

Torque Tactician: A Senior Design Manufacturing Case

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Abstract

No one likes getting flat tires! Torque Tactician is introduced as an innovative automotive tool that will help expedite the time it takes to lift a vehicle and remove and reinstall the lug nuts. This product combines the universal lug nut remover that we all know and love with a ratchet designed to easily connect and lift the scissor jack. The objective of this product is to unify the tools required to change a tire while decreasing the number of motions which ultimately will decrease the amount of time needed to safely change a tire.

Keywords

Lug Wrench, Jack Wrench, New Product Development, Automotive Maintenance, User Experience

1. Introduction

The tire-changing process can be a time-consuming experience that is very labor-intensive. Traditional methods of tire changing involve multiple tools such as lug wrenches, lug sockets, and/or manual jacks. With the circulation of these tools, the process can extend longer than needed leading to time being wasted and even possible safety risks i.e. in the event of roadside emergencies. For an inexperienced user, improper use of the equipment involved in tire changing can lead to injuries or damage to vehicles. The TorqueTactician is a groundbreaking multi-tool aimed to redefine the tire-changing process with its seamless and efficient design. This innovative tool offers a solution for a quick and effortless tire replacement. Engineered using state-of-the-art technology and precise engineering methods, the Tech Tactician simplifies the process of changing tires, minimizing the challenges associated with traditional methods. When faced with roadside emergencies or routine tire maintenance, users can rely on the Tech Tactician to simplify the task of changing a tire with a guarantee of simplicity and safety. With the Tech Tactician available, tire changing becomes a hassle-free experience. Ensuring minimal downtime and maximum convenience for every user. Throughout the duration of this senior project, the team has been committed to identifying and addressing the issues involved with traditional tire changing, with an aim of providing a fully functional multi-tool (Les Schwab, 2024).

1.1 Objectives

The purpose of the project is to create a piece of equipment that will assist people and keep their minds at ease when traveling anywhere by car. The goal is to create a safe product that may be used by virtually anyone at an affordable price. The final product will be small and easy to store, fitting into any car trunk, and being lightweight. Aiming for a weight of less than 5 pounds and a size of 12 inches when put away. While compact, the product will be small enough to go anywhere and will not be a hindrance while traveling long distances.

When the product Torque Tactician is opened and ready to use, the dimensions shift to 3 ft. The tool will have a simple setup guide that will take just 45 seconds to read on average, ensuring an easy setup with enough time to alert for aid

when it is required. Once assembled, the product is expected to have less than 25 minutes of guaranteed time to change a tire. The tool will be resistant to water and durable in inclement weather such as rain or snow. Another goal is to reduce the amount of space needed in a vehicle trunk to store the tool. The tool will be 2-in-1 for the convenience of the user. Torque Tactician will be faster than the generic cross-lug wrench. It is dangerous to change a tire in any scenario, especially for smaller framed or older people. Some companies can come in and swap out a flat tire but it takes about 2 hrs and using generic tools takes about 45 or more minutes. Torque Tactician guarantees to cut that time in half with ease. The product goal is to provide comfort and safety to anyone who drives to have a tool that is easy to use and reduces the overall time needed to uninstall and reinstall a tire.

2. Literature Review

In the United States, one tire puncture occurs every seven seconds, which results in roughly 220 million flat tires each year (Torque News, 2023). This means that someone has a flat tire every seven seconds that must be changed. There are two ways to solve this problem: by calling an emergency roadside assistance company like AAA or changing it manually. When changing out a flat tire alone, one has to do it at a fast pace because it is dangerous to stand outside while traffic is passing by, especially on a highway. As if changing a flat tire on a highway isn't dangerous enough, some drivers might have to change a flat tire in dark or rainy conditions (Cavallo 2024).

AAA is a very well-known tow truck service and emergency roadside service used by many Americans in the country. However, the time it takes for them to arrive or take a car with a flat tire to the nearest car repair shop is a drawback for many customers. AAA is a service where one pays a yearly subscription of sixty dollars and customers are provided with experienced services in car repairs ("Tire Repair Kit Facts.", 2024). Servicers arrive at the customer's location and try to fix their car's issues promptly. It takes about 50 minutes for AAA to arrive at the customer's location to help ("Tire Repair Kit Facts, 2024, Peterson, John, 2020). On average, changing a tire alone, while using generic tools that are found in the majority of trunks takes about 45 minutes (J.D. Power, n.d., 2024). If the user has little to no experience in changing a flat tire, it could take about an hour or more (Figure 1).



Figure 1: Tire Changing

A jack ratchet wrench provides an attractive blend of practical and economical advantages, from increased comfort and safety to increased durability and efficiency (Xometry, 24 Oct. 2022). Businesses as well as individuals can experience considerable cost savings, productivity increases, and long-term health advantages by investing in solutions that prioritize user well-being and performance. When it comes to mechanical activities or emergency rescue, the comparison emphasizes the creative possibilities of adding new capabilities to current equipment. The jacket ratchet wrench presents a significant opportunity to increase efficiency and safety across a range of sectors by utilizing materials science and design engineering improvements to improve functionality, durability, and user comfort.

3. Methods

Often referred to as essential automotive tools, a lug wrench, and a jack wrench are essential for maintaining and repairing vehicles (Figure 2). They are used by mechanics and car enthusiasts for jobs like tire replacement and brake repair (Smith et al., 2023). Typically, the toolset consists of a lug wrench for tightening and loosening lug nuts and a jack wrench for lifting cars. While the lug wrench makes it easier to remove and install lug nuts quickly, the jack wrench gives you the leverage you need to raise the car safely (Zhang 2024).



Figure 2: AAA Service

With the aid of these tools, mechanics can effectively complete tasks necessary for vehicle maintenance, guaranteeing peak performance and road safety. But even with their efficacy, the question remains: Why think about altering instruments that have demonstrated their worth over time? The possibility for ongoing efficiency and safety improvements holds the key to the solution, especially in situations requiring complex automotive repairs (Harbor 2024).

Several crucial steps were involved in our research methodology:

1. To obtain the first set of data, torque tests were performed on the lug wrench and jack wrench.
2. After getting preliminary results, we analyzed the data to assess variables like durability and torque output.
3. We tested our findings on a variety of vehicle models in both real-world applications and simulated automotive repair scenarios.

Our goal is to find ways to improve these essential automotive tools through careful analysis and hands-on experimentation, which will ultimately lead to increased productivity and safety in vehicle maintenance procedures.

4. Data Collection

As mentioned in the Testing section, 3 rounds of inexperienced individuals swapping out a tire using a conventional spare tire kit were timed using a stopwatch. Once they had completed the swap, the wheel was reset and users were timed again while they repeated the tire swap but this time using a replica of the final design of the Torque Tactician. The same procedure was performed for the experienced users. The purpose of timing both groups was to compare and analyze the results to see if Torque Tactician makes a difference for the user. Data collected for the testing is shown below in Table 1. When all rounds of testing were completed, an average was calculated for each of the data sets, resulting in 4 average values.

Table 1: Times Taken to Change Out Tire for Experienced and Inexperienced Users Using Spare Tire Kit and Torque Tactician Replica

Little to no experience user using spare tire kit	Time (Minutes: seconds)	Average	Little to no experience user using Torque Tactician replica	Time (Minutes: seconds)	Average
1	49:28:00		1	26:14:00	
2	55:04:00	49:17:00	2	22:16	24:00:00
3	43:19:00		3	23:31	
Experienced user using spare tire kit	Time (Minutes: seconds)	Average	Experienced user using Torque Tactician replica	Time (Minutes: seconds)	Average
1	27:33:00		1	11:54	
2	23:51	25:38:00	2	11:41	11:52:00
3	25:32:00		3	12:02	

5. Results and Discussion

Analyzing the data within Table 1, users with little to no experience decreased the average time it took to change out a flat tire when they used the TT replica by 25 minutes and 17 seconds. That's a 51% reduction in the time it took compared to using the conventional spare tire kit tool set. The more experienced users took significantly less time

using both methods. However, they especially decreased the average time taken to change the tire using the TT replica compared to the spare tire kit method. A reduction of 13 minutes and 46 seconds was recorded by simply using the TT replica. That's a 53 percent reduction in the time since it took the conventional method an average of 25 minutes and 38 seconds.

The results indicated that the use of the Torque Tactician tool significantly reduces the amount of time needed to lift the vehicle and change out a flat tire regardless of user experience. This is all thanks to the consolidation of the lug nut remover and the scissor lift ratchet into the same tool. The length of the tool also makes removing the lug nuts easier as well as retorquing them after the wheel is swapped out. These results indicate that the product is meeting product objectives and goals of reducing the number of motions and time needed to change out a flat tire regardless of the user's experience (Figure 3 and 4).

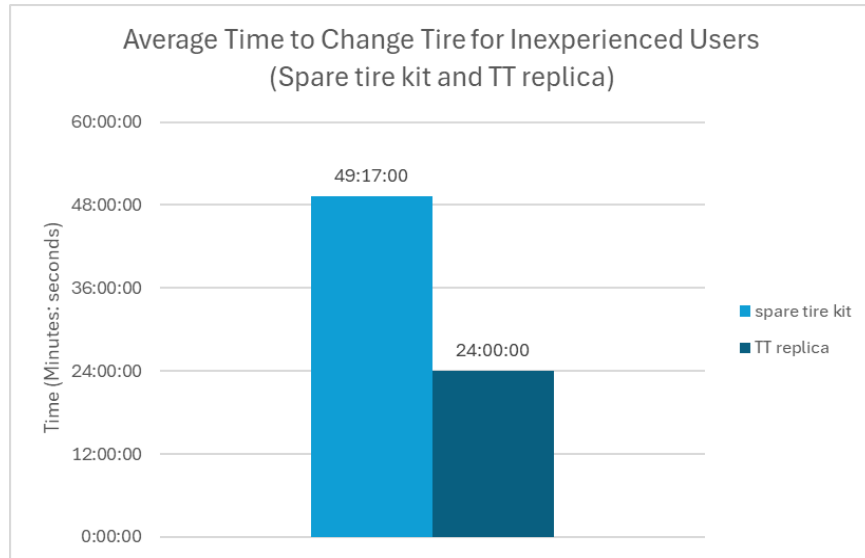


Figure 3: Average Time to Change a Flat Tire for Inexperienced Users Using Spare Tire Kit and TT Replica

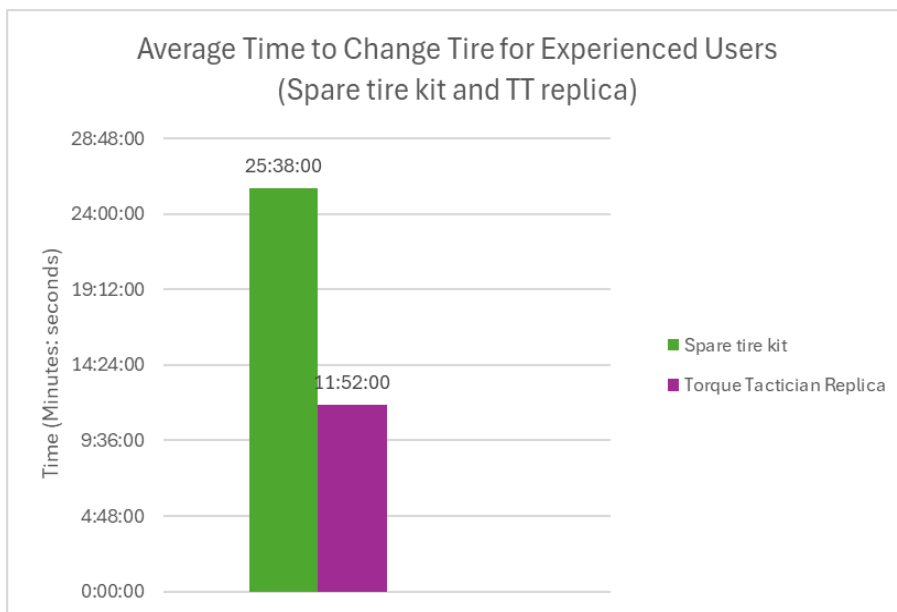


Figure 4: Average Time to Change a Flat Tire for Experienced Users Using Spare Tire Kit and TT Replica

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Biographies

Marquis Amador is a graduating senior in the Manufacturing Systems Engineering (formerly known as Industrial Engineering) program at California State University, Northridge. As a soon to be graduate, Marquis is very passionate about the joining of technology, business, and efficiency. Marquis has always been curious in understanding how things work and how the optimization of processes lead to continuous improvement. Marquis has immersed himself in a diverse range of subjects, from mathematics and physics to management and supply chain logistics. With a solid academic background, hands-on-experience, and a passion for problem-solving, Marquis is ready to begin his journey in the field of Manufacturing Systems Engineering where he can use his expertise to create value, promote efficiency, and make an impact in the world of business and technology.

Ronald Martinez, a dedicated senior at California State University, Northridge, is pursuing a Bachelor of Science in Engineering Management Technology. With an interest in Manufacturing, Ronald has spent his time in college learning and practicing skills he hopes to put into use once he joins the workforce. With aspirations to earn his PE in Industrial Engineering, Ronald hopes to become a key member in a top company where he can continue to learn the ins and outs of a company throughout his career.

Alexis Orozco, a dedicated senior at California State University, Northridge, is pursuing a Bachelor of Science in Engineering Management Technology. Their path is characterized by an unwavering thirst for advancement and an unrelenting pursuit of success, held back by a strong commitment to engineering ethics. Alexis is a proponent of lifelong learning and derives satisfaction from the challenges presented by his academic pursuits. Alexis is driven by his unquenchable curiosity and unwavering will to succeed to pursue an extraordinary career in engineering while adhering to the highest standards of responsibility and integrity. He exhibits an unwavering commitment to both professional and personal development by giving it his all to support businesses and the global community.

Kevin Ayala is a graduating senior who attends California State University, Northridge. Their major of choice is Engineering Management. Driven by a passion for problem-solving and innovation, Kevin, an aspiring engineer, embarked on their journey through academia with a hunger for knowledge. From the early days of tinkering with gadgets to pursuing advanced coursework in mathematics and physics, their trajectory was defined by a relentless pursuit of understanding and mastery. Through internships and hands-on projects, they honed their skills, ultimately emerging as a promising figure in the realm of engineering, poised to leave an indelible mark on the world through their ingenuity and dedication.

Steven Casillas is a graduating senior from California State University, Northridge with a degree in the field of Engineering Management. As a first-generation college graduate, Steven had to work throughout the majority of his college career to support himself. With a background in Pre-engineering and Applied Sciences (STEM), Steven has worked in various jobs that allowed him to build his skillset in the fields of leadership, quality, logistics/supply chain systems, manufacturing, and aerospace engineering.

Sepideh Abolghasem is an associate professor in the Department of Manufacturing Systems Engineering and Management at California State University at Northridge. Prior to this appointment, she was an associate professor in the Department of Industrial Engineering at the University of los Andes, Bogotá, Colombia. She earned her B.Sc. degree in Industrial Engineering from Sharif University of Technology, Tehran, Iran and her M.Sc. and Ph.D. degrees in Industrial Engineering from University of Pittsburgh. Her main research interests span the integration of the disciplines of Operations Research and Materials Science. Much of her work has been focused on the machining

manufacturing process where she tries to improve the understanding of the interrelationships among the process parameters and the microstructure of the materials. Recently, she has been working on the application of machine learning techniques combined with simulation for material properties prediction.