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Design of Jig for a Four-jaw Independent Chuck Lathe Machine

Full Paper

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Abstract

This study discusses the process of designing a jig for a four-jaw independent chuck on a lathe machine. The aim of this study is to provide a design of jig that can be used in the teaching and learning process for Mechanical Workshop Practice 2 course for students of Diploma in Mechanical Engineering program at the Department of Mechanical Engineering, Politeknik Mukah, Sarawak. The main factor in the development of the jig is to simplify the student's task and reduce the time taken for setting up the workpiece on the lathe machine. The process of designing this jig involves several stages, namely the study of the surface, angle and direction and the details design using CATIA software. By using the jig, the process of setting up the workpiece on the lathe machine is expected to be easier and faster. In addition, students are also able to understand the function and importance of tool angle. Indirectly, the level of students' understanding of the process could also be improved.

Keywords: - Innovation, jig, four-jaw chuck, lathe machine

1. Introduction

Mechanical Workshop Practice 2 offered to Diploma in Mechanical Engineering students at the Department of Mechanical Engineering, Mukah Polytechnic, Sarawak, can basically be divided into four main topics, i.e., Lathe, Foundry, Oxyacetylene Welding (OAW) and Shielded Metal Arc Welding (SMAW).

For the topic related to lathe machine, students have to complete a project using the lathe machine. However, before the lathe process begins, students have to mark on a workpiece and set up the workpiece on the four-jaw chuck of lathe machine. These processes could take a long time as it is done manually and sometimes could risk the students for having imprecise workpiece mounting as the project requires eccentric turning.

A method to assist and speed up the process for setting up the workpiece on the four-jaw chuck of lathe machine needs to be developed to overcome the problems as stated earlier (Lutsiv, Voloshyn & Bytsa, 2015). Therefore, it is crucial to design the jig with a precise setting so that the exact center point of workpiece could be obtained. By having this jig, it will ease the mounting process and produce a workpiece with an acceptable tolerance (Miturska et al., 2020).

This jig design is developed to assist and ease the students for mounting the workpiece on the four-jaw independent chuck of lathe machine for eccentric turning process (Uysal, 2014).

2. Literature Review

In the early years lathe machine has become the most importance machines before CNC machines were invented (Jaiswal et al., 2017). This machine is able to produce various cylinder-shaped materials. One of the process this machine can produce is eccentric turning. The eccentric turning is a cylindrical part with two separate axes of rotation, i.e. one being out of the center of the other center (Patel & Chauhan, 2020). In simple word, eccentric turning can be called as off-centered turning. The distance from one axis to another is called offset. Four jaw chucks are the most common device that will be used when executing an eccentric turning and this process has a unique set of challenges. An operator with specialized training, knowledge and experience is usually required for setting up an eccentric turning and carrying out the operations (Mukilan, Karthikeyan & Gowtham, 2014).

For an eccentric process, four jaws must be used and each jaw moves independently. Due to this, it will take a considerable amount of time to tighten each jaw precisely when setting up the workpiece (Shrikant, Wachtler & Read, 2009).

In the conventional manufacturing process, performing operations on an eccentric shaft is critical and it needs to hold the workpiece properly. This is important to hold the workpiece in proper to avoid any accident or final product damage. Learn how to control the 4-jaw chuck and understand how to align parts has a direct application on any machine tool with rotary elements (Tate, 2015). The experience person to handle the four-jaw chuck, usually will find the way how to make it quick but in same time maintain the quality of product (Rao, Prasad & Sreenivasulu, 2013). At some time, the expert also faces the difficulties and takes more time to set up a workpiece at the four-jaw chuck (Nanthakumar & Prabakaran, 2014). In order to assist the workpiece holding process, the jig and fixtures must be designed so that the process will be done correctly (Peshatwar & Raut, 2013).

In Politeknik Mukah, it is essential for students to use both of their hands for setting up eccentric turning process, i.e. right hand is used to hold the workpiece whereby left hand is used to tighten the chuck. Therefore, with the intention of improving this method, the jig needs to be designed to hold the workpiece precisely at its position by minimizing human error (Wang, 2014).

3. Methodology

This jig will be able to solve the problem stated above when the students using four-jaw lathe machines. The jig was designed so that it can be attached to the tail stock of lathe machines, which are available in the machine workshop, Politeknik Mukah, Sarawak.

Based on the current process for setting up the workpiece, the student requires to match the center of eccentric at the tail stock manually by holding the workpiece using hand. Fig. 1 shows the first step to set up the workpiece.

The next process is to push the tail stock forward and meanwhile need to hold the workpiece. When the workpiece is close to the four-jaw chucks, the student needs to tighten the chuck and in the same time still need to hold the workpiece. It is difficult to maintain the center position while tightening all four-jaw chucks. Fig. 2 shows the tightening process.

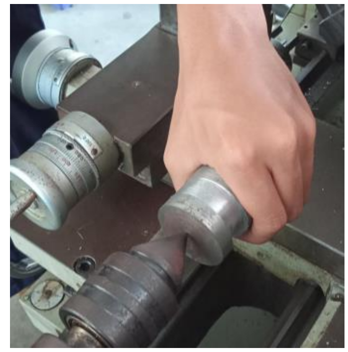

Fig. 1. First step to set up workpiece

Fig. 2. Existing tightening process (without jig)

Based on an existing manual process, it is crucial to design a jig, that could assist students to hold the workpiece. This jig will replace the manual process which holds the workpiece by using hand (Wang et al., 2017 and Liang et. al, 2013).

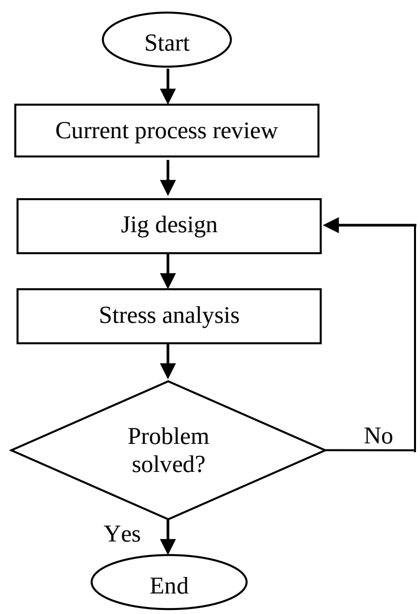

Fig. 3. Process flow chart for designing the four-jaw jig

In this study, the jig was designed by using CATIA software. The jig was assembled on tail stock design to simulate the feasibility of jig design (Pachbhai & Raut, 2014). This jig was designed based on the easiest method to assemble a workpiece for eccentric turning on four-jaw machines. It is easier to match the workpiece center point on tail stock and after that to place the workpiece at the correct position without having to hold it by hand. For this purpose, this jig was designed to be adjustable, i.e. it can be rotated and its height can also be adjusted (Kamarudin, 2017 and Shete & Gandhe, 2016). Fig. 3 shows the process flow chart to design jig for four-jaw independent chuck lathe machine.

4. Result and Discussion

Based on the researches done to assemble the workpiece on a four-jaw chuck, the new design of the four-jaw jig is as the followings. This jig is divided into three parts, that is base, connecting and front part.

Fig. 4 shows the base part for the jig. This base is attached to the tailstock. It is assembled to the tailstock at the bottom by using M10 bolt.

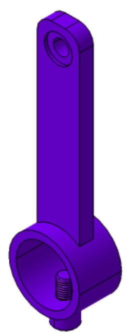

Fig. 4. Base part for four-jaw jig design

The next part is connecting part of the four-jaw jig. Fig. 5 shows the part design. This connecting part is used to connect and hold the front part and base part. This connecting part is assembled to the base part and front part also using M10 bolt.

Fig. 5. Connecting part for four-jaw jig design

The last part is front part design as shown in Fig. 6. This front part is used to hold the workpiece at its position. It is designed so that it can be rotated and its height can be adjusted easily.

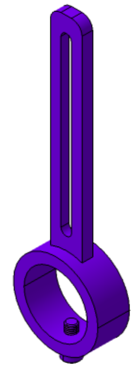

Fig. 6. Front part for four-jaw jig design

All three parts are assembled together and become a complete jig. The detail design is shown in Fig. 7 - Fig. 10.

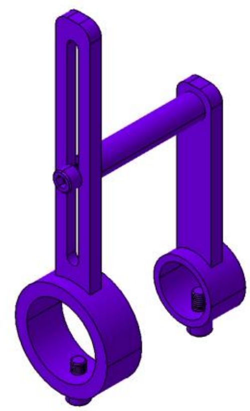

Fig. 7. Isometric view for four-jaw jig

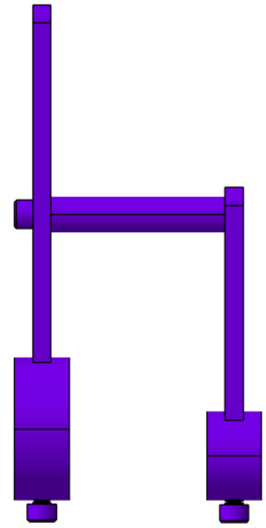

Fig. 8. Side view for four-jaw jig

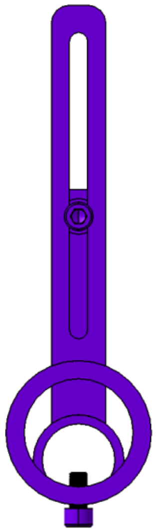

Fig. 9. Front view for four-jaw jig

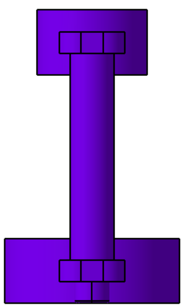

Fig. 10. Top view for four-jaw jig

The design of this jig was simulated on tail stock to check its feasibility. The results from the simulation are shown in Fig. 11 to Fig. 15.

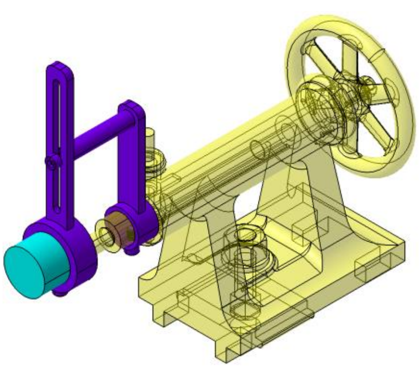

Fig. 11. Isometric view (front) of jig assembly to tail stock

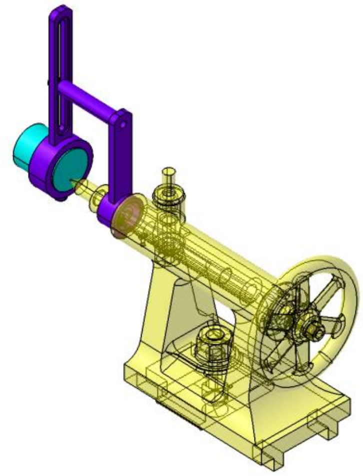

Fig. 12. Isometric view (rear) of jig assembly to tail stock

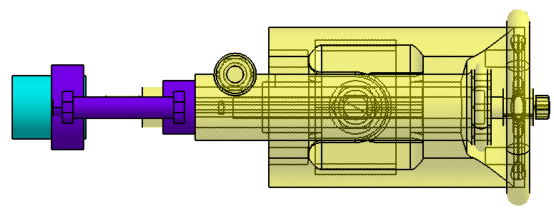

Fig. 13. Top view of jig assembly to tail stock

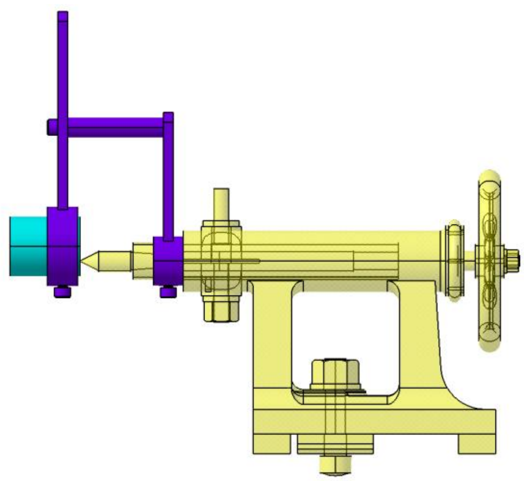

Fig. 14. Side view of jig assembly to tail stock

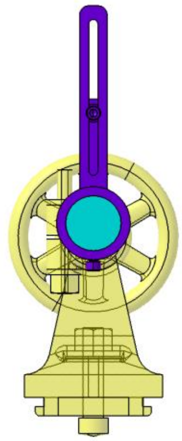

Fig. 15. Front view of jig assembly to tail stock

The design of this jig will assist students to improve their understanding on the four-jaw chuck operation and also to learn the correct method for clamping the workpiece during eccentric turning process for Mechanical Workshop Practice 2 course.

Based on the design, connecting part is most critical because it attaches to base part and hold front part. Three types of material had selected which is aluminum, steel and iron. Static load analysis had conducted to see the best material to use for connecting part (Cheng et al., 2022 and Dhagate et al., 2017).

Fig. 16 shows the result for aluminum. The maximum stress for aluminum is $1.17e^{+8}$ N/m^2.

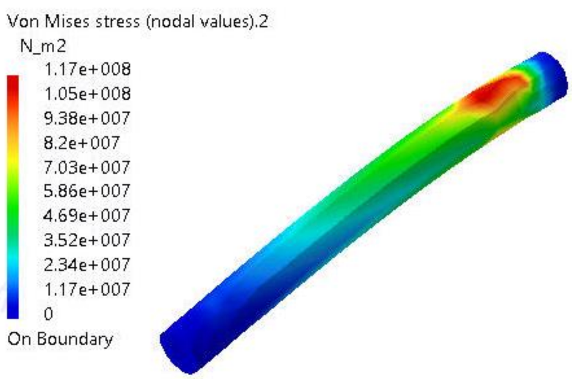

Fig. 16. Von Mises stress result for aluminum

Fig. 17 shows the result for iron. The maximum stress for iron is $1.2e^{+8}$ N/m^2.

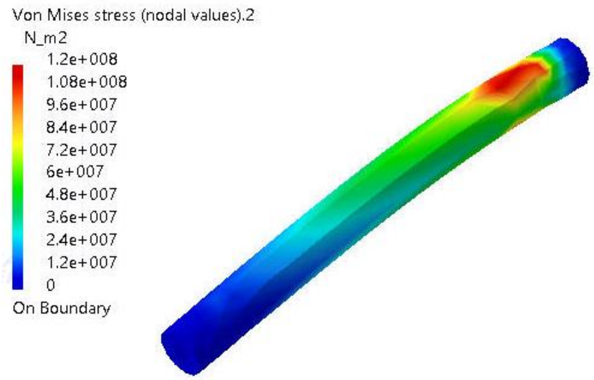

Fig. 17. Von Mises stress result for iron

Fig. 18 shows the result for steel. The maximum stress for Steel is $1.21e^{+8}$ N/m^2.

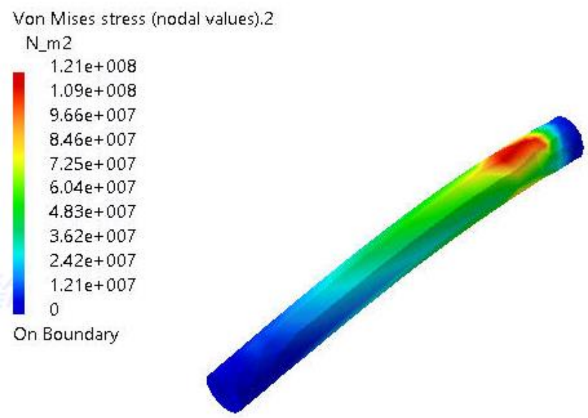

Fig. 18. Von Mises stress result for steel

By referring to Fig. 16 to Fig. 18, it shows steel is the suitable material to use develop the four-jaw jig since it can withstand the highest stress (Ashtekar Trupti & Gawande, 2014).

5. Conclusion and Recommendation

Based on the results of the jig design, the four-jaw jig for setting up an eccentric workpiece is suitable and meets the syllabus where it can help in improving teaching and learning methods. From the analysis done, it was found that the most suitable material to develop the actual four-jaw jig is steel as it is able to withstand the highest stress in comparison of aluminum and iron. In addition, the jig design also has the potential to be expanded its usage where it can prevent misalignment during the workpiece assembly on a three-jaw chuck lathe machine. Further research can be done with a focus on designing jigs that can be used on various types of lathe machine available in the market and can be used for various sizes and shapes of workpiece. Besides, analysis on deflection could also be carried out in the future for improving the material selection process.

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