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A Simple and Reliable Eccentric Locking Mechanism

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Abstract

In view of the time-consuming and unreliable deficiencies of the cross-axis work piece in the clamping process, combined with the working characteristics of the eccentric mechanism, a simple and fast eccentric locking mechanism is designed. The push rod is quickly driven by the combined action of the handle and the drum, so that the cross shaft work piece can be quickly locked in the axial direction. The eccentric locking mechanism not only has simple operation and convenient maintenance, but also has the characteristics of low manufacturing cost and high life, and has certain reference value for future special fixture design.

Keywords: *cross shaft, eccentric mechanism, locking mechanism, special fixture*

1 Introduction

The cross shaft is a fundamental component extensively utilized in various mechanical transmission systems [1]. Its primary function is to endure bending moments and torques during power transmission, thereby ensuring the efficiency and stability of the system. Due to its critical role, the machining and heat treatment processes of the cross shaft are paramount to its overall performance and durability [2].

In conventional manufacturing processes, securely and efficiently clamping the cross shaft workpiece presents significant challenges [3]. Traditional clamping methods often involve the use of large nuts for axial positioning, a technique that can be both time-consuming and potentially unreliable during high-volume production runs [4]. This approach can lead to inefficiencies in the manufacturing process, and in some cases, even accidents if the workpiece is not adequately secured. Traditional methods may fail to provide sufficient locking force, resulting in misalignment or movement during machining, which adversely affects the precision and quality of the finished component [5-7]. Hence, it is imperative to develop an improved clamping mechanism that ensures quick, reliable, and robust fixation of the cross shaft workpiece [8].

The reliance on large nuts and similar conventional locking methods can be cumbersome and inefficient, especially in high-volume manufacturing settings. The manual effort required to secure and release these nuts not only slows down the production process but also introduces variability in the clamping force applied [9]. This variability can lead to inconsistent machining results, where the precision and quality of the cross shaft are compromised. Moreover, in scenarios where the locking force is insufficient, there is a heightened risk of the workpiece shifting during the machining process, which can result in defective products and potential safety hazards [10].

To address these challenges, it is essential to explore alternative clamping mechanisms that can offer more consistent, reliable, and efficient performance [11]. The eccentric mechanism, known for its simplicity and effectiveness in various mechanical applications, presents a promising solution [12]. An eccentric mechanism operates on the principle of using a driving and a rotational locking mechanism that are not coaxial [13-17]. This unique arrangement allows for significant motion amplification from minimal input movement, making it particularly suitable for applications that require rapid and secure locking.

Integrating the eccentric mechanism into the design of a specialized fixture for the cross shaft can significantly enhance the clamping process [18]. The proposed design leverages the inherent advantages of the eccentric mechanism to develop a straightforward, fast, and reliable locking system. This system comprises a handle, roller, and support structure that collaborate to drive a push rod, thereby securing the cross shaft axially. The innovative approach aims to reduce setup times, improve locking force, and ensure consistent precision during machining operations, particularly when drilling

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the Φ8 hole in the cross shaft.

Through detailed analysis and rigorous testing, this paper demonstrates that the eccentric locking mechanism simplifies operation and maintenance. Additionally, it reduces manufacturing costs and extends the fixture's lifespan. The findings underscore the potential of this mechanism to serve as a valuable reference for future fixture designs in similar applications. This advancement paves the way for enhanced efficiency and reliability in mass production environments, marking a significant improvement over traditional clamping methods.

By implementing this novel clamping mechanism, manufacturers can achieve more reliable and efficient production processes, ultimately contributing to higher quality components and reduced operational risks. This paper highlights the critical aspects of the design and testing phases, providing comprehensive insights into the practical benefits and potential applications of the eccentric mechanism in mechanical transmission systems. The success of this innovative approach underscores the importance of continuous development and optimization in manufacturing technologies to meet the evolving demands of modern engineering and production.

2 Cross Shaft Workpiece Analysis

Considering the process requirements of the cross shaft, a special fixture needs to be designed for the machining of the Φ8 hole [19]. The part drawing of the cross shaft is shown in Figure 1.

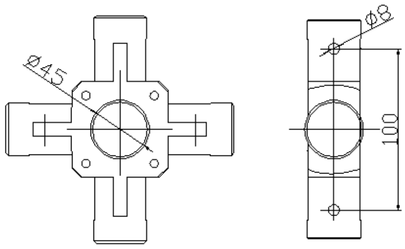


Figure 1 Part Drawing of the Cross Shaft Workpiece

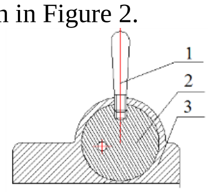
According to traditional clamping methods, a Φ45 hole is typically used for axial positioning, and the workpiece is rotationally constrained using a limit groove [20-22]. After positioning the workpiece, the simplest way to lock it is by using a large nut that fits with the Φ45 positioning shaft; rotating the nut secures the workpiece. However, cross shaft parts are widely used and usually need to be produced in batches. If the aforementioned method is used to lock cross shaft workpieces, the loading and unloading process becomes cumbersome, and there is a risk that the locking force may be insufficient, potentially leading to accidents.

In traditional methods, manually rotating the large nut during loading and unloading is time-consuming, affecting production efficiency [23]. This method is particularly inconvenient in batch production [24]. Additionally, the manual operation may result in an unstable locking force, which could loosen during production, causing the workpiece to shift or even fall, leading to safety hazards and quality issues.

To address these problems, this paper designs a simple and fast locking mechanism based on the principle of the eccentric mechanism. The eccentric mechanism generates locking force through changes in the eccentric distance, enabling quick and reliable locking. Compared to the traditional method of locking with a large nut, the eccentric mechanism offers advantages such as ease of operation, stable locking force, and strong adaptability. The use of an eccentric mechanism significantly reduces the loading and unloading time of the workpiece, improves production efficiency, and ensures the reliability and safety of the locking process.

3 Principle of the Eccentric Mechanism

The eccentric mechanism primarily operates by using a driving mechanism and a rotational locking mechanism that are not coaxial [25]. The structural principle is shown in Figure 2.



1-Handle; 2-Roller; 3-Support

Figure 2 Principle of the Eccentric Mechanism

From Figure 2, it can be seen that the eccentric mechanism is designed to be simple yet effective, consisting of core components such as the handle, roller, and support. The handle is the driving component in the eccentric mechanism, used to apply external force [26]. When force is applied to the handle and it begins to rotate, it will drive the movement of the eccentric axis. The roller serves as the rotational locking component. There is typically an eccentric axis hole on the roller, used to connect other structural components of the mechanism and achieve eccentric motion. The base acts as the fixed component of the eccentric mechanism, providing support for the roller and other moving parts to ensure stability and reliability of the mechanism. During machining and assembly, it is common to thread the handle and roller together to ensure their coordinated operation. Once external force is applied to the handle, it begins to rotate, activating the eccentric shaft hole on the roller. This action initiates the movement of the mechanism connected to the roller, thereby enabling eccentric motion of the entire mechanism [27].

One of the advantages of the eccentric mechanism is its simple and easy-to-manufacture structure, along with rapid operation. Even when the handle is rotated at a relatively small angle, it can generate a large range of motion within the mechanism connected to the roller. This characteristic allows the eccentric mechanism to quickly and effectively tighten and secure the workpiece, thereby improving work efficiency.

Furthermore, due to its relatively small space occupation, the eccentric mechanism offers greater flexibility in design and layout. This versatility enables the eccentric mechanism to be widely used in various engineering and mechanical applications, making it an ideal choice for solving complex workpiece fixation and positioning problems.

4 Application of the Eccentric Mechanism in Fixture Design

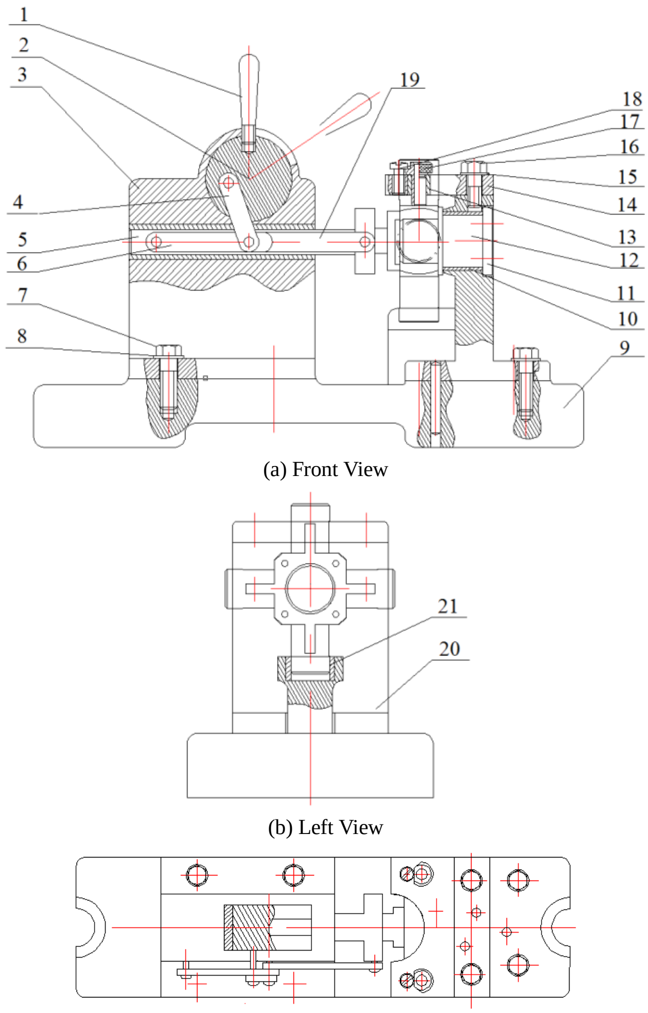
Through the analysis of the cross shaft workpiece, when machining the Φ8 hole on the cross shaft, in order to achieve rapid and efficient positioning of the cross shaft, the following strategy is adopted based on the characteristics of the eccentric mechanism for positioning and tightening the cross shaft workpiece [28-30]:

(1) Use the Φ45 hole and the frame to provide axial positioning and axial movement restriction for the cross shaft.

(2) Utilize a limit groove to restrict the rotation of the cross shaft around the axis of the Φ45 hole. To ensure proper positioning, the limit groove needs to be of a through-hole type.

(3) Incorporate the features of the eccentric mechanism by adding a connecting rod on the roller of the eccentric mechanism. With the action of the handle and roller, the push rod can move along the axis of the Φ45, thereby locking the cross shaft.

The application of the eccentric mechanism in the specialized fixture for the cross shaft is shown in Figure 3.



(a) Front View

(b) Left View

(c) Top View

1- Handle; 2- Roller; 3- Support; 4- Connecting Rod; 5- Shaft; 6- Push Rod; 7- Bolt; 8- Washer; 9- Base; 10- Liner; 11- Cover Plate; 12- Positioning Pin; 13- Drill Sleeve Liner; 14- Drill Template; 15- Thick Washer; 16- Bolt; 19- Connecting Rod; 20- Support Plate; 21- Groove Liner

Figure 3 Application of the Eccentric Mechanism in the Fixture

To efficiently achieve the machining of the Φ8 hole while ensuring accuracy, it is necessary to design a quick-change drill sleeve structure. Considering that this part is typically produced in large quantities, the fixture design needs to incorporate a quick-change drill sleeve on the drill template. The structure is shown in Figure 4.

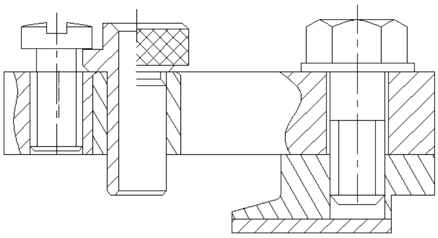


Figure 4 Schematic Diagram of Quick-Change Drill Sleeve

Through the manufacturing and testing of this specialized fixture, it has been shown to effectively improve machining efficiency while enhancing the reliability of the clamping process. This fixture design serves as a valuable reference for future similar designs.

4 Conclusion

Initially, the study identified the inefficiencies of the conventional machining process for cross shafts, highlighting its time-consuming nature and low reliability. Drawing upon the principles of the eccentric mechanism and recognizing the mass production requirements of cross shafts, the research team developed a straightforward, swift, and dependable eccentric mechanism. Following this, extensive analysis and practical experimentation were conducted to validate the efficacy of this clamping technique. The results not only confirmed the simplicity and ease of operation of the proposed method but also underscored its robustness and reliability. Additionally, the study emphasized the potential applicability of the eccentric mechanism in similar fixture designs, offering a framework for future optimization endeavors in this domain.

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