Control and Design of Magnetic Levitation Structure of Jacquard Circular Knitting Machine Needle Selection Device

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Abstract—Based on magnetic levitation theory, the paper designed the electromagnetic force directly on the knitting needles knitting needles driven high-speed maglev-style, the suspension of driver jacquard knitting needle selection control theory; knitted by magnetic levitation control theoretical analysis, design floating needle PID control, self-tuning of PID parameters. Analysis of the entire system using Matlab and output control knitting, knitting needles to obtain suspension motion simulation results, simulation results show that the system has good dynamic performance, to meet the new maglev-style jacquard machine control systems..

Keywords- Maglev needles; Jacquard Circular Knitting Machine; Matlab simulation

I. INTRODUCTION

The textile industry, domestic and foreign electronic knitting computer jacquard needle selectors are electro-magnetic and piezoelectric. According to the statistics of documents and data, in order to improve weaving efficiency at home and abroad, mainly in two aspects: one is the study of new materials and other key parts of the needle or design for improving wear resistance, heat treatment process improvement, needle shape details of materials; two is the use of piezoelectric ceramic transducer drive element. The above two kinds of electronic needle selector can achieve efficiency of jacquard fabric and effective, and in the current jacquard fabric can be widely used in production, but driven by the way that they are rigid contact drive, if to further improve efficiency, reduce knitting jacquard fabric friction, will be subject to the drive restraint mechanism and principle of the. In this paper, the theoretical exploration of magnetic needles on, solve the traditional needle in high energy consumption, wear, mechanical transmission efficiency is low.

The magnetic bearing is the use of electromagnetic force, to support a stable suspended in space, the support and there is no mechanical contact the support elements performance electromechanical bearing, has the characteristics of no mechanical contact, no need of lubrication, high speed, high precision, low power consumption, intelligent control. Based on the above characteristics, the magnetic levitation technology has extensive application value in many fields. At present, the domestic and foreign electronic knitting computer jacquard needle selector are electromagnetic and piezoelectric.

II. SUSPENSION NEEDLE PRINCIPLE OF JACQUARD CIRCULAR MACHINE

Suspension needle by using the principle of magnetic levitation theory and technology, the needle axial suspension, the attraction and repulsion control knitting needle electromagnetic device and the up and down reciprocating movement, parameters of current size, direction and mode of driving load continuous by changing the electromagnetic device, so as to control the needle of various height and speed of movement, and complete the continuous weave.

Suspension needle selecting device will selector, triang ular parts, jacquard, needle and needle together jacquard m achine. According to the characteristics of suspended needl e, needle selection device configuration uses a cylindrical s tructure. Distributed suspension needle by Chinese and for eign three ring staggered distribution form, namely the nee dle is divided into three types: the inner, middle and outer needle knitting needle. The middle of the straight needle, needle with a lateral bending at the top, as shown in Fig.1.

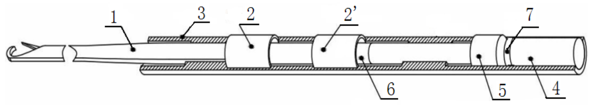

Figure 1. Suspension needle structure diagram.

Traditional jacquard knitting machine, the triangular shape of the track trajectories of knitting needle is decided by shape, triangle cam shape and speed determines the push rod movement speed and height of the needle selection, low efficiency, high energy consumption, serious environmental pollution, we must study the principle of new process. This paper studies the maglev technology based on jacquard needle selector technique, the magnetic suspension technology and control is applied to the design of needle selection jacquard machine controller, realize high speed series of knitted jacquard electronic needle selection control. The size and frequency of electrical parameters change needle electromagnetic force, the needle up and down reciprocating linear motion according to the motion rule set, at the same time the needle with the needle cylinder with circular motion, the sensor control device, to achieve reliable jacquard accurately knitting action.

III. DESIGN OF A SINGLE DEGREE OF FREEDOM SYSTEM OF MAGNETIC NEEDLE CONTROL

Magnetic levitation control must satisfy the speediness, stability, robustness of the system, in industrial applications, to the general PID control method. In this paper, research of single degree of freedom magnetic needle selector experiment system and control method, theoretical modeling for suspended needle system.

The magnetic levitation system consists of propulsion system, sensor system and suspension system controller. For such a complicated electromechanical integrated control system, to accurately describe the mathematical model is very difficult. The usual practice is to approximate linearization in the vicinity of dynamic equilibrium, were analyzed using single degree of freedom magnetic system. The propulsion system consists of a permanent magnet linear synchronous motor, permanent magnet linear synchronous motor rotor and the structure of the moving parts are connected together, the guide rail fixed on theme, mathematical model for the convenience of coefficient of the mixed suspension, simplified structure of single magnet as shown in Figure 5 shape. The magnetic levitation system using hybrid magnetic electromagnet, permanent magnetic force guarantee provided by the static balance system, reduce the power consumption of the system; magnetic electromagnet guarantee provided by the dynamic balance system, when the mixed reluctance when current flows through the electromagnet, magnetic will add downward force on the guide rail; interactions due to force on the magnet, guide also has the upward force, so long as the control of hybrid current magnet winding, motion platform can be suspended in the air, is in a state of equilibrium.

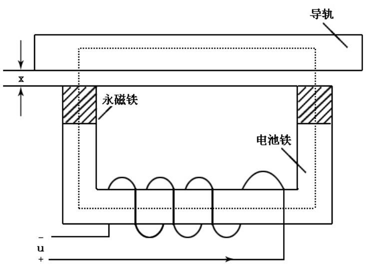

Figure 2. Single magnet suspension structure diagram

Needle control schematic diagram is shown in Fig.3.:

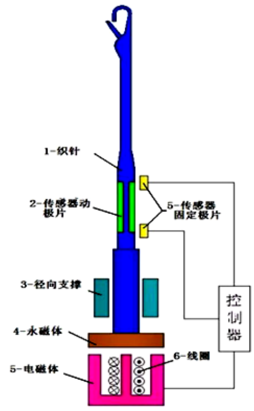

Figure 3. Needle magnetic levitation control

In Fig.3. the following is simplified:

1) The function of rail surface stiffness coefficient of infinity, not considering the elastic vibration and deformation;

2) Neglecting leakage flux and the reluctance of iron, the electromagnetic field in the air gap and the permanent magnet and uniform effect on;

3) Rotor is axially symmetric rigid rotor;

4) The structure and parameters of degrees of freedom of the radial magnetic bearing is completely consistent.

In the vertical direction of the electromagnet, with Newton's second law:

$$m\frac{d^2x}{dt^2} = mg - F(i,x) + F_d(t) \tag{1}$$

Here: m: an electromagnet moving parts (needle) to quality, g for the acceleration of gravity, x: the pelectro-magnet, $F_d\,(t)$: interference.

According to figure 3 the equivalent magnetic circuit model,calculation of magnetic flux:

$$\Psi(x,i) = \frac{\mu_0 A(Ni + 2H_c l)}{2x(t) + 2l/\mu_r} \tag{2}$$

Here: μ_0 is air permeability; A is the magnetic pole area; H_c is the permanent magnet coercive force of magnet magnetization direction length; $x\,(t)$ as the gap between the magnet and the guide rail. The equation is:

$$F(i,x) = \frac{B^2 A}{\mu_0} = \mu_0 A\left[\frac{Ni + 2H_e l}{2x(t) + 2l/\mu_r}\right] \tag{3}$$

In the equilibrium point (t_0, x_0) at:

$$mg = F(i_0, x_0) = \left[\frac{Ni_0 + 2H_e l}{2x_0(t) + 2l/\mu_r}\right] \tag{4}$$

The dynamic model of the system through the above equation expression, get Maglev at the balance point (i_0, x_0) denote the approximate linearization:

$$m\Delta x(t) = -k_x \Delta x(t) - k_i \Delta i(t) + \Delta F_d(t) \quad (5)$$

The equation of Laplass transform dynamic stress, the formation model:

$$Ms^2 X(s) = k_m X(s) - k_e I(s) + f(d) \quad (6)$$

Magnetic levitation system, displacement reference volume X_{ref} is usually set in a static position 0, a measure of a main index of stability of maglev control system should be the ability of the system to suppress the interference, if the response to disturbance of the ideal system, then the response of displacement of reference should also be satisfied, because $X(s)/f_d$ and $X(s)/X_{ref}$ transfer function with the same characteristic equation. Design of the magnetic levitation controller with PID control.

IV. PID CONTROL DESIGN OF SUSPENSION NEEDLE

The PID parameter adaptive principle, in the conventional PID control, the correction link has the following characteristics:

1) Proportion (P): proportionately reflect deviation control system, deviation controller once, immediately feedback effect, reduce the deviation. The proportional gain KP increases can accelerate the response speed, reduce the steady-state error of the system, improve the control precision.

2) Integral (I): a phase lag effect to eliminate the static error, system, strengthen the integral effect, can reduce the static error of the system.

3) Differential (D): reflect the change trend of error signal, and become the deviation signal is too large, the introduction of an effective early correction of signals in the system, accelerate the speed of action system.

The control goal is to ensure the output of the system with $y_m(t)$, since the initial parameter uncertainties, the controller parameters can not be adjusted well, produces the deviation signal $e(t)$. By $e(t)$ drive adaptive mechanism, a regulatory role of appropriate, directly change the parameters of the controller, so that the $y(t)$ and $y_m(t)$ gradually close, until the deviation signal reaching 0.

Control strategy is:

$$\begin{cases} \dot{K}_p = -\gamma\delta(t)\cdot e(t) - \alpha_1(K_p - K_p(0)) \\ \dot{K}_i = -\gamma\delta(t)\cdot \int_0^t e(\tau)d\tau - \alpha_2(K_i - K_i(0)) \\ \dot{K}_d = -\gamma\delta(t)\cdot \dfrac{de(t)}{dt} - \alpha_3(K_d - K_d(0)) \end{cases} \quad (7)$$

The adaptive law based on PID adjustable parameters, which is based on the model reference adaptive controller.

V. SYSTEM SIMULATION RESULTS AND ANALYSIS

This paper uses matlab/simulink software to analyze the control system, PID control module maglev system based jacquard circular knitting machine needle selecting device, system simulation model as shown in the figure, the system parameters of the controlled object as follows: suspended platform quality of M = 500kg, stiffness is 1.8 × $10^6 N/m$,magnet pole area of A =28cm×31cm, relative permeability=1 permanent magnet, the coercive force H_c = 8 × 105A/m,permanent magnet magnetization direction of length L =28mm. The electromagnet coil resistance R = 1, N = 500, the number of turns, the suspension gap of 10mm, the simulation parameters and actual test parameter, simulation time is 4s.

When no electrified, quiescent current of the electromagnet is zero, the suspension rotor in the initial equilibrium state due to the static attraction of the permanent magnet rotor and, when subjected to axial step disturbance deviate from the equilibrium state, the rotor from the initial state to the new1mm 0 stable equilibrium position, the rise time less than 2.5ms, displacement the overshoot and steady-state error, radial displacement is 0, the control system has good dynamic and static performance.

The simulation result is shown in figure 4:

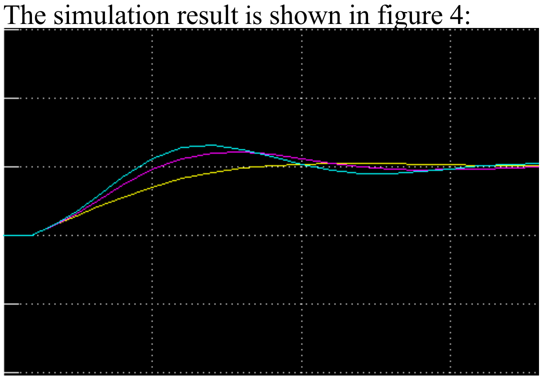

Figure 4. System simulation graphics

VI. CONCLUSION

The jacquard needle selection device, the magnetic needle principle, realization of jacquard woven needle “zero transmission” mode, analyzes the structure characteristics and working principle, the needle selecting device characteristics of various forms of. Magnetic PID control method of knitting jacquard machine, through the MATLAB simulation analysis, the simulation results show that: the suspension system PID control to achieve a smaller overshoot, shorter adjusting time, good anti-interference, comply with the control requirements of magnetic suspension platform. This paper establish electromagnetic-permanent action control mode in knitting jacquard machine, used for magnetic levitation technology extends the model and field.

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