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Design of A Spin-coating Used Manipulator

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Abstract. A spin-coating used manipulator system is designed, which mainly includes the mechanical system design of coating machine, hardware circuit design and software design of the control system. Operational principle of spin-coating used manipulator in this design can be elaborated as: the manipulator grasps a workpiece to rotate fully in the liquid for coating, the whole process can be controlled by compiled SCM programs, so as to meet different coating demands.

1. Introduction

As a new technology, coating is widely used in various fields, correspondingly, a robot that is suitable for different conditions is needed to complete these actions, but coating robot is seriously deficient. Therefore, robots with easy and convenient operation, low price are to be studied to solve current problem, so as to better serve the human beings[1-2].

Film thickness uniformity is quite important in the production of optical film components. As for interferometric film, dielectric mirror, anti-reflection mirror and other optical components, film thickness uniformity is an important factor, as well as the key to produce precision optical components[3-4]. The larger area of coating film, the more difficulty to control the film thickness uniformity. Poor film thickness uniformity will seriously damage the film properties, which may not only lead to great drift of spectral curves in different positions for optical elements and thus affecting the optical properties of whole components, but also affect light distribution on the components. Moreover, it also has a certain effect on the surface shape of components. Film thickness uniformity also determines the rate of finished film coating products. Therefore, film thickness uniformity has attracted wide attention in recent years[5-6].

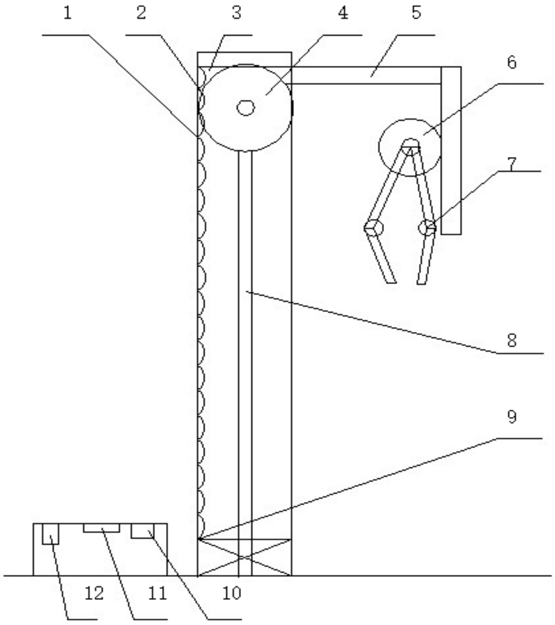
Most of previous coating-used manipulators only coat film on single surface, when it’s required to coat the entire workpiece, it has to be operated repeatedly for many times. As a result, the coated film on the surface is not uniform enough, thus affecting the overall surface effect of the workpiece[7-8]. The spin-coating used manipulator in this design can realize a rotated coating, and one-off coating on the whole workpiece.

2. Structure Design

In order to meet mechanical function requirements, a gear-rack drive is adopted in this design to realize the ascending and descending movements of manipulator under the support of slider blocks and guideway. The rotating part realize rotation movement of the workpiece through fixed gripper.

After the circuit is powered on, the SCM controls the motor and drives the manipulator to descend, it starts to coat the workpiece. When the manipulator descends to a certain position and touches the lower limit switch, the limit switch sends feedback signal to SCM while controlling the gripper engine to work on at the same time, thus continuously coating the workpiece. After coating, the SCM controls the motor and drives the manipulator to return to its original position. When the manipulator touches the lower limit switch and stops ascending, the coating operation is completed.

In this design, the descending and ascending movement is applied to the manipulator according to coating requirements. Combined with the rotation movement of gripper, a simple spin-coating function is completed. Structure of the coating-used manipulator is shown in Figure 1.



1-Rack 2-Gear 3-Upper Limit Switch 4- Gear Motor 5-Mechanical Arm 6- Gear Motor 7-Gripper 8-Slider Block and Guideway 9-Lower Limit Switch 10-Relay 11-SCM 12-Power Switch

Figure 1. Structural Sketch of the Coating-used Manipulator

3. Hardware Design of Control System

Control system determines the performance and cost of the spin-coating manipulator .In this design, the SCM controls engine to work, handles the position information and rotation information of the manipulator through limit switches, then it sends the processed signal to the controller. The controller makes corresponding treatment to realize the automatic ascending and descending, rotation of the spin-coating manipulator. Structural sketch of the control system hardware is shown in Figure 2.

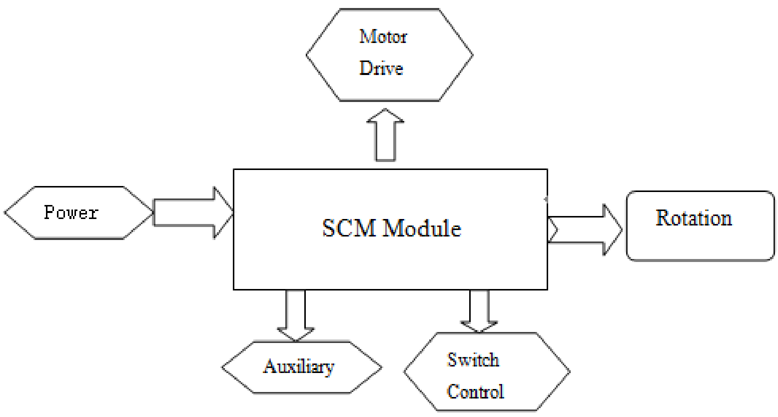


Figure 2. Structural Sketch of the Control System Hardware

4. Software Design of Control System

Hardware and software are two interdependent parts of a complete intelligent system, hardware is the material basis for software while normal operation of software is the only way for hardware to function. A computer system can only work normally with a complete software system and fully playing all functions of its hardware. The control system in this design consists of main program, coating rotation control program, limit switch control subprograms and time delay program.

In coating operation, the mechanical arm has to rotate the workpiece while moving the workpiece upwards and downwards, so as to complete a full coating. When the workpiece leaves the coating liquid or reaches the highest position, it stops rotating, so as to avoid uneven film thickness on the surface caused by rotation inertia.

In order to meet the ascending and descending of mechanical arm and guarantee the rotation effect of manipulator, programs are compiled for the control system in this design. The program flow chart is shown in Figure 3.

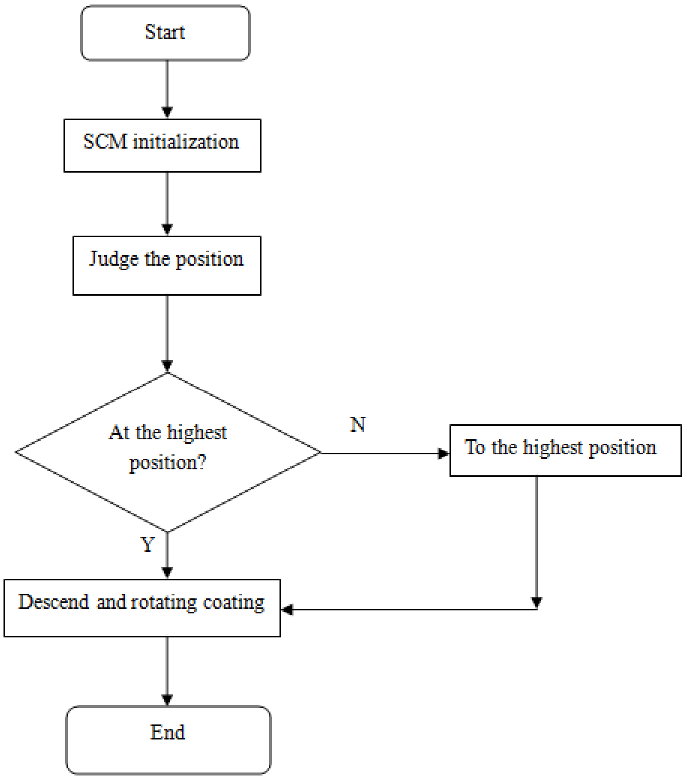


Figure 3. Program Flow Chart of Control System

5. Conclusion

Design of the spin-coating manipulator involves the mechanical field, electronic field and program design. With SCM as control center, this design realizes the straight and rotation actions. Contents involved in this design are as follows. First of all, considerations for operational principles of the spin-coating manipulator and the whole mechanical structure, as well as the comparison and selection of motor. Secondly, design the mechanical structure of spin-coating manipulator. Gear and rack, guideway and base are used to form a simple mechanical frame. Thirdly, design SCM control program. However, there are also shortcomings in this design. Moving speed and rotation speed of the mechanical arm need to be further improved, thus enabling the spin-coating manipulator to meet different coating requirements.

Acknowledgments
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References
[1] P J Kelly, J Hisek, Y Zhou, et al. Advanced Coatings through Pulsed Magnetron Sputtering[J]. Surface Engineering, 2004, 20(3):157-162.
[2] H Yu, Z Wu, T Wang. A Survey of Thickness Uniformity of Thin Films Deposited by Planar Magnetron Sputtering Process[J].Vacuum, 2010(3): 9-15
[3] H Dong, J Zhao, R Lin, et al. Study and Analysis on the Film Uniformity[J]. Piezoelectrics & Acoustooptics, 2006(5): 578—580
[4] G Duelen, H Stahlmann, X Liu． An Off-line Planning and Simulation System for the programming of Coating Robots[J]． Annals of the CIPP，1989，38(1)：369-372
[5] S Girma. Robot path integration in manufacturing processes: genetic algorithm versus ant colony optimization[J]. IEEE Transactions on System, Man, and Cybernetics-Part A: System and Humans, 2008:38(2):278-287
[6] C L Fu, C R Yang, L G Han, et al. The Thickness Uniformity of Films Deposited by Magnetron Sputtering with Rotation and Revolution[J]. Surface & Coating Technology, 2006, 200: 3678—3689.
[7] P Veljko, S Goran, K Dordevic. Dynamics of anthropomorphic painting robot: Quality analysis and cost reduction[J]. Robotics and Automomous System,2000,32(2):17-38
[8] X Q Meng, X J Fan, H X Guo. A New Formula on the Thickness of Films Deposited by Planar Cylindrical Magnetron Sputtering[J]. Thin Solid Films, 1998, 335: 279-283.