Industry 4.0 Approach for Development of Automatic Sanitation Unit

Tahsin Topbaşoğlu[1], Berkcan Babuz, [1] Oğulcan Söğüt[1], Yasin Yağız Şimşek[1], Onur Cimen[1]*, İbrahim Etem Saklakoğlu[2]
KANSAN R&D Center, İzmir, Turkey[1]
Ege University Faculty of Engineering, Mech. Eng. Dept, Izmir, TURKIYE[2]
*onurcimen@kansanmak.com

Abstract: *In wet wipe machines, equipment such as tanks, pumps, pipes, and valves that come into contact with the wet wipe solution, conveyor belts, and steel surfaces with which the liquid comes into contact, must be disinfected at regular intervals under hygienic production rules. Disinfection is carried out using hot water, alcohol-based disinfectants, surfactants, detergents, oxidizing agents, or a mixture of all these methods. In current applications, liquids are drained manually from preparation units or tanks, and machine surfaces are cleaned manually. Cleaning and sanitation is done by hand. At the same time, performing some cleaning scenarios is harmful to human health because of hot steam or water, chemical cleaning steam, etc. So, it is impossible to ensure the hygiene level of systems. In this study, safe by design and prevention approaches were used and a system equipped with several measurement sensors was designed to work with different sanitary liquids and their preparation units according to sanitary recipes, producing a report at the end of the cleaning process. There are devices such as pH meters, temperature sensors, pressure sensors, and several water analyzers in the system, and it is decided that cleaning is completed by processing the data from these sensors. This article describes the system developed in compliance with industry 4.0 applications*

KEYWORDS*: SANITATION, WET WIPE MACHINES, MACHINE DESING, INDUSTRI 4.0*

1. Introduction

Wet wipes have become an essential tool for maintaining personal hygiene. These wipes are designed to address a wide array of needs, from cleansing and refreshing to sanitizing, and they play a crucial role in daily personal care routines. As wet wipes are intimately linked with personal hygiene, ensuring the highest standards of cleanliness and safety in their production is paramount.

Wet Wipes and Personal Hygiene:

Wet wipes are versatile products widely used for personal hygiene. They offer a convenient and effective way to clean and freshen up while on the go. These wipes are commonly employed in various situations, including:

Hand and Face Cleaning: Wet wipes are often used for quick hand cleaning when access to water and soap is limited, providing a solution for maintaining cleanliness in various situations.

Baby Care: In childcare, wet wipes serve as a fundamental tool for diaper changing and gentle cleaning of a baby's delicate skin.

Makeup Removal: They are also widely used in makeup removal routines due to their gentle cleansing properties, particularly for sensitive skin.

General Cleansing: Whether during travel or in public spaces, wet wipes offer a convenient way to maintain personal hygiene.

Relevance to Personal Hygiene in Production:

Given the close association between wet wipes and personal hygiene, it's imperative that the production process ensures the highest standards of cleanliness and safety. Hygienic production rules and the use of disinfection processes in the machinery are critical to guarantee the safety of these products.

In reality, control of hygiene during wet wipe production involves two aspects: Although the goal of sanitation is to prevent contamination completely, nevertheless it often occurs. Sometimes, sanitation is seen as a cost that does not provide any immediate financial return to a company. In addition, in developed countries, there is an increasing trend for busy consumers to purchase goods that require maximum hygiene.

Along with the increasing attention being paid to sanitation has come an increasing supply and complexity of chemicals and equipment to be used in cleaning procedures. It is sometimes difficult for practitioners to decide which chemical to use and which cleaning procedure to adopt.

Wet wipes are a product used for hygienic purposes, and the prerequisite for the machines that produce wet wipes to produce hygienic products is that the machine itself is hygienic.

One of the important aims of this study is to remove the different odors of different products from the system during the transition from product to product. In addition to hygiene purposes, it is possible to preserve the different odors of wet wipe products and to prevent the odors from mixing, thanks to effective sanitation.

The scope of this study is to design and develop a system that will fully automatically perform the sanitation processes that are currently carried out manually in wet wipe production machines.

2. Material and methods

The machine's design, aiming to maintain the highest levels of hygiene, is crucial to producing safe wet wipes for personal use. The machine's features, such as modular design for easy cleaning, careful material selection, intuitive automation controls, and stringent safety features, directly impact the hygiene standards of the produced wet wipes.

In response to these challenges, this study employs a "safe by design" and "prevention-first" approach to address the issue of hygiene in wet wipe production machines. The primary objective is to design a system that automates the cleaning and sanitization process, thereby reducing the dependence on manual labor and eliminating potential risks to human health.

This innovative system is equipped with a suite of measurement sensors, each serving a unique purpose. The sensors include pH meters, temperature sensors, pressure sensors, and various water analyzers. These sensors collectively enable to monitor the system and control the cleaning process with precision.

System Operation:

The system is designed to work with a variety of sanitary liquids and their preparation units, following specific sanitary recipes to ensure effective disinfection. The automation of the cleaning process is driven by real-time data collected by the various sensors. This data includes:

pH Levels:

pH meters provide insights into the acidity or alkalinity of the cleaning solution, ensuring it remains within the specified range for effective disinfection.

In this study, to clean the wet wipe solution from the inner surfaces of the pipes, in the first stage; anionic and cationic surfactants are used. In the second stage, rinsing is done with deionized water. A pH meter decides the application time of deionized water, and water application continues until the pH value reaches 7. The pH meter makes analog measurements and provides continuous information to the PLC system. When the target value, the neutral level, is reached, the system closes the water inlet. Figure-1 shows the Endress-Hauser Orbisint CPS11 pH sensor used in the system.

Figure-1: *Endress-Hauser Orbisint CPS11 pH sensor*

Temperature Control:

Temperature sensors play a crucial role in maintaining the optimal temperature for the cleaning solution, thereby enhancing its disinfecting capabilities.

While hot water is used as a sanitation fluid, hot water is pumped into the system until it equalizes the liquid temperature values at the farthest point of the system and liquid tank. Thus, it is ensured that the sanitation process is carried out successfully at every point of the pipe system. Temperature sensors are connected to the PLC system and the temperature level is constantly controlled with analog data. Figure-2 shows the Endress-Hauser Thermophant T TTR35 temperature sensor used in the system.

Figure-2: *Endress-Hauser Thermophant T TTR35 temperature sensor*

Pressure Monitoring:

Pressure sensors help in managing the pressure within the system, avoiding potential issues that may impact the cleaning process.

It is very important to make sure there is fluid in the system during the sanitization process. This is monitored by the pressure sensor. Analog data received from the pressure sensor is constantly monitored by the PLC system. Figure-3 shows the Endress-Hauser Cerabar PMP51 pressure sensor was used in this study.

Figure-3: *Endress-Hauser Cerabar PMP51 pressure sensor*

Water Quality Analysis: Water analyzers assess the quality of water used in the cleaning process, ensuring that it meets the required standards for effective sanitation.

The electrical conductivity values of pure water and those containing impurities are different. Using this basic information, it is possible to ensure that the sanitation process is done correctly. For this purpose, after the rinsing process is completed (before the rinsing water is discharged from the line), the conductivity value is measured with an electrical conductivity sensor and monitored by PLC. Figure 4 shows the Condumax 16d electrical conductivity sensor that used for electrical conductivity measurement.

Figure 4: *Condumax 16d electrical conductivity sensor*

Data-Driven Cleaning:

Based on the data collected by these sensors, the system makes real-time decisions, adjusting parameters to optimize the cleaning process. This data-driven approach ensures that the cleaning process is not only efficient but also highly effective in achieving the desired level of hygiene.

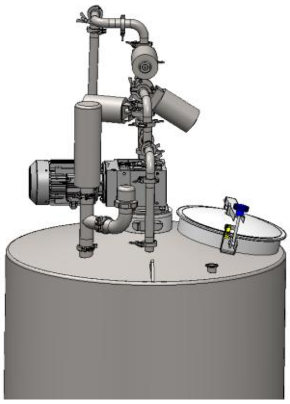
Furthermore, the system generates a comprehensive report at the end of each cleaning cycle, detailing the parameters monitored, the actions taken, and the overall effectiveness of the sanitization process. This report serves as a valuable record for quality control and regulatory compliance.

Selection of Material:

AISI 304 SS was used to manufacture the sanitation system. Stainless steel is a popular material choice for such units due to its excellent properties that make it well-suited for sanitation and hygiene purposes. Stainless steel is a corrosion-resistant and non-reactive material that is easy to clean, making it ideal for environments where cleanliness is a top priority. It doesn't rust, stain, or corrode, which ensures a longer lifespan for the sanitation unit. Stainless steel surfaces are smooth, easy to clean, and resistant to bacterial growth, making it a hygienic choice. The absence of pores and cracks in stainless steel reduces the potential for contamination. Stainless steel is known for its strength and durability. It can withstand harsh cleaning agents and repeated use without deteriorating, ensuring the longevity of the sanitation unit.

Figure 5 shows the tank used in the system. Figure 5a shows the design phase, and 5b shows the tank made of stainless steel.

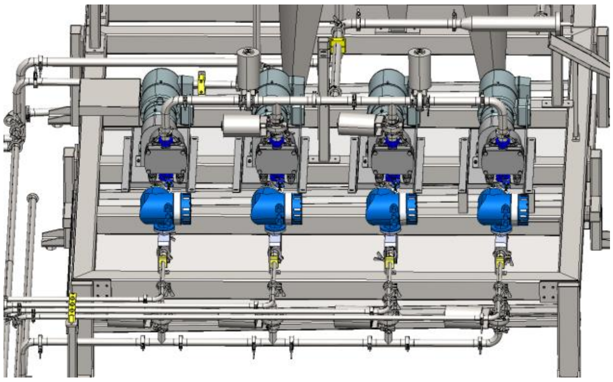
Figure 6 shows the pipes and the flowmeters on the system. Figure 6a shows the design phase, and 6b shows the pipes made of stainless steel and flowmeters.



a.

b.

Figure 5: *The tank used in the system. a) design phase b) the tank made of stainless steel.*



a.

b.

Figure 6: *The pipes and the flowmeters on the system a) design phase b) the pipes made of stainless steel and flowmeters.*

4. Conclusion

The development of an automated system for the cleaning and sanitization of wet wipe production machines represents a significant advancement in the industry. By integrating multiple measurement sensors and utilizing data-driven decision-making, this system offers a highly efficient and consistently hygienic solution to an ongoing challenge. This paper explores the technical details and practical implications of the system, providing a comprehensive overview of its operation and the potential benefits it brings to the field of wet wipe production.

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