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# Research on Web Press Tension Control System

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**Abstract:** Tension control of press is a key and difficult point of the whole machine control. The stand or fall of tension is directly related to the quality of the products. According to the characteristics of the web press tension control, this paper expounds the main factors influencing tension and the purpose of tension control, researches on the tension control principle of web tape, analyzes control rule and control circuit of tension control system, illustrates the advantages of PID control law adopted in the tension control system, and concludes the influencing factors of paper tape tension control system and the corresponding problems needed to solve in the control.

## Introduction

In the process of web press work, tension control of paper is quite important. If tension control is inappropriate, fold and deformation occurs upon coil, influencing printing quality and causing waste of paper. Now most printing enterprises use traditional unit-type printer, in which power of printing unit is provided by the power source, transferred and obtained via transmission parts such as belt, mechanical shaft and gear. In this process, the shear interference transfers with the mechanical shaft, which results in the reduction of printing precision. And existing magnetic powder brake may be stuck or fail to work due to improper installation, over-speed, long time of usage, and etc. These factors directly or indirectly lead to biased printing machine tension control, which affects printing quality. So, the stability of the tension control is especially important in the field of printing production and processing, and tension control system also becomes a very important part of printing production line.

## 1. Purpose and influencing factors of web press tension control

Web press supplies printing material in the form of coil. Web press has very extensive application in the newspapers, books and periodicals, as well as exquisite products. In China, the web press devices currently used are mostly imported products. Both commercial paper and newspaper printing production is generally completed via a variety of brands of foreign advanced printing machine, such as WIFAG, MAN ROLAND, KBA, HEIDELBERG, GOSS, and etc. In order to achieve the work of paper printing, paper tape must keep flat and moderate degree of tension before entering the printing device, which is to keep a certain paper tension. In the process of transmission of paper tape of paper roll, the force which keeps paper tape tight is called tension. If paper tape is in an unconstrained condition in the process of printing, the tape will not be able to finish printing work. The degree of tape tension is directly related to the state of image transfer. In the process of printing, paper tape tension needs to be constant and appropriate [1]. If the degree of tension is not appropriate, a series of slips will happen, such as shifted, wrinkled, broken or torn paper tape, imprecise overprint, as well as wrong position of top/down margin, resulting in paper tape waste, affecting the machine efficiency, increasing the intensity of labor, and ultimately affecting the quality of production. When the paper tape tension is too large, it will produce certain deformation of printing network, and longitudinal folds and even transverse cuts of paper tape; when the paper tape tension is too small, it can cause imprinting fuzzy, imprecise overprint and transverse folds; when the paper tape tension is instable, it can also cause imprecise overprint, double image, longitudinal folds and other printing failures, affecting the printing production. So during the web press printing process, paper tape must have a certain tension, in order to control the movement of the tape, and the paper tape tension should be ensured constant in the process of printing. There are many reasons resulting in the change of paper tape tension and the influence of various factors has different results. The shape change of paper roll in the process of manufacture, transportation, and use will cause the paper roll to shake and skew. Unequal and oblique winding of paper roll in the process of manufacturing as well as squeezing of paper roll in transportation and storage can all result in paper roll shape changes, such as being off-center and irregular outside circle. In addition, in the use process, paper roll will be smaller and smaller in diameter. As for the same tape drive, when the paper roll diameter is not the same, the paper tape tension would be different. When the diameter of the paper roll is reduced, paper tape tension will then become bigger. In order to keep constant paper tape tension in the process of printing and satisfy the requirement of printing work, paper roll brake must be able to automatically adjust according to the paper tape tension fluctuation, to ensure that the paper tape goes into the printing device constantly and smoothly. During the steady running of the machine, paper roll brake should guarantee the stability of paper tape tension on the given value; during starting and braking, it should prevent paper roll overload and loose roll. In the process of production, as the paper roll size decreases continuously, the braking torque needed adjustment in order to keep the paper tape tension constant [2].

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## 2. Research on intelligent fuzzy PID control of tension

### 2.1. Principle and characteristics of PID control

In practical engineering, the regulator control rule most widely used is the proportion/integral/differential control

or PID control (also known as PID adjustment). Having appeared in the world for nearly 70 years, the PID controller is of simple structure, high stability, reliable operation, and easy adjustment and has become one of the main techs in industrial control. When the structure and parameters of the controlled object are not fully grasped, or precise mathematical model cannot be obtained, or other technology of the control theory is difficult to use, then the structure and parameters of system controller must depend on experience and on-site commissioning, and the application of PID control technology is most convenient. In others words, when workers don't fully understand a system and the controlled object, or cannot obtain system parameters through effective measures, then PID control technology is most suitable. PID controller uses proportion, integral, differential to calculate control quantity and to accurately control, according to the system error.

**2.1.1 Proportion (P) control**

Proportional control is one of the simplest control methods. The controller output error signal is proportional to the input error. With only proportional control, system output will have steady-state Error.

**2.1.2 Integral (I) control**

In integral control, the integral of controller output error signal is proportional to that of input error signal. For an automatic control system, if there is steady-state error after entering the steady-state, this control system is then called having Steady State Error or is called system with steady-state error for short. In order to eliminate the steady-state error, the controller must introduce "integral item". Integral item depends on the time integral of error. With the increase of time, integral item will increase. In this way, even if the error is very small, integral item will also be increased with the increase of time, and promote the output of the controller, further reducing the steady state error until it is equal to zero. Therefore, with proportional and integral (PI) controllers controlling at the same time, the system could get rid of steady-state error in the steady state.

**2.1.3 Differential (D) control**

In the differential control, the differential of the controller output error signal (i.e., the rate of change of error) is proportional to that of input error signal. Automatic control system might vibrate or lose stability in the adjustment process of overcoming the error. This is because there is a big inertia component (link) or a lag (Delay) component which inhibits the action of the error and its change is always behind the change of the error. The solution is to advance the change of action that inhibits the error, namely when the error is close to zero, the action that inhibits the error should be zero. In short, the only introduction of "proportion" in the controller is often not enough. The role of proportional is only to amplify amplitude of error and now it needs to add the "differential" which can predict the trend of the error change. In this way, a proportional and differential (PD) controller can advance to make control function that suppresses error be zero, even negative, so as to avoid the serious overshoot of the controlled. For controlled object with large inertia or lag, proportional and differential controller can improve system dynamic characteristics in the process of adjustment.

## 3. Analysis of PID control

PID control algorithm, which is mature, has good control performance, high system stability and simple control algorithm. It is convenient and flexible to use and its control field is applicable to all walks of life. It has been widely used in the production process.

PID control algorithm is made up of deviation proportion (P), deviation integral (I), and deviation differential (D). In the process of research and development, if one can't fully grasp the structure and parameters of the controlled object, or can't get a more accurate mathematical model, or other control theory is hard to use, then it is particularly important to adopt PID control technology. Based on the experience and site commissioning, developers get structure and related parameters of the main system controller and do PID control calculation. In other words, when we don't have an effective measuring method for system parameter or when we have no way understand control system and the controlled object, it is most suitable for us to use PID control algorithm. PID control includes PI and PD control when applied to the actual development process [3].

PID controller calculates the controlled object mainly through proportional, integral and differential items, and on the basis of system error. The following makes a brief introduction of the three items.

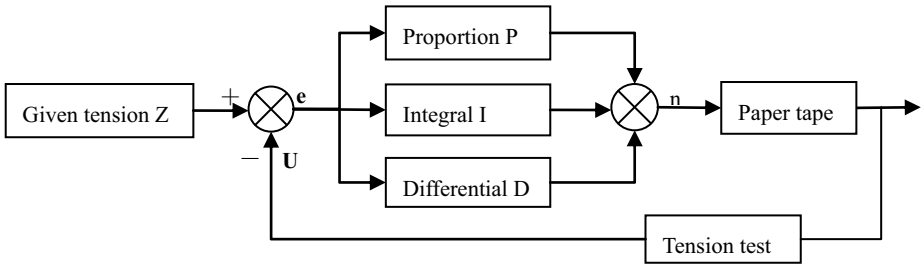
When the system output error signal is proportional to the input error, this kind of control mode is proportional control, indicated by the letter P. With only proportional control, system output will have steady-state.

When the integral of system output error signal is proportional to that of input error signal, this kind of controller is integral control, namely the integral term in the PID controller, indicated by the letter I. Integral item has a role to eliminate the system steady-state error. If a control system has steady-state error after the stable operation of equipment, then the control system is called a system with error. Accordingly, it is required to introduce integral item for the system to eliminate the steady-state error. Integral item depends on the time integral of error. With the increase of time, integral will increase. Hence, even if the error is very small, integral item will also be increased with the increase of time, driving controller to increase the output and reduce steady-state error further till zero. As a result, proportional and integral items only can guarantee no steady-state error in the control system after entering the steady state. This is the commonly used PI control.

When the differential of the controller output error signal is proportional to that of input error signal, this controller is differential control, namely the differential item in the PID controller, indicated by the letter D. Because of the

large inertia or delay link, some systems present system turbulence or instability. In this case, the only introduction of proportion is not enough, because the closed-loop system makes the change of the error always faster than adjustment item, which is due to the inhibitory effect by above links or parts in the process of error control. So, we should try to make the action which inhibits error be proportional to error change. Proportion item has the effect of amplifying amplitude of system error, but now it needs to solve the problem of predicting the tendency of the error. The only solution is to introduce differential item and derive a controller with proportional and differential items at the same time so as to achieve the effect of error control in advance, to avoid excessive adjustment of the controlled, and to improve dynamic characteristics of the control system in the process of adjusting the input error. This is the commonly used PD control [4].

PID control system diagram is shown below. Error e is difference between the actual output value and the given tension. Speed n is derived after calculation. The value of tension is detected through the tension detecting device so as to form closed-loop control. The discretization of PID calculation formula and including it in programs will help to realize the tension control. And for a more accurate and stable system, the torque control module is introduced, also in the form a closed loop control, to complement PID control.




## 4. Conclusion

Tension control system is one of the most important parts in the printing and packaging industry. The difficulty of solving the problem of coil tension control is to reduce as far as possible the influence of speed, roll diameter and others in the process of winding. Tension control system is a system with large time-varying, strong coupling and much interference. The traditional PI control law is very difficult to get ideal control effect, so control strategy must be improved. Integral separation PID and speed change integral PID can be used in start process, automatic roll change, and parking process. Variable PID control can effectively reduce the change intensity of system damping ratio in the winding process. Compared to a single PI control law, the damping ratio changes much more slowly, so that the stability of the system can be obtained.

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