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# Design and Development of Fixable Clamping for Milling Machine Based on Machining Performance

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**Abstract**

Milling machine vise is one of the common clamping device used in the industry and for learning purposes. The purpose of milling vise is to reduce working time by permitting snappy set-up. It also functions as a supporter during the machining process and help to increase accuracy of the completed parts. However, limited surface of the work-piece can be cut in only one single clamping. This requires the operator to load and unload the clamping vise repeatedly. Obviously, the process is not effective and efficient. In this project, the design of the clamping is presented for flexible positioning of the work-piece during the machining process. This product will allow the manufacturer reduce their setup time and manual inspection. Portable Surface Roughness Tester, SJ-401 is used to evaluate the surface roughness of the work-piece. Delrin and aluminium are used as the work-piece.

**Keywords:** milling; flexible; clamping; work piece; vise; surface roughness

## INTRODUCTION

Milling process is one of the most important processes in manufacturing process in which it can make an assortment of elements on a material by removing the unwanted material. Thus, the milling process requires a milling machine, work-piece, fixture and cutter. There are many types of milling machine with different functions and characteristics namely, universal horizontal milling machine, ram-type milling machine, universal ram-type milling machine, knee-type milling machine, and swivel cutter head ram-type milling machine, etc (Milling, n.d.)[1]. Materials are removed from the work-piece by sustaining the work-piece into the rotating cutter as little chips form the wanted shape. This makes the manufacturing environment more competitive; an idea for new manufacturing systems is necessary to meet new challenges in order to survive and keep growth in the market. To overcome these diverse issues, technology support in improving flexibility and automation to enhance the manufacturing environment is required and becomes the main reason for the introduction of Flexible Manufacturing Systems (FMS) (Nurdin & Hakim, 2015)[2].

The operations that are often performed by a manufacturer in a milling machine are face milling, end milling, slotting, thread milling, plain milling and side milling, etc (Vukelic et al., 2012)[3].

The primary function of a clamping vise is to position and fix the workpiece. Once placed, the workpiece should be able to be controlled to stop movement throughout the process.When using the current vise on a conventional milling machine, the operator usually requires a lot of time to load and unload the work-piece into the milling machine. Obviously, the process is not effective nor is it efficient. This can affect the production output. The process requires a lot of manual labour to load and unload the work-piece. This can affect the quality of their work and also the quality of the product.

The main drawback of the clamping of this machine is it allows a limited surface of the workpiece to be cut in one clamp. This can increase the time setup of the clamping during machining process. Hence, this flexible clamping was developed with the following objectives:

1) To design a flexible clamping for milling machine.
2) To develop a flexible clamping for milling machine.
3) To evaluate the results of surface roughness by using the developed clamping device.

## RESEARCH METHODOLOGY

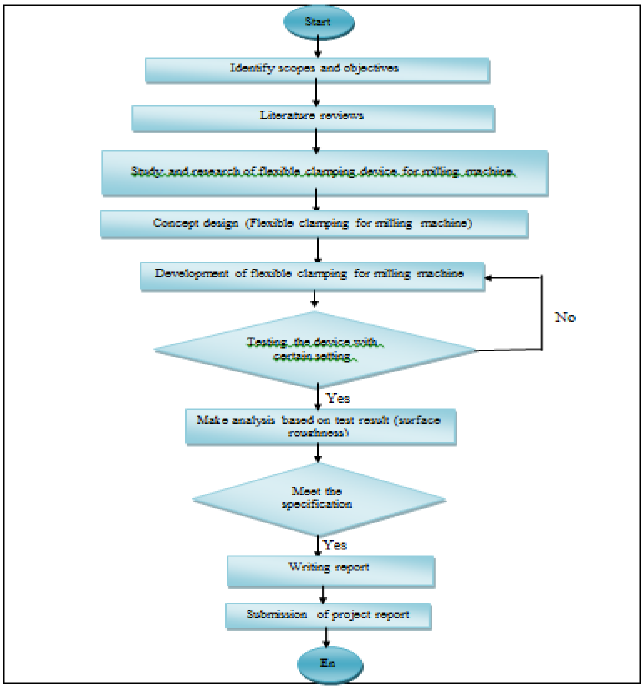



**Figure A:** Flow chart of research methodology

*A. Design of flexible clamping using CATIA software*

- In this stage, since the problem statement was well defined and all the variables related to the study were well established, the idea of product design was sketched.
- Next, a sketch of the product was drawn to solve the problem statement. Then, the sketch was redrawn by using CATIA software. Figure 1 shows the final expected product to be processed.

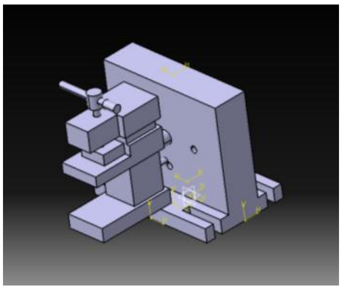


**Figure 1:** Design of flexible clamping using CATIA software

*B. Developement of flexible clamping*

- The machining processes which uses conventional machines that are available in the laboratory are milling machine, drilling machine and turning machine.
- Eight parts were developed.

*C. Surface roughness testing*

- The completed product was tested on the milling machine with certain setting parameters to compare with the current vise that uses the same setting parameters.
- The comparison was made based on the surface roughness of the work-piece between both clamping methods used.
- Two types of material were used in this testing namely, aluminium and delrin.
- Experimental setup :

**Assemble part**

**Base part**

**1)** Figure 2 shows that the part c (rod) was inserted into the fully threaded of center hole at part a (base).

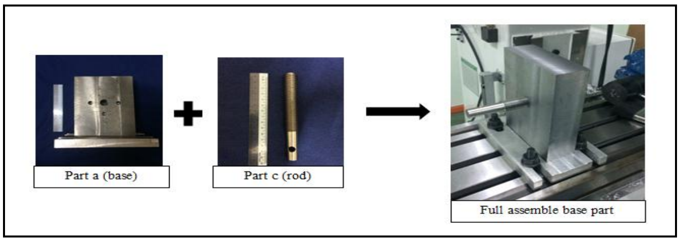



**Figure 2:** Full assemble of base part

**Clamping part**

**2**) Figure 3 below shows part c (clamp 2) and part d (clamp 1) were inserted first onto the part b (beam). Then, part h (pin) was inserted at the back of part b (beam). Lastly, part f (rod clamp) with fully thread on the rod was inserted into part d (clamp 1).

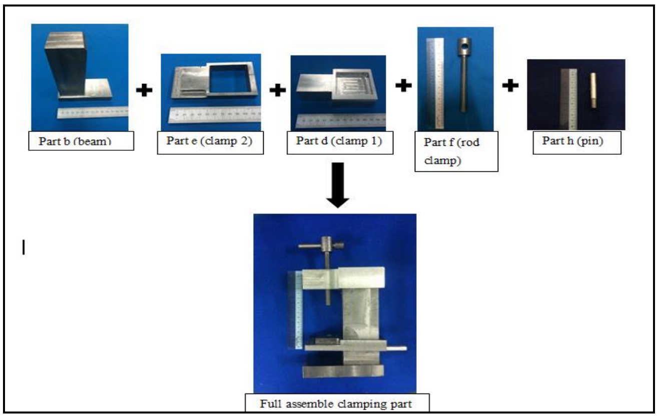



**Figure 3:** Full assemble of clamping part

3) After the base part and clamping part were assembled, the base part was checked for allignment process. The dial indicator was attached on the base part as shown in Figure 4 below.

**Figure 4:** Allignment process

(Clamp lever assemble)

4) In this assemble process, part g (clamp lever) have 2 functions as shown in Figure 5 and Figure 6. In Figure 5, it was inserted into the rod at the base part. Its function was to move the rod forward and backward. While in Figure 6, the clamp lever was inserted into the rod at the top of the clamping part and it had the same function of moving the rod, but this time, downward and upward.

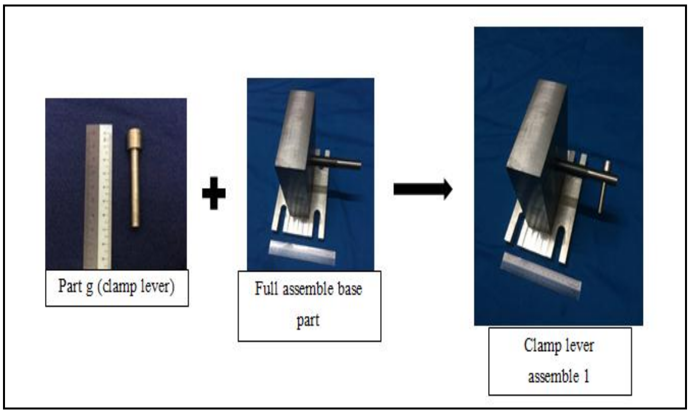



**Figure 5:** Clamp lever assemble 1

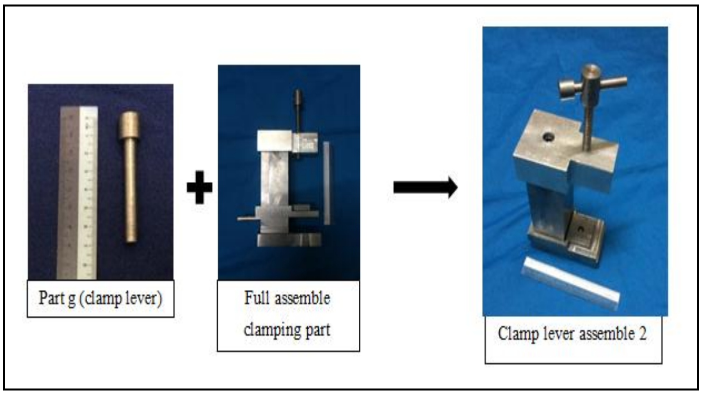



**Figure 6:** Clamp lever assemble 2

(Full assemble finish part)

5) After the base part and clamping part were assembled, both assembled parts were attached to each other by inserting the pin at the clamping part into the base part. Next, the rod at the base part was moved into the clamping part until both assembled parts were tightened as shown in Figure 7.

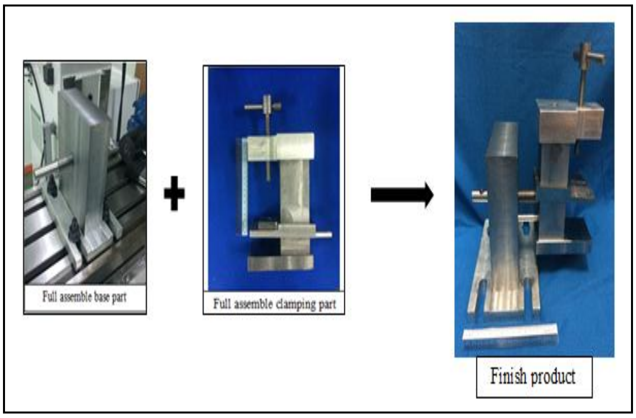



**Figure 7:** Assemble of finish product

6) After all the assembled parts were done, the work- piece was clamped and ready to be machined as shown in Figure 8 below.

**Figure 8:** Work piece clamp using flexible clamping

7) Next, the delrin work-piece was cut using face mill and work-piece, and then aluminium was used as a work-piece to be cut using face mill too.

8) The surface finish of the work-pieces that had been cut is shown in Figure 9, Figure 10, and Figure 11.

**Figure 9:** Delrin clamped using flexible clamping before rotation

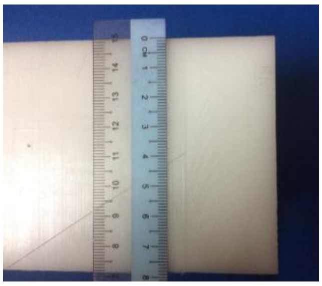


**Figure 10:** Delrin clampe using flexible clamping after rotation

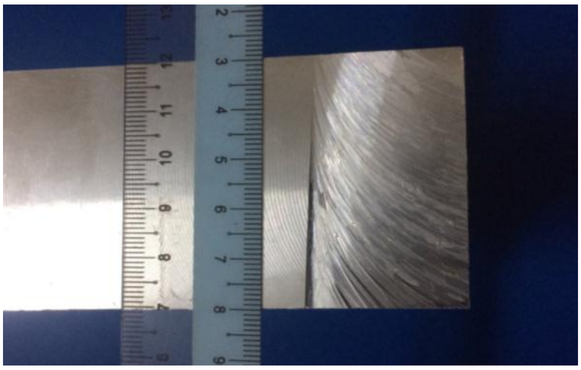


**Figure 11:** Aluminum clamped using flexible clamping

9) Next, another set of work-pieces comprising delrin and aluminum were also cut using face mill but clamped using the current vise. The cut work-pieces are shown in Figure 12 and Figure 13.

**Figure 12:** Delrin clamped using current vise

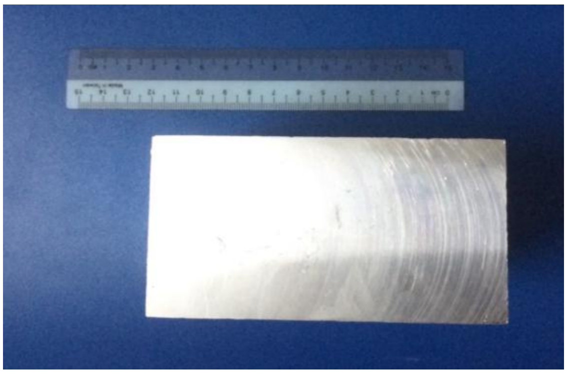


**Figure 13:** Aluminum clamped using current vise

10) The work-pieces were then tested on its surface roughness using Portable Surface Roughness Tester, SJ-401 as shown in Figure 14.

**Figure 14:** Portable Surface Roughness Tester, SJ-401

## RESULT AND DISCUSSION

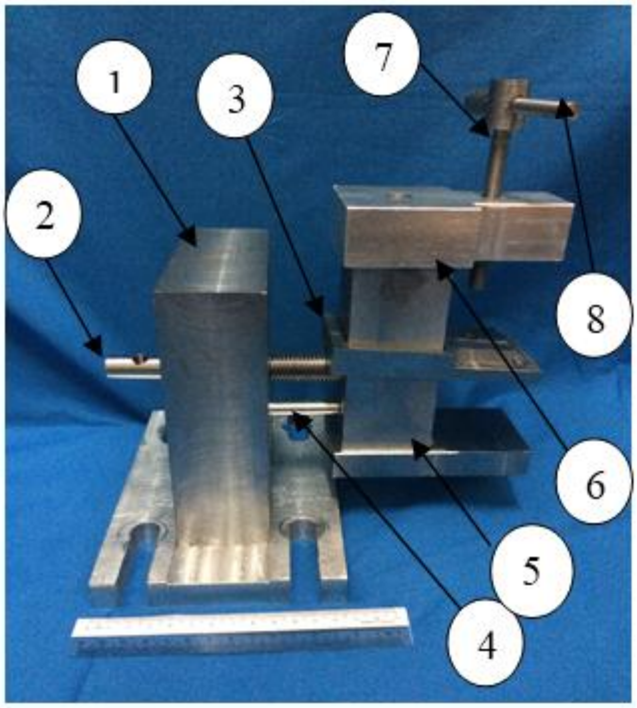



**Figure 15:** Developed flexible clamping

Figure 15 shows the developed flexible clamping after it underwent through all machining processes as planned, whereas Figure 16 shows all of the developed parts with their respective function.

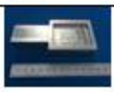
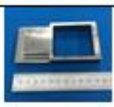
| No/Part Name | Figure | Function |
|---|---|---|
| Part a (base) 1 |  | -To support and hold the clamping part.<br>-The centre hole was fully threaded with diameter of 20mm.<br>-This part also was fixed on the milling table using bolt and nut. |
| Part b (beam) 5 |  | -To place the work piece that want to machine. |
| Part c (rod) 2 |  | -To rotate the clamping part. |
| Part d (clamp 1) 6 |  | -Act as a cover of the clamping part. |
| Part e (clamp 2) 3 |  | -Its function is to clamp the work piece. |
| Part f (rod clamp) 7 |  | -To press part e on the work piece. |
| Part g (clamp lever) 8 |  | -Act as a clamp lever at clamping part and base part. |
| Part h (pin) 4 |  | -To make the clamping part stable.<br>-Act as a marker of the clamping to be rotate perpendicular to the left and right of the base part. |

**Figure 16:** All developed parts

## DISCUSSION

### Part c (rod)

In this part, the changes were in its shape as shown in Figure 17 and Figure 18 below. The clamp lever in the initial planning was difficult to find. Therefore, the drawing was changed as shown in Figure 18. This developed rod was used with the same clamp lever as part F (rod clamp). The diameter of this rod remained at 20mm as same as the previous planning, but the length was changed from 175mm to 150mm.

**Figure 17:** Previous planning design of part c (rod)

**Figure 18:** Developed of part c (rod)

### Part h (pin)

The changes made were in the pin is its dimension and material. The length of the part was changed from 50mm to 65mm and the diameter also changed from 8mm to 10mm. It was because the limitation of tools to make thread for the part. The material was also changed from mild steel to aluminum as the latter was easier to work with.  Figure 19 and Figure 20 below show the previous planning of part h (pin) and developed of part h (pin) respectively.

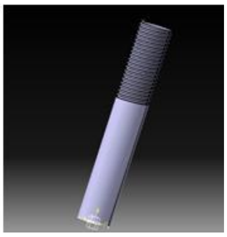


**Figure 19:** Previous planning design of part h (pin)

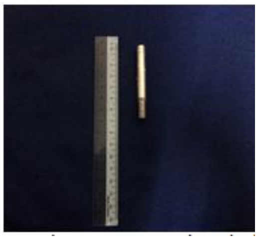


**Figure 20:** Developed of part h (pin)

### Part a (base)

In this part, the changes made were its dimensions and material. The material of the lower base was changed from mild steel to aluminum in order to reduce the time of machining process. Next, the dimension that was changed was in the upper base part. The length of the previous planning was changed from 198.5mm to 135 mm in order to minimize the cost and machining time. Besides that, the distance between pin holes and centre hole was changed from 35 mm to 31 mm. The diameter of pin hole was also changed from 8 mm to 10 mm. However, the pin hole was not perpendicular to the centre and it automatically made the clamping part tilted slightly and affected the surface finish of the work-piece.

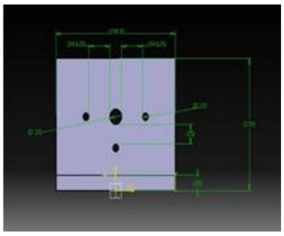


**Figure 21:** Previous planning design of part a (base)

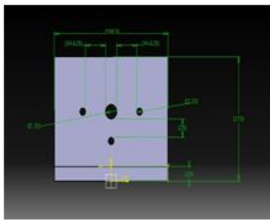


**Figure 22:** Developed of part a (base)

**Surface roughness testing**

*(Delrin as a work-piece)*

**Table 1:** Comparison of Ra value

| Reading | Ra value using current vise | Ra value using flexible clamping |
|---|---|---|
| 1 | 0.553 | 0.613 |
| 2 | 0.537 | 0.682 |
| 3 | 0.558 | 0.550 |
| 4 | 0.567 | 0.822 |
| 5 | 0.547 | 0.689 |
| 6 | 0.485 | 0.805 |
| 7 | 0.570 | 0.549 |
| 8 | 0.487 | 0.492 |
| 9 | 0.561 | 0.687 |
| 10 | 0.551 | 0.510 |
| Average | 0.542 | 0.640 |

Table 1 shows the average of Ra value by using the current vise as a clamping method was higher than using the flexible clamping which was 1.543 for the current vise, and 1.151 and 1.106 for the flexible clamping before and after rotation respectively. This proves that the flexible clamping can be used as a clamping method due to its better surface finish as compared to using the current vise.

*(Aluminum as a work-piece)*

**Table 2:** Comparison of Ra value

| Reading | Ra value using current vise | Ra value using flexible clamping | Ra value using flexible clamping-rotate left side |
|---|---|---|---|
| 1 | 1.484 | 0.639 | 0.917 |
| 2 | 1.469 | 1.958 | 0.812 |
| 3 | 1.764 | 0.599 | 1.282 |
| 4 | 1.431 | 1.097 | 1.292 |
| 5 | 1.739 | 1.194 | 1.228 |
| 6 | 1.737 | 1.323 | - |
| 7 | 1.410 | 0.980 | - |
| 8 | 1.495 | 1.244 | - |
| 9 | 1.418 | 1.278 | - |
| 10 | 1.481 | 1.194 | - |
| Average | 1.543 | 1.151 | 1.106 |

Table 2 shows the average of Ra value by using the current vise as a clamping method was lower than using the flexible clamping which was 0.542 as compared to 0.640. This proves that the surface finish when using the current vise is better than using the flexible clamping as a clamping method.

## CONCLUSIONS

Thisproject was developed to overcome the problem when using the current vise at a milling machine where there are limited surface that can be cut in one single clamp. This flexible clamping is able to rotate 90 degree for both sides. So, all surfaces of the work-piece can be cut in one single clamp. All three objectives were achieved when the flexible clamping for milling machine was designed and developed. The results of surface roughness were also evaluated by using this developed clamping device. When delrin was used as a work-piece, the results showed that the Ra value when using the flexible clamping was lower than the current vise. However, when aluminum was used as a work-piece, the Ra value using the current vise was lower than the flexible clamping. This proves that the rigidity of the flexible clamping is not good for hard material like aluminium as compared to soft material such as delrin.

## ACKNOWLEDGMENT

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