Dogo Rangsang Research Journal
ISSN : 2347-7180

UGC Care Group I Journal
Vol-10 Issue-07 No. 16 July 2020

Development of Application Domains of Industry4.0 for Light Motor Vehicle Engine Assembly System

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***Abstract*— An automobile is a wheeled vehicle that carries its own weight and transports from one destination to another. An automobile consists of around 15,000 parts for its sub-systems like engine, transmission, suspension, brake system, electrical systems and chassis and body. Light Motor Vehicle (LMV) Engine Assembly system combines assembling of various engine sub systems to enable the engine assembly to improve its life. In the present work an attempt has been made to consider the research issues and their solution strategies which highlight the influence of Industry 4.0 techniques on LMV engine assembly system. The application domains to the assembly system envisage modern approaches to the assembly systems. Several useful conclusions are arrived at.**

***Keywords*—Automobile, Light Motor Vehicle, Engine Assembly, Industry 4.0, Cyber Physical System**

1. INTRODUCTION

India is the sixth largest automobile manufacturer in the world. It creates large employment and utilizes emerging technologies continually. An automobile [1] is a self-propelled wheeled vehicle that transports passengers from one destination to another. The first self driven automobile powered by steam was invented by Nicolas Joseph Cugnot for locomotion in 18th century. Initially the vehicle powered by steam dominated the automobile industry. Commercial success of an automobiles started with the invention of internal combustion engines which fueled by diesel and gasoline. In 1885 AD, Karl Benz, the German Inventor built his first gasoline powered vehicle at Mannheim, Germany. The Benz Cars started Commercial production in 1888 AD. Panhard et Levassor of France was the first company to exclusively build and sell motor cars from 1889 AD.

The curved-dash Olds mobile is three-horse power machine was the first mass produced automobile and sold 5,000 units in the United States by 1904 AD. Within a interval of 10 years the Model T vehicle has achieved a milestone of world's first mass produced vehicle where one million units were sold by 1920.The two British car manufacturers namely William Morris and Herbert Austin were introduced new assembly line production methods in the automobile manufacturing history. The first compact car is the Austin Seven in the world. Later the engine had been mounted on the front of the vehicles which are manufactured by Morris. After 1970, the automotive industry have witness the growth only in tractors, commercial vehicles and scooters. Hindustan Motors Ltd. Hooghly produced the first car in India in 1949 AD. Establishment of Maruti Udyog Ltd. in 1985 AD into Indian automobile sector mass production in LMVs was started. The present govt. policy of digital India, make in India, Industry 4.0 has expanded the horizon of LMV companies operations in emerging technologies.

An automobile [2] consists of engine, transmission system, chassis, body, braking system, suspension system and electrical system. Automobiles may be classified from the point of capacity are Two Wheelers,Light Motor Vehicles, Heavy duty Vehicles.Light motor vehicles (LMV) population in global, India and Arunachal Pradesh are shown in Table 1.There are more than 800 millions [3] are plying globally. In India there are around 125 million light motor vehicles. There are large numbers of manufacturers of LMV and they have large network of dealers who look after sales and service in India.

2. VEHICLE ASSEMBLY SYSTEMS

The LMV system consists of chassis, engine, transmission system, brake system ,suspension system, electrical system and and body. The chassis houses engine, suspension ,brakes ,steering and transmission system. The engine is the main system in the vehicle which provides the motive power to all other systems to do various functions for which they are designed to perform. Generally Internal Combustion Engine is classified as Compression Ignition Engine and Spark Ignition Engine. The electrical system gives electricity for cranking the engine, charging the battery and gives power to lighting and other accessories. The transmission system includes of a clutch, a gearbox which provides different torque ratios, propeller shaft and differential. The torque transmitted from gear box to rear axle by propeller shaft. Finally the power flows to driving wheels through differential gear and half axles.The suspension system, which absorbs the shock of the tires and wheels meeting uneven surface of the road. The brake system is provided to stop the vehicle within the smallest possible distance. The body provides compartments for the engine, passengers and luggage or cargo.

3. LMV Engine Assembly Sub-Systems

The engine assembly which contains major components namely crankshaft, cylinder block, piston-assembly with piston pin along with connecting rod, cylinder head comprising valves and camshaft with the provision of spark plug or injectors and ignition system including starting mechanism. It involves systematic step by step procedure which is summarized in the Table 2.

4. Industry 4.0

The term Industry 4.0 [4] was first coined and made known in 2011 AD as "Industrie 4.0" to improve efficiency in the manufacturing sector under the program to augment the competiveness among manufacturing Industry. In near future the smart factories under Industry 4.0 will play a major role which gives a road map in terms of smarter and efficient manufacturing practices that to be implemented in the manufacturing Industry. To achieve these different technologies to be allowed to communicate in such a way that it allows independent decision making with no human intervention between the facilities and processes. Now the Business entities are showing interest to make use of this connectivity in different areas which includes automatic material ordering of parts with the help of cloud-based technology. The essence of Industry 4.0 allows the entire factory to communicate as s single entity rather than connecting to single machine of whole factory. In the present era, high speed internet allows more data to be transmitted and processed remotely and guide us to have more control on the top of different features of our normal day to day lives, and this way the industry may see massive change in the workplace. To accommodate these changes in the workplace the Industrial Internet of Things will be used to accomplish this goal. With the help industrial IoT the smart devices and machines interact with each other and outside the world to improve competiveness among the manufacturing Industries.

The revolution of industries 1.0 to 4.0 has undergone through four stages and it is shown in Fig. 1. The mechanical manufacturing tools were first introduced in the stage one i.e. the mechanical loom revolutionized the path goods are finished. Later steam powered engines where water is a source of power was come into picture for manual agriculture production. In the beginning of 20th century, the second industrial revolution was started on the basis of the first revolution. The electrically powered mass production was evolved during Industry 2.0. The industrial third revolution i.e. Industry 3.0 started during the early 1970s and it employed information and electronics including communication to automate the manufacturing process processes and products.

4.1 Application domains of Industry 4.0 for LMV

Nine technologies [5] which are the part of Industry 4.0 are being used in the engine assembly system which includes adaptive robots, cyber physical systems (CPS), cloud ttechnologies, simulation, data analytics and Artificial intelligence, Industrial Internet, cyber security and RFID technologies, sensors and actuators and mobile Technologies are shown in Fig. 2.

4.1.1 Adaptive Robotics

It is a merging of services, products, machines and microprocessors with AI technologies, which provides autonomy and added proficiencies to perform different functions namely communicating, control and computing. It provides easier assembling of various components by acknowledging the lower part of each component. In addition the adaptive robots are finding their application in the field of manufacturing systems right from design and development, manufacturing and assembly phases.

4.1.2 Cyber Physical Systems

CPS are embedded systems generally integrate computational capabilities and physical infrastructure. In order to get desired result for decentralized actions pertains to CPS, the digital and physical tools should be connected and integrated with other devices. CPS for LMV assembly is presented in Fig.3.

4.1.3 Cloud Technologies

These serve as a main area which establish relationship and imparting and exchanging information of various elements of the Industry 4.0. In order to achieve faster data transmission as well as reaction the industry require large amount of data sharing across the sites and industries. "Digital production" refers to a concept where information is exchanged from the connections obtained from the devices to the same cloud and can be extended to one machine to another or group of machines which are belongs to existing shop floor as well as entire industry.

4.1.4 Simulations

In a factory set up , simulations are used for plant operations which give maximum advantage to the real-time data and reflects the clear image of physical world in a virtual model, which comprise humans, products and machines. This is ultimately reduce machine installation time as well as quality improvement. There are various simulations namely 2D and 3D simulations which can be used for virtual commissioning, cycle times, energy consumption or ergonomic features of a manufacturing facility.

4.1.5 Data analytics andArtificial Intellignece

The data analysis used to identify the threats occurred in various previous production processes in the industry and also predict new threats occurring and suggest different solution to avoid occurrences repeatedly in the industry. The collection of data and comprehensive data evaluation obtained from various production facilities and systems as well as organisation and customer- friendly management systems will become norms to support real-time decision making. Data may be classified as value of data, analysis and velocity generation of new data, Volume of data, Diversified Data. Artificial Intelligence is an idea where it is to help to interpret the data obtained and suggest the line of action needed.

4.1.6 Industrial Internet of Things

The Internet of Things (IOT) is an combination of Information and Communication technology (IICT) where

entities of uniform addressed objects are interconnected by worldwide network and exchange data and information through internet protocols. Internet of Service (IOS), Internet of people (IOP), Internet of Manufacturing Services (IOMs) combined together named as Internet of Everything (IOE).

4.1.7 Cyber Security and Radio Frequency Identification Technologies

Cyber security system enables the protection for devices , machines and sensors which provides ultimate safeguarding of remote communication and end users using different security features namely authentication measures including certificate chains and merged with digital signature.Radio Frequency Identification Technologies (RFID) is a method to locate products or components and observe the condition using condition monitoring methods from resources available inside the organisation across the industry using Auto-ID technologies.

4.1.8 Sensors and Actuators

Sensors which collect data or information from the real world and send to control system embedded with one or more micro controller and monitor the function of sensors and give command to actuators based upon the input. The control unit performs processing of signal and send command to actuators provided in the systems. The data from the sensors are transmitted to a main control unit which maintains communication between sensor and actuator through field buses.

4.1.9 Mobile Technologies

Mobile Devices make sure receiving and processing of large amount of information under the enabled internet environment which are obtained from microphones and high quality cameras, and again allow them to record and transmit information. Using mobile technologies, issues can now be recognized and dealt with faster as information moves with a higher velocity in the right position. The mobile devices are now used in practical way and able to interact with process equipment, material, finished goods and parts through IIoT.

5. CONCLUSIONS

In the present work LMV engine sub-assembly systems was considered for applying Industry 4.0 application domains and developed cyber physical systems for nine assembly sub-systems. The details of engine sub assembly procedure was described for each sub-assembly. The LMV engine assembly sub-system for Industry 4.0 application domains was discussed and matrix of application domains prepared (Table 3). From the present work, it is pertinent that the future of current assembly phase is developing in the direction of Industry 4.0.

ACKNOWLEDGMENT

Authors would like to express sincere thanks to Department of Mechanical Engineering, North Eastern Regional Institute of Science and Technology (deemed to be University), Nirjuli, Itanagar, Arunachal Pradesh, India for the necessary help rendered in the present work.

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Table 1: Light Motor Vehicle Population

Sl..No.	Geographical Area	Number Of Light Motor Vehicles (In Millions)
01	World	800
02	India	125
03	Arunachal Pradesh	0.2

Source: Motor Transport Statistics of India 2018

Table 2: Light Motor Vehicle Engine Assembly Sub-systems

Sequence of Assembling and Sub-Assembly (SA)	**Sequence of Assembly Operations**
SA-1: Cylinder block with crankshaft including oil seal housing	1. Mounting of crankshaft bearing caps to journals after placing the crankshaft in the block 2. Bolting the housing to the block with gasket.
SA-2 : Oil Pump Assembly	1. Apply sealant to mating surfaces around the oil discharging port of both the oil pump case and the cylinder block, 2. Install oil pump to crankshaft and cylinder block.
SA-3: Piston Assembly	1. Assemble the piston rings in the grooves of the piston. 2. Feed the piston and connecting rod combination into the bore from the upper side of cylinder block.

SA-4 : Oil Pan and Flywheel Assembly	1.Mount the oil pan with new gasket to the block 2.Tighten the drain plug in the oil pan 3. Install flywheel to crankshaft.
SA-5: Cylinder Head and Block Assembly	1. Install valve guide and valve spring seat into cylinder head. 2.Install new valve stem seal to valve guide 3.Install valve to valve guide 4.Install cylinder head onto cylinder block with new gasket
SA-6: Camshaft and Rocker Arm Shafts	1. Fit the thrust plate 2. Insert the camshaft into cylinder head from distributor gear case side and oil its journals. 3. Install rocker arms, springs and rocker arm shafts.
SA-7: Camshaft and crankshaft timing belt pulleys	1. Install the pulleys having punch-mark towards timing belt outside cover side. 2. Tighten camshaft pulley bolt to specified torque.
SA-8:Timing belt and Crank Pulley	1. Put the tensioner and the spring together before installing them as one to the timing belt cover. 2. Put timing belt when two pulleys correctly related to each other in angular sense. 4. Install crank shaft pulley to flywheel
SA-9:Distributor gear case and Generator	1. Secure the distributor gear case to the cylinder block. 2. Install the generator by tensioned the water pump drive belt.

Table 3: Light Motor Vehicle Engine Assembly Sub System for Industry 4.0 Application Domains

	Adaptive Robotics	Cyber-Physical Systems (CPS)	Cloud Technologies	Simulation	Data Analytics and Artificial Intelligence	Industrial Internet of Things	Cyber Security and Radio Frequency Identification technologies	Sensors and Actuators	Mobile Technologies
SA-1: Cylinder block with crankshaft including oil seal housing	✓	✓	✓	✓	✓	✓	✓	✓	✓
SA-2 : Oil Pump Assembly	✓	✓	✓	✓	✓	✓	✓	✓	
SA-3: Piston Assembly	✓	✓	✓	✓	✓	✓	✓	✓	✓
SA-4 : Oil Pan and Flywheel Assembly	✓	✓	✓	✓	✓	✓	✓	✓	✓
SA-5: Cylinder Head and Block Assembly	✓	✓	✓	✓	✓	✓	✓	✓	✓
SA-6: Camshaft and Rocker	✓	✓	✓	✓	✓	✓	✓	✓	✓

Arm Shafts									
SA-7 Camshaft and crankshaft timing belt pulleys	✓	✓	✓	✓	✓	✓	✓	✓	✓
SA-8:Timing belt and Crank Pulley	✓	✓	✓	✓	✓	✓	✓	✓	✓
SA-9:Distributor gear case and Generator	✓	✓	✓	✓	✓	✓	✓	✓	✓

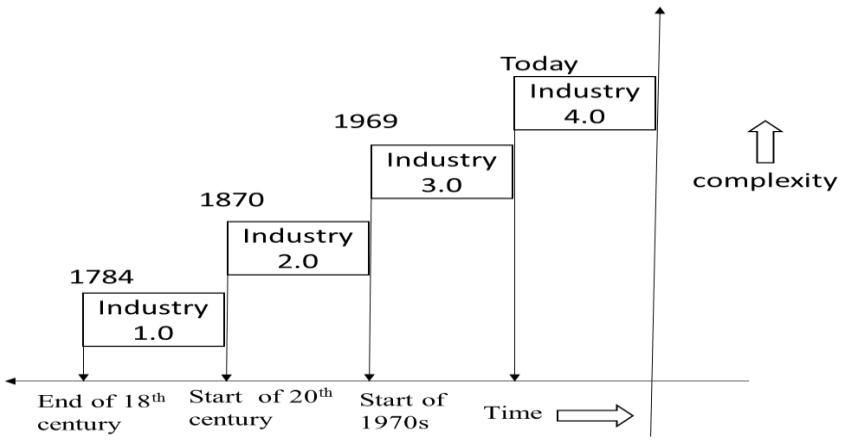

Fig. 1: Revolutions of Industry 1.0 to 4.0.

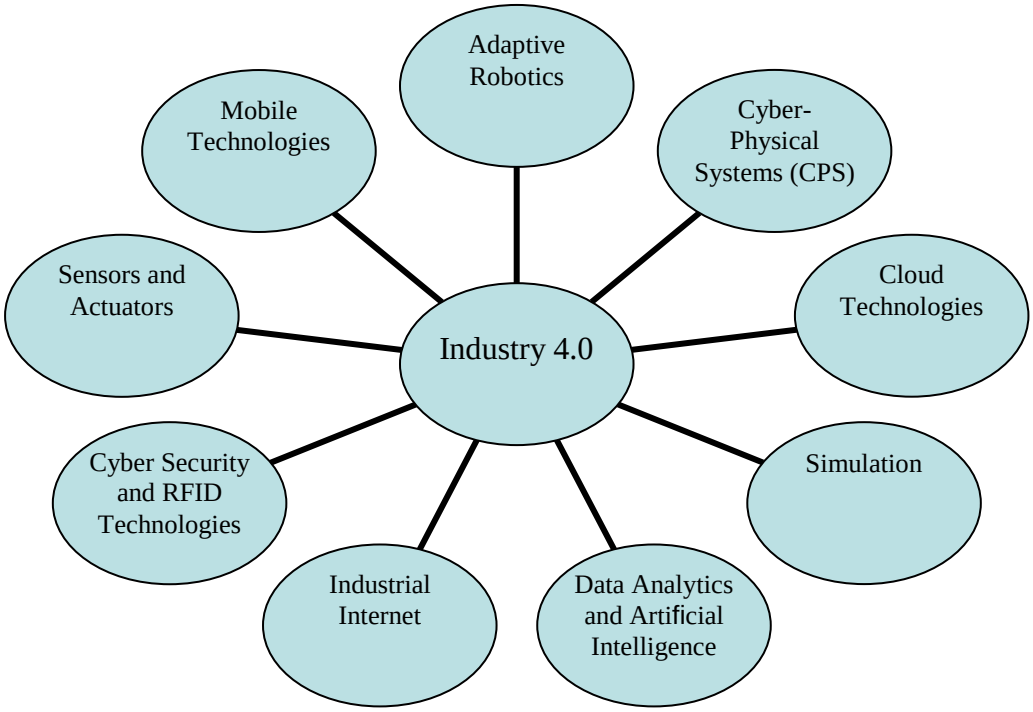

Fig 2. Technologies of Industry 4.0 for Engine Assembly

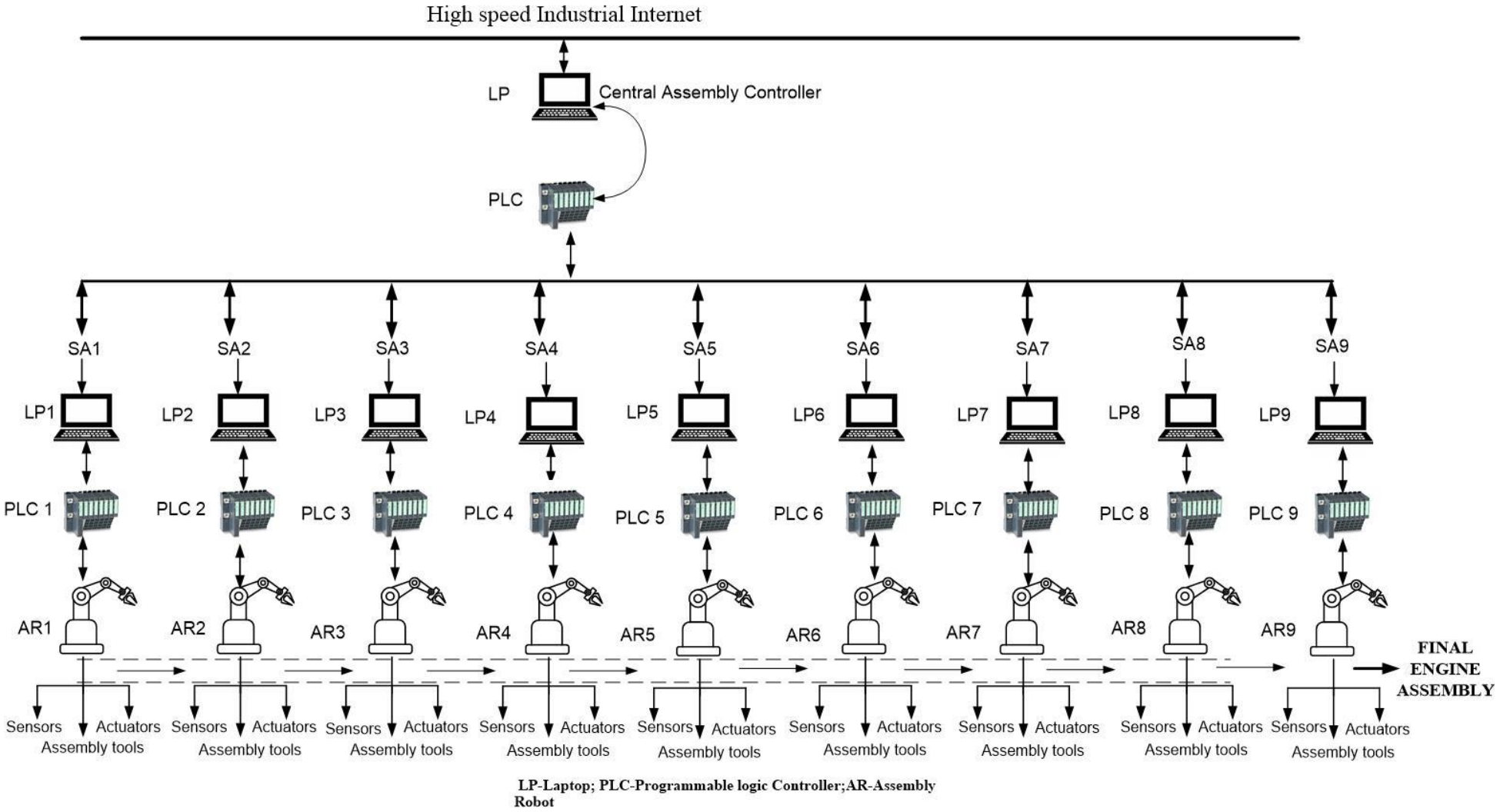

Fig 3: Cyber Physical Systems for Engine Assembly