Internship Report
Mahindra & Mahindra Chakan Manufacturing Plant

Summary of Internship

During my internship at the Mahindra & Mahindra Chakan Plant, I gained practical insight into modern automobile manufacturing driven by Industry 4.0, lean systems, and AI integration. I saw how sensors, robotics, and digital tools enhance efficiency and boost productivity across key stages—from the press shop to painting, engine assembly, and final assembly. Lean practices like pull-based systems and single-piece flow minimized waste and streamlined operations. AI was used to predict breakdowns, reduce engine testing, and optimize energy use, all contributing to higher uptime and output. This experience deepened my understanding of how smart technologies are reshaping car manufacturing to be faster, smarter, and more productive.

Summary

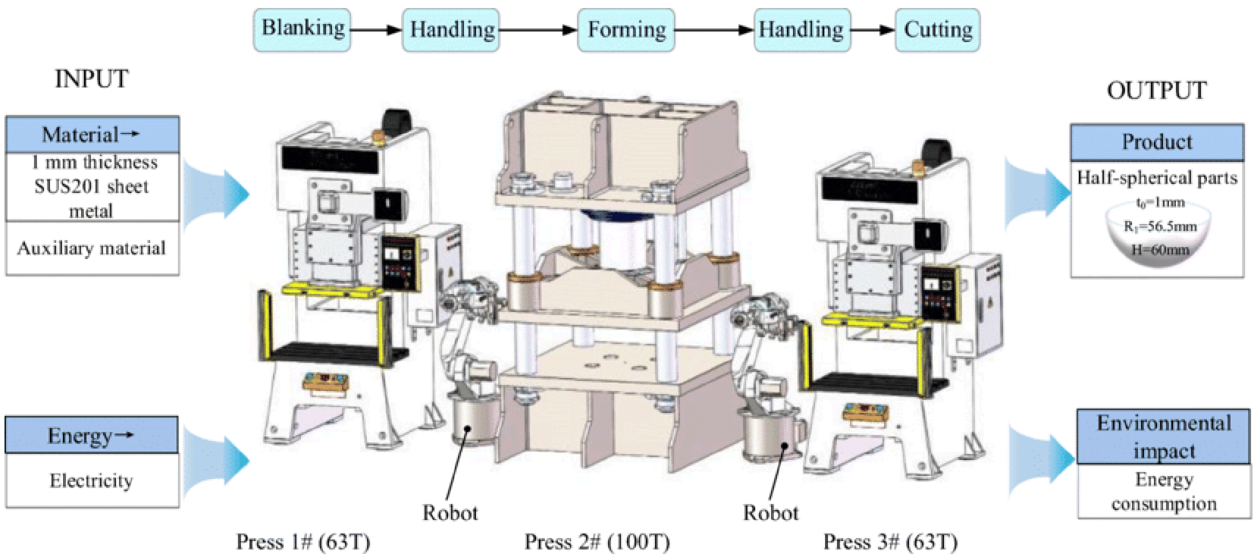
Shop	Key Learnings
Press Shop	• Learned how large metal sheets are transformed into vehicle body parts. • Observed high-tonnage pressing machines in action and how dies are used. • Understood importance of safety systems and machine precision.
EV Body Shop	• Gained insight into robotic welding of car underbodies and side panels. • Understood use of cameras and jigs for alignment and panel gap accuracy. • Learned how manual interventions are done in hard-to-reach areas. • Observed final inspection procedures for body quality and alignment.
Paint Shop	• Understood the full automated painting process: pretreatment, primer, base coat, and clear coat. • Learned about robotic paint switching and solvent cleaning. • Observed quality checks using special lighting and polishing techniques. • Noted how environmental factors (temperature, humidity) affect paint quality.
EV TCF	• Saw step-by-step EV assembly from

	wiring harnesses to dashboards and axles. ● Understood how robots assist in sealing, placing windshields, and fitting wheels. ● Observed axle and battery preparation and their integration into the chassis. ● Learned about quality checks and software loading before delivery.
Truck TCF	● Observed full truck assembly in three stages: trim, chassis, and final. ● Understood installation of cab interiors, bumpers, fuel tanks, and axles. ● Learned about the use of robotic monorails and hydraulic machines. ● Note how the engine is integrated into the truck frame.
Aggregate Shop	● Learned about engine and transmission assembly from base components. ● Observed leak detection tests using vacuum and high-pressure air. ● Understood use of cameras and servo robots for precise gear placement. ● Gained awareness of hot vs cold testing and its sustainability implications.

Press Shop

The Use of Robotics and Automation

The Press Shop at Mahindra & Mahindra's Chakan Plant plays a foundational role in automotive manufacturing, where large metal sheets are transformed into key body components like doors, hoods, roofs, and fenders. Robotics and automation are deeply embedded in this process, enhancing precision, consistency, and safety. Robotic arms equipped with vacuum suction or magnetic grippers handle heavy sheet metal with minimal deformation risk. These robots work in synchrony to lift, place, and transfer parts between pressing stations, maintaining orientation and reducing chances of damage.



Programmable Logic Controllers (PLCs) and sensor-guided alignment systems ensure metal sheets are accurately positioned and pressed. These systems automate the feeding and extraction processes, minimizing human error and reducing manual intervention. Servo-driven press machines are programmed to apply variable amounts of pressure depending on the complexity of the part, whether it involves blanking, deep drawing, or trimming. These adjustments are made in real time, ensuring each press cycle meets dimensional standards.

Automation also helps with quick and consistent die changes through automated die-handling systems, enabling smooth transitions between part types and reducing machine downtime. Inline quality control is further managed by high-resolution cameras and laser scanners that scan each part after stamping. These vision systems detect dimensional inaccuracies or surface defects, ensuring that any flawed components are flagged and removed before moving down the line.

Productivity and Efficiency

Automation in the Press Shop has significantly improved productivity and operational efficiency. The synchronized operation of robotic arms and PLC-controlled presses ensures a seamless and continuous workflow, reducing cycle time between stamping operations. Robots not only reduce the need for manual labor but also ensure consistent part handling, improving throughput without sacrificing quality.

Real-time monitoring systems collect data on pressure, alignment, material flow, and die wear. This data is analyzed using machine learning to support predictive maintenance, reducing unplanned downtime. By anticipating wear and tear, the system schedules maintenance during non-peak hours, minimizing disruption to production. As a result, machine availability improves, and costly breakdowns are avoided.

The shop layout further contributes to efficiency by enabling a streamlined flow of materials. Raw metal enters at one end and moves through a linear or U-shaped series of operations, minimizing unnecessary handling. Automated conveyors and part elevators move components between stages without delay. With lean manufacturing principles in place, waste is minimized, and work-in-progress inventory is kept low. This efficient flow supports higher output, shorter production times, and reduced operational costs.

Safety measures integrated into automation also indirectly enhance productivity. Robots work in enclosed cells with protective barriers, interlocks, and emergency stop systems, reducing the likelihood of accidents. Fewer interruptions due to safety issues mean the line can run longer and more smoothly, supporting overall production goals.

Industry 4.0

The Press Shop is a core contributor to Mahindra & Mahindra's Industry 4.0 initiatives. The integration of IIoT (Industrial Internet of Things) technologies, robotics, and data-driven systems has created a smart manufacturing environment where human intervention is minimized, and real-time decisions drive production.

All machines, sensors, and vision systems in the shop feed data into a centralized cloud-based digital twin. This digital twin allows plant engineers and managers to monitor machine performance, production metrics, and quality indicators in real time. It also enables simulations for layout optimization, workflow adjustments, and maintenance planning. The ability to visualize and manipulate digital replicas of the press line makes continuous improvement more strategic and effective.

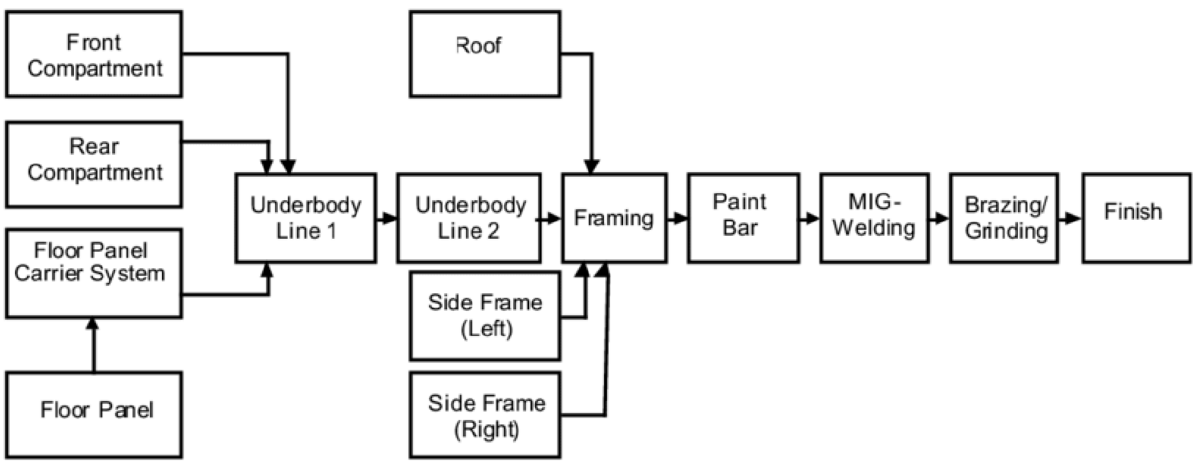
Moreover, the predictive maintenance approach enabled by AI analysis of sensor data reduces the Mean Time to Repair (MTTR) and extends equipment lifespan. This supports a longer-term goal of creating a sustainable and reliable production ecosystem. Automation also contributes to environmentally friendly practices by reducing energy consumption and material waste. For example, optimized stamping parameters and automated lubrication systems prevent overuse of materials and resources.

In this context, robotics and automation are not merely tools but pillars of a larger smart ecosystem. By enabling faster decision-making, reducing human error, and supporting sustainability, they elevate the Press Shop from a traditional stamping facility to an intelligent, data-driven production hub. The results are not only visible in the quality of the parts produced but also in the adaptability, responsiveness, and competitiveness of the plant as a whole.

Body Shop

The Use of Robotics and Automation

The EV Body Shop at Mahindra & Mahindra's Chakan Plant plays a vital role in constructing the structural framework of electric vehicles using a highly automated, modular assembly process. The underbody of the vehicle is assembled in parts—the front compartment, front underbody, and rear underbody—which are joined using a mix of arc and spot welding. These operations are largely performed by robotic arms equipped with welding tools and advanced sensors. Operating within enclosed, safety-equipped cells, these robots follow pre-programmed paths with precision, ensuring consistent weld quality and structural integrity.



Jigs integrated with high-resolution cameras hold each component in place while vision systems assess alignment, panel gaps, and fitment accuracy. This feedback is processed in real time by machine vision software, allowing robotic arms to make micro-adjustments before welding begins. This ensures precision in every weld and reduces the need for post-weld corrections. In sections where robotic arms cannot access due to complex geometries, skilled operators step in using guided manual tools, exemplifying a hybrid approach that balances automation with human adaptability.

Material handling is also extensively automated. Overhead conveyors, robotic lifters, and Automated Guided Vehicles (AGVs) manage the movement of components between stations. This reduces manual handling and improves the speed and consistency of part transfers. All movement and coordination are overseen by a central Manufacturing Execution System (MES), which keeps the production line synchronized and reduces bottlenecks.

Productivity and Efficiency

Robotics and automation have had a significant impact on productivity within the EV Body Shop. By reducing human involvement in repetitive and precision-based tasks like welding and part handling, automation ensures consistent quality and accelerates the assembly process. Robots operate continuously with minimal fatigue, maintaining high output rates. Welding quality is also elevated, with robots executing every weld to precise specifications, reducing rework and wastage.

The use of automated jigs and in-line vision systems has streamlined the quality assurance process. Defects can be detected and corrected early, minimizing delays and avoiding costly downstream repairs. Automated handling systems keep the workflow steady, while MES-driven coordination allows for efficient job sequencing and quick responses to any production irregularities.

Additionally, by combining robotics with smart inspection systems, the shop has moved closer to a zero-defect manufacturing approach. This leads to higher first-pass yield, reducing time and cost spent on corrections. The ergonomic benefits of automation also translate into reduced strain and fatigue for human operators, further enhancing productivity through safer and more comfortable working conditions.

Industry 4.0

The EV Body Shop is a key player in Mahindra & Mahindra's Industry 4.0 strategy. All robotic operations, vision systems, and part movement data are fed into the plant's digital twin—a virtual model of the manufacturing process. This allows engineers to simulate different production scenarios, identify inefficiencies, and test modifications without disrupting live operations.

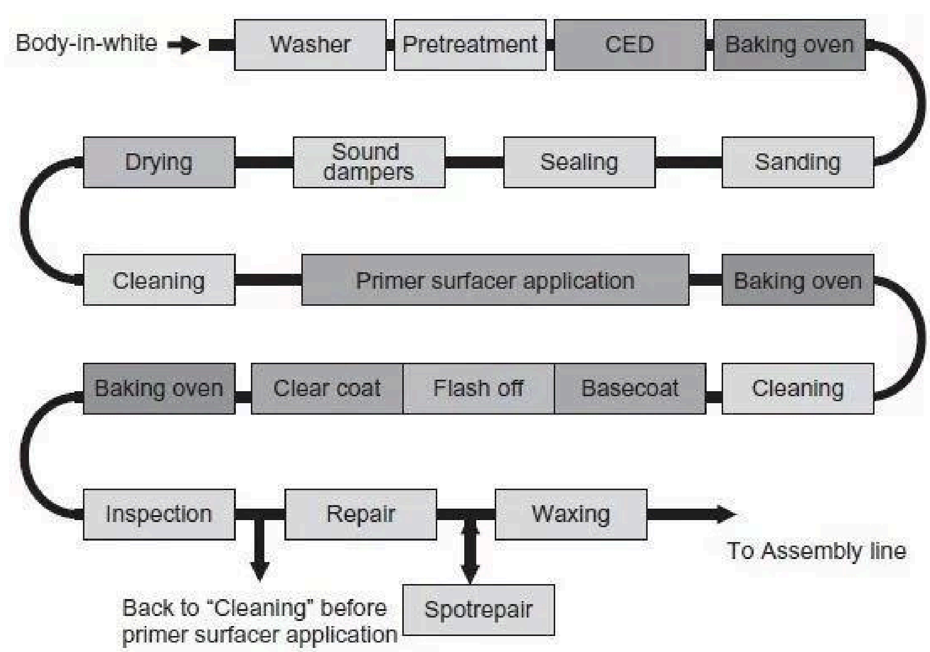
The shop's use of IIoT-enabled systems ensures real-time visibility into robot performance, quality metrics, and material flow. This data is continuously analyzed to support predictive maintenance and process optimization. For example, data from welding robots can highlight wear in tools or alignment drift, prompting preemptive adjustments to maintain quality.

By integrating smart systems with physical operations, the EV Body Shop contributes to a more agile, responsive, and data-driven production model. Automation isn't just improving speed—it's enabling a higher level of control, adaptability, and continuous improvement. Safety systems, including interlocks, light curtains, and automated shutdown protocols, further align the shop with Industry 4.0's emphasis on smart, safe, and efficient operations.

Paint Shop

The Use of Robotics and Automation

The Paint Shop at Mahindra & Mahindra's Chakan Plant is a technologically advanced area designed to enhance vehicle appearance, protect against corrosion, and ensure long-term durability. It uses a series of automated and robotic systems to carry out complex painting and coating processes with precision. From surface preparation to final inspection, robotics plays a vital role in delivering consistent and high-quality results.



The painting process begins with Pretreatment (PT), where the car body undergoes cleaning and chemical coating. Using Cathodic Electro Deposition (CED), the body is submerged and rotated to apply a uniform anti-corrosive layer. This fully automated step ensures complete surface coverage, including hard-to-reach areas. After PT, the car enters an oven for curing, solidifying the corrosion-resistant base.

Following PT, robotic arms apply sealants to small panel gaps and underbody areas. These robots use precision nozzles, including ultra-fine 2.5 mm nozzles, to ensure accurate placement, especially in tight or complex spaces. A layer of Polyvinyl Chloride (PVC) is also applied to the underbody to guard against road debris and moisture.

In the painting booth, robotic arms with multi-axis mobility apply primer, base coat (color), and clear coat. These robots are programmed to paint every surface evenly, adapting to the contours of the vehicle. One of the most advanced features is their ability to switch between different paint colors rapidly. Each arm houses multiple paint lines and a solvent system that flushes out previous colors in under five seconds, enabling seamless transitions without halting the production line.

The final inspection is also supported by automation. After painting, vehicles pass through a lighting tunnel where trained inspectors, supported by tools, check for paint defects. If needed, polishing robots or manual stations correct minor imperfections before the vehicle proceeds to final assembly.

Productivity and Efficiency

Automation significantly boosts productivity and throughput in the Paint Shop. By minimizing human intervention in repetitive and precision-demanding tasks, robots maintain a continuous workflow and ensure consistent application quality. Each stage—from CED coating and sealant application to final paint—is completed with minimal downtime.

The rapid paint color change system is a key driver of efficiency. Traditional color changes require extensive flushing and time, but Mahindra’s robots clean and reload colors in seconds. This reduces wait times and allows for greater flexibility in production scheduling.

The ability to handle diverse paint jobs on back-to-back vehicles improves line efficiency and meets varied customer demands without slowing operations.

Automated cleaning systems, such as the use of ostrich feather rollers to remove dust before painting, further protect against defects that would otherwise require rework. These rollers rely on static properties to attract dust, ensuring the car's surface is spotless before paint application.

The use of inline curing ovens after each coating phase ensures rapid and consistent drying. This not only shortens the process cycle but also improves paint adhesion and durability. Robots also help reduce material waste by applying exact quantities of sealants and paints, optimizing resource usage while ensuring uniform protection and finish.

Quality control is enhanced through integrated inspection points and automated alerts. Any deviation in coating thickness, surface finish, or curing temperature triggers immediate corrective actions. The reduced rate of rework, along with optimized material flow and scheduling, helps the Paint Shop maintain high output with lower operational costs.

Industry 4.0

The Paint Shop is a key node in Mahindra & Mahindra's Industry 4.0 ecosystem. Automation is not limited to physical operations; it is deeply connected to the plant's digital infrastructure. Data from every stage of the painting process is collected and fed into a centralized digital twin—a real-time virtual model of the Paint Shop.

Each robot's cycle time, paint thickness, sealant volume, oven temperature, and inspection outcome are monitored and analyzed. This data supports predictive maintenance by identifying trends that indicate equipment wear or process drift. For example, if a robotic arm starts taking longer to complete a spray cycle or produces uneven coats, alerts are triggered for inspection before a failure occurs.

Environmental controls, including humidity and temperature, are also automated and tracked through IIoT systems. Maintaining these parameters is critical for paint quality, and the system dynamically adjusts them to maintain optimal conditions. These smart systems contribute to a zero-defect, energy-efficient, and sustainable manufacturing process.

Sustainability is further reinforced through the use of water-based paints and low-VOC solvents, as well as air purification systems that treat exhaust fumes before release. Closed-loop solvent cleaning reduces chemical use, while precise robotic application minimizes overspray and material loss.

EV TCF

The Use of Robotics and Automation

The EV TCF (Trim, Chassis, Final) Shop at Mahindra & Mahindra's Chakan Plant integrates multiple stages of electric vehicle assembly with the strategic use of robotics and automation. From the moment the painted body enters the shop, automation takes over key operations to enhance precision and reduce human fatigue. Initially, a robotic hanger removes the car doors and places the vehicle onto a conveyor. Robot-assisted tools support human operators in installing critical systems like the main wiring harness and dashboard, where pneumatic robotic arms offer stability and alignment.

Windshield installation is a fully automated process. A robot applies sealant, while two vision-enabled robots measure the exact fit of the front and rear openings. Based on this input, two more robots accurately position and install the glass, ensuring airtight and watertight seals. Reattachment of the pre-trimmed doors is also handled by robotic systems.

Seats and interior trims are added next, with pneumatic robot arms assisting workers in lifting and placing heavy components accurately. Simultaneously, the front and rear axles and battery are assembled elsewhere, with cameras inspecting each axle against a digital reference model to ensure alignment and completeness. Once verified, these components are transported via automated rail to the assembly station beneath the suspended car body. Hydraulic lifts hold them in place while four robots torque and secure them, completing the drivetrain installation.

Further down the line, robotic hangers move the vehicle to the final trim line where wheels are installed and software systems are loaded. Diagnostic systems confirm correct installation and functionality. Automation ensures precision in each step, minimizing errors and enabling the seamless integration of mechanical, electrical, and electronic systems.

Productivity and Efficiency

Automation at the EV TCF Shop has directly contributed to improved productivity, reduced cycle times, and higher assembly accuracy. The ability of robots to perform repetitive and complex tasks such as windshield fitting, torqueing, and material handling has significantly decreased the physical burden on workers while increasing consistency in assembly.

By dividing tasks across four specialized lines, the shop allows parallel operations. For example, while the body is being fitted with internal systems, axles and battery modules are being prepared in another area. This modular workflow ensures continuous movement and minimizes bottlenecks. Robot-assisted reinstallation of doors and automated part transport reduces idle time and boosts overall line efficiency.

The ergonomic design of robot-human collaborative stations further improves productivity by enhancing worker comfort and reducing injuries. Robots maintain a steady pace and can operate around the clock, contributing to higher output without compromising quality. Advanced inspection systems integrated into each station catch defects early, reducing rework and maintaining a high first-pass yield.

Fast, accurate installation of critical systems such as dashboards, seats, and powertrain elements is achieved through servo-controlled tools and robot-guided lifting devices. These technologies ensure optimal positioning and fastening, reducing assembly errors and ensuring structural integrity.

Industry 4.0

The EV TCF Shop is a flagship example of Industry 4.0 in action. Central to this is the digital twin system, which captures real-time data from all robots, vision systems, and assembly stations. Each task—from sealant application and torque values to software uploads—is logged and monitored to ensure compliance and efficiency.

This integration allows predictive maintenance, where trends in sensor data forecast potential failures before they happen. For instance, anomalies in torque values or robot cycle time can trigger alerts, prompting checks and preventive interventions. The system also adjusts line speeds based on task completion, balancing workloads and avoiding bottlenecks.

The Manufacturing Execution System (MES) connects all elements of the EV TCF process, providing visibility into every part's location and status. This synchronization supports real-time decision-making, efficient job sequencing, and agile response to any disruptions.

Vision systems used for axle inspection and glass alignment are part of a broader effort toward zero-defect manufacturing.

The shop's automation strategy also contributes to sustainability goals. Cold testing methods for powertrain integration reduce energy consumption compared to traditional hot testing. Automated application of sealants and precise part placement minimize material waste. Data analytics further optimize the use of tools and resources.

Aggregate

The Use of Robotics and Automation

The Aggregate Shop at Mahindra & Mahindra's Chakan Plant is responsible for manufacturing some of the most critical components of a vehicle, including the engine, drivetrain, and transmission systems. The shop combines mechanical engineering precision with extensive robotics and automation to build these components to exacting standards. Robotic arms are used to carry out high-precision tasks such as piston alignment, gear installation, and torqueing of bolts. These robots are guided by laser and camera systems to ensure that every part is installed with micrometre accuracy.

In engine assembly, robots assist in inserting cylinder liners and honing the bores, ensuring dimensional accuracy. Cameras and laser-guided sensors confirm piston ring installation, preventing incomplete assemblies from moving forward. Torque-controlled tools, often robotic, are used to fasten the cylinder head with a uniform clamping force. Leak testing using high-pressure air and vacuum methods is automated, allowing for consistent and reliable detection of faults.

In the transmission section, the input and counter shafts are assembled using servo-powered robots that press gears into position with pre-set gaps. Cameras at each station monitor the alignment, ensuring each gear is placed with high accuracy. Synchronizer hubs, sleeves, and selector mechanisms are fitted robotically, while automated systems handle oil filling and sealing. Collaborative robots (cobots) operate safely alongside human workers in shared spaces, pausing or adjusting movement when human presence is detected.

These robotic systems reduce manual intervention in physically demanding and repetitive tasks, thereby enhancing safety and precision across the shop floor. By integrating vision systems, servo motors, and real-time feedback loops, the Aggregate Shop ensures that every operation—from part placement to quality inspection—is executed with speed and reliability.

Productivity and Efficiency

Automation in the Aggregate Shop has significantly improved productivity by reducing cycle times and minimizing human error. Robots handle repetitive and time-intensive processes such as torquing bolts and aligning gears, ensuring consistent execution across all units. Automated inspection systems identify misalignments and anomalies early, reducing the need for rework and maintaining a high first-pass yield.

Parallel operations in engine and transmission assembly enhance throughput. For example, while an engine is being built on one line, its matching transmission can be assembled simultaneously on another. Once both components are complete, they are merged into a single powertrain unit with robotic precision. This modular workflow increases line flexibility and ensures continuous production without bottlenecks.

The use of automated test systems for air and vacuum leak detection enables non-destructive, reliable quality checks during assembly. These cold tests replace traditional hot testing methods, which are energy-intensive and less environmentally sustainable. By shifting to cold testing, Mahindra & Mahindra not only maintains quality but also reduces resource consumption and emissions.

Robotic assistance also improves worker ergonomics, particularly in lifting heavy parts like seat structures or gear assemblies. Ergonomically designed workstations combined with robotic support reduce operator fatigue and workplace injuries. This balance between human oversight and machine precision boosts overall productivity and workplace efficiency.

Industry 4.0

The Aggregate Shop operates under a digital twin framework, where real-time data from every step of the manufacturing process is collected and fed into a cloud-based simulation model. This digital twin mirrors live production, enabling engineers to monitor trends, test new configurations, and predict future performance without interrupting the actual assembly line.

Sensors embedded throughout the shop capture data on torque levels, alignment, pressure, leak detection, and robot cycle times. This data is analyzed using AI-powered systems to identify anomalies and predict equipment wear. Predictive maintenance minimizes unexpected breakdowns and reduces mean time to repair (MTTR), thereby ensuring smoother operations.

The shop's data-driven approach also supports continuous improvement. Insights from the digital twin allow adjustments in robot programming, process flow, and material handling strategies to optimize output and minimize downtime. Integration with the Manufacturing Execution System (MES) provides visibility into production stages, part locations, and cycle time variations, enabling real-time decision-making.

Environmental sustainability is another benefit of Industry 4.0 adoption. Automated lubrication systems and optimized sealing processes reduce material wastage. Closed-loop testing and data-driven part validation improve energy use and reduce emissions. The cold testing approach is a direct result of sustainability-driven analytics and process redesign.

In essence, the Aggregate Shop is a fully connected, intelligent manufacturing environment where physical processes and digital technologies operate in harmony. Robotics, real-time monitoring, and predictive analytics together create a production ecosystem that is not only more efficient and accurate but also future-ready.

Conclusion

My internship at the Mahindra & Mahindra Chakan Plant offered a firsthand look into the workings of a automobile manufacturing facility deeply aligned with Industry 4.0 principles. Through exposure to the Press Shop, Body Shop, Paint Shop, EV TCF, and Aggregate Shop, I witnessed how automation, robotics, data analytics, and lean manufacturing practices combine to create a highly efficient and technologically advanced production environment.

The consistent theme across every department was the strategic integration of robotics to handle repetitive, high-precision tasks such as welding, painting, torqueing, sealant application, material movement, and component testing. These systems not only reduced manual effort but also increased accuracy, consistency, and production speed. The use of vision systems, servo motors, pneumatic robotic arms, and collaborative robots ensured quality while maintaining worker safety.

Automation played a critical role in boosting productivity. By reducing human error, streamlining operations, and maintaining workflow, each shop achieved higher throughput with fewer bottlenecks. For example, color-switching in the Paint Shop or simultaneous engine and transmission assembly in the Aggregate Shop demonstrated how advanced planning and system coordination could support flexibility without sacrificing efficiency.

Equally impressive was the use of Industry 4.0 technologies like digital twins, real-time monitoring, predictive maintenance, and data-driven decision-making. The ability to capture data from every step of the process—whether it was robot cycle times, part inspection metrics, or test outcomes—and use it to simulate, analyze, and optimize production reflected the plant's strong commitment to continuous improvement.

Sustainability was embedded throughout the facility, with practices such as cold testing, optimized resource usage, low-VOC paints, and energy-efficient operations contributing to environmentally conscious manufacturing. The focus on ergonomics, safety interlocks, and collaborative automation further reflected a forward-thinking approach to workforce welfare and operational excellence.

Overall, this internship has deepened my understanding of how future-ready manufacturing plants operate—merging precision engineering with smart technologies to deliver high-quality, sustainable vehicles. It reinforced the importance of automation not just in reducing costs or increasing speed, but in enabling a smarter, safer, and more adaptable industrial environment. This experience has been instrumental in shaping my perspective on the evolving role of technology in modern industry and has inspired me to explore further how innovation drives real-world impact in manufacturing.