

Glass Gluing Conveyor System

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Abstract - The increasing demand for precision and automation in automotive manufacturing has accelerated the development of advanced glass bonding systems. This paper presents an automated glass gluing conveyor system integrated with a primer shaker and adhesive dispensing unit for efficient bonding of automotive glass components such as windshields, rear glass, and side windows. The proposed system aims to improve adhesive application accuracy, process consistency, and material handling efficiency while reducing manual intervention. The review examines recent advancements in conveyor automation, adhesive bonding technologies, decentralized control strategies, and PLC-based industrial systems. Existing studies reveal several limitations in conventional conveyor systems, particularly in handling fragile glass materials where vibration control, positional accuracy, and surface protection are critical. Research on adhesive dispensing techniques highlights challenges related to trajectory accuracy, rheological behavior, and real-time monitoring during automated operation. Although vision-guided and jetting technologies provide improved precision, their integration with synchronized conveyor and primer management systems remains limited. The proposed system addresses these gaps through coordinated PLC-based control, uniform primer mixing, precise adhesive dispensing, and synchronized conveyor operation, thereby enhancing reliability, bonding quality, production efficiency, and overall automation performance in automotive glass assembly applications.

Keywords - Glass Gluing Conveyor, Adhesive Dispensing, Primer Shaker, PLC Automation, Automotive Manufacturing, Conveyor Systems, Smart Manufacturing

I. INTRODUCTION

In the modern automotive industry, the bonding of glass components such as windshields, rear windows, and side panels is a critical process that directly affects vehicle safety, structural integrity, and durability. Traditional glass bonding methods are often manual or semi-automated, leading to inconsistencies in adhesive application, increased labor dependency, and higher chances of defects such as air gaps, misalignment, and weak bonding. These limitations highlight the need for a more efficient, precise, and automated solution. The Glass Gluing Conveyor System is designed to address these challenges by integrating advanced automation

technologies into the bonding process. The system combines a conveyor mechanism for controlled material handling, a glass fixture assembly for accurate positioning, a primer shaker unit to maintain uniform adhesive properties, and an automated glue dispensing system for precise application. A Programmable Logic Controller (PLC) coordinates all operations, ensuring synchronized and reliable performance. By automating the glass bonding process, the system improves production speed, reduces human error, and enhances overall product quality. Additionally, it provides flexibility to handle different glass shapes and sizes, making it suitable for modern, high-speed automotive manufacturing environments focused on efficiency, precision, and safety.

II. LITERATURE REVIEW

The development of automated glass gluing conveyor systems has gained significant importance in automotive and industrial manufacturing due to the increasing demand for precision, productivity, and product quality. Conventional manual glass bonding methods often lead to uneven adhesive application, alignment errors, glue leakage, and excessive labor dependency. These limitations reduce production efficiency and affect bonding reliability. To address these issues, researchers have focused on conveyor automation, adhesive dispensing technologies, PLC-based control systems, and intelligent inspection methods.

Studies on conveyor systems emphasize the importance of efficient material handling and synchronization in automated production lines. Existing conveyor systems are mainly designed for transportation, sorting, and sequencing operations. Research indicates that high-density conveyor systems face challenges such as synchronization delays, deadlock prevention, and scalability issues. These limitations highlight the need for advanced conveyor solutions specifically designed for fragile glass handling applications.

Adhesive bonding technology has become an important alternative to traditional welding and riveting because it provides uniform stress distribution, sealing capability, and improved structural performance. Literature shows that bonding quality depends on adhesive flow properties, curing behavior, wetting characteristics, and surface preparation.

However, many existing systems lack real-time monitoring methods for controlling adhesive consistency and curing performance during automated manufacturing processes.

Researchers have also studied conveyor belt materials suitable for fragile glass transportation. Conventional rubber belts may cause scratches and micro-cracks on glass surfaces. Therefore, composite materials such as polyurethane foam, polyamide fabric, and reinforced fiber structures are preferred because they provide better flexibility, damping, and positioning accuracy. Lightweight composite rollers further improve conveyor performance by reducing sagging and vibration.

Recent advancements in adhesive dispensing systems include jet dispensing technology, UV curing, machine vision, and neural network-based inspection systems. PLC-based automation integrated with sensors and Human Machine Interfaces (HMI) has significantly improved operational reliability, reduced labor costs, and enhanced production efficiency. Despite these advancements, there remains a research gap in developing a fully integrated glass gluing conveyor system capable of combining precise glass handling, primer control, adhesive dispensing, and automated inspection within a single synchronized platform.

III. PROBLEM STATEMENT

In the automotive manufacturing industry, the bonding of glass components such as windshields and side windows is a critical process that directly affects vehicle safety, structural strength, and product quality. Conventional manual and semi-automatic glass gluing methods often suffer from problems such as uneven adhesive application, improper glass alignment, primer inconsistency, glue leakage, and higher production time. These issues increase material wastage, labor dependency, and chances of bonding defects. In addition, handling fragile glass manually may lead to scratches, cracks, or displacement during processing. Existing systems also lack proper synchronization between conveyor movement, primer preparation, and adhesive dispensing operations. Therefore, there is a need for an automated glass gluing conveyor system capable of providing accurate positioning, controlled adhesive application, improved production efficiency, and reliable bonding quality while minimizing human intervention and operational errors.



Figure1: Manual system and Automated system

IV. METHODOLOGY

The proposed Glass Gluing Conveyor System is developed to automate the complete process of glass handling, primer preparation, and adhesive dispensing for automotive glass manufacturing applications. The system integrates mechanical components, control systems, sensors, and adhesive handling units to achieve accurate, safe, and efficient glass bonding operations. The primary objective of the system is to improve production efficiency, reduce manual intervention, and ensure consistent bonding quality.

The system mainly consists of a conveyor mechanism, glass fixture assembly, primer shaker unit, glue dispensing unit, sensors, actuators, motors, and a Programmable Logic Controller (PLC)-based control system. Initially, the glass panel is manually loaded onto the fixture assembly positioned on the conveyor. The fixture assembly is specially designed to securely hold the glass component in a fixed and stable position during transportation and adhesive application. Proper alignment of the glass is essential to prevent displacement and ensure uniform glue application throughout the process.

The conveyor system is responsible for transporting the glass panel sequentially through different operational stages. Depending on the industrial requirement, either a roller conveyor or belt conveyor mechanism can be used. The conveyor movement is controlled by electric motors connected to the PLC control system. The PLC regulates conveyor speed and movement according to the process sequence and sensor feedback.

Once the glass reaches the primer application station, the primer shaker unit starts operating. The main purpose of the primer shaker is to continuously agitate the primer solution and prevent sedimentation of chemical particles. Maintaining uniform primer consistency is important because uneven primer composition may reduce adhesive bonding strength and durability. The shaker unit ensures that the primer remains homogeneous throughout the process, resulting in improved adhesion performance and long-term reliability.

After primer preparation, the glass panel is transferred to the glue dispensing station. At this stage, adhesive is applied using a controlled dispensing nozzle mounted above the glass surface. The dispensing system is designed to provide accurate flow rate, uniform glue thickness, and precise adhesive positioning. The nozzle movement and dispensing timing are synchronized with conveyor movement using PLC logic and sensor feedback. This synchronization minimizes glue wastage and ensures consistent adhesive application along the required bonding path.

The system uses photoelectric sensors and proximity sensors to detect the position and movement of the glass panel at various stages. These sensors provide real-time input signals to the PLC, allowing accurate control of conveyor motion, motor operation, dispensing activation, and process sequencing. Timers and counters programmed within the PLC help maintain proper operational timing and coordination between all units.

The integrated automation system significantly reduces manual labor, minimizes human error, improves production speed, and enhances product quality. In addition, the automated handling system ensures safer transportation of fragile glass panels while reducing the possibility of scratches, cracks, or

alignment defects. The proposed methodology provides a reliable, repeatable, and efficient solution suitable for modern automotive glass manufacturing industries.

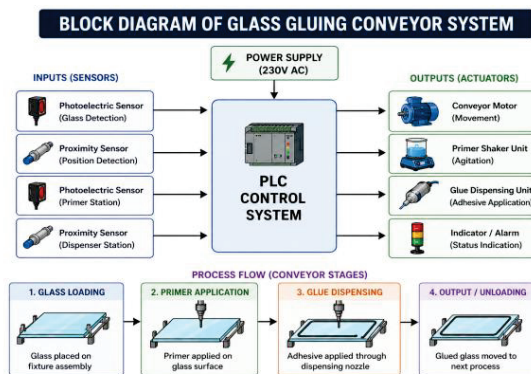


Figure2: Block Diagram

V. PROPOSED SOLUTION

The proposed solution is an automated Glass Gluing Conveyor System integrated with a primer shaker and glue dispensing unit to improve the efficiency and accuracy of automotive glass bonding processes. The system uses a PLC-controlled conveyor mechanism to transport glass panels through different operational stages in a synchronized manner. A specially designed fixture assembly securely holds the glass to maintain accurate positioning during primer application and adhesive dispensing.

The primer shaker unit ensures continuous mixing of the primer solution, preventing sedimentation and maintaining uniform chemical properties. This improves adhesive strength and bonding durability. The glue dispensing unit applies adhesive with controlled flow rate and precision, reducing glue wastage and eliminating uneven application. Sensors integrated within the system provide real-time feedback for glass detection and process synchronization.

The automated setup minimizes human intervention, reduces production time, improves product quality, and enhances operational safety. Compared to manual systems, the proposed solution offers better consistency, reduced labor dependency, higher productivity, and improved reliability. The system is also flexible enough to accommodate different glass sizes and shapes, making it suitable for modern automotive manufacturing industries.

VI. HARDWARE REQUIRED

1. CONVEYOR SYSTEM:

The conveyor system is used to transport glass panels smoothly through different processing stages such as primer application and glue dispensing. It ensures continuous material flow, reduces manual handling, and improves production efficiency while maintaining proper positioning and safe movement of fragile glass components.

2. PLC (PROGRAMMABLE LOGIC CONTROLLER):

The PLC acts as the main control unit of the system. It controls conveyor movement, sensor operations, primer shaker activation, and glue dispensing sequence. The PLC processes input signals from sensors and provides accurate output control for synchronized and automated industrial operations.

3. PHOTOELECTRIC SENSOR:

Photoelectric sensors are used to detect the presence and position of glass panels on the conveyor. These sensors provide non-contact detection, ensuring accurate operation without damaging fragile glass surfaces. They help maintain proper sequencing and synchronization during automated processing stages.

4. PROXIMITY SENSOR:

Proximity sensors detect the position and movement of metallic or nearby objects within the system. They help control conveyor operation, positioning accuracy, and dispensing timing. These sensors improve automation reliability and ensure precise operation of the glass handling process.

5. PRIMER SHAKER UNIT:

The primer shaker unit continuously agitates the primer solution to prevent sedimentation and maintain uniform consistency. Proper primer mixing improves adhesive bonding strength, durability, and application quality. It ensures stable chemical properties during long-duration industrial operations.

6. GLUE DISPENSING UNIT:

The glue dispensing unit applies adhesive accurately on the glass surface through a controlled nozzle mechanism. It ensures uniform adhesive thickness, minimizes glue wastage, and improves bonding quality. The unit operates in synchronization with conveyor movement using PLC control.

7. CONVEYOR MOTOR:

The conveyor motor provides mechanical movement to the conveyor system. It controls the speed and direction of glass transportation through various process stages. The motor ensures smooth, continuous, and vibration-free operation required for handling fragile automotive glass safely.

8. GLASS FIXTURE ASSEMBLY:

The glass fixture assembly securely holds the glass panel during conveyor movement and adhesive application. It prevents displacement, vibration, and misalignment during operation. Proper fixture design ensures accurate positioning and improves the precision of primer and glue dispensing processes.

9. HMI (HUMAN MACHINE INTERFACE):

The HMI provides an interface between the operator and the automation system. It allows monitoring and controlling of conveyor speed, sensor status, dispensing operations, and system parameters. It improves operational convenience, troubleshooting, and process management in industrial environments.

10. POWER SUPPLY UNIT:

The power supply unit provides electrical power to all system components including PLC, sensors, motors, and dispensing units. It ensures stable voltage and reliable operation of the automation system while protecting components from electrical fluctuations and disturbances.

VII. WORKING

STEP 1: GLASS LOADING

The working process begins with the loading of the automotive glass panel onto the glass fixture assembly mounted on the conveyor system. The fixture assembly securely holds the glass in a fixed and stable position to prevent displacement, vibration, or misalignment during transportation and adhesive application. Proper positioning of the glass is essential to achieve accurate primer coating and uniform glue dispensing.

STEP 2: CONVEYOR MOVEMENT

After loading, the conveyor motor starts operating and moves the glass panel smoothly through different processing stations. The conveyor system is designed to transport fragile glass safely without causing scratches or damage. The movement and speed of the conveyor are controlled by the Programmable Logic Controller (PLC) according to the programmed operational sequence.

STEP 3: GLASS DETECTION USING SENSORS

As the glass panel moves along the conveyor, photoelectric sensors detect the presence and position of the glass at different stages. These sensors provide non-contact detection, which is suitable for fragile glass handling applications. The detected signals are transmitted to the PLC, allowing automatic control and synchronization of the next process.

STEP 4: PRIMER SHAKER OPERATION

When the glass reaches the primer application station, the primer shaker unit starts functioning. The main purpose of the primer shaker is to continuously agitate the primer solution and prevent sedimentation of chemical particles. Maintaining uniform primer consistency is very important because uneven

primer composition can reduce bonding strength and affect adhesive durability. The shaker ensures proper mixing throughout the operation.

STEP 5: PRIMER APPLICATION

After proper mixing, the primer is applied uniformly onto the glass surface. The primer improves the surface adhesion characteristics of the glass and prepares it for strong adhesive bonding. Uniform primer coating helps improve sealing quality, bonding strength, and long-term durability of automotive glass components.

STEP 6: GLUE DISPENSING PROCESS

The conveyor then transfers the glass panel to the glue dispensing station. At this stage, the glue dispensing unit applies adhesive through a controlled dispensing nozzle. The nozzle dispenses glue accurately along the required bonding path with uniform thickness and controlled flow rate. The dispensing process is synchronized with conveyor movement to avoid glue wastage and ensure precise application.

STEP 7: PLC-BASED CONTROL

The PLC acts as the central control unit of the entire system. It controls conveyor movement, motor operation, sensor feedback, primer shaker activation, and adhesive dispensing timing. Proximity sensors and photoelectric sensors continuously provide real-time signals to the PLC, ensuring accurate coordination between all processing stages.

STEP 8: MONITORING THROUGH HMI

The Human Machine Interface (HMI) allows the operator to monitor conveyor speed, sensor status, dispensing operation, and overall system performance. It also provides fault indication and operational control for easy management and troubleshooting.

STEP 9: OUTPUT AND UNLOADING

After adhesive application is completed, the conveyor transfers the glued glass panel to the unloading or curing station for further inspection and processing. Indicator lamps and alarms display the operational status of the system. Overall, the Glass Gluing Conveyor System improves production efficiency, reduces manual labor, minimizes material wastage, and ensures accurate and reliable bonding quality in automotive manufacturing industries.

VIII. DISCUSSION OF RESULTS

The performance of the proposed Glass Gluing Conveyor System was analyzed based on production efficiency, adhesive quality, automation accuracy, and operational reliability. The integration of conveyor automation, primer shaking, and glue dispensing significantly improved the overall manufacturing process compared to conventional manual methods. The

conveyor system ensured smooth and safe transportation of fragile glass panels, while the fixture assembly maintained accurate alignment during operation. The primer shaker successfully prevented sedimentation and maintained uniform primer consistency, improving bonding strength and durability. The glue dispensing unit provided precise adhesive application with minimum wastage. Sensor-based PLC control improved synchronization between conveyor movement and dispensing operations, resulting in better process accuracy and reduced human intervention. The system demonstrated higher productivity, improved safety, reduced labor dependency, and better product quality suitable for automotive manufacturing applications.

Parameter	Manual	Automated
Adhesive Application	Uneven	Precise
Glass Alignment	Manual	Automatic
Production Speed	Low	High
Labor Requirement	High	Reduced
Material Wastage	More	Minimal
Bonding Quality	Moderate	Improved
Process Accuracy	Human Based	PLC Controlled
Safety	Less Safe	Improved
Primer Consistency	Non-uniform	Uniform
Reliability	Moderate	High

IX. BENEFITS OF THIS SYSTEM

- **Improved Production Speed**

The automated conveyor system reduces manual handling and enables continuous glass movement, increasing overall production speed and reducing manufacturing cycle time in automotive industries.

- **Accurate Glue Dispensing**

The glue dispensing unit applies adhesive uniformly with controlled flow rate and thickness, improving bonding quality while minimizing adhesive wastage during operation.

- **Better Bonding Strength**

The primer shaker maintains consistent primer composition, ensuring strong adhesive bonding, improved sealing performance, and long-term durability of automotive glass assemblies.

- **Reduced Manual Labor**

Automation reduces human involvement in glass transportation, positioning, and adhesive application, lowering labour requirements and minimizing operator fatigue during industrial operations.

- **Enhanced Operational Safety**

The system minimizes direct handling of fragile glass panels, reducing the risk of accidents, scratches, cracks, and workplace injuries during manufacturing processes.

- **High Process Accuracy**

PLC-based control and sensor integration provide precise synchronization between conveyor movement and dispensing operations, ensuring reliable and repeatable industrial performance.

- **Consistent Product Quality**

Automated operation eliminates variations caused by manual processes and ensures uniform adhesive application, proper glass alignment, and consistent bonding quality.

- **Lower Material Wastage**

Controlled adhesive dispensing reduces excess glue usage and prevents unnecessary material loss, improving cost efficiency and production management.

- **Easy Monitoring and Control**

The Human Machine Interface (HMI) allows operators to monitor conveyor operation, sensor status, and dispensing processes easily for better system management.

- **Suitable for Mass Production**

The continuous automated process supports large-scale industrial production while maintaining high efficiency, reliability, and product quality in automotive manufacturing industries.

X. LIMITATIONS

1.High Initial Cost – Installation of PLCs, sensors, and conveyor components increase overall system cost.

2.Maintenance Requirement – Regular servicing of sensors, motors, and dispensing units is necessary for proper operation.

3.Power Dependency – System operation completely depends on continuous electrical power and PLC functioning.

4.Limited Flexibility – Conveyor fixtures may not easily support irregular or customized glass shapes.

5.Adhesive Flow Problems – Changes in glue viscosity or nozzle blockage can affect bonding quality.

6.Skilled Operation Needed – Trained personnel are required for programming, monitoring, and troubleshooting the system.

XI. FUTURE SCOPE

1.AI-Based Defect Detection – Artificial intelligence can be integrated for automatic glass defect and adhesive inspection.

2.IoT Monitoring System – IoT technology can enable real-time monitoring and remote control of system performance.

3.Robotic Glue Dispensing – Robotic arms can improve adhesive application accuracy for complex glass shapes.

4.Automatic Glass Loading – Automated robotic loading systems can further reduce manual labor requirements.

5.Advanced HMI Integration – Modern touch-screen HMIs can improve operational control and troubleshooting efficiency.

6.UV Curing Technology – UV curing systems can be added for faster adhesive curing and reduced production time.

7.Energy-Efficient Automation – Future systems can use energy-saving motors and smart control techniques to reduce power consumption.

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XII. CONCLUSION

The proposed Glass Gluing Conveyor System with Primer Shaker and Glue Dispensing Unit presents an efficient, accurate, and reliable solution for modern automotive glass bonding applications. The system successfully integrates conveyor automation, primer preparation, adhesive dispensing, sensor-based monitoring, and PLC-controlled operation into a single synchronized platform. This integration significantly improves production efficiency, bonding consistency, and operational safety compared to conventional manual bonding methods. The conveyor mechanism ensures smooth and safe handling of fragile glass panels, while the glass fixture assembly maintains precise positioning throughout the process. The primer shaker unit effectively prevents sedimentation and maintains uniform primer consistency, resulting in improved adhesive strength and long-term durability. The glue dispensing system provides controlled and precise adhesive application with minimum material wastage and enhanced sealing quality.

The implementation of PLC-based automation and sensor integration enables accurate synchronization between conveyor movement and dispensing operations, reducing human intervention and minimizing operational errors. The system also improves productivity, lowers labor dependency, enhances process reliability, and ensures consistent product quality suitable for large-scale industrial applications. Although the system requires higher initial investment and periodic maintenance, its advantages in terms of precision, automation, safety, and efficiency make it highly beneficial for modern automotive manufacturing industries. Overall, the project demonstrates the important role of industrial automation in achieving high-quality, reliable, and cost-effective glass bonding operations.

XIII. REFERENCES

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