Design of a Fully Automated Logistics Handling Platform

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Abstract

With the progress of science and technology and the development of society, the world's countries on industrial production efficiency, intelligent manufacturing transformation continues to grow. Therefore, we designed a fully automatic logistics handling platform, which is a multi-modular device based on mechanical design, microcontroller control, visual positioning, the device can realize autonomous identification, autonomous transportation, improve production efficiency, the device has a wide range of applications, can be applied to food packaging, parts processing, intelligent manufacturing, and other automation scenarios.

Keywords: Mechanical design, Circuit design, stepper motor drive, logistics and transportation

1. Introduction

With the development of society and the progress of science and technology, artificial intelligence technology is gradually changing the traditional mode of industrial production [1]. Through the introduction of intelligent manufacturing technology, some advanced products such as unmanned technology, drone courier, intelligent medical care and so on are born. This design is based on the fully automatic logistics handling platform in the context of intelligent manufacturing technology, which effectively solves the problem of time-consuming and labor-consuming manual operation [1], [2], [3], [4].

The rest of this article is organized as follows. the second part introduces the mechanical model and related structural analysis, the third part gives the finite element analysis, and the fourth part shows the related hardware design

2. Mechanical modeling and related structural analysis

Automated item transportation and handling systems are an essential part of the production line in modern factories. Its main purpose is to transport items from one place to another and to perform handling and assembly operations when needed. Such systems usually consist of many different mechanical, electrical and control components to accomplish various tasks. In this product, the transportation and handling of items is mainly achieved by means of a screw slide and rack and pinion mechanism. The main features of this system design are stability and reliability in the face of a variety of items to be transported.

2.1Design of mechanical parts

The mechanical part of the transportation and handling system of this design is mainly composed of the following parts:

(1) Screw slide: used to transport items from the starting position to the designated position.
(2) Rack and pinion mechanism: used to ensure stability and reliability during transportation.
(3) Pneumatic Cylinder: Used to carry out the transportation and stamping assembly of the articles.

The design of the mechanical part is shown in Fig. 1.

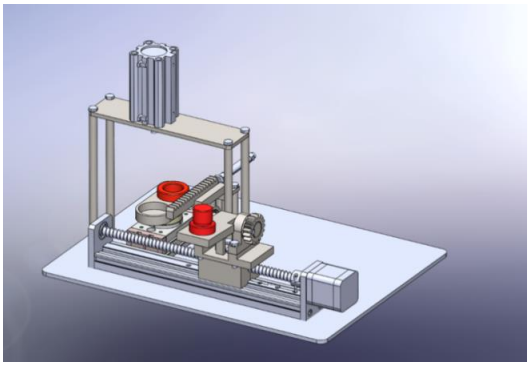


Fig. 1 The Mechanical design drawings

2.2Component Introduction

(1) Screw slide table: It is a kind of mechanism that utilizes the principle of screw rotation to carry out linear motion, which consists of threaded rod and slider, and pushes the slider to carry out linear motion through the rotation of the threaded rod. Screw slide has the advantages of high precision, good stability and smooth movement, so it is widely used in automated item transportation and handling systems. Screw slide is one of the most important components in the system and is responsible for transporting items from the starting position to the specified position. Screw slides usually consist of a threaded rod, a slider and a guideway. The threaded rod rotates to drive the slide in a linear motion, while the guide rails are used to ensure the orientation and stability of the slide.

(2) Rack and pinion mechanism: it consists of a set of gears, racks and guiding shafts, which is mainly used to realize the overturning and handling of the goods and ensure the stability of the goods in the transportation process. At the same time, the guiding shaft in the rack and pinion mechanism can avoid the lateral displacement of the spiral slider in the transportation process.

(3) Cylinder: It is used to realize the handling and stamping assembly of the articles. When the article reaches the specified position, the cylinder starts to work, clamps the fixture to the article, and moves the article to the stamping assembly area for operation.

The system has a variety of functions, including transportation, handling and stamping assembly of items, etc., and at the same time, it is characterized by stability and reliability, easy operation, safety and high efficiency. It is suitable for various application scenarios in logistics, production and manufacturing industries.

3. Mechanical design

The following focuses on the mechanical design of the handling part of the automated article transportation and handling system.

3.1 Design Idea

The syringe pushes the rack and pinion to mesh with the gear to provide the circumferential force, the gear is connected with the shaft in the handling mechanism through the key to drive the shaft to rotate circumferentially, and at the same time the shaft is connected with the loading fixture in the handling mechanism through the key to realize that the syringe drives the loading fixture to rotate circumferentially to realize the handling of the goods.

3.2Material selection

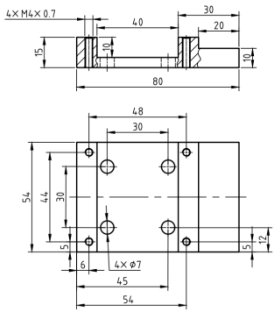
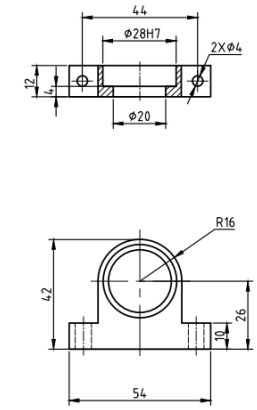
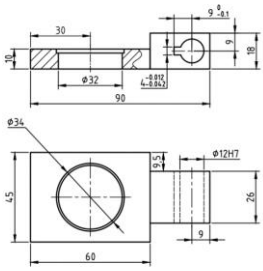
The material selection of the parts of this system is 6063 aluminum alloy, because 6063 aluminum alloy has excellent weldability, extrudability and plating, good corrosion resistance, toughness, plasticity, and can meet the high requirements of precision machining.

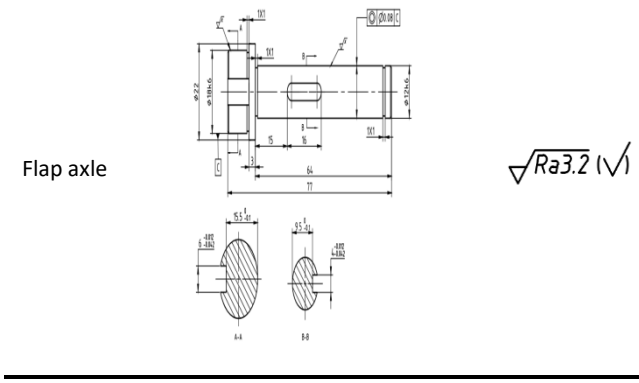
3.3Manufacturing process

The mechanical parts in this system mainly take two kinds of machining methods: turning and milling, in which turning is mainly used for machining shaft system parts, and milling is used for machining other configurations of parts.

The following table provides a brief parts drawings, drawings include a brief machining accuracy, assembly requirements note. As shown in Table 1.

Table 1 Parts Drawings

Part Name	Summary Drawings	Machining precision
Turntable		√Ra3.2 (√)
Flip Table Stand		√Ra3.2 (√)
Flip Carrier		√Ra3.2 (√)



4. Finite Element Analysis and Simulation

Finite element analysis is the use of mathematical approximations to simulate real physical systems. By utilizing simple but interacting elements, it is possible to approximate a real system with a finite number of unknowns to an infinite number of unknowns.

The tipping mechanism is based on mechanical design to analyze the degree of deformation when it is subjected to forces to ensure its safety. Because the material of the device is aluminum alloy 6063, by checking its permissible stress is 160MPa, through solid works finite element analysis, the following diagrams are obtained.

As shown in Fig. 2 is the cylinder table.

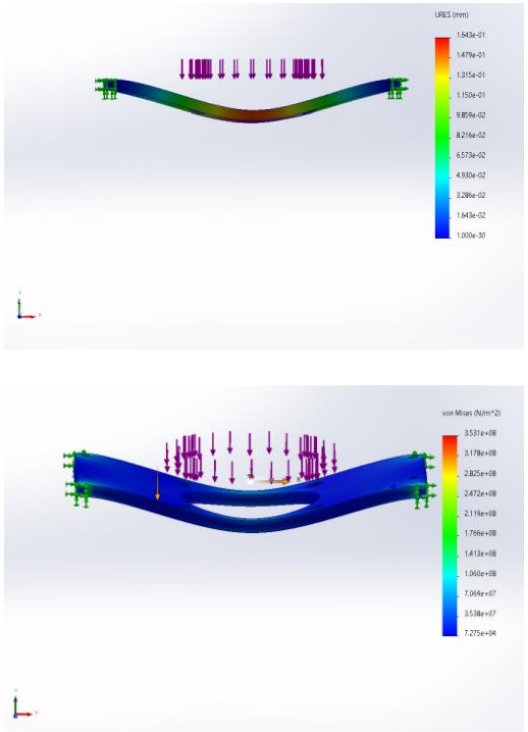


Fig. 2 Cylinder table

As can be seen from the figure, this design is not safe, although the actual cylinder table is not subjected to such a large force, but it can be added with reinforcement to ensure its safety.

Next is the flip shaft, as the most core part, its safety is also the most important part of the flip mechanism. As shown in Fig. 3.

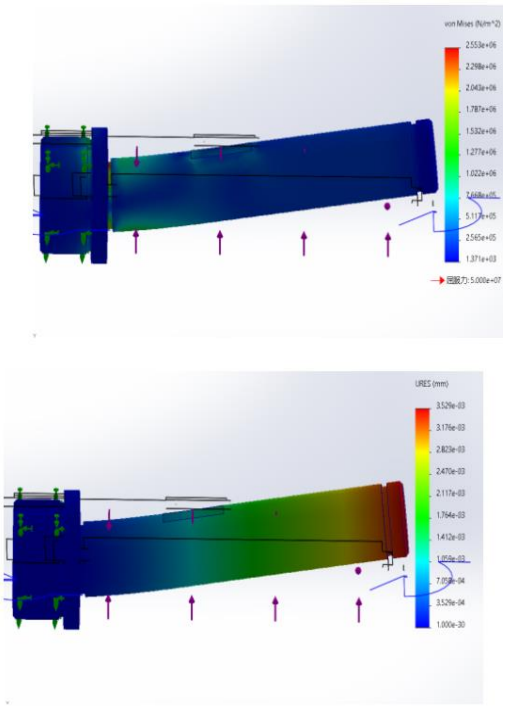


Fig. 3 Flap axle

From the above figure, it can be seen that the maximum shear stress of this shaft is 2.553×10^{7} Pa, while the permissible stress of aluminum alloy 6063 is 1.6×10^{8} PA.

Therefore this shaft is safe.

There is also the fit between the rack and pinion, which is the key condition for the flip mechanism to be able to flip. This is shown in Fig. 4.

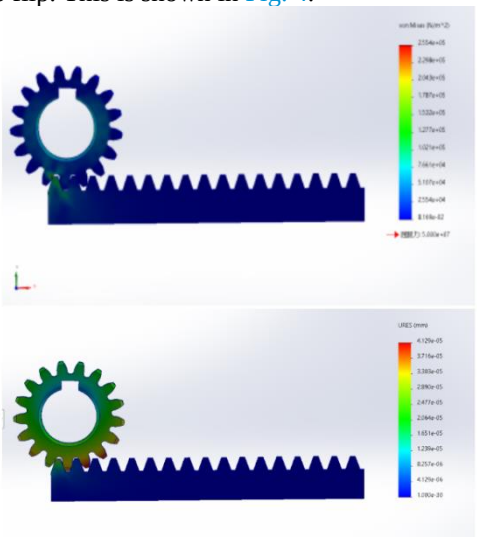


Fig. 4 Pinion

As can be seen from the figure, the maximum shear stress is 3.102×10^{9} Pa, which is too large compared with the permissible stress, so it is not safe, but it is still feasible in the flip mechanism because it is calculated not

to use such a large force.

Overall, the designed tilting mechanism is completely feasible.

5. Hardware design

To accomplish this, the team designed a PCB motherboard that implements the above features. The PCB schematic diagram is shown in Fig. 5.

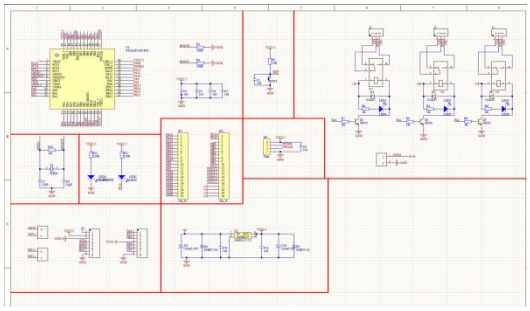


Fig. 5 PCB schematic diagram

The design of this PCB board with STM32F103C8T6 as the main chip, equipped with a stepper motor driver and a three-way relay, realizes precise stepper motor control and solenoid valve on/off. Through programming, the board can control the speed, direction and movement distance of the stepper motor, while it can control the on/off of the circuit through the relays to realize automation control.

5.1 Solenoid Valve Drive:

The Relay is shown in Fig. 6.

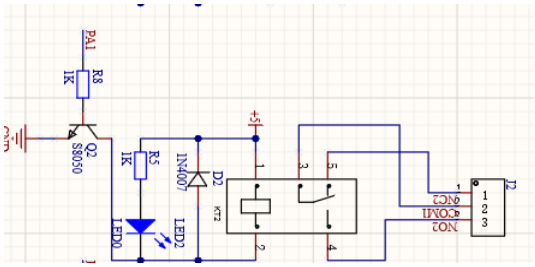


Fig. 6 Relay

Through the main control board to send high and low level signals to control the relay on and off, and then control the solenoid valve on and off.

5.2 Stepping motor drive:

This design mainly adopts two stepper motor driving methods, the first one is stepper motor driver and the second one is TB6612FNG stepper motor driver module [4], [5], as shown in Fig. 7.

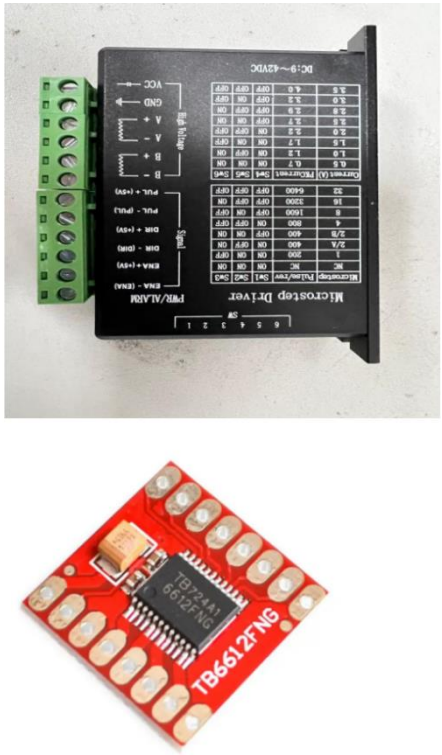


Fig.7 Stepper Motor Driver and TB6612FNG Stepper Motor Driver Module

The actual principle of a stepper motor driver is to convert a pulse signal from a control system into an angular displacement of the stepper motor. Whenever the stepper driver receives a pulse signal, it drives the stepper motor to rotate in a set direction at a fixed angle (called the "step angle"). The stepper motor rotates step by step at a fixed angle. The angular displacement can be controlled by controlling the number of pulses for precise positioning. The speed and acceleration of the motor rotation can also be controlled by controlling the pulse frequency for speed regulation [5], [6], [7], [8], [9].

5.3 Voltage regulator module

This design voltage regulator module mainly uses the chip for AMS117-3.3V for 3.3v voltage regulator design.

6. Product Summary

Through the test, the product can complete the recognition of objects and achieve the desired position to achieve flipping and stamping through the precise control of the stepper motor, which can be adapted to the automatic scenes such as product packaging and parts processing.

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