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Research of Automatic Pad-printing Machine of  
Date Indicators

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## 摘要

我国是世界上主要的手表生产地之一。但是，当前我国手表行业的生产工艺水平却与这一数据并不相符：手工装配和半自动化生产仍是手表行业的主要生产方式，生产效率低、产品一致性差。改用自动化生产线，以自动化的机械生产替代人工操作，可大幅提高生产效率，减少人为因素对生产过程的干扰。

本课题设计了一套手表日历环全自动移印设备，用于实现手表日历环转移印刷生产的全程自动化。传统的移印机仅能自动完成日历环印刷过程，而日历环的上下料动作均依赖手工，生产效率低，人力成本高，产品质量受人为因素的干扰，废品率居高不下。本课题设计的设备可自动完成日历环从送料到印刷的全过程，实现了日历环移印生产的全程自动化，能明显提高日历环的印刷效率，保证产品质量，节约人力成本。由于目前国内移印自动化设备受关注较少、同类产品不多，而市场需求相对较大，因此，该套设备的成功研制具有较明显的经济效益。

本论文的主要研究内容包括：

(1) 综合研究工业自动化生产的相关技术，分析现有的手表日历环移印生产工艺，指出日历环移印生产自动化改造的必要性，确定本课题的研究内容。

(2) 采用模块化设计和机电一体化设计方法，根据生产线的总体设计要求，针对日历环移印生产的工艺特点，完成生产线的总体设计方案设计，确定各个模块的功能原理，绘制系统总体结构示意图，建立系统的运动学模型和动力学模型，分析系统的动态特性。

(3) 完成生产线上各个功能模块，包括振动送料装置、自动上下料装置、移印装置和输送带、烘干装置等的具体结构和参数设计，完成自加工零件的尺寸设计、外购零件的选型等工作。

(4) 完成生产线气动回路的设计与气动元件的选型。利用有限元软件校核日历环在输送过程中的受力和变形情况，校核设计方案的合理性。

(5) 完成全自动移印生产线的 PLC 控制系统的设计：建立系统的动作流程图和控制原理图；完成了控制单元、人机界面和传感器的选型，PLC 的输入输出端口的分配；完成了 PLC 控制程序的编写，以及人机界面画面的设计。

(6) 完成生产线的装配和调试工作，包括零部件的安装调试、电器元件的安装调试、控制电路的连接布线等，并针对现场出现的问题，调整和完善系统，以适应实际生产。

本课题设计的手表日历环全自动移印生产线，具有生产效率高、产品质量稳定、降低人工成本、减少污染等特点。课题设计方案适应实际生产，并对样机进行了调试和适应性改造，能够达到预期生产目的。

**关键词：**日历环 移印 自动化 结构设计 PLC

## Abstract

China is one of the major watch producers in the world. However, the current producing technology level of China's watch industry is not consistent with this situation. Manual and semi-automatic assembly is still the main mode of watch production in China's watch industry, which leads to a low production efficiency and a low product consistency. Switching to the automatic production lines and using the automated machinery production instead of manual operations will greatly improve the production efficiency and reduce the effect of human interference factors on the production process.

An automatic pad-printing equipment is designed in this thesis for the date indicators' pad-printing process. Traditional pad-printing machines could only complete the printing process of date indicators automatically, while the feeding and blanking process still relies on manual movements. It results in a low productivity and the product quality is unstable with a high rejection rate. The equipment designed in this thesis could complete the whole printing process automatically, not only the printing process but also the feeding one. It will greatly increase the printing efficiency, ensure the quality of products and save labour cost. Currently, less attention is paid to the field of pad printing. Similar products are uncommon in domestic market while the demand of automatic pad printing equipments is relatively large. Therefore, the successful design of this automatic equipment has an obvious economic benefit.

The main contents of this thesis include:

(1) It is analysed in this thesis that the development of current industrial automation technology and date indicators' pad printing producing process already existed. Then the necessity of reforming date indicators' semi-automatic pad-printing producing process is pointed out, and the research contents of this subject are determined.

(2) The methods of both modular design and mechanical & electrical integration



design are used in this research. The overall design scheme of the production line is completed according to the design requirements of the production line and the characteristics of the date indicators' pad-printing producing process. The functional principle of every module is determined and the system of the overall structure schematic drawing is completed. The kinematic model and dynamic model of the system are established. And the dynamic behavior of the system is analyzed in this thesis.

(3) It is completed in this thesis that the design of production line's structure and the parameters of every functional module, including vibration feeding device, automatic feeding and blanking device, pad printing device, and conveyor belt, drying device, etc. It is completed that the design of size and model selection of the machining parts.

(4) It is completed that the pneumatic circuit design of production line and the selection of pneumatic components. The design is verified by using the finite element software to check the force and deformation of the date indicator during the process of conveying.

(5) It is completed in this thesis that the design of PLC control system of the automatic pad printing producing line. The system's process flow diagram and control principle diagram are established. The selection of control unit, man-machine interface and sensors are completed. It is also completed that the writing of the PLC control program, the distribution of PLC's input/output ports and the design of man-machine interface.

(6) It is completed in this thesis that the assembly and debugging of production line, including the installation and debugging of components and parts, the installation of electrical components, the connection of control circuit, etc. Using the method of testing under the real scenario to improve the system and make it adapt to the actual production.

The design of rate indicators's automatic pad printing line has a high production efficiency. It will improve the product quality and reduce labor costs. As well as it reduces the pollution of printing ink. This research has been carried by debugging to

improve the prototype. As a result, it could achieve expected purpose.

**Key Words:** Date Indicator; Pad Printing; Automatic Production; Structure Design;  
PLC

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