EML 4905 Senior Design Project

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IN
MECHANICAL ENGINEERING

Pneumatic Pass-Thru Impact Wrench
25% Report

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ETHICS STATEMENT AND SIGNATURES

The work submitted in this B.S. thesis is solely prepared by a team consisting of Ryan Lucia, Felipe de la Cruz, and Milton Ceotto and it is original. Excerpts from others' work have been clearly identified, their work acknowledged within the text and listed in the list of references. All of the engineering drawings, computer programs, formulations, design work, prototype development and testing reported in this document are also original and prepared by the same team of students.

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ABSTRACT

Tools are essential to human existence as we know it today. These physical objects with specific properties enable us to complete certain tasks that would otherwise be impossible, at the very least, more difficult. Modern tools include hand tools, power tools, and even large, stationary machinery. Pneumatic (or air powered) tools have been omnipresent in the industrial and manufacturing setting, offering more power to weight, greater durability, and higher operating safety compared to electric powered equivalents.

One popular pneumatic tool is the air ratchet. This tool uses a small turbine to convert compressed air into rotational mechanical energy that develops a torque to drive mechanical fasteners via standard hex sockets. Some limiting factors for this tool are its low torque, low RPM's (rotational speed), and high air consumption (CFM or cubic feet per minute). A similar tool that offers remedy to this torque and speed issue is the air impact wrench. Like the air ratchet, it uses a small air turbine to drive mechanical fasteners via interchangeable sockets. Unlike the air ratchet, it features a mechanism that employs the conservation of energy. For the major portion of one revolution, the drive (turbine side) is separated with a rotating mass from the final output shaft. At the very end of that revolution, the rotating mass is engaged to the final output shaft, transferring its rotational inertia as an impact to the fastener. A higher final torque is achieved with the use of the impact mechanism, but at the cost of a larger tool that has a cumbersome gun configuration, unusable in many tight positions that mechanics and service engineers encounter.

PROBLEM STATEMENT

In the field manufacturing, technology has been improving the way we interact with tools. Currently three tools, pneumatic ratchets, pneumatic impact wrenches, and pass-thru sockets, have problems.

The pneumatic ratchet currently does not have a mechanism to prevent the handle of the tool from disengaging from the final drive at maximum torque. In instances where the fastener is fully tightened and the user does not release the trigger in time, the tool will continue to rotate about the bolt or stud as opposed to rotating the fastener. Injuries caused by pneumatic ratchet are common in the workplace such as smashed knuckles, cuts and bruises. Pneumatic impact wrenches are superior in torque and rotational speed, but lack a light weight and nimble package. Pass-thru sockets are relatively new and few power tools exist that are capable of using them.

Air consumption for the pneumatic tools is another important factor. They consume on average about 4-6 cubic feet per minute of air at 90 psi. Reducing this would help reduce the cost of running a mechanics shop or manufacturing facility, directly impacting the facilities production, and also reduce wasted energy needed to generate the supply air pressure.

MOTIVATION

Air ratchets play a customary role in a variety of industries, encompassing both small and large manufacturing process. Also known as pneumatic ratchets, these air tools are primarily used to unscrew bolts, also giving the handler the ability to do so with minimal effort. Through a systematic arrangement of turbines and gearboxes, compressed gas is converted into mechanical energy which supplies the attached socket with a torque (25-75 ft lb.) used to loosen the bolt.

The motivation for a new air ratchet design stems from the current models producing an insufficient torque and lacking efficiency. The new design will focus on combining three existing technologies: pneumatic ratchet, pneumatic impact wrench, and pass-thru sockets. The pneumatic pass-thru impact wrench is expected to surpass the industry standard performance of most current standard pneumatic ratchets.

LITERATURE SURVEY

This survey serves as a platform for the reader to be informed and gain knowledge on the many specifications of current pneumatic ratchets and wrenches, as well as the concept of the team's new design.

1.3.1 International Usage

The ratchet and impact wrench mechanisms are used in a variety of applications.

- Manufacturing, assembly, and maintenance
- Roller coasters, submarines, car engines, airplanes, and much more

Many industries worldwide can benefit from this multifunctional, ergonomic tool

1.3.2 Environment Impact

This interior restructuring of this product will lead to a decrease in air consumption. Currently, pneumatic ratchets consume about 4-6 CFM (cubic feet per minute) at 90 PSI. The implementation of the impact mechanism will allow for less time needed to remove a bolt, directly reducing total air consumption.

Combining both tools (pass-thru ratchet and impact wrench) should reduce the future production of both tools, which will result in a smaller carbon footprint.

1.3.4 Power Consumption

Compressed air is often mistaken to be inexpensive or even a free source of power. On average, it costs over $30,000 a year to run a standard 1000 scfm air compressor due to the amount of electricity consumed. Companies are likely to be equipped with much machinery that utilizes compressed air as its source of energy. A typical 1000 scfm installation will waste about 30% of the compressed air generated, which amounts to about $9,600 annually in lost profits. A decrease in energy consumption will result in a direct increase in overall profits as well as providing a valuable contribution to the environment.

1.3.5 Waste Reduction

The possibility of accomplishing tasks in a reduced amount of time will decrease energy and electricity consumption. Providing air tools will lower the demand of batteries, reducing chemical waste.

1.3.6 Safety

A reactionless mechanism (the toll will not produce a force on the user's hand if the socket budges) isolates the final output from the drive turbine. Solely the mass momentum of the mechanism drives the output shaft. The newly designed mechanism will decrease injuries caused by current pneumatic ratchets common in the workplace, including smashed knuckles, cuts, and bruises.

1.3.7 Cost Effect

Merging the capabilities of a ratchet and impact wrench will eliminate the need of the mechanic, engineer, or company to invest in multiple tools. In many industries, particularly engineering, inefficiency in timing leads to lost revenue. The multi-functionality of the tool, along with increased torque output and higher RPMs, drastically cuts the time needed for the tool to perform its respective tasks

1.3.8 Concept of Pneumatic Pass-Thru Impact Wrench

The pneumatic pass-thru impact wrench will combine three existing technologies: pneumatic ratchet, pneumatic impact wrench, and pass-thru sockets. The restructured design is expected to surpass the industry standard performance of most current pneumatic ratchets.

PROJECT OBJECTIVE

The objective of this project is to design and manufacture a wrench with the capabilities of three existing technologies: pneumatic ratchet, impact wrench, and pass-thru sockets. The implementation of these characteristics will produce a safer and more practical tool with a greater torque and ultimately result in a smaller, more powerful, and ergonomic package. In order to achieve our objectives, it is imperative that that our finalized product, the pneumatic pass-thru impact wrench, competes with or exceeds industry standard performance of similar tools.

On average, most pneumatic ratchets today with a 3/8" and 1/2" socket drives produce an output torque of about 50 foot-pounds and a rotational speed of 130- 150 rpms. The impact mechanism itself is expected to increase the torque by about 25 percent, to 75 foot-pounds, and the angular velocity by roughly 265 percent, to 400 rpms. Manufacturing the tool to possess the pass-thru function will enable long bolts or studs to extend through the socket and ratchet head.

Safety and ergonomics are taken into consideration during the design process of this project. The main concern involving pneumatic ratchets is knuckle and hand protection. If the torque needed to loosen a bolt surpasses the maximum allowable torque of the tool, that tool will continue to rotate, risking crashing the user’s hand into another object in the vicinity.

CONCEPTUAL DESIGN

Figure 1 - Impact Ratchet Example (ii)

Many of the design components will be similar to the ones found in current air ratchets. Figure 1, above, is an example of a specialty air ratchet that has an integrated impact mechanism. We will take a closer look at the breakdown of components and how this air ratchet works in the following images.

Figure 2 shows an overview of all of the components found in this tool. Categories are labeled differently, corresponding to their section of the tool. In silver (left-most), the handle assembly can be seen. This includes the air coupler (to air hose/power source), trigger, and valve assembly.

The air turbine, labeled in red, consists of multiple components. This system of the air ratchet has many variables that can be changed to optimize the balance between power output and air consumption. We will be modifying some parameters in our design to better fit the project goals, including efficiency, durability, and ergonomics.

Blue labeled parts belong to the impact mechanism, in this case a Pin and Clutch impact mechanism. Figure 6 shows a conventional air ratchet, which features all of the same components with the exception of an impact mechanism. It is this unique impact mechanism that will enable the final design to achieve higher torque ratings compared to its "conventional" equivalent.

At the other end, the ratchet head components are labeled in green. This is the other significant system that will have extensive modifications made to incorporate the pass-thru socket design feature.

Figure 2 - Impact Ratchet Exploded View

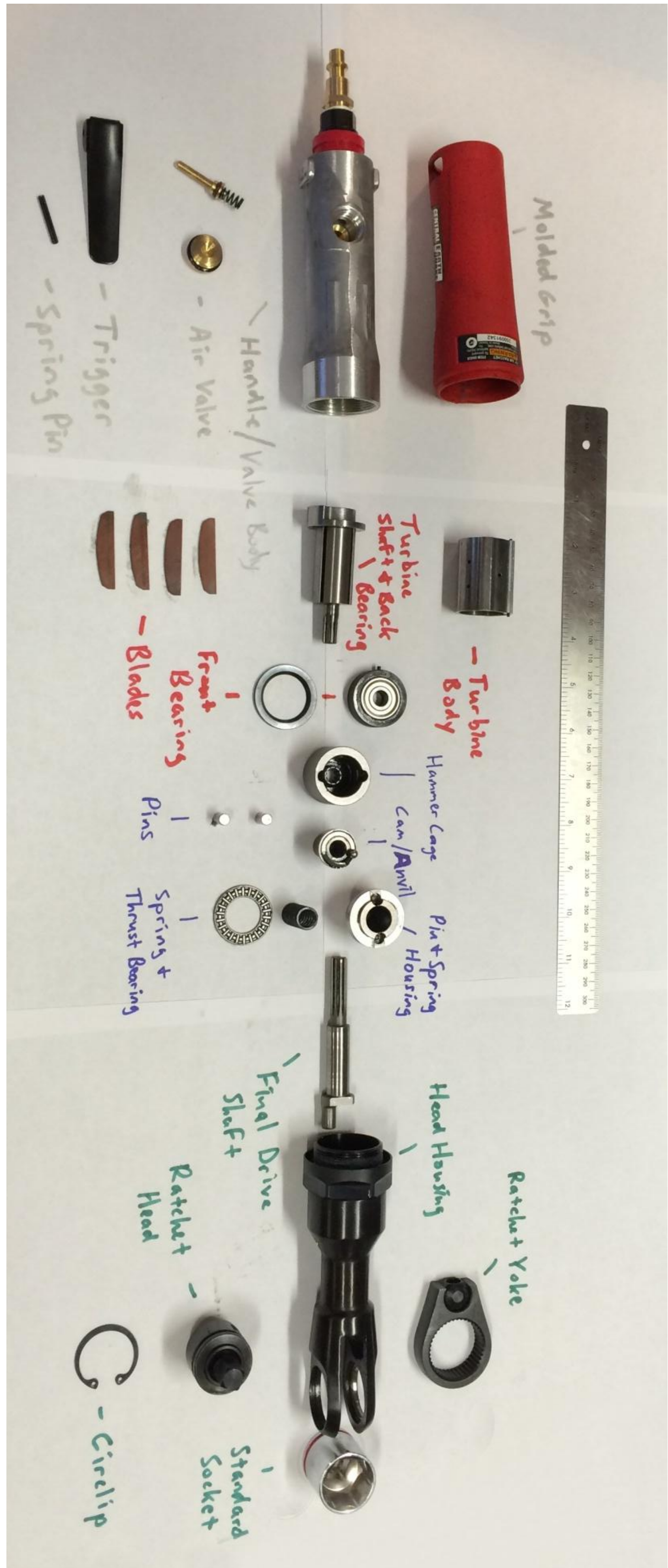

Molded Grip
Handle/Valve Body
Air Valve
Trigger
Spring Pin
Turbine Shaft + Back Bearing
Turbine Body
Front Bearing
Blades
Hammer Cage
Cam/Anvil
Pins
Pin + Spring Housing
Spring + Thrust Bearing
Head Housing
Final Drive Shaft
Ratchet Yoke
Ratchet Head
Standard Socket
Circlip

Figure 3 - Air Turbine Components

Figure 4 - Pin and Clutch Impact Mechanism Components

Figure 5 - Ratchet Head Components

Figure 6 - Conventional Air Ratchet

The following figures show a comparison between standard sockets and our third design feature, pass-thru sockets. Figures 7 and 8 show a standard 3/8" ratchet equipped with a standard socket. Figure 8 emphasizes the limitation on applications that standard sockets can be used on, due to its designed limited depth, shown in Figure 12.

Figures 9 and 10 show the relatively new tool technology, pass-thru socket and ratchet. We can see the unique design of the socket in Figure 10, which features a hole the entire way through the cylindrical cross section of the socket. One of many benefits of this unique designs can be seen in Figure 12, which depicts tightening of a nut on a long section of threaded rod. Also note the overall head height difference between standard sockets and pass-thru sockets (Figure 7 vs. Figure 9).

Figure 7 - Standard Ratchet and Socket

Figure 8 - Standard Socket Depth Limitation

Figure 9 - Pass-Thru Ratchet and Pass-Thru Socket

Figure 10 - Pass-Thru Socket Infinite Depth

Figure 11 - Standard Ratchet Application

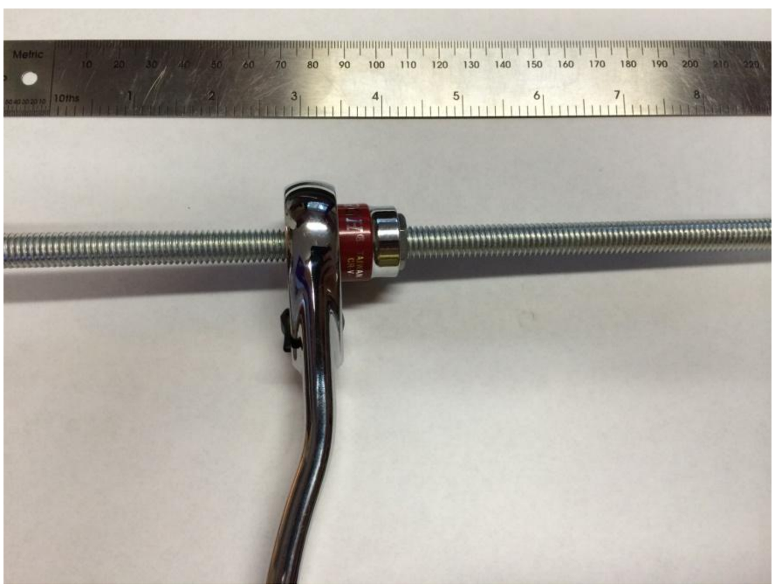


Figure 12 - Pass-Thru Socket Application

PROPOSED DESIGN

Figure 13 - Proposed Design

Figure 14 - Selected View of Racthet Head

Figures 13 and 14 are images of our proposed design. It is similar in shape and size to conventional air ratchets. The impact mechanism is proposed to be located in the middle section of the tool, shown as a hexagonal shaped housing in both figures above. The pass through head is also integrated to the design of this tool as shown.

An important factor in the design of any tool is material selection. For pneumatic tools specifically, torque and mechanical wear are significant in the design selection of materials to manufacture the tool with. The most common materials for existing pneumatic tool technologies are hardened steel alloys for internal components and cast aluminum for a light weight, yet strong housing. Both materials are relatively cheap and easily processed with common manufacturing techniques, such as casting, cutting, milling, turning, etc...

A selection of material property samples will be collected during the design and prototype phase of our project. With an extensive background knowledge of material sciences, our faculty advisor, Dr. Benjamin Boesl, will be assisting us in testing, evaluating, and creating our own components with specific desired mechanical properties.

PROTOTYPE

To better facilitate the design process we will be incorporating methods of prototyping. The primary tool we will utilize is 3D printing, specifically, fused deposition modeling (FDM). We have a 3d printer readily available for use; a Solidoodle 3, capable of a print size 8x8x8 inches (200x200x200mm) with a layer resolution up to 0.004in (0.1mm). The material used is ABS plastic. We will use the rapid prototyped (3d printed) parts for form and fit verification and visual aid during the design process. The ABS prototype will not withstand any significant stresses in the assembly, and therefore we will rely on software simulation of the design elements and theoretical equations to verify functionality of the systems.

Once we have a final design, we will be manufacturing multiple units of our pneumatic pass-thru impact wrench, one for each team member and faculty advisor, and one for extensive testing.

TESTING & EVALUATION

With our completed pneumatic pass-thru impact ratchet, we will run many extensive tests to verify all predicted results and ensure fulfillment of the project goals. These tests include evaluation of the torque and RPM ratings, ergonomics, and long-term durability.

PROJECT MANAGEMENT

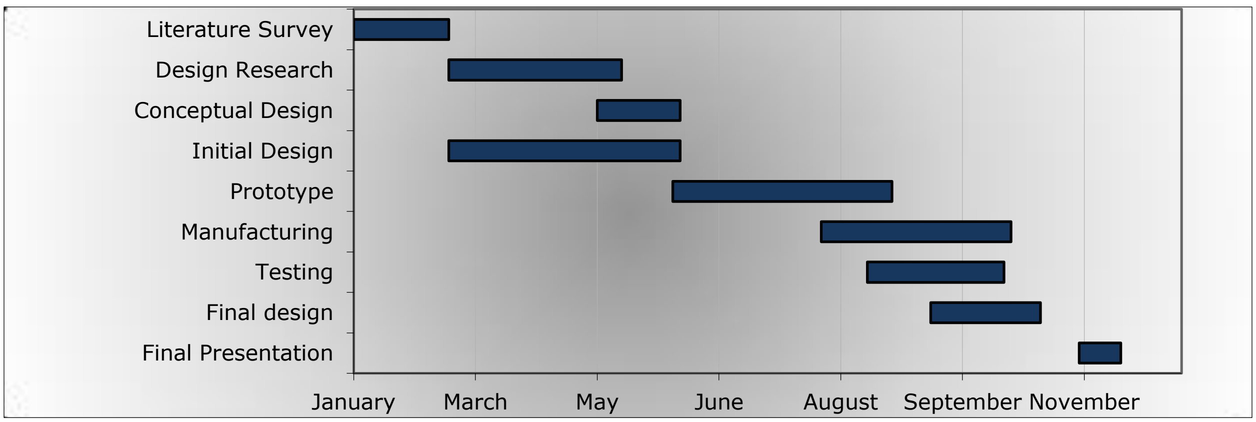


Figure 15 - Project Timeline

Table 1 - Project Event Dates

Event / Name	Start	End	Length
Literature Survey	1/21/2014	3/1/2014	39
Design Research	3/1/2014	5/11/2014	71
Conceptual Design	5/1/2014	6/4/2014	34
Initial Design	3/1/2014	6/4/2014	95
Prototype	6/1/2014	8/30/2014	90
Manufacturing	8/1/2014	10/18/2014	78
Testing	8/20/2014	10/15/2014	56
Final design	9/15/2014	10/30/2014	45
Final Presentation	11/15/2014	12/2/2014	17

In the above timeline, the time management for the project is presented. Initially, during the first four months of the project, most of the basis and fundamentals necessary to give rise to a new tool should be achieved. The literature survey has given start to research that will be extended throughout an entire year.

During the Literature survey stage, all three members involved have tasks to research as many different sources as possible and familiarize with the proposed goal for this research. Following the completion of the literature survey, which takes place in March, the design research and the initial design takes place. During these stages, the entire group still has the same responsibilities in order to keep all members on the team on the same pace with the newly acquired information and ideas for a design.

By summer, when the first semester is over, more things have to be done at once and therefore the need to divide tasks becomes more urgent. With an initial design already in its final stages, the next steps are prototyping, manufacturing and testing. These tasks will be divided as follows: Ryan Lucia will be responsible for prototyping and testing while Milton Ceotto and Felipe de la Cruz will be responsible for the manufacturing of the tool. This extends throughout the entire summer and most of the fall semester. By the end of the fall semester we will establish a final design including any modifications made after testing and evaluation to conclude this project.

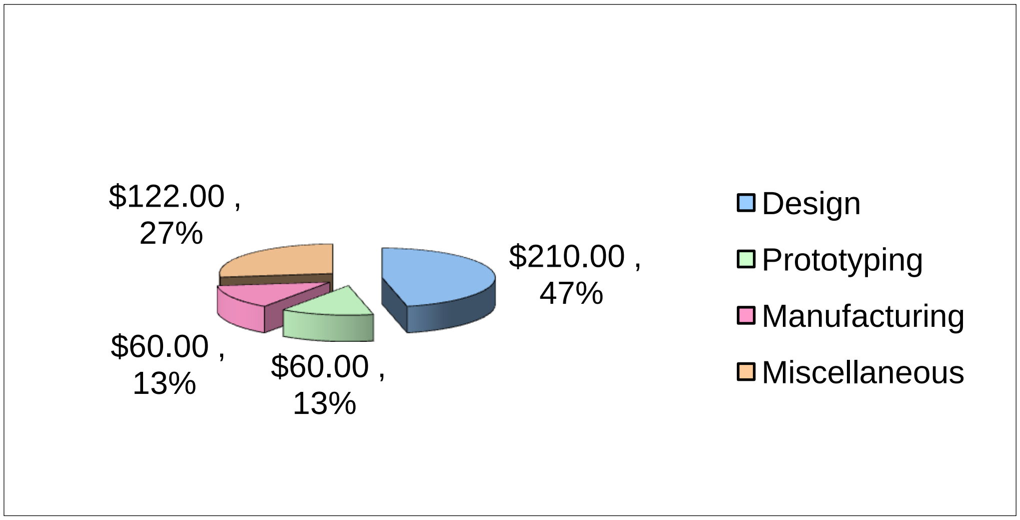
COST ANALYSIS

In addition to the costs presented, the price per hour of work that each engineer puts in this project is included in Table 2 below. During the year that the project took place at least three hundred hours were spent. The hours are divided into research, design, prototyping, manufacturing and miscellaneous. During research, things like applications, materials and processes are taken into consideration. During design, the hours are mostly the result of software modeling and simulations combined with planning of materials selection. During prototyping, hours included are for printing and testing of the design. Manufacturing is its own component and finally miscellaneous includes meeting times, presentations, design of posters and preparation of reports.

Table 2 - Cost Analysis

Category	Description	Unit Cost	Quantity	Total Cost
Design	Impact Wrench	$100.00	1	$100.00
Design	Pass-Thru Socket	$40.00	1	$40.00
Design	Air Ratchet	$70.00	1	$70.00
Design				$210.00
Prototyping	ABS Plastic 600g	$30.00	2	$60.00
Prototyping	3D Printer Use	$0.00	1	$0.00
Prototyping				$60.00
Manufacturing	Raw Materials	$60.00	1	$60.00
Manufacturing				$60.00
Miscellaneous	Compressed Air per hour	$1.22	10	$12.20
Miscellaneous			1	$0.00
Miscellaneous				$122.00
Hours	Research	$0.00	50	$0.00
Hours	Design	$0.00	100	$0.00
Hours	Prototyping	$0.00	50	$0.00
Hours	Manufacturing	$0.00	60	$0.00
Hours	Miscellaneous	$0.00	40	$0.00
Total Hours			300	$0.00
Hours				$0.00
Total				**$452.00**

Table 3 - Cost Summary



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