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Product Design and Analysis of Engineered Electromechanical Grip Wrench

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ABSTRACT
Recent world economic situation enables the fluctuation of market demand and market volatility, asserts the enhancement of engineering tools design to uplift its efficiency. Tools design requires modification and facelift to explore new methods of working way more productive, meeting the market and customer demand trend. Exerting the conventional wrench product design as a portfolio of improvement initiative, this paper digs the opportunity of the grip design, with the research methodology presented in injecting the product redesign concept to an advanced design with electro-mechanical mechanism. As a result, the proposed design is analyzed, which alerts that the optimized design approach could be implemented.
Keywords – product, redesign, enhancement, wrench, machinery tools

I. INTRODUCTION

Industry of machinery tools contributes a specific role to supply the engineering equipment for the national economy contribution. The way of thinking of machinery as a subject matter over the most recent 15 years is effectively concentrated by homegrown and foreign researchers fundamentally as far as recognizing normal examples and standards of hardware advancement, because of the rise of new advances, changes in scientific, operational, and engineering exercises. The development of products destined to cover specific important role when it is possible to have feedback, in terms of functionality, on the part of the final user for the consolidation of the product. As a reference, Chen, et al [1] developed a novel vacuum-suction grip that more capable of changing gripping position, for the various industrial object and its shapes. Authors has also verified the model through the simulation on different patterns. The adaptability has also test to workpieces with different patterns through the gripping experiments. Previous research inspires the article to proposed the study. Customers' requirements nowadays lead to several subjective factors in purchasing the products such as convenience, simplicity, and the price point. Customers allocated their capital on what considered correct and are often uncapable to state the opinion of their reasons. While there is no straightforward formula to plan an item thriving on the market lookout, inclusion of the product requirement of the target population in the design stage is a fundamental component of the process cycle. The design of the product is accepted as quite possibly the most essential variables affecting the triumph of the product in a market, the interaction of the market atmosphere and the new product marketing strategy and also the product itself (e.g. product design, product advantages) [2]. Above explanations becomes the rationale that encourages our research on improving engineering tools product within redesign strategy.

A wrench (or spanner) is an instrument that assists to hold and give a mechanical benefit in applying forces to turn objects usually revolving latches, such as nuts and bolts to hold them back from turning [3]. The most well-known shapes are referenced as open-ended spanner and ring spanner. The term wrench alludes to different sorts of customized spanner. In The United States, wrench is the standard term and its most common shapes are known as open-end wrench and box-end wrench [4]. In American English, spanner alludes to a specific wrench with a progression of pins or tabs around the outline (these pins or tabs fit into the openings or notches cut into the object to be turned.) In American business, such a wrench may be known a spanner wrench to recognized it from the British feeling of spanner. Better quality wrenches are originally produced using chromium-vanadium composite and are regularly drop forged [5].

This research gathers the quantitative data from the current conventional product design according to the collective research, design, development, machining, also distribution - marketing costs. Each task was adjusted qualitatively as indicated by the principle sort of instrument design (e.g., furniture, CNC operations, engineering tools), engineering design, engineering plus industrial design and visual computerization. The task deliverables were additionally evaluated qualitatively and quantitatively: first thought, regardless the venture will be implemented (put and run into production), then second, it's monetary and business viewpoint, and abberant advantages such as mastering design-management skills [6]. This research explains and provides the development and analysis stage of new wrench product design due to formulation of electromechanical operation aspect consideration. Nevertheless, the new idea design zooms on design of grasp system to limit the necessary human-energy along the tools activity. In this work, the proposed materials are also analyzed with several analysis parameters.

II. LITERATURE REVIEW

Considering the historical backdrop of the improvement apparatuses, which is indistinguishable to the history of humanity, Kapp set up that modifying the climate, man unconsciously imitates his organs, their shape, capacity and he knows himself, in view of these artificial creatures. The cycle of organ projection is a progressive change from the natural body in itself to the counterfeit body for itself [7], it tends to be oblivious, natural and cognizant, rational and systematic. The cycle of information of machinery and human self-knowledge, which is consistently because to artificial organs and mechanical gadgets as indicated by the idea of E. Kapp can be addressed schematically as follows (see Fig. 1).

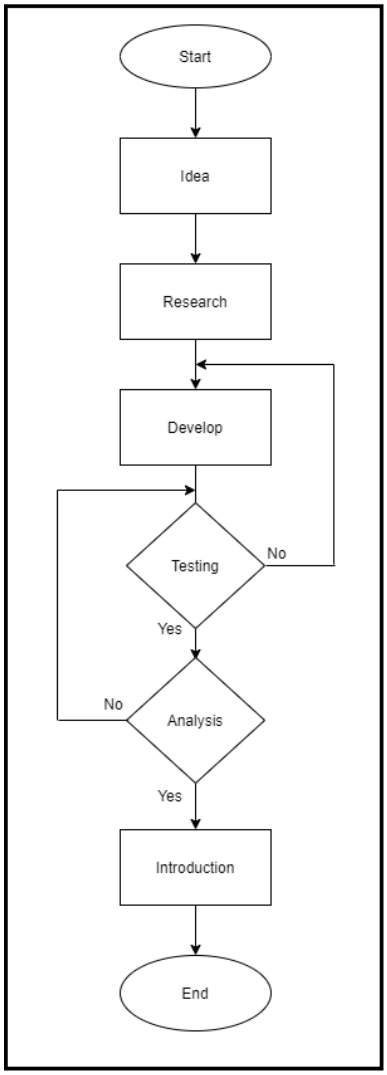

Fig. 1. Product Design Cycle [7]

The idea of multipurpose item configuration design depends on a extensived research area of product family design. Product family design is an approach to accomplish financially mass customization by permitting exceptionally separated products to be created from a typical stage [8].

Capacity-based secluded product architecture intends to recognize the common modules for practical design [9]. The new concept of item platform can be stretched out for adaptable items with comparable base module and variable capacities to fulfill a bigger accomplishment of client requirements [10].

Vismanathan, et al. [11] categorized the guidelines of multi-purpose product design, a qualitative material analysis of item surveys was performed during customer reviews collected from a randomized sample of 28 mechanical and electromechanical multipurpose products. The textual information in the reviews is cleaned up and analyzed using the formalized content analysis technique. They summarized two common rules were utilized to select the appropriate items for examinations: (1) the item must have at slightest two major purposes and (2) the item must have at slightest 10 reviews composed by buyers. The customer reviews provided by supplier-verified buyers were copied to a text document. The main steps in the material examination procedure executed in their learning area: the end of undesirable information, introductory sorting of the information, and the inter-rater investigation [11].

In regards of customer satisfaction survey, Vismanathan, et al. [11] conducted further investigation based on the insights gained from the content analysis. The survey was designed to address customer preferences about the purpose, structure, and cost of a multipurpose product. The information was collected from 100 participants via paid survey collection tool surveymonkey.com. The survey specifically investigated different aspects of multipurpose products such as: why they prefer it, how they carry it, and what functions they prefer. The survey results indicated that most people prefer multipurpose for unexpected situations [11].

According to the results from the content examination and the survey, the following guidelines about purposes, functions and interfaces, structure, and cost are formulated to assist the designers in developing new multipurpose products [11].

a) Purposes: identify the target population for the product and determine the purposes accordingly. Utilize a vital search for the purposes required by the clients – a review of the client input on comparable items seems provide valuable experiences. Anticipate all possible purposes of the product, both intended and realized – it is critical to consider as many purposes as possible.

b) Functions and Interfaces: the interfaces between functions should be efficient and the functions should not interfere with each another. Whereas including different capacities to the product, do not compromise on the quality of the products or execution of the primary function(s).

c) Structure: the item design empathically or contrarily impacts the product's planning or realized purposes. The structure of the product should also allow ease of assembly, ease of cleaning, and ease of storage.

d) Cost: wherever possible, keep the cost same or lower than the individual products. The higher cost is justified only when the product is very well made.

Above four development criterias of new product development should be the basis and or the fundamental aspect this paper aims for. Purpose, function and interface, structure and cost are considered when applying product redesign concept to a conventional wrench to an advanced one.

The idea of multifunction item architecture depends on a wider research area of product family design. Product family design is the strategy possessed to realize cost-effective mass customization by permitting profoundly separated items to be created from a regular platform [8]. Capacity-based modular product architecture aims to distinguish the regular modules for fetched-cost effective design [9]. The concept of product platform can be stretched out for flexible items with comparable fundamental module and variable capacities to fulfill bigger accomplishment of client requirements [10]. On the other hand, some designers believe that to inject new functions into products is innovation [12].

Manufacturers provide services to customers according to market demand, so designers' ideas must be consistent with customers' ideas. The customer is not the user of the product itself, or the customer can represent the expectation of a very

small number of users, but the designer must make the customer happy and listen to the customer's feedback. In this case, the designer's design ideas and user's design methods need to be maintained [13].

III. RESEARCH METHOD

In research methodology phase, the in-general cycle is begun with mechanical drawing of ordinary wrench product, non-electrical bionic grip wrench, and the design of the 2D & 3D engineering drawing with electrical-mechanical bionic grip operation wrench. Inventor software was used and perform the stress of the nuts gripper, by considering it as a critical functional components. Figure 2 shows the development stage flowchart.

Research introduction was firstly explained the importance of product redesign or existing product modification to adapt recent world economic situation, where customer and market demand fluctuate in daily period.

This thing should be an important one for the organization to meet the stakeholders' expectation, while the literature review provides supporting theory for product redesign concept and its application used in world-wide. Authors investigate the existing design of ordinary wrench before the upliftment (the existing design).

Afterwards, we did several literature reviews related to wrench product design that available in the market. We realize it has another room for enhancements, and we try to dig in more deep for the new idea of rotary motor that possible to grasp the nuts with its electro-mechanical bionic grip then fasten the nuts with rotary force performed by the motor and the power source. We used the Inventor program to result the 3D modeling and deploy several stress examinations as a result came from the nuts grip and fastening for the critical parts of the product.

This stage will recognize the production-ability of this product redesign and distinguish the most appropriate material to use. Figure 3 shows the conventional wrench product that will be the object of the research.

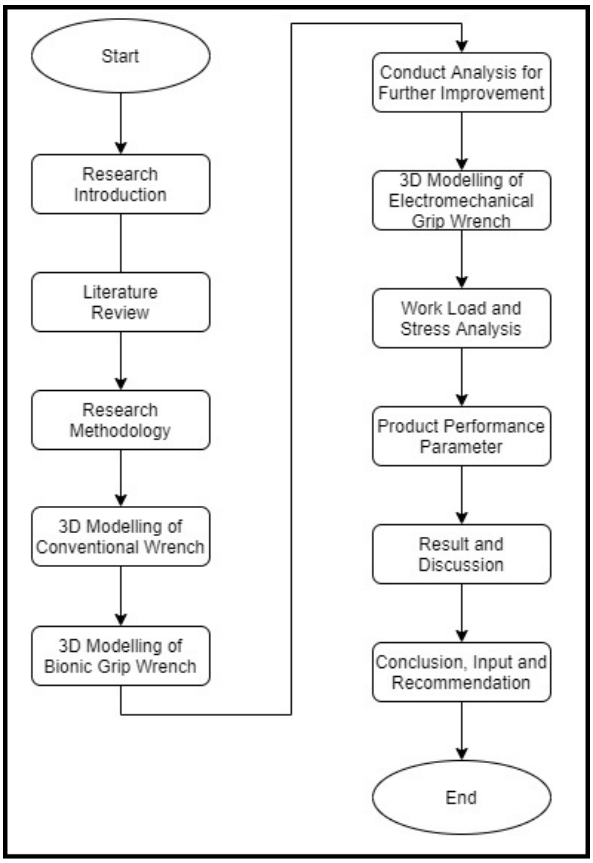

Fig. 2. Research Methodology

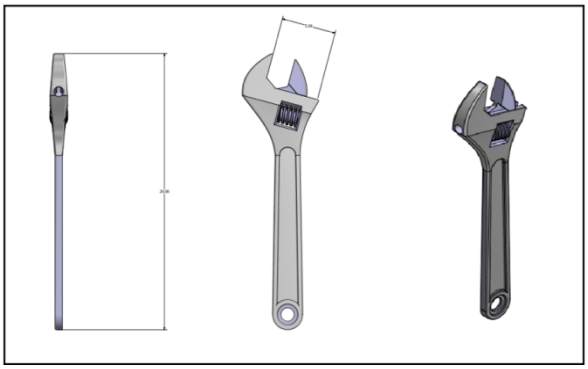

Fig. 3. Conventional Wrench Product Design

IV. RESULT AND DISCUSSION

The result of this paper will perform, introduce and analyze the new proposed product design that uplifts the bionic grip spanner with its specification of electrical-mechanical rotary motor. The stress examination resulted by Inventor Program literally would exhibit the force resulted from nuts grip and fastening of each six-eye sides grip. The concept was gathered by the perception of the researchers in

order to minimize the effort required and produced by operators.

Recognizing the time and motion study concept, the new product design is proposed and to be future known as electro-mechanical grip wrench, resulting the rotary force to fasten the nuts after conducting the grip operation and it is possible to deploy the fastening operation for following types of nuts: flange bolts, hex bolts, hexagon nuts, and lock nuts. Figure 3 evinces the existing design (ordinary wrench product) which still require manual motion and positioning and human forces.

In the next step, researchers found the available architecture of bionic grip wrench that available in the market. This proposed design minimizes the operation time to do the manual positioning for the nuts and bolts, since it has several sides on the material surface that need to be fit before do fastening. Figures 4 shows the design of bionic grip wrench that could support to reduce the needed time of tool manual positioning. It helps to reduce some cycle time in repetitive work.

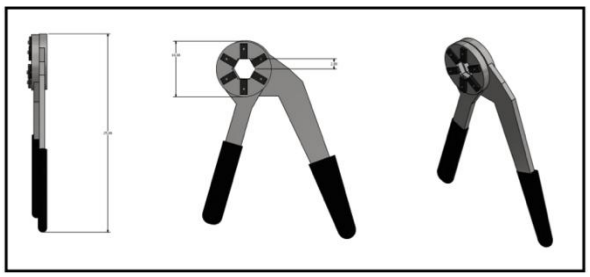

Fig. 4. Bionic Grip Wrench Design

To continue into the next phase of enhancement, the researchers dig the opportunity and further chances to eliminate the waste of the manual operation. Learnt and explored that, after the bionic arm grips the nuts or the bolts, it still need the manual operator effort to do the bolt and nuts fastening by rotating the tools manually. Hence, the researchers initiate the new design proposal that applying the motor (rotary motor) to perform rotary force after material grips been done, yet the force will fasten the nuts and bolts to the work object surface. It minimizes the operator's manual effort by utilizing electrical-mechanical power that results rotary force of the wrench to the bolts and nuts.

The clear requirement is to realize the standardization of product function and structure. Please do not sacrifice the conceptual model of previous users, and build a new one at cost [14]. In order to shorten the production and manufacturing cycle of enterprises, enterprises often make plans, leaders approve, modify and finalize, and produce in a production mode with high production efficiency. This design and manufacturing process shortens the product development cycle [15].

Figure 5 and Figure 6 presents the proposed design to overcome the issues mentioned earlier.

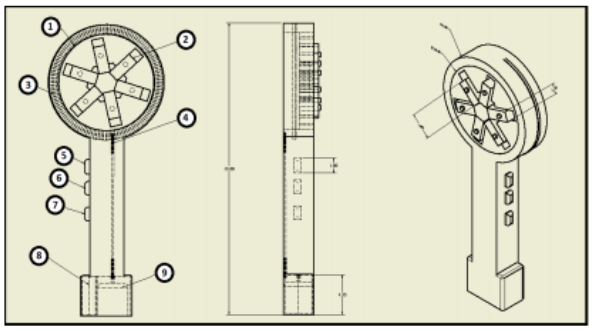

Fig. 5. Powered Bionic Grip Wrench Design

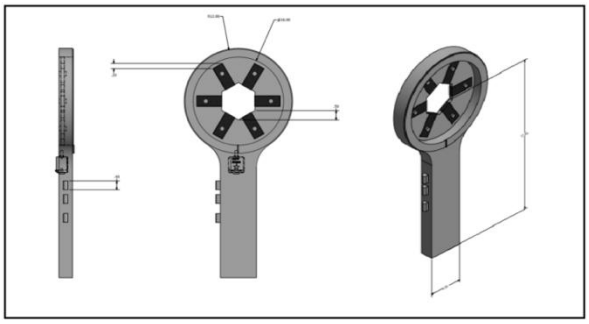

Fig. 6. Powered Bionic Grip Wrench 3D Design

Researcher used the alloy material as a core material analysis. Aluminium alloys are alloys in which aluminium becomes the major composition [16]. The typical alloying materials are copper, magnesium, manganese, silicon and zinc [17]. Aluminium alloys are grouped as casting alloys and wrought alloys, both of further subclassified into the heat treatable and non-heat-treatable. In this work consider three aluminium alloys like as AA2014, AA6061 and AA7075 [18].

The inventor program is utilized to generate the proposed electro-mechanical bionic grip's material

to 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 1 presents the outline of the product's performance parameter.

For the bionic grip arms section, Figure 7 presents the stress analysis performed by Inventor program. Investigating the presented 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, meanwhile, XX, XY, and XZ section stress are shown on below figure 7, 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. XX, XY, and XZ section stress are shown in Figure 8, 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.

YY, YZ, and ZZ section stress are presented on below Figure 9, 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.

Table 1. Product Performance Parameter

Name	Minimum	Maximum
Volume	170184 mm^3	
Mass	0.848246 lbmass	
Von Mises Stress	0.0000000103897 MPa	0.976116 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 XZ	-0.321135 MPa	0.357921 MPa
Stress YY	-1.12067 MPa	0.824607 MPa
Stress YZ	-0.514684 MPa	0.512301 MPa
Stress ZZ	-0.985721 MPa	0.73289 MPa
X Displacement	-0.00000887554 mm	0.00000731301 mm
Y Displacement	-0.0000804611 mm	0.0000811575 mm
Z Displacement	-0.0000708529 mm	0.0000703227 mm
Equivalent Strain	0.00000000000109227 ul	0.00000453767 ul
1st Principal Strain	0.00000000000328693 ul	0.00000384647 ul
3rd Principal Strain	-0.00000538668 ul	0.000000000913305 ul
Strain XX	-0.00000146908 ul	0.00000212581 ul
Strain XY	-0.0000019045 ul	0.00000201984 ul
Strain XZ	-0.0000020665 ul	0.00000230322 ul
Strain YY	-0.00000496889 ul	0.00000346498 ul
Strain YZ	-0.00000331199 ul	0.00000329666 ul
Strain ZZ	-0.00000416781 ul	0.00000340111 ul
Contact Pressure	0 MPa	4.0863 MPa
Contact Pressure X	-0.422555 MPa	0.531656 MPa
Contact Pressure Y	-1.0387 MPa	2.70131 MPa
Contact Pressure Z	-0.950508 MPa	3.11938 MPa

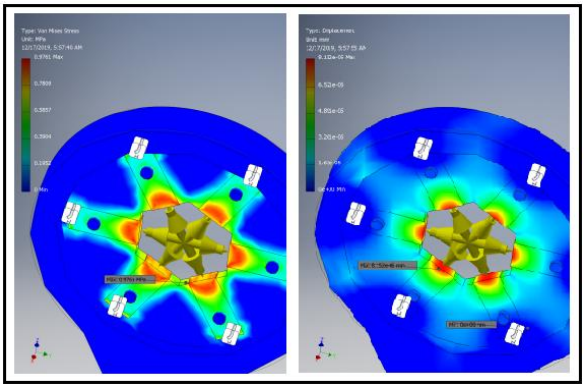

Fig. 7. Product's Maximum Stress and Displacement Analysis

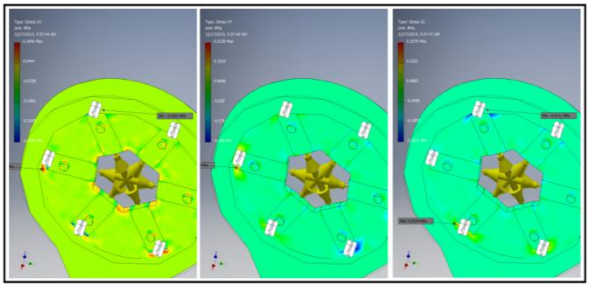

Fig. 8. XX, XY, XZ Section Stress Analysis

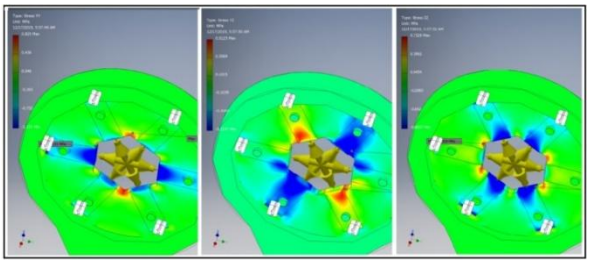

Fig. 9. YY, YZ, ZZ Section Stress Analysis

V.CONCLUSION

The proposed design, 3-dimension mechanical drawing, yet stress and force examination were performed by utilizing the Inventor software. The result was proposed to reduce the operator's manual effort that results higher processing time needed compared to manual grip positioning, rotary force performed by human motoric, and design manufacturability. The stress examination were performed especially in the side of bionic grip that directly contributing the main rotary force to fasten the nuts and bolts, with the maximum proposed torque is 45 NM, maximum screw diameter is 6 mm, maximum drilling diameter is 10/20 mm on steel or wood surface.

The battery type use Lithium Ion with charger input 110V-240V AC , 1.5 A to provide safety and

maturity on the battery cell level, power capability and charge or discharge characteristics, energy contents of the battery cell, cycling efficiency and self-discharge that suitable for modern power grid [19].

For further research and development input, another mechanism apart of electromechanical could also be considered, for example using the pneumatics. The force needed to deploy the movement in the air obtained according to physical laws of motion [16]. There are many different devices that consist in pneumatic wrench where some used for impact and some for optimum torque [20].

REFERENCES

[1]. H. Chen, J. Chen, J. Luo, H. Zhang, Y. Guan, and H. Zhu, "Development of A Novel Vacuum-Suction Gripper Capable of Changing Gripping Position," 2018 IEEE Int. Conf. Robot. Biomimetics, ROBIO 2018, pp. 1384–1390, 2018, doi: 10.1109/ROBIO.2018.8665335.

[2]. R. Cooper, "New products: What separates winners from losers?," J. Prod. Innov. Manag., vol. 4, no. 3, pp. 169–184, Sep. 1987, doi: 10.1016/0737-6782(87)90002-6.

[3]. D. Singh, A. Srivastava, G. Verma, M. Chauhan, and A. Gupta, "Innovative Design of Multi Jaw Wrench and its Analysis," no. May 2013, 2014, doi: 10.13140/2.1.2404.7686.

[4]. Lu XS and Zhou H 2000 Pneumatic automation system optimal design. Shanghai: Shanghai Science and Technology Literature Press

[5]. Brij N Agrawal and Max FPlatzer 2018 Standard Handbook for Aerospace Engineers (Beijing: McGraw-Hill Education) p 128

[6]. B. Design, I. Group, and R. Roy, "By R o b i n Roy," 1987.

[7]. "Балаклеец Н.А. Тело, власть и трансгрессия: концепция органопроекции Э. Каппа и ее современные рецепции," Философия и культура, vol. 6, no. 6, pp. 866–874, Jun. 2015, doi: 10.7256/1999-2793.2015.6.15070.

[8]. J. Roger and J. Timothy, "Product family design and platform-based product development : a state-of-the-art review," pp. 5–29, 2007, doi: 10.1007/s10845-007-0003-2.

[9]. R. B. Stone and D. A. Mcadams, "A product architecture-based conceptual DFA technique," vol. 25, pp. 301–325, 2004, doi: 10.1016/j.destud.2003.09.001.

[10]. P. K. P. Rajan et al., "An empirical foundation for product flexibility," vol. 26, 2005, doi: 10.1016/j.destud.2004.09.007.

[11]. D. A. Iv and J. B. Moody, "User Preferences in the Design of Multi-Purpose Products: A Case Study on the Redesign of a Utility Tool," pp. 1–10, 2017.

[12]. X. Cao, N. Yoshikane, I. Popescu, T. Tsuritani, and I. Morita, "Software-Defined Optical Networks and Network Abstraction With Functional Service Design [Invited]," vol. 9, no. 4, pp. 65–75, 2017.

[13]. S. N. A. Zawawi, R. Anwar, and M. H. Abdullah, "Creating Product Innovation: The Insight of Elicit in Design Process," Adv. Sci. Lett., vol. 23, no. 8, pp. 7771–7774, Aug. 2017, doi: 10.1166/asl.2017.9573.

[14]. W. Chow and M. Shieh, "A study of the cultural and creative product design of phalaenopsis in Taiwan," vol. 0502, 2018, doi: 10.1080/09720502.2017.1420568.

[15]. H. Forbes and D. Schaefer, "Social Product Development : The Democratization of Design , Manufacture and Innovation," Procedia CIRP, vol. 60, pp. 404–409, 2017, doi: 10.1016/j.procir.2017.02.029.

[16]. T. Sathish and J. Jayaprakash, "Multi period disassembly-to-order of end-of-life product based on scheduling to maximise the profit in reverse logistic operation," vol. 26, no. 3, pp. 402–419, 2017.

[17]. T. Sathish, "Experimental investigation of machined hole and optimization of machining parameters using electrochemical machining," Integr. Med. Res., vol. 8, no. 5, pp. 4354–4363, 2019, doi: 10.1016/j.jmrt.2019.07.046.

[18]. Sathish, T., Muthukumar, K., Palani Kumar, B."A Study on Making of Compact Manual Paper Recycling Plant for Domestic Purpose", International Journal of Mechanical and Production Engineering Research and Development, Vol. 8, Special Issue 7, Dec 2018, pp. 1515-1535, 2018.

[19]. H. C. Hesse, Lithium-Ion Battery Storage for the Grid — A Review of Stationary Battery Storage System Design Tailored for Applications in Modern Power Grids. 2017.

[20]. L. M. Balderama, "Shiq ley ' s Mechanical Engineering Design."