Axle Arm Pressing 3.0automation For Enhancing Efficiency, Quality and Workplace safety

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Abstract*- Heavy lifting is required for the Axle Arm Sub-Assembly procedures, especially while pressing the oil seal, ABS sensor sleeve, and kingpin bush by hand. The dependence on human labor, particularly the use of hammers for some pressing tasks, has resulted in an increase in physical strain on employees and the introduction of irregularities into the assembly process. The press machine is located a good distance away from the main assembly line, which presents a major challenge. Because of this geographical gap, axle arms must be manually transported to the main assembly line, which causes inefficiencies and may cause workflow delays. Operational complexity is increased by the average of 280 axle arms being transported per shift from the sub-assembly to the main assembly line. This project is to address the manual processes in the Axle Arm Sub-Assembly that are labor-intensive and inconsistent in order to address these challenges. The emphasis is on applying automation and process optimization strategies to improve overall efficiency and expedite urgent tasks. Furthermore, efforts will be focused on minimizing the need for manual transportation in order to provide a more seamless transfer of axle arms from sub-assembly to the main assembly line. Through reducing manual labor, eliminating irregularities, and streamlining the workflow, this project aims to enhance the quality of Axle Arm Sub-Assembly procedures, helping the manufacturing shop meet its production and safety objectives.*

Keywords- Axle safety, Pneumatic systems, Press machine, Automation, Hammer

I. INTRODUCTION

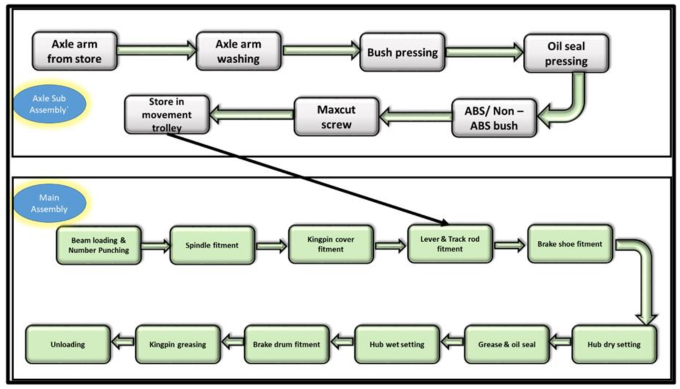
In the dynamic world of manufacturing, attaining efficiency and quality on an assembly line requires process optimization. This study explores the details of the Axle Arm Sub-Assembly procedures, with a particular emphasis on the pressing the oil seal, ABS sensor sleeve, and kingpin bush. These procedures have historically involved labor-intensive manual labor, which has presented issues with worker physical strain and assembly line irregularities. Manual pressing, which frequently requires the use of hammers, has shown to be both physically taxing and prone to output fluctuations. Axle arms must also be manually transported due to the physical separation between the press machine and the main assembly line, which inefficiencies the operation. Human carelessness leads to unsafe actions and conditions, and these lead to accidents. This fact must be kept in mind when performing work in compliance with safety requirements.The main objective of this project is to use process optimization and automation to change the Axle Arm Sub-Assembly procedures. By taking care of the labor-intensive aspects of hand pressing tasks and simplifying the workflow, the initiative seeks to reduce assembly line inconsistencies and maximize overall efficiency. In addition, efforts will be made to lessen the need for manual transportation, which will facilitate the easier transfer of axle arms to the main assembly line. The results of this project are expected to support the larger goals of meeting production targets and maintaining quality standards, in addition to improving the assembly line's operating efficiency as set out on this path of process improvement. Requirements for safety in the industrial facility.

Goal is to revolutionize the Axle Arm Sub-Assembly procedures by means of invention and optimization, thereby establishing a benchmark for superiority in manufacturing techniques.In addressing the axle arm problem statement, three potential solutions were thoroughly evaluated based on key criteria, including sufficient space for implementation, cost, Bill of Materials (BOM), manufacturability, standard tooling, feasibility of use for all variants of axles, implementation time, and durability. The three solutions considered were robotization, semi-automated press machine, and outsourcing. Each solution underwent a comprehensive analysis to determine its suitability for the specified criteria. The first criterion, sufficient space for implementation, was critical to ensure the seamless integration of the chosen solution into the existing manufacturing setup. The second criterion, cost, weighed the financial implications of each solution, considering initial investment as well as long-term operational costs. The third criterion, Bill of Materials (BOM), assessed the material requirements for each solution to ensure compatibility with the axle arm manufacturing process. The implementation time was carefully scrutinized to gauge the speed at which each solution could be integrated into the manufacturing process. Durability, the final criterion, assessed the long-term reliability and robustness of each solution under regular operational conditions. After a thorough evaluation, the semi-automated press machine emerged as the optimal solution. Its selection was based on its ability to meet the specified criteria effectively, offering a balance between cost-effectiveness, manufacturability, tooling compatibility, feasibility for all axle variants, reasonable implementation time, and durability. This decision represents a strategic choice that aligns with the overarching goal of enhancing the axle arm manufacturing process, optimizing efficiency, and ensuring long-term sustainability.

II. METHODOLOGY

The beam loading stage involves loading the front axle beams onto the production line, followed by number punching to assign each axle a unique identifier for tracking purposes. Subsequently, the spindle fit process connects the axle beams to the spindles, crucial for supporting bearings and connecting the axle to the wheels. Kingpin covers are then fitted to protect the pivotal steering kingpins from impurities, ensuring their smooth functionality. Next, the levers and track rods are secured, essential for proper steering and suspension operations, emphasizing stability and controlled steering. Brake shoes are then put in place within the brake assembly to facilitate braking, engaging with the brake drum for effective stopping. The hubs are initially set dry on the spindle before grease and oil seals are applied to ensure proper lubrication and prevent contamination.

This leads to the wet hub configuration, where oiled bearings and oil seals are installed on the spindle before placing the hubs for seamless wheel rotation. Finally, brake drums are fastened to the hubs, and the kingpins are greased for smooth articulation and reduced friction during steering movements.After the sub-assembly procedure is finished, the product moves on to the main assembly phase. Lever and track rod fittings receive special attention during this phase. In order to form the finished product, these components must be integrated into the assembly as a whole in this stage. Levers and track rods are included, which implies a concentration on mechanical precision and raises the possibility that the assembled product is a component of a larger mechanical system, such a car or piece of machinery.



Pic:1. Product Assemble Process flow

Semi-Automated press machine operation process:

Loading the Component (Axle Arm):The process begins with loading the axle arm component into the designated position within the assembly line. This step sets the foundation for all subsequent processes and requires careful positioning to ensure proper alignment and fitment.

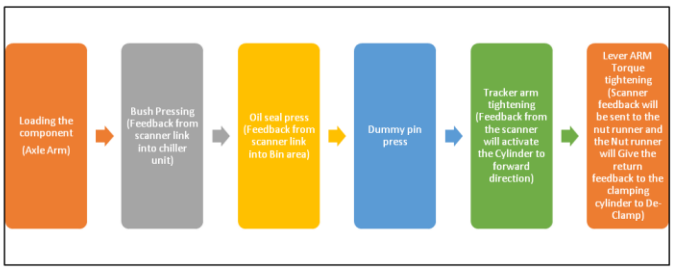
Bush Pressing (Feedback from Scanner Link into Chiller Unit):Once the axle arm is loaded, the next step involves pressing a bush into place. This bush pressing operation is crucial for securing components and providing structural integrity to the assembly. Feedback from a scanner is integrated into this process and linked to the chiller unit. The scanner feedback may include measurements, quality checks, or other parameters that help monitor and control the bush pressing operation.

Oil Seal Press (Feedback from Scanner Link into Bin Area): Following the bush pressing, the assembly proceeds to press an oil seal into position. Similar to the bush pressing step, feedback from a scanner is utilized in this process as well. The scanner feedback is linked to the bin area, which may be responsible for sorting, storing, or quality control related to the oil seal installation.

Dummy Pin Press: As part of the quality assurance and alignment procedures, a dummy pin is pressed into the assembly. Dummy pins serve as temporary placeholders or testing tools to ensure proper alignment, fitment, and functionality of the axle arm assembly during the manufacturing process.

Tracker Arm Tightening (Feedback from the Scanner will activate the Cylinder to Forward Direction): Moving forward, the tracker arm tightening process begins. This step involves securing the tracker arm to the desired specifications. Feedback from a scanner is crucial here, as it activates the cylinder to move in the forward direction, indicating successful tightening of the tracker arm.

Lever ARM Torque Tightening (Scanner feedback will be sent to the Nut Runner and the Nut Runner will Give the return feedback to the Clamping Cylinder to De-Clamp): The final critical step in the manufacturing process is torque tightening the lever arm. This step requires precision and accuracy to ensure optimal performance of the axle arm assembly. Scanner feedback plays a pivotal role in this process, as it is sent to the nut runner tool responsible for torque tightening. Once the desired torque is achieved, the nut runner sends return feedback to the clamping cylinder, initiating the de-clamping process and completing the torque tightening operation.



Pic.4. Operating Instruction of the Semi-automated press machine

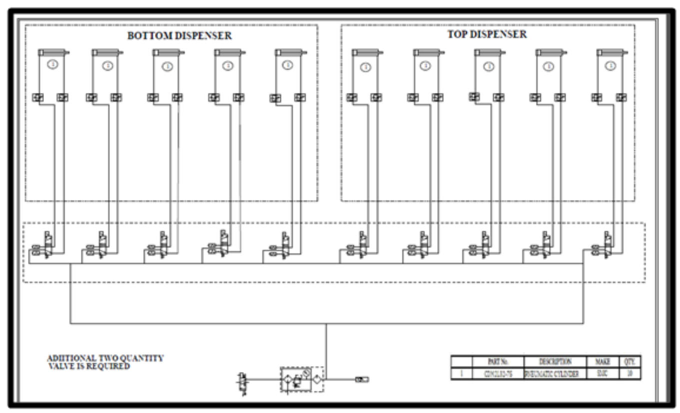
The process or methodologyfor Axle arm assembly is explained and results of deployed solution explain in the next.

III. RESULT AND DISCUSSION

In addressing the axle arm problem statement, three potential solutions were thoroughly evaluated based on key criteria, including sufficient space for implementation, cost, Bill of Materials (BOM), manufacturability, standard tooling, feasibility of use for all variants of axles, implementation time, and durability. The implementation time was carefully scrutinized to gauge the speed at which each solution could be integrated into the manufacturing process. Durability, the final criterion, assessed the long-term reliability and robustness of each solution under regular operational conditions. After a thorough evaluation, the semi-automated press machine emerged as the optimal solution. Its selection was based on its ability to meet the specified criteria effectively, offering a balance between cost-effectiveness, manufacturability, tooling compatibility, feasibility for all axle variants, reasonable implementation time, and durability.

The semi-automated press machine substation is a sophisticated system comprising five distinct stations, each contributing to the overall efficiency and functionality of the machine. These stations are designed to handle specific tasks efficiently, thanks to a PLC-based pneumatic system. The stations include the Bottom and Top dispenser, the Bush and Oil seal indexing unit, the Floating bush press, and the Poke yoke press tightening for both the LH and RH sides, all operated at a standard pressure of 6Bar. This comprehensive setup ensures a seamless workflow and precise execution of tasks within the manufacturing or production environment.

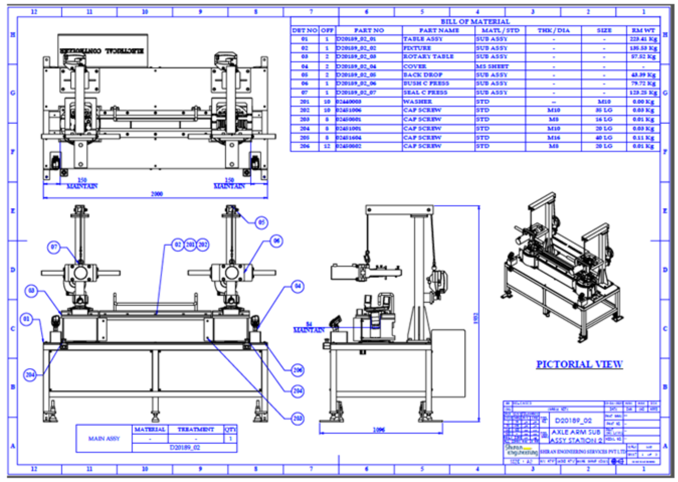
One of the critical aspects of the press machine substation is its emphasis on safety features. These safety measures are meticulously incorporated to protect both operators and equipment from potential hazards and to ensure smooth and reliable operation. One such safety feature is the Emergency stop switch, strategically placed within easy reach in case of any emergency situation. The switch, identifiable by its red push-button located on the Top Right of the front operation panel, serves as a quick and effective means to halt the pressing process and simultaneously shut down the Hydraulic Power Pack.



Pic:3. Pneumatic Circuit

This immediate response mechanism is crucial in averting accidents or damage to the machine or the products being processed. Furthermore, the emergency condition is clearly indicated on the IPC (Industrial Personal Computer) display as "Emergency Stop Pressed," providing visual confirmation and alerting operators to the status of the machine. In addition to the Emergency stop switch, another essential safety feature is the Main power indicator. This indicator, situated on the control panel, serves as a visual cue to indicate when the mains power supply is active and the machine is ready for operation. The illuminated indicator not only confirms the power status but also enhances safety by providing operators with a clear indication of the machine's readiness. This feature plays a crucial role in preventing accidental start-ups or operations under unstable power conditions, contributing to a safer working environment overall. The integration of these safety features underscores the commitment to safety and reliability in the design and operation of the press machine substation. By combining advanced technology with user-friendly safety mechanisms, the machine ensures optimal performance while minimizing risks and potential downtime due to safety-related issues. Operators can work with confidence, knowing that the machine is equipped to handle emergencies effectively and that safety is prioritized throughout its operation. Moreover, the PLC-based pneumatic system is a key component that enables precise control and automation of various functions within the press machine substation. This system utilizes programmable logic controllers (PLCs) to manage the operation of pneumatic components such as cylinders, valves, and actuators. The Bottom and Top dispenser stations, for instance, rely on this system to dispense materials accurately and consistently, ensuring uniformity in the production process. Similarly, the Bush and Oil seal indexing unit utilizes the PLC-based system to index components precisely, facilitating efficient assembly and positioning for further processing. The Floating bush press station, another integral part of the machine, leverages the PLC-based pneumatic system to apply controlled pressure during the pressing operation. This ensures that the desired force is exerted evenly, resulting in accurate and reliable assembly of components. Likewise, the Poke yoke press tightening stations on both the LH and RH sides benefit from the precise control offered by the PLC-based system, enabling consistent and repeatable tightening of fasteners or components.

Furthermore, the pressure control aspect of the pneumatic system plays a crucial role in ensuring optimal performance across all stations. The standard pressure of 6Bar is carefully chosen to provide sufficient force for operations while avoiding excessive pressure that could lead to component damage or safety risks. The system's ability to maintain this pressure within specified parameters contributes to the overall reliability and efficiency of the press machine substation. In terms of maintenance and troubleshooting, the PLC-based pneumatic system offers several advantages. Its modular and programmable nature allows for easy diagnostics and adjustments, reducing downtime associated with maintenance tasks. Operators can access diagnostic information through the IPC interface, enabling them to identify and address issues promptly. Additionally, the system's compatibility with modern diagnostic tools and software simplifies troubleshooting and enhances overall system reliability. Overall, the combination of a PLC-based pneumatic system with advanced safety features makes the press machine substation a robust and dependable solution for various manufacturing and production applications. Its ability to automate processes, ensure precision, and prioritize safety makes it a valuable asset in industries where efficiency and reliability are paramount. As technology continues to evolve, further enhancements and optimizations in both the pneumatic system and safety features are expected, driving continuous improvements in performance and safety standards.



Pic:4. Mechanical drawing of Sub Assembly Station

The results and discussion of the Semi-automated press machine concept is explained and conclusion of the solution deployed will explain in the next content.

IV. CONCLUSION

The research conducted on the Axle Arm Sub-Assembly procedures has provided valuable insights into the challenges faced in traditional manual labour processes and the potential for significant improvements through process optimization and automation. By focusing on pressing tasks, such as the oil seal, ABS sensor sleeve, and kingpin bush, this study has highlighted the physical strain on workers and the inconsistencies in assembly line output associated with manual pressing techniques. The need for manual transportation of axle arms has also been identified as a bottleneck, leading to inefficiencies and safety risks.

The primary objective of this project is to revolutionize the Axle Arm Sub-Assembly procedures through innovation and optimization, aiming to set a benchmark for excellence in manufacturing techniques. The evaluation of potential solutions, including robotization, semi-automated press machines, and outsourcing, led to the selection of the semi-automated press machine as the optimal solution. This decision was based on its ability to meet key criteria such as space requirements, cost-effectiveness, Bill of Materials (BOM), manufacturability, tooling compatibility, feasibility for all axle variants, implementation time, and durability. The implementation of the semi-automated press machine is expected to bring added value to the production system of the organization across various dimensions, including safety, productivity, quality, workforce satisfaction, and cost efficiency.

By streamlining pressing tasks, reducing manual labour, enhancing workflow efficiency, and ensuring compliance with safety standards, this initiative is poised to contribute significantly to the overall success and competitiveness of the manufacturing operations. This strategic approach aligns with the broader goals of meeting production targets, maintaining quality standards, and achieving sustainable growth in the manufacturing sector.

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