Development of Special Dowel Pin Piler for Dowel Pin Sink in The Flat Surface

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Abstract

A dowel pin puller in simple word is a hand tool that is used to remove dowel pin that has been tapered from their insertion holes. Using the various head sizes, the tool threads into the extractable dowel pin and pulls it out using the slide hammer technique. Meanwhile, dowel pins are a type of industrial fastener that is used to connect two or more products. Therefore, in this project, a durable and affordable dowel pin puller that can reduce set up time during production is designed and fabricated. During the earlier stages of design, a PDS and DFMA guidelines is constructed based on the datum to set a range for the design. Then, after the conceptual design had been sketch, the approach of concept scoring matrix is used to select one of the best designs, where design A is selected. SOLIDWORKS software is then being used to detail out the design and for design analysis, FEM. As result, the safety factor for the parts that been simulated, is greater than 2, which is acceptable and safe. A survey also conducted during design analysis to get the feedback from expert, and user, where most than half of the respondents were chosen and satisfied with the design A, as in the selection of matrix. Thus, design A is fabricated. The dowel pin puller is made of main materials which is low carbon steel and costed RM95.80 for fabrication cost. In conclusion, the objective, and scope of the project is achieved, and the design is successfully fabricated within the period of time. For future works, more improvement can be made for the design in terms of feature, and safety to make it more attractive and functionality.

Keywords

Dowel Pin Puller, Dowel Pin, Shaft, Handle, Low Cost

1. Introduction

The tool's extractor design varies by purpose. The tapered end of the extractor is tapped into the dowel's body to gently remove the pin (*Encyclopedia of Alternative Energy Id_battery.Html*, 2015). Dowel pin extractors remove dowel pins from insertion holes. Using different-sized heads, the tool threads into the extractable dowel pin and pulls it out (*DPE Dowel Pin Extractor Tool | Boneham*, n.d.).

Dowel pins connect two or more goods. Wood, metal, or plastic cylindrical rods. Tapered, slotted, grooved, or otherwise modifying dowel pins changes their mechanical properties. They are often available in imperial and metric (G.L. Huyett Marketing Department, 2020) . CNC uses dowel pins for fine tolerances. They go into tight-tolerance reamed holes. Fixtures, dies, and tooling plates are used to support workpieces on a machine's reference plane. The machine to which the fixture or die is mounted often includes a base plate, often called a master plate, into which dowel pins are put to properly locate the fixtures relative to the reference or data plan (Devening, 1981).

The usage of dowel pin puller has become essential especially in CNC industry. This is because dowel pin puller is a tool necessary to pull dowel pin, (wikiHow Staff, 2020) which is used during the set – up process for product such as vector chamber. During the usage of the dowel pin puller, it had been found out that the dowel pin puller being used are having difficulty in order to use the in-house customization puller. Firstly, the major problem is that the pulling process was too hard to handle, which is using the method of hammering process. One of the problems that being faced, is that the time taken for the puller that being used to remove the pin from the jig is too long. Thus, causing high set – up time of the machining process of a certain product to be longer. In CNC industry, time is very important because the faster the product being completed, the faster the product can be delivered to the client. Furthermore, normal dowel pin puller can cause pain towards user hand especially on the palm and also on the wrist during the pulling process. This also occurred many times to the worker. This is because of the design of the puller itself, which using the hammering process method. In addition, the available dowel pin puller at the market is expensive. Most of the company that are using dowel pin puller will not consider the available product, thus, there are making their own special tool. This is also in the case where the internship programme been conducted, the company, which is CNC manufacturing company, are producing their own tool in order to pull the dowel pin from the jig.

1.1 Objectives

The key objectives of this study are:

- To design a dowel pin puller which can reduce set up time.
- To design a special dowel pin puller than can reduce discomfort, thus will bring convenience to the user.
- To develop an affordable dowel pin puller for CNC and machining used.

2. Literature Review

In order to design the dowel pin puller that met the objective of this project, study on the dowel pin puller and its market in Malaysia which consists of criteria of the finding and researching about the competitive landscape of dowel pin puller products that are available through the literature review, E – commerce, and also by conducting survey. Furthermore, identifying the problem within the available dowel pin puller which the problem that the user had in using the available dowel pin puller by conducting survey and also by gathering data from literature review, E – commerce review and observing niche forums. Additionally, study on the dowel pin sink in the flat surface also being done, in the area of the dowel pin that are available and focusing on the dowel pin sink in the flat surface and understanding the type and mechanism through literature review. Moreover, study on the puller mechanism available in the market also being conducted in order to understand the various product of dowel pin puller mechanism, structure and system through literature review.

3. Methodology

The methodology defined in this research is divided into two parts. Part A consists of five stages: studying the dowel pin puller and its market in Malaysia, identifying the problem within the available dowel pin puller, studying the dowel pin sink in the flat surface, and studying the puller mechanism available in the market. Each phase has a key task, method, and deliverable. Part B includes the detailed design of the dowel pin puller, refinement of the final design and details, CAD/SOLIDWORKS modelling of the final design, simulation analysis and results, prototype fabrication, prototype testing, and final report writing.

4. Product Design Development

Discusses about the process of product design where included the design specification, morphological chart, design guidelines, sketching and selection of the conceptual design, material and process selection, and the method of conducting the design analysis on the critical part of the design.

4.1 Product Design Specification

According to background studies, product design specifications describe a target and restriction. This list helps develop the model and prototype. The list includes model performance, size, weight, material, cost, customer, quantity, maintenance, product life span, competition, patents, service life, ergonomics, safety, appearance and project timeline (Eyere et al., 2018), (Neumann et al., 2004), (Sarazyn, 2014). In order to develop the final product design specification, a process of establishing target specifications contains 4 steps, which are:

(e) List of metrics from the customer needs

(f) Marginal and ideal values based on the customer needs

(g) Collect competitive benchmarking information

(h) Final product design specs

4.2 Morphology chart

The potential solutions are covered in this section. The list is created using the previously discussed function, and it includes suggested solutions next to each function. After filling up the morphology chart, three designs are created. Therefore, the solution type and its components must be different from the others. This ensures more diverse options. Depending on the answer, three conceptual designs are developed.

4.2 Matrix Selection

In this topic, past concepts and designs will be compared using the chosen criterion. Only meaningful and relevant criteria should be used for comparison. Some important criteria that must be studied and monitored are grouped by function, and these groupings are generated for each carefully specified function. This list considers each function's most important factors. When comparing the three concept concepts, the most relevant criteria must be chosen, thus all of the mentioned criteria are studied and discussed. The list is then input into the matrix selection table to evaluate the design.

4.3 CAD drawing

The detailed drawing of the design of concept A is sketched by using the Solidworks software, where in Figures 1 and 2 below shown the orthographic view of the overall dimension of the puller shaft and also the thrust handle design of the puller respectively. From the Figure 1, the dimension of the shaft is 480mm of length and 20mm of width. While, from Figure 2, the dimension of the shaft is 154mm of length and 40mm of width.

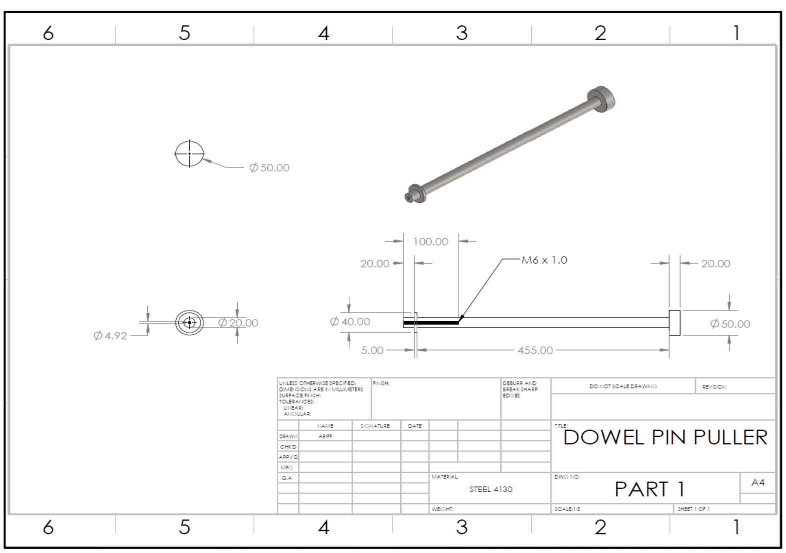


Figure 1 Overall dimension of the shaft

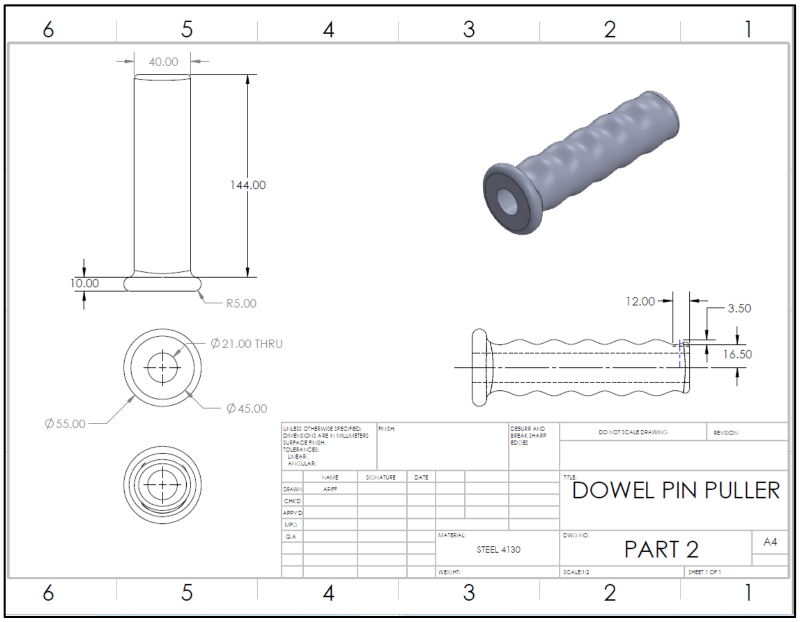


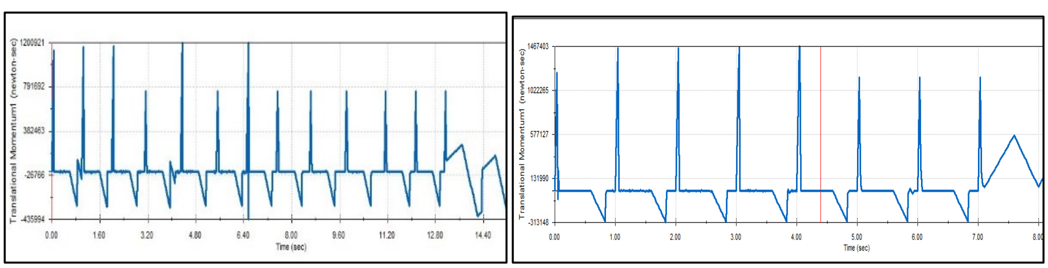
Figure 2 Overall dimension of the thrust sleeve handle

5. Results and analysis

This chapter will demonstrate the results obtained after completing the design of the experiment, as well as some analysis of the experiment's findings.

5.1 Motion Analysis

During the motion analysis being conducted, few graph has been plot, specifically for the thrust sleeve. The graph of the translational momentum over time in order to pull the dowel pin out of the hole of has been plot as in Figure 3 (a) for the old version of dowel pin puller, while in (b) is for the new design of the dowel pin puller.



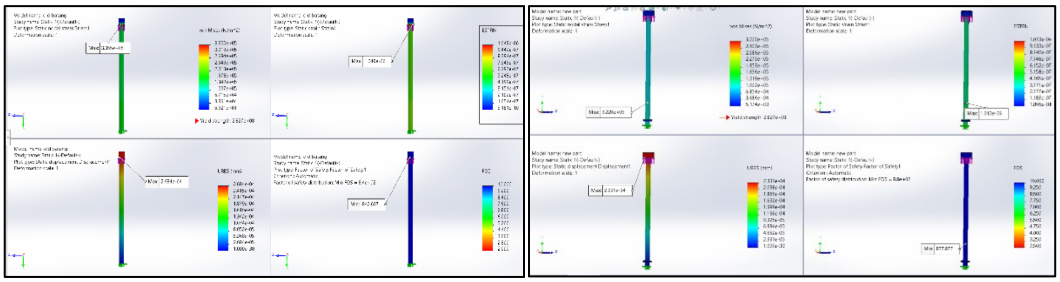
(a) (b)

Figure 3 [(a): old design, (b): new design]

Based on the graph, firstly, it can be seen that the time taken for the old version of puller to pull the dowel pin from out of the jig is longer, which is 12 sec, compared to the new version, which is 7 sec. The difference which is 5 sec can greatly reduce the set-up time during production. Secondly, from the graph, it can be seen that the maximum momentum generated by the old version of puller is lower, which is 1200921 N/s, compared to the new version, which is 1467403 N/s. The new design which has longer shaft compared to the old design significantly help in increasing the generated momentum. The amount of momentum generated can greatly help the user to pull out the dowel, thus reducing the time taken needed (Urone & Hinrichs, 2020).

5.2 Finite Element Method

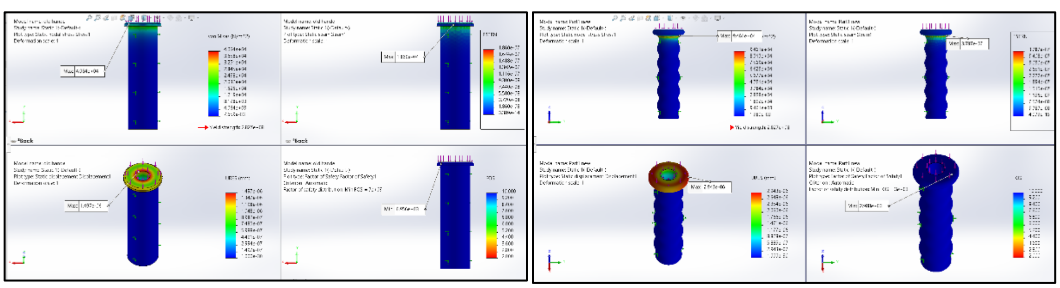
Finite Element Method (FEM) is used, to analyze the behavior of the critical part of the product in order to eliminate the failures on the material especially when the forces or loads applied, as well as to ensure the design meet the elements in the PDS that had been defined before (Harish, n.d.). The FEM analysis was conducted using the Advanced Simulation in SOLIDWORKS software.



(a) (b)

Figure 4 [(a): old design, (b): new design]

Based on the Figure 4 (a), following are the result of the static analysis for the old design which are the maximum stress and strain were detected at the top part of shaft with $3.355e^6\ N/m^2$ and $1.049e^{-6}$ respectively. Maximum resultant displacement was $2.684e^{-4}mm$ at the center of the top surface. Based on the Figure 4 (b), following are the result of the static analysis for the old design which are the maximum stress and strain were detected at the top part of shaft with $3.220e^5\ N/m^2$ and $1.013e^{-6}$ respectively. Maximum resultant displacement was $2.331e^{-4}mm$ at the center of the top surface.



(a) (b)

Figure 5 [(a): old design, (b): new design]

Based on the Figure 5 (a), following are the result of the static analysis for the old design which are the maximum stress and strain were detected at the top part of shaft with $3.355e^6\ N/m^2$ and $1.049e^{-6}$ respectively. Maximum resultant displacement was $2.684e^{-4}mm$ at the center of the top surface while minimum FOS recorded was 842.607. Based on the Figure 5 (b), following are the result of the static analysis for the old design which are the maximum stress and strain were detected at the stopper part of the handle with $9.461e^4\ N/m^2$ and $3.787e^{-7}$ respectively. Maximum resultant displacement was $2.943e^{-6}mm$ at the center of the top surface while minimum FOS recorded was $2.988e^3$.

5.3 Fabrication of Prototype

The dowel pin puller prototype is made of mild steel alloy. Mild steel is the main material because it has high strength, malleability, and durability, (*What Is Mild Steel? An In-Depth Guide to Carbon Steel | Metals4U - Ideas & Advice | Metals4U*, n.d.) which meet the PDS and design objectives. During fabrication, different tools and equipment were used to cut and drill the material. The main method in order to fabricate the dowel pin puller is the MIG welding, (Taylor et al., n.d.), which is important in order to shape the prototype into its design. The process of fabrication of puller used a total period of 8 weeks to complete from raw until the end product, where shown in Figure 6. The long shaft of the puller provide higher force could be generated, thus making the dowel pin to be pulled out easily.

Figure 6 Fabricate Dowel Pin Puller Prototype

5.4 Bill of Material

Bill of Materials (BOM) is a list of raw material, sub-assemblies, part, and component that needed to fabricate and manufacture the final product. It included the part name, description, material of the part, quantities required, as well as the price for each element that in the list, as shown in Table 1 below. The dowel pin puller contained 2 major part which including all the fasteners used and costed RM95.80 including the estimation of expenses for labour fee. This is the price for fabrication of a sample, and if for mass production, the overall price will be reduced around 20% due to high purchased volume of stock of the material and also parts.

Table 1 Bill of Materials

Items	Unit	Price (RM)
Mild steel bar	20 x 609.6 mm	11.0
Circular hollow	40 x 304.8 mm	10.0
Steel Epoxy	292g	15.8
Aerosol spray paint	400ml	9.0
Welding	-	50.0
	Total cost	95.8

6. Conclusion and Recommendation

6.1 Conclusion

This project aims to design and develop a special dowel pin puller that can pull out dowel pin sinks on flat surfaces to reduce set-up time. The study found that most dowel pin pullers were expensive, which brought a negative and minor response from people. This project developed a high-quality, low price dowel pin puller. Motion analysis is used in this project to analyze the dowel pin puller before fabrication as part of the design process to ensure user safety. During the design analysis, an online survey is also conducted to get expert and user feedback. This survey aims to hear their thoughts on choosing a product and rating its design. As a result, more than half of the responses were satisfied with design A. So, A is being fabricated. The dowel pin puller is made of low-cost, high-strength, and durable mild steel. This dowel pin puller was successfully, which cost only RM95.80, from defining and identifying the problem to design and analysis to fabrication, where the result met the project's objective and scope.

6.2 Recommendation

In the road of designing, improving is the most important word that should practice by designer, and also engineer. Since the product seems like perfect but improving is to get the product become better to fulfil the needs of human, as well as advancing the technology. For the dowel pin of this project, although it had been successfully fabricated and safe to use, it also has many areas or parts that can be improved, and modified from the aspects of functionality, safety, and also design. From the survey, the usage experience is the major attention that need to be focused and improved in the future. For example, changing the mechanism of the puller into a more user-friendly mechanism, thus making new user to easily operate the hand tools.

As today world, sustainable was a topic that always be discussed by the people in order to protect the environment. Therefore, a green material, or recycled material can be a practice in making the dowel pin puller. Besides that, designing a dowel pin puller that affordable that able to be use universally with dowel pin of other size should also be considered. In a short summary, although all of this improvement can bring convenience to human life, but the approach of DFMA, and also the safety analysis needs to be well considered in order to design a safe, durable, and quality dowel pin puller.

References

Devening, K. *United States Patent (19). 19*. (1981).

DPE Dowel Pin Extractor Tool | Boneham. (n.d.). Retrieved August 19, 2022, from https://www.boneham.co.uk/dowel-pins/tapped-dowel-pin-extractor-tool/dowel-pin-extractor-dpe

Encyclopedia of alternative Energy id_battery.html. (2015). https://www.daviddarling.info/encyclopedia/S/AE_slide_hammer.html

Eyere, E., Agberegha, O. L., Oreko, B. U., & Peter, O. Development of a Mechanical Puller. *Ijisrt.Com*, *3*(7), 284–289. (2018). https://ijisrt.com/wp-content/uploads/2018/07/Development-of-a-Mechanical-Puller.pdf

G.L. Huyett Marketing Department. *Dowel Pin Selection - Quick Reference Guide | Blog by G.L. Huyett | G.L. Huyett*. (2020). https://www.huyett.com/blog/dowel-pin-features

Harish, A. (n.d.). *What Is FEM & FEA Explained | Finite Element Method | SimScale*. Retrieved July 24, 2022, from https://www.simscale.com/blog/2016/10/what-is-finite-element-method/

Neumann, C. R., Mihm, M. W., John, O., Place, D., Classification, P., & Ci, U. S. *(19) United States (12) Patent Application Publication (io) Pub . No .: US 2004 / 0033823 Al. 1*(19). (2004).

Sarazyn, J. *(12) Patent Application Publication (10) Pub . No .: US 2014 / 0332121 A1 Eiongation (%) Patent Application Publication*. *1*(19), 33. (2014). https://patents.google.com/patent/US20140331942A1/en

Taylor, P., Ono, K., Liu, Z., Era, T., Uezono, T., & Ueyama, T. (n.d.). *Development of a plasma MIG welding system for aluminium*. *January 2015*, 37–41. https://doi.org/10.1080/09507110902836945

Urone, P. P., & Hinrichs, R. *8.1 Linear Momentum, Force, and Impulse - Physics | OpenStax*. OpenStax. (2020). https://openstax.org/books/physics/pages/8-1-linear-momentum-force-and-impulse

What is Mild Steel? An In-Depth Guide to Carbon Steel | metals4U - Ideas & Advice | metals4U. (n.d.). Retrieved July 24, 2022, from https://www.metals4u.co.uk/blog/mild-steel-in-depth-guide

wikiHow Staff. *How to Remove Tight Dowel Pins: 8 Steps - wikiHow*. (2020). https://www.wikihow.com/Remove-Tight-Dowel-Pins

Biography

Muhammad Ariff Helmy bin Amir Hamzah is currently a student of Bachelor of Engineering (Hons) of Engineering (Mechanical – Manufacturing), at the Faculty of Engineering, Universiti Teknologi, Malaysia, Skudai, Johor. He had graduated in Diploma (Mechanical Engineering) from Universiti Teknologi Malaysia in 2019. He had experience in working in CNC industry as a machinist by operating Mazak Iintegrex e1600V/10 at AME Manufacturing SDN BHD in 2021. He also had experiences in mechanical inspection industries by assisting engineers in observing and inspecting mechanical defect on engineering component at Weldline Inspection in 2019

Muhd Ikmal Isyraf Bin Mohd Maulana currently work at the University Technology Malaysia (UTM) as Senior Lecturer. A Ph.D. holder in Lean Product and Process Development from Cranfield University, United Kingdom. His core competencies are in Lean Product Development, Lean Manufacturing, Shop Floor Management, Lean Six Sigma, and Continuous Improvement. He received his bachelor's degree in Mechanical Engineering with Honors from University Tun Hussein Onn Malaysia in 2005. Having worked within the automotive and aerospace industry for over 10 years, he has developed a wide range of Production and Lean Manufacturing skills. He started his career with UMW Toyota Motor Malaysia as Assistant Engineer in 2003. In 2005, he joined Proton Holdings Bhd. as an Engineer in the Production Trim & Final Department. In 2009, he was appointed as Section Manager in the Industrial Engineering Department, responsible for the development of Proton Production System. In early 2014, he joined Volkswagen Group Malaysia as Assistant Manager of Process Improvement Department at Pekan Plant. In 2018, he joined Composites Technology Research Malaysia (CTRM) as Head of Operation Improvement Division. During his career, he has been certified as Lean Six Sigma Black Belt from International Association for Six Sigma Certification (IASSC) in 2012. He is a certified graduate engineer and member of the Board of Engineers Malaysia (BEM). He also a Professional Technologist and member of Malaysia Board of Technologist (MBOT). Moreover, he undergoes an extensive one-to-one training program for two years with Japanese Expert from Hiroshima International Vehicle Engineering Company (HIVEC), Japan on Shop Floor Management (Genba Kanri), and been certified as a professional evaluator and instructor.