Design of Some Type of the Laminator

Yan MA¹,*, Peng HUANG² and Zhao-gang LI¹

¹Shenyang Academy of Instrumentation Science, Shenyang City, Liaoning Province, 110043, China
²Au Optronics Co. Ltd. Suzhou City, Jiangsu Province, 215021, China
*Corresponding author

Keywords: Laminator, Belt drive device, Pneumatic device, Ball screw.

Abstract. The design of the semi-automatic lamination machine is presented. The drive device, pneumatic device, ball screw drive, stepper motor drive is analyzed. In the belt driving device, the tension pull and the loose side pull are analyzed in the critical state, and the power of the driving design is obtained. In the pneumatic device, the air pressure of the drum lifting device is analyzed, the main parameters of the cylinder are calculated and the volume of the gas is obtained. In the screw transmission device, the step Angle and torque of the required stepping motor are designed. With the aid of three dimensional modeling software, the model of the main parts is constructed.

Introduction

The working principle of the lamination is that the self-adhesive part of the material is pulled on the stripping plate under the suction device of the drive device, under the guidance of the self-adhesive, and is peeled off by a series of tensioning devices and then corrected by the manipulator. After being automatically mounted to the work piece with a fixture positioning. Flat type film machine to achieve the work piece on the plane, the upper surface of the label and foil, such as boxes, books, plastic shell, etc., there are two methods of nap and suction, mainly based on efficiency, accuracy and bubble requirements for selection. Round bottle type film machine to achieve in the cylindrical, conical products on the circumferential surface of the label or foil, such as glass bottles, plastic bottles, etc., can be achieved circumference, semi-circumference, double-sided, circular positioning labeling and other functions, Type labeling and horizontal labeling in two ways. Side of the labeling machine to achieve the side of the work piece side, side of the surface labeling or film, such as cosmetics flat bottles, boxes, etc., can be matching round bottle labeling equipment, while achieving round bottle labeling.

The design[1,2] of the ball screw drive roller will be pressed on the film needs of the film, through the ball screw drive cutting knife to cut off the film, the next film. When cutting the diaphragm, the rotating arm is driven by the motor, and the blade is cut according to the shape required by the work piece. Through the cylinder to raise and lower the lid, while the cylinder also control the drum movements and clamping clip clamping and release.

Design of Device

In the roll of the material on the drum, a tension device is needed to prevent the too large use of tension, which will result in wrinkles. Pulley is used as the tensioning mechanism. The film machine requires the lifting and lowering of the lid, the opening and clamping of the clip, and the lifting and lowering of the drum. Consider the simple and convenient design agency, as well as cost issues and easy to operate, the use of pneumatic devices is proposed to achieve these actions. Ball screw drive work process is presented as, the ball screw acts as the main body, the nut with the screw rotation angle accords with the corresponding specifications of the lead into a linear motion, passive parts can be connected through the nut seat and nut, in order to achieve the corresponding linear motion.
Analysis of Drive Parameters

The belt drive is mainly played a preload effect, the required speed of the transmission is relatively low, so the choice of ordinary flat belt. As shown in Figure 1, F1 is called the tight side tension, F2 is called the loose tension. The critical state of the tight side of the tension and loose pull force is shown as follows:

\[
F_1 = F_{emax} \frac{e^{fa}}{e^{fa} - 1} +qv^2
\]

\[
F_2 = F_{emax} \frac{1}{e^{fa} - 1} +qv^2
\]

\[
F_{emax} = 2(F_0 - qv^2) \frac{e^{fa} - 1}{e^{fa} + 1}
\]

And \( f \)-coefficient of friction; \( \alpha \) - the angle of the small pulley.

Take the diameter of the tension wheel \( d1=50\text{mm} \), the diameter of the belt on the film \( d2=200\text{mm} \). The film is pulled out at a rate of 50 mm / s. Find \( \alpha_0 = 400m \); \( \alpha_1 = 2.77 \); \( L_c = 1210\text{mm} \); Baseline length \( L_d = 1200\text{mm} \). Since the belt drive used is a tensioning device, the number of selected bands is one. Pull the film required to pull the tensile strength \( F_{emax} = 20N \). According to formula (1) to obtain the initial tension \( F_0 \), \( F_0 = 37.3N \). The initial tension is obtained according to the initial tension calculation formula of the single band \( F_0 \):

\[
F_0 = 500 \frac{P}{v_z} (\frac{2.5}{K_d} - 1) +qv^2(\text{N})
\]

Find the design power: \( P_c \approx 2.5W \). The pressure \( Q \) on the shaft is described as:

\[
Q = 2F_0z \sin \frac{\alpha_0}{2} = 73.2\text{N}
\]

Analysis of Pneumatic Device Parameters

Drum diameter of 50mm, length 400mm, the material can be used plastic. Drum weight of about 2kg, consider other parts, pneumatic devices need to make 5kg heavy objects rise. The diameter of the primary cylinder \( D = 20\text{mm} \), the piston rod \( d = 8\text{mm} \). \( p_1 = 0.33\text{Mpa} \); \( p_2 = 0.1\text{Mpa} \). Ball screw drive efficiency \( \eta = 0.5 \).

The diameter of the cylinder D:

\[
D \geq \sqrt{\frac{4F_i}{\pi p}} = \sqrt{\frac{4 \times 100}{\pi \times 0.33}} = 20.6\text{mm}
\]

Piston stroke \( L = 15\text{mm} \), piston width \( H = 5\text{mm} \), cylinder length.
\[ l \geq L + H = 15 + 5 = 20 \text{mm} \]

Cylinder wall thickness

\[ \delta = \frac{pD}{2[\sigma] + C} = \frac{0.33 \times 20}{2 \times 30} = 0.11 \text{mm} \]

The theoretical air consumption of the cylinder

\[ V = \frac{4}{\pi} D^2 L = \frac{4}{\pi} \times 20^2 \times 10 = 5093 \text{mm}^3 \]

Actual air consumption

\[ V_s = 1.5V = 7640 \text{mm}^3 \]

Pressurized air consumption

\[ q_s = \frac{V_s}{t} = 7640 \text{mm}^3 /s \]

Free air consumption

\[ V_{sc} = V_s \frac{P + 0.1013}{0.1013} = 32528 \text{mm}^3 \]

Actual free air consumption flow

\[ q_{sc} = q_s \frac{P + 0.1013}{0.1013} = 32528 \text{mm}^3 /s \]

**Analysis of Ball Screw Drive**

Selection of one end fixed, one end of the support of the way. Selection of double nut washers preload. Ball screw thread angle \( \varphi = 6.06 \). Ball screw drive efficiency \( \eta = 0.425 \). Selection of stepper motor drive. Known pulse equivalent of 0.001mm/step, the smaller the step angle, the higher the processing accuracy. The primary step angle is 3.6°/step.

Motor starting torque:

\[ M = F_a \times d / 2 \times t g(\varphi + \rho) = 0.04 \text{N} \cdot \text{m} \]

The starting moment of the stepper motor output shaft is estimated as:

\[ T_q = M / i \eta \]

Stepping motor starting shaft on the starting moment

\[ T_q = 2.35 \text{N} \cdot \text{m} \]

Among them:

\[ \delta_p = 0.001 \text{mm/step} \quad M = 0.04 \text{N} \cdot \text{m} \quad \varphi = 3.6^\circ / \text{step} \quad P_h = 0.4 \text{cm} \quad \eta = 0.425 \]

And \( \delta_p \) - Pulse equivalent; \( \varphi \) - Step angle; \( P_h \) - Lead lead; \( \eta \) - Ball screw drive efficiency.

**Three Dimension Modeling**

The three-dimensional model of the whole model of the film machine is shown in Figure 2, Figure 3 and Figure 4.
Summary
Design of part device of semi-automatic film machine is presented in the paper. Pneumatic devices, ball screw drive, belt drive and other major parts are included. In the belt drive, the tension in the critical state of the belt drive is analyzed, and the power of the belt drive design is obtained. The required air pressure of the pneumatic drum lifting device is analyzed and the volume of the required gas is obtained. The step angle and starting torque of the stepper motor required for the screw drive is analyzed. Three-dimensional model of the main components is established with the help of three dimention modelling software.

Acknowledgement
Thanks for the support of Shenyang Academy of Instrumentation Science.

References