Tablet Press Model Analysis in Automated Production Equipment

Qi He [1 *], Chang Li [2] and WeiHao Yuan [3]

[1] School of mechanical and electrical engineering, Beijing Institution of Technology, Beijing, 102488, China

[2] School of mechanical and electrical engineering, University of Electronic Science and Technology of China, Zhongshan Institute, Zhongshan, 528400, China

[3] School of agriculture, Yanbian University, Yanji, 133002, China

* Corresponding Author Email: 1120213156@bit.edu.cn

Abstract. Tablets are one of the indispensable pharmaceutical forms in healthcare, and it has been developed based on powders and pills with a long history of application. Its commonly used production equipment is a tablet press, which directly presses pharmaceutical powder granules into tablets. This paper uses the traditional tablet press as a model to introduce the six-bar mechanism, reducer, and motor part. Based on real data, the rush return characteristics, pressurization and holding characteristics of the six-bar mechanism are analyzed. Finally, the shortcomings of traditional tablet presses are proposed, and improvement methods are given. Through the mechanism analysis of the tablet press in this paper, people can clearly understand the working principle of the tablet press. The model construction and motion analysis in this paper help to analyze the motion characteristics of the mechanism. This paper provides a theoretical basis for the construction of tablet presses.

Keywords: Tablet Press; Six-Bar Mechanism; Reducer; Y100-6 motor.

1. Introduction

Automated equipment production provides great convenience for people. Therefore, the production of various tablets or other items has long been free from the traditional manual production method. In this process, tablet presses play a vital role, which not only improves the efficiency of making products, but also improves the quality of finished products [1]. Through the analysis of the tablet press, it will help people to develop more efficient, safe, and convenient material pressing equipment in the future, which can improve people's quality of life and promote the process of industrialization and modernization.

By analyzing the known tablet press models and listing most of the parameters, the 2D and 3D models of the main part are constructed in the paper. The body of this paper is divided into the following parts. First, this paper introduces the main structure of the tablet press and which parts it is composed of, and then introduces the six-bar mechanism part, the reducer part, and the motor part respectively. In the six-bar mechanism section, the focus is on his rush return characteristics and holding pressure characteristics. The reducer part focuses on building a 2D model. All of the above can help people to clearly understand the tablet press. At the end of the paper, some theories for improvement are proposed. These will help to further improve the industrialization of tablet press applications.

2. The main part of the tablet press

The tablet press is composed of three parts, namely the six-bar mechanism part used for tableting, the motor part used to drive the six-bar mechanism, and the reducer connected between the first two parts [2]. In addition to those mentioned above, there is also a feeding part, and a reclaiming part. The structure of these two parts is simple, and some mechanical equipment can be discarded, so it is not too much introduced in this paper. Fig.1 shows a Schematic diagram of the overall work. The

workflow is roughly where the feeding part continuously feeds the raw materials into the pressure section, and then the pressure part presses it into a specific shape and is sent out.



Fig.1 One sort of tablet press model (Photo/Picture credit: Original)

2.1. Six-Bar Mechanism Section

2.1.1 Parameters of the six-bar mechanism

The important parts of the six-bar mechanism are the swing angle of the rocker, the displacement of the lowest die part, and the stroke speed ratio coefficient. The swing angle determines the amplitude of the tableting part. The displacement of the die part determines the holding pressure characteristics and booster characteristics of the tablet press [3]. The stroke speed ratio coefficient determines the rapid return characteristics of the tablet press. Table 1 are the parameters of the punching part of the six-rod mechanism [4].

Table 1. Parameters of the six-bar mechanism

Die part displacement--h	Swing angle of the rocker--ψ	Stroke speed ratio coefficient--K	Crank angle between extreme positions--θ	Number of cycles per minute--N
90mm	55°	1.2	16.36°	40

2.1.2 2D graphic of six-bar mechanism

In fact, the six-bar mechanism can be simplified to this four-bar mechanism. Because the tableting part can be simplified to a punch with vertical up and down movement [5]. Therefore, according to the parameters in Table 1, 2D diagrams can be made using CAD software. The model is shown in Fig.2.

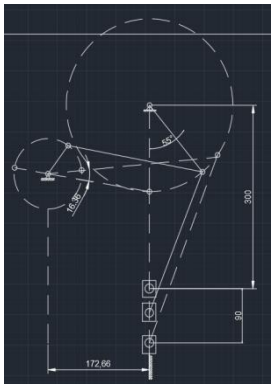


Fig.2 2D model in AutoCAD (Photo/Picture credit: Original)

The pressure part of the tablet press needs to be pressed by a mechanism; in this case it is a six-bar mechanism driven by an electric motor. The drive axis is the leftmost axis, which is mentioned again in 3D model construction.

2.1.3 3D model of six-bar mechanism

If you want to analyze the rush return characteristics and booster holding characteristics of this mechanism, only 2D drawings are not enough. So, SolidWorks is used here to build the 2D model from 2.1.2 into a solid. And the 3D model shown is Fig.3. The length is consistent with what is stated in the drawing. The width and height are unified at 10mm and 5mm respectively (The width and height do not affect the nature of the mechanism). At both ends of the rod there are through-holes and boss with a diameter of 5mm. These are used to connect the rods. Since the tablet press moves vertically, many coordinate systems need to be added to limit it.

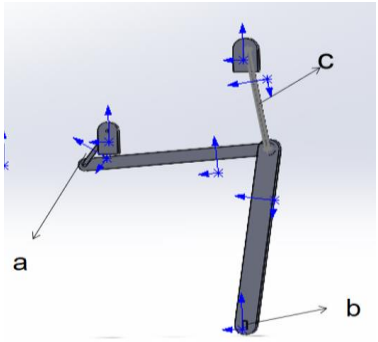


Fig.3 3D model in Solidworks (Photo/Picture credit: Original)

2.2. Analysis of Model

2.2.1 Structural analysis

Rod a is the rod that connects the drive, that is, the rod that the motor is connected by the reducer. This rod can be rotated 360°. Rod c swings back and forth in a range (55°). And b is the place used for tableting. There are many coordinate systems in Fig.3. These coordinate systems are the constraint mechanisms in SolidWorks so that they move in a plane.

2.2.2 Motion analysis

Using the motion plug-in in SolidWorks, add a motor to the a-bar. Adjust the speed to match the N mentioned earlier--40 per minute. The motion simulation and analysis of the bottom die part can be carried out in Fig. 4.

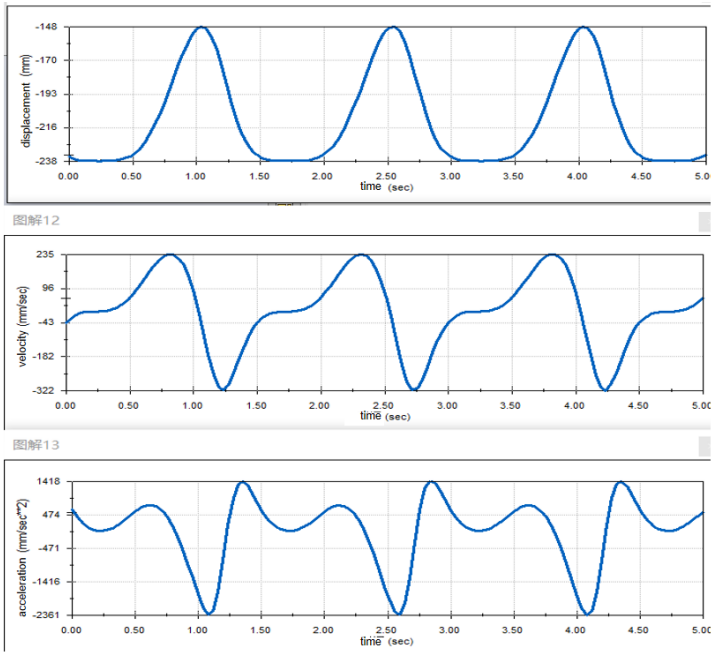


Fig.4 Motion analysis (Photo/Picture credit: Original)

From top to bottom are images of displacement, velocity, acceleration. First analyzing the displacement, this is a reciprocating cycle. The displacement of the up and down movement of the die part is equal. As can be seen in the velocity image, the average speed of the return of the lower die section is greater than the speed of the push [6]. This is also the rush back feature. In the acceleration image, the average acceleration of the push is greater than the average acceleration of the return pass Because of F=ma, The force of the push is greater than the force of the return [7]. This is also known as the holding pressure characteristic earlier.

3. Reducer Design

When the tablet press is working, the maximum resistance is set here to 7000N. The resistance for non-working strokes is F/4. Since p =F*h/t. The power can be calculated. Based on the above parameters, a load spectrum can be made in Fig.5. Positive and negative work done in one cycle is equal. This gives the power Pd=525W. Due to the shunt of the reducer, the power is twice as much as Pd. So, P=1050W. Therefore, the motor should choose a commonly used and power match. Y100-6 motor is chosen in this paper. The maximum power of the Y100-6 motor is 1.5KW, which is greater than the required power, so it meets the requirements [8].

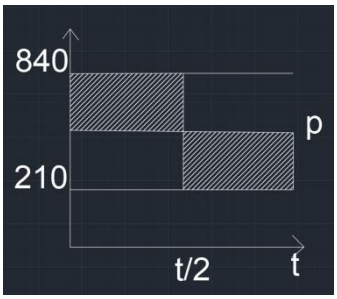


Fig.5 Load Spectrum (Photo/Picture credit: Original)

Since the speed of Y100-6 motor is 940r/min. So, it must go through a three-stage reduction transmission. The sequence is V-belt transmission, bevel gear transmission, cylindrical gear transmission. Fig.6 shows the model of reducer.

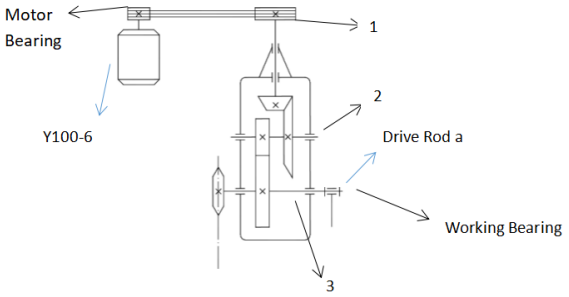


Fig.6 Reducer model (Photo/Picture credit: Original)

The distribution of gear ratios at all levels, motion and power parameters at all levels are shown in Table 2 below.

Table 2. Parameters of reducer

Number	Motor Bearing	1	2	3	Working Bearing
Power	1210W	1150W	1104W	1059W	1050W
Rotate Speed	940r/min	376r/min	188r/min	40r/min	40r/min
Torque	12.3N*m	29.2N*m	56N*m	252N*m	250N*m
Transmission Ratio	1	2.5	2	4.7	1
Efficiency	0.99	0.95	0.96	0.96	0.99

Fig.7 shows the reducer 2D model in AutoCAD.

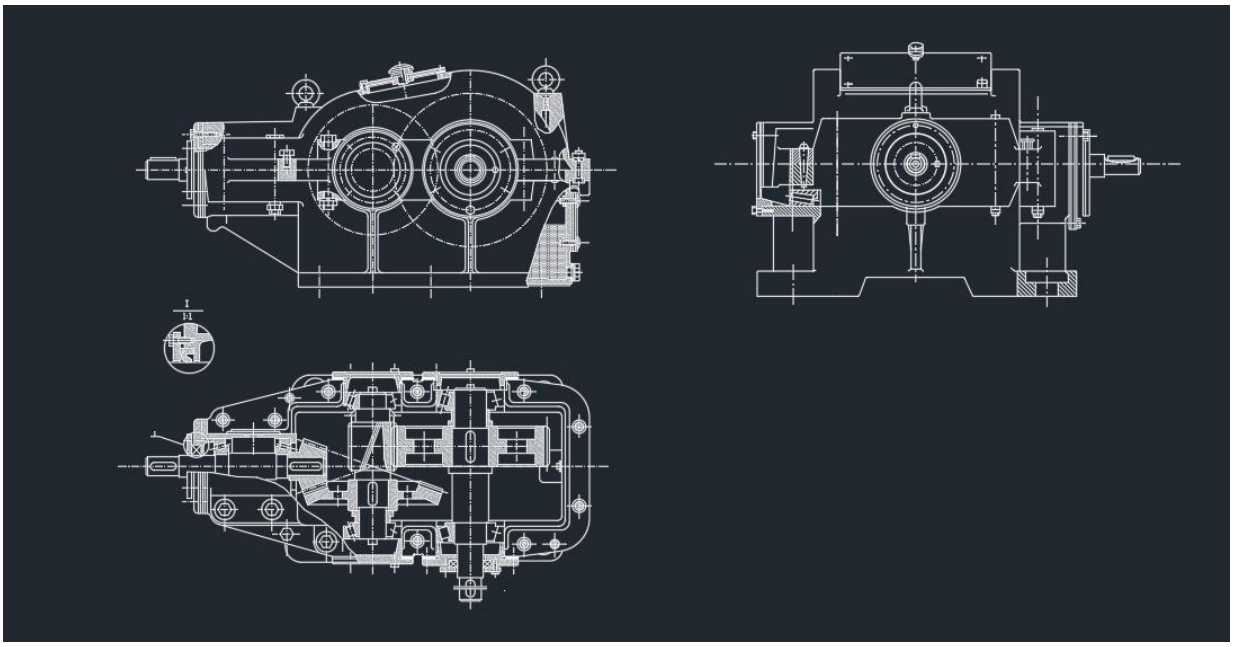


Fig.7 2D model of reducer in AutoCAD (Photo/Picture credit: Original)

4. Model and Working Principle of the Y100-6 Motor

In this section, some reasons for choosing the Y100-6 motor are described. The Y100L-6 motor, a prominent model of the Y series three-phase asynchronous motor, is renowned for its high efficiency, low noise, lightweight design, and effortless maintenance. This versatile motor is extensively utilized in a broad range of industrial equipment and mechanical transmission systems. The Y series three-phase asynchronous motor follows a systematic naming convention with the parameters of the Y100L-6 motor signifying the Y series designation, a frame size of 100, a speed of 1000 rpm related to the rotor type and power frequency, and a maximum output power of 1.5 kW [9]. Since the maximum power of the tablet press in this paper also does not exceed 1.2kW, it is sufficient. The Y100L-6 three-phase asynchronous motor operates through a sequence of stages, which include: connection of the stator winding to a three-phase AC power supply; generation of a rotating magnetic field due to the periodic change of AC current; rotor induced electromotive force stemming from the interaction between the rotating magnetic field and squirrel cage rotor; creation of electromagnetic torque; and achievement of stable operation when the electromagnetic torque balances with the rotor's resistance, producing constant torque and speed [9].

5. Deficiencies and Directions for Improvement

Although tablet presses are widely used, there are still the following shortcomings. Dust harmful to the human body will be generated during production and transportation. Dust occurs in the production process of tablet presses, and there is a problem that people need to solve. The solution is that the dust generated by the high-speed rotary tablet press during the production process is sucked up by a vacuum cleaner. Due to the existing level, the sealing effect of the tablet press is not very good, and there will still be a lot of dust leakage. In addition, dust may also be generated during transportation [10].

Tablet press also has contamination and cleaning problems. Since the lubrication of the tablet press is a liquid lubricant, the sealing effect is not good, which will cause the tablet to be contaminated. In addition, dust contamination can occur in the gap between the feeder and the rotary table in the tablet press. The current tablet press cannot be cleaned as a whole, and the parts must be removed during cleaning, so in many cases it cannot be thoroughly cleaned, and it is difficult to clean the dead corner.

In the process of improving it, one of them is the impeller part of the forced feeder, which plays a great role in making drugs. Its principle is to fill the powder into the important parts of the mold hole, and the feeding impeller follows the blade in the feeder [10]. The wheel shaft rotation movement plays a role in dialing the powder into the middle die hole, uniformizing the powder and promoting. The effect of the flow of powder. Suitable impeller structure and motion form (speed, steering, shape, number of blades, etc.) can effectively improve the fluidity of powder particles. The filling effect is a direct factor. Among them, the impeller speed is stable to the filling.

6. Summary

This paper analyzes the overall structure and function of the tablet press and decomposes it into three parts: six-bar mechanism, reducer, and motor. And 2D or 3D models of six-bar mechanism, reducer, motor were built. Based on the model, the movement of the six-bar mechanism is analyzed. The physical characteristics of the holding pressure property and the rush return characteristic were obtained. And the working principle of the Y100-6 motor is explained in detail. The final chapter summarizes the shortcomings and improvement methods of traditional tablet presses. And improved methods are proposed. If people read this paper carefully, people will have a deep understanding of tablet presses. People will recognize and understand how tablet presses work. This paper can be used as a theoretical basis for some simple physics lab lessons. And the models can also be used for some simple physics teaching. Tablet presses have a long history. And in the fight against the epidemic, it has played an important role in the pharmaceutical field. This paper only introduces one of the simplest. It is believed that there will be more precise and efficient tablet presses in the future.

7. Authors Contribution

All the authors contributed equally, and their names were listed in alphabetical order.

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