A Feasibility Study of the Design and Calculation of Fully Hydraulic Paper Cutting Machine System

Xinxiang Wang[1], Guoqing Hu[2], and Haifeng Zhou[1]

[1] Marine Engineering Institute, Jimei University, Xiamen 361021, China
[2] School of Mechanical and Automotive Engineering, South China University of Technology, Guangzhou, 510641, China
gqhu@scut.edu.cn

Abstract. As sort of traditional paper process machinery equipments, paper cutting machines are developing rapidly in hydraulic, digital display and computer control machines. But a great number of products of the paper cutting machines in the market are that the pressing paper units are controlled by hydraulic drive and cutting paper units still adopt mechanical driven by worm wheel and worm. These kinds of paper cutting machines have many disadvantages, such as: complex structure, low driven efficiency and low availability factor of hydraulic system and so on. One type of the paper cutting machine with fully hydraulic system both in pressing paper and cutting paper units is studied in detail. The hydraulic system element circuit are delivered and analyzed in detail. The loading and working condition of hydraulic system are also analyzes and calculated; the main parameters of performing elements including the power of motor are confirmed as well.

Keywords: Paper cutting machine; fully hydraulic control; design and calculation; hydraulic circuit; Motor.

1 Introduction

Paper cutting machine is a sort of paper machinery equipments. It is extensively used for paper making industry, paper carton, leather, plastic and food industry. With the developing of these industries, technical level of paper cutting machine becomes higher and higher. It's developing from mechanical machine to hydraulic, digital display and computer control machine. With the width use of hydraulic products, hydraulic control is adopted in the paper pressing unit of paper cutting machine. Because this pressing paper unit driven by hydraulic system has many advantages, such as: smooth working, high precision, heavy cutting force, broader pressure adjusting range [1], and so on. Nowadays, most products in inland and all products in developed countries adopt pressing paper unit driven by hydraulic system. But, at the same time, a great number of them still adopt traditional cutting paper unit driven by worm wheel and worm. The paper cutting machine having adopted this kind of cutting paper unit has advantage of low cost, but availability factor of its hydraulic system is low, and this cutting paper unit driven by worm wheel and worm has many disadvantages, for example: this type of cutting paper unit has complex structure and low driven

C. Xiong et al. (Eds.): ICIRA 2008, Part II, LNAI 5315, pp. 301–310, 2008.

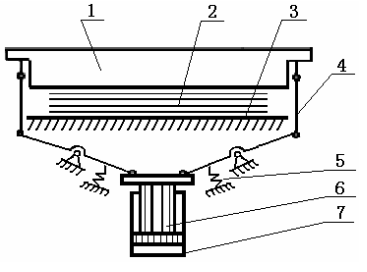
efficiency. The cogwheels engaged between worm wheel and worm are easily worn; For the reason that break tray has remaining magnetism, it makes the electromagnetic clutch action more slowly and makes break capability reduce, safety decline. If gear wheel skids for a long time, the friction would produce heat, make gear wheel wear rapidly; the solenoid of electromagnetic clutch heat easily, voltage fluctuation is heavy, interference strong; the gear driven system has disadvantage of heavy noise; small and fixed cutting force, so the output torque is changing and the instability cutting paper quantity[2]~[4].

If cutting paper unit can adopt hydraulic control as pressing paper unit does, it markedly improves the availability factor of hydraulic system; and because the hydraulic system has characteristics of rapidly response and adjustable pressure, it commendably settle the matter of fixed cutting force and badly break capability. As the worm wheel and worm driving unit and electromagnetic clutch is removed, the problems caused by them will be settled, such as, serious wear and tear, heavy noise, high heating, unstable torque output and so on. In this paper, the authors major study in detail in the design and calculation of one type of fully hydraulic system of the paper cutting machine.

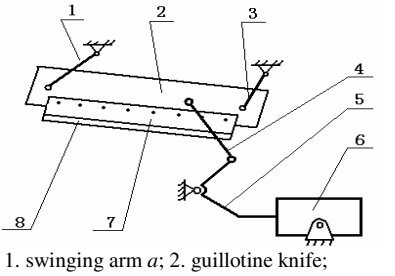
2 The Analysis of Pressing Paper Unit System and Cutting Paper Unit

The cutting paper part of the paper cutting machine are composed of pressing paper and cutting paper units, which controlled by fully hydraulic system.

Pressing paper unit [4] is shown in figure 1. When the piston of hydraulic cylinder moves upward, the lever construction makes the pressing paper machinery move downward. In order to ensure the quantity of paper, the pressure of the pressing paper machinery can be adjusted and kept stability, the gauge pressure should modulated within 4~10 *MPa* and not allow to exceed 15 *MPa* [5].



1. pressing paper machinery; 2. paper pack
3. working table; 4. pull rod; 5. spring
6. piston; 7. pressing paper hydraulic cylinder

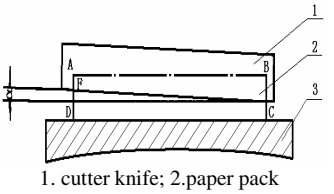


1. swinging arm *a*; 2. guillotine knife;
3. swinging arm *b*; 4. pull rod;
5. crank; 6.cutting paper hydraulic cylinder;
7. cutting knife; 8. knife blade

Fig. 1. (a) pressing paper unit (b) cutting paper unit

Cutting paper unit [6] is shown in figure 2. The cutting knife moving along with the complex curve locus is realized, when the advanced technology has been used in the paper cutting machine. The characteristic of this oblique blade style is: When the

piston of hydraulic cylinder moves towards the left, pulls paper cutting machinery downward, the cutting knife making an angle of α with paper. Cutting knife has a minuteness turning when it's moving. When knife blade touches the paper, only cuts a part of paper. As the descending of the knife blade; the knife blade touches the cutter blade slips gradually and the angle α decreases gradually to 0, both sides of papers separate gradually along with the width direction of paper pack in succession, so the cutting force is lesser than other cutting styles, and it approximates to a constant. The advantage of this oblique blade is reducing the cutting resistance of stuff and the shock force of the knife blade, improves cutting quantity. This oblique blade style is divided into two kinds of way according to the angle blade slope: $\alpha > \arctan(h/l)$ and $\alpha < \arctan(h/l)$. The way of $\alpha > \arctan(h/l)$ is almost impossible, because the structure of paper cutting machine is limited. Therefore, there are a lot of products are adopted the way of $\alpha < \arctan(h/l)$, the authors selected the way for further study. $\alpha < \arctan(h/l)$ cutting way is shown in figure 3.



1. cutter knife; 2.paper pack
3. working table

Fig. 1. The oblique blade style of

The four corners of the paper are named as A, B, C, and D. When the knife blade moves to the corner C, cutting force increases to the maximum value, the corner A has already been cut off at this time. The cutting area having been cut off is a trapezoid, the equation to calculate cutting force [4] is:

$$F_{ic} = S_{afcb}\tau = \left[\left(h - L\tan\alpha\right) + h\right]L\tau \div 2 = Lh\tau - 0.5L^2\tau\tan\alpha \tag{1}$$

where: F_{ic}: The cutting force of the oblique blade (N); L: The width of the paper (m); h: The thickness of the paper (m); τ: The paper's anti-break strength. The white cardboard paper is 2.156×10^5 (N/m^2); α: cutting angle of the knife

3 The Design of Hydraulic Circuit

The hydraulic system is shown in figure 4. At first, hydraulic system downloads pressure through 2/2 way electromagnetic directional valve. When hydraulic system begins to work, the electromagnetic YA5 is on and the systemic pressure is established.

When worker pedals machine, the electromagnetic YA2 is on. The mineral oil passes through 3/4-way electromagnetic directional valve to the right chamber, pilot operated check valve, and modulation speed valve to the down-chamber of the pressing paper hydraulic cylinder. The pressing paper machinery decreases, the pressure of down-chamber increases quickly after the machinery has touched on the paper pack. When pressure increases to the target maximum value, pressure sensor sends a signal to electromagnetic YA2 and makes it off. 3/4-way electromagnetic directional valve works in middle position. The mineral flows into the down-chamber of hydraulic

cylinder keeps pressure in stability by pilot operated check valve. When pressure decreases to target minimum value, pressure sensor sends signal to electromagnetic YA2 and makes it on, at the same time, YA1 is off. The system can be realized the mineral oil in the hydraulic system automatic compensation and pressure automatic stability. When the electromagnetic YA1 is on, 3/4-way electromagnetic directional valve works in the left position, the pressing paper machinery moves upwards.

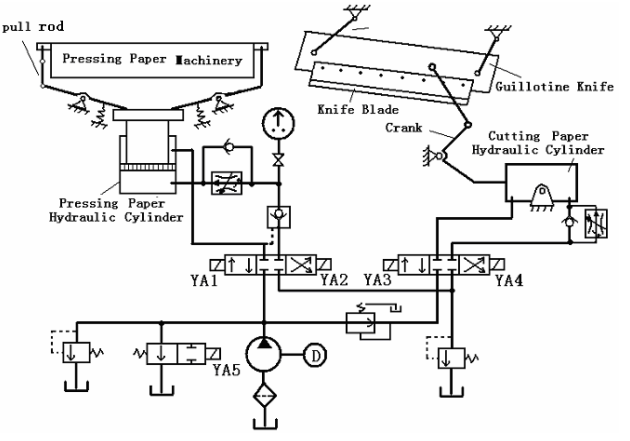


Fig. 2. Hydraulic system

If the pressure of down-chamber increases to the setup maximum value, the electromagnetic dowel is on. The dowel is magnetized from the knife-hole and then the electromagnetic YA4 is on, the cutting knife declines. When knife touches the down-side and switch is on, the electromagnetic YA4 is off and YA3 is on, at the same time, the knife returns till touches the upside and switch is on, then electromagnetic YA3 is off, the electromagnetic dowel is off and return to knife-hole under the effect of spring. These measures can avoid the cutting knife declining itself.

The electromagnetic acting order is shown in table 1

Table 1. The electromagnetic acting order

Electromagnetic / Action	YA1	YA2	YA3	YA4	YA5	YA6
stop	-	-	-	-	-	-
Start	-	-	-	-	+	-
Pressing paper machinery decrease	-	+	-	-	+	-
Pull out the dowel	-	+	-	-	+	+
Paper cutting machinery decrease	-	+	-	+	+	+
Paper cutting machinery and Pressing paper machinery returns	+	-	+	-	+	+
Insert the dowel	-	-	-	-	+	-
Start	-	-	-	-	+	-

4 The Design and Calculation of the Hydraulic System

The height of the paper pack is set 100*mm*. this is because, the more higher the paper pack is, the more higher cutting resistance of the paper pack is, the more higher pressure the pressing paper machinery need thus, enlarges the deflections and distortion of the paper pack, the paper pack having been cut off, it maybe appear the case of up long and next short. So the best height of paper pack is below 100*mm*. the different height of paper pack is adjusted from the different thickness the paper[6]. The width of the paper pack is set 920*mm*. The cutting angle of the cutting knife is set 1.5º.

4.1 Design the Parameter of Cutting Paper Hydraulic Cylinder

4.1.1 Calculating the Speed of the Cutting Knife

For Most hydraulic control or programmable control paper cutting machine, cutting frequency is about 40 times/ *min*, thereout, so, the period of the cutting knife is following:

$$T=1min/40=60s/40=1.5s$$

To ensure the requirement of the period of 1.5*s*, the circulating period can be separated as following in detail: descending is 1*s*, rising is 0.5*s*; the distance of rising and descending is 12*mm*. So the average speed v_1 and v_2 of descendent and rising for cutting knife can be calculated, respectively. Here: $v_1=0.12m/s$; $v2=0.24m/s$.

4.1.2 The Maximum Cutting Force of Cutting Knife

According to the calculation equation of oblique blade style [2]: Substitute parameters into equation (1), got $F_{ic}=17445.96(N)$.

Assume the ratio of tension arm compares with heavy tension arm is 1 to 1.

In consideration of the whole loss in the transmission mechanics, and the gravity of guillotine knife, when computes the maximum pushing force of cutting hydraulic cylinder, need remain 20% amount. if the maximum pushing force F_{max} is 21807.45(*N*).

4.1.3 Working Pressure and Back Pressure of Cutting Paper Hydraulic Cylinder

According to the working pressure under different load conditions is shown in table 2.

Table 2. The working pressure under different load conditions [10]

Load F (*N*)	Working pressure ofhydraulic cylinder (*MPa*)
<5000	<0.8~1
5000~10000	1.5~2
10000~20000	2.5~3
20000~30000	3~4
30000~50000	4~5
>50000	≥5~7

Primary assume the working pressure of cutting paper hydraulic cylinder as 4 *MPa*.

According to the experience data of back pressure in hydraulic system [10] is shown in table 3

Table 3. The experience data of back pressure

Character of circuit	Back pressure$P_2(Pa)$
Meter-in inlet	$(1\sim2)\times10^5$
Meter-in inlet and back pressure valve is set in return circuit	$(2\sim5)\times10^5$
Meter-out outlet	$(6\sim15)\times10^5$
Close circuit with affixes pump	$(10\sim15)\times10^5$
Working pressure exceed 25MPa	0
Use inner-curve hydraulic motor	$(7\sim12)\times10^5$

If the back pressure of the circuit is 0.5 *MPa*.

4.1.4 The Parameter of Cutting Paper Hydraulic Cylinder

Because the chamber without pole is the work chamber, according to the simultaneous equations (2) and (3) [11]:

$$P_1A_1 - P_2A_2 = \frac{F_{\max}}{\eta_{cm}} \tag{2}$$

$$\frac{v_2}{v_1} = \frac{D_1}{(D_1 - d_1)} \tag{3}$$

P_1, P_2 : the pressure of working chamber and returning chamber of hydraulic cylinder, respectively (Pa); A_1, A_2: the effective area of rodless chamber and rod chamber of hydraulic cylinder, respectively (m^2); $F_{\max}$,: the maximum load force in hydraulic cylinder (N); η_{cm}: the mechanical efficiency (0.9~ 0.97); v_1, v_2: the speed which guillotine knife descend and ascend, respectively, (m/s); D_1, d_1: the diameter of hydraulic cylinder and diameter of piston, respectively (m)

Substitute all parameters into equations (2) and (3), get D_1 =89.8m*m,* d_1=44.9*mm*

If pressure of the cutting hydraulic cylinder increased appropriately, cutting will be easy. Therefore, the authors got the standard diameter of cylinder is smaller than that of calculating. From the regular of GB/ T 2348-1993 and GB/※7933-1987[12], the diameter of standard cylinder and piston are 80*mm* and 50*mm,* respectively.

Thereout, the working area and working pressures of cutting paper hydraulic cylinder are as following:

Rodless chamber area $A_1 = \pi D_1^2/4 = 5.02\times10^{-3}$ (m^2)

Rod chamber area $A_2 = \pi(D_1^2 - d_1^2)/4 = 3.06\times10^{-3}$ (m^2)

Substitute the parameters F=21807.45N, $\eta_{cm} = 0.95$, , p_2, A_1, A_2 , got working pressure $P_1 = (F/\eta_{cm} + P_2A_2)/A_1 = 4.88(Mpa)$

The maximum flow $q_{\max}$ can be given:

$$q_{\max} = A\ v_{\max} \tag{4}$$

A_1 or A_2: the area of hydraulic cylinder (m^2), respectively, $v_{\max}$: the maximum speed of hydraulic cylinder (m/s).

Substitute all parameters into equation (4), and got $q_{\max}$ is 0.734×10^{-3} (m^3/s).

4.1.5 Check Strength and Stability of Cutting Paper Hydraulic Cylinder

1) The thickness of cutting paper hydraulic cylinder

If low-pressure system or $\delta/D \leq 0.08$, the thickness of hydraulic cylinder is consideration as thin wall.[13,14]

$$\delta \geq \frac{P_{\max} D}{2[\sigma]} \tag{5}$$

$$[\sigma] = \frac{\sigma_s}{n_s} \tag{6}$$

δ: the thickness of hydraulic cylinder (m); $P_{\max}$: the maximum allowable pressure. (MPa); When working pressure $P \leq 16MPa$, $P_{\max}=1.5P$; D: the diameter of hydraulic cylinder (m); $[\sigma]$: Allowable stress of cylinder's material (MPa); σ_s: Material's bow limit, $\sigma_s=355MPa$; n_s- Safety coefficient $n_s=1.5\sim2.5$, here is 2.55 commonly.

Substitute all parameters into equations (5) and (6), and got $\delta \geq 2.06\times10^{-3}(m)$.

So the outside diameter of the cylinder is D_2 is $84.12\times10^{-3}(m)$

For the regular the standard [14], the outside diameter is $D_2=0.095m$, nominal pressure $P_N=16MPa$.

2) The strength of piston [13]

$$d \geq \sqrt{\frac{4F}{\pi[\sigma]}} \tag{7}$$

$$[\sigma] = \frac{\sigma_s}{n_s} \tag{8}$$

D: The diameter of piston. (mm); F- Load applies on the piston(N); $[\sigma]$: Allowable stress of piston's material.(MPa); σ_s: Material's bow limit, $\sigma_s=355MPa$; $n_s=2\sim4$.

Substitute all parameters into Eq. (7) and (8), and got $d \geq 17.69$ *and* $[\sigma] = 88.75$

So, the diameter of piston is chosen as 50mm, satisfied the requirement of the strength.

4.2 The Parameter of Pressing Paper Hydraulic Cylinder

4.2.1 Working and Back Pressure of Pressing Paper Hydraulic Cylinder

From the regulation of paper enterprising, the value of pressure gauge in pressing progress should maintain the scope of 4~10 MPa, not over 15 MPa[6]. Therefore, the working pressure P_1 of pressing paper hydraulic cylinder is chosen as 11 MPa. From table 3, the back pressure of the hydraulic system is chosen as 0.5 MPa

4.2.2 The Maximum Push Force of Pressing Paper Hydraulic Cylinder

The pressure of the pressing paper machinery i.e. the force on the stuff prepare cutting, its value equals to the pressure resistance and its direction contrary. The maximum pressing force is one of the main performances of paper cutting machine[5]. The type of 920 Litong paper cutting machine's maximum pressing force is 35000N, other types of 920 paper cutting machines are about 30000N. Therefore, the maximum pressing force of paper cutting machine is chosen as 35000 N.

So, the results of the load of pressing paper hydraulic cylinder in different working condition are as follows:

When pressing paper machinery falls, but still not touch the paper pack, considers load as 0. After having touched the paper pack, the pressure of pressing paper hydraulic cylinder is loading. When pressure loading process is over, load is equal to the maximum pressing force. Meanwhile, the pushing force of pressing paper hydraulic cylinder is up to maximum.

While pressing paper machinery returns back, considers load as 0.

4.2.3 The Speed of Pressing Paper Machinery

As the pressing paper machinery descends to touch paper pack, pressing paper hydraulic cylinder enter to pressure loading process. In this process, the paper is pressed solidly. Because the different kinds of paper need different pressing force, the pressure of pressing paper hydraulic cylinder should be controlled between 4~10 *MPa*[6]. The pressing time of pressing paper machinery is corresponded to vary between 0.5*s*~ 5*s* [9]. The softer the texture of paper which needs to cut is, the bigger the pressing force adopts and the longer pressing time is.

Therefore, for calculating the moving speed of pressing paper machinery, supposition as follows.

The moving time of the pressing paper machinery from starting to contact the paper pack is 0.2*s*, the distance is 20*mm*; From touching the paper pack to pressure loading over, spend 5s, the distance is also 20 *mm*. The return speed of pressing paper machinery is 0.0024*m/s*.

The average falling speed of pressing paper machinery v_1=0.1(*m/s*);

The average falling speed of pressure loading process: v_2=0.004*m/s;* the average returning speed, v_3=0.24*m/s*

4.2.4 The Parameter of the Pressing Paper Hydraulic Cylinder

If the chamber with rodless is the working, in term of the simultaneous equations (2) and (3) [11]: Substitute all data into equations (2) and (3), got: D_1 =0.0663(*m*); d_1=0.0386(*m*)

To be ensure that the pressing paper hydraulic cylinder could maintain pressure over 10MPa after having been designed. The serial standard diameter of cylinder is smaller than calculated.

In term of the regular standard GB/ T 2348-1993 and GB/※7933-1987[12], the standard diameter of cylinder and piston are 63*mm and* 45*mm,* respectively.

Thereout, the working area and working pressures of pressing paper hydraulic cylinder are as following:

Rodless chamber area $A_1 = \pi D_1^2/4 = 3.12\times10^{-3}\ m^2$

Rod chamber area $A_2 = \pi(D_1^2 - d_1^2)/4 = 1.53\times10^{-3}\ m^2$

Working pressure $P_1 = (F/\eta_{cm} + P_2A_2)/A_1 = 12.05Mpa$

Substitute data into equation (4), calculate the max. flow $q_{max} = 0.367\times10^{-3}\ (m^3/s)$.

4.2.5 Check Strength and Stability of Pressing Paper Hydraulic Cylinder.

(1) Checking the thickness of pressing paper hydraulic cylinder.

Substitute all data into equations (5) and (6), got $\delta \geq 4\times10^{-3}m$

Because $\delta/D = 0.063 \leq 0.08$, the thin wall equations (5) and (6) are not suit for computing the thickness, the thickness of hydraulic cylinder is consideration as medium wall equations for checking. The medium equations [13] (6) and (9):

$$\delta \geq \frac{P_{\max} D}{2.3[\sigma] - 3P_{\max}} \tag{9}$$

δ: the thickness of hydraulic cylinder. (*m*); $P_{max:}$ the maximum allowable pressure. *MPa*; when working pressure $P \leq 16MPa$, $P_{max}=1.5P$; *D*: the diameter of hydraulic cylinder (*m*); [σ]: Allowable stress of cylinder's material (*MPa*); $\sigma_{s:}$ Material's bow limit, $\sigma_s=355MPa$. n_s: Safety coefficient $n_s=1.5\sim2.5$ commonly.

Substitute all data into equations (6) and (9), got $\delta \geq 4.18mm$; and the outside diameter $D_2=D+2\delta=71.36$ *mm*

The outside diameter is[14], $D_2=78mm$, nominal pressure $P_N=25MPa$.

(2) The strength of piston [13].

Substitute all data into equations (7) and (8), got $d \geq 22.41mm$; So the diameter of piston is chosen as 45*mm*, satisfied the requirement of the strength.

5 Design Hydraulic Pump

5.1 The Working Pressure of Hydraulic Hump

$$P_p = P_1 + \Sigma\Delta P_1 \tag{10}$$

P_p: the maximum pressure of the pump (Mpa); P_1: the maximum pressure of the components (MPa); $\Sigma\Delta P_1$: the total pressure loss of the inlet circuits in the same working condition (MPa); $\Sigma\Delta P_1$ is an experiment data: the throttle speed control system or simple system, $\Sigma\Delta P_1 = 0.2\sim0.5$ *MPa*, Meter-in inlet or complicated system, $\Sigma\Delta P_1=0.5\sim1.5$ *MPa,* here: $\Sigma\Delta P_1=0.5$

Substitute $P_1 = 12.05Mpa$ and $\Sigma\Delta P_1=0.5$ *Mpa* into equation (10), got $P_p = 12.55Mpa$

5.2 The Flow of Hydraulic Pump

$$Q_p \geq K (\Sigma Q_i)_{max,} \tag{11}$$

Here: Q_p: the flow of hydraulic pump; *K*: the leakage coefficient of circuit; ΣQ_i: the total flow of all components

To throttle flow speed control system, the total flow of the system is the maximum flow of the flow control system and the minimum flow of the relief valve (5×10^{-5} m^3/s). Substitute all data into equation (11), got $Q_p \geq 8.8\times10^{-4}$ m^3/s

The gear pump of type CB-F_c31.5 is chosen here, it has character as follows and is satisfied the requirement.

And confirm the power of motor is 11.16*KW*

Table 4. The parameters of the type CB-F_c31.5

type	Theoretic displacement ($ml \cdot r^{-1}$)	Rated pressure (MPa)	Maximum pressure (MPa)	Rated rotate speed ($r \cdot min^{-1}$)
CB-$_c$31.5	32.02	16	20	2000

6 Conclusions

The hydraulic system draft of the fully hydraulic paper cutting machine was got; the control system process was studied in detail in the paper. In term of the structure and cutting method of the paper cutting machine, the different kinds of the loads and speeds of the cutting and pressing paper hydraulic cylinders are calculated. From above results, the diameter of the cutting paper hydraulic cylinder is 80mm, the diameter of the piston is 50 mm; the diameter of the pressing paper hydraulic cylinder is 63mm, the diameter of the piston is 45mm. The strength of the hydraulic cylinder was checked. From the analysis, the parameters of gear pump are: the displacement is 32.02 ml/r, nominal pressure is 16MPa, Nominal rotation is 2000rpm. The power of the motor is over 11.16KW.

References

1. Li, Y., et al.: The Research of Fuzzy Control on Hydraulic of Paper Cutting Machines. China Academic J. Equipment and Instrument (add) 24(4) (2003)
2. The Paper Cutter Gearing in Paper Cutting Machine, China patent No: 02266637.0
3. The Hydraulic Cutting Mechanism of Paper Cutting Machine, China patent No: 2005200002589.5
4. The Electromagnetic Clutch in Gearing of Paper Cutting Machine, China patent No:200420021858.8
5. Zhang, X.S.: A Research for Tests on the Pressure Resistance of Main Loading of Slitters. J. Beijing Institute of Printing 6(2), 14–20 (1998)
6. The Analysis of the main Mechanical Factor which Influences Cutting Quantity, http://www.hc360.com
7. Zhang, X.S.: The Research of Tests on the Main Cutting Resistance of Loading of Slitters. J. Beijing Institute of Printing 5(2), 17–23 (1997)
8. Chen, Y.W.: Analysis and Calculation of Guillotine Level Blade and Oblique Blade Cutting Force. J. Packing and Food Machine 23(5), 27–28 (2005)
9. Hu, Y.K.: The Application of C200H Programmable Controller in QZX1300 Paper Cutter. J. Changzhou Institute of Technology 14(4) (2001)
10. Jia, M.X.: Hydraulic Transmission and Control (ver.2). Defense Industry Publisher (2001)
11. Zhang, L.P.: Hydraulic Transmission System and Designs. Chemistry Industry Publisher (2000)
12. Cai, C.H.: M.E.H Design Handbook. Machine Industry Press, Northeast Univ. press (1997)
13. Dong, F.L.: Hydraulic and Pneumatic Drive. Chemistry Industry publisher (2006)
14. Cheng, D.X.: Mechanical Design Handbook. Chemistry Industry Publisher (2004)