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The Vermicelli Cutting Machine Control System Design and Structure of the Finite Element Analysis

Jianzhong Zhang[1,2], Zhaoming He[3], Xingming Xiao*[1], Kun Li[3], Yingying Xin[3], Xinpeng Xie[3]
[1]School of mechatronic engineering, China University of Mining and Technology, Xuzhou 221116, China
[2]School of Mechanical and Electronic Engineering, Shandong University of Science and Techology, Taian 271019, China
[3]School of Mechanical and Electronic Engineering, Shandong University of Science and Techology, Qingdao 266510, China
*Corresponding author, e-mail: xl6265@cumt.edu.cn

Abstract

Along with the social demands for the amount of food and constantly improve, the cutting way is not able to meet the user's requirements. So the automatic production line for automatic vermicelli cutting machine is designed. This paper mainly introduces the design of control circuit for cutting off machine. The parameters are optimized by programs. Static analysis for supporting structure of cutting machine is given by ANSYS software. The distribution of stress and strain is obtained. The maximum stress position is found. Determine whether or not to meet the use requirements and provide optimization proposal, and discuss the feasibility of the improvement scheme. The modal analysis for the cutting machine is done by ANSYS which provides theoretical basis for optimization design.

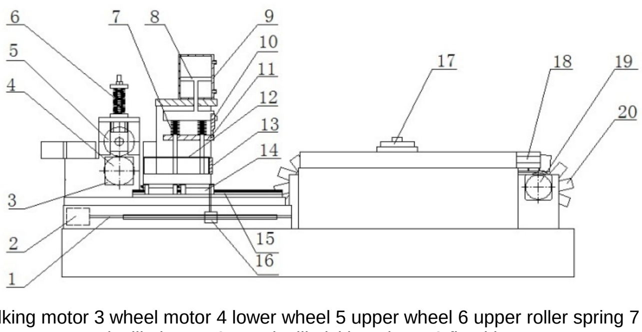
Keywords*: cutting machine, control circuit, modal analysis*

1. Introduction

With the development of food industry, the requirement of the food is more and more high. There are still some problems. The vermicelli cutting machine is a special tool in food machinery and production line machinery which is important in improving production efficiency, ensuring food safety and reducing labor costs. But the research and application of vermicelli cutting machine is little at home and abroad. According to the blank space of the field and the requirement of society and food industry, a vermicelli cutting machine is designed to meet the demand of annual output of 20000 tons of vermicelli for some vermicelli processing production line. The controlling system and its structure is significant for high speed vermicelli processing production line. Therefore, proper elect-control system and stable structure is necessary.

2. Composition of the Cutting Machine

The composition of the cutting machine is shown in Figure 1.



1 ball screw 2 walking motor 3 wheel motor 4 lower wheel 5 upper wheel 6 upper roller spring 7 rag iron spring 8 piston 9 cylinder 10 upper cutter 11 vermicelli platen 12 vermicelli picking plate 13 fixed lower cutter 14 walking slider 15 linear rolling guide 16 screw nut 17 sensor 18 sensor walking motor 19 production line motor 20 production line belt conveyor

Figure 1. Structure of Vermicelli Cutting Machine

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It contains vermicelli cutting system, tool movement system, vermicelli input device, vermicelli output device and vermicelli length detection and adjustment of system [1].

3. Design of Cutting Machine Control Circuits

Control circuits of cutting machine is designed to meet the demand of cutting machine automated running. PIC single chip processor is selected for vermicelli processing production line as because of its fast speed, less operational orders, high performance of storing code and low power consumption. Control circuit is shown in Figure 2.

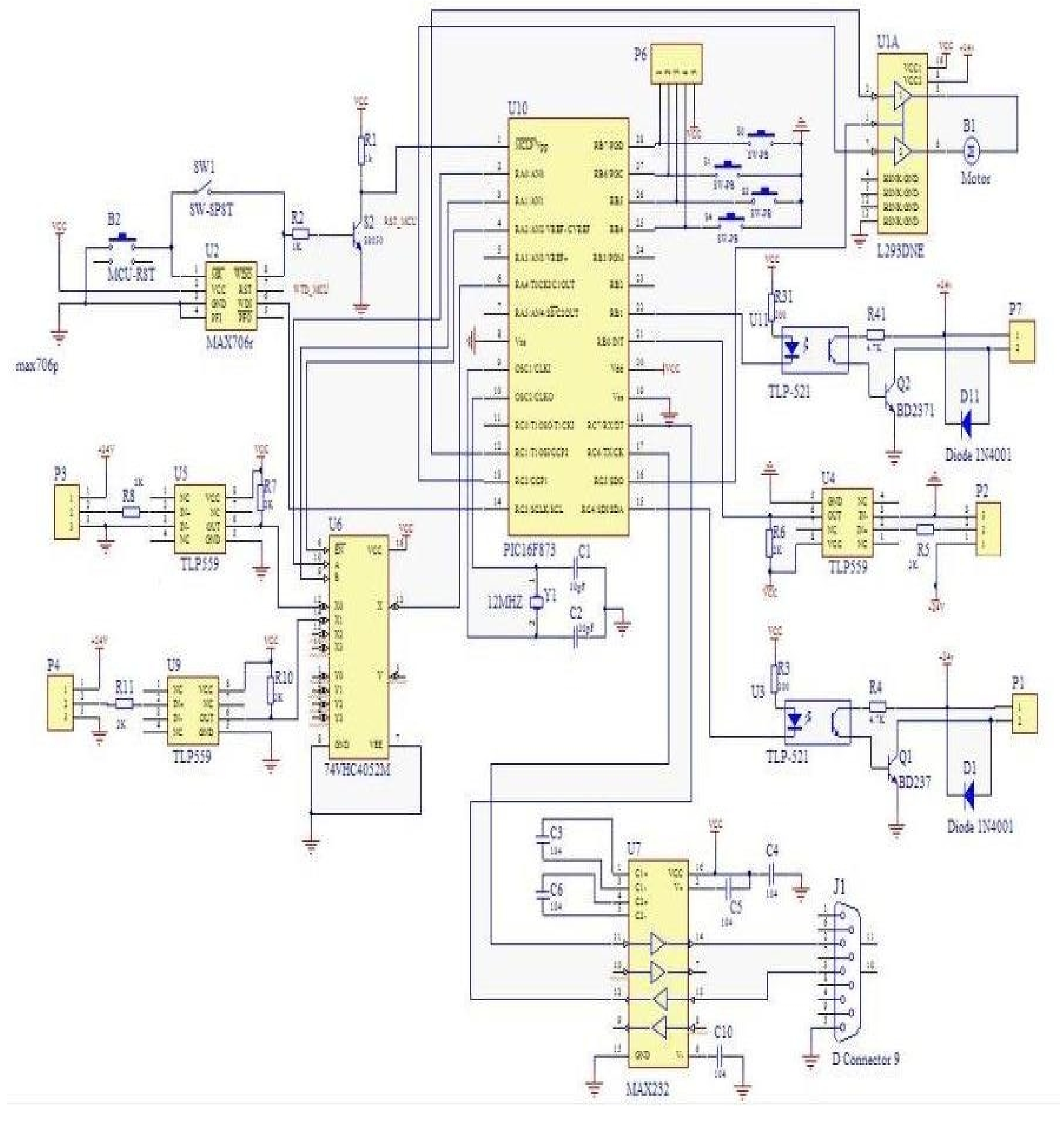

Figure 2. PIC Control Circuit of Cutting Machine

The control structure and the work principle of circuit is as follows [2]:

(1) Control circuit of cutting machine is a power conversion circuit as shown in Figure 2. 5VDC power is generated according to HDW5 24S05 module when working, and SW2 is manual master switch. Watchdog circuit is interfaced with VPP and RC3 of PIC control circuit. As the industry environment is bad and anti - interference ability of single chip processor is poor, PIC is equipped with built-in watchdog circuit which can prevent the program run effectively and

improve the system stability. Press SW1 when downloading program, and press B2 to reset. RC6 and RC7 is set to communicate with principal computer and communicate between vermicelli cutting machine and vermicelli processing production line.

(2) RC4 is the output for cutting off process instruction. Cutting off instruction controls the RC4 by built-in program of single chip processor. Cutting off control is realized by controlling the on-off of BD237. The effect of optoelectronic isolation is to isolate the interference of external 24 v power supply. RB0 of PIC is the input of photoelectric sensor for vermicelli detection according to the electro-optical information detected by the sensor and built-in interrupt program.

(3) RB7、RB6、RB5、RB4 of PIC is the input of limit switch. RB7 is the left limit switch of the cutting machine. RB6 is the right limit switch of the cutting machine. RB5 is the upper limit switch of the cut-off tool. RB4 is the lower limit switch of the cut-off tool. Switch control is determined by the location of cutting machine and cut-off tool.

(4) RB1 is the output of cut off the return instruction. Its principle of circuits is the same as connecting circuit of RB4. RC1, RC2, RC5 is the output of walking instruction of cutting machine. When the output of RC5 is valid, the motor rotates. RC1 outputs the forward instructions. RC2 outputs the reverse instructions. The three instructions realize walking control of the cutting machine according to L293DNE driver chip. RC1 and RC2 operate register directly to realize output of PWM for different duty ratios. No external timer is needed to output PWM and control the speed of assigned motor.

(5) OSC1 and OSC2 are clock interfaces. Clock frequency is timer 12MHZ. RA4 is the input of Coded pulse detection. Photoelectric code placed in the servo motor detects the rotate speed of motor spindle. Corresponding x channel of 74VHC4052M is selected by A or B, and collect coder pulse for assigned motor. The results are put into the PIC according to RA4 finally.

4. Analysis of Statics and Dynamics for Support

According to the structure of the cutting machine, the support part is the basic component, and its strength and stiffness has an effect on the structure life. Thus, analyze the statics and dynamic by ANSYS [3-6] and obtain the information of stiffness and vibrate are important to design the machine.

Geometric model is built by 3D software which is imported into the finite element analysis [7-9] software. The 3D model is meshed by element type 10node/solid92, and the meshed model is shown in Figure 3 [10, 11]:

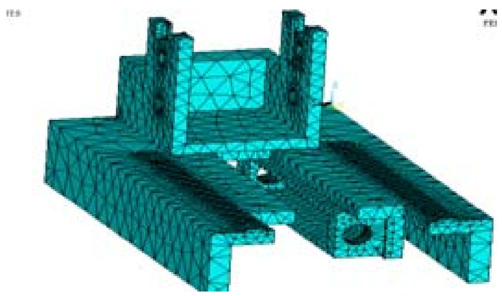

Figure 3. Meshed Model

The force is refined according to the actual stress. Track roller is loaded with the supporting gravity of the roller. Ball screw bearing hole sustains the gravity of the screw, and the upper end face is loaded with the pressure from guide rail. All the forces above are surface load.

The boundary conditions are: set two bottom surfaces of the support and one bottom surface of rolling screw according to the characters of installation and structure of vermicelli cutting system support. All the X, Y and Z directions are restrained on the constraint plane.

The volume of roller is 0.001m3, the weight of stainless roller is 77.7N, and support area of bearing hole is 7.06×10-4m2. Each roller bearing hole is under the pressure of 5.5×104Pa, and the pressure spread all over the lower semi-cylinder of bearing hole. The upper end face is loaded with the sum of cutting system gravity and cutting force where cutting system gravity is 860N, cutting force is 1058N, the upper end face force is 1918N, the stressed area of the end face is 1.995×10-4m2 and the pressure of the upper end face is 9.6×104Pa.

The vermicelli cutting system force of the upper ball screw is born by the upper end face of the support surface and the bearings are loaded with the reaction force of the screw. The volume of screw is 1.72×10-4m3 and the weight of the screw is 1.36N. The support area of bearing hole is 2.375×10-3m2, each roller bearing hole is under the pressure of 573Pa, and the pressure distributes along the lower semi-circle of the bearing hole. The boundary conditions are shown in Figure 4, the distribution of stress of the support is shown in Figure 5, and modal analysis diagram is shown in Figure 6.

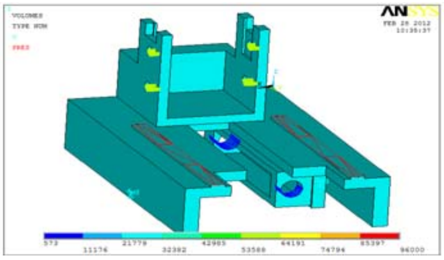

Figure 4. Boundary Conditions

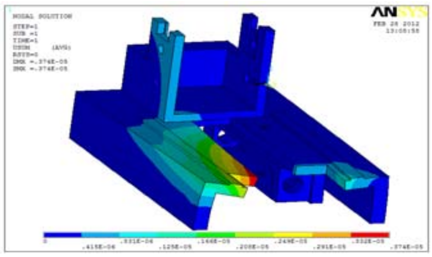

Figure 5. Distribution of Stress for the Support

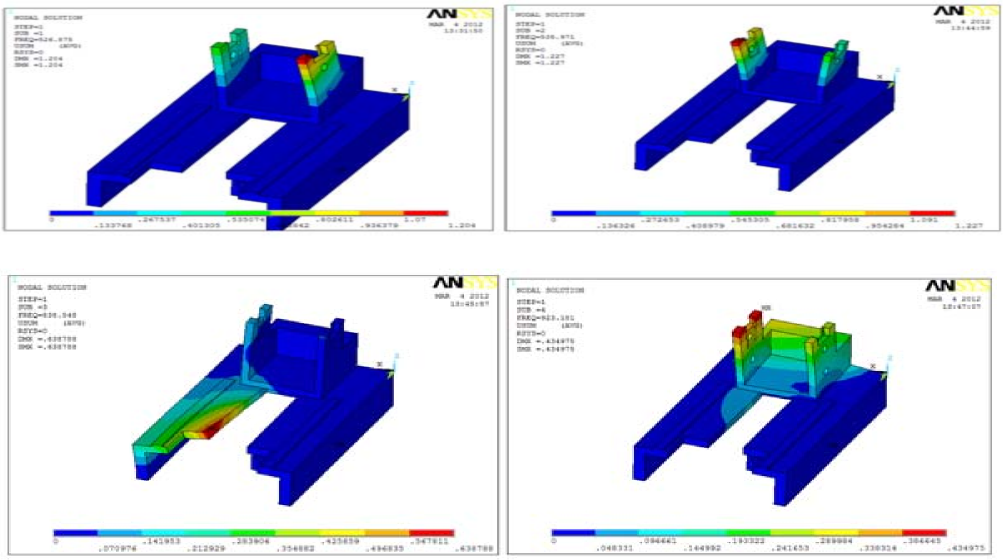

Figure 6. Deformation Diagram of 1-4 Order Nature Frequency for the Support

According to the modal analysis, the result data is corresponding change value of vibration quantity, and the value only reflects the ratio of vibration quantity at certain frequency. The following conclusion is obtained by the deformation diagram.

(1) At the first-order natural frequency (526.88Hz), roller support plate of support structural part for tool rest mobile system swings along X direction.

(2) At the second-order natural frequency (535.97Hz), two roller support plates of the structural part rotate toward two sides along Y direction respectively.

(3) At the third-order natural frequency (838.55Hz), guide rail support of the structural part swings along Z direction.

(4) At the fourth-order natural frequency (923.18Hz), roller support plate of the structural part rotates along X direction.

5. Conclusion

Control circuit of vermicelli cutting machine is designed based on PIC single chip which meet the demand of high-speed vermicelli production line and realize automatic production. The structure of the cutting machine is designed and the support structure is analyzed by finite element method. The maximum stress is obtained which provides theoretical basis for further improvement and structure optimization design.

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