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Design a Special Fixture for Tractor Lever

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Abstract

Aiming at the problems of long time and poor machining precision in processing the tractor lever workpiece, a special fixture suitable for the tractor lever workpiece is designed by analyzing the processing technology of the lever workpiece, and the workpiece is accurately positioned and tightened under the action of the special fixture. Efficient machining of the workpiece can be achieved by using a drill template. The fixture not only has the advantages of high production efficiency, low cost and high life, but also effectively improves the processing technology of the workpiece, and has certain reference value for the subsequent fixture improvement design.

Keywords: *tractor lever; special fixture; drill template*

1 Introduction

1.1 Classification of fixtures

Machine tool fixtures according to the use of machine tools can be divided into lathe fixtures, milling machine fixtures, drilling machine fixtures, boring machine fixtures and grinding machine fixtures. Machine tool fixtures according to its general characteristics can be divided into general-purpose fixtures, special fixtures, adjustable fixtures, combined fixtures and production line fixtures, mainly reflecting the characteristics of the fixtures in different types of production.

1.2 Introduction to specialized fixture

Specialized fixtures are designed and manufactured for a certain process of machining parts, they are used in the production of relatively stable products and large batches. Special fixtures can effectively reduce the labor intensity at work, improve labor productivity, and obtain higher machining accuracy. These fixtures are usually composed of positioning elements, clamping devices, tool guidance elements, indexing devices, connecting elements and clamping specific, for a certain kind of product parts in a certain process of clamping needs to be specially designed and manufactured, the object of the service is dedicated to a very strong target.

Specialized fixtures of various types, including but not limited to lathe fixtures, milling machine fixtures, drilling molds, boring molds and fixtures with the line. These fixtures can be used to replace or adjust components as needed, and consist of standardized components of different shapes, sizes, and uses, and are suitable for single-piece, small-batch production of new products for trial production and frequent product replacement, as well as for temporary tasks. Machine tool fixture is an indispensable process equipment in modern production, which directly affects the precision of processing, labor efficiency and product cost.

1.3 Research status of specialized fixtures

The research of special fixtures is involved both at home and abroad, mainly including the following aspects: design optimization and intelligence, material and manufacturing technology, flexible fixtures, digital technology application, standardization and normalization.

For different workpieces and production requirements, researchers are committed to optimizing the design of fixtures so that they can improve productivity and machining accuracy. At the same time, through the introduction of sensors, control systems and machine learning and other technologies, to realize the intelligence of the fixture, so that it can adapt to different workpieces and machining conditions. In addition researchers are exploring new materials and manufacturing technologies to improve the performance and durability of fixtures.

With the change of production demand and the increase of personalization, flexible fixtures have become one of the hot spots of research. This kind of fixture has a strong adaptive ability, can quickly adjust and adapt to the shape and size of different workpieces,

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so to improve the flexibility and efficiency of the production line. Digital technology is also widely used in the research of special fixtures. These technologies can help engineers design and optimize fixtures, identify potential problems in advance, and optimize the production process. And in order to improve the interoperability and universality of fixtures, some international organizations and standardization agencies are also promoting the standardization and normalization of special fixtures to promote technical exchanges and cooperation within the industry. In general, the research status of special fixtures is constantly developing in the direction of intelligence, flexibility and digitization, aiming to meet the increasingly complex production needs and improve production efficiency [1-4].

1.4 Specia fixture for tractor lever

The primary function of lever parts is to support and secure components; and they are one of the core components of tractor engines. With nation's increasing emphasis on agriculture, and considering that tractors are crucial machinery and equipment in agricultural production, so the demand for lever parts has gradually increased. To address the issue of multiple processes in lever parts, multifunctional fixtures have been adopted internationally for clamping workpieces, and they have already been applied on CNC machine tools. However, due to the typically high costs of multifunctional fixtures, their demand remains relatively low among small and medium-sized enterprises. In nation's small and medium-sized enterprises, products are usually processed using a multi-process, multi-fixture approach.

For certain processes, specialized fixtures are often used for clamping and machining workpieces to reduce auxiliary processing time and improve machining accuracy [5-8]. Considering the characteristics and precision requirements of tractor lever workpieces, a set of specialized fixtures has been designed to achieve efficient and cost-effective machining, thereby meeting the product's precision requirements.

2 Analysis of Lever Workpieces

2.1 The importance of tractor levers

Special fixture for tractor levers has a great role in the field of agricultural machinery. Tractor levers are one of the key components of the tractor, and their quality and precision directly affect the performance and lifetime of the tractor. The use of special fixtures can ensure the machining accuracy and consistency of the lever, thus improving production efficiency and reducing human errors and losses in the production process.

Specialized fixtures can ensure stable clamping of tractor levers during machining, avoiding machining errors and quality problems caused by unstable clamping. Through accurate clamping and positioning, the size and shape of the lever can be ensured to meet the design requirements, thus ensuring the quality of the product. Although the design and manufacture of specialized fixtures may require a certain cost investment, the total production cost can be reduced by improving productivity and product quality, which can reduce the scrap rate and rework rate during the production process. Specialized fixtures can reduce the risk of accidental injury by reducing direct worker contact during the machining process. Through automated clamping and machining, the safety of the work environment can be improved and the health of workers can be protected. Therefore, special fixtures for tractor levers are important in improving production efficiency, ensuring product quality, reducing production costs and enhancing worker safety, and have a positive impact on the development of agricultural machinery manufacturing enterprises [9-10].

2.2 Structural shape of the tractor lever

The structural shape of a tractor lever can vary depending on the model and function, but it usually has the following characteristics: body part, connecting joint, supporting structure, adjusting device, and surface treatment.

Body part: the body of a tractor lever is usually a long or curved shaped member that connects to the frame or other parts of the tractor and transmits force or carries a load. Connecting Joints: Tractor levers usually have connecting joints that are used to connect the lever to other components such as a trailer, implement or hitch. These connecting joints may be ball joints, pins, threaded connections, or other forms. Supporting structures: In order to increase the strength and stability of the lever, supporting structures such as stiffeners, braces or frames may be added to the structure of the lever. Adjustments: Some tractor levers have adjustments that allow the length or angle of the lever to be adjusted to suit different work requirements or terrain conditions. Surface treatment: Tractor levers are often given a surface treatment, such as spray coating, galvanizing or anodizing, to improve their corrosion resistance and cosmetic quality.

The part structure and shape of the lever of a certain model of tractor are shown in Figure 1. It is made of QT400-18 casting, which has good machinability and can withstand certain impacts and vibrations. Based on the part requirements, the main processes that need to be machined include: Rough and finish milling of the upper and lower platforms with a width of Φ40mm, drilling a Φ10 (H7) hole, drilling of 2×Φ8 holes, and rough and finish milling the upper and lower surfaces of the Φ30 tabs. Based on the requirements of the lever workpiece, the traditional machining process scheme is shown in Table 1. It mainly includes milling, drilling, and reaming to ensure the machining accuracy of the workpiece. During the milling and drilling processes, a set of fixtures is usually modified or combined to ensure machining

Table 1 Tractor lever machining process plan

Operation number	Operation content
05	Rough and finish milling of the upper and lower platforms with a width of 40mm
10	Rough and finish milling of the convex surface with a width of Φ30mm
15	Drill hole Φ25 (H9) to achieve a size of Φ23mm
20	Reaming to enlarge the hole from Φ25 to Φ24.8mm
25	Reaming Φ25 to achieve a size of Φ25 (H9)
30	Drilling a Φ10 hole to achieve a size of 9.8mm
35	Rough reaming the Φ10 hole to achieve a size of 9.96mm
40	Finish reaming the Φ10 hole to meet the requirements.
45	Drilling, rough reaming, and finish reaming 2×Φ8 holes to meet the requirements.

quality. In mass production, this not only causes excessive labor intensity but also makes it difficult to preserve the fixtures [11]. Additionally, the repeated use of fixtures results in a decline in their accuracy, thereby reducing the quality of the lever products.

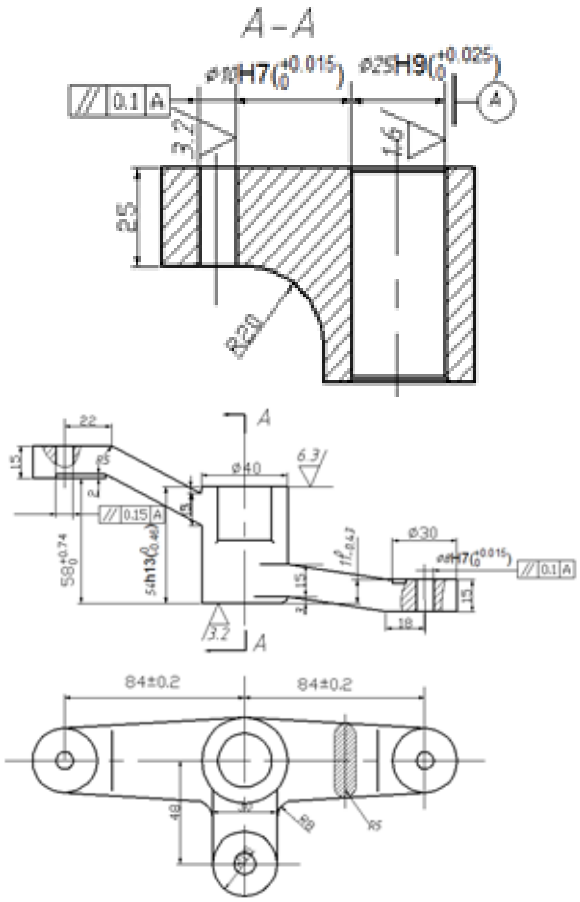


Figure 1 Tractor Lever Part Drawing

3 Scheme Selection and Error Calculation

3.1 Positioning scheme and selection of positioning elements

To ensure proper positioning of the workpiece, in this design, Φ25 and the horizontal plane bottom, as well as Φ30 boss, are selected for positioning. To prevent deformation of the workpiece during drilling of Φ8 (H7) mm holes, a spiral auxiliary support is used. When the auxiliary support contacts the workpiece, it is tightened with a nut.

To prevent phenomena such as rotation during machining, rotation is locked using a nut, thus limiting its six degrees of freedom. At the same time, the option of adding auxiliary support to prevent deformation of the workpiece during machining [12].

3.2 Calculation of positioning error

In the drilling process, in order to ensure that the coaxiality of the holes in the drilling process meets the requirements, so it is necessary to calculate the positioning error of this program. According to the principle of datum coincidence, the positioning error of this fixture is: 0.015+0.015=0.03mm, and the datum displacement error is: 0.052+0.052mm=0.104mm; combining with the accuracy requirements of the positioning holes in the parts diagram, it can be seen that 0.03+0.104mm=0.134＜0.15mm, so it can be seen that the positioning accuracy of this special fixture can Therefore, it can be seen that the positioning accuracy of this special fixture can meet the requirements.

4 Fixture Design

4.1 Fixture design process

The fixture design process usually includes the following steps: requirement analysis, conceptual design, detailed design, material selection, manufacturing and assembly, testing and commissioning, use and maintenance.

First, it is necessary to communicate with the customer or production department to understand the needs and technical requirements for the use of the fixture. This includes the type, size and shape of the workpiece to be clamped, as well as the special requirements of the production process. After the needs

are clarified, a preliminary conceptual design is carried out. This stage usually consists of sketches, hand-drawn or CAD drawings, which are used to explore possible fixture forms and configurations, as well as to define basic clamping principles and schemes. After the conceptual design has been finalized, detailed design work is carried out. This includes developing the detailed structure, dimensions and materials of the fixture, and considering specific details of the fixture's mechanics, clamping methods, and positioning to ensure that the fixture meets the design requirements and performs well. Selection of suitable materials according to design requirements and usage environment. Fixtures are usually made of metal materials such as steel, aluminum, and so on, and special surface treatments or coatings may also need to be considered to improve durability and corrosion resistance. After completing the design, the manufacturing and assembly of the fixture is carried out. This includes machining of the fixture components, heat treatment, surface treatment, assembly and other processes to ensure that the components of the fixture meet the design requirements and are able to function properly. After the completion of manufacturing, the fixture test and debugging work. This includes checking the functions and performance of the fixture to ensure that the fixture can clamp the workpiece stably and accurately and meet the production requirements. Finally, the fixtures are put into service and a maintenance program is established accordingly. The fixtures are regularly inspected and maintained to ensure proper functioning, and adjustments or improvements are made as needed [13-15].

4.2 Structural design of the fixture

The structural design of a fixture is a critical step in ensuring that the workpiece is held securely and machined accurately. First of all, according to the shape, size and machining requirements of the workpiece, determine the clamping method of the fixture. Common clamping methods include mechanical clamping, pneumatic clamping, hydraulic clamping and so on. Selecting the appropriate clamping method can improve the stability and accuracy of the fixture.

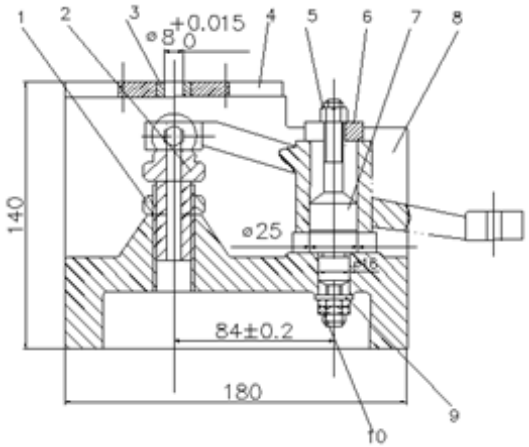
Then determine the clamping point and clamping force of the fixture to ensure that the workpiece can be firmly clamped, and will not damage the surface of the workpiece due to excessive clamping force. The structure of the fixture is designed according to the requirements of the clamping method and clamping force. This includes the main structure of the fixture, the layout and configuration of the fixture's clamping components, and the fixture's support and positioning structures. When designing the fixture structure, the requirements of the machining process need to be taken into account. For example, if the workpiece needs to be machined on multiple sides, the structure of the fixture needs to take into account the turning and positioning of the workpiece.

Next, select the appropriate material and surface treatment to ensure that the fixture has sufficient strength, rigidity and durability. Common fixture materials include steel and aluminum alloys, and surface treatments include coating, chrome plating, and nitriding[16].

Finally, in the process of fixture structure design, the operator's use habits and safety requirements are taken into account to design reasonable fixture operating handles, adjusting devices and protection devices to improve the operator's work efficiency and safety. Verify the structural design of the fixture through computational analysis, digital simulation or physical model to ensure that the fixture can meet the requirements of workpiece processing, and has sufficient stability and accuracy. Fixture structure design is a continuous improvement process. During the use of the fixture, feedback information is constantly collected, and the fixture is adjusted and improved according to the actual situation in order to improve the performance and efficiency of the fixture.

Through the analysis of the workpiece, it can be seen that Φ8 holes are relatively small, the quality of the blank parts is relatively small, in order to facilitate mass production and suitable for small and medium-sized enterprises low-cost requirements, so in this design will be designed as a fixture for the flip-type drilling mold mode[17-19].

In order to meet the requirements of the two Φ8 holes and address the shortcomings of traditional methods, a set of specialized fixtures has been designed. This fixture primarily utilizes auxiliary support for positioning the lever, thus enabling adjustment of the cutting forces generated during machining. It mainly consists of components such as a drilling template, locating pins, fixture body, and drill sleeves. To enhance the durability and accuracy of the specialized fixture, Q235 material is used for its design. A schematic diagram of the fixture is shown in Figure 2.



1- Locking nut; 2- Spiral auxiliary support; 3- Drill sleeve; 4- Drilling template; 5- Tightening nut; 6- Open washer; 7- Locating pin; 8- Fixture body; 9- Screw; 10- Locking nut

Figure 2 Schematic diagram of specialized fixture

Through the design and manufacture of the special fixture, and the use of automation to assist the clamping. After the test in the workshop, the quality and precision of the processed workpieces have been greatly improved, and the qualification rate of the products is as high as 99.2% or more, so the design of the fixture meets the demand of the generation; at the same time, the special fixture has the advantages of low cost, high efficiency, and low labor intensity, which can be popularized in the small and medium-sized enterprises and realize mass production.

5 Conclusion

Taking into account the long processing time and poor machining accuracy encountered during the machining of lever components for a certain model of tractor, a specialized fixture has been designed. After the physical inspection in the workshop, the fixture is safe and reliable, and significantly increase the production efficiency. Considering to reduce the number of special fixtures for small and medium-sized enterprises, this fixture still has a large optimization space, which is an important reference value for the optimization of special fixtures in the future.

Fixture design has a broad development outlook in the future, which is mainly reflected in the following aspects: intelligence and digitalization, flexibility and customization, lightweight and composite materials, augmented reality and virtual simulation, environmental protection and sustainable development.

With the development of artificial intelligence, IoT and digital technology, fixture design will become more intelligent and digital. Fixtures will be equipped with sensors and control systems that can monitor the status of the workpiece and machining parameters in real time and make adaptive adjustments based on real-time data to achieve more efficient and accurate machining.

Future fixture design will pay more attention to flexibility and customization, can quickly adapt to different workpieces and production needs. Through modular design and programmable control, the fixture can be flexibly adjusted to adapt to different workpiece shapes, sizes and machining processes, thus improving the flexibility and adaptability of the production line.

Future fixture design will pay more attention to lightweight and material innovation. The use of lightweight materials and composite materials manufacturing fixtures can reduce the weight and inertia of the fixture, improve the speed and accuracy of robot clamping, while reducing energy consumption and environmental pollution.

Augmented reality and virtual simulation technologies will be widely used in the fixture design process. Designers can use augmented reality technology to design and debug fixtures in a realistic environment to improve design efficiency and accuracy; at the same time, virtual simulation technology can help designers design and optimize fixtures in a computer-simulated environment to reduce the cost of experimentation and trial and error [20].

Future fixture design will pay more attention to environmental protection and sustainable development. The use of environmentally friendly materials and clean production technology to manufacture fixtures to reduce energy consumption and waste emissions; at the same time, the design of fixtures will take into account the recyclability and recycling of materials to reduce resource waste and environmental pollution.

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