Optimization of Assembly Process for Hand Primer

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Abstract— The main intention of this paper is to automate a manual assembly line following a step by step procedure in an automotive industry. An assembly process planning system reducing the man power or human intervention and the computational effort has been discussed here. Optimization of assembly process is implemented in order to upgrade and automate the assembly operations for a particular product named hand primer in an automotive industry. The transformation from the manual process to the new semi- automated assembly process is usually composed of four main steps: the analysis of before- after stage, the process re arrangements, the assembly layout design, training to the workers to operate the machines and finally the mass production. This work has shown that the automation of the assembly process yields significant improvements like sizeable increase of workstation saturation, significant reduction in the human labour required and increase of the quality control process diligence. The scope of the work was limited to one of the compacted assembly lines. In the upcoming days, the company plans to upgrade themselves to automate the process for the remaining assembly lines. This detailed study shows significant benefit associated with a sequential implementation of automation in the field of assembly process.

Index Terms— assembly line, assembly layout design, hand primer, Optimization, process diligence, process re- arrangements, semi-automated.

1 INTRODUCTION

A product assembly planning affects both the efficiency of assembly process and the design of assembly line. Planning and usage of efficient assembly process can actively contribute to the reduction of a product's overall manufacturing cost. Assembly process planning mainly includes the identification of a feasible method and assembly layout, in order for a particular product to get assembled from its components.

Automotive products often have multiple assembly sequence plans because of its complexity and the multiplicity of their child parts. Henceforth, some assembly sequence plans are much more efficient than others and in order to select the appropriate sequence requires high level of expertise and experience from the planner's side. Assembly process is a sequential and time-consuming procedure and requires high precision and, as a result, the automation of this process is necessary. The goal of the current study is to sub automate the assembly process of hand primer that can finally contribute to the reduction in time and efforts on process planning generation.

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2 LITERATURE SURVEY

2.1 PROCESS PLANNING

The Robotic equipment has found great application to a broad range of automatic assembly systems, specifically in the assembly lines of automotive industry, electronics, rubber/plastics and metal/machinery industrial sectors. The robots' intrinsic characteristics, such as high accuracy, speed, repeatability, strength and reliability, have enabled production firms to invest in large scale installations that can work around the clock with minimal human intervention [1]

Nevertheless, technological limitations impose the contribution of human operators on the process, by providing support to the system. [2]

The development of such complex systems and the variation of production conditions bring about new problems [3]

A plethora of such problems have been extensively analysed by researchers [4][5][6][7][8], and include conflicts between process planning and scheduling, unbalanced resources in the production line and the problem of selecting suitable resources with respect to the given conditions.

2.2 ASSEMBLY PLANNING

The assembly process planning aims at identifying and evaluating the different methods of assembling an automotive or mechanical product from its child parts. "Given a geometrical and technological description of a product, find an appropriate assembly sequence that satisfies the precedence relations between operations and meets required optimization criteria" [9]

In the last decade, several approaches have been proposed to automatically generate assembly sequences. Summarizing, the existing approaches for the generation of assembly plans, can be roughly classified into three main

approaches [9][10][11]: human-interaction, geometry-based reasoning and knowledge-based reasoning

3 METHODOLOGY

MANUAL ASSEMBLY TO AUTOMATION ASSEMBLY PROCESS

Many challenges are faced by many industries is that changing the existing manual conventional production system into automated production.so, that is reason we as team and with the guidance of our internal guide as well as external guide decided to migrate from manual to automation assembly in our production line. There are many reasons going for automation of the manual assembly line mainly includes a need increase competitiveness, a need to meet the customer requirement specification (i.e., higher quality demand from the customer), also keeping labours away from hazardous tasks and materials, this creates awareness of health and safety among worker and also need to improve the production efficiency parameters i.e., manufacturing lead time, improve production capacity and production flexibility. This part of the project deals with identification of procedures, advantages and disadvantages of manual as well as automation assembly.

The child parts and subassemblies required for assembling all parts of Hand primer are as follows:

- Pump housing
- Pump piston
- O-ring
- Plain washer
- Handle
- Reduction threaded joint
- Protective cap
- Adhesive

Analysis of Manual assembly process

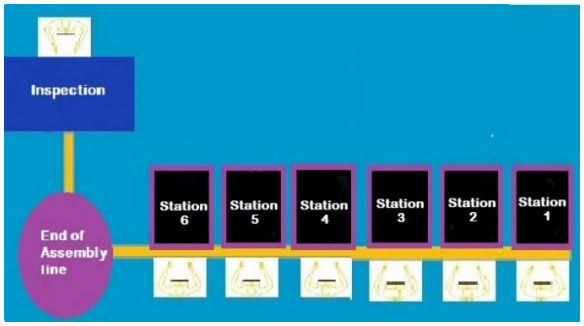

Fig.1 Manual Assembly line layout

The layout of the manual assembly station is illustrated in the figure 3.1 with six substations and an inspection line. Only one labour works in each substation and as there are six substances totally six labours works in assembly line. Due to the limitation at the end of the assembly line steps, only one model of hand primer is assembled at a time. The procedure followed to assemble at each substation are mention below:

- Select the sub assemble of plunger plate and connecting rod
- Select the O-ring and place the O-ring into the plunger plate manually.
- Select the housing from the input tr ay and ensure that burnishing operation is completed and check of any visual defects like Bore ovality, bore line marks, chamfer uneven etc.
- Select the sub assemble part, reduction threaded joint (Nipple) from the input tray and apply met-lock (adhesive) on
  threads of nipple and manually tighten it to housing part.
- Torque tightening is done between nipple and housing using torque tightening machine (i.e., the applied torque should be in the range of 4-5 Nm).
- Fix the handle grip to the housing.

Drawbacks faced in manual assembly process:

- There was less consistency in labours due to heavy work pressure, which resulted in decreased labour productivity.
- Number of labours required was more.
- Cost required was more which includes labour cost, increment and many other secondary costs.
- The time required to assemble one model of hand primer was around 2-3 minutes. i.e., on an average 1200-1400
  pieces per shift were produced.
- As this process is completely human perspective or human intervention, there is a high chance of missing Many of the visual defects which may the quality of the product.
- As this assembly line consists of six sub assembly stations, the floor space required is more.

MIGRATION OF MANUAL ASSEMBLY PROCESS TO AUTOMATION ASSEMBLY PROCESS:

Due to the significant increase in projected order volume from the customer and also there is a necessity of an increase in production capacity, as well as providing a good opportunity to obtain the returns that is invested on the production line, we go with migration of manual to automation assembly process.

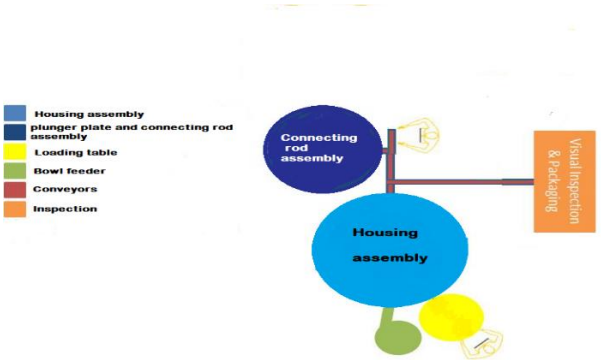

Fig.2 Shows the cell layout of automation assembly line

The layout of the automation assembly station is illustrated in the figure 3.2 which consists of inspection station and two substations, one for plunger plate and connecting rod assembly and another for housing assembly. Only one labour works at each substation. As there are two

substations totally two labours work in assembly line. The procedure followed to assemble at each substation is mentioned below and also reflects in the control plan of assembly process:

- Step 1:
  Here assemble O-ring is selected and placed in the plunger plate and plunger plate is inserted into housing, before
  loading into conveyor the housing thread is cleaned with a cloth properly. This is done manually.
- Step 2:
  In this operation, the connecting rod is placed on the conveyor and is dropped into the vibrating bowl from here it
  goes to pick and place robot, where connecting rod is tightened to plunger plate with a torque in the range of 2-2.5
  Nm.
- Step 3:
  In this operation the housing thread is thoroughly using acetone and place in the second substation.
- Step 4:
  In this operation, adhesive is applied on the threads of the reduction thread joint and it is tightened to housing with a
  torque of 4-5 Nm. Also, the handle grip is fixed to the housing. This complete process is done through advanced automation technology.

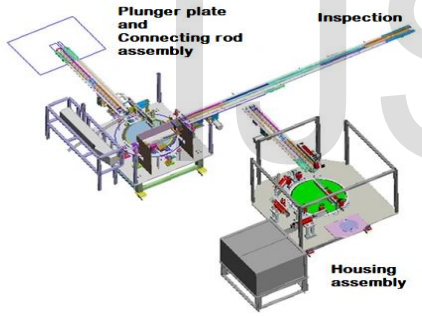

Fig.3. A 3-D rendition of cell layout of automation assembly line

Advantages of implementing automation in manufacturing process:

- Consistency is more which results in increased productivity.
- Number of labours required is less.
- Initial investment cost is high, but in the long run the invested amount is returned with profit.
- Time required to assemble is one model of hand primer is around 1-2 minutes. i.e., on an average around 2000-2400 pieces per shift is produced.
- As it is automated process, chances of getting defected pieces is less.
- As assembly line consists of only two substations. Therefore, the floor space required is very less compared to manual assembly station.

4 RESULTS

4.1 FLOOR SPACE

The layouts of both manual (1) and assembly (2) production line is illustrated in figure 4.1. By comparing both the cell layout of the both assembly line we can tell that manual assembly line requires more floor space compared to automation assembly line**.**

4.2 INVESTMENT COST

MANUAL ASSEMBLY INVESTMENT COST

Number of Operators = 6

Number of shifts/days = 2

Number of operators/ days = 12

Cost per operator = 16,800/ month

Total labour cost = 2,01,600/ month

The above cost is the only salary of labour and does not include cost such as training, taxes, maintenance and the remaining

expenses that needs to run the business.

SUB AUTOMATED ASSEMBLY INVESTMENT COST

Number of Operators required = 2

Number of shifts/ days = 2

Total investment cost to automate the process = 4 lakhs

Cost of labour (salary/ wages) = 67,200/ month

4.3 RETURN ON INVESTMENT

The main drawback of this automation was initial investment was twice the total salary or wages of the workers per month. But this drawback can be easily overcome by reducing the number of workers required to operate the machines in automated assembly line.

The following calculations show the initial investment and Return on Investment (ROI).

		MANUAL	AUTOMATION
MONTH 1	Capital Investment	Rs 0	Rs 4,00,000
	Number of Operator	12	4
	Wage / Operator	Rs 16,800	Rs 16,800
	Total Wages	Rs 2,01,600	Rs 67,200
	Total Expenses	Rs 2,01,600	Rs 4,67,200

Table 1. Shows the overall cost of manual and automation assembly process for month 1

		MANUAL	AUTOMATION
	Capital Investment	Rs 0	Rs 0
	Number of Operator	12	4

MONTH 2	Wage / Operator	Rs 16,800	Rs 16,800
	Total Wages	Rs 2,01,600	Rs 67,200
	Total Expenses	Rs 2,01,600	Rs 67,200

Table 2. Shows the overall cost of manual and automation assembly process for month 2

5 CONCLUSION

By migrating to automation assembly, we have overcome all the drawbacks of manual assemble process. This has resulted in a corresponding increase in the production capacity, Thus, also improving the flexibility of the company since it is able to react to new customers order very quickly. This has also resulted in reduction of manufacturing lead time, also increased the production capacity up to 50% more. The initial investments on the automation is also justified, since there is a significant reduction in labor cost, resulting in the returns on the investments made. The study can also be further extended by implementing automation in manufacturing production as well, also instead of using labours as it is mentioned above in the automated assembly line it can be made fully automated by using conveyors and pick and place robots. initially it may cost more but in long term can be very profitable to the company.

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REFERENCES

[1] G. Michalos, S. Makris, N. Papakostas, D. Mourtzis, G. Chryssolouris, Automotive assembly technologies review: challenges and outlook for a flexible and adaptive approach, CIRP Journal of Manufacturing Science and Technology, Volume 2, Issue 2, pp. 81-91 (2010).

[2] Sekoranja B, Basic D, Svaco M, Suligoj F, Jerbic B. Humanrobot interaction based on use of capacitive sensors. Procedia Eng 2014; 69:464–468.

[3] Groten R, Feth D, Klatzky RL, Peer A. The role of haptic feedback for the integration of intentions in shared task execution. IEEE Trans Haptics 2013; 6:94–105

[4] Gindy NN, Saad SM, Yue Y. Manufacturing responsiveness through integrated process planning and scheduling. Int J. Prod Res 1999; 37:2399–2418

[5] Li X, Zhang C, Gao L, Li W, Shao X. An agent-based approach for integrated process planning and scheduling. Expert Syst Appl 2010; 37:1256–1264.

[6] Li X, Gao L, Li W. Application of game theory-based hybrid algorithm for multi-objective integrated process planning and scheduling. Expert Syst Appl 2012; 39:288–297.

[7] Li X, Gao L, Shao X. An active learning genetic algorithm for integrated process planning and scheduling. Expert Syst Appl 2012; 39:6683–6691.

[8] Lv S, Qiao Process planning and scheduling integration with optimal rescheduling strategies. Int J Comput Integr Manuf 2013; 27:638–655.

[9] Papakostas N, Pintzos G, Matsas M, Chryssolouris G. Knowledge-enabled design of cooperating robot's assembly cells. 5th CIPR Conference on Assembly Technologies and Systems, (Procedia CIPR) 2014; 23:65-170.

[10] Papakostas N, Alexopoulos K, Kopanakis A. Integrating digital manufacturing and simulation tools in the assembly design process: a cooperating robots cell case. CIRP Journal of Manufacturing Science and Technology 2011; 4:96-100.

[11] Papakostas N, Michalos G, Makris S, Zouzias D, Chryssolouris G. Industrial applications with cooperating robots for the flexible assembly. International Journal of Computer Integrated Manufacturing 2011; 247:650-660.