DESIGN AND DEVELOPMENT OF PORTABLE VACUUM CLAMPING (PVAC CLAMP) FOR TOOL ROOM

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Abstract: Clamping in tool room usually uses tools and holding devices such as vise to clamp workpieces. However, conventional clamping device such as vise is time consuming, expensive and can not hold thin workpiece. Therefore, this project presents the design and development of portable vacuum clamping (Pvac CLAMP) for tool room to overcome those limitations. To design and develop Pvac CLAMP, the machines used in the process are milling machine and drilling machine. After Pvac CLAMP had been developed, a test were carried on the Pvac CLAMP. The test was surface roughness measurement. The result shows that Pvac CLAMP has better surface roughness than the conventional vise about 40% reduction.

Keywords: Vacuum Clamping. Surface Roughness.

1.0 INTRODUCTION
Clamping is the process that holds the workpiece securely. Each clamping device and its location on the workholder is chosen carefully to ensure that it works properly. Figure. 1 shows Conventional Clamp on Milling Machine.

![Figure 1. Conventional Clamp on Milling Machine](image)

Clamps provide two main functions namely, to hold the piece of work against its locators and prevent the movement of the workpiece (Vukelic, et al, 2012). Clamps should resist the secondary cutting force.
When the cutting tools leave the workpiece, secondary cutting forces are generated. In drilling, for example, in the axis of the drill, the primary forces are directed down and radially. The secondary forces are generated when the part raises as the drill breaks through the alternative aspect of the half. The clamps need to be strong enough to secure the workpiece against the locators and also resist the secondary forces (San-juanat et al., 2015).

To select a clamp, the next factor to be considered is the stress and vibration expected in the process. In some operations, the vibration can loosen the workpiece from the workholding (Klotz et al., 2014). A safety margin can be added to estimate the force acting on the clamp and study the effect of cutting parameters (Chawale et al., 2013).

Clamping the workpiece may damage the workpiece therefore a correct clamping method must be implemented. Damage to the workpiece can occur commonly due to too much clamping force acting on the workpiece (T V Harini et al., 2014). Common damage to the workpiece are marring and distortion. The process to clamp and unclamp must be fast to increase the productivity of the overall process and save time. Labor cost will also be reduced and productivity increased. In milling machine process, there are four common clamping methods namely, vises, v-blocks, angles plates and mounting to the table. Current techniques of conventional clamping are unsuitable for the future since they present a number of drawbacks, such as reduced accuracy due to elastic deformation of the parts, less adaptability to complex shapes, and high costs of specific tools for each operation. (Yangui, H. 2010)

2.0 RESEARCH METHODOLOGY

2.1 Design of PVac CLAMP
In this stage, based on the information in conventional vises, a sketch was drawn for the design of the PVac CLAMP. The sketch was redrawn using Catia V5 software as illustrated in Figure 2.

![Figure 2. PVac CLAMP CAD Model (isometric view)](image)

2.2 Material Solution of Design
Materials and tools needed in developing the vacuum clamping were first identified. Aluminium was chosen as the main material due to ease of machining and being light in weight.

2.3 Development of PVac CLAMP
The machining process for each part of the PVac CLAMP are completely used the milling machine. Processes included were milling and drilling.

2.4 Evaluation of PVac CLAMP
The surface roughness testing was conducted to evaluate the vacuum clamping. Testing was done on aluminium and delrin workpieces. The experimental setup was depicted in both Figure 3 and Figure 4, respectively where Part 1 and Part 2 were assembled using four screws. Next, the assembled parts were then attached to the milling table using bolts and nut, as shown in Figure 5. The device was then connected to the vacuum pump using pneumatic hose as depicted in Figure 6.

A sealing cord was placed on the PVac CLAMP according to the size of the workpiece as shown in Figure 7. The workpiece was then placed on the PVac CLAMP and the vacuum pump was turned on to complete the clamping process as illustrated in Figure 8. Finally, the workpiece was cut using the face mill. The workpieces were tested on their surface roughness using the Portable Surface Roughness Tester, SJ-401.
3.0 RESULT AND DISCUSSION

Table 1 shows the result of surface roughness of the workpiece clamped using PVac CLAMP and conventional vise. From the table, the average arithmetic mean value, Ra for Delrin clamped using conventional vise is 1.943 micrometer. The surface roughness of Delrin clamped using PVac CLAMP is lower 40% than using conventional vise.
Table 1. Result of surface roughness on Delrin

| Reading number | Arithmetic mean value, Ra |
|----------------|--------------------------|
|                | Conventional vise | Vacuum clamping |
| 1              | 2.031                | 1.245           |
| 2              | 2.023                | 1.358           |
| 3              | 1.874                | 1.243           |
| 4              | 1.863                | 1.357           |
| 5              | 1.882                | 1.018           |
| 6              | 2.008                | 0.936           |
| 7              | 1.923                | 0.920           |
| Average        | 1.943                | 1.154           |

4.0 CONCLUSION
The result of the surface roughness showed that the workpiece that was clamped with vacuum clamping had lower Arithmetic mean value, Ra as compared to using conventional vise. The surface roughness of workpiece clamped with vacuum clamping, which was lower than the use of conventional vise for aluminium, proves that there is less vibration on the workpiece clamped using vacuum clamping during the milling process.
From this result, it is clear that the vacuum clamping is reliable and able to achieve the objective in clamping workpiece for the milling machine. Thus, all objectives of this study had been achieved.

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