Dynamic Automobile Assembly Process using IOT

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Abstract: In the wake of #AtmanirbharBharat and #MakeInIndia planks, there is a huge thrust to Manufacturing. This paper focuses on the Automobile Manufacturing process, enabling a customizable product, vis-a-vis a rigid Manufacturing process developed as per Industry 4.0 principles aided by IOT (Internet of Things) tools. The solution proposes to modularize entire Automobile Production/ Assembly Process, which simulates the whole process of the delivery to every customer through to the Manufacturer facilitates highly customized products based on dynamic user choices.

Seamless integration of Networked Production Components is realized by building interfaces between existing ERP systems and MES (Manufacturing Execution Systems). The system adopts M3 - Modular Manufacturing Mode, via Wireless Networks for Industrial Automation - Factory Automation (WIA-FA) and Dynamic Control System, to Manufacture and Maintain Automobile Products at Scale. Proposed approach also improved Production Equipment utilization. Another aspect of this approach is flexibility of the Production/ Assembly Processes to enable high customization in product specification.

Keywords: Internet of Things, Modular Manufacturing, ERP Systems, MES (Manufacturing Execution Systems, Industry 4.0

1. Introduction

The Indian Manufacturing Sector is at a fulcrum of establishing itself as a Manufacturing Hub for the entire world. With the concept of German Industry 4.0, has become an underlying blueprint and has formally become Nations #MakeInIndia Strategy. As a renewed approach Indian Manufacturing – Smart Manufacturing will provide necessary technical support for enhancing Made in India to Design in India and significantly enhance export potential and establish India as a leader in this space. India also has vast Engineering Talent and Skill to develop home grown IoT Models to enable the above strategies.

Observing Global trends in Manufacturing and other sectors as well as local demographic and labour cost scenarios, India has to adopt Intelligent Models into earlier Mass/ Large Scale Monolith Manufacturing Techniques, to stay ahead in the game or even to stay afloat. During the recent years there has been huge strides made by Engineers to up skill themselves into newer technology tools like Artificial Intelligence and Internet of Things (AI and IoT).

In the Automobile Sector too, things are very dynamic. There are newer models, functions and features being introduced to satisfy Customer demands. This needs to evolve a robust Manufacturing Strategy, which is Intelligent, more discrete and able to handle diverse products and make it economical too.

In order to address above mentioned situations, this paper proposes an Smart Manufacturing Solution based with underlying technology frameworks like “Internet of Things”. This system can meet the dynamic and diverse demands of Customers by Producing Discrete Products on a large scale. By introducing Data Standardization methods, an enhanced cycle times from Design to Production can also be achieved.

2. System Architecture

This paper proposes an Highly Adaptive Internet of Things based Manufacturing process for making Automobiles. Through this process, there will be an ERP backend, which is already a backbone of any Manufacturing Entity. Modules of ERP are integrated with IoT Components and Digital Platforms for Accepting Orders from Customers and also provide them an intuitive and customizable opportunity to self-design (select features) their Cars or any Automobiles.

Subsequently the orders will be tightly integrated with the system of manufacturers background ERP, where Purchase, Inventory, Materials management activities are optimally handled. Production plans and other relevant information of the Order will be sent to “Manufacturing Execution System” (MES). MES will further be interfaced with Workshop Control Systems… All these systems seamlessly interface at real-time and manufacture a dynamic Customer Specified Product.

This paper explores various aspects of Industrial Internet of Things (I-IOT) models, and build much of the customization via Software defined Management and Control Processes.

The paper also Suggests necessary Hardware and Software to build such a system to manufacture Specific Customer Orders are. Seamless Integration of Networked Production Processes is enabled by building Communication Interfaces between eCommerce (Cloud Platform), ERP (Enterprise Software), MES and other entities, to successfully manufacture designed products.

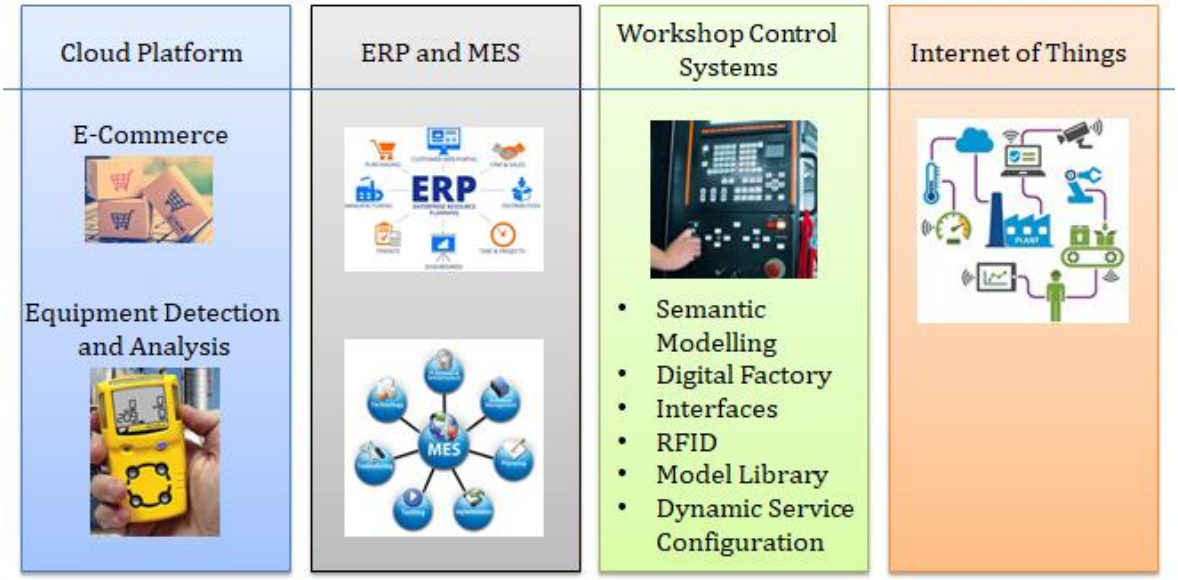

Fig 1: Manufacturing Process over Industrial IoT Architecture

Key aspect of this approach is the Workshop Control Systems module, which will enable dynamic reconfiguration as demanded by customer needs. These reconfigurable components are software based, hence a slew of such software blocks can be stored in Model Library for quick deployments.

This approach makes the Production System highly flexible and shuns rigid methods of the past. Fully delivers the benefits of Highly Modularized, Self Reconfigurable nature of Production Line itself. Also enables better Predictive Maintenance of Production Equipment and other aspects of Production/ Assembly Floor management.

Nuts and Bolts of the Framework with Operating Principles

There is an entire restructuring of the Production/ Assembly floor, which will enable producing highly personalized products. The main restructuring is in breaking down of a more monolith production line into a highly modularized line. There are various machinery/ modules/ equipment, which are associated with each of these modules and the same are stashed in a staging area and the same are called in based on various customizations defined in the order. Due to this Fault Diagnosis and Maintenance becomes easier. The Modular Production/ Assembly Framework combine use of a library of Industrial Controlling Semantic Ontology. These aspects reduce the downtime of Production/ Assembly Line and improves the efficiency [15]

The entire Production/ Assembly Floor is modularized, to the extent as to allowable customization of the final output, which is an automobile itself. By highly modularizing the components of Production floor, it has enabled to quickly build in the customizations as well as lets the control of every aspect of Production floor more centrally and that way a better output is achieved.

This highly modularized Manufacturing Framework with various plug and play components, including machinery. As part of this paper; we are exploring this Framework through following modules, the same is illustrated in Figure 2.

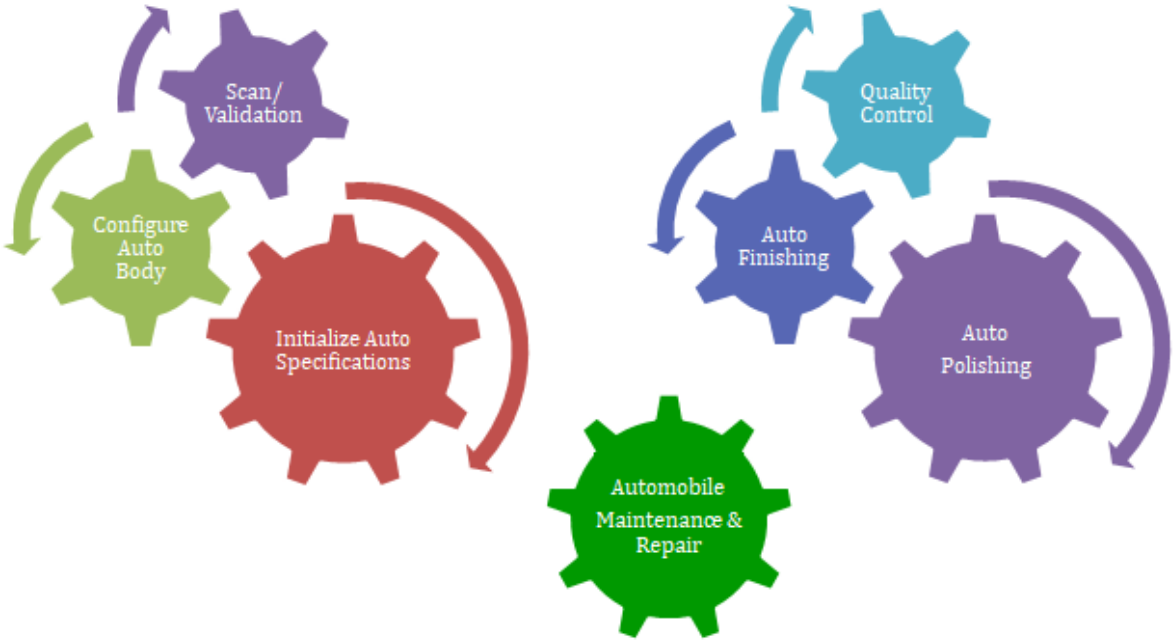

Fig 2. Aspects of Smart Production/ Assembly Floor

Initialize Auto Specification

In a custom (specific) order scenario too, the chassis remains same for a particular model of the automobile, so the process of building the car starts with fetching the chassis from the store. Then as per order specifications, which are received from eCommerce Platform, the entire order details is communicated via a code, which has all the details.

Upon the receipt of this order, pallet tray, will position the chassis into the production/ assembly floor for further tasks/ activities, which are automated and keeps moving to the next work stations.

Configure Auto Body

Next stage after the Chassis is placed on the Production/ Assembly floor is assembling the body of the automobile. The elements of body are verified for the specicity in the order and the same is executed.

Scanning/ Validation

After the Assembly of a very custom automobile is complete, it comes to a station, where laser scanning is done to check for the size as well as if all the custom aspects are taken care. After this step, then the automobile moves to Sanding and Polishing stage based on the type of automobile.

Sanding and Polishing

Sanding happens in a very state of the art, multi-dimensional spraying machinery, which is robot controlled and as the automobile moves through this framework, the entire car gets sanding appropriately. This activity, achieves the desired finish.

Inspection and Auto Finishing

Another final validation happens for all the variables as far as the final output is concerned like, color, size, custom variations, etc.

Quality Control

This is the last stage in the Production/ Assembly Floor, after which the automobile is marked as complete and ready to be delivered to the Client/ Customer. There is a rigorous checklist of items to check if the automobile which is being put together is ok, from all the aspects of performance, safety as well as all the good to have things, some of which are specifically picked and chosen by the Customer himself.

Auto Maintenance and Repair

The process here in Auto Maintenance and Repair is different from a manufacturing process, but few of the modules from the library are invoked to address the Maintenance Request and attend to the suggested and identified repairs.

3. Enabling Strategies and Technologies

WIA-FA (Wireless networks for Industrial Automation - Factory Automation)

The proposed solution utilizes Wireless Communication Technology WIA-FA for Industrial Applications. WIA-FA is an International Standard for IEC Wireless Technology High-Speed Automatic Control Applications for the factory [16]. Through Industrial Wireless Communication Products, such as independently developed Industrial Wireless Router, Industrial Wireless Switches, all Internet Wireless Gateway based on the Management and Control of Industrial SDN, all these together provide a system of Industrial Internet of Things (IoT). This will also enable in Preventive Maintenance by monitoring Vibration and Temperature of Equipment.

Real-time collection of the information of Manufacturing Process at any time and realize Wireless and Modularization of High Availability and Highly Reliable Communication in Control Systems. This lays the foundation for Interconnection of Equipment, Production Information and Flexible Reconfiguration of Control Systems [14].

Software Enabled Control System

Semantic Modeling technologies are used to build a digital twin of the actual Production floor, with production equipment, sensors, Materials/ Inventory and other Physical Entities, mapped to what is actually present. Hence we have a Digital and Actual Production floor similar to each other. Another framework - Dynamic Service Composition Engine, the Manufacturing Processes and Production Tasks are integrated. Hence, Interoperable interface between different protocols, software's and systems is established which enables Information Integration across various systems [18].

Plus due to the unique Dynamic and Automatic Reorganization framework, any specific custom design specific to an order is accomplished quickly, which is completely different from the traditional rigid production methods.

MES, ERP

Any Manufacturing Establishment has traditional ERP and MES softwares. Based on Customers Personalized Product specifications, the order is manufactured through Plant Automation Modules of ERP systems including Inventory, Material Preparation, Production Planning and others. Production Order is passed on into the Workshop Management System (MES). Production Configuration Parameters are read through RFID scanned data. Full Integration of various Business domains from Customer Sales modules to the Enterprise Management Platform and Production Floor/ Assembly Floor Management is achieved.

Cloud Manufacturing Platform

eCommerce Platform is implemented to the Equipment Predictive Maintenance System which is part of the Cloud Manufacturing Platform. Customers can pick car model configurations on the ecommerce platform from the available provided options as per their choices, for example, color, attachments etc. Based on them, an Order is created for a personalized product and this initiates the process in Scheduling and Manufacturing of Systems. It also can perceive the health and Safety of Production Equipment, by monitoring Vibration and Temperature of Equipment.

4. System Function

Product Customization Function

Through eCommerce Platform, Customers build their custom product, by selecting various offered customizations.

Then Custom parameters are inputted into the

- MRE system and are in real time integrated with the EMS System for scheduling.
- Control Systems, through the RFID system,
- ERP Modules for Standard Enterprise entities like Products/ Materials

To combine all individual components and completes personalized products.

Real-Time Monitoring of the Production Schedule and Status as an end of the process, we have an output of a very custom specified Product, as intended by the Customer.

Re-Organization Function

Heart of the solution is how a standard Production System or Assembly line is made to reorganize for a customization.

There is a super monitor system, which is continuously viewing at the order pipeline and existing Production/ Assembly line, which is configured to take care of standard variant of the product. When a custom order comes onto the Production floor, this Monitoring System, will analyze the need of reorganizing the Production Line to cater to this specific order by adding certain reorganizing certain modules within it, which are always kept in the backup area… say, a certain custom fitment has to be made to the dashboard of the car, then, the standard module is replaced dynamically with a specific module, which will fulfill the custom need in the production line. Once this custom variant is completed, then the module is again removed and replaced with standard module… since the system is highly modularized and simple plug and play mode, this happens fast and enables handling custom variants, without hugely building bottlenecks in the Production floor.

For this kind of an operation of the system is hugely modularized at all possible places of offering customizations and also keeping all those modules in the backup area, while standard variant is deployed in the Production floor.

Predictive Maintenance Function

The concept of Predictive Maintenance is an old paradigm, however our proposed solution, integrates various aspects of the newer technologies, which have enabled us to measure and act on various aspects at real time, hence can address 'Predictivity' more meaningfully. Say, for example, various sensors as part of Industrial Internet of things, will be connected to various important machines or systems of Production floor, which can be temperature of the machine (is it within a tolerant level or beyond that), vibration, sound, speed, etc... all these measurements will be happening continuously and when an aberration is sensed, then arrangements are being made to review the upcoming problem and take a look at that. The same has been intimated through dashboards to the personnel, who are working on the production floor as well as maintenance personnel, who are responsible to keep the machines up and running all the time.

When that particular machine or system, with unexpected behavior, then Maintenance personnel, replace that with a well-functioning one and then take out the faulty one for maintenance. Then it is repaired and kept in backup for such deployments in future…

WIA-FA wireless communication technology, Historical Data of the System behavior in HANA cloud, predicts the fault and enables reduced downtime and improves productivity.

5. Conclusion

Intelligent Manufacturing Framework is developed on the Industrial Internet of Things, this can

- Quickly Scale up Manufacture of Custom/ Specific Products,
- Production Modules are built on a plug and play mode and dynamically enabled to integrate different modules
- Highly optimized to cater to ever growing Custom Orders with real-time changes to Production Floor/ Assembly.
- Gives more meaning to Predictive Maintenance of the equipment, hugely reduces downtime and increase Productivity.

New and State of the Art Technical Innovations help us build solutions for Intelligent Manufacturing that enables #AtmanirbharBharat initiative, which hugely accelerates Manufacturing Sector through Digital Transformation.

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