Kristina Bessarabenko

ECOSYSTEM AND INFRASTRUCTURE OF SMART MANUFACTURING FOR COMPOSITE PRODUCTS

Innovative Transformation of the Ecosystem and Infrastructure for the Production of Composite Products into an Integrated Online Monitoring Supersystem

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The book examines the development and implementation of composite technical solutions in the context of the transition to smart manufacturing systems. Particular attention is paid to the transformation of traditional production ecosystems into integrated digital infrastructures capable of providing continuous monitoring, adaptive control, and optimization of technological processes. The study highlights the growing importance of integrating software products, intelligent control systems, and system-integrative inventions to improve production efficiency and industrial competitiveness.

Special emphasis is placed on the application of innovative composite materials, including cermets and carbon-carbon composites, which significantly improve the operational characteristics and precision of industrial products. The article also considers the role of specialized technological equipment and modern methods of contactless monitoring, especially electromagnetic spectroscopy and electromagnetic resonance spectroscopy, as effective tools for real-time quality assessment and process control in smart manufacturing environments.

In addition, the study addresses issues related to patentability criteria, intellectual property protection, and the balance between information disclosure and preservation of novelty for patenting purposes. The importance of compliance with modern environmental standards, sustainability requirements, and consumer expectations is also emphasized. The authors conclude that the integration of advanced materials, intelligent technologies, and digital monitoring infrastructures is essential for achieving sustainable development and long-term success in innovation-driven economies.

Keywords: *Confectionery Production; Ecosystem and Technologies of Confectionery Production; Infrastructure and Specialized Technological Equipment for Smart Confectionery Production; Monitoring and Control of Smart Confectionery Production Processes; Contactless Monitoring of Smart Confectionery Production Parameters; Electromagnetic Spectroscopy; Electromagnetic Resonance Spectroscopy*

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Contents

Introduction

Real-time monitoring and control subsystems of confectionery production.

For modern smart confectionery production, the main indicator is the quality of the manufactured products. For the ecosystem and infrastructure of confectionery production, quality control is a fundamental parameter, and it is extremely important that this control is performed without physical contact, with very high accuracy, and at exceptionally high speed.

Figure 1. Reference pH Measurement Instrument with Calibration Solutions Used for Experimental Testing and Calibration Procedures

In the classical and standard methodology, for example, when measuring the acidity level before the direct measurement of the acidity level of the tested sample, calibration adjustment of the measuring instrument using calibration liquids with acidity levels of 4 and 7 pH units is mandatory.

In accordance with this standard methodology, calibration mechanisms are also required for the proposed experimental measuring system before the control measurement of the acidity level.

This circumstance significantly increases the time required to perform the measurement process.

For testing and comparative analysis of the measurement results, two basic types of liquids were used: distilled water and ordinary tap water.

To change the acidity level of the tested samples, concentrated hydrochloric acid specially prepared by a chemical laboratory was used.

Various types and designs of sensors, namely solenoids, were used for the tests. At the final stage of testing, a planar version of the sensor, or solenoid, was applied.

Based on the results of an extensive patent search across different countries, this sensor variant for this type of measurement and monitoring, as well as the method of its use and structural implementation, was applied for the first time.

The electrical circuit for connecting the planar sensor to the instruments of the test equipment set is presented below.

Excitation coil is connected to generator with frequency sweep. Resistance of R1 depends on output resistance of the generator and length of line between the sensor and the generator. If the length of line is less then ¼ of wavelength, the resistor can be omitted. Sensing coil is connected to Data Acquisition (DAQ). If operating frequency of the sensor is more than frequency capability of the DAQ, then the diode can solve that problem.

Both the generator and the DAQ are connected to personal computer and work under control of computer program. The program calculates resonant frequency and amplitude of the sensor and measure their changes caused by presence of analyte under test.

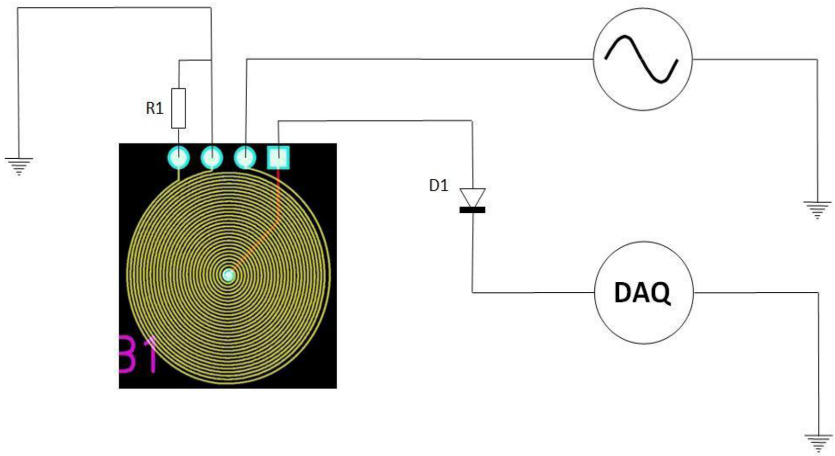

Figure 2. Schematic of planar Impedance Resonance Sensor connection

The following diagram presents the results of resonance level measurements in samples of distilled water and ordinary tap water obtained using the planar sensor.

All versions of the tests and measurements demonstrated that the planar sensor has the greatest potential for further application, including its use in the final product – a capsule for autonomous monitoring of gastric juice acidity levels in cows.