A Proposal on Future Two Wheeler Chassis Weldnig with Internet of Things

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Abstract. Current manufacturing industries are shifting towards smart intelligent technologies. The advanced technologies (AL, ML, IOT, Smart manufacturing, Industry 4.0, Data analytics) are being used by electrical industries and related parts. Frame line chassis welding is a complex process with higher process variation. The use of Industry 4.0 concepts such as Internet of Things in frame welding line will bring improvement in terms of productivity, quality and overall operational efficiency. The use of IOT PLCs with robotic technology will arrest all the process variations and manual process deviations with better control by bringing the entire production line to real time monitoring/control. With advanced analytics and visualizations, the response time to cut any defects/deviations gives drastic benefit rather than manual interventions. All fabrication new product manufacturers (OEMs/Suppliers) shall incorporate this IOT technology to achieve first time right quality and delivery with lesser cost for higher customer satisfaction hence to remain competent/agile in the market.

Keywords: Welding advancements; Chassis welding; Internet of things; Robotic welding

1 Introduction

Welding is the general term for the fusion of two materials—the same or different—by causing heating through coalescence; this is a firm joint production procedure [1-2]. The automobile, aerospace, nuclear, marine, and power industries are among the many useful sectors it finds. These welding techniques are then used by the automobile industry to permanently attach panels, frames, and chassis. The MIG/MAG welding methods are utilized extensively for automotive constructions due to their low cost and high production efficiency when compared to other welding procedures [3-5]. The mass production of two-wheeler industries necessitates a highly flexible manufacturing system that can produce parts at a high volume with consistent quality at a minimum cost, taking into account the manufacturing process and its environment. This leads to automation in the welding processes [6, 7]. Robots are mechanical devices that automate human labor in order to replace it; robotic welding has become more popular in chassis welding MIG/MAG welding processes. Despite being widely utilized in the automotive industry, robotic welding is not a feasible option for chassis welding because of its nonlinearity, which leaves humans vulnerable to unexpected or unknown situations. Therefore, enterprises cannot attain the efficiency and quality of the goods by deploying robots to do repetitive jobs [8–10]. Industries have begun to enhance their

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manufacturing methods in an effort to improve part quality while maintaining competitive product launch and rigorous speed, due to an advanced transition towards smart manufacturing technology. Among the technologies, the following are worth noting: 1. Industry 4.0, 2. Internet of things, 3. Cyber physical systems; 4. Artificial intelligence; and 5. Machine learning. By using these technologies to foresee more accurately and avoid losses or problems, businesses will be able to grow and succeed. One such field is the internet of things, which is an unified manufacturing system with a number of devices and machinery connected on the internet to work collaboratively or to interact with corporate management [11–14]. This will support the industries to efficient use of resources, best-in-class work content allocation, improved part traceability to customers, and astute inventory/work-in-progress management. Using data and interne with cloud, industries are able to link at the management level from tasks and activities. As seen in Fig. 1, this ultimately causes more efficient decision-making in business scenarios and focuses on the factory's long-term performance through a variety of representations, visualizations upending status-quo [15-17].

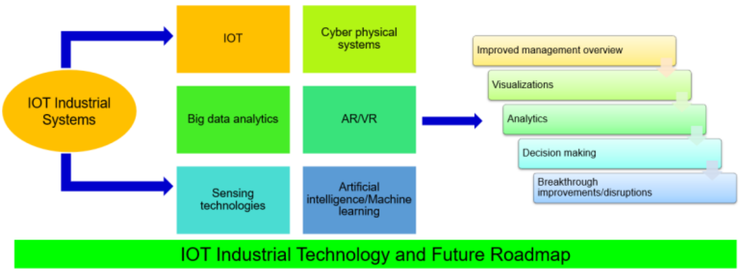

Fig 1. IOT in smart industries with technology perspective

Many conceptual advancements in the industries have been integrated into the process of improving the quality, reliability, operability, and repeatability of welding operations. The concept principle depicted in Figure 1 is the basis for the various definitions applied to welding improvements. Although fundamentalism has not changed, as Fig. 2 illustrates, many reviewers and writers have named their advances with different nomenclatures [18,19].

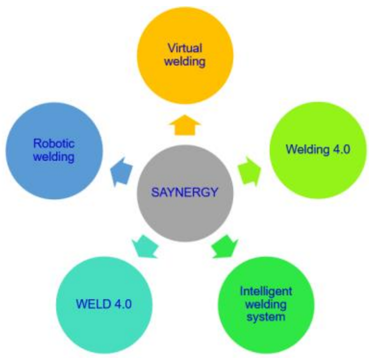

Fig 2. Synergy of welding technology in industry 4.0

The introduction to the latest advancements in smart manufacturing technology concentrates on the application of soft computing in a number of industries, it does not entirely address the automobile chassis welding and fabrication industries. The supply chain management, logistics, productivity, quality, and on-time delivery are just a few of the issues that the Indian manufacturing sector is currently facing. These issues are particularly acute for the fabrication sector. Spot welding is used for body panels in the auto industry, namely in four-wheeler vehicles. The primary structural components used in the two-wheeler industry are the handlebar, swingarm, and chassis, which are welded using MIG/MAG welding methods [20–22]. Controlling the consistent welding quality becomes difficult as these sections add to the overall strength of the vehicle.

The evaluation criteria for these structural components is based on two factors: strength and dimension. Today's Indian fabrication sector vendors face significant challenges in achieving the same. The literature reviews indicate that there have been sufficient studies, research, and experiments conducted in the areas of Industry 4.0, IOT, and advanced analytics applied to the aerospace, automotive, and electric vehicle battery parts industries. From 2018 to 2023, India saw a notable surge in the sales of electric vehicles because to technological developments. The electrical components of an electric vehicle (EV) are more numerous than the mechanical ones since they are integrated. When it comes to process planning, design, and development, electrical components like batteries, motors, BMS, lighting, and VCUs are quite important. With very much competition in the EV industry, improving the speed of part development for both mechanical and electrical parts is essential to remain competent with quality standards. Hence, this paper will give a roadmap on IOT (Internet of Things) implementation and its potential benefits for the automotive chassis welding industries/ Indian fabrication industry suppliers. Section II will reward the chassis welding process, section III will emphasize the incorporation of IOT at possible areas of manufacturing line. Finally, section IV will elaborate on future challenges and Section V on ways to forward for betterment in chassis welding.

2 Chassis welding line

2.1 Important elements of chassis welding

The MIG/MAG welding process is used for the majority of chassis welding because of its robotized flexibility and high production at a consistent and acceptable quality. Only inert gases devoid of CO2 are used in metal inert gas welding. Metal Active Gas welding is the process of using a mixture of gases in a specific ratio[23]. The chassis is made up of numerous separate tubular, stamped, and standard components. As seen in Fig. 3, these are welded together with the appropriate fixturing in place. After the child sections are placed into the fixtures, the welding will be completed and the fixtures will be locked in place by stopping all three degrees of freedom. In the current practice, industries are using semi-automatic welding where manually parts are being moved and clamped in to welding fixtures, manual inducing is done for robots to start the welding process.

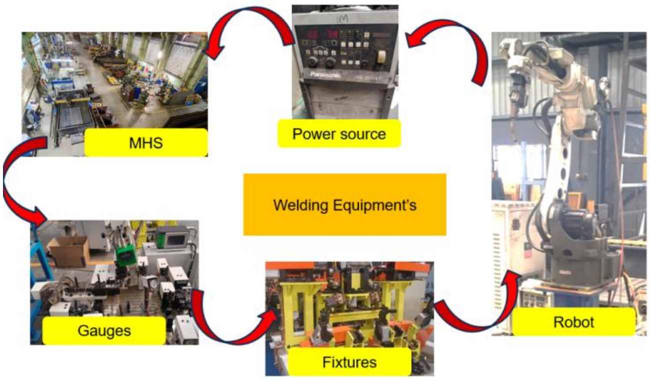

Fig 3. Welding equipment's for fabrication parts

2.2 Fish bone diagram for chassis delivery/quality

When using an Ishikawa diagram or fish bone diagram, all potential reasons why a process or product may not work as planned should be brought to light. As shown in Fig. 4, the same has been utilized to assess the underlying causes in order to attain the delivery and quality for the chassis.

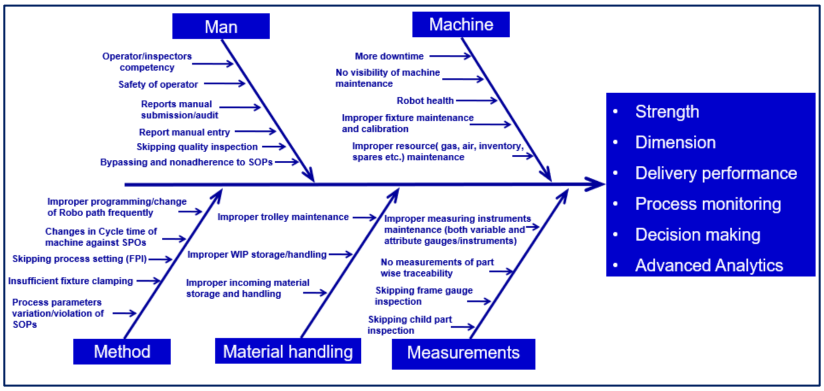

Fig 4. Causes/factors contributing for chassis welding quality and delivery requirements

The context of Fig. 4's specific area includes all probable and possible parameters pertaining to part quality, delivery, and manufacturing system performance. To ensure that market demands are satisfied, and that agile product development and maturity are attained in first time, the gaps in these kinds of sectors must be filled using contemporary technologies like IOTs.

3 Internet of things in chassis welding line

When using an Ishikawa diagram or fish bone diagram, all potential reasons why a process or product may not work as planned should be brought to light. As shown the implementation of IOT in the fabrication sectors should be encouraged considering the original study's evidence of its ability to enhance an organization's operational efficiency in the manufacturing sector. The integration of IOT within these businesses will be divided into several 6M categories, as depicted in Fig 5.

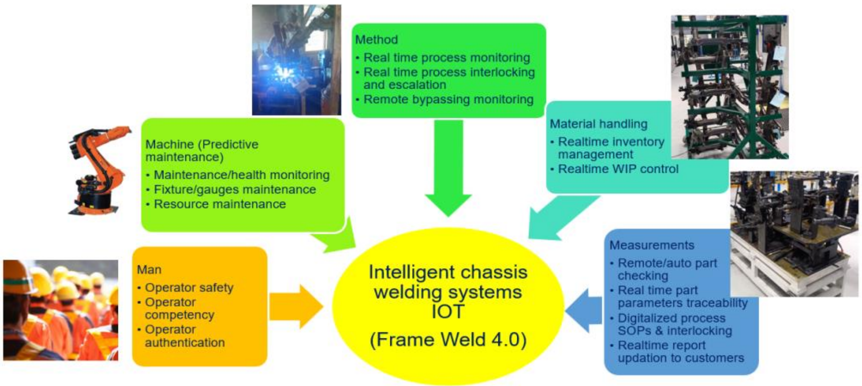

Fig 5. IOT application areas in chassis welding

3.1 Man

Since an organization's ability to succeed as a business rests solely on its workforce, manpower is an important resource. Therefore, maintaining the same labor for the welding line is severely hampered by the shortage of workers in the welding sector. Since India's welding industry has not yet reached its full potential, interest in entering these fields is declining and is extremely low. IOT can enable the real-time monitoring of the same in order to address the issue and obtain high-quality parts manufactured by the same workforce.

3.1.1 Operator safety

Manpower safety is an important aspect in welding industries as its being handled among hot environemnt with hazardous gasses, robots with heavy machinaries/equipements. To ensure the same the welding robots with fixtures are covered with sheet metals cells cum doors. Operator need to load the component in fixture and comes out of door closure then presses the button to start the operation/cycle. IOT enables the use of proximity sensors at the top of the door & will ensure that the operator is outside of the cell during operation. The same is being interlocked with robot logic to start the cycle after sensing the helmets and operator outside position.

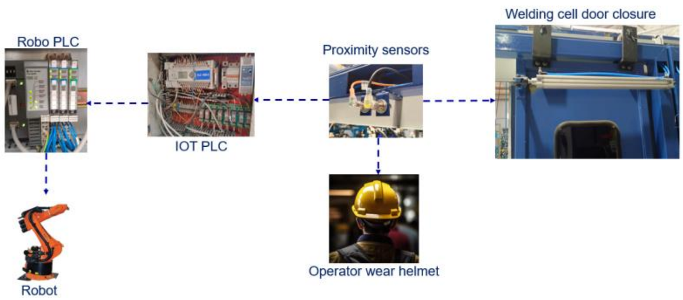

Fig 6. Operator safety interlocking with IOT

The proximity signal given to Robo PLC logic, and the interlock is made in such a way that both the signals shall be positive to start the operation which ensures that the operating environment is safer.

3.1.2 Operator competency and authentication

Having qualified workers and maintaining a fixed workforce in the production facility are crucial principles for guaranteeing the output's quality. The existing procedures fall short in that regard in terms of managing both variables. Figure 7 illustrates the IOT infrastructure for production line competency adherence and operator authentication. To guarantee that the facility is staffed with qualified personnel, the biometrics of the trained workers are interlocked with the IOT PLC to start the cycle.

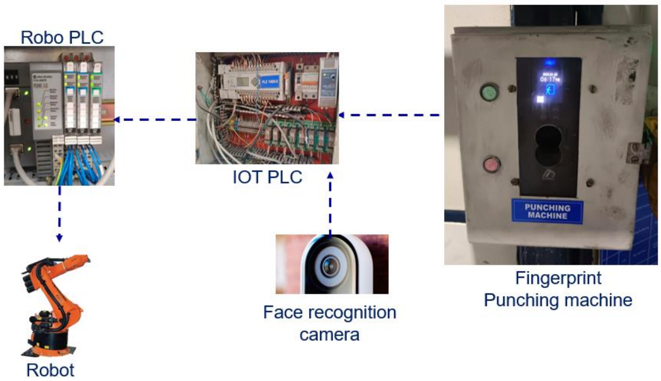

Fig 7. Operator competency and authentication

3.2 Machine(Preventive maintanance)

Achieving the intended output requires the use of machinery like gauges, fixtures, and robots. In order to guarantee that there is no downtime during the operation, the welding line of chassis will have all process and facility variables, including air/gas pressure for the line, fixture clamping, robot spares (Contact tip, Path accuracy, Nozzle replacement, Nozzle clean), gauge and fixture calibration, and others, shall be interlocked via the internet throughout the production facility.

3.2.1 Process parameters/air/gas line monitoring:

To achieve the desireed welding strength at each joint of chassis, the right optmized process parameters plays a key role. The adherence to process parameters shall be monitored by connecting the robots to the IOT PLCs & cloud to take out all the cirtical process paramreters from robot in real time with traceability. The right rigidity of parts or sub assy is ensured by right fixturing with proper clampings. Clamping with pneumatic cylinders are essentiasl and controlled by reed switch signals & the same will be interlocked with IOT. Fig. 8 gives an eloborate architecture on the same.

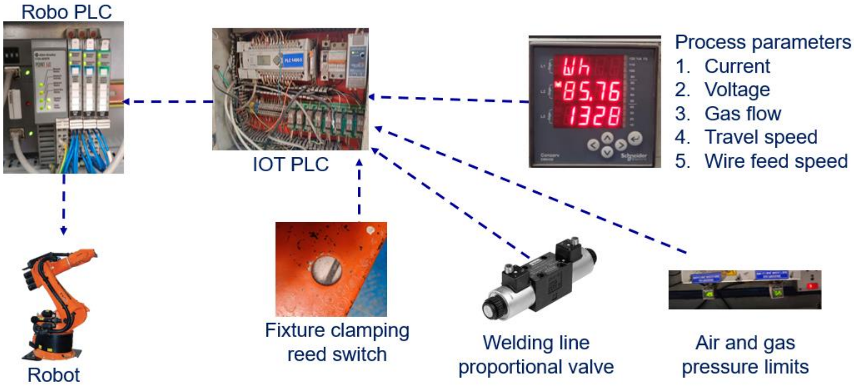

Fig 8. Process monitoring in welding with IOT

3.2.2 Process parameters/air/gas line monitoring:

The primary automated component that welds throughout the process is the robot, and consistent welding output depends on all robots being healthy. The robo arm's contact tip needs to be replaced after a specified number of operating cycles since failure to do so can result in wire stick-up and weld problems like porosity and uneven weld. The portion that allows the shielding gas to be pumped to the welding region is called the nozzle. Heavy, repetitive welding causes the nozzles to gather spatters over time; therefore, cleaning cycles at a specific frequency are necessary. Even though the robots have a high degree of accuracy when welding, the path accuracy will eventually depart from what should be within 0.2mm. The fixtures and gauges need to be calibrated (Eg. Monthly once)/maintained (everyday) with certain time frequency to ensure the quality. To address all these requirements IOT shall be an great solution as indicated in the architecture Fig 9.

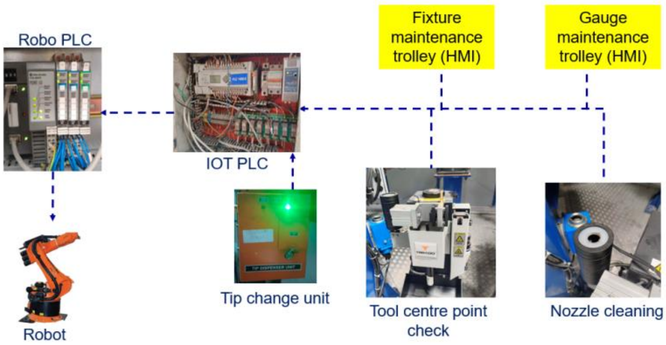

Fig 9. Facility maintenance and replacement with IOT

As the Fig. 9 clearly indicated that all the spare replacement and maintenance related to robots, fixtures and gauges are connected to IOT PLC via sensors with fixed interlocks. Once all the intended maintenance/replacements are being done then the sensor signal goes to IOT PLC, and it gives signal to robot to start the operation.

3.3 Method

Real-time welding process monitoring must be implemented, as shown in Figure 8. The welding line will be designed with a specific capacity with cycle time/piece. Arc on time, air cut time, and welding time make up a robot's cycle time. In these kinds of situations, raising any of the robo's time components will significantly reduce the output's quality amidst of boosting output volume. With the aid of IOT, the intended cycle periods are constantly watched over and interlocked with an escalation mechanism to guarantee consistency. The entire management of the firm will be notified by mail or SMS if there is any deviation from the scheduled cycle time so that appropriate measures or corrections may be taken.

3.4 Material handling

The joint preparation of the materials that are going to fuse together is what primarily determines the quality of metal inert gas welding. Thus, it's critical to keep the welding line's material and handling proper. Another problem in the contemporary just-in-time manufacturing environment is inventory. To satisfy customer needs, child component inventory control is crucial for the fabrication industries. Here, the arriving child component receipts quantities are automatically sent to the IOT cloud, which manages the entire welding line, and saved in the local IOT PLC. In order to guarantee that there is adequate inventory, the store's alerting system and primary storage count are automatically adjusted for each child part deduction in line.

3.5 Measurements/Quality

A variable or attribute method of inspection is used to assess the output product in the fabrication operations. Since welding involves fusion and constitutes a greater variable than other production processes, 100% attribute gauging is carried out to assure the quality of the final product. In order to guarantee the quality of the item, calibration of all facility-related devices and gauges is crucial. The manual nature of the quality checks used currently causes significant disagreements over measurements and manual reports. Therefore, as seen in Fig. 10, IOT permits the employment of robotic inspection using a laser sensor installed on a robotic arm in order to enhance the part output quality.

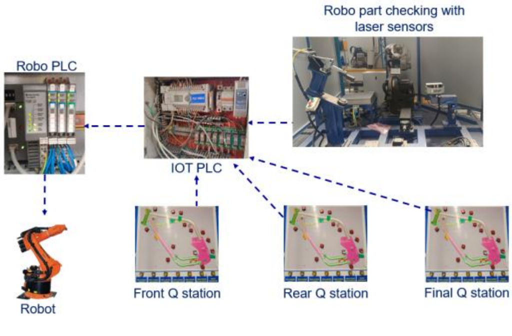

Fig 10. Quality inspection and Robo part check with IOT

In order to prevent defects from advancing to the next stage, the frame line welding method uses stage gates and in-process inspections. Quality inspectors visually evaluate the front, rear, and final components of the chassis; the weld flaws are put into push-button dashboards and forwarded to the IOT cloud for recurrence prevention. In this particular scenario, real-time machine-to-machine (M2M) communication will be implemented to facilitate automatic machine-to-machine communication. For instance, the IOT PLC signals the specific stage robot to stop or warn if any of the flaws are entered consecutively more than three times. In robotic part presence checking, if a part is missed 2 times consecutively in the inspection sequence, then the PLC sends a signal to the corresponding stage and stops the same for correction.

4 Future directions for fabrication IOT

The current IOT adoption rate in the fabrication industry has the potential to boost business in the Indian market. However, a clear step toward integrating AI and sophisticated predictive/preventive modeling with the aid of machine learning technology is required to grow the organization. The framework in Fig. 11 will offer a detailed architecture to improve data gathering, modeling, and parameter predictions, taking IOT to the next level. As previously mentioned, data gathered from robots, gas lines, airplanes, human workers, and inspectors will be processed in the cloud; as a result, real-time line performance visualization will be observed. The performance trend will be tracked using Power BI and advanced analytics to improve decision-making and identify the underlying causes in the workplace. In order to evaluate business performance more pro-actively, industries are now utilizing machine learning. Python, MATLAB, and other programming languages are being used to model the data using machine learning approaches [26]. This allows the model to estimate and predict line performance in terms of delivery, robot, fixture, and gauge maintenance, as well as quality problems [27]. The facility monitors worker skill levels, fixture calibrations, gauge and measuring instrument calibrations, robot health, and process parameters. Based on historical data and the aforementioned input monitoring, the amount of performance deviation is predicted.

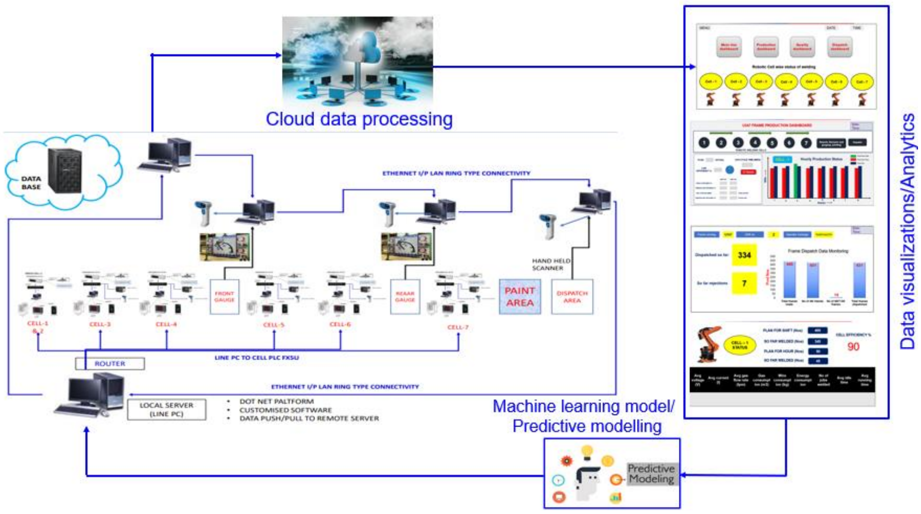

Fig 11. IOT Architecture and cloud system

5 Conclusion

The paper has focused on the evaluation of current manufacturing practices in two wheeler chassis welding and its demerits in terms of system and process deficiencies. Use of data analystics and real time clud storage and retrval is explored and the benefit mapping in terms of process and detection monitoring is detiailed with reference to productivity, quality and maintanance. Advacned traceability is proposed with data storage in case of reverse mapping as well. The implementation of the this technology in the fabrication industry calls for complete acceptance and involvement from various stakeholders including OEMs, solution provider and fabrication suppliers expecially.

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