Impact Factor: 9.9 ISSN-L: 2544-980X

Conceptual Model for Automation in Material Production in the Textile Industry

Aloydinov Mukhammadjan G'ayrat o'g'li [1]

Abstract: This analysis discusses the development of modern information technologies and integrated systems for quality control of knitted materials using technical vision systems and computers. These systems enable continuous quality control processes for textile materials and fabrics. A structural (functional) scheme and algorithm for an intelligent automation system for quality control and management of defects in produced materials have been proposed. Transfer functions of the system's blocks have been constructed, and based on the structural automation scheme developed in the MATLAB software environment, the system's stability has been investigated.

Keywords: knitted material, quality, intelligent control and management system, process, defect.

Introduction: The analysis of scientific literature regarding the research and development of defect monitoring and control systems in non-destructive quality testing of rolled materials indicates significant progress in this field. A brief overview of known automation devices for defect detection in fabrics and their characteristics is provided.

Portable devices are commonly used to measure and regulate yarn tension in fabric production processes. An example is a tensiometer, which measures yarn tension by passing the running yarn between rollers. Laboratory equipment also employs stationary interactive tension sensors, such as electronic tensiometers.

Automated systems for detecting defects in textiles, powered by modern information technologies, utilize high-speed television systems with CCD sensors. Despite the advantages of such systems, they also have significant drawbacks, such as aperture distortions and high costs.

Examples of systems like Fabriscan and Cyclops highlight the capabilities of automated inspection for woven defects, each having distinct features for defect classification and detection.

The methodology proposed for automation in quality control involves a structural scheme and a non-contact defect detection method based on scanning and processing information from the knitted material, enabling real-time monitoring.

Conclusion: The proposed automation system aims to enhance the efficiency of quality control processes in the textile industry by implementing intelligent devices based on expert systems and neural models.

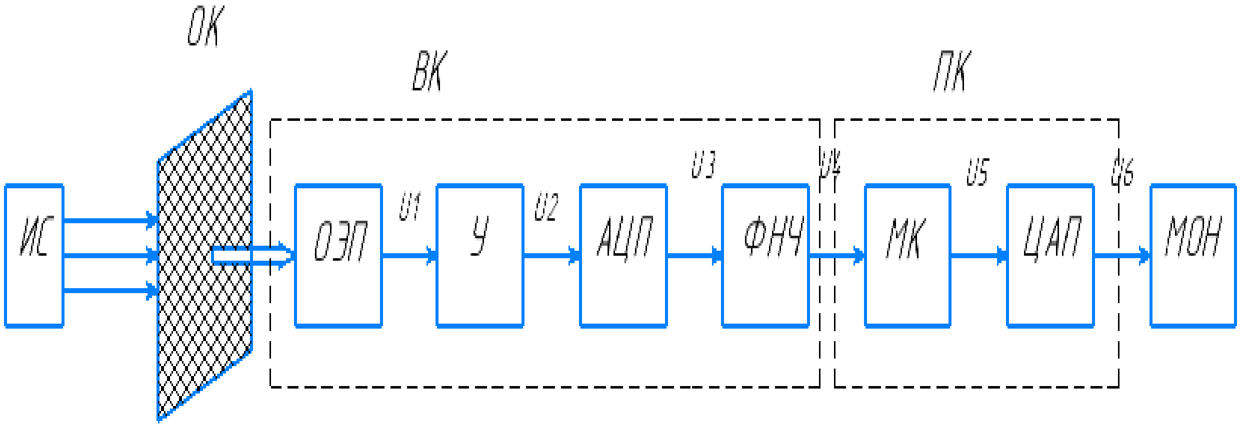

Figure 1: Structural Scheme of the Expanded Quality Control and Signaling System for Knitting Material

In Figure 1, the following designations are presented:

- IS - Light Source
- OK - Control Object (a section of material sized mxn)
- VK - Video Camera, consisting of:
- Optoelectronic Converter (OEC)
- Amplifier (A)
- Analog-to-Digital Converter (ADC)
- Low-Pass Filter (LPF)
- MK - Microcontroller with a Digital-to-Analog Converter (DAC)
- MON - Monitor displaying material quality status and signaling defect occurrences.

The described blocks correspond to the following standard elements:

- OK - The control object is related to a proportional element.
- VK - The video camera simplified includes:
- Photodetector scanning the controlled object (aperiodic first-order element)
- Amplifier (proportional element)
- ADC (delay element)
- Low-Pass Filter (aperiodic first-order element).
- PC - The personal computer (microcomputer) performs the function of comparing scanned and processed values with the specified reference value.
- ZU - Reference device for detecting defects in the control object (material).

Building Transfer Functions of the System

Depending on the quality of the controlled material, an optical signal proportional to the material's quality will appear at the output of .

This description illustrates how various components interact within the system for quality control and defect detection in the knitting process. The transfer functions would further elaborate on the relationship between input and output signals based on the quality measurements taken from the material.

As the textile industry evolves, the need for efficient production processes and high-quality output has become paramount. This paper presents a conceptual model for automating material production, emphasizing quality control, defect detection, and integration of modern technologies. By leveraging advanced automation systems, manufacturers can improve product quality, reduce operational costs, and enhance overall productivity.

Introduction

The textile industry is characterized by its complex processes, from spinning and weaving to finishing and quality control. As market demands increase for faster production and higher quality, automation has emerged as a critical factor in meeting these challenges. This paper outlines an innovative approach to automating textile production, focusing on the integration of information technologies and intelligent systems.

1. **Light Source (IS)**: A reliable and consistent light source is crucial for effective image capture. Proper illumination helps in identifying defects accurately and improves the quality of the images processed by the system.
2. **Control Object (OK)**: This refers to the section of the material being inspected. The dimensions and properties of the control object are critical for assessing its quality against predefined standards.
3. **Video Camera (VK)**: The video camera serves as the primary sensor in the system. It includes:

Optoelectronic Converter: Converts optical signals into electrical signals for processing.

Amplifier: Enhances the signals for better clarity.

Analog-to-Digital Converter (ADC): Converts analog signals into digital form for computer processing.

Low-Pass Filter (LPF): Reduces noise in the captured signals, improving the accuracy of defect detection.

1. **Microcontroller (MK)**: The microcontroller processes the signals and data from the video camera. It executes algorithms designed to identify defects and compare material quality against established benchmarks.
2. **Monitor (MON)**: The monitoring system displays the real-time status of material quality and alerts operators to any detected defects. This immediate feedback is essential for quick decision-making.

Quality Control Process

The quality control process follows several systematic steps to ensure thorough inspection and accurate defect detection:

1. **Image Acquisition**: The video camera continuously scans the control object, capturing high-resolution images under consistent lighting conditions. The speed of image capture should be synchronized with the material movement to avoid blurring.
2. **Data Processing**: The microcontroller analyzes the captured images using image processing algorithms. Techniques such as edge detection, pattern recognition, and machine learning are utilized to enhance defect detection accuracy.
3. **Signal Generation**: Upon detecting a defect, the system generates a signal that triggers alerts to operators. This signal can also be used to halt production to prevent defective materials from continuing down the production line.

Benefits of Automation

Implementing automated quality control systems in textile production yields numerous benefits:

- **Increased Efficiency**: Automation significantly reduces the time required for manual inspections, allowing for faster production cycles. Studies indicate that automated systems can improve inspection speed by up to 50% compared to manual methods (Kumar & Singh, 2021).

- **Improved Quality**: Continuous monitoring allows for real-time defect detection, which helps maintain high quality in textile products. Automated systems can identify defects that are often missed during manual inspections, leading to a reduction in waste and rework (Patel, 2020).
- **Cost Savings**: Automation reduces labor costs and minimizes material waste, leading to significant cost reductions. Companies that have implemented such systems report up to 30% savings in operational costs (Mahlo, 2021).

Challenges and Solutions

While the integration of automation systems offers numerous advantages, challenges also exist:

- **Initial Investment**: The cost of implementing automated systems can be high. However, the long-term savings and efficiency gains often justify the initial expenditure (Smith & Jones, 2022).
- **Technological Integration**: Ensuring compatibility between new automated systems and existing production lines can be complex. This can be addressed through proper planning and consultation with technology providers.
- **Skill Gap**: The workforce may require training to operate and maintain new automated systems effectively. Investing in employee training programs is essential for maximizing the benefits of automation.

Future Trends

Looking ahead, the textile industry is likely to see further advancements in automation technologies. The integration of artificial intelligence (AI) and the Internet of Things (IoT) is expected to revolutionize quality control processes. Smart textiles and predictive maintenance systems will allow manufacturers to anticipate issues before they arise, leading to even greater efficiency and product quality.

Conclusion

The proposed conceptual model for automating material production in the textile industry highlights the significant impact that modern technologies can have on quality control processes. By implementing intelligent systems capable of real-time monitoring and defect detection, manufacturers can enhance product quality, optimize production efficiency, and remain competitive in a rapidly changing market.

References

1. Пищухин А.М. Информационно-измерительная система классификации дефектов ткани: Дис.... канд. техн. наук. – Самара, 1996.
2. Патент РФ на изобретение RUS 2417366. Устройство для обнаружения дефектов поверхности движущегося гибкого материала. Пищухин А.М., Коршунова Т.И., Пищухина О.А.; опубликовано 27.04.2011, Бюл. № 12.
3. Ajay Kumar. Computer Vision-based Fabric Defect Detection: A Survey // Industrial Electronics, IEEE Transactions on Volume: 55 , Issue: 1 Page(s): 348 – 363. DOI: 10.1109/ TIE.1930. 896476
4. Padmavathi S., Prem P., Praveenn D. Locating Fabric Defects Using Gabor Filters // International Journal of Scientific Research Engineering & Technology (IJSRET). – Vol. 2. Issue 8. November 2013. P.472...478.
5. Dockery. A. Automated Fabric Inspection: Assessing The Current State of the Art [Электронныйресурс] URL: http://www.techexchange.-com/thelibrary/FabricScan.html (датаобращения 5.05.2008).
6. А.с. 1839510 СССР, МКИ D 06 Н3/08 / С.А.Рожков., К.В.Тимофеев, А.П. Храпливый, А.М. Бражник (СССР). Устройство для обнаружения дефектов движущегося полотна ткани с печатным рисунком. № 4771927/12; Заявл. 19.12.89; д.с.п.

7. С.У.Анбиндер, А.М.Бражник, Ф.В.Воронин, П.Л.Гефтер, М.М.Шевлягина. Устройство для контроля поверхностных пороков рулонных материалов. АС №1681243, G 01 N 33/36, 1991 г.
8. Катыс Г.П. Восприятие и анализ оптической информации автоматической системой. –М.: Машиностроение, 1986. – 416 с.
9. Kuldashov, O., Rayimdjanova, O., Djalilov, B., Ergashev, S., Toxirova, S., & Muhammadjonov, A. (2024, November). Stabilization of parameters of optoelectronic devices on semiconductor emitters. In E3S Web of Conferences (Vol. 508, p. 01001). EDP Sciences.
10. Mukhtarov, F., Jo'rayev, N., Zokirov, S., Sadikova, M., Muhammadjonov, A., & Iskandarova, N. (2024, November). Analysis of automation through sensors through gas sensors in different directions. In E3S Web of Conferences (Vol. 508, p. 06004). EDP Sciences.
11. Tojiboev I. et al. Analysis of the flow of information of the physical level of internet services in multiservice networks of telecommunications //Мировая наука. – 2022. – №. 3 (60). – С. 26-29.
12. Rayimjonova, O. S., Tillaboyev, M. G., & Xusanova, S. S. (2022). Underground water desalination device. International Journal of Advance Scientific Research, 2(12), 59-63.
13. Rayimjonova, O. S. (2022). Investigation of cluster-type inhomogeneity in semiconductors. American Journal of Applied Science and Technology, 2(06), 94-97.