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Design and Fabrication of Automatic Car Washing System Using PLC

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Abstract: This project focuses on the design and fabrication of an Automatic Car Washing System using Programmable Logic Controllers (PLC) to enhance the efficiency, effectiveness, and sustainability of the car washing process. The system is engineered to automate key stages of car washing, including pre-wash, soap application, scrubbing, rinsing, and drying, thereby reducing the need for manual labour and minimizing the risk of human error. Through the integration of sensors and actuators, the PLC is programmed to control each phase of the wash cycle with precision, adapting to various vehicle sizes and types to ensure a thorough and consistent clean. The project emphasizes resource optimization, aiming to minimize water and detergent consumption while maintaining high wash quality. Furthermore, safety features are implemented to protect both the vehicle and the washing equipment during operation. The successful fabrication of this system demonstrates its potential to transform traditional car wash methods into more efficient, environmentally friendly, and cost effective solutions, addressing the growing demand for automated car wash services in the automotive industry.

I. INTRODUCTION

The Automatic Car Washing System using a Programmable Logic Controller (PLC) is a modern solution that improves speed, precision, and resource efficiency in car washing. Unlike traditional methods that rely heavily on manual labour and often lead to inconsistent quality, this automated system uses PLCs to control each stage of the wash process accurately—from pre-rinse to drying. It ensures optimal use of water and detergent, reducing waste and costs while supporting environmental goals. The system can be programmed for different washing modes based on vehicle size and customer needs, making it versatile and efficient. Sensors and timers help monitor and adjust wash settings in real-time, ensuring consistent quality and improved customer satisfaction. By minimizing manual involvement, the system also enhances safety for workers and reduces maintenance needs due to the durability of PLCs. Overall, this automated setup offers a reliable, eco-friendly, and customer-focused solution for the car wash industry.

II. OBJECTIVES

The objectives of the Automatic Car Washing System using Programmable Logic Controller (PLC) focus on achieving a high level of automation, consistency, and efficiency in the car washing process. By leveraging PLC technology, the system aims to perform the entire wash sequence—from pre rinse to drying—without manual intervention, ensuring consistent, high-quality results across vehicles. One key objective is to optimize the usage of water, detergent, and energy, with sensors and programmable logic helping to adjust resource levels based on vehicle size and wash requirements, which makes the system both cost-effective and environmentally responsible. Additionally, safety is a priority, as the automated process minimizes the need for human involvement in hazardous areas, reducing labour costs and creating a safer work environment. Flexibility is also integral, as the PLC allows for customizable wash cycles to cater to different vehicle types and customer preferences, enhancing user satisfaction. Finally, by relying on the durability and reliability of PLCs, the system aims for continuous, low-maintenance operation, reducing downtime and meeting the demands of high-traffic car wash facilities. Altogether, these objectives align to create a sustainable, efficient, and customer-oriented solution for the modern car wash industry.

III. LITERATURE REVIEW

A. Automatic Car Washing System Using PLC & SIMATIC HMI

In their study, "Automatic Car Washing System Using PLC & SIMATIC HMI", Nandkishor Lokhande, Vaibhav Deshmukh, Rajesh Pawar, and S.P. Bijawe present an automated car washing system that leverages PLCs and a SIMATIC HMI to streamline and control the washing process, published in April 2023 in the Proceedings of Students and Assistant Professor, Department of Instrumentation Engineering, Government College of Engineering, Amravati.

This system automates various washing stages, including pre-wash, soaping, scrubbing, rinsing, and drying, using precise control through PLC programming to enhance efficiency and consistency. The SIMATIC HMI provides a user-friendly interface for real-time monitoring and control, allowing operators to adjust parameters based on vehicle requirements, which results in optimized resource usage and reduced labour demands. Additionally, safety features within the system help prevent equipment damage and ensure user safety, illustrating the adaptability and effectiveness of PLC and HMI integration in the car washing industry.

B. Carwash Wastewater Treatment through the Synergistic Efficiency of Microbial Fuel Cells and Metal-Organic Frameworks with Graphene Oxide Integration

In their 2023 study, "Carwash Wastewater Treatment through the Synergistic Efficiency of Microbial Fuel Cells and Metal-Organic Frameworks with Graphene Oxide Integration," Timothy Mkilima, Yerkebulan Zharkenov, Laura Utepbergenova, Elmira Smagulova, Kamidulla Fazylov, Iliyas Zhumadilov, Kamilya Kirgizbayeva, Aizhan Baketova, and Gulnara Abdukalikova investigate an innovative approach to treating carwash wastewater. Published in Case Studies in Chemical and Environmental Engineering, this research explores the use of microbial fuel cells (MFCs) combined with metal-organic frameworks (MOFs) and graphene oxide to improve wastewater treatment efficiency. By integrating MFCs, which harness microbial activity to generate electricity while treating contaminants, with MOFs and graphene oxide, which enhance adsorption and degradation processes, the study demonstrates a significant reduction in pollutants commonly found in carwash effluents. This hybrid approach not only effectively treats wastewater but also produces bioelectricity as a byproduct, making it an energy-efficient and environmentally friendly solution for managing wastewater in the carwash industry. This research offers valuable insights into sustainable wastewater treatment technologies that could reduce the environmental impact of car washing operations.

C. Automated Carwash Using Programmable Logic Control

In the 2022 paper, "Automated Carwash Using Programmable Logic Control," authors M. Z. Azman, S. Z. Mohammad Noor, and Musa Suleiman explore the implementation of a fully automated car wash system controlled by Programmable Logic Controllers (PLCs). Published in International Journal of Academic Research in Economics and Management Sciences, this study details how PLCs are utilized to streamline the car wash process, automating stages such as washing, rinsing, and drying for greater efficiency and precision. The system employs sensors and actuators controlled by the PLC to adjust each phase based on vehicle size and washing requirements, ensuring a thorough and consistent clean. The authors also highlight the advantages of PLC-based automation in reducing water and detergent usage, labour costs, and operational time. This research underscores the reliability, flexibility, and environmental benefits of using PLCs in car wash applications, providing a framework for improving productivity and sustainability in the industry.

D. Automatic Car Washing System

In their 2021 study, "Automatic Car Washing System," N.B. Kapase, Nikita R. Sayagavi, Shreya A. Patil, Snehal S. Patil, and Sameeksha P. Shete present a design for an automated car wash system aimed at improving efficiency, consistency, and resource management in car washing operations. Published in IOSR Journal of Mechanical and Civil Engineering, this study outlines the use of automation to streamline stages like pre-wash, soap application, rinsing, and drying. The system employs sensors and control mechanisms to monitor and adjust each stage according to the vehicle's size, ensuring a thorough and uniform clean. The authors emphasize the system's benefits, such as reduced water and detergent usage, minimized manual labour, and shorter cycle times, making it both economically and environmentally advantageous. This research highlights the potential of automation in revolutionizing car washing, enhancing operational efficiency, and supporting sustainable practices.

E. Automatic Vehicle Washing System using PLC

In their 2020 paper, "Automatic Vehicle Washing System using PLC," Dr. M. Ponni Bala, M. Dharanidharan, K. Janani, S. Kalaianbumani, and S. Magima Shree present an automated vehicle washing system controlled by Programmable Logic Controllers (PLCs). Published in the International Journal of Scientific & Technology Research, this study focuses on using PLCs to enhance the efficiency and precision of vehicle washing. The system automates key washing stages—such as pre-washing, soaping, scrubbing, rinsing, and drying—by controlling sensors and actuators that adjust the wash cycle to accommodate different vehicle sizes. The authors emphasize the benefits of PLC-driven automation, which include reduced water and detergent consumption, lower labour costs, and improved wash consistency and speed.

This research demonstrates the reliability and adaptability of PLCs in automating complex processes, positioning them as a viable solution for modernizing car wash operations while supporting environmental and operational efficiency.

F. PLC based Automatic Car Washing System

In their 2019 paper, "PLC based Automatic Car Washing System," May Thwe Oo, Hla Ya Min, and New New Oo discuss the design of an automated car wash system controlled by a Programmable Logic Controller (PLC). Published in IRE Journals, this study investigates how PLC technology can improve the efficiency and reliability of car wash operations. The authors designed a system that automates each stage of the car wash process—including pre-washing, soap application, scrubbing, rinsing, and drying—by using sensors and actuators managed by the PLC.

The research highlights the advantages of PLCs in optimizing resource use, reducing water and detergent consumption, and minimizing manual labour, thus making the process faster and more consistent. This study underscores the potential of PLC-based systems in the car washing industry, offering a scalable and cost-effective approach to achieve higher operational efficiency and sustainability.

G. Arduino Based Automatic Car Washing System

In the 2019 study, "Arduino Based Automatic Car Washing System," Kyaw Kyaw Lin explores an alternative approach to automated car washing by using Arduino microcontrollers instead of PLCs. Published in International Journal of Engineering Development and Research, this research presents a system design that automates various stages of car washing—such as pre-washing, soap application, rinsing, and drying—by integrating sensors and actuators managed by an Arduino controller. The study demonstrates that an Arduino-based system can effectively control washing parameters, adjusting to different vehicle sizes to ensure consistent cleaning.

The author notes that Arduino is a cost-effective and flexible solution, making it a viable choice for smaller-scale operations where budget constraints may limit the use of PLCs. This study highlights the potential of Arduino in automation applications, particularly in industries where affordability and adaptability are key.

H. Smart Car Washing Center using IoT Based

In their 2019 paper, "Smart Car Washing Center using IoT Based," Mayuri Kshirsagar, Karishma Inamdar, Anil Shinde, and Prof. M. N. Kadam explore the integration of IoT technology into car washing systems. Published in the International Journal of Engineering Research and Technology, this study introduces a smart car wash system that leverages IoT to monitor, control, and automate the washing process remotely.

By connecting sensors and controllers through an IoT platform, operators can oversee and adjust washing parameters such as water flow, soap dispensing, and drying times, ensuring a customized wash for each vehicle. The IoT-based approach not only enables real time data monitoring and operational flexibility but also supports efficient resource usage, reducing water and detergent waste. This system provides a user-friendly interface, accessible via mobile devices, allowing customers to book services and monitor wash status remotely.

This research illustrates how IoT can transform car wash centers into efficient, user-centric, and environmentally sustainable operations, aligning with modern smart technology trends in industrial automation.

I. Automatic Car Washing System,

In their 2018 paper, "Automatic Car Washing System," P.B. Patel, S.V. Rokade, and P.S. Tujare present a design for an automated car wash system intended to increase efficiency and reduce labor dependency in car wash operations. Published in a special issue of International Research Journal of Engineering and Technology (IRJET), this study focuses on using automation to streamline various stages of the car wash process, including pre-washing, soap application, scrubbing, rinsing, and drying. The system employs sensors to detect vehicle size and adjust wash parameters accordingly, ensuring a consistent and thorough cleaning. The authors highlight the benefits of automated systems in lowering water and detergent usage and reducing the time required per vehicle, making car washes more cost-effective and environmentally friendly.

This research underscores the impact of automation on improving resource management and operational efficiency in the car washing industry.

J. Design and Implementation of Automatic Car Washing System using PLC

In their 2018 study, "Design and Implementation of Automatic Car Washing System using PLC," Raj Deepak Singh, Sunny Nigam, Sagar Aggrawal, Md. Raish Neelgar, Shivendra Kaura, and Kailash Sharma explore a PLC-controlled automatic car washing system designed to improve washing efficiency and minimize manual intervention. Published in the International Research Journal of Engineering and Technology (IRJET), this paper details how the system automates essential car washing stages—such as pre-wash, soaping, scrubbing, rinsing, and drying—by utilizing sensors and actuators managed through a PLC. The authors emphasize that the PLC's precision in controlling each wash phase allows for optimal resource usage, reducing water and detergent consumption, while also shortening the overall wash cycle. This study highlights the advantages of PLC-based automation in delivering consistent, high-quality car wash results and demonstrates the potential of such systems to streamline operations in the car wash industry.

K. Experimental Study on Car Washing Wastewater Treatment by Coagulation and Nano Filtration Method

In their 2018 paper, "Experimental Study on Car Washing Wastewater Treatment by Coagulation and Nano Filtration Method," Jin Hana, Hongmei Luo, and Biyao Wang investigate an advanced approach to treating wastewater generated by car washes. Published in Desalination and Water Treatment, this study examines the effectiveness of using coagulation and nanofiltration methods to remove contaminants from car wash wastewater. Coagulation is used as a pre-treatment step to aggregate and remove suspended solids, while nanofiltration is employed to further filter out smaller pollutants, including dissolved organic materials and heavy metals. The study results indicate that this combined approach significantly improves the quality of treated water, making it suitable for reuse or safe disposal. This research demonstrates how coagulation and nanofiltration can effectively reduce environmental pollution from car wash wastewater, offering a sustainable solution that aligns with wastewater management and water conservation goals in the industry.

L. PLC Based Car Washing System

In their 2016 paper, "PLC Based Car Washing System," Prof. Mhaske D.A., Bhavthankar R.G., Saindane A.R., and Darade D.J. explore the design and development of an automated car washing system controlled by a Programmable Logic Controller (PLC). Published in the International Journal of Innovative Research in Science, Engineering and Technology, this study emphasizes the benefits of PLC-based automation in streamlining the car wash process, which includes stages like pre-wash, soaping, rinsing, and drying. Using sensors and actuators managed by the PLC, the system can automatically adjust washing parameters to accommodate different vehicle sizes and types, ensuring consistent results with minimal human intervention. The authors highlight the advantages of PLC technology in enhancing operational efficiency, conserving water and detergent, and reducing cycle times, which collectively contribute to making car wash systems more sustainable and cost-effective. This research supports the viability of PLCs as a reliable solution for advancing automation in the car washing industry.

IV. METHODOLOGY

The automatic car wash system begins with a proximity sensor detecting the presence of a vehicle. Once detected, the conveyor belt is activated to move the car through different washing stages while the dryer system is also turned on. The first stage involves soap water spraying, which is controlled by a pump to ensure uniform distribution of soap across the vehicle's surface. Following this, motor controlled brushes rotate and scrub the car, removing dirt and grime effectively.

After scrubbing, the car moves to the rinsing stage, where normal water is sprayed to wash off the soap and loosened dirt. The used water, now contaminated with dirt and soap residues, is collected for recycling. The wastewater is directed through a sedimentation filter, where larger dirt particles and impurities settle at the bottom. The relatively cleaner water then passes through a carbon filter, which helps remove finer contaminants, odours, and residual chemicals.

Meanwhile, the cleaned car progresses to the drying stage, where a heater-assisted dryer removes moisture from the surface. Finally, a second proximity sensor detects when the vehicle has exited the system, automatically stopping the conveyor belt and dryer. This entire process ensures an efficient, automated, and eco-friendly car wash, utilizing PLC-controlled operations for precision and water recycling to minimize wastage.

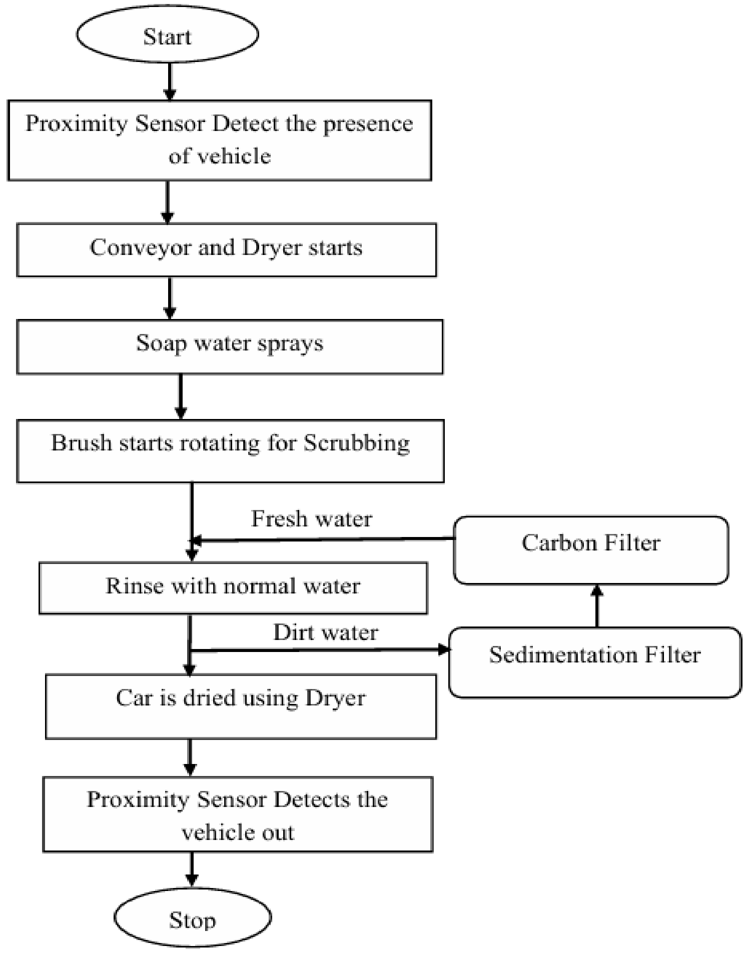

Fig. 1 Methodology

V. COMPONENTS AND DESCRIPTION

A. Programmable Logic Controller

The PLC is the main control unit in the system, responsible for executing the programmed instructions to manage the wash cycle. It controls the sequence of operations, such as rinsing, detergent application, scrubbing, and drying, by receiving inputs from sensors and sending outputs to actuators. The GENIE NX PLC is a compact yet powerful programmable logic controller (PLC) designed for industrial automation applications, offering a balance of flexibility and reliability. It comes equipped with 6 digital and 2 analog inputs, enabling it to process signals from a variety of sensors, and 4 relay outputs, which can be used to control actuators, motors, solenoids, or other external devices. The combination of digital and analog inputs allows for precise monitoring of both discrete and variable signals, enhancing the system's adaptability to different automation requirements. The relay outputs ensure robust switching capabilities, making the PLC suitable for diverse industrial environments. Additionally, the GENIE-NX PLC is designed for seamless integration into automation systems, supporting efficient data acquisition, real-time processing, and reliable execution of control tasks. Its user-friendly programming interface and compatibility with standard communication protocols further enhance its applicability in modern industrial setups.

Fig. 2 Genie-NX PLC

B. Battery

The Chloride Safepower Sealed Lead-Acid Battery (CS 7-12, 12V, 7Ah) is a crucial hardware component for projects requiring reliable and rechargeable power sources. This battery is designed for stable and maintenance-free operation, making it ideal for applications such as uninterruptible power supplies (UPS), robotics, automation systems, and embedded electronics. It operates on a constant voltage charge with a standby voltage range of 13.6V to 13.8V and a cycle use voltage range of 14.1V to 14.4V, ensuring efficient energy management. With a maximum initial current of 1.4A, it provides a consistent power output for extended durations. Additionally, its sealed construction makes it spill proof and non-hazardous, reducing the risk of leakage and ensuring safe operation in various environmental conditions. The recyclable and non-spillable design aligns with safety and environmental standards, making it a reliable choice for battery-powered systems in engineering and automation projects..

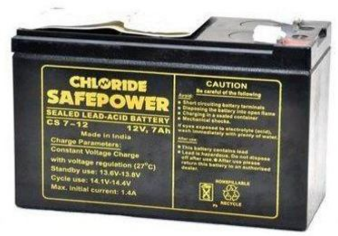

Fig. 3 Battery

C. Proximity Sensors

The NPN Proximity Sensor (5V) is an essential hardware component for detecting objects without physical contact, commonly used in automation, robotics, and industrial control systems. This sensor operates on a 5V DC power supply and functions as an NPN-type switch, meaning it provides a low (0V) output when an object is detected and a high (5V) output in the absence of an object. It is suitable for detecting metallic objects using electromagnetic fields, ensuring high reliability and fast response times. The sensor is widely used in applications such as object counting, position sensing, and safety mechanisms in conveyor systems and robotic arms. Its compact design, low power consumption, and non-contact operation make it a crucial component for precise and efficient automation in various engineering projects.

Fig. 4 Proximity Sensor

D. Voltage Regulator

A voltage regulator that converts 12V to 5V is an essential electronic component used in various applications to step down voltage while ensuring a stable output. It is commonly used in power supply circuits for microcontrollers, sensors, and USB-powered devices. This regulator ensures that sensitive electronic components receive a consistent 5V output, preventing damage from higher voltages. The two main types of regulators used for this purpose are linear regulators and switching regulators (buck converters). These regulators are ideal for applications requiring energy efficiency, such as battery powered devices and automotive electronics.

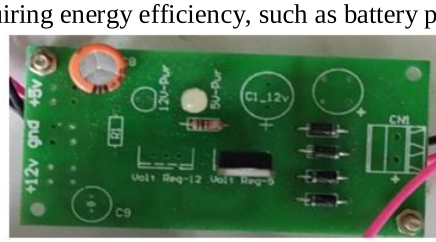

Fig. 5 Voltage Regulator

E. Relay Module

A relay module is an essential component in a PLC-based car wash system, working alongside a 12V to 5V voltage regulator to control various high-power electrical devices such as water pumps, motors, and dryers. The relay module acts as an electrically operated switch, allowing the PLC (Programmable Logic Controller) to control high-voltage AC or DC equipment using low-power control signals. Since the PLC typically operates at 5V logic levels, the 12V to 5V voltage regulator ensures that the relay module receives the correct voltage for proper functioning. This setup enables efficient automation of different stages of the car wash process, such as spraying water, applying soap, and activating brushes. In a car wash automation system, relay modules provide electrical isolation between the PLC's low voltage logic and the high-power loads, ensuring safety and system stability. These modules can be single-channel or multi-channel, depending on the number of devices being controlled. The combination of a voltage regulator and relay module ensures smooth and reliable operation, enabling the PLC to manage power distribution effectively in a car wash system.

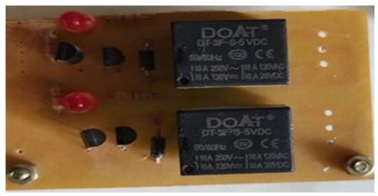

Fig. 6 Relay Module

F. Water Pump

The 12V 40W 3000 RPM Rotary Vacuum Pump is a vital hardware component for applications requiring suction or vacuum generation. This pump operates on a 12V DC power supply, consuming 40 watts of power, making it energy-efficient while providing reliable performance. With a rotational speed of 3000 RPM, it generates a strong vacuum, making it suitable for tasks such as fluid transfer, air suction, pneumatic automation, and vacuum-based holding mechanisms. Its compact and lightweight design allows easy integration into automated systems, robotics, and industrial processes. The pump's rotary mechanism ensures continuous and smooth operation, reducing pulsation effects often found in diaphragm pumps. Additionally, its sealed construction minimizes leakage and enhances durability, making it ideal for applications in medical devices, laboratory equipment, and industrial automation where precise vacuum control is required.

Fig. 7 Water pump

G. Brush Motors

Brush motors drive the rotating brushes used to scrub the vehicle's surface, effectively removing stubborn dirt and grime. A Permanent Magnet Direct Current (PMDC) motor with a speed of 150 RPM is a key component in automated car wash systems, primarily used to drive rotating brushes. This motor operates on DC power and utilizes permanent magnets to generate a consistent magnetic field, eliminating the need for external field windings. This design enhances efficiency by reducing energy consumption and simplifying the motor structure. The low-speed and high-torque characteristics of the 150 RPM PMDC motor ensure smooth and controlled brush movement, preventing excessive force that could damage a vehicle's paint while still providing effective cleaning. The motor's compact size and lightweight construction make it easy to integrate into various car wash designs, whether for conveyorized tunnel systems, rollover wash units, or self-service stations. Additionally, PMDC motors are known for their high reliability and minimal maintenance requirements, as they have fewer components prone to wear and tear. Their quick response to speed and torque variations allows for precise control, ensuring uniform cleaning pressure across different vehicle surfaces. Due to their cost effectiveness, durability, and efficiency, these motors are widely preferred in the car wash industry for ensuring consistent performance and long service life.

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Fig. 8 Motor

H. Gear Motor

A DC gear motor with a speed of 60 RPM and a power rating of 90 watts is commonly used as a conveyor motor in automated car wash systems. This motor is equipped with an integrated gear reduction system, which allows it to deliver high torque at low speeds, making it ideal for moving conveyor belts that transport vehicles through the wash cycle. The low-speed, high-torque output ensures smooth and controlled movement, preventing jerks or sudden acceleration that could misalign vehicles on the conveyor. The 90-watt power rating provides sufficient strength to handle the load while maintaining energy efficiency. Its compact design allows for easy installation within the conveyor system, while the DC operation ensures precise speed control and quick response to load variations. Additionally, the gear motor’s durability and reliability make it well-suited for the demanding environment of a car wash, where exposure to water, detergents, and dirt is common. It typically features a sealed housing for protection against moisture and debris, reducing maintenance needs. This makes DC gear motors an efficient and cost-effective choice for conveyor systems in modern car wash operations.

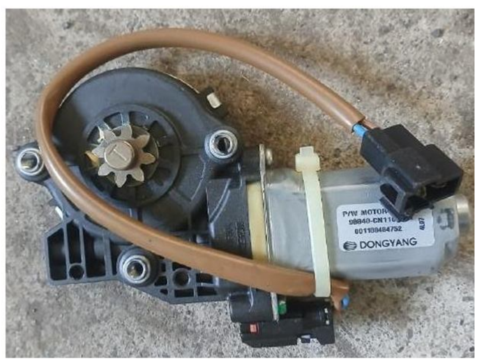

Fig. 9 Gear Motor

I. Conveyor Belt System

The conveyor belt system is used to move the vehicle through each stage of the wash process, ensuring it progresses smoothly from one stage to the next. This system is essential in fully automated car wash setups. The conveyor is driven by a motor, which is controlled by the PLC to maintain a consistent speed. Rollers, ball bearings and belts are selected based on the weight of the vehicles being washed and the expected load on the system.

Fig. 10 Conveyor belt

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J. Drying Unit

The drying unit includes air blowers that use high-speed air to remove water from the vehicle after the wash cycle. The PLC controls the blowers to operate only during the drying stage, ensuring efficient use of energy. Typically, axial blowers are used to provide a powerful airflow that can effectively dry the vehicle. The air blower accompanied with a heater of 12V to provide an effective drying. The heater placed on the top of the blower provides hot air. The air blowers are positioned to cover the vehicle's entire surface for an even and thorough drying.

Fig. 11 Dryer System

K. Nozzle

A water spray nozzle with adjustable pressure is a crucial component in an automatic car washing system, ensuring efficient and controlled cleaning. This nozzle is designed to regulate water flow and pressure based on the cleaning requirements, allowing for effective removal of dirt, grime, and contaminants from the vehicle's surface. The adjustable pressure feature enables optimization of water usage, preventing excessive consumption while maintaining sufficient force for thorough cleaning. Typically, these nozzles incorporate a mechanism such as a rotating or variable-orifice design to modify the spray pattern and intensity. In automated car wash systems, pressure adjustment is often controlled through pneumatic or electronic actuators, ensuring seamless operation in different washing stages, including pre-wash, soap application, rinsing, and final touch-up. By integrating adjustable pressure nozzles, the system enhances cleaning efficiency, reduces water wastage, and minimizes the risk of surface damage, making it a vital element in sustainable and effective car washing solutions.

Fig. 12 Water Spray Nozzle

L. Pre-Carbon Filter

In a water recycling system for car washing, the pre-carbon filter plays a vital role in refining the water quality by targeting dissolved chemical contaminants. Unlike sedimentation filters that focus on capturing large particulate matter, the pre-carbon filter employs activated carbon media characterized by its highly porous structure and enormous surface area. This structure enables the adsorption process, where contaminants such as chlorine, volatile organic compounds (VOCs), and other dissolved impurities adhere to the carbon surface. By removing these chemicals, the filter not only improves the water's taste and odor but also prevents chemical corrosion and degradation of downstream components, including pumps and additional filtration units. Additionally, the pre-carbon filter can help in reducing scale formation and biofilm development by eliminating substances that promote bacterial growth. This process is critical in car wash applications because it ensures that the recycled water maintains a high quality, which is essential for both effective cleaning and the longevity of the equipment. Over time, regular maintenance and replacement of the activated carbon are necessary to sustain optimal performance, as the adsorption capacity diminishes once the carbon becomes saturated with contaminants.

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Fig. 13 Pre-Carbon Filter

M. Sedimentation Filter

In a car washing water recycling system, the sedimentation filter is often placed as the first stage in the treatment chain to address the bulk of suspended solids, such as sand, silt, and other particulates. By relying on gravity-based settling or mechanical filtration methods, the sedimentation filter effectively captures and removes these larger impurities, preventing them from fouling or overwhelming subsequent treatment steps. After this initial clarification, the water is routed through the pre-carbon filter, which contains activated carbon media designed to adsorb a range of dissolved contaminants, including chlorine, volatile organic compounds (VOCs), and other chemical pollutants. This adsorption process helps protect downstream equipment by reducing corrosive substances, and it also improves water quality for reuse in the car wash process. Consequently, the combined effect of sedimentation followed by pre-carbon filtration not only enhances cleaning effectiveness but also extends the service life of the entire recycling system, minimizes operational costs, and supports more sustainable water usage practices.

Fig. 14 Sedimentation Filter

N. Software G-SOFT NX

G-SOFT NX is a Windows-based programming application developed by General Industrial Controls Pvt. Ltd. for configuring the Genie NX series of programmable logic relays. It provides a user-friendly interface that allows users to program and control Genie NX devices using ladder logic programming. The software includes a comprehensive offline simulator, enabling users to test and validate their programs without the need for physical hardware. Key features of G-SOFT NX encompass a variety of function blocks such as input contacts, output coils, internal contacts/coils, counters, timers, time switches, counter comparators, analog comparators, text messages, and advanced motor control functions. This extensive suite of tools facilitates the creation of complex control logic tailored to specific automation requirements. Additionally, G-SOFT NX offers real-time error detection and correction during program entry, enhancing efficiency and reducing the likelihood of programming errors. The software's intuitive design ensures that even users with minimal programming experience can effectively develop and implement control solutions for their automation projects. Programming with G-SOFT NX is straightforward, utilizing a pick-and-place functionality that simplifies program generation, project simulation, and documentation. This approach ensures that even users with minimal programming experience can effectively develop and implement control solutions for their automation projects. Additionally, G-SOFT NX allows for program transfer between devices using a memory card, facilitating quick duplication of programs without the need for a laptop or PC. One of its standout features is the seamless integration with Genie NX hardware, offering live monitoring capabilities.

Users can track real-time status updates of inputs, outputs, and internal memory elements, making troubleshooting and debugging significantly more efficient. The software also provides password protection and security features, ensuring that unauthorized modifications to programs are prevented. Moreover, G-SOFT NX is compatible with various communication protocols, enabling integration with SCADA systems and external monitoring tools. Its compatibility with different file formats ensures that projects can be easily backed up, shared, and restored when needed. For engineers and technicians, the software offers detailed logging and diagnostic tools, helping in predictive maintenance and system optimization. The ability to update firmware directly through the software ensures that users always have access to the latest features and improvements. Overall, G-SOFT NX is a powerful, flexible, and reliable tool designed for both beginners and professionals in industrial automation, providing an efficient and error-free programming environment for control applications.

VI. BLOCK DIAGRAM

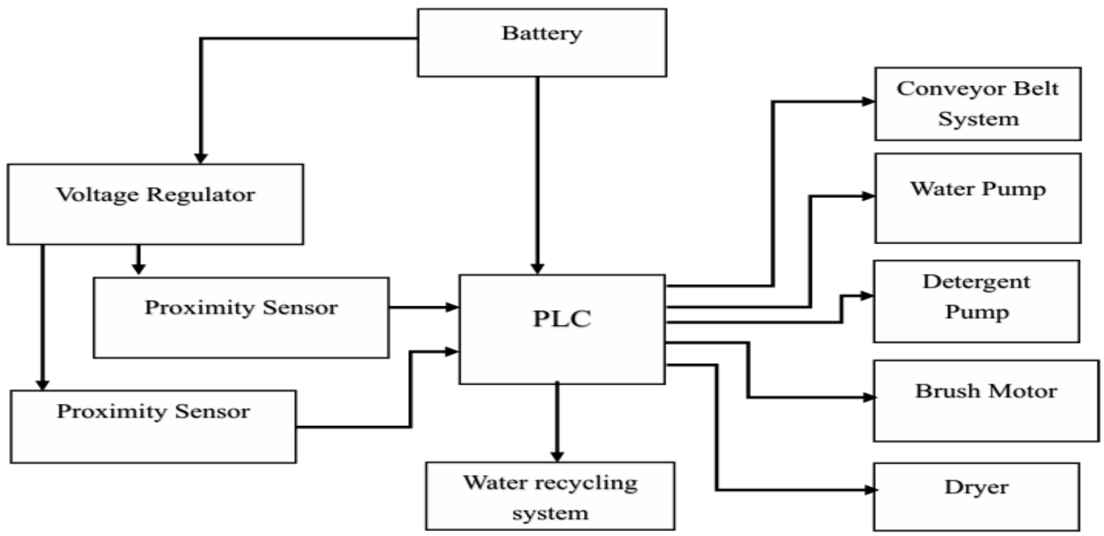

Fig. 15 Main Block Diagram

VII. WORKING

The automatic car wash system is a fully automated vehicle cleaning solution that operates using a Genie-NX PLC, which controls a conveyor belt, sensors, pumps, brushes, and a dryer with a heater. As a vehicle approaches, proximity sensors detect its presence and signal the PLC, which starts the conveyor belt, moving the car through various cleaning stages. First, a soap water pump sprays detergent onto the vehicle through high-pressure nozzles, loosening dirt and grime. Then, two motor controlled brushes rotate and scrub the car's surface, ensuring effective cleaning while being gentle on the paint.

After scrubbing, the system activates the normal water pump, which sprays clean water to rinse off the soap and contaminants. The vehicle then moves to the drying section, where a dryer with a heater blows warm air over the car, removing water droplets and preventing streaks. To promote water conservation, the used water from the washing and rinsing stages is collected and processed through a two-stage filtration system. First, a sedimentation filter removes large particles such as dirt, sand, and soap residues, allowing heavier contaminants to settle. The partially filtered water then flows into a carbon filter, which removes chlorine, organic impurities, and dissolved chemicals, ensuring that the recycled water is clean and safe for reuse. This filtered water is then stored and pumped back into the system, reducing water consumption and making the car wash more sustainable and cost-effective. The PLC ensures seamless automation by managing sensor inputs, controlling motor speeds, regulating water flow, and ensuring each stage operates in a well-timed sequence. Additionally, safety features such as overload protection, emergency stop mechanisms, and controlled pressure regulation enhance system reliability and efficiency. By integrating automation and water recycling, the system delivers a consistent, eco-friendly, and efficient vehicle cleaning process, reducing manual labour while maintaining high-quality results.

VIII. CONCLUSION

Integrating a Programmable Logic Controller (PLC) with various components in an automatic car washing system brings numerous operational and environmental benefits. The PLC ensures seamless coordination between the conveyor belt, brushes, gear motor, water pump, dryer, actuators, and sensors, enabling a fully automated and efficient cleaning process. NPN proximity sensors play a crucial role in detecting vehicle position with high precision, ensuring that each stage of the wash cycle—from pre-soak to scrubbing and rinsing—operates at the right moment and for the appropriate duration. This precision minimizes errors, reduces energy consumption, and optimizes the use of cleaning resources. Additionally, incorporating a water recycling system with sedimentation and carbon filters enhances sustainability by effectively treating and reusing wastewater, significantly reducing fresh water consumption and environmental pollution. The sedimentation process removes large debris and suspended particles, while carbon filtration eliminates contaminants and odors, ensuring high-quality recycled water for the next wash cycle. Overall, this automation not only improves operational efficiency but also enhances service quality, promotes resource conservation, and aligns with modern eco-friendly initiatives in the automotive industry. Moreover, automation in car washing improves service speed and reliability, allowing for a higher throughput of vehicles without compromising quality. The PLC-driven control system ensures that every stage of the wash cycle—from pre-wash to final drying—is executed with precision, adapting to different vehicle sizes and shapes. Safety features can also be integrated, such as emergency stop mechanisms and fault detection systems, ensuring smooth and secure operation. By combining advanced automation, precise sensor technology, and an efficient recycling system, this modern car wash setup represents a significant technological leap in the automotive service industry, providing enhanced customer satisfaction, resource efficiency, and environmental responsibility.

IX. FUTURE SCOPE

The future of automatic car washing systems is poised for significant advancements through the integration of Programmable Logic Controllers (PLCs) and a suite of sophisticated components. PLCs serve as the central control units, orchestrating the seamless operation of conveyor belts, brushes, gear motors, water pumps, dryers, actuators, NPN proximity sensors, and advanced water recycling systems. This integration enables precise coordination of each stage in the car washing process, enhancing efficiency, consistency, and adaptability to various vehicle types. In a typical conveyor driven automatic car wash, the vehicle is placed on a conveyor belt that guides it through a series of cleaning stages. Initially, the car undergoes a pre-wash phase where high-pressure water jets and specialized detergents loosen dirt and grime. Following this, rotating brushes or soft cloth strips scrub the vehicle's surface, effectively removing stubborn contaminants. Subsequent stages involve rinsing, waxing, and drying, each meticulously controlled by the PLC to ensure optimal results. The incorporation of NPN proximity sensors plays a crucial role in detecting the presence and position of the vehicle, allowing the system to adjust operations dynamically for different vehicle sizes and shapes. Actuators, driven by gear motors, control the movement of brushes and other mechanical components, ensuring thorough cleaning without causing damage to the vehicle's surface. Water pumps manage the precise delivery of water and cleaning solutions, optimizing resource usage and reducing waste. A significant advancement in these systems is the implementation of water recycling mechanisms, including sedimentation and carbon filters. These systems treat and reuse water within the car wash, substantially reducing freshwater consumption and minimizing environmental impact. As environmental regulations become more stringent and the demand for sustainable practices intensifies, such eco-friendly features position automated car washes as responsible and forward-thinking solutions in the vehicle maintenance industry. As technology continues to evolve, we can anticipate further enhancements in automatic car washing systems. Innovations may include advanced sensors for more precise vehicle profiling, adaptive control algorithms for customized cleaning cycles, and the integration of IoT devices for real-time monitoring and maintenance. These developments promise to elevate the efficiency, effectiveness, and environmental sustainability of automatic car washes, aligning with the global shift towards automation and green technologies.

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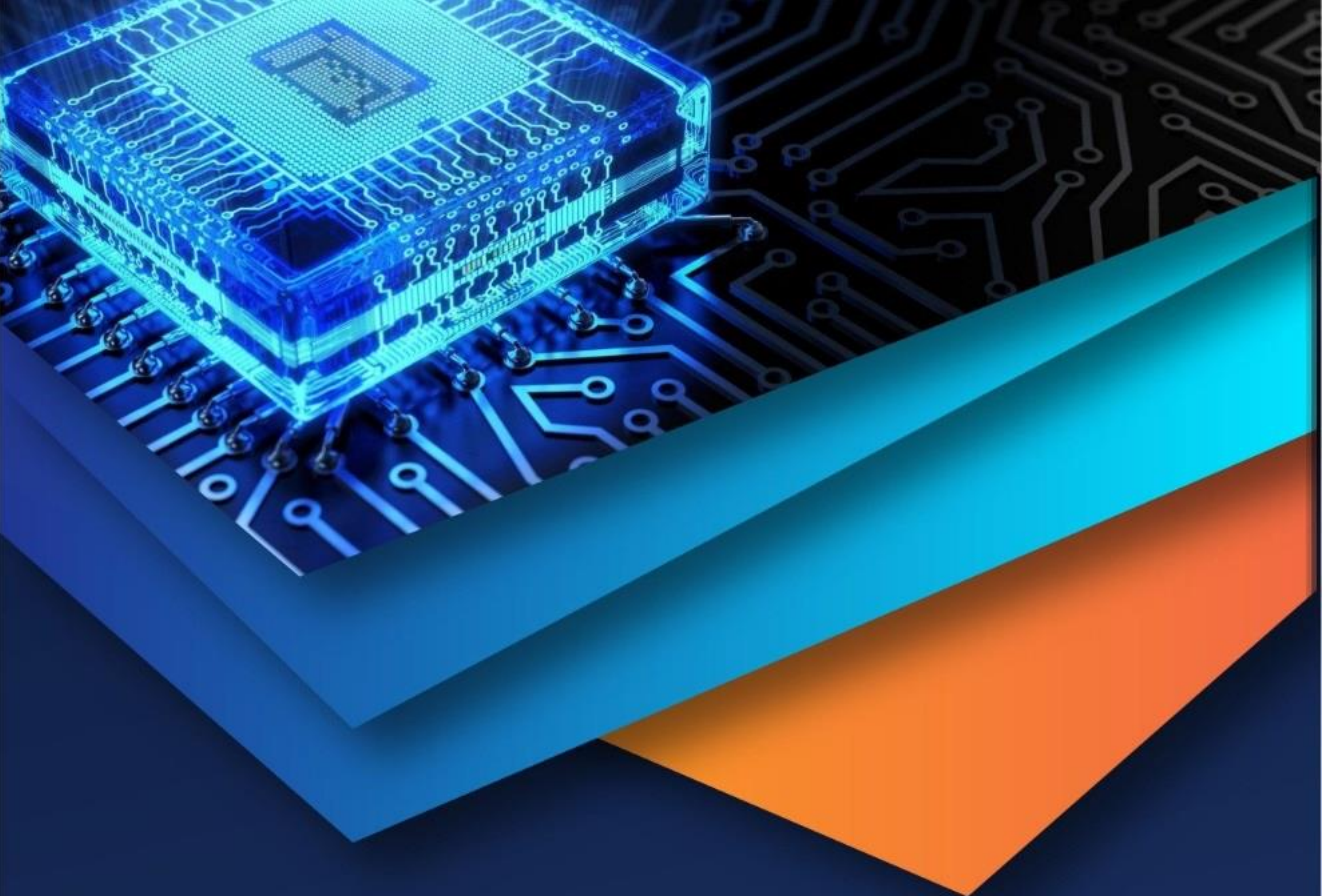

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