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Lean Manufacturing for Productivity Improvement

Krunal Desai
M.tech Student at School of Electrical Engineering,
VIT University Vellore, Tamilnadu
desaikrunal23@gmail.com

Dr. K.V.L.Narayana
Professor at School of Electrical Engineering,
VIT University Vellore, Tamilnadu.
kvlnarayana@vit.ac.in

Abstract-This Paper describes improvement in functioning of water pump in assembly line. By using Lean manufacturing tools like Poka – Yoke, the performance of assembly line should be improved. Programming of all five stations is done in Mitsubishi Nexgen PLCs and Mitsubishi HMI Ms60ct Software. Main Objective of project is reduction in lead time by programming of the stations which will lead to improve productivity, minimizing scrap cost, reduces human element so to prevent from human errors. Two subs- Stations are directly connected to the external devices like Leak testing Unit F-510 and 2D marking. The experiment results explain 35 seconds gap between manual and proposed method operation. Comparison of figures of scrap cost shows that D-Plug substation has high rejection level. Accuracy can be improved of water pump in automatic mode as compared to manual mode.

Keywords: *Lean manufacturing, Mitsubishi Nexgen PLCs, Mitsubishi HMI Ms60ct, Reducing lead time, Reducing Scrap cost, Leak testing Unit F-510, 2D marking and reading.*

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I. Introduction

Lean Manufacturing is process of identifying and eliminating waste through continuous improvement by flowing product. There are 5 different assembly stations for DAF water Pump. All five stations consists sub-parts of water pump. Water pump is fitted into the DAF Trucks. There are 25 essential tools of Lean Manufacturing. But Main tools like Poka yoke and Autonomation can be used in project. Autonomation refers to the process due to which substation will automatically stop whenever defects occur. Multiple Stations can be monitored by persons and quality of the product can be improved. Because of Poka- Yoke technique there are lesser the chances of mistakes [4]. This technique helps to recognize defect of product & process and also improves quality and reliability. It is technique which is use methods in products and process designs which can prevent human and mechanical errors.

II. Methodology

Block diagram of the assembly line system is given below which consist five sub- stations of assembly line.

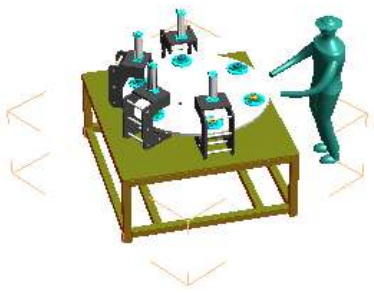

Figure 1 Block Diagram of the system

Five substations are 1). Water Seal and cover assembly 2) D- Plug Assembly and Leak Testing 3) Cover and Impeller assembly 4) Pulley Assembly to cover sub assembly 5) Assembly Leak Test Marking and Reading. The Functions of the each station and programming of the PLC are explained below. 5 PLCs have 32 Inputs and 32 outputs. As per various applications, number of the inputs and outputs will change.

1) Sub stations of Seal Assembly indicate that water seal is being fitted into the water pump. As seen in figure 2, if we put assembled part (water seal) on the fixture then Laser sensor senses the part and signal will be given to PLC. Once Water pump is fitted on the fixture then, Second laser sensor senses the water pump, and laser sensors pass on the signals to PLC.

Figure 2: Water Seal

- After PLC unit sends signal to top cylinder, top cylinder will go downward and the water seal will be pressed (certain distance).
- Second Laser sensor senses the top cylinder and then the cylinder automatically goes to original

position. Afterwards, Actuator is used for cleaning area of D-Plug assembly.

- Actuator moves horizontally. After moving certain distance in horizontal direction, it will move in vertical direction. Once it reaches in vertical direction, Actuator motor will start. It will spread the water in area of the D-Plug assembly. Then Actuator will return to the original position.
- Pump feeding cycle will start and RAM Cylinder moves forward. After reaching certain distance, cylinder will be in position to feed water seal into the water pump.
- Depending upon diameter of the water seal, Load cell value will be applied. During Feeding operation, water seal is fitted into pump then cylinder will move in vertical direction. Cylinder is at original position.
- Locktite is similar to actuator which put liquid into d-plug for fixing d- plug assembly into the water pump. After filling liquid in d-plug, Locktite will come to its original position and cycle will be over.
- Here water seal is fitted into the DAF water pump. There are four different water seal diameters present in it. If Water seal is not fitted into pump, error message will be displayed on the screen of the HMI.

2) D-Plug Assembly and leak Testing indicates that D plug is fitted into water pump. It will check if there is leakage in water pump using staking tool.

Figure 3: D-Plug Assembly

- `As seen in figure 3 “D” plug Laser sensor, Cover Laser sensor, sense the parts and that sensor sending signal to PLC unit, Staking tool will go down, then component will be clamped.
- After fixture clamping automatically, leak testing unit (ATEQ) will start cover leak testing with the help of PLC unit. After leak testing, if sub assembly leak testing found fine then “V” mark will appear on cover with the help of pneumatic cylinder controlled by PLC unit. If cover is not proper then mark (“V”) won’t appear on cover.
- As a result, it will automatically generate alarm (siren) indicating rejection with the help of PLC unit. Then rejected part kept on rejection rack (for reject), and appropriate parts are forwarded to next operations. Here, RAM cylinder won’t be used. Instead of the cylinder, Staking tool will be externally connected to the leak detector F-510.
- Now Staking tool will go down and Leak test will consume setting parameters in the ATEQ leak detector machine. Current Pump parameters will be compared with reference parameters which are stored into leak detector.
- Once parameters are matchable then next operation will be performed else error message will be displayed on the HMI screen .Pass Punch and Staking tool will be at original position. Cycle for one water pump operation is over.

3) Cover and Impeller Assembly indicate that impeller is being fitted in DAF water pump. There are total 3 to 4 types of impeller. PLC can differentiate impeller by using diameter of the impeller. HMI screen will display part no of the given impeller which is being fixed on the fixture.

- Figure 4 indicates that impeller is being fixed on fixture. Then, Laser sensor senses impeller and sends signal to PLC.
- Water Pump is fixed on fixture then Laser sensor will sense its bearings and will give signal to PLC. In continuation, another Laser sensor checks D-Plug and later on it will be fitted to water pump. If it won’t get fixed then alarm will ring.

Figure 4: Impeller assembly

- PLC sends signal to cylinder which is positioned at downward. Applied force value will depend upon type of impeller. Impeller is being fixed into water pump then RAM cylinder will be positioned to its original position.

4) Pulley Assembly (sub assembly) indicates that pulley is fixed into DAF water pump.

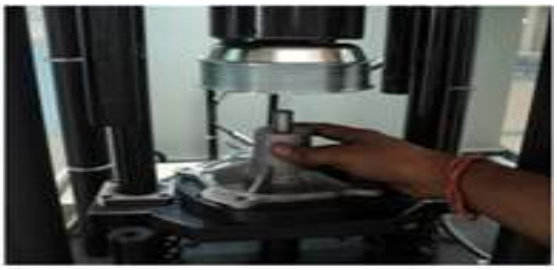

Figure 5 : Pulley Aseembly

- As Shown in figure 5, pulley is being fixed upper side of fixture. Assembled part can be fixed on the fixture then , Second Laser sensor senses the sub assembly and Laser sensor gives signal to PLC.
- After PLC unit sends signal to top cylinder, top cylinder goes to downward to press assembled parts up to certain distance. Later on, another Laser sensor senses top cylinder and cylinder will automatically go back to its original position.
- Pulley will get fixed on water pump depending upon the force applied by cylinder. Applied force value will depend upon the type of assembled part.
- Applied force value for pulley will be greater than the applied impeller's force. Both impeller and pulley has same programing stucture.

5) In this Sub-Station , There are total 6 Laser sensors placed for checking other sub station's parts like D-plug, water seal, impeller, and pulley. It will check parts fixed into the water pump. Because if any part is missing then water pump may get rejected and scrap cost will go on higher side.

Figure 6: 2D Marking and Reading

- 2D Marking is placed for writing current date, time and to identify the quantity of water pumps produced at a time.
- Keyence vision Laser sensor is used to throw lights on the water pump during marking. Scanner will scan and compare the date, time and specific code respectively.
- If date, time and code are not perfect during scanning activity then the water pump will be rejected. Comparison of date, time and code should be correct to minimize the scrap cost.
- For specific code, 16 bit binary data is being transferred to boost strap loader first and then to memory location which consists binary file with new operating system.

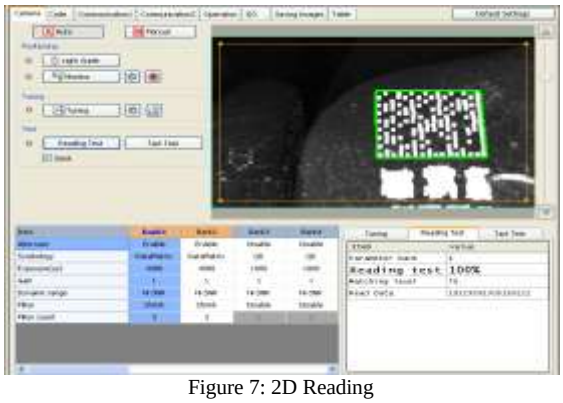

Figure 7: 2D Reading

- Specific code, which is written on the water pump, will be checked by the reader and if Reader's test is 100% fine.
- Scanner data matched with the written data. For writing data on water pump, address of date and time should be converted in to hexadecimal. PLC won't allow data in ASCII code.
- If reader test is 0% then water pump will be rejected. Scanner won't match data with data which is written and system won't highlight.

Figure 8: 2D Reading Not OK

III. Programming of PLC and Connections

Power circuit Diagram:

A power circuit distributes power from source to connected load. Control circuit controls power through use of motor, on/off switches and start/stop buttons. Here, directly 3-phase supply won't be given to PLC unit. First, it will be given to the MCB. If overload error occurs in electrical circuit then it may damage all circuits' components. To overcome this, MCB is used after the 3- Phase supply. MCB is more reliable than the fuse. Output of the MCB is given to master control relay. MCR is protected against higher

voltage and current. Output of the Relay is directly connected to the power supply of the PLC. Second MCB is used for applied load voltage to the SMPS. 3-Phase voltage is converted to the 24 V DC using converter.

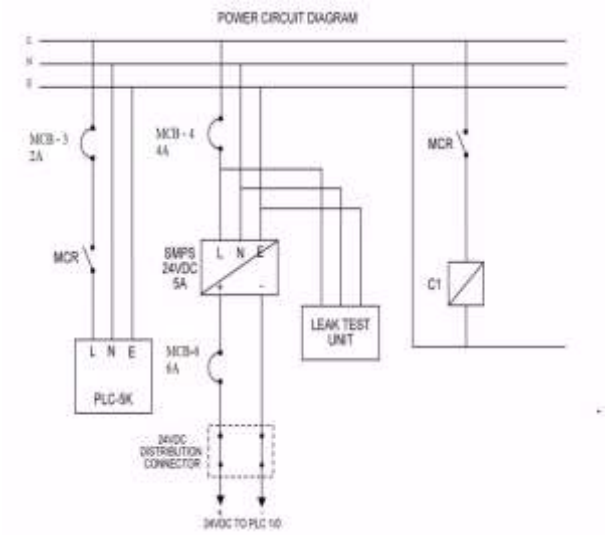

Figure 9: Power Circuit Diagram

And connector is used for the given 24 V DC supply to the PLC Input /Output. MCB output is given to leak testing unit for operating F510. Common PLC Program is given in below figure 10. In this programming unit every other programming unit is called [2]. By default in this PLCs PLC-PRG program unit is executed. Total 8 different programming units are executed.

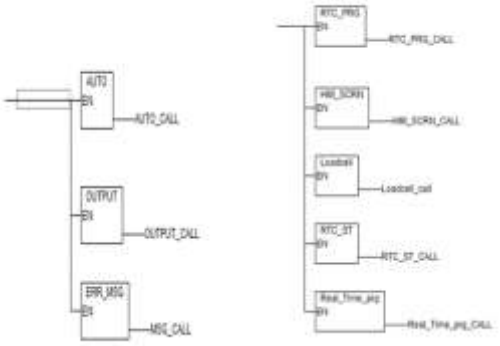

Figure 10: Different Programming Units

- Below figure 11 shows basic flowchart of the programming of substations. There are 7 to 8 programming units for ladder logic in which all stations have different programming features.
- RAM Cylinder is replaced by staking tools in d-plug and leak testing sub stations. Conditions for checking water seal by laser sensor in the first substation are given.
- It will change by the changing substation like if impeller substation is placed instead of water seal substation to check impeller diameter by Laser sensor sense.
- Output programming unit is partially same for all assembly stations except 2D marking and reading. Marking and reading processes are replaced by RAM cylinder on down and up positions.

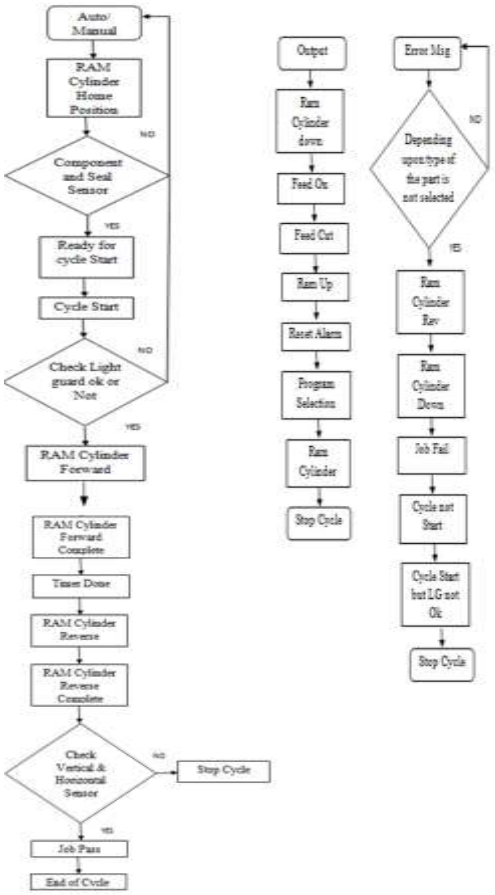

Figure 11: Flowchart

IV. Results and Discussions

There are totally five sub stations of assembly line and for reducing cycle time for improving operations PLC ladder diagram is effectively prepared. Photoelectric Laser sensors are ensuring properly working of sub stations [1]. Manually operating system has 4 men working on the sub stations. Automatic operating system has 2 men working on the substations. For moving from one station to another, travel time will be reduced. Following is the table which indicates comparison of manual and automatic substations of assembly line. Comparison of cycle time reduction is shown in below table 1.

Table 1: Cycle Time Comparisons

Substations	Manual	Propose Method
Water Seal	75 Sec	60 Sec
D-Plug	55 Sec	45 Sec
Impeller	35 Sec	30 Sec
Pulley	35 Sec	30 Sec
2D Marking and Reading	65 Sec	55 Sec

Distribution of man power in every substation is compared with manual and proposes method in assembly line shown below table 2.

Table 2: Men Power Comparison

Substations	Manual	Propose Method
Water Seal	1	1
D-Plug	1	
Impeller	1	1
Pulley		
2D Marking and Reading	1	

Below table 3 shows increase of scrap cost due to increase in rejection in substations.

Table 3: Rejection of Pumps Comparison

Substations	Manual	Propose Method
Water Seal	-	-
D-Plug	25	12
Impeller	1	-
Pulley	-	-
2D Marking and Reading	24	15

Table 1 shows total 35 seconds gap between manual and propose method operation. Time required to move from one substation to another is also decreases. Comparison in table 3 shows D-plug substation has 25 pumps rejected out of 180 pumps. Same thing happens in 2D marking substation with 24 pumps rejection out of 180 pumps. Rejection of the pumps is more in manual operation. Scrap cost will keep increasing. Accuracy of given water pumps in proposed method is more than the manual operations. Leakage parts are greater in manual operation as compared to proposed method. Final product is shown in figure 12.

Figure 12: Final Product

V. Conclusion

This paper represents developing assembly line for water pump and increasing number of water pump in a day with automated system. In this experiment Nexgen 5000 PLCs and MS60c HMI series are used. Processor cp 5220- B0 is attached to the PLC and many electro-mechanical devices are connected. Production of assembly line is improved by ladder diagram of the PLC. Wiring and installing of F510 and 2D marking are improved because PLC inputs and outputs are attached to the specific addresses. Cost reduction and man power reduction is greatly achieved. For more improvement in assembly line, Scada with PLC interfacing is required in the industry. Usage of other than PLC process in industry, integrating the artificial intelligence method such as artificial neural network and genetic algorithm are replaced to PLC.

References

[1] Joana Marie M. Baroro, Melchizedek I. Aipio, Angelo A. Beltran Jr., ‘’Automatic of Packaging and Handling Using PLC,” IJSET, Volume no3, PP: 767-770, 1 June 2014.

[2] L.A. Bryan and E.A. Bryan. “Programmable Controllers: Theory and Implementation,” Industrial Text, Chicago, IL, 1988,pp. 20 – 40.

[3] Y. Liu, “Design of automatic control system for waterworks based on PLC,” IEEE Trans. Antennas Propagation, to be published.

[4] M. Dudek-Burlikowska*, D. Szewieczek, “The Poka-Yoke method as an improving quality tool of operations in the process,” Volume 36, Issue 1, September 2009.