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DEVELOPMENT OF PORTABLE LINEAR POSITIONING TABLE FOR DRILLING MACHINE

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ABSTRACT

Drilling operation is an operation which produces holes by bringing a rotating cutter into contact with the workpiece. Drilling operation is commonly done in drill press, however some of the time; it is done on mills or lathes. Holding parts to be drilled is one of major problems faced by the students. If the material has many holes to be drilled, then the procedure adopted is by marking out with a center punch, setting on the machine (Drill Press Machine), and holding the workpiece. This is time consuming and dangerous as the students need to hold the material they throughout the drilling process. This project presents an innovative linear sliding table to ease the operator during drilling process. In addition, the clamping system will also be provided for better rigidity and less movement of the workpiece during the drilling process. Some toggle clamps are fixed on the table to hold the position of the part securely from moving throughout the machining cycle. Furthermore, this project focuses on the execution of the drilling process in one single clamping. A simple and economic design is proposed.

Keywords: drilling, linear position, clamping.

1. INTRODUCTION

A fastening device known as a clamp is used to grip objects securely to limit its movement through the application of inward pressure. During high speed cutting process, clamping is very essential. The workpiece to be machined must be clamped tightly and securely. The workpiece must be held against the locators firmly throughout the machining cycle. The system can be described as follows:

a) The clamp should not deform or damage the workpiece
b) The clamp should allow rapid loading and unloading of parts and be fast-acting.
c) The clamp must have enough strength to restrict its movement and hold the parts.

The objective of this project is to design and also develop a clamping device for the drilling machine. The specific research tasks to fulfill the objectives of this project are summarized as follows:

a) To design a linear positioning table for drilling machines (ALZSTAR 30/S).
b) To select the best material for the linear table.
c) To develop a linear positioning table for the drilling machine (ALZSTAR 30/S).
d) To evaluate the complete product by using surface roughness testing.

2. RESEARCH METHODOLOGY

2.1. Introduction

Research methodology is divided into four parts. The first part is the design of the linear table. The second part is the material solution of the design with a selection of material to make the product. The third part is the development of linear table whereby the process to make it is explained in detail. The last part is on evaluation of the product. Two tests were done to evaluate the product.

2.2. Component selection

The linear positioning table could commence once the system requirements had been determined. Requirements included toggle clamps and other parts of the project. The process involved determining which components needed to be purchased, purchasing the necessary parts, and designing parts that could not be purchased off-the-shelf, which meant they had to be machined. The bill of material is shown as in the Figure below:

Part	Part Name	Material	Estimation Size (mm)	Quantity
1	Base Rails	Aluminum	500 x 40 x 40	2
2	Wood Table	Wood	230 x 180 x 10	1
3	Cross Shaft	Aluminum	400 x 120 x 40	1
4	Roller Housing (Side)	Aluminum	120 x 10 x 85	2
5	Roller Housing (Cross Shaft)	Aluminum	120 x 140 x 85	1
6	Nylon Roller	-	30mm Diameter	12
7	Toggle Clamp	-	-	4
8	G-Clamp	-	-	4

Figure-1. Bill of material.

2.3. Overall design

An online search for similar product was carried out to ensure that this work is not a replicated product. There are other similar linear sliding tables in use, but the

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main differences lie in the intended purposes. None of the existing linear tables were designed for use at the drill press machine. A sketch of the design was drawn after considering the suitable concepts and ideas. After the sketch was approved by the supervisor, it was redrawn by using Solid Work software. The expected final design is shown in Figure-2.The linear table used rollers to ensure the smoothness as it moves. Three rollers were used for each of its housing. The positioning of the roller was two-to-one which meant that two rollers at the top and one at the bottom.

The material chosen the table is wood. Wood is used as the base for the drilling process. This was the only part in this project that uses wood as its material. Basically, during the drilling process for sheet metal parts, the cutting tool passes through the workpiece. The purpose of using a wood table is to reduce tool wear and it would be interchangeable. When the wooden table experiences wear and damage, it can be changed. Four clamps were attached to the wooden plate. It is placed at the center of each side of the table.

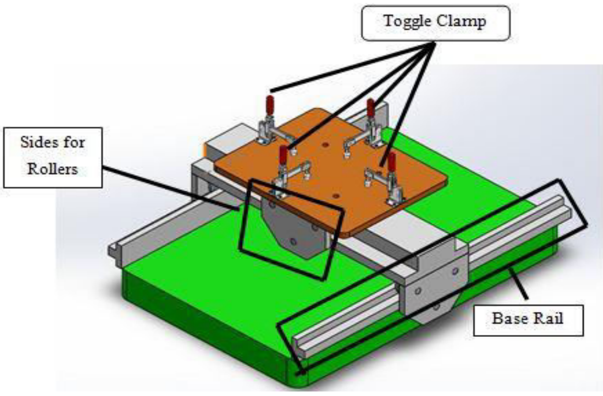

Figure-2. The overall project design.

Toggle clamps are used, as they are suitable to clamp sheet metal or plate. These clamps are fixed to the wooden table with screws. In addition, the wooden table is designed to slidein the x-axis direction along a cross shaft, while the cross shaft itself is can move in y-axis direction. Two side shafts act as its rail. The cross shaft slides along these rails that traversed the entire length of available workspace. Each side shaft are attached on the existing table of the drill press by using a G-clamp. Motion is accomplished along each axis manually by which the operator could move it as he wished. Stoppers are placed at each endpoint for each shaft to restrict its end movement or prevent it from moving off its tracks.

The main purpose for the linear X-Y table is to simplify the setup, since one clamp is needed for the entire drilling process according to certain limits. Further consideration suggested that a rectangular table would be better suited for the test material’s positioning and reaching patterns.

2.4. Selected hardware/ component

The off-the-shelf items were identified first because the rest of the device is designed around the constraints, whereas the selected hardware is placed on the system. The hardware included toggle clamps and bearings.

2.5. Part assembly

First of all, four clamps were attached to the wooden plate. The clamp was placed at the center of each side of the table. Toggle clamps were used, as they are suitable to clamp sheet metal or plate. All these clamps were fixed to the wooden table with screws. Then, the table was combined with the roller housing for the cross shaft by fixing screws through the holes that were made previously. At the roller housing, six rollers were put through all of those holes by using screws. Six meant three for each side. After that, it was put on the rail of the cross shaft to let it slide freely on the rail. Next, a stopper was put at both ends of the cross shaft to limit or prevent the roller from sliding out of the rail. A simple screw could be made as the stopper.

Then, the rest of the rollers were placed on each of the roller housing (side) which meant three for one side. Next, they were combined with the cross shaft by using appropriate screws. After that, all the combined parts were put on the base rail. They were allowed to slide freely, and stoppers were put at each end of the base rails. The entire product was completely assembled and finally placed on the existing drill press table.

3. RESULT AND DISCUSSIONS

3.1. Finish product

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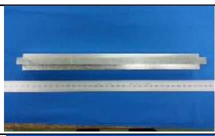
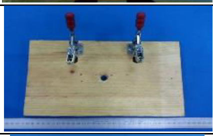
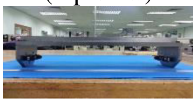
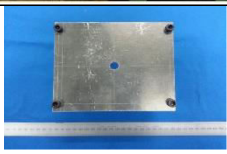
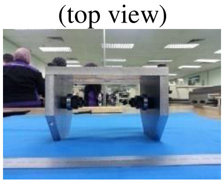
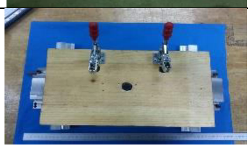
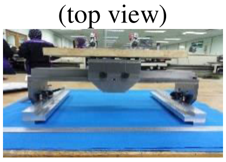
Table-1. Finish product.

Part name	Figure
1. Base rail	
2. Wood table	
3. Cross shaft	 (top view)  (front view with sides)
4. Sides	
5. Top beam	 (top view)  (front view with sides)
6. Overall parts	
7. Assembled parts	 (top view)  (front view)

3.2. Experimental procedure

For the experimental studies, test samples were prepared. Two pieces of aluminum sheet metal with size of 150mm x 100mm x 1mm were used. Both of the samples were assigned with the names Sample A and Sample B respectively. Sample A was for the drilling operation by using the table (finish product) and Sample B was for the drilling operation without using the table. Eight points were marked on each of the samples for drilling purposes. The figure below shows the samples after being center-punched.

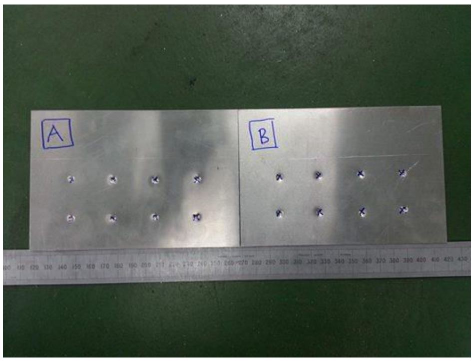


Figure-3. Center-punched Samples.

In order to get precise data, the operator and machining parameter were kept constant. The experiment set-up is shown in table and figure below:

Table-2. Parameter setup.

Samples	Cutting Parameters			Drill Bit Diameter (mm)	Material
	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of Cut (mm)		
A	17.5	0.1	1	3.5	Aluminum
B	17.5	0.1	1	3.5	Aluminum

The time taken to drill eight holes was then recorded for each sample. The time taken started from when the samples were already set up on the machine. Table-3 below records the data:

Table-3. Time taken to drill holes in the samples.

Sample	Time taken
A	0.11
B	0.10

Based on time taken to drill eight holes on each sample, it took 0.01 sec longer to complete the drilling operation in Sample A (with product) compared to Sample B (without product). This was due to experiment set-up for Sample B which was conducted without using any clamping device. There was no device provided for the drilling machine in the lab. Basically, to do any drilling operation, it requires a fixed clamping device such as vise. To drill many holes, it requires longer time as the workpiece needs to be clamped many times. While in this scenario, Sample B was not clamped at all. The sample could be moved simply after the drilling operation was finished. This for sure will reduce time as it has the same concept for this project.

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The samples were then brought to the metrology lab to measure holes diameter by using optical comparator. Figure-4 below shows the optical comparator machine. The dimension of holes diameter were recorded and plotted in a graph to compare the diameter of the drilled holes.

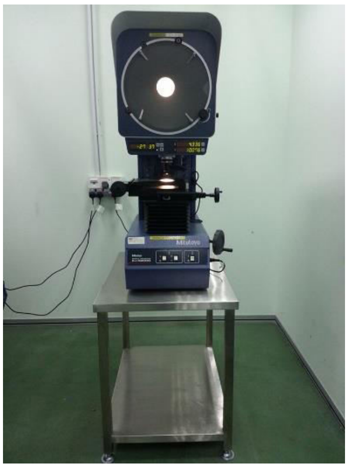

Figure-4. Optical comparator.

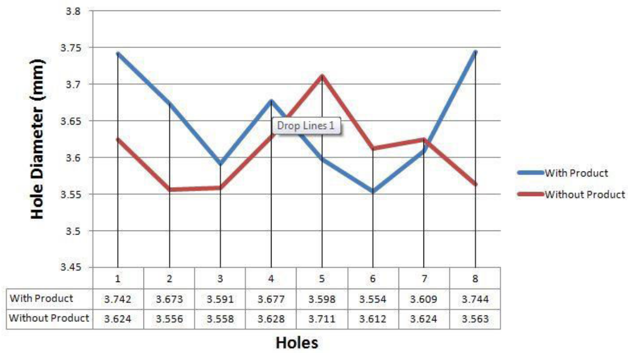

Figure-5. Graph of data collected.

Based on the graph, it can be seen that the data, the diameter of the holes are not precise and accurate. The standard variation of the diameters are shown in Table-4. The variation in the graph exists possibly due to a few factors:

a) Tool wear

b) Result of deflection

c) Vibration

d) Cutting parameters

After all, the experiment was conducted without taking these factors into consideration. This is because the objective of the experiment conducted was to compare the result between the use of this project and without this project. Furthermore, the drilling operation conducted was by an operator, and not by machine (CNC machine). So the variation might also be due to human error such as shaking hands, parallax error and so on. To achieve the objective of this experiment, the average holes diameter and standard deviation were calculated.

Table-4. Value of mean and standard deviation.

Sample		A	B
Holes	1	3.742	3.624
	2	3.673	3.556
	3	3.591	3.558
	4	3.677	3.628
	5	3.598	3.711
	6	3.554	3.612
	7	3.609	3.624
	8	3.744	3.563
Mean		3.6485	3.6095
Standard Deviation		0.071336	0.051752

Based on the calculations made, the mean (average) of Sample A is 3.6485 and Sample B is 3.6095. This shows that the average diameter value closest to the nominal diameter (3.5mm) is Sample B (without product) compared to the Sample A (with product). This means that Sample B has more accurate result.

In addition, the standard deviation value, Sample B had lesser value compared to Sample A. Standard deviation value shows how varied the data is from the mean. Hence, Sample B had less variation to the mean value when compared to Sample A. The absence of locking system was the factor and it gave biggest impact to the data. This was because the table moved so easily; hence, it needed a locking system to hold its movement. Hereby, Sample B was more precise than Sample A as it had lesser standard deviation value.

4. CONCLUSIONS

4.1. Summary of findings

This study was conducted for the purpose of developing a linear positioning table for the drilling machine. The table could be moved linearly, which meant in X-axis and Y-axis direction, so that the drilling operation could be performed in one single clamping. In addition, clamping device was also provided to provide rigidity and strength during the drilling operation. This project also took into account of safety measures. This is because the current method to do drilling operation is used without any clamping device. The operator needs to hold the workpiece by himself whereby this can be considered dangerous.

The descriptive method of research was utilized in order to complete this project. However, there were some changes made from the previous planning in the methodology. The changing of some parts of the material caused the biggest impact in the completion of this project. This change had to be made due to cost. To reduce costs, mild steel replaced aluminum as the material for this project. Due to the change, the finished product became very heavy because of mild steel properties. The rest of the changes made were in terms of design, dimension and hardware. However, these changes did not give any negative impact as they were implemented for product improvement. After the linear positioning table was completely developed, it was tested to analyze the functionality and rigidity of the product. Although the obtained data was not so satisfactory, several things were achieved according to the objectives that the product was designed for and the development of linear table was successfully completed.

4.2. Limitation

While developing this product, there were some limitations encountered, namely:

4.2.1. Cost

The estimated cost of developing this product was about RM 400. It included high quality of hardware and raw materials. To reduce the cost, materials for some of the parts had to be replaced with materials of lower price.

4.2.2. Time of machining process

Although 14 weeks were given to develop the product, it was barely enough. This was because the lab was only available on Wednesday from 2.00 pm to 4.30 pm each week, and some of the time it was used by lecturers to run programs for students. Also, using conventional machines, more time is consumed compared to CNC machines. In addition, the replacement of aluminum with mild steel reduced the cost of expenditure, but at the expense of time. It took a lot of time to machine mild steel as compared to aluminum.

4.3. Recommendation

There are some suggestions and recommendations for the future work that can bring improvements to this project. First, all the parts can have better dimensional accuracy by using CNC machine. Better dimensional accuracy gives better result; hence, the performance and rigidity of the product will increase. The time taken to develop product also can be reduced.

Next, the best raw material that should be used is aluminum. It makes the machining process easier, reduces machining time, and makes the product lighter. It also can increase mobility, which means the product can be easily moved from one place to another.

Furthermore, in the future research, it is recommended to conduct more experiments on the product to test its efficiency, functionality and rigidity such as surface roughness testing. However, the thicknesses of the samples need to be increased in order to conduct this test.

4.4. CONCLUSIONS

In a nutshell, the main objectives of this project were achieved. The product was completely developed by following the process planning even though it needed some modification to increase its efficiency and functionality. The developed product could drill many holes in one single clamping. All these problems were also solved with the completion of this product:

a) The drilling machine currently used by the students has no clamping device.

b) Less safety measure for that particular drilling machine.

c) A workpiece that has a lot of parts to be drilled need to be clamped many times.

In conclusion, even if the implementation of linear positioning table does not significantly reduce the process duration of drilling, it still can act as a safety measure. Besides, the table also provides a clamping device since the current drilling machine has none yet. Furthermore, it can provide high accuracy results once some modifications are made.

ACKNOWLEDGEMENT

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