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Designing Portable Circular Cutter Tools Using Inventors for Straight Cutting Iron at Welding Workshop

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Abstract: This study was carried out with the aim of testing the design of the Portable Circular Cutter with Inventor for straight cutting at welding workshops. This study was performed to carry out the analysis of the product design strengths produced for the cutting process in the preparation of either steel plate or hollow steel. The Product Development Process Model is used as the basis for carrying out the design of this study product. This design model consists of five main phases: idea generation, idea refinement, concept development, product evaluation and product development. As this study uses Autodesk Inventor for designing the model, the concept development, product evaluation and product development were carried out within the application. This study uses the Finite Element Method found in the Autodesk Inventor application to test the design strength of the model being studied. Strengths in question are design endurance studied using Von Mises Stress, 1st Principal Stress, 3rd Principal Stress, Displacement and Safety Factor. The main value used is from Von Mises Stress which shows that the maximum force the design can accommodate before failure is 62.3218 MPa and the minimum Safety Factor is 4.3325 ul. In conclusion, the design of the Portable Circular Cutter Using Inventors for Straight Iron Cutting at Welding Workshop enables the work of cutting in the process of preparing the material to be carried out well and safely.
Keywords: Portable circular cutter, inventors, straight cutting iron, welding workshop

1. Introduction

Todays' technological advances have positively impacted the steel industry as a whole. The impact of this developing technology has opened up opportunities to the construction and civil industry to better develop in terms of processing and marketing (SME) which would able to meet consumer demand. Industrial process is a process that involves large amounts of material flowing regularly or irregularly and often with high safety while manufacturing is associated with the production of discrete objects (Kim, 2019). According to statistics, investment activity that drives the construction industry including steel making has increased from RM81 billion in 2009 to RM127.9 billion which has shown significant economic growth (Hamid, 2013). In this modern age of the industrial revolution in the early 20th century, iron has been a key ingredient in the manufacturing of high pressure pipes and as a catalyst

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for building construction (Katsumi, 2006). Iron is a dense material with high strength compared to non-ductile stone. The properties of these iron are very useful for the construction of machine frames and tools that can produce strong design. The properties of iron itself allows it to be a solid material for the frame of a product. Iron has evolved a lot since the first industrial revolution that introduced steam engines, the second revolution of electricity and conveyor belts and the third revolution saw the development of technologies such as computers and the internet.

The processing of iron ore can be divided into few processes, among which, is the selecting and preparing raw materials which then finalised with the preparation of the product sketch (Rana, 2019). Material preparation means the preparation of goods or materials used in the industry to produce a complete product before the manufacturing process is completed (Kralev, 2017). Material preparation covers a wide variety of goods and is a very important part of the product design process. Therefore, in producing a product that involves a complicated design, this process requires a complete set of tools such as the use of appropriate machines for safety while performing cutting tasks.

This in particular is referring to life safety. Apart from life safety, the safety of use of equipment and machinery should also be taken into consideration (Fred, 2010). A machine should only be operated by a skilful operator in order to avoid accidents. This project implements simple security functions (which may be due to negligence or when users are in semi-conscious conditions from working tiredness) that protect operators/users in the event of user's negligence. Frequent accidents at workshops can be avoided if students are constantly practicing and adhering to the security measures provided (Abdul Ghani, 2009 Generally, accidents while using machines occurred due to human negligence, lack of knowledge of machine handling and raw materials, failure of raw materials being processed and the failure of the machine itself (Pralhad, 2015).

Welding is a fusion between the two bodies of different materials mainly metals. According to Hamzah (2013), welding is a technology that combines two metal objects by fusion with a process called welding. This process can be done by manipulating the use of welding rods on the workpiece. The rods used have their specification to match the nature of the material to be welded. High quality welding work is important in the welding industry. Defects and distortions are major issues that often affect the quality of materials prepared (Biswas, 2010). In the welding process, there are a few guidelines and constraints to keep in mind to ensure the quality of welding work is guaranteed and thus the cost of repairs could be avoided. Preparation of materials used if not properly selected may result in defects and damage to the workpiece or machine itself.

The production of Portable Circular Cutter tools for straight cutting for workshop is a machine innovation to help students innovate on producing better products. This tool frees students from the hassle of having a large iron cutting machine to make straight cuts. The problem that students face when designing and producing is the limitation of their physical ability to produce the design of a device or machine which makes use of precise cut. Human body has its limits when performing a task for a set amount of time (Sebastian, 2011). This study was conducted to address the problem of not having enough precision machines, no specific place for straight-cut steel cutting and the human bodily limits of working long hours using portable circular cutter. Therefore, a product design will be created. In addition, these tools can help students improve their skills in designing new products based on their effective needs and designs through the implementation of Industrial Revolution 4.0.

2. Methodology

Methodology is a process for reaching a solution stage (Lumsdaine, 1999). This is because the methodology serves as a reference used to support and to identify the results of the study whether it complies with product development requirements. This methodology is also part of the creative ideas, principles, ideas and concepts that serve as variables to establish a study topic. In applying the chosen methodology, each phase or process must be followed correctly and consistent so that the product development process is more organized and systematic so that it can be completed within a specified time. The purpose of the study design is to achieve the objectives of the planned study (Acharya, 2012). Each type of design has its own unique characteristics such as the technique used, the data analysis and the design type based on the type of study performed. In this study of portable circular cutter tool

product design, the product developed is categorized as product manufacture that is the evaluation on it is very important to see the product's effectiveness to the consumer (Saxena, 2013). This study employs Product Development Process to study the required design that can be used to achieve the projects objectives and overcomes the problems stated.

2.1 Population and Sample

The population that is was targeted by the researcher were those who use the welding workshop whom mostly welding courses students in UTHM. However, the designed product would only be used or operated by one operator at a time.

2.2 Instrument

For the instrument of this study, the products model designing is drawn into a sketch first. Idea is collected using Divergent Thinking Process. Collected ideas are then to be filtered based on the study scope and boundary. After the filtering process, the remaining sketch are then developed to a course design and compared. The comparison used the concept selection rubric to choose one design with the highest total mark. After a design is chosen, full development for the design ensues until a final design is complete and ready for production. Because this study focuses on simulation instead of producing a final product, the process stopped at final design only. The design of final product as showed in Figure 1.

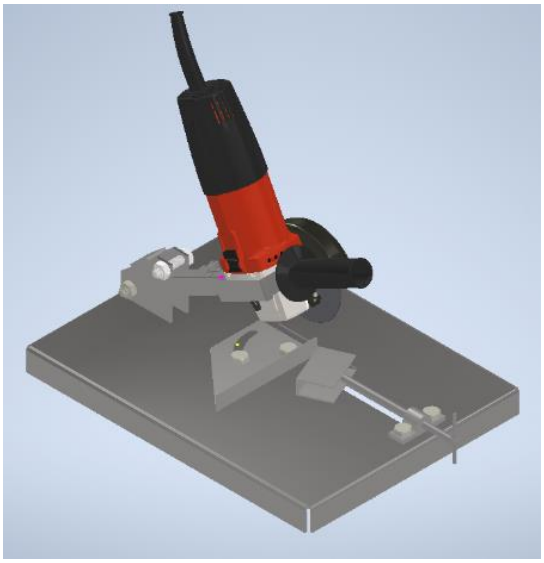

Figure 1: The final product design of this study

2.3 Data Analysis

Data analysis for this study was done by using Finite Element Method inside Inventor. The analysis performed on the design was mainly test for maximum forces introduced into the design and how far the design could hold on without any bends or breaking. The analysis includes Von Mises Stress test, 1st Principal Stress test, 3rd Principal Stress test, Displacement and Safety Factor. All the test catered to the scope and boundary of this study. For the sake of data analysis, only the intended design worked by the researcher is was used. The Portable Circular Cutter is was replaced by force acting on the design.

3. Result

The result obtained for this study showed how much force could be taken by the design when subjected to maximum force to its working parts. The force is was then calculated by using Finite Element Method and divided into five different answers relevant to this study. The result summary is shown in Table 1.

Table 1: The result summary of study on the final product design

Name	Minimum	Maximum
Volume	627603 mm^3	
Mass	4.92668 kg	
Von Mises Stress	0.000000000508978 MPa	62.3218 MPa
1st Principal Stress	-11.7071 MPa	55.4543 MPa
3rd Principal Stress	-73.8383 MPa	11.8298 MPa
Displacement	0 mm	0.0307013 mm
Safety Factor	4.33246 ul	15 ul

First and foremost, we will look at the value generated by Von Mises Stress. Von Mises Stress is a calculation used to determine the maximum degree of ductile and isotropic steel failure. The values used are rounded to four displaced points at a minimum of 0 MPa and a maximum value of 62.3218 MPa. This value means that the strength of steel before failure is a maximum of 62.3218 MPa. 1st principal stress means the maximum value of force on a normal plane where the shear force value is equal to 0. In this study, the model design has a tensile stress on a normal plane of 55.4543 MPa and a minimum force of -11.7071 MPa. This maximum value indicates that if the rated force exceeds 55.4543 MPa is applied to the model design, the design fails.

The 3rd Principal Stress refers to the maximum compressive force applied acting on a plane normal to the model design and the shear force value equal to 0 MPa. The maximum value given is 11.8298 MPa while the minimum value is -73.8383 MPa. Displacement is the number of millimetre size changes that occur on a model's design after applied force before the simulation. The minimum value given is 0 mm while the maximum value of the shape change is 0.0307 mm. This Safety Factor is the value given to a design over the material and aesthetic factors of the design before it fails. In this study, the design of the model was given a maximum safety factor of 15 ul while the minimum value was 4.3325 ul.

4. Findings and Discussions

The result from the product design simulation analysis showed that massive force was needed to act upon the design before it failed. The force acted upon the product design were forces to simulate a person using it, the weight of portable circular cutter strapped on it, the gravity pulls on the Y axis and maximum cutting force it can withstand. In the simulation, the results obtained showed that the final design is a success. This is based on the fact that proper material selection was used. The design incorporates basic shapes like triangle and rectangle which could easily be produced (Stefan, 2020). The material thickness also played a role in determining the maximum force it could take before failing. Most machinery can be seen with the triangle and rectangle shape because of its proven practicality.

The tools that can make accurate cuts on a small scale are iron cutting scissors. This iron cutter is only used for cutting sheet steel but cannot be used for cutting hollow iron such as rectangular or cylindrical hollow iron because the cut will change the shape of the iron. Cutting using a portable circular cutter gives you smoother cuts than using Band Saw or Circular Saw. Cuts produced by portable circular cutter without any aids or assisting tools would produce rough and uneven cuts.

In addition, the use of a portable circular cutter could cause inconsistent cuts due to the fatigue and prolonged shaking experienced by the cutter. Fatigue occurs when physical activity is not sustainable, especially activities that involve repetitive work over a long period of time (Allen et al., 2008). The use of equipment that can enhance the stability of the portable circular cutter will help to provide large amounts of production in the long run. Therefore, the researcher proposed to design a tool that has the function to solve this problem. This tool is called the "Portable circular cutter for precise cutting process". This portable circular cutter is expected to help facilitate the process of product design and production. In addition, these tools can help reduce the time required to complete a project that requires

straightforward cutting. It can reduce user's fatigue and inconsistency in the long run. The conclusion from this discussion is the final product design for this study is a success.

5. Conclusions

In conclusion, the analysis and findings made, showed that the design ~~is~~ has been successfully tested and could be made into a product that can address the problems that arise when preparing materials for a project. The "Portable Circular Cutter" Tool Design can be used to facilitate the preparation of materials by providing users with accurate and robust cutting tools to hold the "Portable Circular Cutter". Design durability through finite element method analysis provides data that can be used for future design production. This data ensures the safety usage of the model design in the event that it becomes a product. A few recommendations to be taken into consideration are improvements in, the type of materials used to produce design components to reduce the weight of the design, and the cutter shield by applying active shielding design using a moving protector that always closes the cutter completely during cutting work. The implications of this study is the researcher hopes that it could serve as a guide for future researchers in pursuing this study. It is hoped that this study will be one of the complementary components to drive the industry in the future.

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