Enhanced Skill of Non-Permanaent Associates In Weld Shop Through Digitalization

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Abstract- *In-cab weld shops are critical for ensuring quality in automotive manufacturing, yet poor weld quality can profoundly affect both Quality Gates (QGs) and Vehicle Evaluation Systems (VESs). This project addresses this challenge by focusing on MiG/CO2 welding and spot welding operations. The primary goal is to implement measures that markedly enhance weld quality, thereby mitigating the impact on QGs and VESs during CO2 welding operations. Adopting a comprehensive approach, the project entails a meticulous analysis of existing welding processes to identify key issues contributing to poor weld quality. Targeted solutions will then be implemented to address these issues, aiming for significant improvements. One such solution is the introduction of DOJO (Japanese Word it's is an honored place to deliberate practice to develop skills) Training to elevate the skill levels of operators, complemented by the development of an application for defect monitoring. By systematically addressing these challenges, this project endeavors to bolster the integrity of welds in in-cab weld shops, thereby enhancing overall manufacturing quality and efficiency.*

Keywords- DOJO Training, MiG/CO2 welding process, Spot welding techniques, Welding standards, Real Time Defect Monitoring

I. INTRODUCTION

Poor weld quality is a common problem in in-cab weld shops, and it can have a negative impact on Quality Gates (QGs) and Vehicle Evaluation Systems (VESs). Through an emphasis on spot welding [1] and MiG/CO_2 welding, this initiative seeks to address these issues. The main objective is to put into practice efficient strategies that greatly enhance weld quality and lessen the effect on QGs and VESs during CO_2 welding operations. We will use a thorough strategy that includes problem identification, in-depth analysis, and focused solutions.

Finding the causes of low weld quality requires a detailed examination of the welding procedures in use today. To identify areas for improvement, this analysis will consider the state of the equipment, welding settings, material preparation, and operator skill.

Methodically addressing the difficulties that have been discovered, effective solutions will be established. Recalibrating welding equipment, putting maintenance plans into place, refining welding parameters, and improving material handling procedures are some possible solutions. Additionally, a defect monitoring tool will be developed in tandem with the implementation of DOJO Training to enhance operator abilities.

Operator competency in welding procedures and techniques will be increased by the implementation of DOJO Training [2], an organized approach to skill development. The main goals of this training programmer are to raise general skill levels and foster a culture of continual development [3]. Additionally, a defect monitoring programmer will be created to facilitate the detection and tracking of weld faults and allow for prompt remedial action.

II. LITERATURE REVIEW

1. The digitalization of process planning for resistance spot welding (RSW) in body-in-white (BIW) automotive structures presents an opportunity to streamline development processes and reduce costs. This investigative study explores the potential for replacing physical welding trials with virtual tests, focusing on a Swedish auto manufacturer's car pillar welding process. Critical conditions for successful virtual testing include information sharing, knowledge reuse, and workflow streamlining. The study establishes criteria for digital tools, evaluates potential implementations, and concludes that digitalization holds promise for significantly reducing lead times and product development costs compared to traditional methods.

2. The study examines the development of instructing techniques in professional training, focusing specifically on welding education. With a growing emphasis on student independence and creativity, traditional teaching roles are evolving towards mentorship and advisory roles. Through an experiment involving third-year students, the researchers found that a combination of oral and written instructions significantly improved learning outcomes compared to solely oral instruction. The incorporation of written briefings, particularly through technological maps, proved instrumental in enhancing students' comprehension and task performance, highlighting the efficacy of supplementary written guidance in vocational education.

3. Enhancing Practical Training in Welding Education: The Efficacy of Project-Based Learning on Power Sources. In the realm of modern education, the adaptation of pedagogical methods to meet evolving demands is crucial. This study delves into the efficacy of instructional methodologies for practical training in welding education, particularly focusing on power sources. Through a comparative analysis between traditional teaching approaches and project-based learning, it was demonstrated that the latter yields superior outcomes in terms of student performance and engagement. The experiment conducted among third-year students revealed that those exposed to project-based learning exhibited significantly higher levels of proficiency in welding tasks compared to their conventionally taught counterparts. This underscores the importance of innovative instructional techniques in nurturing the skills and independence essential for future professionals in welding

4. A theory of individual differences in task and contextual performance. The demand for skilled welders continues to rise in the face of increased industrial manufacturing needs, necessitating efficient training methods while maintaining high quality standards. This study introduces a novel apparatus, the Welder Arm, aimed at enhancing welding training programs in technical colleges, post-secondary institutions, and industry settings. Through analysis, it was found that the Welder Arm significantly improves welding quality for novice trainees. Its effectiveness extends to various fields requiring re-training and industrial applications, offering benefits such as cost and time savings, reduced material usage, and lower electricity consumption. Future research should explore additional features of the Welder Arm and compare data methods related to body positioning movements, promising advancements in welding training efficiency and effectiveness.

5. Real-time Simulation for Virtual Reality-based MIG Welding Training System: This study presents a real-time welding simulation technique tailored for a desktop virtual reality (VR) MIG welding training system. By utilizing motion-tracking data from the welding gun, the simulation accurately predicts weld bead shape, penetration depth, and temperature distribution in the workpiece. Employing a finite difference method, temperature distribution is computed, and weld bead shape is determined at each time step. The system demonstrates promising real-time performance, with simulations closely matching physical tests for welding speeds up to 1,000 mm/min. This approach offers a cost-effective solution for interactive VR welding training, achieving a 93% accuracy in weld bead size and shape compared to experimental results.

6. Study on wire feed speed prediction in double-wire-pulsed MIG welding, utilizing support vector machine regression, addresses the critical challenge of achieving optimal wire feed speed amidst the complex interplay of process parameters. The study conducts comprehensive correlation analysis to identify key factors influencing wire feed speed, selecting duty ratio, frequency, average current of leading wire, and average current of trailing wire as significant independent variables. Through support vector machine regression and mesh optimization, an accurate prediction model is established, validated through actual welding experiments. This research fills a crucial gap in understanding the nonlinear and time-varying nature of double-wire-pulsed MIG welding processes, offering practical insights to enhance both technological design and production efficiency within the intelligent double-wire welding industry.

7. Vision Inspection Systems for Welding Defects: In response to limitations observed in existing vision inspection systems for welding defects, a novel approach using machine vision is proposed. This system, designed for the identification and classification of surface defects in metal inert gas (MIG) welding joints, employs a CCD camera and front light illumination with four zones of LEDs to capture image sequences. By segmenting regions of interest and calculating average gray levels, characteristic features are extracted for classification using a back-propagation neural network. Real sample testing yielded an impressive 95% accuracy in classification. This method not only addresses issues such as image inaccuracy and non-uniform illumination but also demonstrates potential for future enhancement through 3D feature extraction, promising even higher accuracy levels and broader applicability in manufacturing systems.

8. Improving Technical Skills in Machine Manufacturing Technology Students: Enhancing Welding Proficiency. In addressing the imperative of enhancing technical skills among students of Machine Manufacturing Technology, particularly in welding, the focus lies on optimizing training methodologies and equipment utilization. The challenges faced by Thainguyen University of Technology (TNUT) underscore the importance of investing in resources such as semi-automatic welding equipment. By aligning training programs with a structured approach and incorporating the 6-step model, students can augment their proficiency, fostering critical thinking, creativity, and adaptability essential for success in the field.

9. **Cold Metal Transfer (CMT**) Welding of Thin Sheet Metal Products the utilization of conventional welding methods such as MIG and TIG for stainless steel and aluminum alloys has been customary, albeit with inherent drawbacks like distortions and limited productivity. In contrast, the Cold Metal Transfer (CMT) process presents a promising alternative, offering reduced distortions and enhanced productivity owing to its low heat input mechanism achieved through controlled electrode movement. This study focuses on optimizing the CMT welding process for thin sheet metal products, aiming to maintain productivity while mitigating quality concerns such as porosity and distortions. Results demonstrate that the CMT process, when applied with appropriate heat input parameters, yields satisfactory stainless steel joints with minimal distortions, indicating its viability for robotic welding applications. Further investigations are warranted to determine optimal heat input parameters for aluminum alloys. The findings align with previous studies, affirming the suitability of CMT for various welding applications, particularly in minimizing spatter formation and achieving quality welds. It underscores the importance of determining optimal welding speeds to ensure low porosity and minimal distortions, providing crucial insights for enhancing productivity in thin sheet metal welding processes.

10. **Prediction and Control of Asymmetric Bead Shape in Laser-Arc Hybrid Fillet-Lap Joints in Sheet Metal Welds**. In addressing the challenge of predicting asymmetric weld bead shapes in laser-arc hybrid fillet-lap joints, this study introduces an artificial neural network model designed with inputs including welding speed, wire feed speed, voltage, current, and laser power. Utilizing experimentally obtained weld bead profiles digitized in polar coordinates, the optimized neural network topology demonstrates remarkable accuracy in predicting bead shapes and their geometric attributes. The investigation also presents a rational approach for determining the necessary number of coordinate points for accurate modeling, balancing computational efficiency with prediction precision. Moreover, the study highlights the significant influence of welding speed and wire feed speed on bead shape, while noting the minor impact of laser power, which nonetheless enhances weld dilution through additional energy and arc stabilization. This approach, leveraging neural networks for shape mapping in asymmetric weld beads, offers a robust and generalizable solution applicable to various welding processes.

III. METHODOLOGY

Identifying Challenges in Weld Quality within the Automotive Manufacturing Sector

The automotive manufacturing sector is characterized by its dynamic and intricate nature, demanding precision and unwavering quality adherence to meet industry standards. The challenge of poor weld quality persists as a significant issue within the in-cab weld shop of a certain facility. Failure to address this concern not only jeopardizes the Vehicle Evaluation System (VES) but also poses a threat to the overall Quality Gate (QG). Our research aims to meticulously analyze the intricacies of Spot and MiG/CO_2 [5] welding processes, with a specific emphasis on CO_2 welding. The objective is to implement strategies that markedly enhance weld quality, ultimately mitigating the adverse impacts on QG and VES, particularly during the CO_2 welding process [6].

Renowned for its prominence in the automotive sector, a manufacturing facility faces a significant hurdle in its monthly production of 4000 cabins. The manufacturing process is beset by a number of issues, even with an effective throughput: dents, mismatches, poor welds, poorly fitted components, and sometimes erroneous part integration. Poor weld quality is one of these difficulties that is particularly important since it affects the products' overall integrity. The primary goal of this project is to address the issue of inadequate welds and put in place solutions that will benefit the overall production process.

Project Significance

Given the significant effect that poor weld quality has on the production process as a whole, the importance of this endeavor becomes even more apparent. Inadequate welds not only reduce production efficiency but can cause a cascade of problems later on. These problems cover a variety of flaws, such as dents, missing parts, handling damage, improper fitting, and mismatches. The project's major goal is to mitigate a sizable fraction of the total defects recorded in the Quality gate by focusing on poor welds [4].

The severity of the situation is highlighted by the Pareto chart analysis, which shows that a significant 33% of the flaws found at the Quality gate are the result of poor welds. This information emphasizes how crucial a function shoddy welds play in undermining the integrity and calibre of automotive parts. Fixing this significant problem would boost the production procedure right away and help raise the general calibre and dependability of the final result.

In addition, the project seeks to create a complete and long-lasting solution that tackles the underlying reasons of poor weld quality in addition to its symptoms through the implementation of strategic interventions. Raising the bar for automobile manufacture through focused enhancements to the welding process will have a significant impact on the whole production chain and strengthen the industry's dedication to quality. The project's significance ultimately stems from its potential to transform the welding shop and open the door to improved quality control and a stronger production ecosystem.

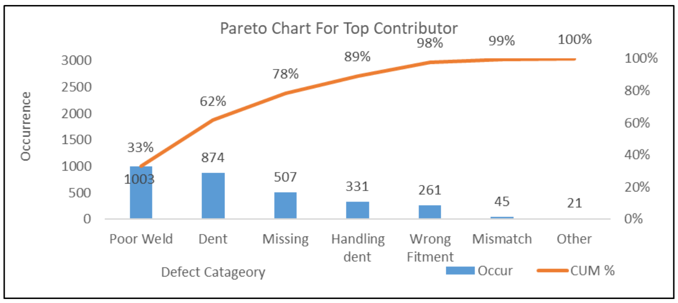

Fig – 1 Pareto Chart

Undoubtedly, the Pareto chart analysis's identification of poor welds as a major contributing factor offers a convincing justification for making this issue the top priority to address. Poor welds make up a considerable 33% of the faults recorded in the Quality gate, therefore solving this particular issue is important for a number of reasons, including the impact on overall quality and cost savings. Resolution of Root Causes

Root Cause Analysis

A cause and effect diagram, sometimes referred to as an Ishikawa or fishbone diagram, is a visual aid for problem analysis and root cause identification. This figure, created by Kaoru Ishikawa, is especially helpful in terms of quality process improvement, problem-solving, and management

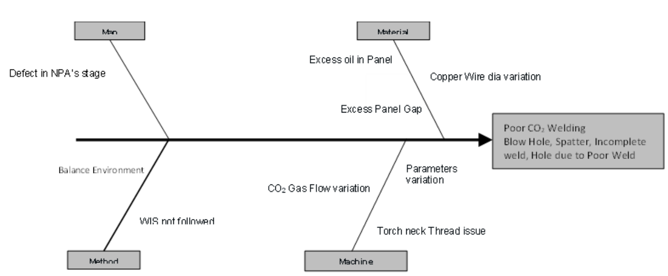

Fig – 2 Cause & Effect

The nine possible reasons why the weld was not up to par. The poor welding problem in this instance is examined from four angles: Man, Method, Material, and Machine (4M).

The "Man" category identifies the defect in NPA's stage as a possible cause, implying that insufficient knowledge or skills among NPA operator may result in a failure to discover welding, errors.

Two possible causes a misaligned environment and a failure to adhere to WIs, or work instructions are emphasized under "Method." These elements may have an impact on the reliability and caliber of welding procedures.

Three possible explanations are mentioned under the "Material" category: excess oil in the panels, variations in the diameter of the copper wire, and extra panel gap. The integrity and quality of the welds may be directly impacted by these material-related problems.

Finally, three possible explanations are listed under "Machine": torch neck thread problems, CO_2 gas flow variance, and parameter variation. These machine-related elements may have an impact on the weld quality by affecting the welding equipment's accuracy and dependability.

Root Cause Validation

To sum up, our study has methodically investigated nine possible reasons that could lead to poor welding. After a thorough validation process, the stage involving Non-Permanent Associates (NPA) has been identified as the primary root cause. This result emphasizes how crucial it is to deal with skill-related problems in the NPA stage in order to greatly enhance welding outcomes. The research's conclusions can direct production processes towards improved quality control procedures by highlighting the necessity of focused skill-development interventions and strict quality assurance at the NPA stage of the welding process.

IV. RESULTS & DISCUSSION

Develop a detailed plan for the implementation of the solution, outlining timelines, responsibilities, and resources required. Identify key stakeholders involved in the implementation process, including management, welders, and IT support. Deploy the mobile application developed using Power Apps to capture welding defects. Ensure that the application is accessible to all relevant personnel and provide necessary training on its use. Establish the DOJO Training Centre within the cab weld shop premises. Equip the training center with necessary welding equipment, safety gear, and instructional materials. Launch the training program aimed at addressing poor welding skills. Schedule training sessions based on the availability of non-permanent associates and instructors from the DOJO Training Centre. Instruct welders to use the mobile application to report welding defects encountered during their work. Establish a process for reviewing and analyzing defect reports to identify trends and areas for improvement. Utilize the data collected from the mobile application to assess the welding skills of individual welders.

Fig – 4 DOJO Training Centre

Fig - 6 Instructions

Fig – 7 Physical Training at DOJO

Identify welders who require additional training based on the frequency and severity of reported defects. Design and deliver customized training modules tailored to address specific skill gaps identified among welders. Utilize hands-on training sessions in the DOJO Training Centre to provide practical experience and feedback to welders. Implement a system for monitoring the progress of welders following training sessions [7]. Solicit feedback from welders and supervisors to assess the effectiveness of the training program and make necessary adjustments. Establish a process for continuous improvement of the solution based on feedback and performance data. Regularly review the effectiveness of the mobile application and training program to identify areas for refinement or enhancement. Maintain detailed records of training activities, defect reports, and skill assessments for documentation and reporting purposes. Use reporting tools to track key performance indicators related to weld quality, defect rates, and training outcomes.

Weld quality in the cab weld shop has significantly improved after the DOJO Training Centre and the mobile application for defect recording and reporting were put into place. Previously, poor welds made up 33% of all welds, but now only 23% do.

This 10% reduction shows how well the remedies that were put in place to resolve welding flaws and improve overall weld quality worked [8].

Furthermore, the release of the mobile application for defect reporting and capturing made it easier to quickly identify and fix welding flaws. Welders might use their mobile devices to report flaws straight from the shop floor, allowing for prompt reaction and remedial activity. This proactive approach to defect control reduced the impact on production efficiency and helped stop the recurrence of poor welds.

Furthermore, the implementation of the solutions fostered a culture of continuous improvement within the cab weld shop. Welders became more engaged in quality assurance processes and took ownership of their welding performance. Feedback from welders and supervisors was actively solicited and incorporated into ongoing training and process refinement efforts, further driving improvements in weld quality.

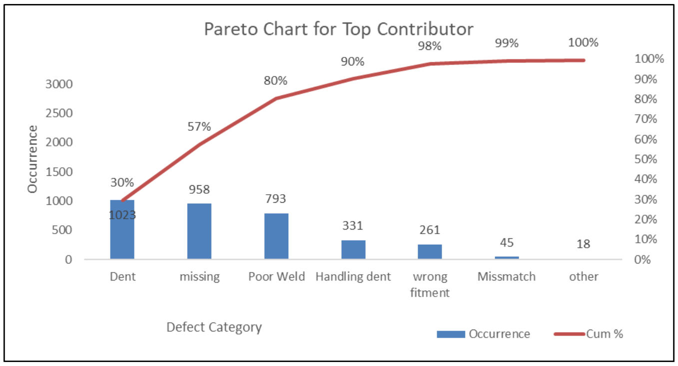

Fig 4 – Pareto chart After Solution Implementation

Overall, the results indicate that the implemented solutions have been successful in reducing poor welds and improving weld quality in the cab weld shop. The 10% reduction in poor welds signifies a tangible improvement in the manufacturing process, leading to cost savings, increased productivity, and enhanced customer satisfaction. Moving forward, continued monitoring and evaluation of weld quality metrics will be essential to sustain these improvements and drive further advancements in welding performance.

V. CONCLUSION

The outcomes of this research demonstrate that the successful application of methods targeted at improving weld quality in in-cab weld shops has produced considerable gains. The project has successfully addressed major issues causing poor weld quality, leading to a noticeable reduction in poor welds. This has been achieved by careful study of current welding processes and tailored solutions.

These advancements have mostly been fueled by the implementation of DOJO Training and the creation of a mobile application for defect tracking. Operators now possess higher skill levels thanks to DOJO Training, which enables them to weld more accurately and consistently. In the meantime, the mobile application has expedited the process of reporting defects and carrying out corrective actions, making it easier to quickly find and fix welding problems. In addition to reducing the impact on production efficiency, this proactive approach to defect management has helped the cab weld shop develop a continuous improvement culture.

The active involvement of welders in quality assurance processes, coupled with ongoing feedback integration, has sustained improvements in weld quality. The project's success, illustrated by a 10% reduction in poor welds, highlights its role in enhancing manufacturing efficiency and customer satisfaction. Continued monitoring of weld quality metrics is crucial for maintaining and advancing these improvements. By prioritizing continuous improvement and proactive defect control, in-cab weld shops can optimize operations and uphold superior quality standards in automotive manufacturing

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