Design and Analysis of Electrical Ergonomic Bionic Grip Wrench

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Abstract. Increasing demand for the use of bionic grip locks as well as customers and markets is increasing day by day, requiring improved design of technical tools to increase efficiency and effectiveness. Supporting tools design needs to be modified for the tools capability improvement and to provide new ways of working. The concept of innovative design can be applied to tools designing for up living the work way more productive in order to boost the manufacturing and service performances, meeting the mounted up customer demand. Taking the wrench product design as an example of observation and improvement initiative opportunity, this article discovers the chance of the mechanical and machinery products innovation, with the project methodology presented in applying the theories of product redesign from a manual conventional wrench to an advance design and puts forward the thought of the wrench innovative engineering design, principles and the process to electrical and mechanical mechanism. As a result, the proposed design scheme is evaluated, which indicates that the optimized design approach can be applied to a manual wrench design.

Keywords: wrench, product, redesign, machinery, tools, improvement

1. Introduction

Machinery tools industry supports an important role in providing the engineering equipment for the national economy contribution. Mechanical product level is one of the absolute parameter of the country modern manufacturing practices. Nation’s industry, agriculture, construction, transportation, national defence and the advancement of science and technology are related with the development of mechanical products, which mechanical engineering design essence is innovation. Pay attention to the machinery products innovative design is a fundamental way to enhance the competitive advantage of the products itself. Economic attraction and market globalization asks for the improvisation of product design and manufacture to meet nowadays requirement which needs the way wore efficient way of working.

Recent customers make product decisions based on subjective factors such as convenience, ease of use, and pricing. People spend their money on what feels right and are often unable to provide an explanation of their reason. While there is no simple formula to design a product that can be exactly successful in the market, inclusion of the needs of the target population in the design process is an essential part of that process. The design of the product is believed to be one of the most important factors influencing the success of the product in a market, the interaction of the market environment and the new product strategy and execution, includes the product itself (e.g. product design, product
advantages) [1]. This is the primary reason that motivates our current research on user preferences for improved engineering tools product.

A wrench (or spanner) is a tool used to provide grip and mechanical advantage in applying torque to turn objects usually rotary fasteners, such as nuts and bolts or keep them from turning [2]. In British English, spanner is the standard term. The most common shapes are called open-ended spanner and ring spanner. The term wrench refers to various types of adjustable spanner. In American English, wrench is the standard term. The very most common shapes are called open-end wrench and box-end wrench [3]. In American English, spanner refers to a specialized wrench with a series of pins or tabs around the circumference (these pins or tabs fit into the holes or notches cut into the object to be turned.) In American commerce, such a wrench may be called a spanner wrench to distinguish it from the British sense of spanner. Higher quality wrenches are typically made from chromium-vanadium alloy tool steels and are often drop forged [4].

Quantitative data was gathered, for conventional product design exists these days. On the total research, design, development, tooling, and launch marketing costs. Each project was then classified qualitatively according to the main type of design expertise involved-product design (e.g., furniture, textiles, engineering tools), engineering design, engineering plus industrial design (e.g., electronics plus ergonomics), and graphic design. The project outcomes were also assessed qualitatively and quantitatively: first, whether the project was implemented (put into production), then its financial results, and finally indirect benefits such as learning design-management skills [5].

This paper describes the necessity of new wrench product in order to utilize the bio-mechanic mechanism and ergonomic aspect. Furthermore, the new design focusses on design of grip mechanism to minimize the required human-energy during the process.

2. Method

In this stage, the overall process begins with 3D mechanical drawing of conventional wrench, 3D mechanical drawing of non-electrical bionic grip wrench, and design the 2D & 3D mechanical design of electrical bionic grip wrench. Using the Inventor program, we make the stress analysis of the nuts gripper due to critical part design analysis. Figure 1 shows the flowchart of the development stage of the research.

![Development Stage Flowchart](image)

Figure 1. Development Stage Flowchart

We observe the current design of conventional wrench before the improvement or product redesign was implemented to the current one. Then, we did some research regarding the updated wrench product design that exists in the market. Thought it still has another room for improvement, we try to think the concept of rotary motor that could grip the nuts with its bionic grip, then fasten the nuts with rotary force, resulted by the motor and the power source. We used the Inventor program to do the design and make some stress analysis as a result came from the nuts grip and fastening. This step will consider the manufacture-ability of this product redesign and decide the most suitable material used.
After the product redesign done, we analyze the 3D modelling with stress and force experienced by the product. From this analysis, we would like to know and understand that the redesigned product could eliminate manual human effort and capable enough of receiving the feedback of stress and force generated by the materials.

3. Result and Discussion

The result of this development research will generate the new product design that improves the bionic grip wrench with its ability with electrically rotary motor. The stress analysis generated by Inventor somehow will show the force as a result of nuts grip and fastening of each six-sides grip. The idea was obtained by the observation of the authors to minimize the effort generated by human. As the importance of time and motion study, the new design is proposed and to be called as electrical bionic grip wrench, performing the rotary force to fasten the nuts after conduct the grip step and it is available to do the fastening activities for following types of nuts: flange bolts, hex bolts, hexagon nuts, and lock nuts. Figure 2 shows the current design conventional wrench that needs manual positioning and manual force driven by the operator.

![Figure 2. Conventional Wrench Design](image)

In this stage, authors observe the updated design of bionic grip wrench, that exists in the market. This product design reduces the processing time to do the manual positioning for the nuts and bolts, as it has several sides on the material surface that needs to be fit before do the fastening. Figures 3 shows the design of bionic grip wrench that successfully reduce the lead time of tool manual positioning.

![Figure 3. Bionic Grip Wrench Design](image)
Continuing to the next stage of development, the authors observe the chance and possibility to reduce the waste of the activity. Found and discovered that, after the bionic arm grips the nuts or the bolts, it is still requires the human effort to do the bolt fastening by rotating the tools, manually. Hence, the authors initiate the new design that implementing the motor to be able performing rotary force after material grips been done. It reduces the human manual effort by utilizing electrical power that generates rotary force of the wrench. Figure 4 shows the proposed design to eliminate the problems stated above.

![Figure 4. 2D Electrical Bionic Grip Wrench Design](image1)

![Figure 5. 3D Electrical Bionic Grip Wrench Design](image2)

| No | Parts Name                  |
|----|-----------------------------|
| 1  | Main Disk                   |
| 2  | Lock Teeth                  |
| 3  | Gear Disk                   |
| 4  | Revolve Lever               |
| 5  | Fasteners Teeth Button      |
| 6  | Looseners Teeth Button      |
| 7  | Revolving Disc Button       |
| 8  | Lithium Ion Battery         |
| 9  | Dynamo bosch GSB 1080 Li    |
The inventor program shows proposed bionic grip’s teeth material is steel on yield strength 30,022.8 pounds per square inch (psi), means the maximum stress that can be applied along material. The ultimate tensile strength shows 50,038 psi that means the maximum force before the material fractures. Table 2 shows the summary of the product’s performance parameter.

**Table 2.** Product’s Performance Parameter

| Name             | Minimum                  | Maximum                  |
|------------------|--------------------------|--------------------------|
| Volume           | 170184 mm³              |                          |
| Mass             | 0.848246 lbmass          |                          |
| Von Mises Stress | 0.00000000103897 MPa     | 0.9676116 MPa            |
| 1st Principal Stress | -0.266194 MPa        | 0.826204 MPa             |
| 3rd Principal Stress | -1.252 MPa            | 0.118056 MPa             |
| Displacement     | 0 mm                     | 0.0000815169 mm          |
| Safety Factor    | 15 ul                    | 15 ul                    |
| Stress XX        | -0.436512 MPa            | 0.164633 MPa             |
| Stress XY        | -0.295959 MPa            | 0.313883 MPa             |
| Stress ZZ        | -0.514684 MPa            | 0.512301 MPa             |
| Stress YY        | -1.12067 MPa             | 0.824607 MPa             |
| Stress ZZ        | -0.985721 MPa            | 0.73289 MPa              |

For the bionic grip arms section, Figure 6 shows the stress analysis performed by Inventor program. Analyzing the result, the product’s maximum stress is 0.9761 MPa with safety factor is 15. For displacement analysis, the maximum value is 8.152 mm.

**Figure 6.** Product’s Maximum Stress and Displacement Analysis

XX, XY, and XZ section stress are shown on below Figure 6, with the value of maximum stress of 0.1646 MPa for XX section, 0.3139 MPa for XY section, and 0.3579 MPa for XZ section.
Figure 7. XX, XY, XZ Section Stress Analysis

YY, YZ, and ZZ section stress are shown on below Figure 8, with the value of maximum stress of 0.824 MPa for YY section, 0.5123 MPa for YZ section, and 0.7329 MPa for ZZ section.

Figure 8. YY, YZ, ZZ Section Stress Analysis

4. Conclusion
Design, 3D modeling, and stress and force analysis are performed using the Inventor program. The results are proposed to eliminate the human manual effort that contributes to the longer processing time needed compared to the manual grip position, the rotating force carried out by the human motor, and the design of manufacturability. Stress analysis is carried out mainly on the side of the bionic handle which directly contributes the main rotating force to tighten the nuts and bolts, the maximum force that applies to the locking gear is $\bar{x} = 0.4843$, the design can be used on regular nuts with a size of 3-6 cm. This type of battery uses Lithium Ion with a charging input of 110V = 240V AC, 1.5 A. To provide power to the dynamo Bosch GSB 1080 Li that could produce 45 nm.

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