A

Dissertation Report On

Design and development of low cost automation system at fuel filling station on vehicle assembly line

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Master of Technology

in

Mechanical Production

by

Dubal Shreekumar Vijaykumar

(Roll No. 1522001)

Sponsored by

TATA MOTORS Pvt. Ltd, Pune

Under the Supervision of

Dr. M. T. Telsang

&

Mr. N. J. Barge

Department of Mechanical Engineering

K.E. Society's

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Department of Mechanical Engineering

DISSERTATION APPROVAL SHEET

This dissertation report entitled **Design and Development of Low Cost Automation System at Fuel Filling Station on Vehicle Assembly Line** by **Dubal Shreekumar Vijaykumar (1522001)** is approved for the degree of Master of Technology in Mechanical Production from the department of Mechanical Engineering, Rajarambapu Institute of Technology, Rajaramnagar.

Date:
Place:

Dr. Martand T. Telsang Supervisor	Mr. Nitin J. Barge Industrial Supervisor
Dr. A. H. Mishrikoti External Examiner/s	Prof. A. M. Mulla Head of Program
Dr Sachin K. Patil Head of Department	Dr S A Pardeshi PG Convener

CERTIFICATE

HR/PCBU/ST/53/16-17

March 31, 2017

CERTIFICATE

This is to certify that Mr Shreekumar Dubal, a student of M.Tech Mechanical Production from Rajarambapu Institute of Technology, Rajaramnagar has successfully completed his dissertation work in Tata Motors, Car Plant Pune

The internship period was from 16th June 2016 to 31st March 2017. He has carried out project titled " **Design and Development of Low Cost Automation System at Fuel Filling Station on Vehicle Assembly Line** ".

We wish him best in all his future endeavours.

For Tata Motors Ltd

Rajesh Naik
Asst. Manager - Human Resource

TATA MOTORS LIMITED
Passenger Vehicle Business Unit - Pune Sector No 15 & 15A PCNTDA Chikhali, Pune 411 062
Tel: 91 20 6613 1111
www.tatamotors.com CIN L28920MH1945PLC004520
Registered Office Bombay House 24 Homi Mody Street Mumbai 400 001

DECLARATION

I declare that this report reflects my thoughts about the subject in my own words. I have sufficiently cited and referenced the original sources, referred or considered in this work. I have not misrepresented or fabricated or falsified any idea/data/fact/source in this my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute.

Name of Student and Roll No.	Signature
Mr. Shreekumar Vijaykumar Dubal (1522001)	

Date:

Place:

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Place: RIT, Rajaramnagar — Dubal Shreekumar Vijaykumar

Date: — (1522001)

ABSTRACT

Nowadays for any industry to survive in the competitive market, automation is required. Low Cost Automation (popularly known as LCA) is the introduction of simple pneumatic, hydraulic, mechanical and electrical devices into the existing production process or/and machinery, with a view to improving the productivity. Automation improves the quality of the product as well as reduces the cost of production. Different components, instruments and techniques are used to implement the low cost automated system.

In the Tata Motors car plant Pune, Indica, Indigo, Zest and Bolt cars are manufactured on their mixed model type of assembly line. These cars are different models with domestic and export categories. This dissertation focuses on the design and development of LCA based fuel filling system on vehicle assembly line. The problem occurs at fuel filling station because of manual categorization of vehicle model with fuel type and selection of fuel dispenser unit with appropriated quantity by the operator. The new design of LCA based fuel filling system categorizes vehicle model with fuel type and energizes appropriate fuel dispenser unit with quantity by the Programmable Logic Controller (PLC). The design and development of LCA based fuel filling system is done on the basis of study of existing system, LCA based system layout and dimensional layout by minimizing human intervention in the process. The selection and installation of the components scanner, LED display board and PLC technique is decided on the basis of system task, application requirement, station area and industrial safety points. The ladder diagram's simulation results helps to implement the LCA based fuel filling system and pilot run of system results in reduction of cycle time, reduction of rework which leads to lower down the rework time and cost.

Keywords: Low cost automation (LCA), components scanner, LED display board and PLC technique, ladder diagram

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ABBREVIATIONS

DRR	Direct Run Rate
EQU	Equal
HMI	Human Machine Interface
HSD	High Speed Diesel
KPI	Key Performance Indicators
LCA	Low Cost Automation
NEQ	Not Equal
PLC	Programmable Logic Controller
ROI	Return On Investment
RON	Research Octane Number
VIN	Vehicle Identification Number
WGD	Winter Grade Diesel

Chapter 1

INTRODUCTION

1.1 Introduction

Nowadays for any industry to survive in the competitive market, automation is a must. For the system to be automated in any industry, the huge capital cost is required and for a quick return on investment requires mass production. Hence, large-scale industries can afford and optimize the option of automation, whereas medium and small scale industries find it very difficult to adopt automation. Low-cost automation (LCA) is one solution especially for those industries where the fully automated system is not required.

Low Cost Automation (popularly known as LCA) is the introduction of simple pneumatic, hydraulic, mechanical and electrical devices into the existing production process or/and machinery, with a view to improving the productivity. This would also enable the operation of this equipment by even semi-skilled and unskilled labor with a little training. LCA involves the use of standardized parts and devices to mechanize or automate machines, processes and systems. LCA is a technology that creates some degree of automation around the existing equipment, tools, methods, people, etc., mostly using standard components available in the market with low investment, so that the payback period remains short. The current financial crisis faced all over the world has posed tremendous challenges for the manufacturing organizations. Even at low volumes, and large variety, they have to be competitive with minimum investment. Low cost automation can play an important role in this situation [2].

Also the small and medium scale enterprises require automation in low cost. But effectively and efficiently they not use automation. Low cost automation in material handling system, parts inspection system plays an important role. But due to high installation cost, they do not use these techniques. In small and medium scale enterprises different types of conveyors are useful. By the use of these instruments, the organization requires less number of workers, also parts handling is easy and part rejection is also reduced.

Low cost automation is used in the applications like clamping – de-clamping of parts, loading – unloading of material, material handling system conveyor system, agriculture work, inspection of material physically and with the help of sensory devices, weighing and packaging of material automatically, modification in the existing machine with small automation.

1.2 Relevance

In the automobile industry, different types of vehicles with the same base product are manufactured. These are assembled on the same assembly line without the need of setup or with a very little setup time required. These types of the assembly line are called as a mixed model type assembly line. The operator is getting confused sometimes by wrong identification of the type of product, due to that problem occurred on the mixed model type of assembly line are also high in number. Those problems are responsible for the loss of product quality and productivity. There is need to solve these problems which will help to improve productivity and quality of the product. These problems can be solved with the help of simple technique and some required additional machinery or system to solve. The critical problems also occur on the assembly line which can be solved by automation or by low cost automation. The automation requires huge investment cost whereas low cost automation requires low investment cost. Low cost automation is a technology that creates some degree of automation around the existing equipment, method, tools which will help to solve some problems. This will save the huge investment cost and also improves the process.

This dissertation work focuses on low cost automated system which will be implemented at fuel filling station on vehicle assembly line. This system replaces the manual fuel filling process on vehicle assembly line.

1.3 Problem statement

Nowadays automotive industries use the mixed model assembly line as they are having variants of vehicles of the same product category. The Tata Motors car plant Pune uses the mixed model assembly line in their vehicle assembly shop. They are producing the Tata Indica, Indigo, Zest and Bolt cars in their vehicle assembly shop. These cars are different models with domestic and export categories. Here the problem occurs at fuel filling station on vehicle assembly line which is manually operated. Sometimes due to ignorance or lack of experience, the operator selects wrong fuel dispenser unit and because of that diesel car filled with petrol and petrol cars filled with diesel. For the problem to be solved, low cost automation based fuel filling system is proposed at that station. This low cost automation system consists of various components such as fixed position barcode scanner, LED display board, interlock system and control system.

1.4 Objectives

1. To design the low cost automation system for fuel filling station on vehicle assembly line by using fix position scanner, LED, interlock system and control system.
2. To implement low cost automation system at fuel filling station to ensure correct fuel type with respect to vehicle model during fuel filling process and hence ensure DRR of line.
3. To minimize the human intervention in the process and elimination of rework occurring due to the wrong fuel filling on vehicle assembly line.

1.5 Scope

The scope of work is to design and develop the low cost automation system at fuel filling station on vehicle assembly line which is manually automated. This work includes following steps

1. Study of the existing system for the identification of problem clearly. The previous year data collection and calculation gives the severity of problem occurred by manual process.

2. The design and development of LCA based fuel filling system include the system layout and dimensional layout on the basis of system requirements and space constraints on the station.
3. The appropriate selection of components and techniques are on the basis of system design, application requirements and task to be performed.
4. The simulation of ladder diagrams is required for checking the system working according to the system task.
5. The implementation of components and techniques is being done according to simulation results of ladder diagrams, dimensional layout and testing of components.
6. The pilot run test of the system is required for checking the working of each component in the system correctly and also for checking fulfillment of objectives of dissertation work.

1.6 Layout of dissertation

The dissertation work deals with the design and develop the low cost automation system at fuel filling station on vehicle assembly line which is manually automated by using components as a scanner, LED display board and technique as PLC. The dissertation work is planned in following chapters.

Chapter 1 includes the introduction of low cost automation system, its need in the industrial applications, its benefits over the manual system, relevance of dissertation, problem statement, objectives and short description about the layout of dissertation report.

Chapter 2 includes the survey of literature on various applications of low cost automated processes. In this chapter design considerations required for the system components like sensor, actuators etc and techniques like relay logic control, microcontroller and programmable logic controller (PLC) are also described.

Chapter 3 includes the study of existing system and effect of it on vehicle assembly line. The existing system is a manual fuel filling process. The assembly line used here is a mixed model type, due to that sometimes wrong fuel filling is done. This problem arose due to wrong identification of the vehicle and incorrect selection of fuel dispenser unit with appropriate quantity.

Chapter 4 includes the design and development of fuel filling system which is based on low cost automation. This system is designed to reduce human intervention in the process of fuel filling and improve the product quality. The ladder diagrams are required for PLC and are prepared on RSLogix 5000 software and its validation on the same software by using emulator tool. The installation of system components are done on the station and its working is tested individually in offline mode. The pilot run test of LCA based fuel filling system is conducted in online mode after successful installation of the system components. The performance of the system working is recorded according to the objectives of dissertation work.

Chapter 5 includes the comparative study of the existing system with LCA based fuel filling system. The pilot run test of system working shows that each component is working with its high efficiency. The economic benefits of the system are also calculated to give the effectiveness of project to the industry. The LCA based system working time with other benefits is tabulated and conclusions are drawn on the basis of that.

1.7 Observations and remarks

This chapter includes the introduction of low cost automation system, its need in the industrial applications, its benefits over the manual system, relevance of dissertation, problem statement, objectives and short description about the layout of dissertation report.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter includes the survey of literature on various applications of low cost automated processes. In this chapter design considerations required for the system components like sensor, actuators etc and techniques like relay logic control, microcontroller and programmable logic controller (PLC) are described. The literature survey is divided main two parts: 1) Design and development of low cost automation system using components and techniques. 2) Design of PLC based system, its simulation on respective software and use of human machine interface (HMI) screen.

2.2 Design and development of low cost automation system

Lodha et al. (2015) design and develops automated pouch packaging machine. An additional weighing and pouring mechanism have been added to increase the accuracy of the system. Various processes involved in the pouch packaging are neatly aligned and properly timed to get optimum production rate. A mechatronics system, developed for this machine, which takes feedback from sensors and accordingly controls the manipulators has been introduced in this paper. A microcontroller technique is used to design used for this particular machine [2].

Bayindir and Cetinceviz (2010) presents a water pumping control system that is designed for production plants and implemented in an experimental setup in a laboratory. The control systems that they use are a programmable logic controller (PLC) and the main function of the PLC is to send a digital signal to the water pump to turn it on or off, based on the tank level, using a pressure transmitter and inputs from limit switches that indicate the level of the water in the tank [1].

Patel et al. (2014) presenting a process loop that can be used in bottle washer machine. A holistic approach is used here to control liquid. Here programmable logic controller is used to controlling parameters as level, flow and pressure of the liquid. Different sensors and valves are used with PLC, which are controlled by the program [3].

2.3 Design of PLC based system

The PLC based system is designed and the ladder diagrams are simulated on respective software. The PLC based system uses human machine interface (HMI) screen for maintenance as well as further modification.

Meenakshipriya et al. (2016) propose a system based on PLC for the petroleum industry to maintain constant flow and pressure till the extreme end in transmitting pipe of petroleum products. In this case, micrologix 1400 PLC is used to automatically regulate the pressure and flow during petroleum product transportation by controlling the percentage of opening of the control valves and pumps respectively. The required set point for pressure and flow rate are obtained by implementing PLC based PID controller and simulation studies are carried out in MATLAB/SIMULINK platform to ensure the performance of the controller [4].

Wang H. (2011) designs automatic turnover device for workpiece turnover in the automatic production line. The hydraulic system required for this is designed, its working principle was analyzed, and the PLC control system was designed according to control requirements to the hydraulic system of workpiece turnover. The Siemens PLC of SIMATIC S7-200 CPU266 was selected on the basis of input and output requirements of the system. A STEP7- Micro/WIN programming software was used to program the system control process [5].

Bula et al. (2016) design the cost oriented weighing and packaging system in the old machine with industry standard PLC and modules for the readings of weighing sensors (load cell). In this case program on software is not that much reliable for a long time, so PLC program can be stored in SD card and its reliability is high. In the case of malfunction, the machine will not put human lives in danger. Because of this, conditions were perfect to use an open source of hardware and software, which helps to minimize production as well as maintenance cost [6].

Arambhadiya et al. (2016) provide a solution for manually operated vacuum system by automation in industry Aditya Vacuum Control System. They provide PLC based automation system in the industry with control system studio which is used for human-machine interface (HMI) screen. The complete system is tested with Aditya Vacuum Control System with process interlocks. Because of this system, the manually operated vacuum system is replaced successfully by automation [7].

Ganesan et al. (2015) propose a prototype model of the hydroelectric pump storage power plant which is of PLC – HMI automation based CFPID control scheme. The old PLC system is compared with new PLC – HMI automation system experimentally and results validated from real time statistics obtained from the hydroelectric pumped storage power plant [8].

Barbieri et al. (2015) propose an interpretation of the tools provided from packing machine learning approach and defined a Rockwell based design pattern for modular PLC code. The approach is taking into consideration because of its simplicity which comes from performance analysis [9].

Gasper M.(2015) propose an approach to maintain the common look and feel of packaging machine learning based automation which simplifies the PLC program to the level that enables the use of low-end or legacy controllers [10].

2.4 Observations and remarks

From the above literature, it is observed that low cost automation is applicable to the particular station which is a bottleneck or key machine. It is important there because once the problem at that station is solved, then the idle time of that operator will reduce, rework is eliminated, less cycle time required to complete the operation, increase in productivity and also less fatigue to the operator. Also by all other benefits of low cost automation, line balancing is done on that particular line. Some of the authors are using this low cost automation for making new special purpose machine by the use of scraps. Some are using this low cost automation for designing fixtures, pallets, some sensory feedback etc. also some are using PLC technique, microcontroller technique for design and development of low cost automation system.

This dissertation uses the literature survey for designing the full proof system at fuel filling station on vehicle assembly line. The selection of sensory devices such as a scanner, LED display is done according to system requirements. The PLC technique instead of microcontroller technique is used in this system because the system is designed for the industrial application [2] [4].

Chapter 3

STUDY OF EXISTING SYSTEM

3.1 Introduction

This chapter deals with the study of existing system and effect of it on vehicle assembly line. The existing system is a manual fuel filling process. The assembly line used here is a mixed model type, due to that sometimes wrong fuel filling is done. This problem arose due to wrong identification of the vehicle and incorrect selection of fuel dispenser unit with appropriate quantity.

3.2 Manual fuel filling process

In the vehicle assembly shop at underbody line, engine assembly with fuel tank is fitted and then vehicle sends to the mechanical line. At the mechanical line of vehicle assembly shop, fuel filling operation of the vehicle is done. This fuel filling station is manually operated. The operator identifies the vehicle on his experience by reading the code or identifying engine of the vehicle. There is no standard technique provided at that station like scanning the code which will help to identify the vehicle. Due to lack of this identification technique sometimes problem occurred in fuel filling process. These problems are identified by the auditor at the quality gate where engine performance is checked.

3.2.1 Flowchart of existing system

The stepwise working of the system is described in this section. The vehicle is dropped on the mechanical line of vehicle assembly line. The operator first checks the engine and on the basis of that categorization of the vehicle is done. The operator further selects the fuel dispenser unit on the basis of categorization. The selected fuel dispenser is energized manually by picking up of the fuel nozzle. The delivery of fuel is started by observing the quantity of fuel to be dispatched. The required fuel when delivered to the vehicle then fuel dispenser unit is de-energized by putting down the fuel nozzle on the stand.

The continuous observation of metering unit of fuel dispenser is required by the operator while delivering the fuel to the vehicle. This time of operator is idle time because he cannot do any other work while observing the metering unit. The manual process requires one operator is permanently assigned for this job. This is the actual working of existing fuel filling process. In the next section, previous year data is collected on wrong fuel filling cases to find its severity on the quality of the product. The following flowchart in figure 3.1 shows the working of the existing system. The manual activities in the process are measured in details to calculate cycle time of the process.

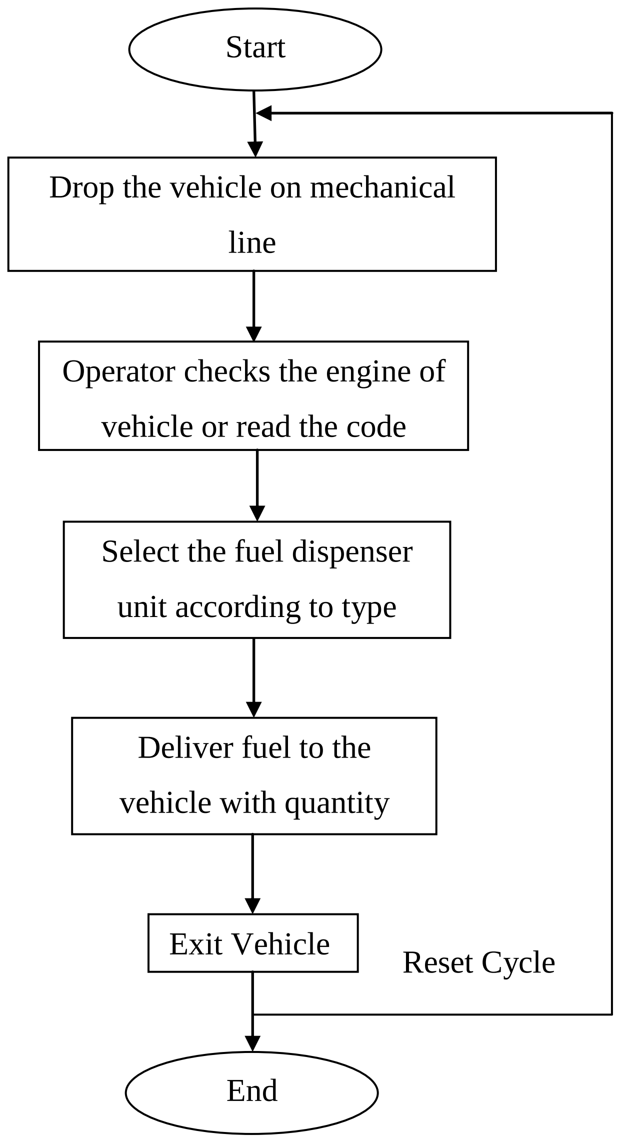

Figure 3.1: Flowchart of working of existing fuel filling system

3.2.2 Cycle time recorded for existing system

The cycle time recorded for the existing system by considering all activities involved in it. The cycle time of domestic vehicles and export vehicles are different. This difference in the cycle time is occurred due to the quantity of fuel for respective vehicles. The domestic vehicles are filled with 7 litres of fuel and export vehicles are filled with 15 litres of fuel. The following table 3.1 and 3.2 shows the cycle time recorded for domestic vehicles and export vehicles respectively.

Table 3.1 Cycle time recorded for domestic vehicles

Sr. No.	Operation	Time in seconds
1.	Operator checks the engine	5
2.	Selection of fuel dispenser unit	5
3.	Delivery of 7 litres of fuel to the vehicle	37
	Total	**47**

Table 3.2 Cycle time recorded for export vehicles

Sr. No.	Operation	Time in seconds
1.	Operator checks the engine	5
2.	Selection of fuel dispenser unit	5
3.	Delivery of 15 litres of fuel to the vehicle	81
	Total	**91**

3.3 Current defect rate

In Tata Motors car plant the fuel filling system is operated manually due to which sometimes defective products are manufactured. Table no. 3.3 describes the production summary and the number of defective products is manufactured in the year 2015-16. This total number of products and number of defective products values are collected from the previous year defect record list. These values are used to find the impact of the defect on the quality and direct run rate (DRR) of that line.

Table 3.3: Production summary and defective products

Sr.No.	Month	Total number of products	No. of defective products
1.	June 2015	4246	9
2.	July 2015	5877	10
3.	August 2015	5496	7
4.	September 2015	5361	9
5.	October 2015	5545	10
6.	November 2015	3839	4
7.	December 2015	1268	3
8.	January 2016	3981	5
9.	February 2016	3528	6
10.	March 2016	3614	4
11.	April 2016	3538	5
12.	May 2016	696	1
13.	June 2016	4286	2
14.	July 2016	5932	3
15.	August 2016	5480	3
		Total	81

In the previous year from the month June 2015 upto August 2016, a total number of products manufactured and the number of defective products data has been collected from the defect register book. Figure 3.2 shows the month wise production and number of defective products. The monthly production of the vehicle is fluctuating according to production planning and control requirements. The products manufactured are high in number due to which the defect generated by wrong fuel filling process is also high. This has been done because the production rate of the line is high and this may sometimes confuse to the operator in manual categorization process of the vehicle type. This may further lead to the wrong selection of fuel dispenser unit and by this way defect has been generated.

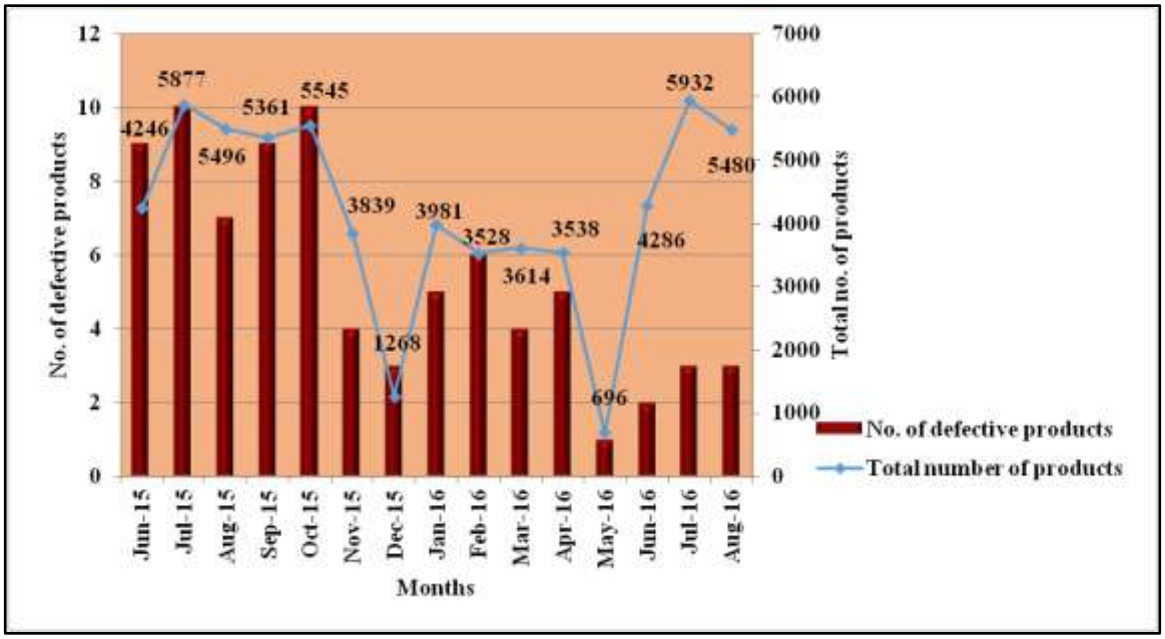

Figure 3.2: Production summary with defective products chart

3.3.1 Impact of defects on quality of the product

The quality of the product is the experience of the customer. The vehicle assembly line is dealing with inbuilt quality of the product. The defect should not leave the line is the main task of manufacturing quality of the product. In the manual fuel fueling process defect generated are high in number and it has been found out at the quality gate of the line. This indicates the poor quality provided to the next customer.

The defective vehicle is found out at the quality gate then that vehicle manually removed out from the line and sends it for rework. The wrong fuel filling cases are identified and reworked also but no any part of the vehicle had been damaged due to that defect. The rework is done like fuel tank removal, remove the fuel line to the engine, flush those parts by air and again reassemble. These operations are done manually by the single operator which takes 8 hrs. This indicates that only operational cost is considered in the rework of vehicle. This operational cost is nothing but the wage of the single operator for 8 hrs which is Rs. 2000 per vehicle.

3.3.2 Direct Run Rate [DRR]

Direct run rate (DRR) is a quality metric used to calculate the percentage of cars which were made 'OK' first time on their assembly line. The term is also referred as 'First Shot OK (FSO)'. During the car assembly process there are many things which can go wrong e.g. the operator fitting a specific part on the car may fit it incorrectly, the part itself may be defective, the tool used for fitting the part may go under break-down.

DRR is the ratio of the difference between the total number of products manufactured and a number of defective products made to the total number of products manufactured.

$$\text{Direct Run Rate} = \frac{[\text{Total no. of products manufactured(N)} - \text{No. of defective products made}]}{\text{Total no. of products manufactured(N)}} \times 100$$

Example: June 2015 month's data is considered here to calculate DRR of line.

Total number of products manufactured = 4246

Number of defective products = 9

$$\text{Direct Run Rate of month} = \frac{[4246 - 9]}{4246} \times 100$$

Direct Run Rate of month June 2015 = 99.79%

Table 3.4 shows the production summary and DRR of a line from month June 2015 to August 2016.

Table 3.4: Production summary and DRR

Sr. No	Month	Total number of products manufactured	Defective Products	DRR
1.	June 2015	4246	9	99.79
2.	July 2015	5877	10	99.82
3.	August 2015	5496	7	99.87

4.	September 2015	5361	9	99.83
5.	October 2015	5545	10	99.82
6.	November 2015	3839	4	99.89
7.	December 2015	1268	3	98.58
8.	January 2016	3981	5	99.87
9.	February 2016	3528	6	99.82
10.	March 2016	3614	4	99.88
11.	April 2016	3538	5	99.86
12.	May 2016	696	1	99.85
13.	June 2016	4286	2	99.95
14.	July 2016	5932	3	99.95
15.	August 2016	5480	3	99.94

The data from table 3.3 indicate that the issue of wrong fuel filling is averagely recorded per week with 1 or 2 vehicles. Table 3.4 also shows this defect adversely impacts the DRR, and the current DRR is below the target goal of 100% DRR.

Low cost automation system provides the solution for this type of problem. We are designing and developing low cost automation system for fuel filling operation, which will follow the standardization of work procedure on that station.

3.4 Observations and remarks

This chapter is mainly focused on the study of the existing system, defects generated due to wrong fuel filling and its impact on the direct run rate of the line. According to production summary and defective products data, it is clear that the manual process generates more defects. This issue does not affect any material part of the vehicle, but it requires high rework time and cost. To overcome this issue, the new system can be designed and developed with low cost automated parts which are described in next chapter.

Chapter 4

DESIGN AND DEVELOPMENT OF LCA BASED FUEL FILLING SYSTEM

4.1 Introduction

In this chapter, we design and develop fuel filling system which is based on low cost automation. This system is designed to reduce human intervention in the process of fuel filling and improve the product quality. Human intervention is reduced in the identification of the vehicle and its categorization with appropriate fuel quantity. This categorization is done with the automated system by using sensory and control devices [1] [4]. Section 4.1.1 describes detail layout of the system.

4.1.1 System layout

The manual fuel filling process was discussed in figure 3.1. This manual process leads to generate defective products. In this process, no any standard procedure is followed by the operator to identify and categorize the vehicle. The operator sometimes categorizes the vehicle wrongly and on the basis of that, selection of fuel dispenser unit is done. This is the main reason where wrong fuel filling of the vehicle is done. In this case, all fuel dispenser units are manually energized by picking up the fuel nozzle.

There is no any provision to avoid wrong selection of fuel dispenser unit. Due to manual selection of fuel dispenser unit, there is a chance to fill the wrong fuel to the vehicle. This issue of wrong fuel filling to the vehicle is found at the quality gate of the line by checking the engine performance of the vehicle and then the vehicle is dropped down from the line for rework. This rework requires much time, headache to the operator and impact on quality of the product. To avoid such wrong identification of vehicle and selection of fuel dispenser unit, the LCA based fuel filling system is designed with the appropriate equipment.

The automated system requires sensors, switches and control devices. The industrial application are performing multiple tasks and control over other machines, so that they use PLC as a control device and sensory devices as a scanner, switches etc. to design the automated system [1] [4]. The full automation system does not require human intervention; semi automatic system requires humans to perform some part of the operation. But in the low cost automation system, the critical part of the process has been automated and the easy task is operated manually [2].

The new design of fuel filling system is required to replace the manual fuel filling process. In this case, the manual activity of categorization of the vehicle is totally automated which requires sensory device as a scanner to read the barcode and control device as PLC to perform the task correctly. The system is categorizing the vehicle by the vehicle identification number (VIN) which is an alphanumeric code in the form of a barcode. The barcode gives information of the vehicle type and vehicle model with fuel type.

This data is transferred to PLC where categorization of the vehicle is done and control activity is performed. The categorization is indicated by the sensor as LED display and controlling action on the solenoid valve of fuel dispenser unit.

The fix position barcode scanner is used here for reading the barcode scanner of the vehicle to the correct categorization. The main PLC is a control unit of the system which consists of human machine interface screen (HMI) and I/O panel. The I/O panel is used to store the primary data coming from the scanner and send it to the processor of main PLC. The main PLC controls the LED display board as well as fuel dispenser unit. The LED display is used for indicating the operator to select the appropriate fuel dispenser unit for the vehicle. The main PLC is used for controlling fuel dispenser unit with quantity by activating the only indicated fuel type on LED display. This is useful to avoid wrong delivery of fuel to the vehicle. The fuel filling process by this system improves the process efficiency and lower down the losses occurred due to a manual process. The HMI screen is used here for maintenance work of the system and also to cross check the float of the vehicle. In this way, the new system is designed to avoid the losses occurred because of a manual process.

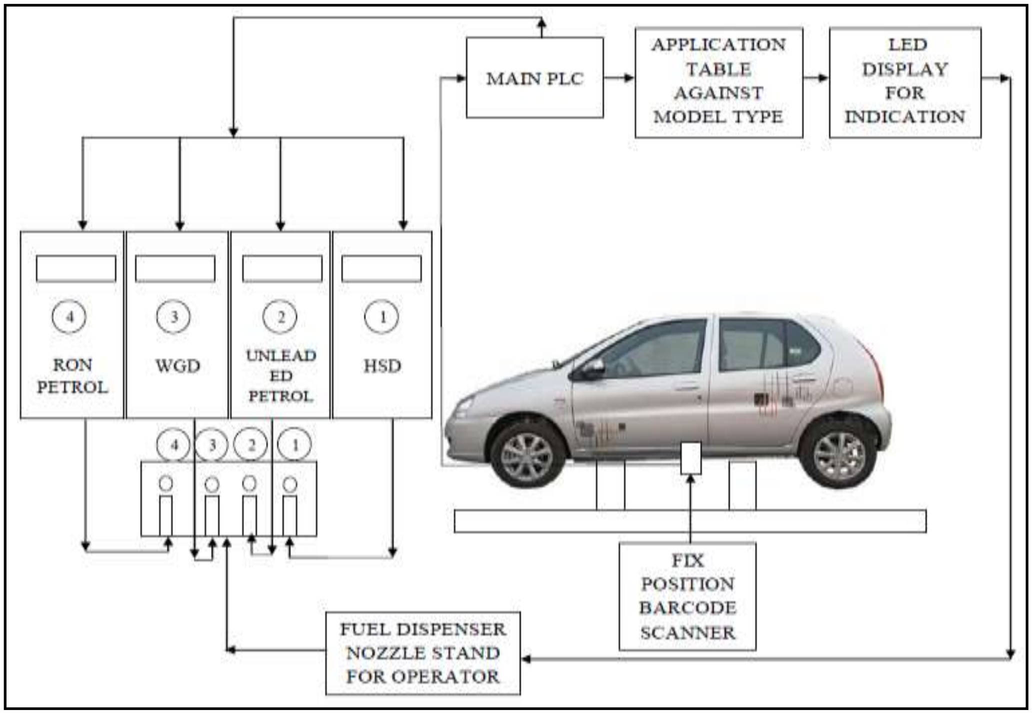

Figure 4.1: LCA based system layout of fuel filling station

In this LCA based fuel filling system, categorization of the vehicle is a critical part of the process which has been automated with the help of barcode scanner and PLC. The full proofing of the process is done by controlling the activation of correct fuel dispenser unit by PLC. Figure 4.1 describes the LCA based system layout of fuel filling station.

The dimensional layout in figure 4.2 is designed according to the system requirement, a survey of the station, industrial safety rules and operator's feasibility. The barcode scanner is a fix position barcode scanner. This scanner is located in the cage where operator's entry is restricted during the production process. The location of the scanner in the cage has two reasons;

1) Space constraints on the station. The barcode scanner is small in size and it has to install at height of 0.36 m from the ground to scan the VIN. The stand of the barcode

scanner may hit the operator while performing its activity on the station and sometimes scanner doesn't scan the VIN due to the interference of operator in the scanning area while performing his work.

2) Barcode scanner is set at autofocus mode due to which continuous flashing is done. This flashing is nearer to the fuel dispenser unit which may cause the fuel to burn. These two reasons are coming under the safety issues so that the location of the scanner is decided at the cage. The PLC has located away from the fuel dispenser unit as it requires more wiring and space constraints on the station. On the basis of station area and systems size, the probable location of system components is decided. This dimensional layout figure 4.2 describes the location of components. This dimensional layout also helps to decide the scanner and length of field wiring for the system.

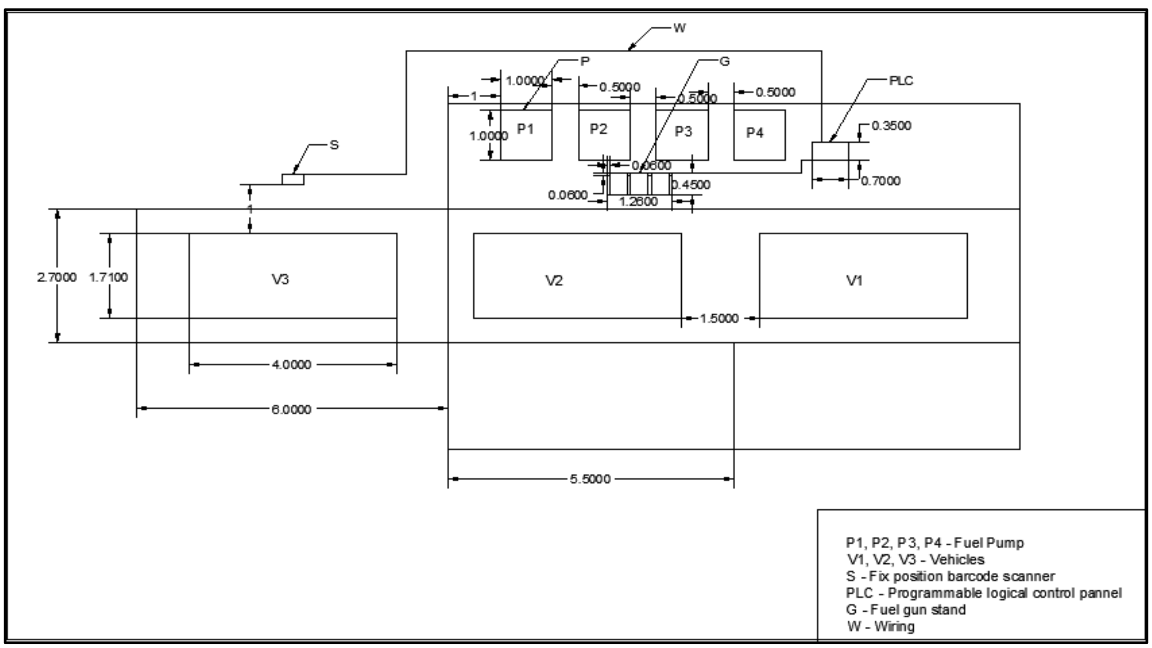

Figure 4.2: Dimensional layout of station and machines

4.1.2 Flowchart of LCA based system

The flowchart describes working of LCA based fuel filling system starts from vehicle dropping on the line. In the first step, the vehicle drops on the mechanical line of vehicle assembly shop.

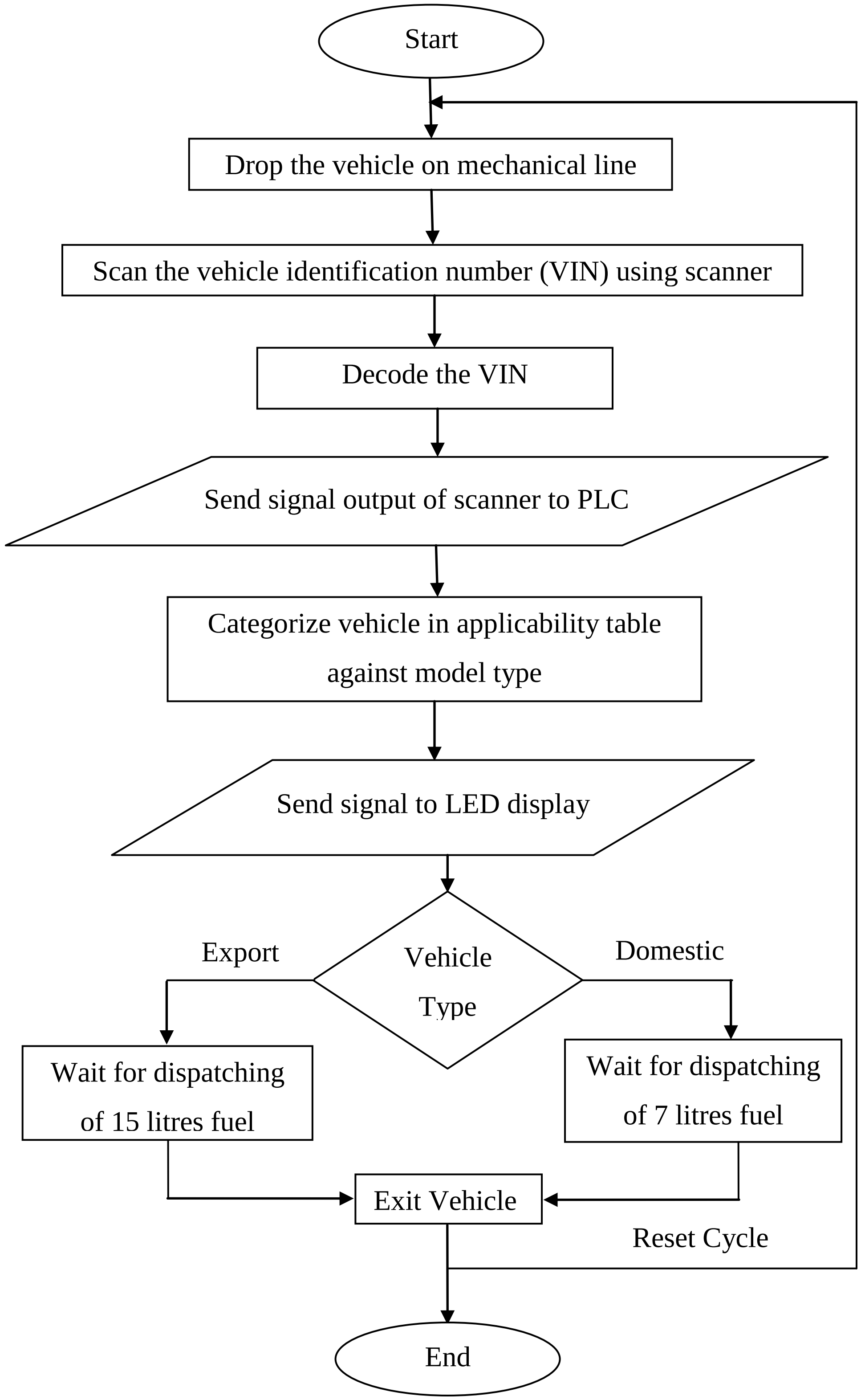

Figure 4.3: Flowchart of working of LCA based fuel filling system

The VIN is scanned by the fix position barcode scanner. This VIN decodes in the scanner according to code family. In the second step, the output of the scanner is sent to the PLC and categorization of a vehicle according to model type is done. This output of categorization is sent to LED display board to indicate operator to select fuel dispenser unit. In the third step, according to model type the quantity of fuel is selected and after dispatching the fuel the system automatically resets. Figure 4.3 shows a flowchart that describes the detail working of LCA based fuel filling system.

4.2 Vehicle Identification Number (VIN)

The vehicle identification number (VIN) is required for the LCA based fuel filling system to categorize the vehicle. The VIN is in the form of a barcode which has been scanned by the scanner. The vehicle description section is used in the system for categorization of a vehicle according to fuel type. The vehicle identification number is 1D barcode type and it is pasted on “B” pillar of the vehicle. The introductory part of vehicle identification number is described here. The Vehicle identification number (VIN) is a unique serial number used by the automotive industry to identify individual motor vehicles. It sets the vehicle apart from the millions of other vehicles out there. In recent time, VINs consists of 17 characters which do not include the letters I, O, or Q to avoid confusion with numerals 1 and 0. It displays a car’s uniqueness and heritage and provides a form of factory to scrap yard identification. It can be used to track recalls, registration, warranty claims, thefts and insurance coverage. Each character or digit of VIN has a particular purpose. Table 4.1 and 4.2 describes each character of VIN.

1. Domestic vehicles

Table 4.1: Domestic vehicle code with description

<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr>
<tr><td colspan="3" rowspan="2">World Manufacturer Identifier</td><td colspan="3">Vehicle Type</td><td colspan="3">Vehicle Model</td><td rowspan="2">Year of Prod.</td><td rowspan="2">Plant Code</td><td rowspan="2">Month</td><td colspan="5" rowspan="2">Sequential Number</td></tr>
<tr><td colspan="6">Vehicle Description Section</td></tr>
</table>

2. Export vehicles

Table 4.2: Export vehicle code with description

<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr>
<tr><td colspan="3" rowspan="2">World Manufacturer Identifier</td><td colspan="3">Vehicle Type</td><td colspan="3">Vehicle Model</td><td rowspan="2">Year of Prod.</td><td rowspan="2">Plant Code</td><td rowspan="2">Drive</td><td colspan="5" rowspan="2">Sequential Number</td></tr>
<tr><td colspan="6">Vehicle Description Section</td></tr>
</table>

The first three characters uniquely identify the manufacturer of the vehicle using the world manufacturer identifier (WMI) code. For TATA MOTORS LTD., the World Manufacturer Identifier code is "MAT" [13].

Vehicle description section is used to identify the vehicle type and may include information on the platform used, the model and the body style. Each manufacturer has a unique system for using this field. The newly designed system requires the vehicle description section. The vehicle description section is used for the identification of vehicle type and vehicle model. We require the vehicle type and vehicle model data here. This data is linked with the standard program made in the PLC. The scanner is configured with the PLC in such a way that, it can read all the data on VIN but store only data from the fourth character to quantity upto six characters. The refined data is further used by PLC for controlling the action of components. On the basis of these requirements, we are going for selection of components and techniques, which are described in the following section.

4.3 Selection of components and techniques

The system components are selected on the basis of automated system requirements and installation requirements. Figure 4.1 is an overview of the actual system to be implemented. The fix position barcode scanner is required for vehicle identification number scanning. This VIN has 17 characters which is an alphanumeric code in the form of a barcode. The output of scanner sends to PLC for further categorization and controlling action. The PLC categorizes VIN and sends a signal to LED display board used for operator's indication. This LED display indicates the operator to select the appropriate fuel dispenser unit. The PLC sends a signal to a metering unit of the fuel dispenser to select the quantity of fuel. At the same time, PLC de-energized other fuel dispenser units by controlling solenoid valve. The indication shown by LED display is the only fuel dispenser unit activated and others are deactivated. This controlling action is useful for delivering the fuel from the activated fuel dispenser unit. For this system following component and technique is required. The basic criteria for selection of each component and technique are described as follows.

4.3.1 Basic criteria for selection of scanner

The scanner is selected on the basis of following points

1. Type of barcode to be scanned: 1D Linear or 2D barcodes

2. Density of code and Code families: The size of the minimum bar width or element in the code

3. Type of connectivity of scanner: Wire connectivity (Tethered) or Cordless type

4. Distance between scanner and the barcode

5. Environment where the scanner is used.

6. Form factor

The above points are described in brief.

1. Type of barcode to be scanned

The 1D linear barcode and 2D linear barcode are two main types of barcode. 1D linear barcodes can be scanned by two types of scanners i) laser scanner, ii) linear imager scanner. Laser scanner uses a red diode laser to read the reflectance of the black and white spaces in a barcode. Laser scanners are only able to read standard linear (1D) barcodes but these are most cost effective option. Standard laser scanners can read from a few inches to a foot or two away depending on the size of the barcode. Linear imager scanners are similar to lasers in that they also only read 1D barcodes. But instead of reading reflected light from the laser, they take a picture of the barcode. It then analyzes this image to extract the information from the code. The read ranges and cost of linear and laser scanners are similar but the linear scanner can read the poorly printed or damaged codes compared to lasers.

The 2D barcodes can be scanned by 2D area imager. The 2D area imager scanner has the same function as like linear imager. These scanners can read 1D, stacked and 2D type of barcode. The 2D imager is taking a more detailed image and is more intelligent, so that user can read a code in any direction and orientation of barcode also not important. This results in faster reads with less aiming.

2. Density of code and code families

Codabar: The code type CODABAR is used for photo finishing and blood bottle labeling applications. It consists of a character set of 16 characters (10 digits, 6 special characters) shown in Figure 4.4.

Figure 4.4: Codabar example

Code 39: The CODE 39 can decode 43 characters. The symbology of the binary Code 39 character set consists of 10 digits, 26 alphabetic characters and 7 special characters. Each character consists of 9 elements (5 bars and 4 spaces). Three of the elements are wide and six are narrow. CODE 39 requires a lot of printing space. Figure 4.5 describes an example of code39.

Figure 4.5: Example of Code 39

UPC/EAN: The UPC (UNIVERSAL PRODUCT CODE) is used for food and consumer goods in the USA and Canada. It can be compared with the European EAN. The UPC is a numeric code with 12 digits (UPC-A) or with 6 digits (UPC-E) shown in figure 4.6. The last digit is the check-digit.

Figure 4.6: Example of UPC

The EAN (EUROPEAN ARTICEL NUMBERING) is used for labeling food and consumer goods in Europe. It can be compared with the American UPC. The first two numbers indicate the country code, the following numbers the manufacturer and the article. The EAN code is a numeric code with 13 or 8 digits, in figure 4.7. The last two digits are used as check-digits.

Figure 4.7: Example of EAN 13

Interleaved: The 2/5 INTERLEAVED (also called ITF) is a very common code type for the coding of numeric information. The main fields of application are in the industrial sector. The 2/5 INTERLEAVED is a binary code which encodes digits from 0-9, shown in figure 4.8.

Figure 4.8: Example of 2/5 Interleaved

CODE 93: CODE 93 is an alphanumeric code comparable with CODE 39. However, Code 93 requires less space. The same character set (10 numbers, 26 alphabetic characters and 7 special characters) can be encoded. Following figure 4.9 shows code93. The code is multiple-valued (valency 4).

Figure 4.9: Example of Code 93

CODE 128: The CODE 128 is an alphanumeric code that can display the complete ASCII character set with the three character set (set A, B and C). A check-digit test is always available.

- Character set A includes digits, uppercase letters and special characters.
- Character set B includes digits, uppercase and lowercase letters.
- Character set C only includes digits, but with a double density.

It is possible to start with one of these sets and to switch to another character set within the code which shown in figure 4.10. CODE 128 is multiple-valued (valency 4).

Figure 4.10: Example of Code 128

Pharmacode: The pharmacode is used exclusively in the pharmaceutical industry. It is a binary code, the narrow and wide bars represent the code content (narrow bars = 0 and wide bars = 1). The spacing does not contain information.

3. Type of connectivity of scanner

The system requires the wired (tethered) type of scanner instead of cordless. The cordless scanner is required to operate by the user and due to safety issues, we cannot use the cordless scanner in the system.

4. Distance between the scanner and the barcode

The dimensional layout describes the distance between barcode and scanner to be mounted. The probable distance between scanner and barcode is 1m. This location of the scanner is decided according to system requirement and station survey.

5. Environmental condition

The scanner is selected on the basis of environmental ruggedness. In this system environmental conditions are not harsh so this factor is not affected.

6. Form factor

The form factor is selected after a type of barcode selection. There are five main types of form factors as a handheld, presentation, a mobile computer, in-counter, fixed mount. The handheld scanner is simple to use as aim the barcode and pull the trigger. Presentation scanners are made for hands free scanning and will not require triggering to read. Mobile computers provide both the PC and scanner are in a single device. In-counter scanners are similar to presentation scanners in that user have to present in front of the reader. The output data is made to be embedded into a counter-top. A fixed mount scanner is integrated with a largely automated system. These scanners are made to be mounted on a conveyor line and do not have a typical trigger or button to scan.

On the basis of above discussed parameters, the scanner is selected for the newly designed system.

1. Type of barcode to be scanned: 1D Linear barcode

2. Density of code and Code families: code family is code 128 and its barcode is of 17 characters

3. Type of connectivity of scanner: Wire connectivity (Tethered)

4. Distance between scanner and the barcode: 1m

5. Form factor: fixed mount according to system requirement, safety guidelines of station and type of application.

The barcode used in VIN is of 1D linear barcode and its associated code family is Code 128. The wired connectivity type of barcode scanner is selected by considering safety guidelines, the location of barcode scanner. The distance of barcode scanner and barcode on the vehicle is 1m. The system designed here is a low cost automated system and the assembly line is based on conveyor system then the suitable form factor of the scanner is fixed mounted type.

Scanner

The parameters discussed in the previous section are similar in CLV650-6120 scanner and its associated part number is 1042125 [12]. The scanner CLV650-6120 is used for scanning the 1D linear barcode. This barcode belongs to Code 128 family and its connectivity type is wired (Tethered). The scanner CLV650-6120 is a fixed mount type and has a maximum range of 1.4m. The following figure 4.11 shows the interpretation of scanner CLV650-6120.

Figure 4.11: Scanner CLV650-6120

The following table 4.3 describes the specification of selected scanner.

Table 4.3: Specification of scanner

Version	Standard Density
Connection type	Ethernet
Reading field	Oscillating mirror
Scanner design	Line scanner
Focus	Autofocus
Light source	Visible red light (658 nm)
MTBF	40,000 h
Oscillating mirror	Fixed (adjustable position), oscillating (variable or fixed

functions	amplitude), one shot
Oscillation frequency	0.5 Hz ... 6.25 Hz
Angle of deflection	–20° ... 20°
Bar code types	All current code types, Code 39, Code 128, Code 93, Codabar, GS1-128 / EAN 128, UPC / GTIN / EAN, Interleaved 2 of 5, Pharmacode
No. of codes per scan	1...20 (Standard decoder) 1 ... 6 (SMART decoder)

4.3.2 Basic criteria for selection of Programmable Logic Controller (PLC)

A programmable logic Controller (PLC) selection criteria consist of, system (task) requirements, application requirements, required input/output capacity, type of input/output required, the size of memory, required speed of CPU, electrical requirements, software used, operator interface and physical environment. The criteria's are discussed in details as follows.

1. System requirements: The system requirements deal with what is to be achieved. The program design starts with breaking down the task into a number of simple understandable elements, each of which can be easily described.

2. Application requirements: The application requirements deal with input and output device required for the system. After determining the operation of the system, the next step is to determine the input and output devices like scanner, LED display board, human machine interface screen (HMI) that the system requires.

3. I/O and electrical requirements: The functions of each device are list down for the selection of hardware in the PLC. It has to check for the special operation needed in addition to discrete (on/off) logic like decoding the data, controlling the other devices. The electrical requirement checks for inputs, outputs, and system power. The electrical requirements are checked by the three items as incoming power (power for the control system), input device voltage, output voltage and current. The speed of operation is dealing with the fastest control over the system. The speed of operation is determined by considering the points as machine operate speed, detection of critical time operations or events, the time frame for the fastest action occur (input device detection to output device activation) and the counting of pulses from an encoder or flow-meter and respond quickly to the control system.

Communication involves sharing application data or status with another electronic device, such as a computer or a monitor in an operator's station. Communication can take place locally through a twisted-pair wire, or remotely via telephone or radio modem. The system also needs operator control or interaction. In order to convey information about machine or process status, or to allow an operator to input data, many applications require operator interfaces. The operator interfaces consist of pushbuttons, pilot lights and LED numeric display. Electronic operator interface devices display messages about machine status in descriptive text, display part count and track alarms. Also, they can be used for data input. The physical environment in which the control system will be located is also considered. The control system is provided with an appropriate IP-rated enclosure for harsh environmental conditions. The above discussed parameters are used for selection of programmable logic controller (PLC).

There are mainly two types of PLCs as micrologix PLC and compact logix PLC which are selected on the basis of applications. The micrologix PLC is very small in size and it is applied where operations to be performed are very less. The operations like scan the code and feed the data into the system in that case micrologix PLC used. The applications like the pick to light system, conveyor control in those cases compact logix PLC used.

In the newly designed low cost automation based pick to light and interlock system, the compact logix PLC is used. For this application Allen Bradley, Siemens PLC is suitable. Here the Allen Bradley compact logix PLC used because, in Tata Motors vehicle assembly shop, skilled labors are available to maintain the same PLC. [11]

Following are the parameters for the processor of PLC

1. Compact Logix PLC

i. Chassis power supply voltage = 24V DC

ii. Digital inputs = 24 points, sink

iii. Digital outputs = 48 points, source

iv. Analog I/O = 4 points, current non-isolated

2. Hardware selection

PLC system consists of Processor unit (CPU), Memory, Input/output, Power supply unit, Programming device, and other devices.

i. Processor unit (CPU): Microprocessor based CPU, may allow arithmetic operations, logic operators, block memory moves, computer interface, local area network, functions, etc. The processor is used for a number of check-ups of the PLC controller itself because of which errors would be discovered earlier. Processor = 1769-L24ER-QB1B (L2 Controller, 2 Ethernet/IP ports with Device Level Ring Capability, 1 USB Port) shown in figure 4.12

Figure 4.12: Processor 1769-L24ER-QB1B

ii. I/O sections: The input cards are used to monitor field devices, such as sensors, scanners and switch etc. The output cards are used to control devices such as motors, pumps, solenoid valves and lights.

Digital input card with 24 points and module 16 points, 24 V DC supply = 1769- IQ16

Digital output card with 48 points and module 16 points, 24 V DC supply= 1769- OB16, shown in figure 4.13

Figure 4.13: Digital input card- 1769-IQ16 and digital output card- 1769-OB16

iii. The PLC controllers generally work either 24 VDC or 220 VAC. The larger PLC controllers have electrical supply as a separate module, while small and medium series already contains the supply module. The PLC also requires programming device which is used to enter the required program into the memory of the processor. The program is developed in the programming device and then transferred to the memory unit of the PLC.

iv. Analog I/O module: The two terms are commonly used to describe the performance of analog input and an output module. A) The resolution defines the accuracy of the analog to digital (A/D) or digital to analog (D/A) converter within the module which can be represented as analog voltage in binary number or vice versa. B) Isolation refers to the ability of each input or output to work at voltage level independent of the system ground. Analog I/O card with 4 points = 1769-ECR (Right end cap), shown in figure 4.14

Figure 4.14: Analog I/O card = 1769-ECR

The newly designed system requires PLC communication because the master PLC is located away from the station. The one master PLC can handle seven extension modules. The extension modules are required to communicate the decisions with the master PLC and by this way, we can minimize the additional cost of the processor. Extension modules can have inputs and outputs of a different nature from those on the PLC controller. When there are many I/O located considerable distances away from the PLC an economic solution is to use I/O modules and use cables to connect these, over the long distances, to the PLC. These extension modules are also called as remote I/O panel.

Remote I/O panel

The remote I/O panel is required to communicate with master PLC. The communication options and controller preferences for remote I/O panel to the processor of master PLC are as follows:

1. Digital input selection = 64 points, sink
2. Digital output selection = 128 points, source
3. Analog I/O selection for expansion purpose = 4 points

On the basis of above discussed parameters Adapter module with analog I/O card 1734 is selected. It contains input and output cards, specialty modules and Ethernet switch.

1. Digital input card with 64 points and module 8 points, 24 V DC supply = 1734- IB8

2. Digital output card with 128 points and module 8 points, 24 V DC supply = 1734-OB8, shown in figure 4.15

Figure 4.15: Digital input card- 1734-IB8 and digital output card- 1734-OB8

3. Specialty module

The remote I/O panel is directly connected to the external input and output devices of the system by serial communication. The serial communication is required for transmitting data of one bit at a time. A data word has to be separated into its constituent bits for transmission and then reassembled into the word when received. A serial communication is used for transmitting data over long distances and it can be used for connection between a computer and a PLC. The standard methods of plc to external device communications are RS232, RS422 and RS423. The RS422 and RS423 are used for data transmits at a higher rate and at longer cable distance but its cost is high as compared to RS232. The newly designed system requires RS232 method as it does not require longer cable distance. ASCII interface is used in the system which is a human readable to computer readable translation code. The above parameters are used to select ASCII card with communication method for the I/O panel = 1734-232ASC shown in figure 4.16

4. Ethernet

Ethernet is one of the most widely implemented LAN architecture. It uses a bus, star or tree topologies. It uses the Carrier Sense Multiple Access/Collision Detection (CSMA/CD) access method to handle simultaneous demands. It supports data transfer rates of 10 Mbps, Fast Ethernet (100 Base-T) - 100 Mbps, and Gigabit Ethernet – 1000 Mbps.

Ethernet switch is selected on the basis of above discussed parameters and it is used for connectivity of system = 1783 - US5T (5 port unmanaged switch) shown in figure 4.16

Figure 4.16: ASCII card- 1734-232ASC and Ethernet switch- 1783-US5T

4.3.3 LED display board

The LED display board is operated by use of a serial port located on the PLC. This can either be a serial module or can be shared with the programming port. The setup is usually done with configuration registers/coils within the programming of the PLC. The RS-232 communication is used for a point-to-point communication, that is - only one PLC can drive one display. The cable to use is 18ga 3-conductor, shielded wire. This method is easy to use but the drawbacks are that the distance is limited, and there is some additional programming required in the PLC. The protocol used is a simple, ASCII-type protocol.

The LED display is used in LCA based system which is operated by serial port RS232 and with the configuration of coils in the programming of PLC. This LED display is taken from the unused material of industry and with small repair it has been used in the system. On the basis of above selection process, appropriate components and technique are selected. In the following section network architecture and the basic structure of PLC are described.

4.3.4 Network architecture

In this section network architecture with the basic structure of PLC is described. The network architecture is designed for Human Machine Interface (HMI) screen. This is designed with the help of “Factory Talk View Studio” software. The following figure 4.17 shows the network architecture of the system in the view machine edition. The figure 4.17 describes the orientation of components of the system in image format with its associated IPs. The nomenclature is also done in the network architecture and the connectivity represents the flow of a process in the system. In the network architecture of the system, all communication process is done through Ethernet cable. The scanner is connected to I/O panel of PLC and then connects to main PLC. Main PLC consists of 1769 processor which is used for data storage and system control. The I/O panel consists of 1734 adapter module. This module is used to collect the data of scanner and send it to the processor of PLC. This network architecture is useful to understand the new user for understanding the process, control action and for maintenance work.

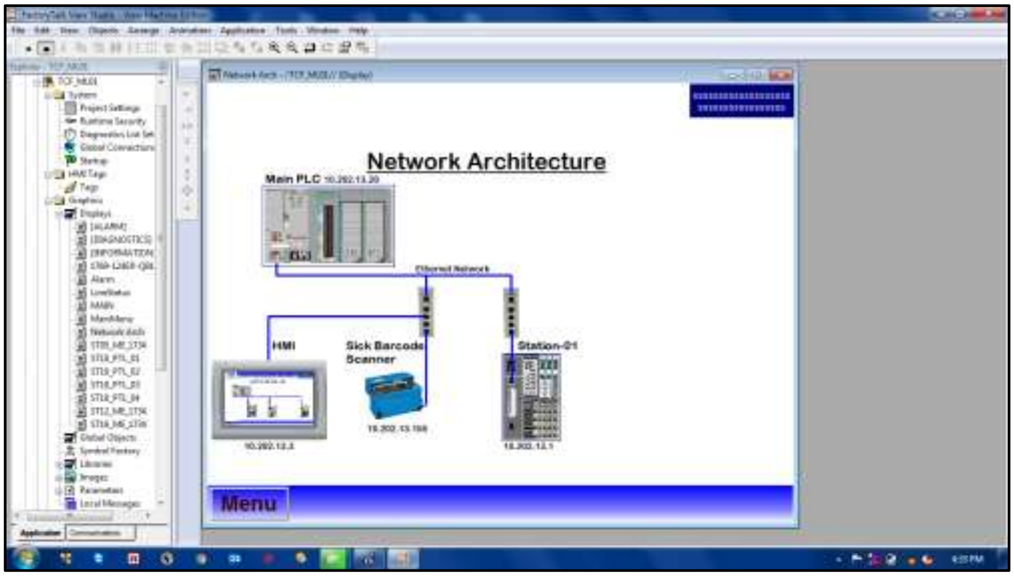

Figure 4.17: Network architecture

The basic functional components of a PLC system are the main PLC processor unit, program storage unit, power supply unit, input from the scanner and I/O panel, output to LED display and fuel dispenser unit, communication through industrial Ethernet and programming software used. Figure 4.18 shows the basic arrangement. The processor unit or central processing unit (CPU) is used to interpret the input signals and carries out the control actions, according to the program stored in its program storage unit, communicating the decisions as action signals to the outputs. The power supply unit is needed to convert the mains AC voltage to the low DC voltage necessary for the processor and the circuits in the input and output interface modules.

The programming is done in software and that program is feed into program storage unit of the processor. The program storage unit also stores input data from for processing and buffers data for output. The input and output sections are where the processor receives information from external devices and communicates information to external devices. The inputs are from the scanner and I/O panel such as vehicle identification number, its categorization according to fuel type. The outputs might be connected to LED display board and solenoid valves of the fuel dispenser unit. Input and output devices can be classified by signal type, such as digital or analog. The communication through industrial

Ethernet is used to receive and transmit data. It manages device verification, data acquisition, synchronization between user applications, and connection management [1].

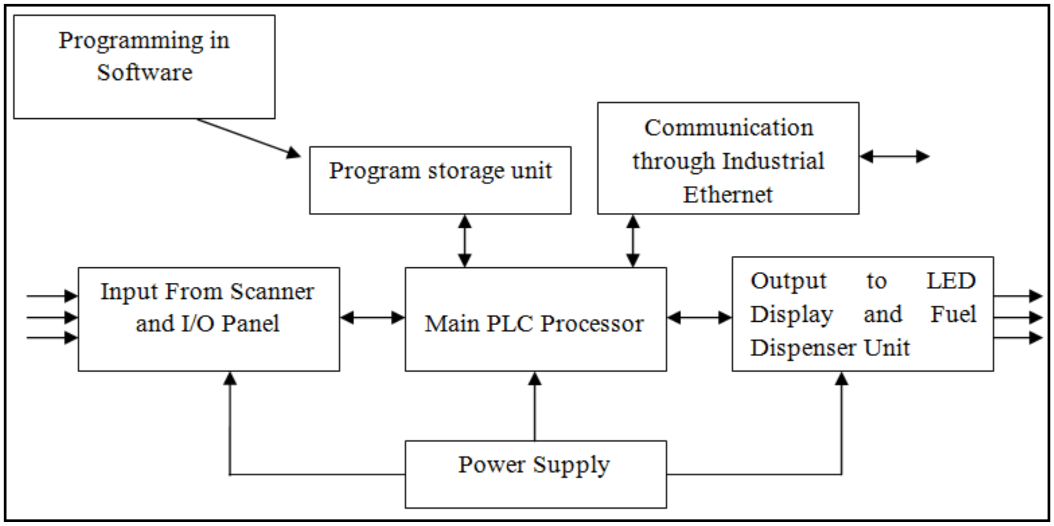

Figure 4.18: Basic structure of PLC [1]

4.4 Ladder diagram

A program loaded into PLC systems is in the form of machine code which is a sequence of binary code numbers to represent the program instructions. Nowadays ladder logic is used for PLC as a programming language that creates and represents a program through ladder diagrams that are based on circuit diagrams. Ladder logic uses graphic symbols similar to relay schematic circuit diagrams. Ladder diagram consists of two vertical lines representing the power rails. Circuits are connected as horizontal lines between these two verticals. Following are the features of the ladder diagram.

1. Power flows from left to right.

2. The output on the right side cannot be connected directly with the left side.

3. Contact cannot be placed on the right of output.

4. Each rung contains one output at least.

5. Each output can be used only once in the program.

A particular input and output can appear in more than one rung of a ladder. The inputs and outputs are all identified by their addresses, the notation used depending on the PLC manufacturer.

The ladder diagrams are prepared on the software like RSLogix, Micro/WIN programming software, S7-300 and MATLAB/SIMULINK which are used to program the system control process [3] [4] [5] [9]. The ladder diagrams are prepared and tested on 'RSLogix 5000 V20.01' to control over the working of a pick to light system and activation of the fuel dispenser unit.

4.4.1 Preparation of ladder diagram and its validation on 'RSLogix 5000 V20.01'

The ladder diagrams are prepared on the 'RSLogix 5000 V20.01' software because the PLC used here is Allen Bradley which is controlled by RSLogix. These ladder diagrams are shown in figure 4.19 to figure 4.22. The validation of ladder diagram is done successfully as shown in figure 4.23. VIN of car scanned by the scanner is compared with each VIN stored in the database and whenever VIN matches with stored data, appropriate LED display unit related with particular VIN glows and it indicates by green light as shown in figure 4.23. This program will be fed into PLC for the accurate working of the system. The detail working of ladder diagram is as follows.

The ladder diagrams are made up of different rungs. These rungs are connected with a power supply which are vertical rails shown in figure 4.19. The circuit of the system is traced from left to right in each rung. The output of rung is at far right indicated by a color change of coil. Here we made six different rungs. In the ladder diagram, after scanning the VIN of the car by scanner it is stored in middle (MID) string. The six characters of VIN are useful for our application by which we can identify vehicle model and fuel type of vehicle. Those six characters are starts from the fourth character of the VIN.

In the second rung, connectivity of supply is denoted as a healthy symbol. The VIN from the MID string is copied in the not equal (NEQ) string where it compares with no read data. The equal (EQU) strings are arranged in parallel form and it consists of VIN of high speed diesel (HSD) vehicles. This VIN of NEQ string is further taken into EQU string which can be compared with standard VIN of HSD vehicles. The HSD output and solenoid output is represented as a normally inactive coil. In this rung, the scanned VIN is matched with EQU string of HSD and it results in activation of coil HSD and solenoid coil. The colour change and output coil activation indicate that the system selects the correct LED unit with appropriate fuel dispenser unit.

In this rung, total 10 numbers of EQU strings are made. In the EQU string, the VINs with different models are stored with respect to fuel type. The HSD vehicles are ten in number so that only ten parallel EQU strings are required. If the VIN is not matched with the first string of EQU then it transferred to the next string for comparison. The VIN in the NEQ once matches with the VIN stored in EQU then the further comparison will stop and we will get the final outcome. In this way, the working of ladder logic in figure 4.19 is done.

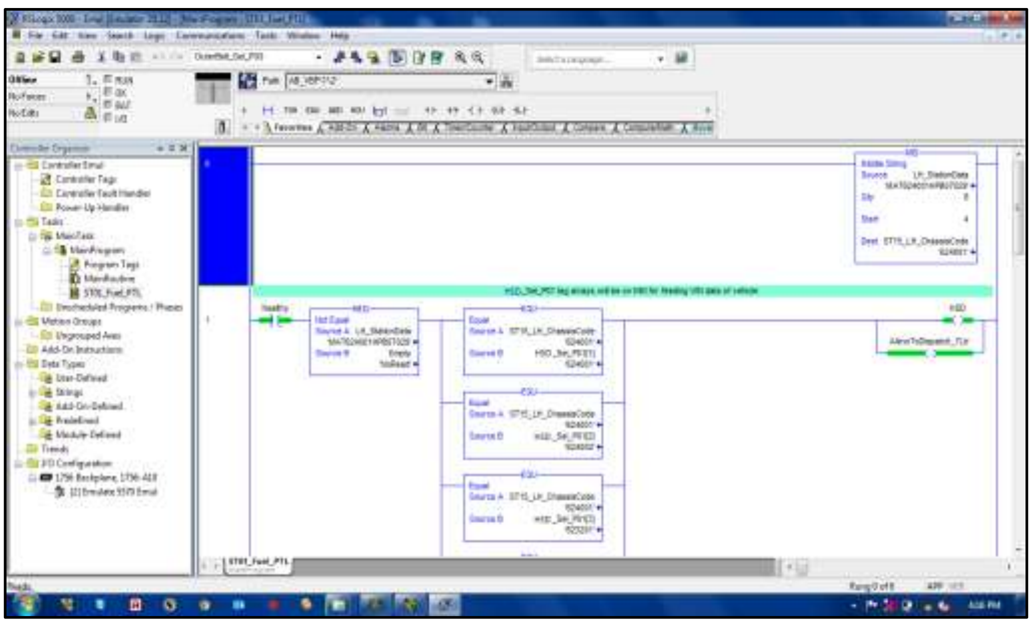

Figure 4.19: Ladder diagram for High-Speed Diesel (Domestic) vehicle

In the third rung, the VIN of unleaded petrol vehicles are stored in EQU which are compared with VIN in the NEQ string. The VIN from NEQ and EQU matches then the normally inactive coils will activate. These will represent a colour change of coil and it is represented in figure 4.20.

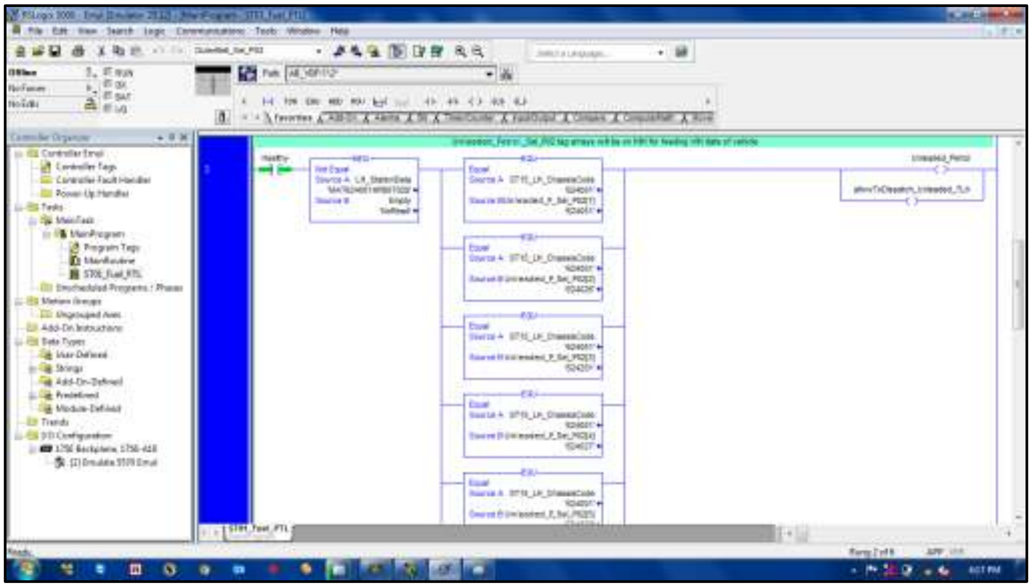

Figure 4.20: Ladder diagram for Unleaded Petrol (Domestic) vehicle

In the fourth rung, the VIN of WGD vehicles are stored in EQU strings which are compared with VIN in the NEQ string. The VIN from NEQ and EQU matches then the normally inactive coils will activate. These will represent by a colour change of coil and it is represented in figure 4.21.

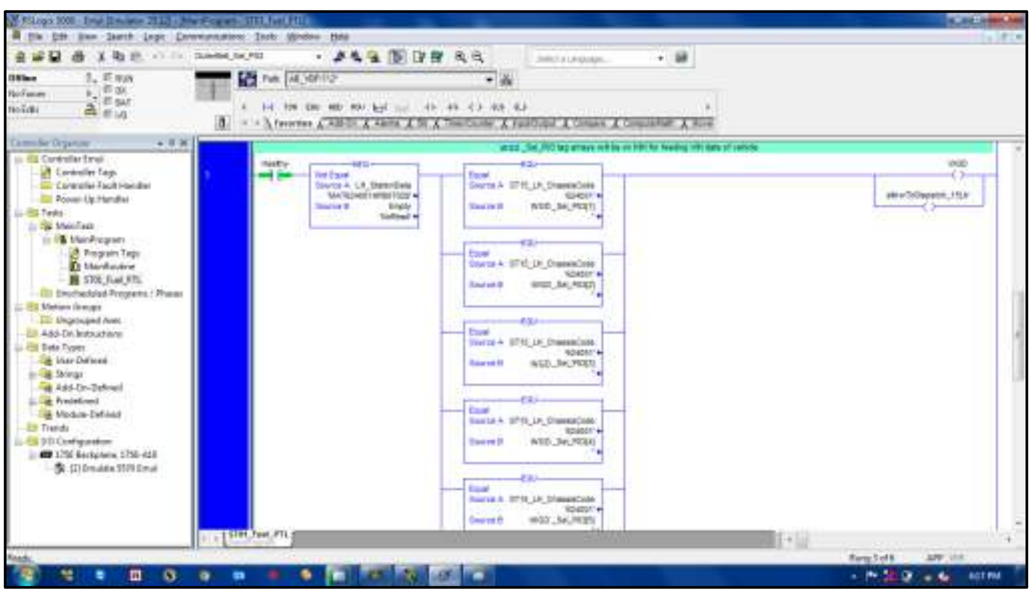

Figure 4.21: Ladder diagram for W. G. Diesel (Export) vehicle

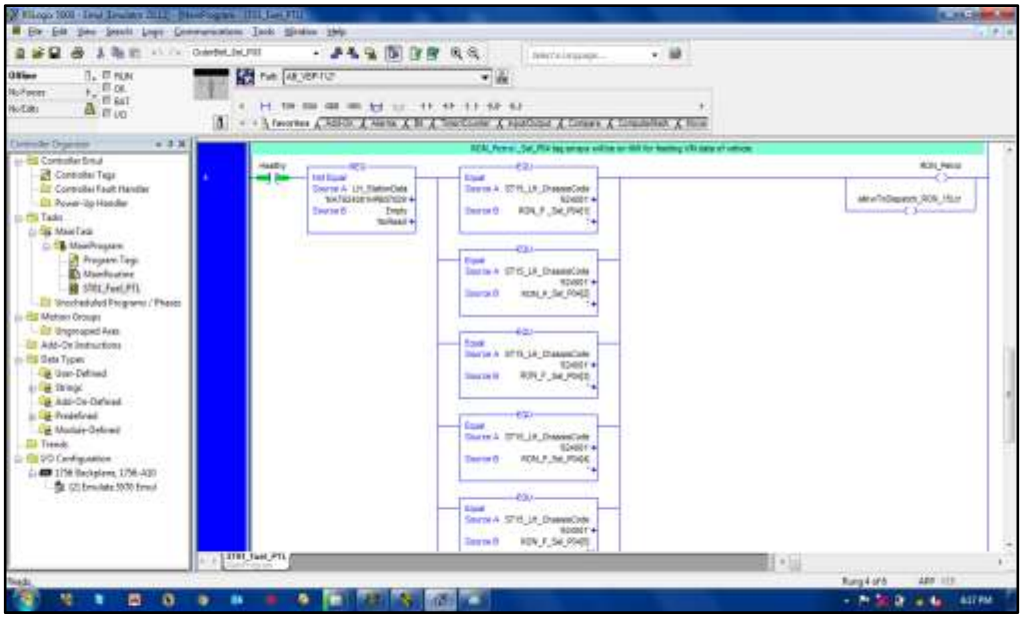

Figure 4.22: Ladder diagram for RON Petrol (Export) vehicle

In the fifth rung, the VIN of RON petrol vehicles are stored in EQU which are compared with VIN in the NEQ string. The VIN from NEQ and EQU matches then the normally inactive coils will activate. These will represent by a colour change of coil and it is represented in figure 4.22.

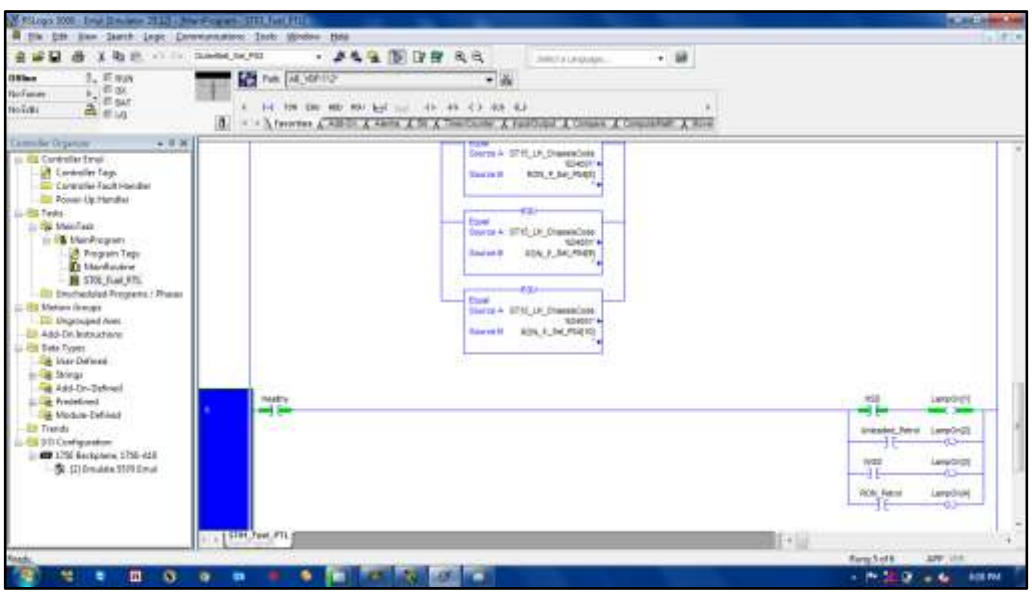

Figure 4.23: Validation of ladder diagram

In this ladder diagram, we have stored the VIN according to vehicle model and fuel type. This stored VIN is useful for comparing the scanned data. The scanned VIN while matching with the stored VIN from the rung then appropriate normally inactive coils will activate. In the same case, all other inactive coils are in the same state. The figure 4.23 represents that only HSD inactive coil is activated and others are in the same state. The cycle will reset when the proper quantity of fuel will be discharged.

The system has some failure mode as no read data comes from scanner then our system will be deactivated. The no read data from scanner doesn't match with any string in the rung due to that normally inactive coils will not be activated. This will result in no activation of the LED display as well as fuel dispenser unit. The system is totally shut down with no read data and it can scan the new VIN of the vehicle with respect to the new vehicle. In this case, manually operator has to select the fuel dispenser unit and deliver the fuel to the appropriate vehicle after that system will reset. The fix position barcode scanner has very high accuracy. Because of high accuracy of the scanner, the data can't be missed. This section results in validation of ladder diagram shown in figure 4.23 which will help us to successfully implement the system. In the following section, the actual implementation of the system is done.

4.4.2 Implementation of system

The implementation of the system consists of fix position barcode scanner, main PLC with human machine interface screen, remote I/O panel and LED display board. Figure 4.24 is shown with LED display board and fuel dispenser unit. The full system is not captured by the camera because the barcode scanner is in the cage where the vehicle dropping operation is done, the master PLC is away from the station due to safety issues, the remote I/O panel is at opposite side of the fuel filling station. The LED display is hung to the upper railings because it can save the floor are of the station and operator can see the indication of LED easily. The photographs of implementation of the scanner, main PLC and LED display board are described in the next section.

Figure 4.24: LCA based system on fuel filling station

Scanner

The system requires fix position barcode scanner shown in figure 4.25. This barcode scanner CLV 650-6120 is installed and connected with main PLC through I/O panel. The scanner is installed at a distance of 1 m from VIN of the vehicle and at a height of 0.36 m. The height provided for the scanner by stand is useful for aiming the barcode correctly. The scanner is configured by the use of software SOPAS ET. The mode of scanning is selected as autofocus mode for continuous scanning. The aiming distance scanner is selected as 1200 mm as its maximum aiming capacity is 1570 mm. The angle of deflection is set with an upper limit of -20^0 and lower limit of 20^0. These settings of the scanner result in a high accuracy of scanning with proper data transmission to the system.

Figure 4.25: Scanner CLV650-6120 in the cage

Programmable logic controller (PLC)

The system comprises of two parts of PLC as main PLC and I/0 panel of PLC. The installation of PLC requires following steps. The primary installation deals with the enclosure of the PLC disconnect device, fused isolation transformer, master control relay, terminal blocks and wiring ducts, suppression devices. The spacing controllers are used for the recommended minimum spacing to allow convection cooling. The PLC should install at a temperature from the range 0 to 60^0 C. The PLC used at extreme temperature is made with special enclosure. The power considerations, safety considerations, grounding guidelines and preventive maintenance considerations are important while installing the PLC.

The commissioning and testing of a PLC system are done after following the installation steps. All cable connections between the PLC and the plant are complete, safe, and to the required specification and meeting local standards have to be checked. The incoming power supply is checked with the voltage setting for which the PLC is set. The protective devices with appropriate trip settings have to be checked. The emergency stop button working has to be checked. All input/output devices are checked with the connected input/output points and giving the correct signals. At last check the working of emergency stop button with loading and testing the software.

In this LCA based system, by following above guidelines main PLC has been installed away from fuel dispenser unit for the safety point of view. The I/O panel of PLC has installed at 5 m away from fuel dispenser unit on the opposite side of the conveyor. The figure 4.26 and figure 4.27 shows internal structure as well as the external structure of PLC. The hardware required for PLC is defined in section 4.3.2 as per those requirements the main PLC and I/O of PLC are configured.

Figure 4.26: Internal and external view of main PLC

Figure 4.27: Internal and external view of remote I/O panel of PLC

LED display board

The LED display board is selected according to system requirement and safety. This LED display is located where the operator can easily see the indication. The LED display is used in LCA based system which is operated by serial port RS232 and with the configuration of coils in the programming of PLC. This LED display is taken from the unused material of industry and with small repair it has been used in the system. LED display is operated at 24 V DC supply by the main PLC so it has fewer chances of getting short circuit or any other damage to LED display board. The LED display board indicates that which fuel dispenser is to be select by the operator. This LED display board has taken feedback from a metering unit of fuel dispenser unit which is used to indicate the quantity of fuel delivered. It also helps to improve the industrial safety points. Figure 4.28 shows the actual interpretation of LED display board.

Figure 4.28: LED display board

4.5 Pilot run test of implemented system

The simulation of ladder diagram gives the appropriate results and on the basis of those results, actual implementation is done. This implemented system is tested on 1026 vehicles as a trial basis. In that trial, we found the no read data by the scanner for 1 time. This no read data comes because of scratch mark on VIN and wrong position of VIN. The scanner cannot scan the scratched data of VIN and wrongly attached VIN. Here we also tested the accuracy of scanner which results in 99 percent.

The scanner in the system plays important role in the system as it scans the VIN clearly and sends it to the PLC then only further operations will be done. The testing of the scanner is done in such a way that different VINs are scanned and its results are verified on the HMI screen of the PLC. The following table 4.4 shows the VINs of the vehicle and their occurrence on the HMI screen.

Table 4.4: Sample of VIN with HMI screen status

Sr. No.	VIN	HMI screen check
1	MAT601636HPC11883	Ok
2	MAT601636HPC11880	Ok
3	MAT601636HPC11873	Ok
4	MAT601636HPC11870	Ok
5	MAT601636HPC11867	Ok
6	MAT601636HPC11863	Ok
7	MAT601636HPC11863	Ok
8	MAT601636HPC11861	Ok
9	MAT601636HPC11860	Ok
10	MAT601636HPC11857	Ok
11	MAT601636HPC11856	Ok
12	MAT601636HPC11853	Ok
13	MAT601636HPC11852	Ok
14	MAT601636HPC11848	Ok
15	MAT601636HPC11847	Ok

The scanner is connected to the PLC through remote I/O panel. The remote I/O panel receives the data from the scanner and saves temporarily in it when the line is stopped. The remote I/O panel of main PLC is used as a temporary device in the LCA based system. The scanned VIN data of scanner is sent to main PLC and that data can be observed by the operator on the HMI screen. The above scanned VINs are displayed on the HMI screen as follows in figure 4.29 with no loss of data. In this data, we have scanned one of the VIN for two times to check the efficiency of the scanner. The components with their IPs are also tested in the system on the HMI screen in figure 4.30.

Figure 4.29: Display of VIN on HMI screen

The network architecture is designed in the section 4.3.4 with the help of "Factory Talk View Studio" software is also checked on the HMI screen of the PLC. This network architecture is used for the maintenance work of the whole system and it is shown in figure 4.30.

Figure 4.30: Display of network architecture on HMI screen

The pilot run of the LCA based fuel filling system is taken on the station. The test results of the scanner are done on offline mode. These results give the accuracy of the scanner with high efficiency. On the basis of those results, the location of the scanner is finalized in the cage at a distance of 1m from the VIN. The LED display is tested after its rework. The testing of LED display is done by connecting it with PLC and it gives the correct result. The pilot run of LCA based fuel filling system was carried out in online mode for six working days. The cycle time is recorded for vehicles online with domestic as well as export categories. The following table 4.5 and figure 4.31 shows the reduction of cycle time by 10 seconds.

Table 4.5: Cycle time recorded for new system

Days	HSD	Unleaded Petrol	WGD	RON Petrol
1	37	37	82	81
2	48	37	81	81
3	37	39	83	82
4	38	37	81	81
5	37	37	81	81
6	37	38	81	82

On the second working day, one HSD vehicle's VIN is not scanned by the scanner because of the scratch mark. The no read data comes in the system due to that the system is reset for that task. For this case manual fuel filling is done which leads to increase its cycle time by 11 seconds and is shown in figure 4.31.

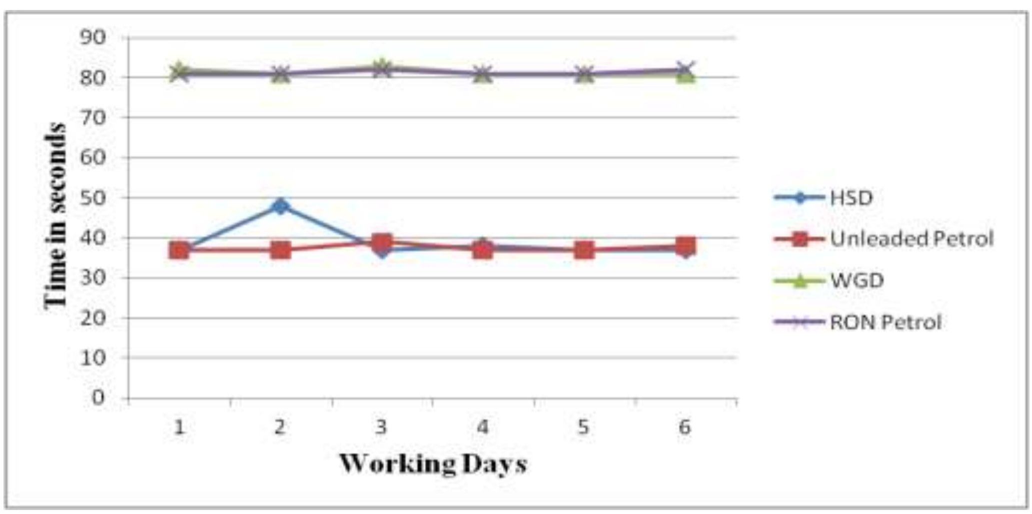

Figure 4.31: Cycle time of process with working days

4.6 Observations and remarks

In this chapter, the design of system layout, dimensional layout according to station survey and flowchart of the system is described which gives the working of the LCA based system. On the basis of the design, system requirements and application requirements the scanner, PLC and LED display board are selected. For the system to be implemented, the ladder diagrams are prepared and validated on the RSLogix 5000 V20.01, the results of validation show that system will work efficiently and effectively. The installation of components is done on the basis of layout design, system requirements and space constraint on the station and operators feasibility. We have conducted the pilot run test of the LCA based system on 1026 vehicles and the system reset case happen for one time due to the scanning problem of scratched barcode. The continuous monitoring of working of the system is done and the cycle time is recorded for the new LCA based system.

Chapter 5

RESULTS AND DISCUSSION

The aim of the dissertation work is to achieve the objectives of the problem which is discussed in chapter 1. The organization is working on the world class quality phase 3 in which the main task is defect should not leave the station. Tata Motors car plant uses a mixed model type of assembly line on their vehicle assembly shop due to that the problem of wrong fuel filling to the vehicle is done. The defect is generated at the fuel filling station because of a manual process. The main task of world class quality phase 3 is not fulfilled by this station due to a manual process. There is a need to automate the fuel filling station at low cost to overcome the issue of wrong fuel filling process. The new design and developed LCA based fuel filling system, automate the process and is used to minimize the issue.

5.1 Observations after implementing LCA system

The study of the existing system is used to find the process defect which has been minimized by the LCA based system. The newly designed LCA based system with the dimensional layout is used to define the location of the machines according to station survey and it can also use for the selection of components and techniques used in the system.

The scanner is selected on the basis of the type of barcode used in VIN, a distance of scanner to barcode and code family. The test results of the barcode scanner show that the selected scanner CLV650-6120 is more efficient. The only drawback scanner is that it cannot scan the scratched barcode. The provision is made for the scratched barcode in the programming of PLC is to reset the system for that task. The main PLC with remote I/O panel is required to eliminate additional cost of the processor and minimizes safety issue if installed near to fuel filling station. The PLC with remote I/O panel is selected here on the basis of system (task) requirements, application of the system and other devices connections.

The LED display board is taken from the unused material of industry with small rework. This LED display is controlled by the PLC through remote I/O panel. The LED display is communicated by the RS232 method and it is hung to the upper railings of the station. The hanging of LED display board results in saving the flooring space of station and minimizes the safety issues. This LED display is hung in such a way that operator can easily see the indication on the LED display and accordingly process of fuel filling is carried out by the operator. The indication of LED display reduces the categorization time of vehicle with fuel type by the operator. The PLC of the system controls both LED display board as well as fuel dispenser unit. The control of PLC on the fuel dispenser unit through solenoid valve reduces the chances of wrong fuel delivery to the vehicle. This also indicates the operator to select appropriate fuel dispenser unit with respect to vehicle model. The control of the system over its components leads to lower down the wrong fuel filling issue. The pilot run of the system results gives the better efficiency of the system on the manual process.

The pilot run of new LCA based system is tested on fuel filling station for six working days. In these six working days total 1026 vehicles were passed through the LCA based fuel filling system. In that pilot run test, we found the cycle time reduction by 10 seconds in the process. In the manual process the cycle time for fuel filling process is stated as 91 seconds, but now it is recorded as 81 seconds. The time required to fill the fuel in domestic vehicle and export vehicle is 37 second and 81 seconds respectively.

In the pilot run test, it is observed that the no read data is sent to the PLC by the scanner for 1 time. This no read data comes because of scratch mark on VIN and wrong position of VIN. The scanner cannot scan the scratched data of VIN and wrongly attached VIN. This issue is also reduced by using the hand scanner. The barcode of VIN on the “B” pillar of VIN is not scanned by the fix position barcode scanner then supplementary hand scanner is used for scanning the VIN on the history card of the vehicle. This hand scanner requires the extra cost and extra time for scanning VIN of the vehicle. In this case, go for the manual process is a better option. This manual process requires the 10 seconds delay in the operation but saves the additional cost of the scanner.

5.2 Opportunity for workload balancing by the dissertation work

In the manual fuel filling process, the categorization of vehicle and selection of fuel dispenser unit is done by the operator. These activities require 10 seconds as mentioned in table 3.1 and 3.2 of the study of existing system chapter. The time required for the process of fuel filling of domestic and export vehicle is 37 seconds and 81 seconds respectively.

On the next station, one operator is assigned for battery tray fitment and fuel sticker fitment which has a cycle time of 101 seconds. At the same time, the operator of the fuel filling station requires the cycle time of 91 seconds shown in figure 5.1.

The LCA system reduced the cycle time of fuel filling station by 10 seconds. In order to balance the workload between the successive stations, the 10 seconds work of sticker pasting is shifted to the operator of fuel filling station shown in figure 5.2.

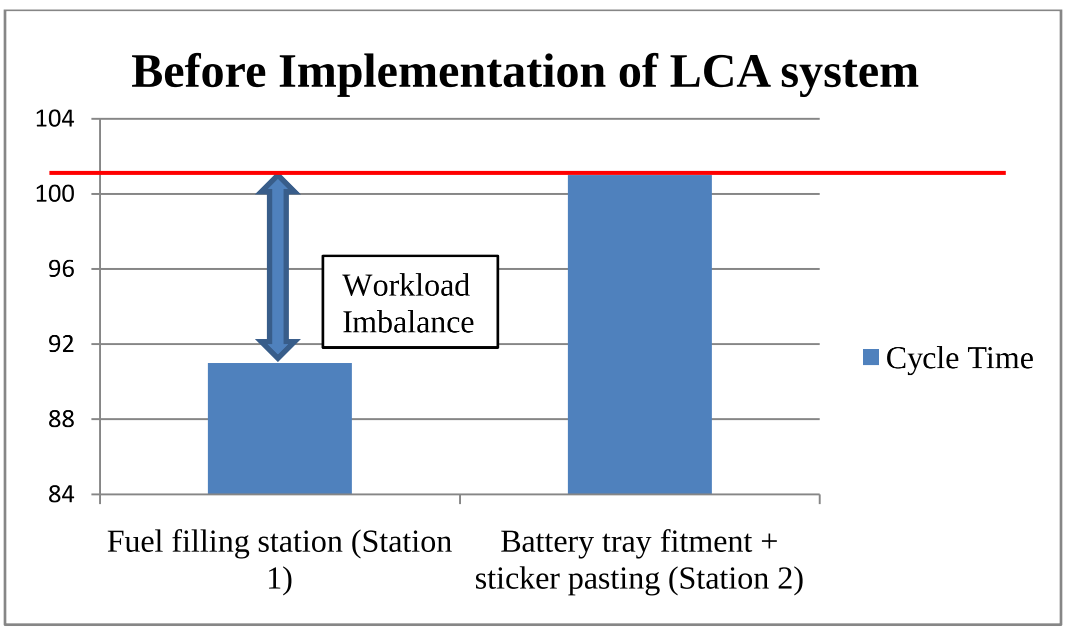

Figure 5.1: Imbalanced workload for successive station in the existing system

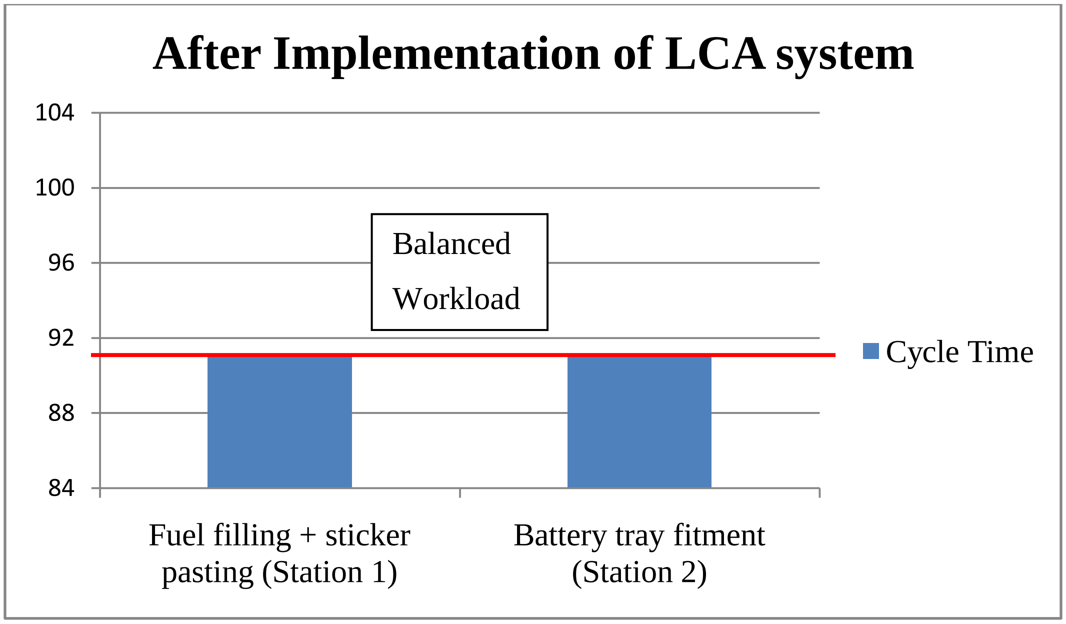

Figure 5.2: Balanced workload for successive station after implementation of LCA

5.3 Economic benefits of the dissertation work

In the manual fuel filling process, the organization faces the issue of wrong fuel filling to vehicle averagely with 1 or 2 vehicles per week. This issue has major rework such as fuel line and tank removal, flushing it with air, and again fitment of all parts to the vehicle. Because of this, the time required for completion of a rework operation is near about 8 hours by a single worker. For that, required rework cost of operation is about 2000 rupees per vehicle. It also affects the continuous flow of vehicle and because of that further workers remain idle. Because of this sometimes ideal cycle time of 91 sec is not followed. On the basis of those defective products rework cost is calculated.

5.3.1 Saving of annual rework time

The rework time is required for wrong fuel filled vehicle is very high. This rework includes fuel line and fuel tank removal, flushing it with air, and again fitment of all parts to the vehicle. This rework is done by the single operator which requires 8 hrs for that rework. The time required for the rework of 81 vehicles in the year 2015-16 is as follows:

Total rework time = 8 hrs × 81 vehicles

= 648 hrs in the year.

The LCA based system is a full proof system which does not create any defect to the vehicle. This system is used to minimize the defect generated by wrong fuel filling and hence it will help to reduce the rework time required for the defective vehicle.

5.3.2 Saving of annual rework cost

The data from the table 3.3 shows that the occurrence of defective products in the year 2015-16. The wrong fuel filling cases in the year 2015-16 impacts on the quality of 81 vehicles. The data from the table 3.4 shows the DRR of line. The quality defect is observed in 1 or 2 vehicles averagely per week but according to DRR concept, it has been rework and again tested which gives the required result. The DRR requirement is 100% but due to that defect, it doesn't match the goal of DRR. The rework operation has been done by the single operator and his one day wage is considered as rework cost. In the wrong fuel filling case of a vehicle, the material part of the vehicle is not affected and due to that material cost of operation is not considered.

Total rework cost of defective products in the year = 2000 × 81

= Rs. 162000

The system requires fix position barcode scanner, PLC with remote I/O panel, field wiring and LED display board. The following table 5.1 represents the cost of the system.

Table 5.1: Cost of LCA system

Sr. No.	Required components/ instruments	Cost in Rupee
1.	Fix position barcode scanner	3,00,000
2.	PLC with remote I/O panel	1,00,000
3.	Field wiring	10,000
4.	LED display board	500
	Total	**4,10,500**

5.4 Return On Investment (ROI)

ROI measures the amount of return on an investment relative to the investment's cost. To calculate ROI, the benefit (or return) of an investment is divided by the cost of the investment, and the result is expressed as a percentage or a ratio.

$$\text{Return on Investment} = \frac{[\text{Gain From the investment} - \text{Cost of investment}]}{\text{Cost of investment}}$$

ROI is key performance indicators (KPI) that are often used by businesses to determine the profitability of expenditure. The ability to calculate return on investment is extremely valuable for any business, regardless of size or industry.

The LCA based fuel filling system is implemented and its total cost is Rs.410500. The company has made a contract with PLC manufacturer with 15 years for its lifespan. In this case, the company is going to pay Rs. 5000 per year for service maintenance and Rs. 4000 per year for part cost. On the basis of this maintenance cost of the system is calculated for 15 years as follows.

Maintenance cost = 15 years × (Rs 5000/year for service + Rs. 4000/year for part)

= 15 years × (Rs. 9000/year)

Maintenance cost = Rs. 135000

In this system, the scanner used is CLV 650-6120 which has a service life of 40000 hrs [12]. The scanner is running for 8 hrs of the shift and for 295 working days in one year.

Working time in hrs for one year = 8 hrs (shift time) × 295 days

= 2360 hrs

Life of scanner in terms of year = (service life in hrs/working time in hrs)

= (40000/2360)

=16.94 years approximately 17 years

The lifespan of the scanner is approximately 17 years so that its maintenance cost is not considered here. Therefore the maintenance cost of PLC comes under the investment cost for the calculation of ROI.

Investment cost = System cost + Maintenance cost

= Rs. 410500 + Rs. 135000

=Rs. 545000

The gain from the investment is calculated by the net profit for the lifespan of the system.

Gain from the investment = 15 years × Rework cost in one year

= 15 years × Rs.162000

= Rs.2430000

On the basis of investment cost and gain from the investment, ROI can be calculated.

$$\textbf{Return On Investment} = \frac{[2430000 - 545000]}{545000}$$

= 3.4587

Return On Investment = 3.4587

The ROI is 3.45 times more than the investment cost of the LCA based system by considering service life of PLC as 15 years. This ROI indicates that the system is beneficial to the organization.

5.5 Observations and remarks

The pilot run has tested and it is observed that 10 seconds of time has saved in this system on each vehicle. This saved time is used to balance the workload of the operator on the next station by shifting his 10 seconds activity to the fuel filling operator. The system failure rate is not observed hence defective products are not generated. This helps to improve the quality of product and causes improvement in DRR. The LCA based system will save the annual rework time and annual rework cost. The ROI is 3.45 times more than the investment cost of the LCA based system.

Chapter 6

CONCLUSION

Low Cost Automation popularly known as LCA integrates the simple mechanical, electrical, pneumatic and hydraulic devices into the existing production process or machinery by keeping the target of improvement in productivity. In an industry where the fully automated system is not required, LCA gives a proper solution for that process. In this work manual fuel filling system has been successfully automated with low cost. The LCA based fuel filling system is designed successfully with the help of system requirements such as fix position barcode scanner, LED display board, interlock system and PLC control system. The barcode scanner, PLC with remote I/O panel, LED display board is selected with the help of design considerations, application requirements, station survey and industrial safety rule. The LCA based system is successfully implemented on the fuel filling station and the pilot run is tested on six working days. The results of pilot run show the elimination of human interference in the LCA based process by automatically categorization of the vehicle and also reduces the cycle time. The LCA based system acts as a mistake proof system due to that defect will not be created which eliminates the rework and improves the quality of product with ensuring DRR.

The automated system is developed and implemented at a cost of Rs. 410500 which is very low as per its minimum service lifespan of 15 years. The calculation of ROI shows that the investment of LCA gives profit up to 3.45 times more than the investment cost.

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APPENDIX - I

Vehicle model with VIN and vehicle chassis code

	Model	Vehicle Identification Number (VIN)	VC NO.	Fuel type	Domestic / Export
INDICA	Indica LS Refresh (MY 13)	MAT600185GPF16623	54025624AR	Diesel	Domestic
	Indica LX Refresh (MY 13)	MAT600175GPF18091	54025524AR	Diesel	Domestic
	Indica LS 13" Refresh (MY 13)	MAT600435GPF16556	54024624AR	Diesel	Domestic
	Indica LX 14" Refresh (MY 13)	MAT600461GPN43653	54024724AR	Diesel	Domestic
	Indica GLS CNG	MAT600636GPN43117	54029924A	Petrol	Domestic
	Indica XETA GLS	MAT600284GPF17879	54029724A	Petrol	Domestic
INDIGO	Indigo eCS LS Refresh (MY 13)	MAT607331GPN43306	54013525A	Diesel	Domestic
	Indigo eCS LS Refresh (MY 13) DCM 2.5	MAT601445GPF16541	54013625A	Diesel	Domestic
	Indigo eCS LX Refresh (MY 13) DCM 2.5	MAT601469GPG21284	54014625A	Diesel	Domestic
	Indigo eCS LS CRAIL NON AC	MAT601446GPF18380	54019325A	Diesel	Domestic
	Indigo eCS LS TCIC NON AC	MAT607332GPN43258	54019425A	Diesel	Domestic
	Indigo eCS GLS CNG	MAT601636GPN43654	54019525A	Petrol	Domestic
BOLT	BOLT XE QJET BS4 VAVE	MAT611601GPN43275	54270424A	Diesel	Domestic
	BOLT XM ABS VAVE	MAT611660GPN43267	54272524A	Diesel	Domestic
	BOLT XMS ABS VAVE	MAT611659GPF18113	54272424A	Diesel	Domestic
	BOLT XT QJET ABS BS4 VAVE	MAT611465GPG21744	54270124B	Diesel	Domestic
	BOLT XE 1.2RT BS4 VAVE	MAT608001GPF16801	54275424A	Petrol	Domestic
	BOLT XM RT	MAT608075GPF17869	54278024A	Petrol	Domestic

	ABS VAVE				
	BOLT 1.2RT BS4 VAVE	MAT608051GPG20444	54275124B	Petrol	Domestic
ZEST	ZEST XE QJET VAVE	MAT624002GPN43268	54221224A	Diesel	Domestic
	ZEST XM QJET ABS VAVE	MAT624031GPN43280	54221424A	Diesel	Domestic
	ZEST XMS QJET ABS VAVE	MAT624030GPN43304	54221324A	Diesel	Domestic
	ZEST XT QJET ABS	MAT624051GPN43624	54220124A	Diesel	Domestic
	ZEST XTA QJET ABS	MAT624201GPD11619	54220424A	Diesel	Domestic
	ZEST XMA QJET ABS	MAT624027GPC11186	54220524A	Diesel	Domestic
	ZEST XE RT VAVE	MAT623202GPF16570	54226324A	Petrol	Domestic
	ZEST XM RT VAVE	MAT623231GPF16553	54226524A	Petrol	Domestic
	ZEST XMS RT VAVE	MAT623232GPN43266	54226424A	Petrol	Domestic
	ZEST XT RT ABS BS4 VAVE	MAT623251GPF16720	54225324A	Petrol	Domestic
EXPORTS	INDIGO LHD DLX TCIC E-III	MAT607157HPL00181	288921250L	High speed Diesel	Export
	ZEST XT LHD QJET	MAT624052HPL10020	54221924A	High speed Diesel	Export
	BOLT XT LHD QJET	MAT611470HPL10025	54271324A	High speed Diesel	Export
	INDIGO LHD GLX III	MAT601292HPL00124	28896025AL	High speed Petrol	Export
	S A BOLT XT RT	MAT608052GPRA0541	54277224A	High speed Petrol	Export
	S A BOLT XMS RT	MAT608072GPRA0606	54277124A	High speed Petrol	Export
	SA ZEST XT RT	MAT623256GPRA0524	54225924A	High speed Petrol	Export

LIST OF PUBLICATION ON PRESENT WORK

Dubal, S., and Telsang, M. (2017) "Design and development of low cost automation system at fuel filling station on vehicle assembly line", *Proceedings of 2nd National Conference on Recent Trends in Mechanical Engineering (NCRTME – 2017),* ISBN: 978-81-931546-5-6.

Status: Published

Dubal, S., and Telsang, M. (2017) "Low cost automation at fuel filling station: A case study of Automobile Industry", *International Journal of Automation and Control*.

Status: Submitted

K. E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

An Autonomous Institute

Synopsis of M.Tech. Dissertation

1. Name of Program : M.Tech. (Mechanical-Production Engineering)
2. Name of Student : Mr. Shreekumar Vijaykumar Dubal
3. Enrollment No : 1522001
4. Date of Registration : July 2016
5. Name of College Guide : Dr. M.T.Telsang
6. Name of Industry Guide : Mr. Nitin J. Barge [Head-Vehicle assembly shop]
7. Sponsor’s Detail : Tata Motors Ltd., Chikhali, Pune.
8. Proposed Title : Design and development of low cost automation system at fuel filling station on vehicle assembly line
9. Synopsis of Dissertation Work:

9.1 Relevance

Now days for any industry to survive in the competitive market, automation is must. For system to be automated in any industry, huge capital cost is required. And for quick return on investment requires mass production. Hence Large Scale Industries can afforded and optimize the option of automation, whereas medium and small scale industries find it very difficult to adopt automation. Low cost automation (LCA) is one solution especially for medium and small scale industries and also in large scale industry where fully automated system is not required.

Low Cost Automation (popularly known as LCA) is the introduction of simple pneumatic, hydraulic, mechanical and electrical devices into the existing production process or/and machinery, with a view to improving the productivity. These would also enable the operation of these equipments by even semi-skilled and unskilled labor, with a little training. This will involve the use of standardized parts and devices to mechanize or automate machines, processes and systems. LCA is a technology that creates some degree of automation around the existing equipment, tools, methods, people, etc., using mostly standard components available in the market with low investment so that the payback period is short.

The current financial crisis faced all over the world has posed tremendous challenges on the manufacturing organizations. Even at low volumes, and large variety, they have to be competitive with minimum investment. Low cost automation can play an important role in this situation.

In the Tata motors car plant pune, Indica, Indigo, Zest and Bolt cars are manufactured. These cars are of different models with domestic and export categories. Here the problem occurred at fuel filling station on vehicle assembly line which is manually operated. Sometimes due to ignorance or lack of experienced operator petrol is filled in diesel car and vice versa. For that low cost automation system is implemented over there which will solve the problem of fuel filling. This low cost automation system consists of components fix position barcode scanner, LED, interlock system and control system.

9.2 Present Theories and Practices

Bayindir and Cetinceviz (2010) presents a water pumping control system that is designed for production plants and implemented in an experimental setup in a laboratory. The control systems that it uses are a programmable logic controller (PLC) and the main function of the PLC is to send a digital signal to the water pump to turn it on or off, based on the tank level, using a pressure transmitter and inputs from limit switches that indicate the level of the water in the tank. [1]

Patel et al. (2014) presenting a process loop that can be used in bottle washer machine. A holistic approach is used here to control liquid. Here programmable logic controller is used to control parameters as level, flow and pressure of liquid. Different sensors and valves are used with PLC, which are controlled by program. [2]

Sugure et al. (2013) propose a virtual prototyping system that can evaluate failure mode and effect analysis. This virtual prototyping system which consists of co-simulation environment between mechanics model and microcontroller model is integrated a fault-injection system and the approach was applied to a validation of vehicle engine control. [3]

Lodha et al. (2015) design and develops automated pouch packaging machine. An additional weighing and pouring mechanism has been added to increase the accuracy of the system. Various processes involved in the pouch packaging are neatly aligned and properly timed to get optimum production rate. A mechatronics system, developed for this machine, which takes feedback from sensors and accordingly controls the manipulators has been introduced in this paper. A microcontroller system is used for this particular machine. [4]

From the above literature it is observed that low cost automation is applicable to the particular station which is bottleneck or key machine. It is important there because once the problem at that station is solved, then idle time of that operator will reduce, rework is eliminated, less cycle time required to complete the task, increase in productivity and also less fatigue to operator. Also by all other benefits of low cost automation line balancing is done on that particular line. Some of the authors are using this low cost automation for making new special purpose machine by the use of scraps. Some are using this low cost automation for designing fixtures, pallets, some sensory feedback etc. also some are using PLC technique, microcontroller technique for design and development of low cost automation system. The low cost automation system is not properly implemented by using components, instruments and techniques.

9.3 Problem statement

In Tata motors (car plant) ltd., Chikhali, Pune on vehicle assembly line, correct fuel filling to appropriate vehicle has got problem. In their vehicle assembly shop, mixed model type assembly line is used.

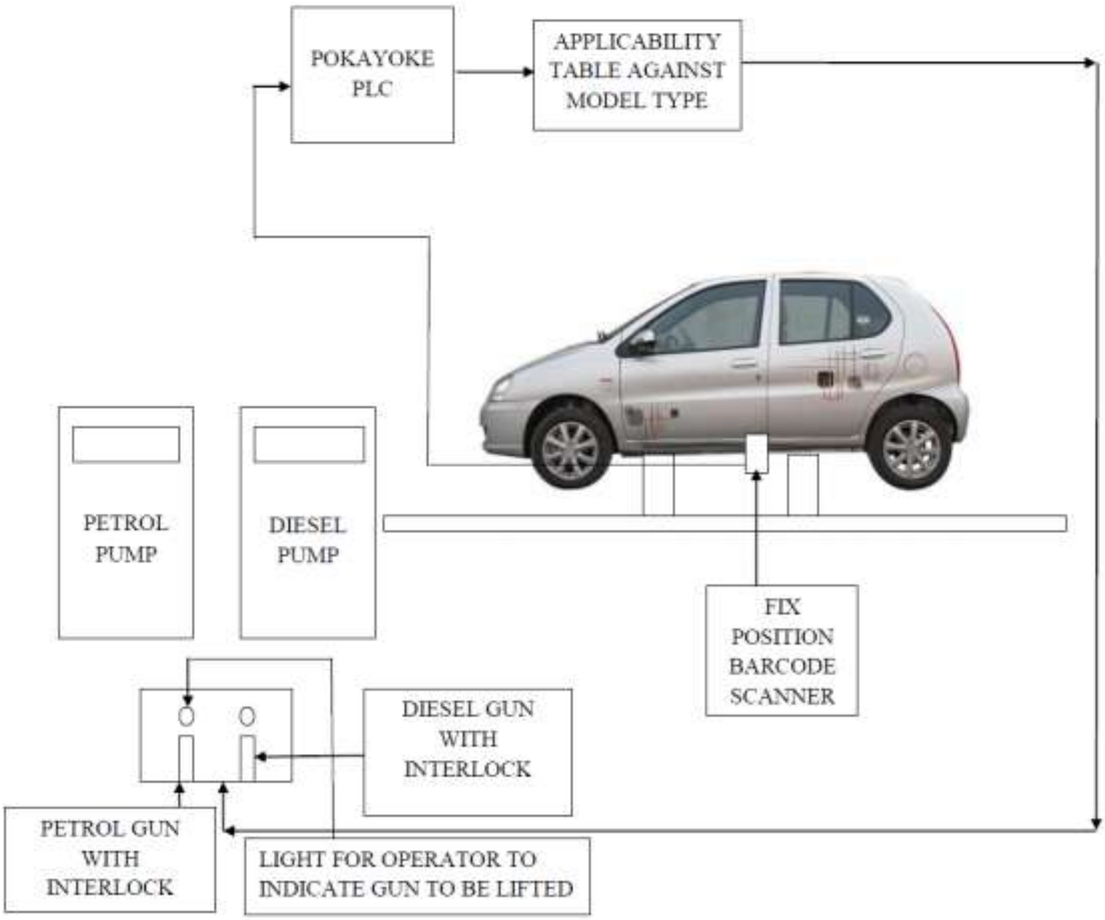

Fig.1: Proposed System Layout of Fuel Filling Station

In the vehicle assembly shop at underbody line engine assembly with fuel tank is fitted and then vehicle send to mechanical line. At mechanical line of vehicle assembly shop fuel filling operation of vehicle is done. This fuel filling station is manually operated. The operator identifies the vehicle on his experience by reading the code. There is no standard technique provided at that station like scanning the code which will helps to identify the vehicle and lack of this technique sometimes problem occurred in fuel filling process. This problem identifies by auditor at quality gate by vehicle ignition operation. This issue recorded per week with 1 or 2 vehicles. So rework done like fuel line removal and flush it with air, tank removal and flushing and again fitment of all parts to vehicle. So the time required for particular operation is near about 8 hours to a single worker. For that rework cost of operation is about 2000 rs. per vehicle. It also affects the continuous flow of vehicle and because of that further workers are idle. So there cost of operation is also considered under loss. It shows increase in cycle time and ideal cycle time is not follow and also it gives poor quality to customer. Hence there is need to correct that operation on that station only and for that low cost automation system is the solution.

Probable estimation of system is as follows:

Table 1: Probable estimation of material required

Sr. No.	**Required components/ instruments**	**Cost in Rupee**
1.	Fix position barcode scanner	3,00,000
2.	PLC	1,00,000
3.	Wiring	10,000
4.	LED lamps (4)	500
	Total	**4,10,500**

9.4. Objectives

- To design the low cost automation system for fuel filling station on vehicle assembly line by using fix position scanner, LED, interlock system and control system.

- To implement low cost automation system at fuel filling station to ensure correct fuel type with respect to vehicle model during fuel filling process and hence ensure DRR of line .
- To minimize the human interface at that station and elimination of rework occurring due to wrong fuel filling on vehicle assembly line.

9.5. Scope of the work

In the Tata motors car plant, at fuel filling station all operations are done manually. Sometime mistakes are done at fuel filling in the vehicle due to lack of observation of operator. So to avoid that, from vehicle entry to that station some standardization is required to avoid rework and improve product quality. Design and development of low cost automation system at fuel filling station solves that problem. For the standardization and LCA system to be implemented, vehicle identification with scanning is required. Then it is categorized according to petrol and diesel vehicle. Once it is categorized, only petrol gun or diesel gun is released from holding stand by using signal from PLC, LED ignition and control system. By checking all feasibility with cost and standard norms of company, the system implemented at that station and results compared with previously manual operations.

9.6. Proposed Work

Phase I – Literature survey and Study of existing manufacturing system

- Study of existing manufacturing system on the vehicle assembly line.
- Study of low cost automation components, instruments and techniques which will be used at that station.

PhaseII – Design of low cost automation system

- Design the low cost automation system with component as fix position scanner, LED, instrument as interlock system and technique as PLC for the same problem.
- Development of program and ladder diagram for the operation by using software as RSLogix 5000 V21 or S7-200.

PhaseIII– Implementation of automation system on that station

- This low cost automation system will be implemented on that station and actual analysis will be done in this phase.
- This phase will also include resource management required during implementation.

PhaseIV – Results and conclusion

- The result of newly implemented system will be taken and compared with previous systems which will helps to prove the objectives of dissertation.
- Dissemination of dissertation and journal papers.

9.7. Proposed Plan (Time and Activity Chart)

Sr. No.	Activity/ Month	Jul 16	Aug 16	Sep 16	Oct 16	Nov 16	Dec 16	Jan 17	Feb 17	Mar 17	April 17	MAy 17	June 17
1	Literature survey												
2	Study of existing system												
3	Design of the low cost automation system												
4	Implementation of LCA system on that station												
5	Results												
6	Comparison and conclusion												
7	Draft												
8	Preparation of manuscript for journal and conferences												
9	Preparation and submission of Report												

10. Expected date of completion of work: **-** April 2017.

Date:

Place: Rajaramnagar

Shreekumar V. Dubal	**Mr. Nitin J. Barge**
Student	**Industry Guide**
M.Tech Mechanical	**Shop Head-TCF**
R.I.T. Rajaramnagar.	**Tata Motors Ltd.**

Dr. M.T.Telsang	**Dr. S.K. Patil**	**Dr.S.S.Gawade**
Guide	**Head of Program,**	**Head of Department,**
Mech. Engg. Dept.	**M. Tech Production**	**Mech. Engg. Dept.**
R.I.T. Rajaramnagar	**R.I.T. Rajaramnagar.**	**R.I.T. Rajaramnagar.**

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VITAE

Name of the Student: Dubal Shreekumar Vijaykumar (Roll No 1522001)

Permanent Address: 179, Water Tank Area, Mhopre,
Tal-Karad, Dist-Satara,
Maharashtra-415114, India.

Email: shreekumar1992@gmail.com

Contact No.: +91 9403011054

Date of Birth: February 15, 1992

Mr. Dubal Shreekumar Vijaykumar, obtained B.E. in Mechanical Engineering from Savitribai Phule Pune University, in 2014. He obtained M. Tech in Mechanical Production from Rajarambapu Institute of Technology in 2017. His Master's thesis was related to the design and development of low cost automation system at fuel filling station on vehicle assembly line. His research interest is in Production Management, Manufacturing Quality and Automation. He has published 1 National conference paper and submitted 1 International journal paper till date.