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# Oil Filter Wrench Attachment

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# Oil Filter Wrench Attachment

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## Table of Contents

Introduction .....	3
Design Criteria.....	3
Existing Design Testing and Problems.....	5
Concept Brainstorming .....	7
Design Evolution .....	15
Conclusions .....	19

## Introduction

The purpose for this report is to outline the design process for an oil filter remover/installer intended to be used with a ratcheting socket wrench. The goal of this project was to design an attachment for a socket wrench that could be used to remove or install oil filters in a vehicle. This report will discuss design criteria for the new design, a few current designs for similar tools and their problem areas, initial design ideas, the design process of the chosen design, and the prototype building and testing for the project.

## Design Criteria

To begin the design process, a number of design criteria had to be established to help form and evaluate a good design versus a bad one. The design criteria are simply a list of desired outcomes the design should display. The first design criteria for the oil filter attachment is that the socket driver should attach in the center of the tool. The center attachment is an attempt to ensure enough space in as many vehicles as possible for the use of a socket wrench. A side attaching wrench will possibly run out of space to rotate on many vehicles. Center attachment will also make it easier to put the tool onto the filter.

As another important functional criteria, the tool must continue to tighten its grip on the filter as the wrench is turned. While there are a few exceptions, most oil filter wrenches work on this concept. As more torque is applied to the wrench, that torque tightens the grip on the filter as well as applies the twisting force required to loosen the filter. This is an easy, effective way to maintain a tight enough grip without having to have a set size and shape for the tool like a typical wrench.

Another preferred criterion is to ensure the tool will work in both a clockwise and counterclockwise direction. Even though they may seem rare, there are instances where a tool like this may be desired to tighten a filter rather than only loosen. Therefore, one goal is to make the tool easily switch between tightening and loosening.

The last design criteria specific to this project is that the tool should work for multiple filter sizes. Even if the tool works excellent every time and is the most ideal tool in every other way, it will give users much more frustration as well as higher cost if they must buy a separate tool for each size filter they remove. While it is possible to sell a set of multiple sizes like a socket set, it is likely to be expensive and impractical for a tool this large.

All the criteria discussed above are specific to the oil filter tool that is the goal of this design project. However, there are many other factors that should be kept in mind for any design project to make it more appealing to the end consumers. While there are possibly many more than can be discussed here, a quick overview of a few common ones will be considered. The tool should be lightweight and easy to use, a bulky tool will cause frustration and inconvenience to the user. Ultimately, the tool should go on and off very quickly and easily with as little user effort as possible. Also in a design such as this, simpler is usually better. A tool that requires a lengthy user manual and is hard to figure out or remember how to use will be avoided by most users even if it accomplishes its job well.

The simplicity of the tool is often closely linked to the next two very important criteria, manufacturability and cost. The more difficult a tool is to manufacture, the more it will cost. A designer must always try to keep in mind the methods that will be used to manufacture the parts being designed. Certain processes like molding or casting are often cheaper, quicker, and

can produce a higher volume than other processes such as machining. Complicated assemblies will also add cost and time to the production of parts. Parts should be designed to be manufactured as easily, quickly, and low cost as possible while still maintaining their functionality, usability, and durability.

### Existing Design Testing and Problems

In order to gather a few ideas of areas where current designs are lacking, a few existing filter wrenches were put through a quick test. Figures 1 and 2 show two designs, common in auto parts stores, which were chosen to be tested for this project.



Figure 1 – Existing Design #1



Figure 2 – Existing Design #2

The first design to be tested was design 1, shown in Figure 1. This design has three arms with teeth on the inside end that mesh with a gear in the center. The center gear is turned by the wrench, rotating all the arms inward to grip the filter.

This design was somewhat clumsy to get on the filter and ready to tighten. The gear connection was loose, yet it would still catch often, requiring the user to wiggle it around to

free the gears to rotate further. The tool then had to be held in place with one hand while the wrench was positioned and torque applied. If left loose, the tool immediately fell off the filter. Also, upon tightening, the metal arms did not grip the filter very well so the tool had to be held still to prevent it turning on the filter.

One of the biggest problems discovered when testing this design was the lack of a locking mechanism. In the vehicle being used for the test, the wrench arm quickly ran out of space to rotate. When the wrench was ratcheted backward for another rotation, the tool on the filter loosened rather than remaining tight and allowing the socket wrench to rotate backward by itself. Two design ideas resulted from this test. Ease of application was already a part of the design criteria, so that problem was ignored in this test. However, the tool's lack of grip lent good support to the planned use of a rubber or fabric strap that would generate a higher friction interaction with the filter. The wrap also results in a higher surface area in contact with the filter, transferring more torque to the filter.

The other idea generated by this test was to add a locking mechanism in the design. This mechanism would hold the tool's tight grip on the filter even when the wrench force was removed. Then, in cases such as the car used for the test, removing the wrench torque to ratchet back for more space would be possible.

The second existing design (Figure 2) is simply two arms attached on a disc. As the disc is turned by the wrench, the attach points rotate around the disc center resulting in the arms pulling in toward the filter. A spring pulls the two arms inward as well. The spring is a good addition as it enables the tool to hold itself on the filter without support from the user.

However, existing design 2 was even harder to apply than design 1. On this tool, the side pieces were curved too much, making the outside edges point in toward the filter. This made them too close together to fit well on the filter. Even with the tool stretched to its maximum size, the edges were scarcely able to fit on the filter and left large scratches on the outside surface of the filter. The curved sides could probably be bent out to provide an easier fit, however the 1/8 inch metal would likely require a pliers and some force to bend. Users would most likely be frustrated if they had to modify the tool before it could be used.

Once in place, this tool was so tight it easily turned the filter. However, without the too tight fit, this tool has the same problem as the first; the metal surface slips easily against the filter. Again, a material that would slide less easily would help the design a lot. The two additional design goals highlighted by these tests were taken into account during the design process, especially the locking mechanism. The concept plans already being formed were utilizing a better grip material so no change was actually required to accommodate that design goal.

### **Concept Brainstorming**

Once the design criteria have been established, brainstorming for ways to accomplish those criteria begins. Often a designer will brainstorm and sketch out several concepts before choosing one or a few to pursue in more detail. These concept sketches are evaluated based on the design criteria and eliminated or given more consideration based on how many of the criteria they fit and how well they fit the criteria.



The initial brainstorming resulted in five main concept sketches. Figure 3 shows design concept number one.

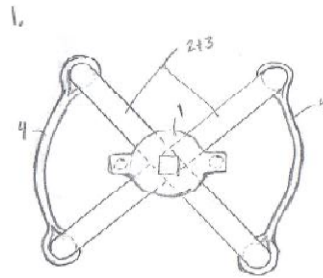


Figure 3 – Concept Sketch 1

In this concept, the driver connects to and rotates the part labeled as number 1. This part then has pins that force either part two or three to rotate, depending on the direction of rotation applied to the wrench. As the arm rotates, it tightens the strap (part four) around the filter, gripping and turning it.

Concept 2, shown in Figure 4, again uses the strap concept to grip the filter. This concept has a very similar center piece that is rotated by the wrench. In this design, when part one is rotated, parts two and three, which are thin bands, wrap around part one, pulling the pins in toward the filter, tightening the grip.

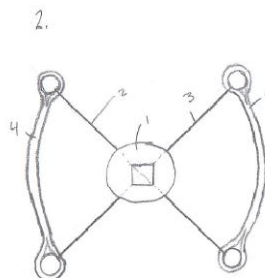


Figure 4 – Concept Sketch 2

Figure 5 shows the third concept. This one also works by pulling pins inward to tighten on the filter. As part one rotates, small pins on the inner end of parts two through five follow a curved groove cut into part one that forces the arms to pull inward toward the center.

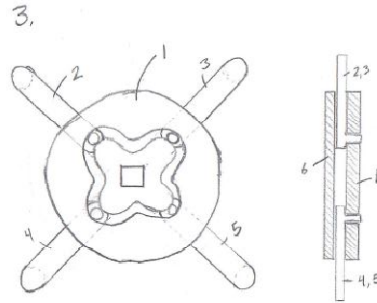


Figure 5 – Concept Sketch 3

The fourth concept, shown in Figure 6, is a slight variation of concept one. In this concept, a torsion spring is added that wraps around the center and pulls arms two and three toward each other pre-tightening the tool before the wrench torque is applied. Vertical pins on part one will then rotate one of the arms around the filter as the wrench torque is applied.

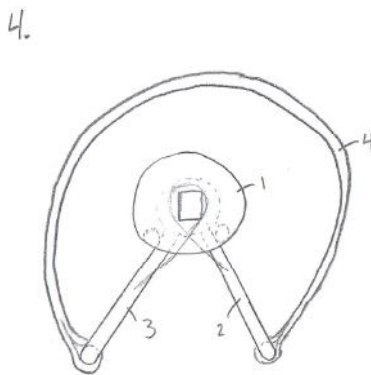


Figure 6 – Concept Sketch 4

The last sketch, Figure 7, is similar to one and four. This concept has two main parts, part one as a base part with a stationary arm, and part two that rotates around part one.

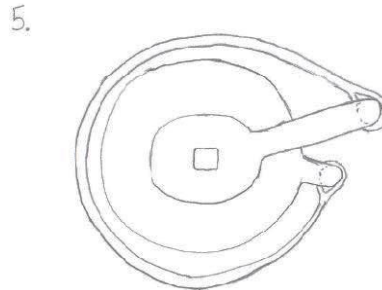


Figure 7 – Concept Sketch 5

All of these designs were given a quick evaluation based on how well they would work and if they met many of the design criteria. They all have the socket slot in the center for a center attaching wrench. Likewise all the concepts will tighten their grip as the torque is applied through the wrench. These designs are also bi-directional since they are all designed to work the same way no matter what direction the wrench is turned. The criterion that is perhaps the least met is the size adjustability. These concepts are able to fit different sizes as they will all grip a smaller radius the further they are tightened, however it is adjustable to a limited range of sizes.

Next, a quick evaluation of the practicality of each design was used to choose a concept to pursue. Concept 1 will be discussed later since it is similar to concepts 4 and 5. Concept 2 was disregarded for two main reasons. First, of all the designs, it would be the clumsiest to fit on the filter. Since the bands (parts 2 and 3 in Figure 2) must be flexible for the concept to work, they would hang down slack making installation difficult. While it could possibly be placed on a filter that is oriented with its axis of rotation horizontal to the ground, any vehicle

that has its oil filter tilted at all toward the ground would make it nearly impossible to get this design on the filter long enough to tighten it. The other problem in this design is illustrated in Figure 8.

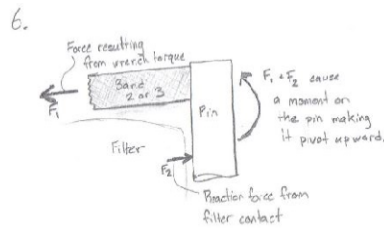


Figure 8 – Concept 2 Forces

The force of bands 2 and 3 pulling inward would put a moment on the outer pins. Without the support the solid arms in the other concepts would provide, the pins could rotate upward, loosening the grip on the filter and slipping off altogether.

Concept 3 was also dismissed because of its likely impracticality. While there is no way to know completely how a design will work until it's built and tested, a close look at the design can give a very good estimation of its behavior. Concept 3 is a little more complicated than the others and would be difficult to get working properly. It would be difficult to provide the correct angle and curvature to the slots to pull the arms in with enough force to grip the filter, yet still allowing the pins to slide farther when the wrench is rotated more. This could possibly be done, yet would be more complicated and would work for a very small size range of filters.

Concepts 1 and 4 are very similar in design and function. However, with these two concepts, the arm that was not actively being moved by the turning wrench was free to turn also and be pulled along by the straps. These two designs morphed somewhat to form concept

5. Concept 5 reduced the three bodies to only two, a fixed arm on the main body and a rotating arm to which the wrench would attach. This design was chosen to develop as it was simple with few parts and could be easily adapted to fit the locking mechanism discussed in the previous section.

Once the overall concept was decided upon, another brainstorming session began to design the locking mechanism that would eliminate backward rotation of the moving arm. As with the main design, several idea sketches were made of the locking mechanism and evaluated based on the practicality of each design.

These designs were sketched out over a period of a few weeks and in several notebooks so are not as neatly arraigned as the main concept sketches. For the sake of time, the lock mechanisms will not all be discussed in detail. Figures 9-11 show the brainstorming sketches made for the locking mechanism.

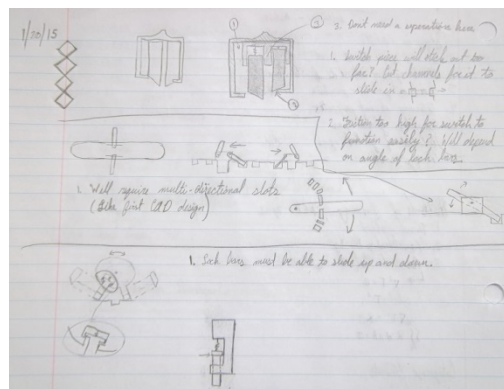


Figure 9 – Lock Mechanism Sketches

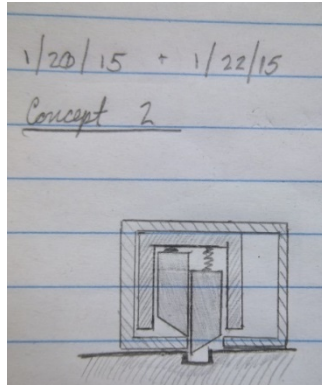


Figure 10 – Lock Concept 2

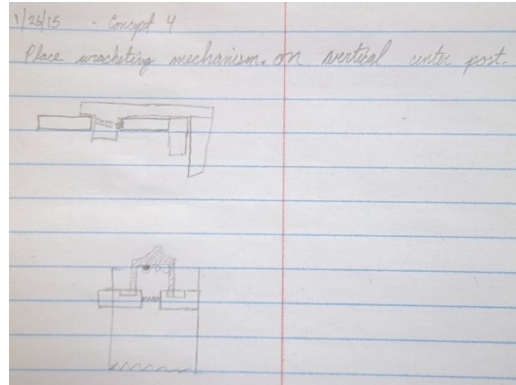


Figure 11 – Lock Concept 4

Rapid prototypes were made of the designs in Figures 10 and 11 on a small Makerbot Replicator. The rapid prototyped concept models of the locking mechanism ideas are shown in Figure 12.

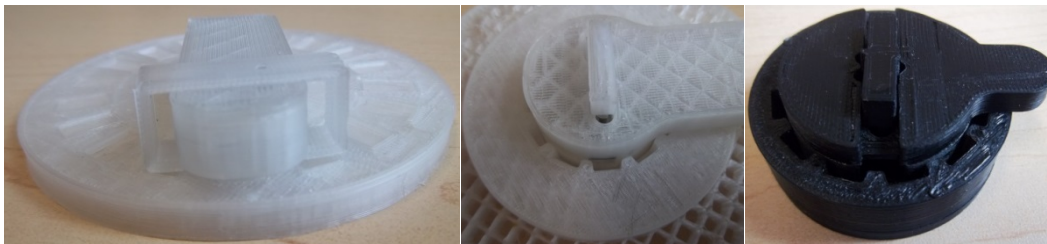


Figure 12 – Lock Mechanism Concept Models

The design chosen as the best working and most practical was the design in Figure 11. This concept was the most optimal because all the parts are internal and therefore protected from damage or tinkering. It also was easy for the user since it employs a simple switch to change direction. Figure 13 shows a sketch of the switch design. The small bumps were added to keep the switch in the proper position while the tool is being used.

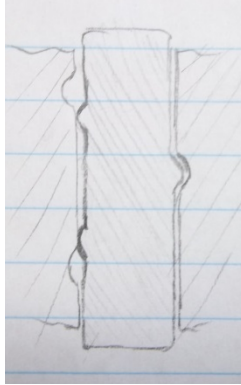


Figure 13 – Switch

Figure 14 shows a cross section of the locking mechanism chosen. Since there was no detailed sketch made for this mechanism, the CAD model is used for this figure.

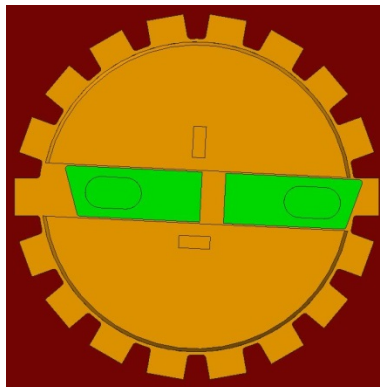


Figure 14 – Locking Mechanism

Two pins on the switch slide in the slots on the lock bars, which are the green parts in the figure. The yellow part in the center is the rotating part of the tool. The red part is the main body of the tool which has internal teeth for the locking mechanism. A spring (not shown) keeps the two lock bars apart. As the center part rotates, the lock bar contacts the internal teeth of the stationary part and therefore allow rotation in one direction only. The switch pulls

the lock bars to the proper position, allowing one to contact the teeth while holding the other away from the teeth on the other side.

## Design Evolution

Once the design sketches were chosen, the tool was modeled using Creo 2.0. As the model was completed, 3D parts were printed on the Makerbot and assembled so the design could be evaluated and revised.

The first two prototypes, shown in Figure 15, were similar to the concept models with the main difference being the shape of the switch.



Figure 15 – Prototypes 1 and 2

While the concept models have a simple rectangular switch, the prototypes have a larger switch with a clearance cutout around a center boss that contains the socket slot for wrench attachment. These two prototypes are essentially the same except for a small modification to the way the switch is held in place. In the first prototype (on the left in Figure 15), the switch is held in position by a single bump on the switch that snaps into detents in the main rotating piece. The second prototype switch has sharp ridges on the inner surface of the



oval cutout that contact the circular boss in the center of the rotating part. After some trial, it was evident that the first (left) switch type was more reliable.

The third prototype, shown in Figure 16, added arms so the tool could actually be equipped with straps and tested on a filter.



Figure 16 – Prototype 3

The arms were made detachable because of the build constraints of the 3D printer. The arms on the rotating part were also made to fit in three different positions thereby varying their length. On real production parts however, the arms would be part of the main two bodies for added strength and stability as well as to eliminate disassembly. In this prototype the upper arms were lengthened so they could pass around the lower arms as they rotate. However, for spacial concerns, they were shortened again in the next iteration.

Besides the shortening of the rotating arms, two other issues were discovered in this prototype. First, the straps would get caught on each other because of the lengths of the bosses on the ends of the arms. The strap mounting bosses on the stationary arms were both short and the rotating arm bosses were longer. One end of a strap would attach to a short fixed boss and the strap would wrap around the filter and downward for the other end to attach to the longer, rotating arm bosses. To remedy this interference, the fourth prototype has one short and one long fixed arm boss as well as one short and one long rotating arm boss. This allows the two straps to be on different levels so they still wrap all the way around the filter without interfering with each other.

The second main change from prototype 3 to prototype 4 was in the rotating part. In proto 3, the rotating part would easily fall out of the main body if the tool was turned upside down. Proto 4 added a lip on the bottom of the rotating part to hold it in. The rotating part was then made as two separate pieces and fastened together in the main part. Figure 17 shows the proto 3 and proto 4 cross sections to illustrate this change.



Figure 17 – Proto 3 (left) and Proto 4 (right) Crosssections

The result of these changes made prototype 4, which can be seen in Figure 18.



Figure 18 – Prototype 4

Prototype 5 is almost the same as prototype 4 but has a few small changes. The top side of the rotating part was increased to a larger diameter to help support the rotating arms and hold them in better. Since the main body part was able to be reoriented in the 3D printer, the stationary arms are now built into the part. This eliminates the problem of them falling out when under stress.

Figure 19 shows proto 5 in its assembled state.



Figure 19 – Prototype 5

Figure 20 gives a partially disassembled proto 5 to provide a better view of its parts.



Figure 20 – Disassembled prototype 5

## Conclusions

This project could definitely continue to be improved upon. A few problems still exist with the latest design iteration. The base part is still free to move with the rotating part and must be held in place with one hand while the other applies force to the wrench. This could be solved by having the lower arms pinch the filter, but that would add more complication to the tool and would decrease the size flexibility. Another issue often seen in the prototype is that the direction switch easily falls out. This would likely not be an issue in a production part; however the 3D printing resources do not offer high enough precision in the parts to have a tighter fit while still allowing the required motion.

The overall success of the project will be hard to estimate without producing solid material prototypes that are strong enough to be vehicle tested. The tool resulting from this project would likely perform as well as some of the existing tools discussed in the Existing Designs section of this report but would maybe be higher in cost since it has more parts and

requires more assembly. As the part evolved, it became somewhat bulky and, was the project to continue, other designs may be pursued to find a cleaner, more compact solution.