

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Mecatrónica

Tesis

**Design of an Automated Dosing and Mixing System for
the Production of Biodegradable Biomass Based on
Sweet Potato Starch and Sugar Cane Fiber**

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Design of an Automated Dosing and Mixing System for the Production of Biodegradable Biomass Based on Sweet Potato Starch and Sugar Cane Fiber

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Abstract—The food sector consumes a large part of the world's packaging production, 35% of which is discarded after the first use. However, most of this packaging is made from fossil fuel feedstock plastics. The continued production of plastic packaging represents a series of negative impacts on the environment in terms of air, soil, and water, all due to its long degradation time and chemical composition. To mitigate this impact, new materials based on plant biomass have been used to find an eco-friendly substitute for traditional plastic packaging. To streamline and optimize the processes of dosing and to mix ingredients during the production of biodegradable trays, this research proposes the design of an automated mixing system for obtaining biodegradable biomass based on starch and vegetable fiber. The system was controlled by a PLC S7-1200 and monitored through an HMI interface, and the software structure was designed in the TIA Portal program. Finally, the system was commissioned and simulated in the Factory I/O software, where a process plant was recreated to simulate the signals from the water level sensors of the agitator tank and the weight sensors of the quantities of the ingredients to be dosed, also to activate actuators such as the agitator and the tank filling and dosing valves.

Keywords—PLC, TIA Portal, HMI, biodegradable packaging, mixing, dosing.

I. INTRODUCTION

Currently, the use of plastic has been increasing in the last 54 years exceeding 360 million tons in the year 2018. In the next 20 years, this will be doubling; plastic waste worldwide has generated an adverse effect on the environment [1]. The main synthetic components of plastic are really toxic to living beings, likewise the processes of eliminating it are harmful to the air, soil and water, it should be noted that micro plastics are more dangerous since they can be attached to the food chain [2]. On the other hand, the food sector is the largest user of single-use packaging and consumes up to 35% of the world's packaging production. Therefore, research on biomass-based packaging has been carried out in recent years, and it was concluded that it could reduce greenhouse gas emissions by 32% [3].

During the production process of biodegradable packaging based on vegetable fibers and starch, processes such as washing

and drying of raw materials, grinding and sieving, homogeneous mixing with water to obtain biomass, and finally, a thermo-compression molding process are required to produce a commercial biodegradable tray as a result. During these processes, the correct dosage of the materials is one of the fundamental parts, as it must be accurate in order not to alter the physical and mechanical properties of the final product [4][5]. However, these processes involve precision, time, and manpower. Automation allows control of any operation with little or no human intervention, which is why industries opt for automated processes that provide efficient and effective operations [6].

To automate mixing processes involving the dosing of exact quantities of ingredients into agitator tanks, most systems opt for using a programmable logic controller “PLC”, solenoid valves, continuous level, weight sensors, and human-machine interfaces “HMI” [7]. Also, during in-plant implementation, it is recommended to use soft starters to limit the starting current of the agitator tank motor, over-voltage, over-temperature, and short-circuit protection to extend the system's lifetime [8].

On the other hand, other research suggests embedded system designs using microprocessors such as Raspberry Pi or STM32 as system controllers. They also designed a control stage isolated from the power stage to protect the system in case of a power failure. For the dosing system, low-cost weight sensors are used, and these signals are processed by an A/D converter to make them easier to read in the microcontrollers. Finally, the process control and monitoring interface designs are made in Visual Studio software [9].

Due to the number of processes and the precision of the dosing of ingredients required during the production process of biodegradable packaging, this research proposes the design of an automatic mixing system for obtaining biomass based on sweet potato starch and sugar cane bagasse fiber. The methodology to be followed during the design is shown in a flow chart detailing the processes of ingredient dosing, mixing, and filling of biomass in the mold, which will be controlled by a PLC S7-1200 and monitored through an HMI interface. The