultimate solution. A smaller hook is also a safer hook: it doesn't get hung up accidentally while being carried, it can be thrown farther, which offers greater mobility in scaling obstacles, and it affords greater distance in clearing hazards.



Figure 3 : Retractable Grappling Hook

Grappling hooks have many uses, including gaining entry or providing exit from buildings. For climbing and descending, the user places or tosses the grappling hook onto a roof, through a window or anywhere that catches and secures itself to give the necessary support. The other end of the hook is attached to a rope, which the user climbs or fastens to an item that is to be raised or lowered. (4)

Most grappling hooks are large, heavy, bulky, and risky to use because the breaking strength of the metal is largely unknown. To improve the safety of this useful equipment, engineers at the Natick Soldier Systems Center in Massachusetts developed super new lightweight, high strength materials that cut the weight and bulk by 50 percent over the standard grappling hook.

POCKET GRAPPLING HOOK

The pocket grappling hook was originally built by EOD Robotics, Inc. at the request of a desert warfare operator. He explained his need for a light weight, reusable grappling hook that could be used to snag trip wires or command detonation wires on IEDs in a combat environment. (3) See Figure 4 below.



Figure 4 : Pocket Grappling Hook

Features include:

Pocket size: stowed size: 1" x 5.5 " (also fits in your collapsible mine probe pouch)

Weight: (without water or sand ballast) 5 oz.

Collapsible: The spikes unscrew and are stored in the water resistant O-ring sealed body.

Variable weight: by adding sand, dirt or water into the body of the grappling hook you can increase the weight of the hook for more effective throwing range.

These hooks are not certified for life support activities and should not be used for any life support function. They are designed to pull trip wires.

Summary

Versatile: Easy to carry, quick to deploy and quick to stow.

Multi-mission capable: Maritime applications, SWAT, EOD, radio telephone operator

Flexible: use it as a specialized grappling hook to remotely capture lines, tear down phone lines, reposition barbed wire emplacements, disrupt wires, move packages and bags, rake and break windows, tear down blinds/curtains in SWAT entry applications.

Remove the spikes from the outside and use it to cast a line. This is currently being used by military RTOs (radio telephone operators) to string field expedient HF antennas.

Use it as a waterproof storage container to protect important items from water damage (when the spikes are removed).

Materials: The body is made of T6061 aluminum. The spikes are made of 300 series stainless steel (5)

MIL GRABBERS

The Grappling Hook is designed to be used for entry and egress in a MOUT environment and also for trip wires, concertina and minefield clearing.

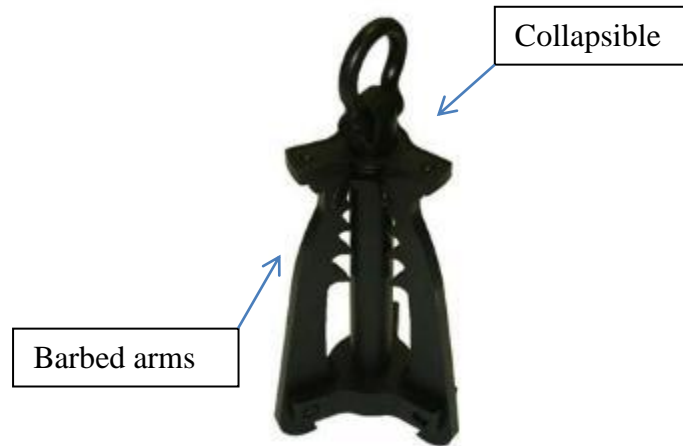


Figure 5 : Mil Grabbers

The Patented Military Grabber was chosen by the US Army as it's Collapsible Grappling Hook of choice in April 2003. It was also the hook of choice for the Special Operations Forces Urban Ops Kits.

Rated at 750 kg per arm; weight 720 grams; 220 mm long.

Laser cut aluminum - Grade 7075 T651.

Mil Grabbers can be found in the 101st, 82nd, and 509th Airborne; 2nd, 3rd, and 4th Infantry Divisions, 1st Cav. 10th Mountain Units. The hook is designed to be used for entry and egress in a MOUT environment and also for trip wires, concertina and minefield clearing. (7)

CUSTOMER FEEDBACK, FEATURES, AND OBJECTIVES

SURVEY ANALYSIS

A survey of a 100 was sent out to numerous military personal, Marines, Army, Army Reserves, and veterans, fire fighters, and police departments, only 39 came back. The survey included a general questioner about a self-releasing grappling hook. The results will help during the design phase.

Listed in Table 1, are the responses from the surveys. They are organized to show the most important feature first and the least important feature last.

Out of the 39 surveyed people, two important features showed a higher weight for customers; Reliability and Safety. Ease of Maintenance was third, but the value was adjusted to 10%, by the designer. This was because if it is not simple and common to use no one will want it. Ease of Operation and Maintenance now weighs the same. Without the design multiplier ease of operation would be at 9%. Also ease of maintenance was enhanced due to designer belief that simpler is better. Maneuverability was increased in importance due to terrain control. The hook will be design for multiple terrains, water rescue being one of them. The planned satisfaction came close the actual customer satisfaction, largest difference being appearance.

Table 1 - Survey responses in order of importance.

	Customer importance	Designer's Multiplier	Current Satisfaction	Planned Satisfaction	Improvement ratio	Modified Importance	Relative weight	Relative weight %
Reliability	4.8	1.0	4.0	4.9	1.2	5.9	0.14	14%
Safety	4.9	1.0	4.5	5.0	1.1	5.4	0.13	13%
Maneuverability	4.3	1.2	4.4	4.0	0.9	4.7	0.11	11%
Versatility	2.5	1.0	1.6	3.0	1.9	4.7	0.11	11%
Ease of operation	4.2	1.0	4.9	5.0	1.0	4.3	0.10	10%
Ease of maintenance	3.7	1.1	4.0	4.0	1.0	4.1	0.10	10%
Ease of releasing	3.9	1.2	4.3	4.0	0.9	4.4	0.10	10%
Appearance	3.4	1.0	3.6	4.5	1.3	4.3	0.10	10%
Corrosion resistance	4.2	1.0	4.4	4.5	1.0	4.3	0.10	10%

Table 2 - Engineering characteristics.

	Safety factor	Reduced number of components	Use of Standardized Part	Force to open	Loading setup	Number of hooks	Guarding	Color	Material	Weight (lb)
Safety	9					3			3	1
Reliability	9	3							1	
Ease of maintenance		3	9	3			1			1
Ease of operation			1	9		1				1
Versatility		1			9				1	
Maneuverability						9				1
Ease of releasing				9			9			
Appearance								9		
Corrosion resistance									9	
Abs. importance	2.43	0.82	0.98	2.14	1.01	1.50	1.03	0.91	1.56	0.44
Rel. importance	0.19	0.06	0.08	0.17	0.08	0.12	0.08	0.07	0.12	0.03

The engineering characteristics mirror the costumers' features in terms of finding a way to measure and design what the customer wants.

PRODUCT FEATURES AND OBJECTIVES

1. Reliability (4.8) – 14% Relative Weight
 - a. Treated as an OSHA level 5 safety rating rescue equipment
2. Safety (4.9) – 13% Relative Weight
 - a. Pinch points will be marked by caution symbol
 - b. OSHA guidelines
3. Versatile (2.5) – 11% Relative Weight
 - a. Use on any terrain
 - b. Changeable arms – Water, Forest, Dessert
 - c. Collapsible, for tighter storage (8)
4. Ease of Maintenance (3.7) – 10% Relative Weight
 - a. Maintenance with 5 or less standard tools, with no specialty tools required.
 - b. Field strippable in 2-5 mins
5. Ease of Operation: (4.2) – 10% Relative Weight
 - a. Hook will operate in the same manner as standard rescue hooks, but with a new feature, a releasing mechanism. (9)
6. Self-releasing: (3.9) – 10% Relative Weight
 - a. One man operation
 - b. Able to use the releasing mechanism with one free hand
7. Environmental friendliness: N/A
 - a. Marine safe, for water rescue
 - b. Paint used on the Hook will be Eco-friendly.
8. Cost: N/A
 - a. The Hook will be built for under \$500.
9. Balanced: N/A
 - a. Number of arms
 - b. Ease of use by means of ergonomics
10. Stable: N/A
 - a. Number of arms, hooks
 - b. Able to plum in water and drag

In order of customer importance:

Reliability, safety and versatility ranked as the top three.

These values will highly affect the design and application of this project.

CONCEPT SENERATION AND SELECTION

Primary design started with single, double and triple fixed hooks.

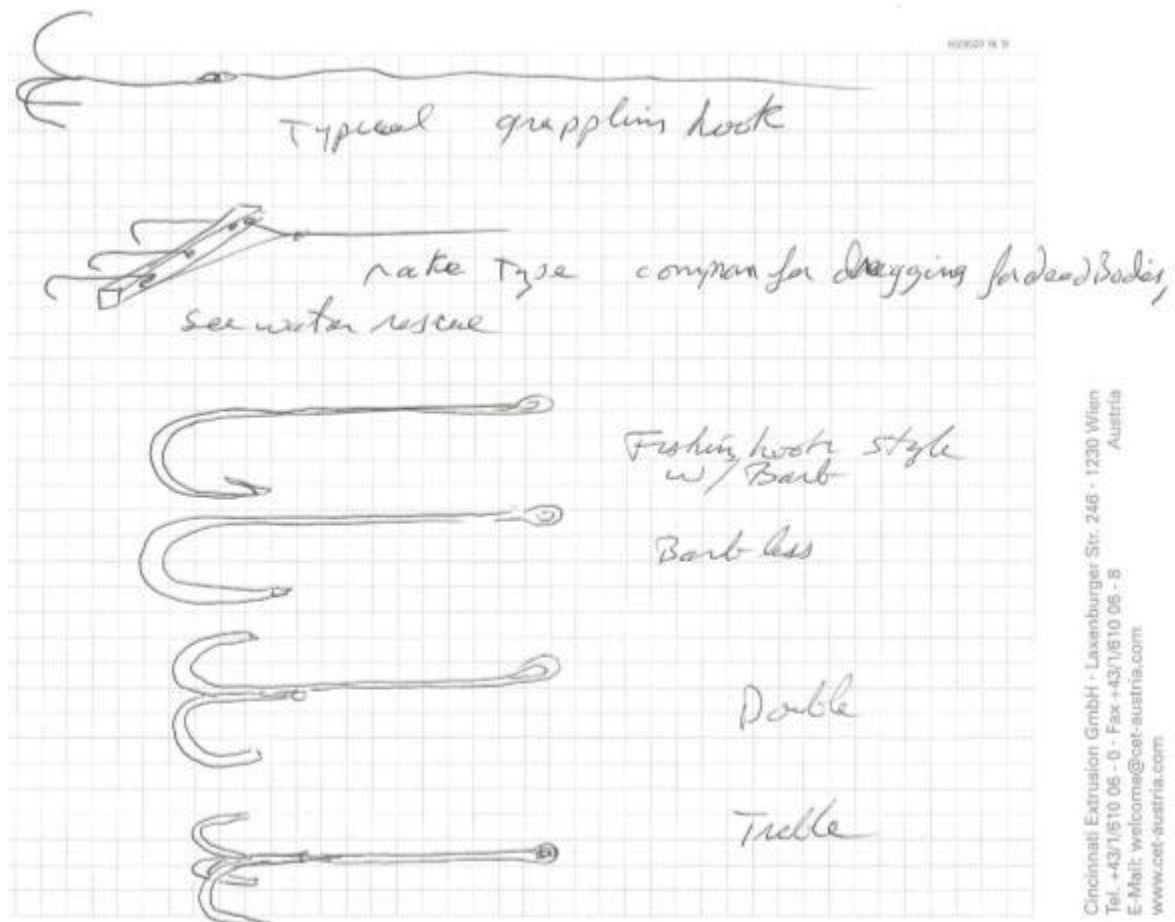


Figure 6 : Design sketches v1

Using the common fixed grappling hook and /or rake design, became the starting point of the self-releasing design.

Design of the release mechanism. Using a slip collar with a single hook idea.

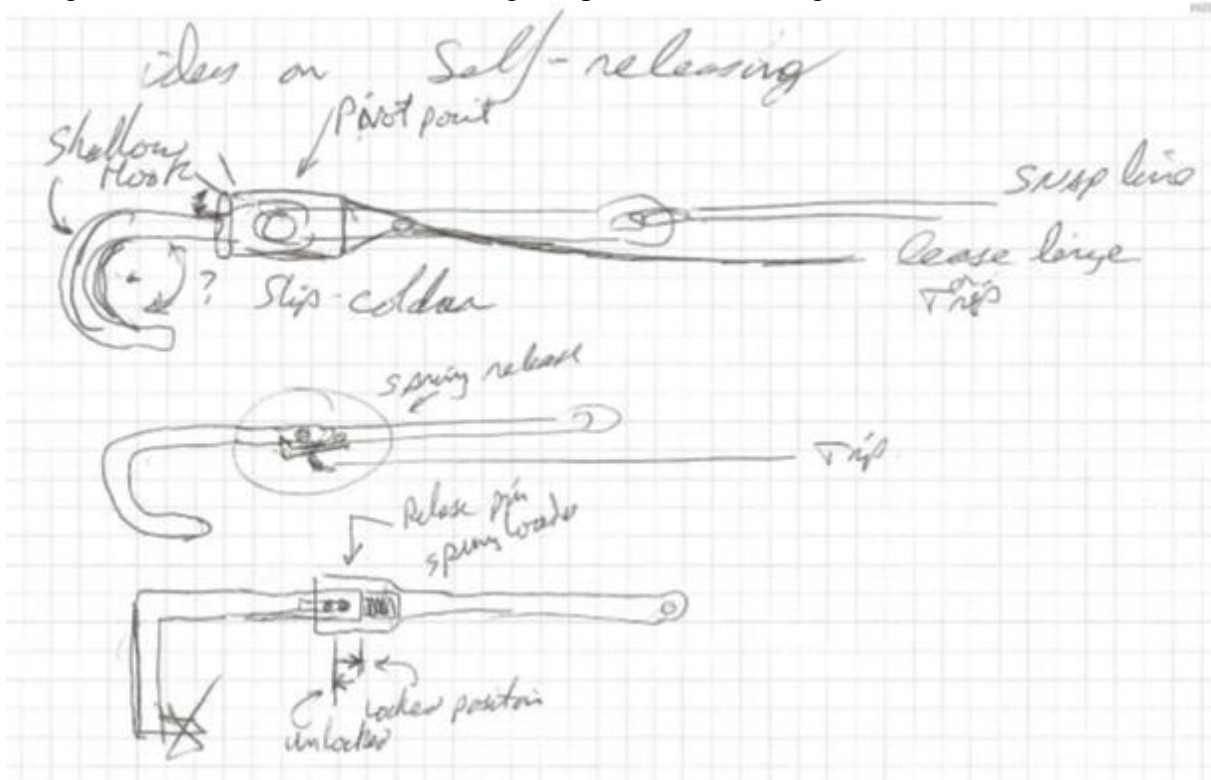


Figure 7 : Design sketches v2

Top design - shows a collar holding a twist or a bend point for the hook.

Center design – use of a trip line on a release catch and spring

Bottom design – This design later honed into the choosing design. Use of a release pin, spring and collar all of which are self-contained inside the hook itself.

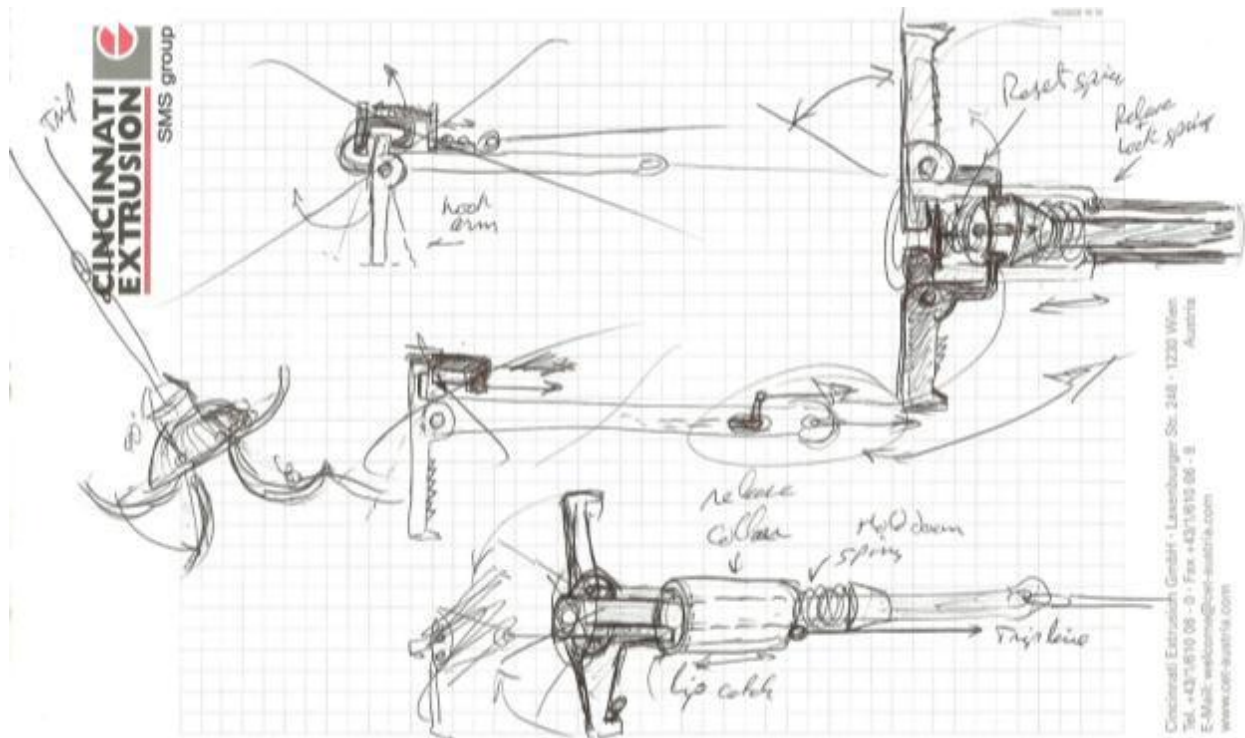


Figure 8 : Expanding the idea of the collar and spring release

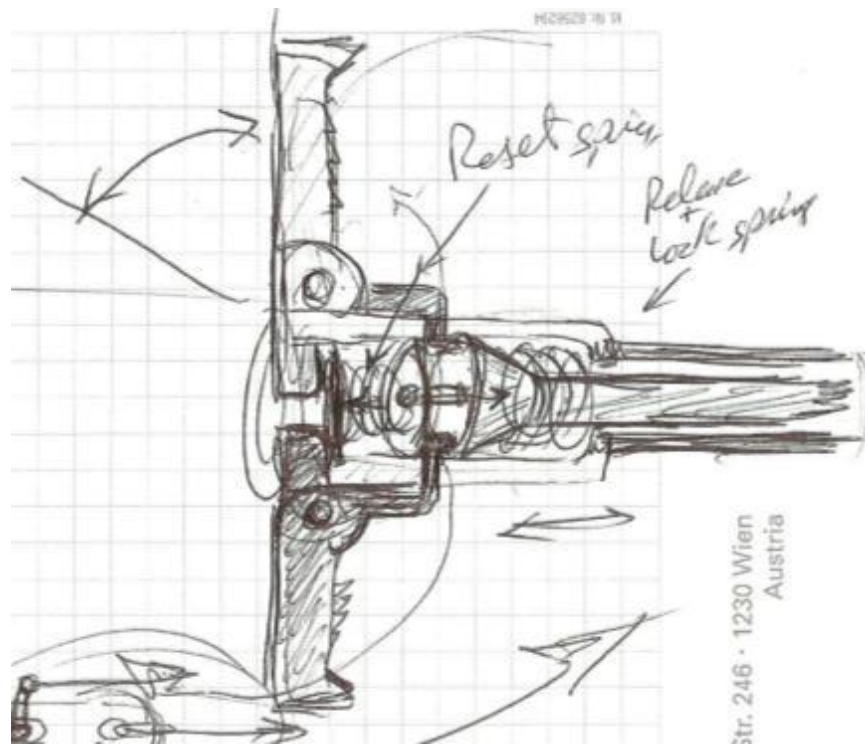


Figure 9 : Close up of the top right design concept.
This is used and focused on throughout quarter.

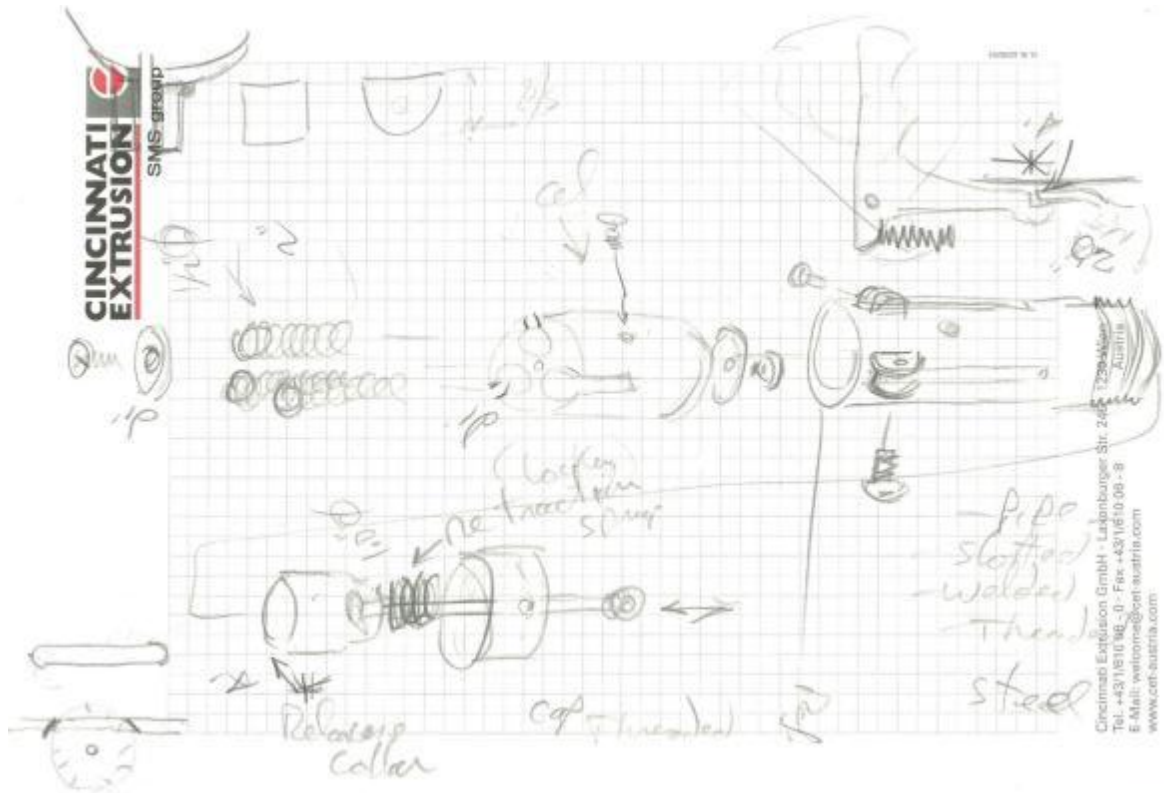


Figure 10 : Sketch of the reset spring cylinder and design of assembly.

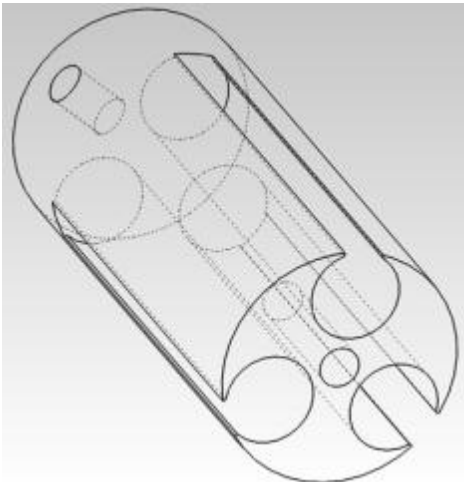


Figure 11 : Design of the reset cylinder.

This will be used to reset the flukes back into the rest position.



Figure 12 : Final design of assembly

As part of the final assembly, the SRGH will come with an instructional booklet. My proposed assembly is to create an instruction booklet informing operators, instructors, and interested parties of the Self-Releasing Grappling Hook (SRGH). The hook is designed particularly for Water Rescue. With this in mind, operators will need to be instructed on the proper usage, safety, and throwing technique. See Folder 'Instructional Booklet' for details.

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CALCULATIONS

Keeping to the schedule at hand, testing was needed to be done. The figures below show past and modified designs. In order to fix problematic areas on the flukes, design modifications were made, tested, and noted.

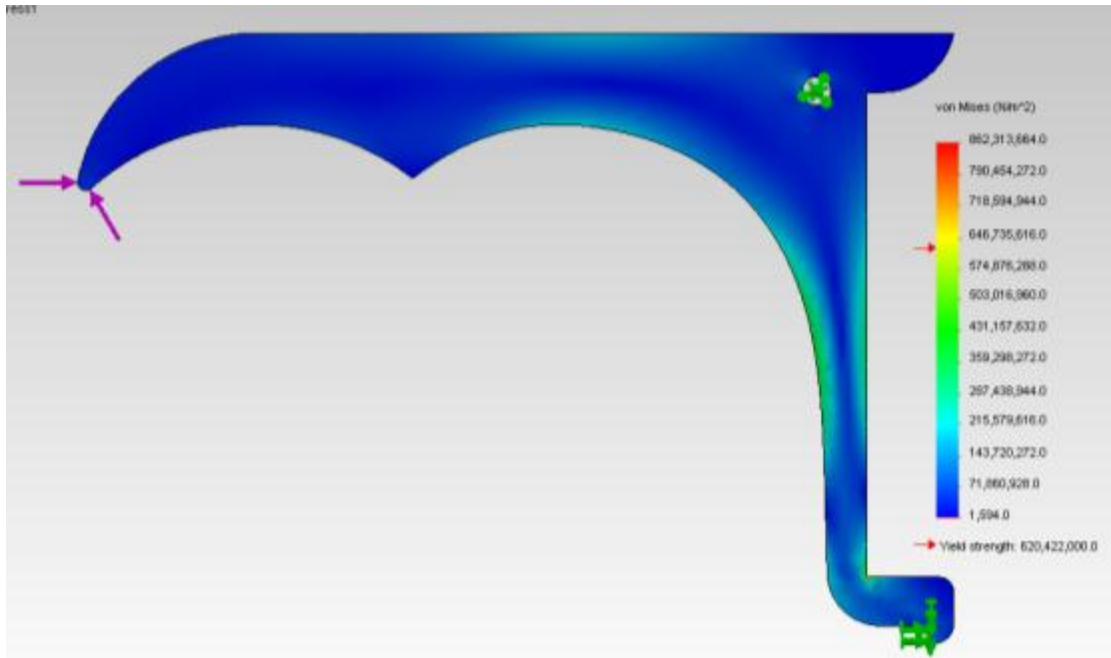


Figure 13 : 600lbs. load on the furthest point

Using a 600 lbs. force on the furthest point on the fluke gives the worse scenario and stress over fluke's body. The SRGH is design for 150 lbs. of towing capability. This number was chosen by being the average weight of a normal human. The hook is not design be pulled by a wench and tackle. However, in the case of doing so will require a higher safety factor. Originally the SRGH was treated like an OSHA level 5 product, where the item needed to be treated no different than a defibrillator is to be treated. By doing so required a safety factory of four. Hence the 600 lbs. load, 4 times the intended load.

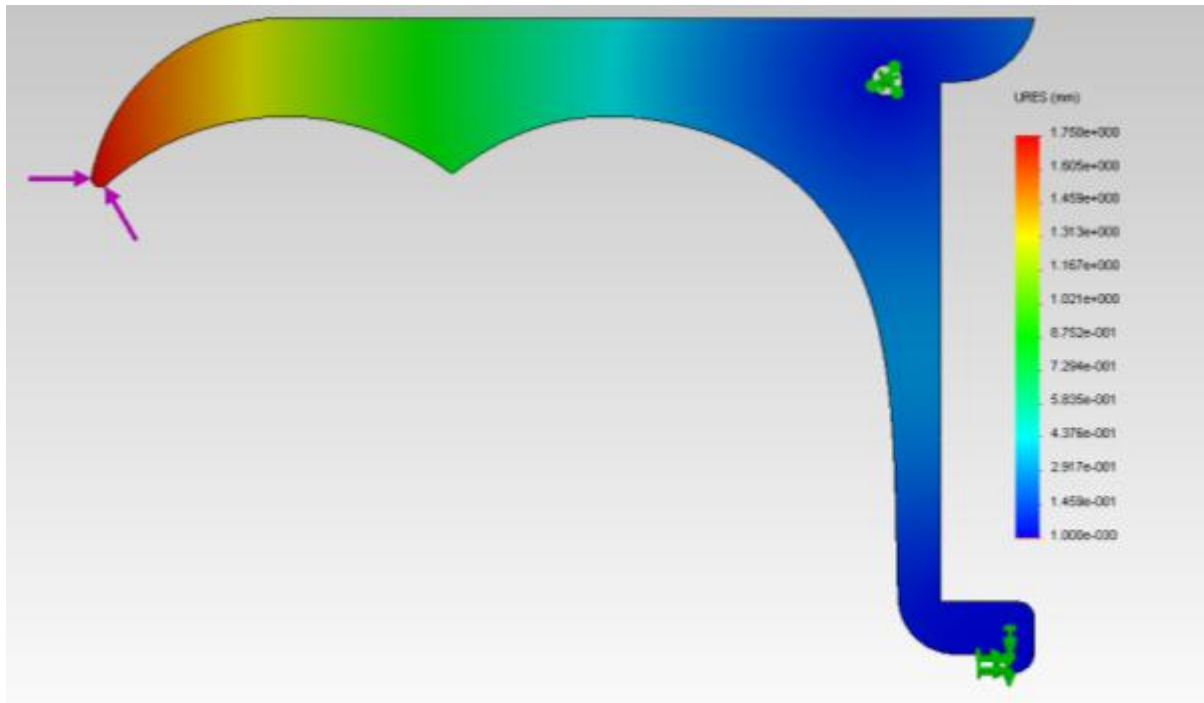


Figure 14 : 600 lbs. load stress over the fluke.

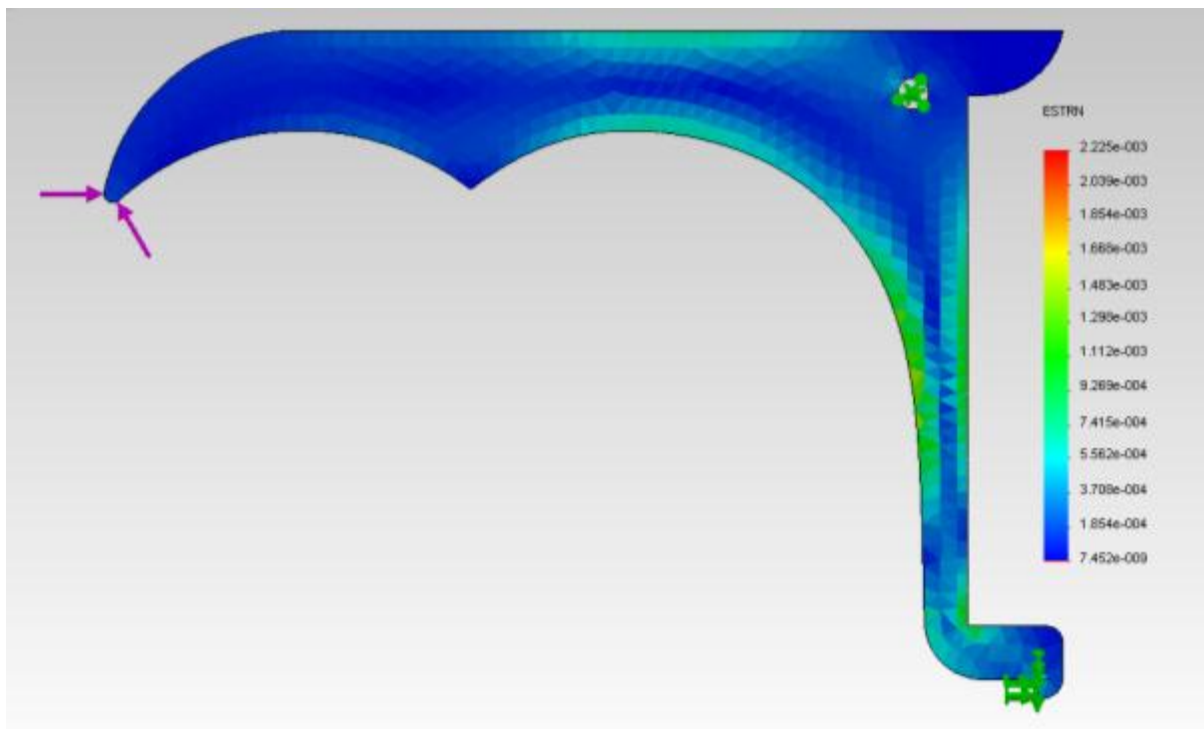


Figure 15 : 600 lbs. alloy steel.

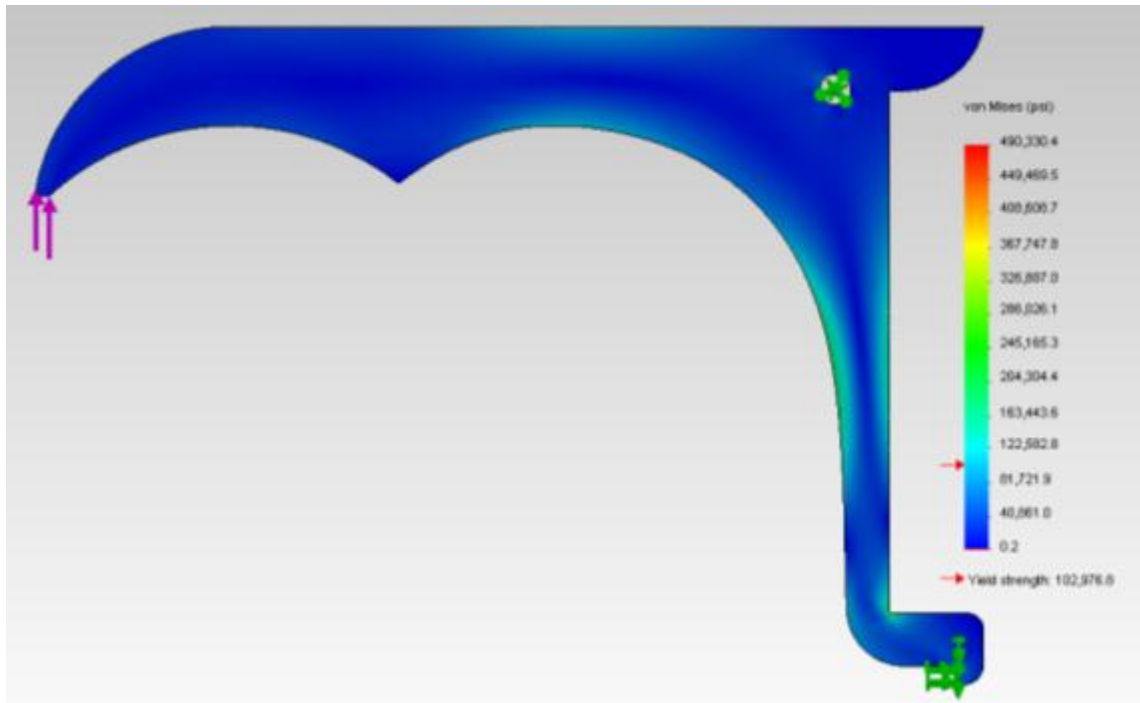


Figure 16 : Upward force of 600 lbs.

The results failed, exceeding the yield strength of alloy steel. In figure 17, shows high stress concentration on the corner of the fluke.

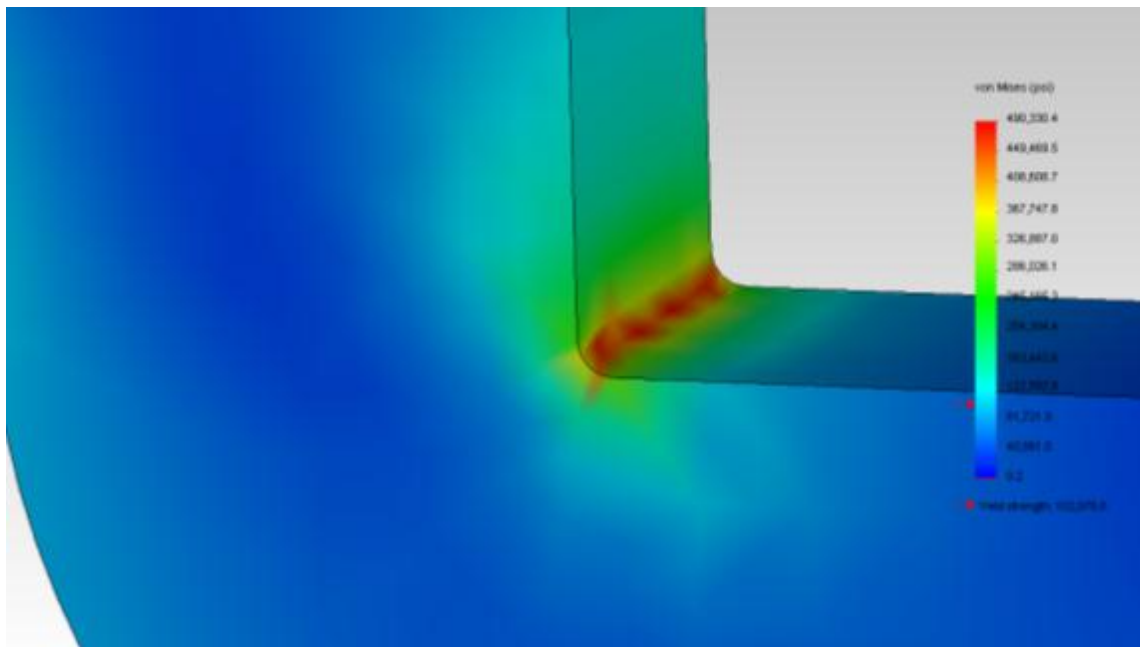


Figure 17 : Stress point 1.

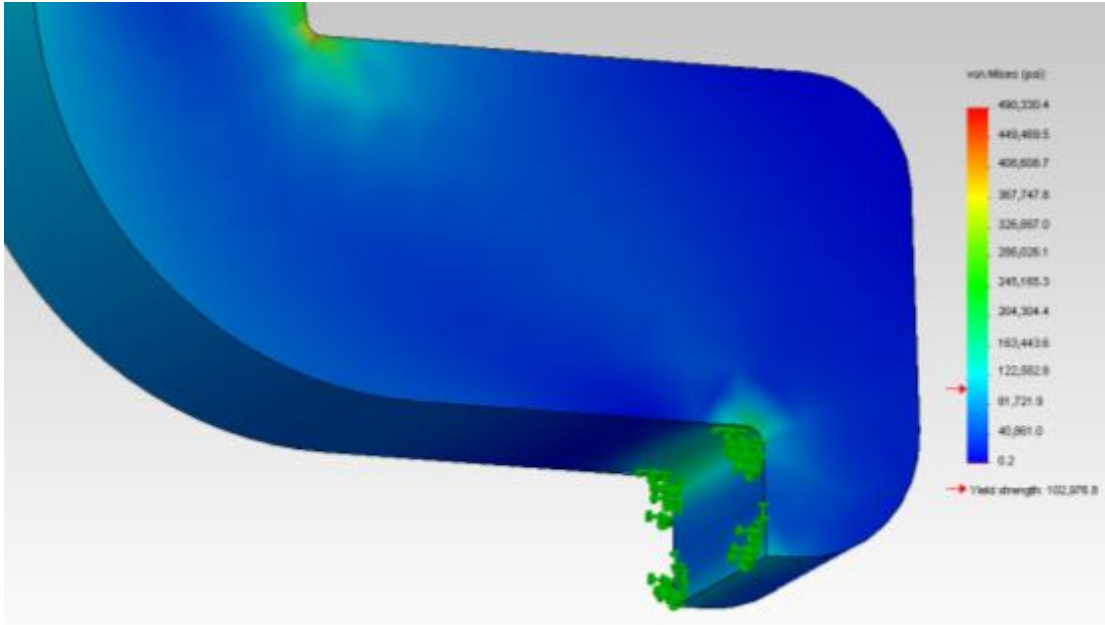


Figure 18 : Release collar tooth.

The same radius was used on the tooth, where is to catch on the release collar, for the corner of the fluke in figure 17. Yet the stress yielded nominally lower. A redesign is needed to dissipate the concentrated stresses, seen in Figure 17.

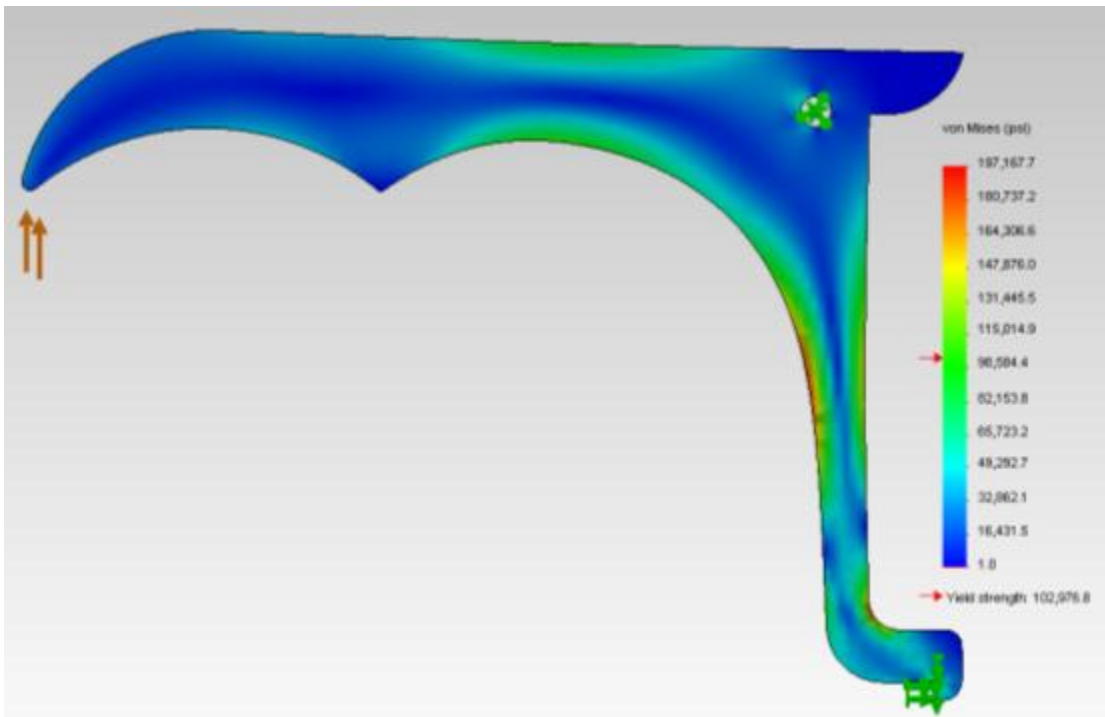


Figure 19 : 600 lbs. load with a larger corner radius of 0.25"

By changing the corner radius to 0.25" dramatically dissipated the stress. Dropping from 500 ksi to under 200 ksi, as seen in Figure 19.

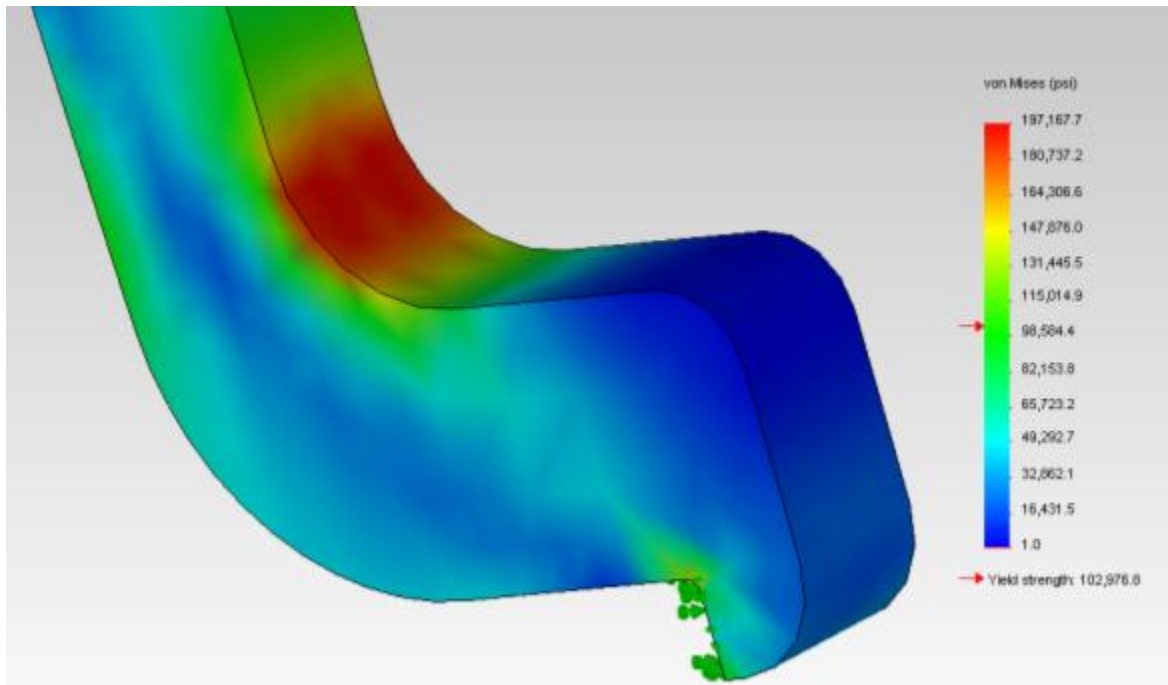


Figure 20 : Closer look of the 0.25" radius.

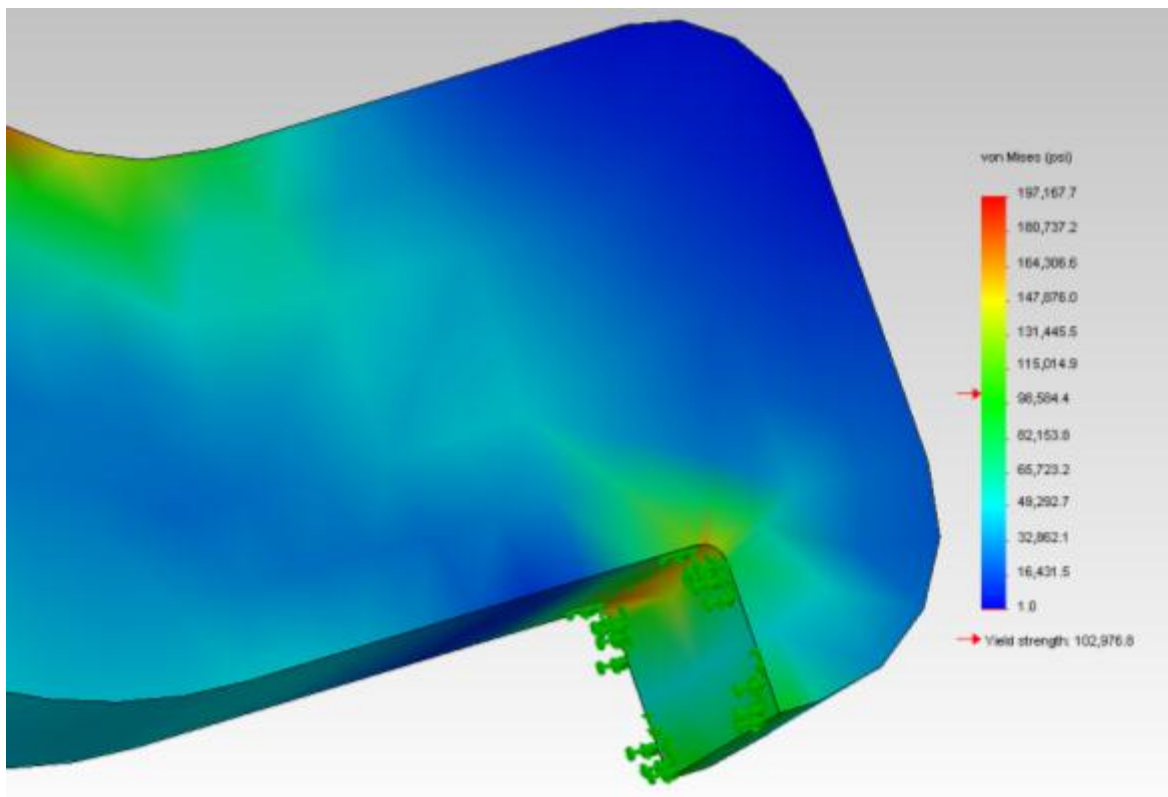


Figure 21 : Release collar tooth.

In doing so moved some of the stress to the release tooth, but was under the yield strength.

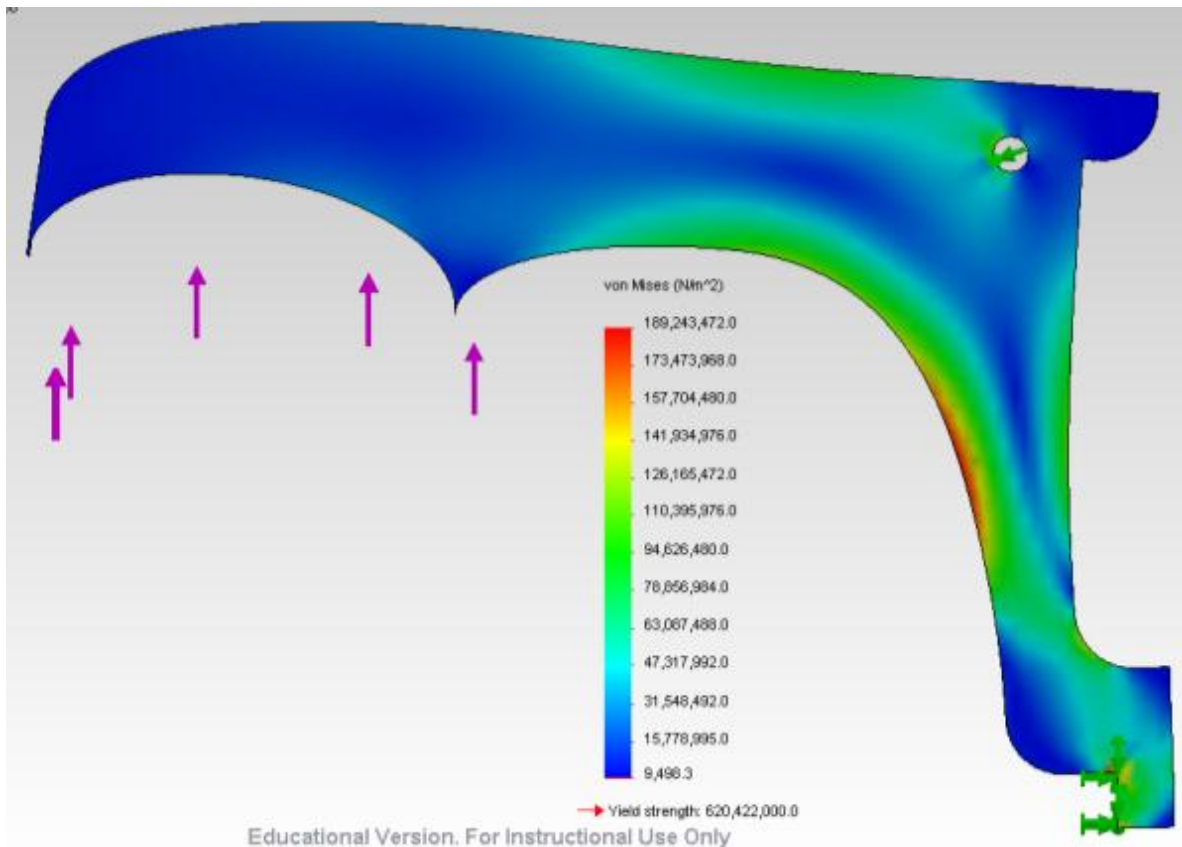


Figure 22 : 600 lbs. pre-existing fluke design

Beefing up the flukes by raising the corner, drastically improved the displacement of the stress. Dropping the stresses from 200Ksi to 20Ksi with a yield strength of 90Ksi thus, keeping a safety factory of 4.5.

Using this design would require a larger force to warp the fluke(s) if the S.R.G.H. would get entangled and unable to be retrieved. With this note a break point should be added to the flukes. Reverting back to a high stress point on the corner, but to use a harden material, a Rockwell 30 or more will do the job. By doing so will add another process to the build of the S.R.G.H. but is necessary to keep the design of the fluke the same with low design change.

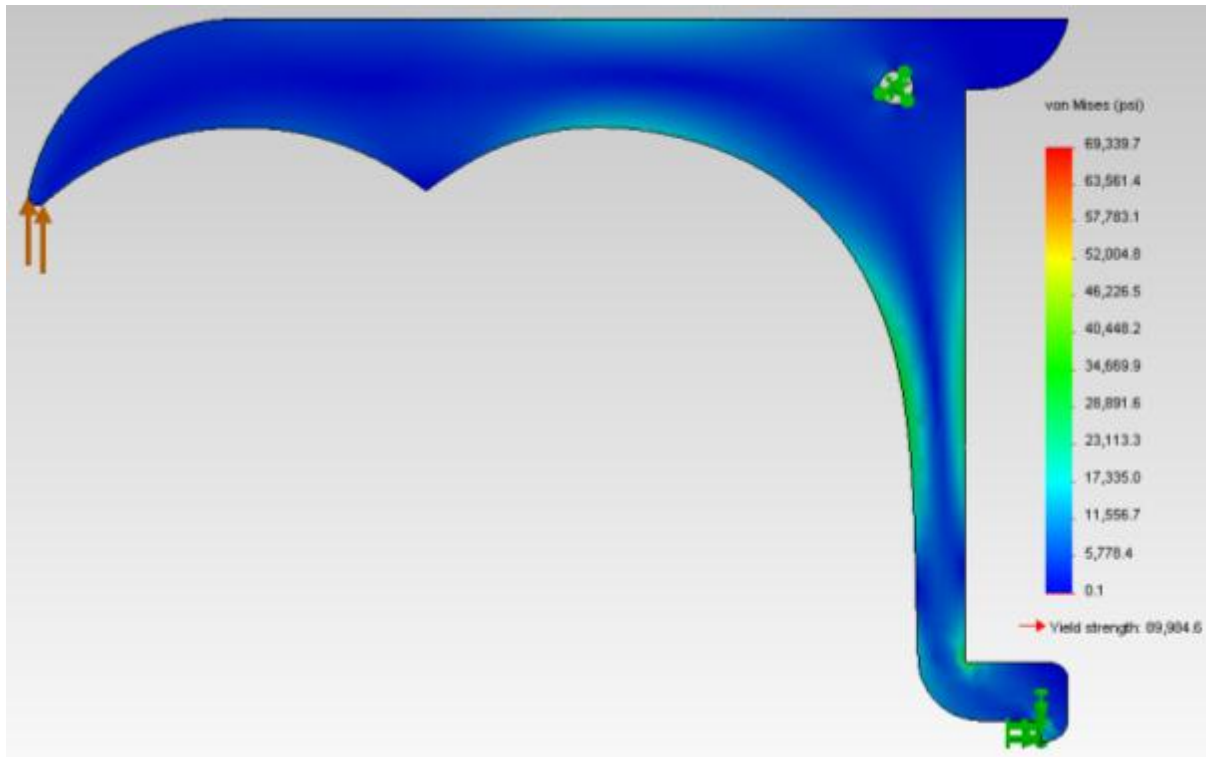


Figure 23 : 600 lbs. existing fluke design

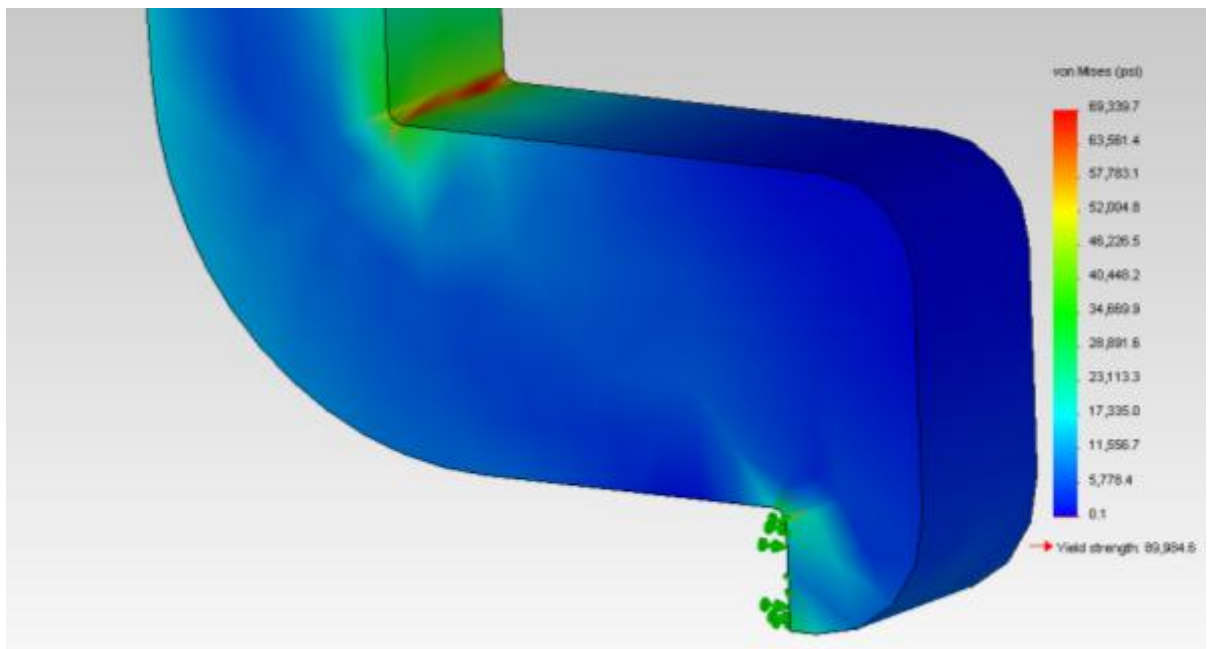


Figure 24 : 600 lbs. existing fluke design, corner.
Break away point with exceeding the 600 lbs. mark.

ASSEMBLY DESIGN

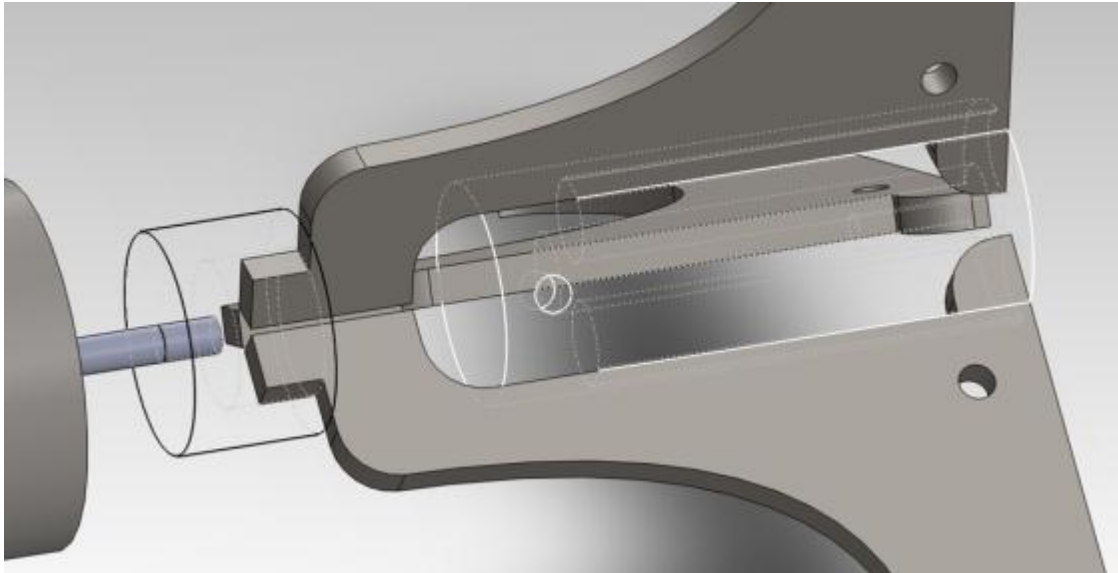


Figure 25 : Release Collar and Reset Cylinder

This model shows the improved release mechanism. Inside the Release Body in white lines, is the reset spring cylinder. This is where three 3" springs will seat. The spring will have the ability to return the flukes back to the rest position as shown.

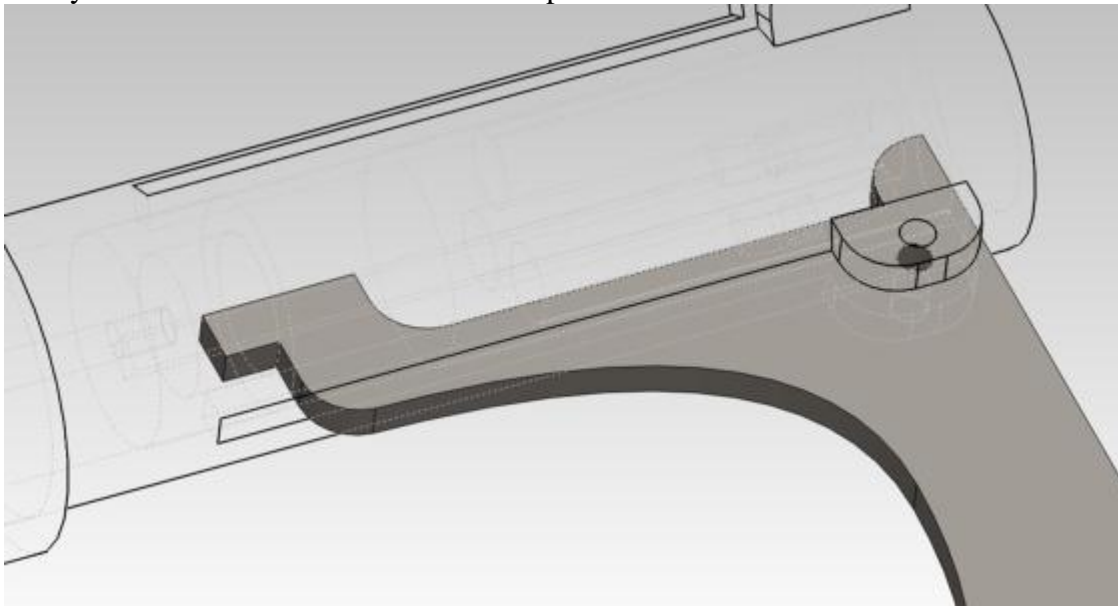


Figure 26 : Dog-ear and Release Body's slots for the flukes

This model is showing how the flukes will attach to the release body. The Release Body will have milled slots for each of the three flukes to pivot through. The dog-ears will have to be welded onto the Release Body. Design on the dog-ears is not final and are subject to change.

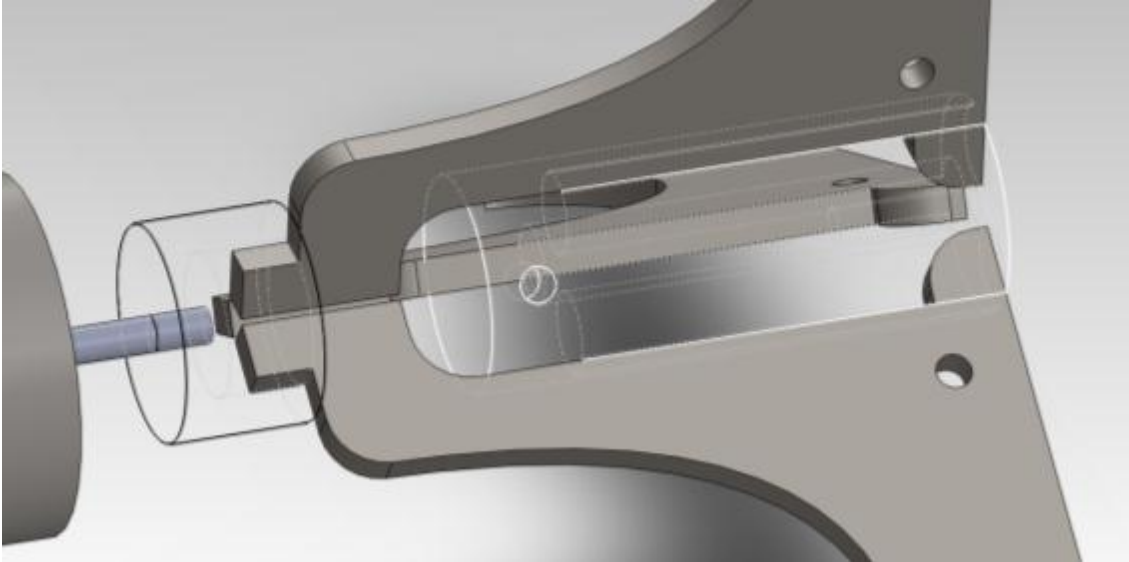


Figure 27 : Complete assembly of Flukes

Above shows the depiction of the flukes resting in the Release Collar.

TESTING

While testing the S.R.G.H. I had to make sure that the release mechanism was seated properly and able to release the flukes. Shown in Figure 28 and 29.



Figure 28 : Locked position.



Figure 29 : Released position.

The release collar is able to pull back without interfering any part of the release body and flukes.

Once the S.R.G.H. is fully assembled, testing of the full operation of the release mechanism had to be performed. Inside the release body held, the release spring, release collar, reset springs, and flukes.

Shown below in Figure 30, the fully assembled product in the locked position with a strong pulling force of an adult male. The operator is bearing back on the S.R.G.H. with his body weight.



Figure 30 : S.R.G.H. Locked.

Pulling on the Release Eyelet (Release Line), frees the flukes allowing each individual fluke to pivot and release on an undesirable object. Figure 31.



Figure 31 : S.R.G.H. Released.

Once the S.R.G.H. is assembled a marine primer coating was applied on each of the parts. This will hinder the corrosion of rust and seal the tempered steel. A neon orange and yellow color scheme was then added on top of the primer. (Figure 33) The bright colors help aid in the location and placement, when dredging for an item, of the S.R.G.H. when in murky waters.

After the paint has cured, testing the S.R.G.H. in water followed: Ability to reach target area, retrievability of the Hook when ensnared, and an item rescue.

Figure 32 demonstrates the launching and landing of the S.R.G.H. The S.R.G.H. was thrown over the recuse item, (a large foil wrapped steak hoagie)

Note: the foil wrapped steak hoagie was a 10 lbs. dumb-bell with clothing bound around it. It was a running gag in my department to save a steak hoagie.



Figure 32 : Water testing.



Figure 33 : Item retrieval testing.

Figure 34 and 35 demonstrates the release mechanism when ensnared. Once the S.R.G.H. is ensnared a quick jerk on the secondary release line will cause the flukes to collapse, freeing it from the ensnarement and thus able to be retrieved.



Figure 34 : S.R.G.H. submerged and ensnared.



Figure 35 : S.R.G.H. submerged and freed.

The S.R.G.H. met the entire requirements by COSMOS testing and Field testing.

SCHEDULE AND BUDGET

The project schedule for calculations and design instigates January 3, 2012 with the completion of a weighted objective method and proof of design statement. The project timeline ends June 4, 2012 when the final report is submitted.

Key milestone dates:

Table 3 : Key Milestone Dates

	Start	End
Concept Development	10/15/2011	12/11/2011
Proof of Design Agreement	11/23/2011	
3-D modeling	12/11/2011	1/3/2012
Calculations and Design	1/3/2012	1/5/2012
Material Selection	1/5/2012	1/6/2012
Order Materials	1/20/2012	
Fabrication	2/10/2012	3/9/2012
Winter Oral	3/9/2012	
Winter Report	3/16/2012	
Final Assembly and Modification	4/6/2012	5/28/2012
Spring Oral	5/28/2012	
Final Report	6/4/2012	

Budget

This is the projected budget for this project.

Included is a general list of supplies needed to complete this project. The total cost of the project is expected to be just under \$350.00.

Table 4 : Preliminary Budget

<u>Material, Components or labor</u>	<u>Forecasted Amount</u>
Steel rod	\$100.00
Steel tubing	\$100.00
Steel cable	\$20.00
Heavy gaged spring	\$15.00
Bolts	\$15.00
Pins	\$10.00
Bushings/O-rings	\$20.00
<u>Misc. parts</u>	<u>\$60.00</u>
Total	\$340.00

When going out to purchasing the materials, I've took in consideration of limiting my budget to under \$400.00. Since I will be using my own funds in creating my product, I will not have the privilege and financial plan that of a large company. In actuality, most of my material can be bought in most hardware stores. In my case I've chosen Home Depot.

Below is a copy of my receipt from Home Depot.

	Black Iron Parts
\$ 4.29	2" dia. X 10" Black Iron Pipe
\$ 8.29	1/2" glav. Swivel
\$ 4.19	2" x 1" reducer
\$ 7.29	1 1/4" x 1 1/2" reducer
\$ 1.39	1" x 1/2" glav bushing
\$ 2.19	1 1/2" x 1/8" glav bushing
\$ 1.39	1/2" x 6" black nipples
\$ 2.19	1 1/8" x 6" glav nipple
\$ 3.87	1 1/2" x 3" Springs (3)
\$ 1.19	3/4" x 1/2" spring
\$ 14.83	1/2" 14 TAP
\$ 5.00	8" x 12" x 1/4" Steel Plate (steel alloy)
\$ 56.11	Total

Table 5 : Actual Bill

In the grand scheme, the most expensive martial came to be the 1/2" 14 TAP. This is for the threading of the Shaft, Release Collar and Release Body.

CONCLUSION

I chose a self-releasing grappling hook for my senior design project at the University of Cincinnati, College of Applied Science, Mechanical Engineering Technology program. In working on this project, I relied heavily on the knowledge that I gained from my welding, machining and fabricating courses. These skills greatly aided and reduced my spending cost for the project. I was able to work out of my own shop to fabricate instead of using a manufacturer. This gave me even a greater experience and personal satisfaction in the design process.

In water rescue, multiple grappling hooks are used to retrieve a submerged body. During the rescue, it is very common to encounter submerged debris which becomes entangled in the fixed flukes which makes the hook irretrievable. This is a very expensive and time-consuming method, as a second hook must be used while the initial ensnared hook is lost. This is the only method that is currently used.

My design eliminates the need for a second hook. This design allows for an internal unlocking mechanism that disengages the flukes so that the debris can release itself. This is crucial when time is of the essence in water rescue.

The SRGH is cast to a target area, using the pull line to drag the hook. When the SRGH is ensnared, the operator exerts a quick jerk on the secondary (release) cable. The release cable pulls back on the release collar which unlocks the flukes. The freed flukes now become loose and able to release from whatever they are attached. Once released, the flukes can be reset by the operator. Resetting the flukes back to the locked position allows for continued operation. This operation is repeated until the operator retrieves the desired target.

Using the self-releasing design could open the door to other problematic equipment that would benefit from a quick return and possibly in the near future, a one hand operation or a hands free unit.

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APPENDIX A – RESEARCH

Interview with Vietnam Veteran and grappling hook expert, Dwayne Haskell, Oct. 24, 2011

Dwayne Haskell, Retired, POW Union, Kentucky

After talking with Dwayne about his experience with grappling hooks that he used in the Vietnam War, it sparked new ideas.

He explained how grappling hooks have expanded into more varied uses. He used them to detonate booby traps in minefields. He relied on them to scale mountains and cliff faces, and how rescue teams used them for open sea and building rescues.

While traditional grappling hooks need to be thrown by hand, most military versions are propelled by compressed air or rocket launchers. Some models are attached to and launched from an M4/M16 rifle.



http://www.battelle.org/spotlight/11_18_10_hook.aspx
9/26/11 Battelle, Columbus Ohio
Battellee.org

Battelle has developed a successor to a longtime Navy staple—a pneumatically powered grappling gun that deploys a hook and line higher, further, more quietly, and more reliably than its predecessor.

Kevlar line for use in Visit Board Search and Seizure (VBSS) operations.

Simple rugged design

Low maintenance

Tactical hook and line or hook and ladder deployment

Line deployment for ship to ship re-supply

Line deployment for water or fire rescue

Life vest deployment for Coast Guard and rescue units

Mine clearance

Delivery of sensitive electronic payloads

<http://www.columbussupply.com/products/?productid=160>
9/26/11 Drag Grappling Hook
Columbussupply.com



The Drag Grappling Hook (or Drag Grapnel) is made to be balanced for throwing to upper levels.

Special steel-forged hooks

Arrow-shaped points

Five grappling hooks welded to a 1 in. shaft

Eye on one end for rope attachment

Weight: 5 lbs.

Strength: ~400lbs.

http://www.ehow.com/about_4685223_grappling-hook-design.html
9/26/11 Grappling Hook Design
Ehow.com



This article covers Function, types, features, size, considerations, and history on grappling hooks.

Today's grappling hooks are used for a variety of outdoor activities, including high tech military applications, rock climbing and open sea rescue operations.

Boarding Hooks

Secured by means of entanglement

No means of quick release

Single to multiple hooks

Standers features a rescue hook has

NO standard (set) size

Retractable models

<http://www.countycomm.com/hook.html>

9/26/11 Pocket Grappling Hook
countycomm.com



The pocket grappling hook was originally built by EOD Robotics, Inc. at the request of a desert warfare operator.

He explained his need for a light weight, reusable grappling hook that could be used to snag trip wires or command detonation wires on IEDs in a combat environment.

Soon other members of the military saw how useful they were and ordered another production run.

Pocket size: stowed size: 1" x 5.5 "

Weight (without water or sand ballast) 5 oz

Collapsible: The spikes unscrew and are stored in the water resistant O-ring sealed body.

Variable weight: by adding sand, dirt or water into the body of the grappling hook you can increase the weight of the hook for more effective throwing range.

Versatile: Easy to carry, quick to deploy and quick to stow.

Multi-mission capable: Maritime applications, SWAT, EOD, radio telephone operator

Flexible: use it as a specialized grappling hook to remotely capture lines, tear down phone lines, reposition barbed wire emplacements, disrupt wires, move packages and bags, rake and break windows, tear down blinds/curtains in SWAT entry applications.

Materials: The body is made of T6061 aluminum. The spikes are made of 300 series stainless steel

Cost: \$29.95

http://catalogue.carletonrescue.com/do/ppa/1802/CMI_Grappling_Hook.html?1=1&s=cmi+grappling+hook&bs=0
9/26/11 CMI grappling Hook
Carletonrescue.com



The tines on this grappling hook are heat treated steel hard enough to be strong, but are left ductile enough to fail by opening up rather than breaking. Finished with a baked on epoxy for long lasting protection.

For Tactical Entry **ONLY**

Not for life support or routine usage

This device was designed with the needs of military and law enforcement users in mind

Flexible: Hooks are soft enough to bend “open”

More hooks: tines

Stability: number of tines

Easier to grapple: number of tines

<http://www.emergencyresponderproducts.com/grapnelhooks.html>
9/26/11 Grapnel Hooks
emergencyresponderproducts.com



Assault Hook Special Steel Forged Hooks, Arrow Shaped Points, (3) Grappling Hooks welded to a 1" shaft. Made and balanced for throwing to upper levels. An eye is on one end for rope attachment.

Drag Hook Special Steel Forged Hooks, Arrow Shaped Points, (5) Grappling Hooks welded to a 1" shaft. Made and balanced for throwing to upper levels. An eye is on one end for rope attachment.

Weight: 3 lbs. for 3 hooks

Weight: 5 lbs. for 5 hooks

Cost: \$65.00

Fire hooks

Common design in fire rescue

<http://www.reddenmarine.com/marine-supplies.cfm/general-gear-miscellaneous/harbor-mechanical-pcgrphook/plastic-coated-grappling-hook.html>

9/26/11 Plastic Coated Grappling Hook
Reddenmarine.com



The Harbor Mechanical grappling hook is plastic coated for the marine environment and has soft vinyl for a comfortable grip. Used for retrieving crab pots, shrimp pots and long-line sets.

For retrieving crab pots, shrimp pots and long-line sets

Plastic Coating

Marine environment friendly

Comfortable grip

Cost: \$25.50

Load: low

Small loads

<http://www.botachtactical.com/cagrho.html>
9/26/11 Retractable Grappling Hook
Botachtactical.com



Designed by the Army Natick Soldier Center by soldiers... for soldiers.

The Capewell Retractable Grappling Hook is the ultimate solution. A smaller hook is also a safer hook: it doesn't get hung up accidentally while being carried, it can be thrown farther, which offers greater mobility in scaling obstacles, and it affords greater distance in clearing hazards.

Constructed of high-strength steel

Supports over 1,600 lbs Or Six 268 lbs. men

Convenient Compact, Only 8-Inches High

Lightweight Only 1.5 lbs

Easy to Operate, It Offers Maximum Mobility & Safety

ONE WAY operating hook

Folds in

Fold out to a fix hook

<http://www.botachtactical.com/tagrho.html>
9/26/11 MR Grappling Hook
Botachtactical.com



The Collapsible Grappling Hook has been tested to exceed military specifications & Deploys in 1 second, has independent/simultaneous blade access and includes a tactical swivel.

Tested to double the Military Spec for toughness.

Can be spray-painted to any color.

Weight Rating On 2 Blades
3000 lbs

Built To Exceed Military Specifications

Deploys In 1 Second

3 Folding Arms With Grip Teeth

Body, Turn Key, Blades & Rope Loop / 7075 T-651 Aluminum

Pins for hooks and rope loop - 18-8 stainless steel

Detents for locking - Carbon steel with black oxide finish

Detent Springs - 17-7 stainless steel

Screw - 18-8 stainless steel

Exterior Finishing - Bead-Blasted

Can Be Spray Painted To Any Color

Weight: 1.59lbs

Width Deployed: 13.75"

Width Collapsed: 11.5"

Height: 11.5" Free-Height

Height: 9.5" free-height rope loop collapsed-right or left

http://www.baledefence.com/grappling_hook.htm
11/1/11 Patented Military Grabber
Baledefence.com



The Grappling Hook is designed to be used for entry and egress in a MOUT environment

The Grappling Hook is designed to be used for entry and egress in a MOUT environment and also for trip wires, concertina and minefield clearing.

Dimensions

Closed: 10" x 4" (with shackle extended)

Open: 10" x 11" (with shackle extended)

Weight: 1.512 lbs

Materials and Individual Piece

3 Tines(Arms): 3/16" plate* with 3/8" stainless pins

Shaft: Cut and machined 1" solid rod*

Base: Machined 3/4" plate*, secured with a 1/4" stainless pin

Spring Housing: Machined 5/8" plate*

Pins: Machined (303) stainless steel with 125,000 psi tensile strength
Overall Rating: 1650 lbs

7075-T651 aluminum, Mil-spec black anodized

Net weight: 0.71kg

APPENDIX B – SURVEY AND QFD

CUSTOMER SURVEY WITH RESULTS

The purpose of this survey is to aid water search and rescue, by a self-releasing Grappling Hook. The primary objective is to establish satisfaction with current Grappling Hooks out on the market and discover what improvements customers desire most.

How important is each feature to you in the design of a Releasing Grappling Hook?
Please circle the appropriate answer. 1 = low importance 5 = high importance

							Avg.
Safety	1	2	3(1)	4(2)	5(36)	N/A	4.9
Reliability	1	2	3	4(9)	5(30)	N/A	4.8
Ease of maintenance	1	2(4)	3(10)	4(17)	5(8)	N/A	3.7
Ease of operation	1	2	3(9)	4(12)	5(18)	N/A	4.2
Versatility	1(7)	2(19)	3(2)	4(8)	5(3)	N/A	2.5
Maneuverability	1	2	3(4)	4(21)	5(14)	N/A	4.3
Ease of releasing	1	2(1)	3(5)	4(28)	5(5)	N/A	3.9
Appearance	1(1)	2(3)	3(14)	4(10)	5(7)	N/A	3.4
Corrosion resistance	1	2	3(9)	4(13)	5(17)	N/A	4.2

How satisfied are you with your current Grappling hooks?
Please circle the appropriate answer. 1 = very UNsatisfied 5 = very satisfied

							Avg.
Safety	1	2(3)	3(1)	4(8)	5(27)	N/A	4.5
Reliability	1(1)	2	3(8)	4(19)	5(11)	N/A	4.0
Ease of maintenance	1(1)	2	3(2)	4(31)	5(5)	N/A	4.0
Ease of operation	1	2	3(1)	4(2)	5(36)	N/A	4.9
Versatility	1	2	3	4(14)	5(20)	N/A(5)	4.5
Maneuverability	1	2	3(3)	4(16)	5(20)	N/A	4.4
Ease of retrieval	1	2(2)	3(5)	4(13)	5(19)	N/A	4.3
Appearance	1(1)	2(3)	3(14)	4(12)	5(9)	N/A	3.6
Corrosion resistance	1(1)	2(2)	3(1)	4(12)	5(23)	N/A	4.4

How much would you expect to pay for a grappling hook?

\$200- \$400(6) \$401 - \$600(21) \$601 - \$800(8) \$801 - \$1000(3) over \$1000(1)

How much would you expect a releasing grappling hook to weigh?

Under 3 lbs. (1) 3-5 lbs.(13) 5 – 10 lbs.(18) Over 10 lbs.(7)

Thank you for your time

House of Quality

Jeremy Belknap Releasing Grappling Hook 9 = Strong 3 = Moderate 1 = Weak	Safety factor	Reduced number of components	Use of Standardized Part	Force to open	Loading setup	Number of hooks	Guarding	Color	Material	Weight (lb)	Customer importance	Designer's Multiplier	Current Satisfaction	Planned Satisfaction	Improvement ratio	Modified Importance	Relative weight	Relative weight %
Safety	9					3			3	1	4.9	1.0	4.5	5.0	1.1	5.4	0.13	13%
Reliability	9	3							1		4.8	1.0	4.0	4.9	1.2	5.9	0.14	14%
Ease of maintenance		3	9	3			1			1	3.7	1.1	4.0	4.0	1.0	4.1	0.10	10%
Ease of operation			1	9		1				1	4.2	1.0	4.9	5.0	1.0	4.3	0.10	10%
Versatility		1			9				1		2.5	1.0	1.6	3.0	1.9	4.7	0.11	11%
Maneuverability						9				1	4.3	1.2	4.4	4.0	0.9	4.7	0.11	11%
Ease of releasing				9			9				3.9	1.2	4.3	4.0	0.9	4.4	0.10	10%
Appearance								9			3.4	1.0	3.6	4.5	1.3	4.3	0.10	10%
Corrosion resistance									9		4.2	1.0	4.4	4.5	1.0	4.3	0.10	10%
Abs. importance	2.43	0.82	0.98	2.14	1.01	1.50	1.03	0.91	1.56	0.44	12.8					42.0	1.0	
Rel. importance	0.19	0.06	0.08	0.17	0.08	0.12	0.08	0.07	0.12	0.03								

APPENDIX C - PRODUCT OBJECTIVES AND SCHEDULE

Product Objectives Self-releasing Grappling Hook S.R.G.H.

The following is a list of product objectives and how they will be obtained or measured to ensure that the goal of the project was met. The product objectives will focus on a self-releasing grappling hook as opposed to the standard fixed grappling hooks. The hook is intended as a proof of concept to be utilized with retrieval and rescue, focused on water rescue.

Reliability: 14%

Treated as an OSHA level 5 safety rating rescue equipment

Safety: 13%

A factor of safety of 2 will be utilized and proven by Cosmos to show that structural components of the hook will not fail under loads.

Mechanical assembly will follow allowable working loads of mechanical moving parts.

Pinch points will be addressed by safety “keep hands away” symbol

Versatile: 11%

Use on any terrain

Changeable arms – Water, Forest, Dessert

Collapsible, for tighter storage

Ease of Operation: 10%

Hook will operate in the same manner as standard rescue hooks, but with a new feature, a releasing mechanism.

Ease of Maintenance: 10%

Maintenance with 5 or less standard tools, with no specialty tools required.

Field strippable in 2-5 mins

Self-releasing: 10%

One man operation

Able to use the releasing mechanism with one free hand

Balanced: N/A

Number of arms

Ease of use by means of ergonomics

Environmental friendliness: N/A

Marine safe, for water rescue

Paint used on the Hook will be Eco-friendly.

Cost: N/A

The Hook will be built for under \$500.

Stable: N/A

Number of arms, hooks

Able to plum in water and drag

Minimal tumbling when airborne or dragging

Schedule

Jeremy Belknap S.R.G.H.	Nov 20-26	Nov 27 - Dec 3	Dec 4 - 10	Dec 11 - 17	Dec 18 - 24	Dec 25 - 31	Jan 1 - 7	Jan 8 - 14	Jan 15 - 21	Jan 22 - 28	Jan 29 - Feb 4	Feb 5 - 11	Feb 12 - 18	Feb 19 - 25	Feb 26 - Mar 3	Mar 4 - 10	Mar 11 - 17	Mar 18 - 24	Mar 25 - 31	Apr 1 - 7	Apr 8 - 14	Apr 15 - 21	Apr 22 - 28	Apr 29 - May 5	May 6 - 12	May 13 - 19	May 20 - 26	May 27 - Jun 2	Jun 3 - 9
TASKS																													
Proof of Design to advisor	23																												
Concept sketches to advisor	28																												
Sketches		9																											
3D Modeling				24																									
Engineering Calculations							3																						
Material Selection				3																									
COSMOS Testing					6																								
Design Modification							13																						
Order Materials								20																					
Build body of Hook									10																				
Build arms and release										24																			
First assembly ready for testing											9																		
Oral												9																	
Report													16																
Final Assembly																6													
Test Hook																		13											
Demo to Adviser																								7					
Demo to Faculty																									14				
Oral Final Presentation																										28			
Final Report																												4	

APPENDIX D - BUDGET

Preliminary Budget

<u>Material, Components or labor</u>	<u>Forecasted Amount</u>
Steel rod	\$100.00
Steel tubing	\$100.00
Steel cable	\$20.00
Heavy gaged spring	\$15.00
Bolts	\$15.00
Pins	\$10.00
Bushings/O-rings	\$20.00
<u>Misc. parts</u>	<u>\$100.00</u>
Total	\$380.00

Actual Budget

<u>Material, Components or labor</u>	<u>Fixed Amount</u>
2" dia. x 10" Black Iron Pipe	\$4.29
½" Glav. Swivel	\$8.29
2" x 1" Reducer	\$4.19
1 ¼" x 1 ½" Reducer	\$7.29
1" x ½" Glav. Bushing	\$1.39
1 ½" x 1/8" Glav. Bushing	\$2.19
½" x 6" Black Nipple	\$1.39
1 1/8" x 6" Glav. Nipple	\$2.19
1 ½" x 3" Springs (3)	\$3.87
¾" x ½" Spring	\$1.19
½" 14 TAP	\$14.83
<u>8" x 12" x ¼" Steel Plate</u>	<u>\$5.00</u>
Total	\$56.11