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JIG FOR CLAMPING THE CHUCK DURING MILLING

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Abstract

Nowadays, production processes are very demanding to constantly improve productivity, reduce the energy and ecological load and strive for the highest possible efficiency of the entire process. One of these aspects is precisely the reduction of secondary times when clamping the workpiece or fixtures. For example, clamping a universal chuck when milling on the table of classic machine tools or multi-axis milling centres. This issue is also related to many other companies that deal with piece or small-batch production of milled flat surfaces on rotary components. The aim of this article is to present a clamping jig that improves the clamping of chucks on the machine table, but at the same time it can be used for clamping other components or fixtures. The article deals with the principle of the product's function and the possibilities of its use in practice.

Keywords: Universal chuck; Clamping; Milling; Clamping jig

1. Introduction

At the Department of Machining Technology of the Faculty of Mechanical Engineering of the University of West Bohemia in Pilsen, a requirement arose for a solution to the problem of clamping a universal chuck during milling on the table of conventional machine tools. This problem is also faced by many other companies involved in piece or small batch production of milled planar surfaces on rotating components.

The universal chuck is used for clamping rotary components mainly on lathes. However, in many cases the use of a chuck is necessary for milling flat surfaces on rotating components, where the universal chuck is also widely used. It simplifies workpiece alignment and at the same time ensures a sufficiently rigid clamping [1], [2], [3].

The universal chuck is usually clamped to the milling machine table by two or three clamps secured by screws in the T-slots. This method of clamping can also be used in combination with a rotary table, mostly used on manual machine tools. Since the shape and design of the universal chuck is primarily adapted for clamping to the lathe spindle, clamping the chuck to the milling machine table presents several problems [1], [2], [3], [4], [12].

The aim of this bachelor thesis is to propose a design solution-fixture for simple, rigid, and fast clamping of universal chucks on milling machine tables. This task was directly assigned by the Department of Machining Technology of the University of West Bohemia in Pilsen.

2. Determination of the requirements for the new product design

The design of the universal chuck is mainly adapted for turning, where the chuck rotates together with the workpiece, or the main cutting motion is performed by the workpiece. It is clamped by means of screws for which threaded holes are formed on the rear wall of the chuck. This assembly is clamped to the flange, which is part of the lathe spindle, by means of these screws. However, in a number of cases, the use of a universal chuck is necessary in milling, where the chuck must also be clamped, but in this case on the machine table [1], [5], [6], [7], [12], [13].

In the current state, the chuck is clamped in small batch and piece production mainly by two or three flat or adjustable clamps supported by washers that approximate the height of a universal chuck.

In some cases, the machine operator has made special clamping stones for a specific chuck. This method of clamping is much faster compared to using flat chucks. The big disadvantage of this method is that it is limited to one specific height or can only be used to clamp one type of chuck [5], [6], [7], [12], [13].

Description of the process of simultaneous clamping of the chuck with flat clamps on the machine tool table

- Placing the chuck on the machine table
- Insertion of 2 T-nuts into the table grooves
- Assembling 2 washers close to the height of the chuck
- Placing the flat clamp on the chuck and washer
- Pushing the bolt through the clamp and screwing it into the T-nut
- Comparison of chucks and clamps on the machine table
- Tightening the screws

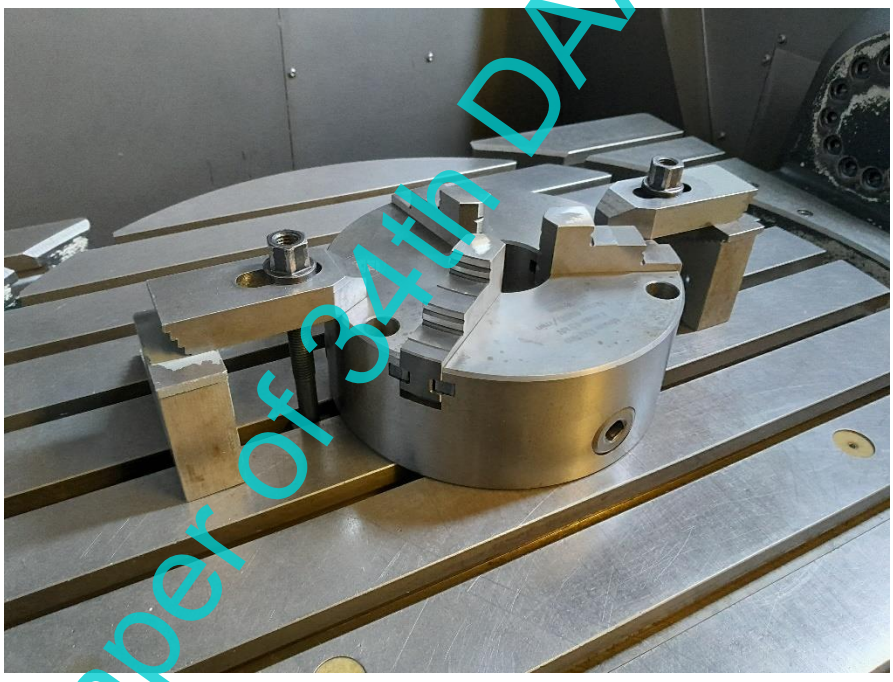

Fig. 1. Clamping the universal chuck with flat clamps

According to the experience of the machine tool operator, the conventional method of clamping by means of clamps is laborious and lengthy, due to which the lead time for clamping the chuck is significantly extended, which is approximately 5 minutes. A further complication is the protruding part of the screw above the chuck and the long end of the chuck which is remote from the chuck and its length is not precisely defined. These facts complicate work especially on 5-axis and multi-axis milling centres. When tilting and rotating the table, care must be taken to ensure that the tool does not hit the protruding screw above the chuck and the protruding end of the chuck next to the chuck when machining or travelling in a rapid feed.

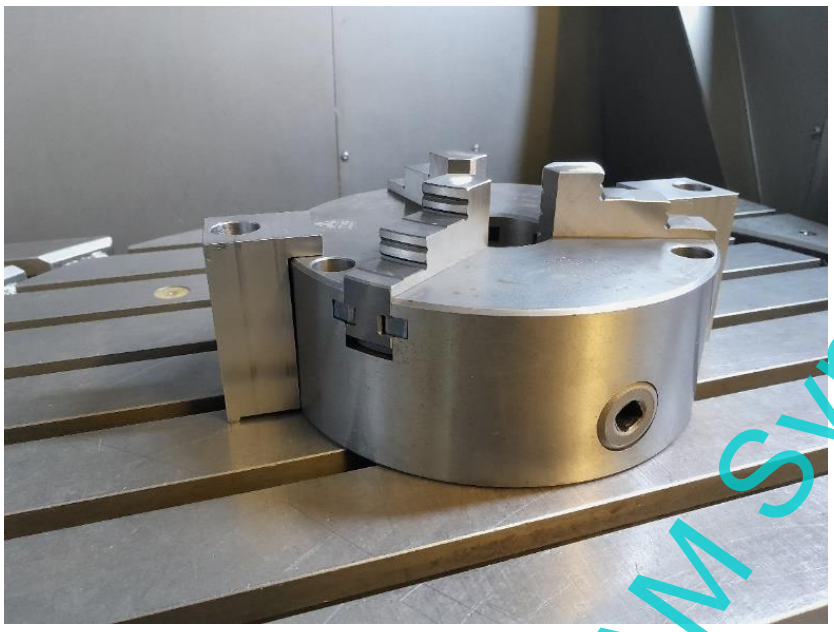

Fig. 2. Another way of clamping the universal chuck with clamping stones

Determination of points for a new clamping solution

a) Time-consuming clamp assembly

The new clamping design should be easy and quick to assemble, thus significantly reducing lead times. Consequently, the financial costs of clamping the chucks will also be reduced.

b) Incorrect chuck alignment

In the case of chuck clamping, it is very difficult and laborious to set the chuck in the same position when re-clamping. The new design should make it more accurate and easier to position the chuck when re-clamping.

c) Laborious assembly of the pad under the clamp

For the correct functioning of the flat clamp, it is necessary to support the opposite side, in relation to the clamped part, so that both ends lie at the same height from the machine tool table surface. The new clamping method could ideally eliminate this action or at least reduce the laboriousness of assembling the washer.

d) Protruding screw above the clamp

In the case of a flat clamp, the clamping force is exerted by tightening a bolt or nut (when using a clamp bolt), the head of which, however, protrudes above the clamp. This is a complication especially on multi-axis machine tools when tool passes and workpiece tilting. As machining centres are now a common part of production, the new design should ideally not protrude too much or only minimally.

e) Preservation of partial universality

In this case, this feature is perfectly fulfilled by clamping with flat clamps and it would be advisable to maintain it when designing a new fixture. After consultation with the machine operator, it was found that the most used types of universal chucks clamped on the milling machine table are: 80, 100, 160, 200, 250. As mentioned above they differ not only in outer diameter but also in width. That is why the new design of the jig should be applicable in this range of universal chucks.

3. Design of the adjustable jig

One suitable solution for clamping the universal chuck is by means of an adjustable jig, which is guided by a flat guide. The name Cobra was chosen from the upper part of the jig, which resembles the head of a snake. The clamping force is exerted by tightening a screw passing through the jig [6], [8], [9], [10], [11].

The fixture consists of sliding member 1, fixed member 2, and screw 3, member 4 is a universal chuck TOS IUS200 whose height is 76mm. The individual parts are better seen in Figure 3, where the individual parts are shown. [6], [8], [9], [10], [11]

The clamping surface on member 1 is intentionally not milled perpendicular to the guide, it is milled at a 4° angle due to the clearance in the flat guide and the clearance between the T-slot and the T-nut. This design feature ensures that when the bolt is tightened and member 1 is tilted, the clamping force at the end of this face is still perpendicular to the milling

machine table and does not "push" the chuck out of the jig. Another design element on member 1 is the U-shaped milled area, which is designed to centre the chuck in the axis of the jig, thus simplifying the adjustment during re-clamping [6], [8], [9], [10], [11], [13].

The product provides chuck clamping from a height of 45mm to 82mm, or the most used chucks clamped on milling machine tables from 80mm to 250mm diameter (6 chuck bits). It can also be combined for different sizes of T-slots in machine tables. Depending on the size of the T-slot, the size of the clamping screw can also be varied, as well as the size of the entire jig [6], [8], [9], [10], [11], [13].

This jig can be used to clamp any workpiece that has a plane surface height from the machine table within the jig's adjustability range. To increase the clamping range, it would be a good solution to produce this fixture in sets.

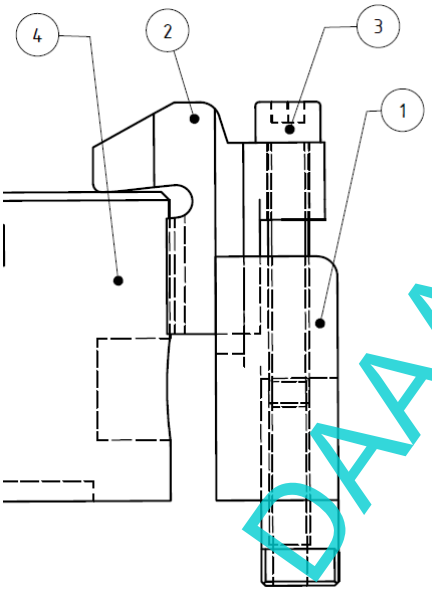

Fig. 3. Adjustable jig

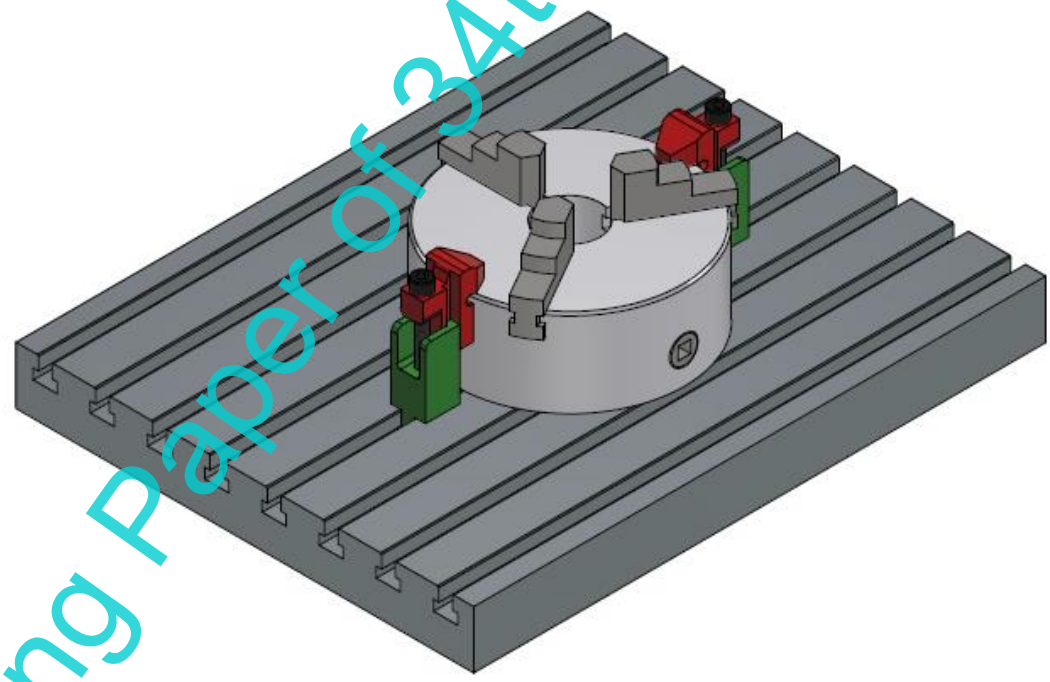

Fig. 4. Model of the adjustable jig with chuck

4. Design of the adjustable jig for tighter clamping

To ensure a tighter clamping or to be used as a stop in combination with the above-mentioned fixture, a variant of the adjustable clamping fixture with an extended seating area to the machine table and a hole for an M10 screw, which is tightened by means of a conventional T-nut to the machine table, was also designed. The sliding member and the hexagon socket head screw are identical to the previous design.

The assembly of this type of fixture is shown in Fig. 5. The main disadvantage of this type of fixture is the increased clamping time for tightening the two additional M10 screws, however, this fixture can be used without the M10 screws in the same manner as the previous adjustable fixture design. However, due to the extended seating area, the tilting of the entire jig is reduced when tightening the M10 hexagon socket head screw. As a result, this type of jig has a more versatile application compared to the previous type.

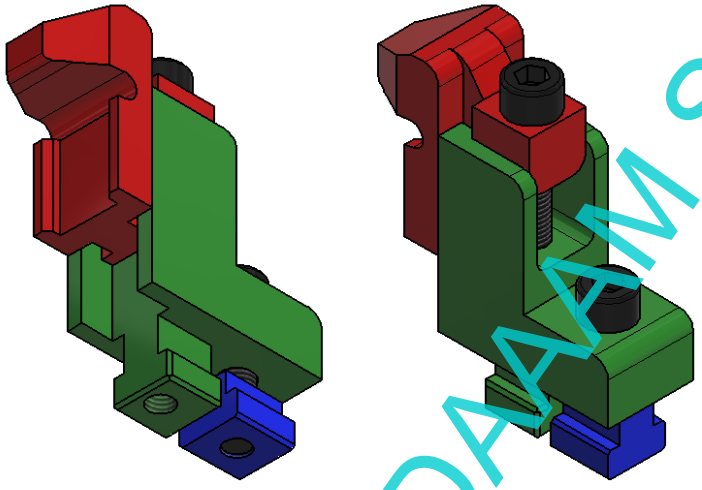

Fig. 5. Adjustable jig for tighter clamping

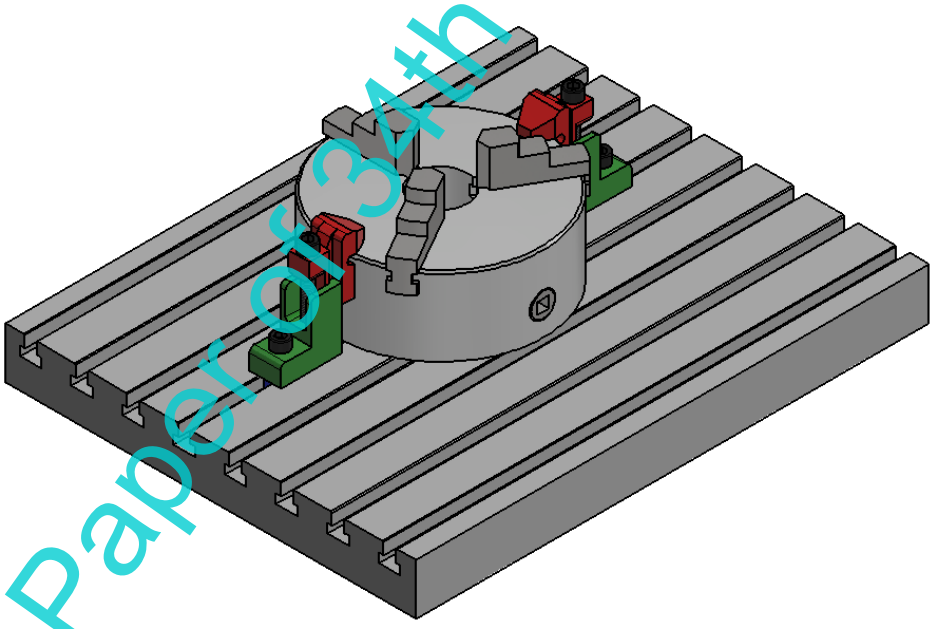

Fig. 6. Model of the adjustable jig with chuck for tighter clamping

5. Prototype production using 3D printing

To produce the prototype of the selected product, a currently widely used technology was chosen, namely 3D printing of plastics. Figure 7 and Figure 8 below show the fixture assembly produced by 3D printing that clamps the TOS IUS 160 universal chuck. Unfortunately, using this manufacturing method, the correct manufacturing tolerances of the fixture cannot be determined because this type of 3D printing of plastic is not accurate enough, the plastic curls due to temperature, and the roughness of the seating surfaces is also much worse than indicated in the drawing. However, to introduce the idea and function of the design, this prototype is quite sufficient [6], [8], [9], [10], [11].

Fig. 7. Universal chuck TOS 160 with prototypes of adjustable jig

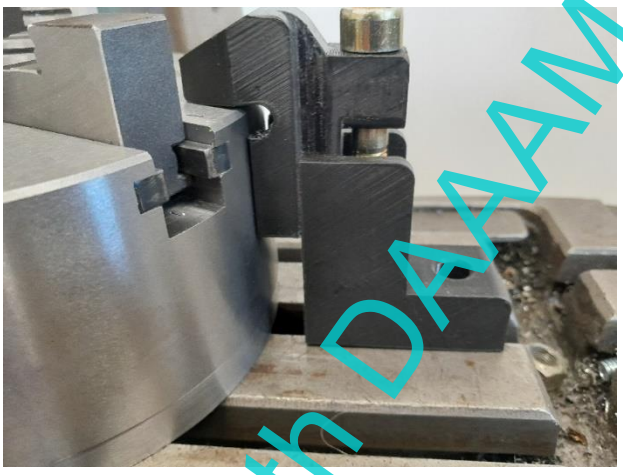

Fig. 8 Detail of the model of the adjustable jig

6. Conclusion

The article discusses a practical solution to address the challenges associated with clamping universal chucks for milling on conventional machine tools. This issue is relevant not only to academic institutions, such as the University of West Bohemia in Pilsen but also to numerous companies involved in piece or small-batch production of milled planar surfaces on rotating components. The existing method of clamping universal chucks with flat clamps is time-consuming and has several limitations, including difficulty in chuck alignment, laborious assembly of support pads, and protruding screws that can interfere with the machining process, especially on multi-axis milling centres. To overcome these challenges, a new clamping solution called the "Cobra" jig was proposed, which aims to simplify, expedite, and improve the clamping process. The "Cobra" jig is designed to be adjustable, accommodating a range of universal chuck sizes and heights, making it a versatile solution for a variety of milling applications. Additionally, a variant of the adjustable clamping fixture was introduced for tighter clamping and as a stop, enhancing its flexibility and usability. To validate the design concept, a prototype was produced using 3D printing, although it had some limitations in terms of manufacturing tolerances and surface quality. Nonetheless, it effectively showcased the functionality of the design. This article highlights the importance of innovation in manufacturing processes to improve productivity, reduce setup times, and enhance efficiency. The "Cobra" jig represents a step forward in addressing clamping challenges in milling operations, offering a promising solution for both academic and industrial settings. Further development and refinement of the design may lead to significant improvements in the clamping processes for universal chucks, benefiting the broader manufacturing community.

7. Acknowledgements

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