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Analytical Study on Automobile Engine Line Work Stations and Analyze Their Working

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Abstract- **In an automobile assembly line, a series of stations are arranged along a conveyor belt and an automated guided vehicle performs on tasks at each station. Parallel assembly lines can provide improving line balance, productivity and so on. Combining robotic and parallel assembly lines ensure increasing flexibility of system, capacity and decreasing breakdown sensitivity. Although afore mentioned benefits, balancing of robotic parallel assembly lines is lacking – to the best knowledge of the authors- in the literature. Therefore, an observed study is proposed to define/solve the problem of automobile assembly line. The automobile assembly line also tested on the generated benchmark problems for automated guided vehicle/robotic parallel assembly line balancing problem. The superior performances of the proposed algorithms are verified by using a statistical test. The results show that the algorithms are very competitive and promising tool for further researches in the literature.**

Keywords: Assembly line balancing, beam search, automobile parallel, CNC.

I. INTRODUCTION

An assembly line is a manufacturing process in general known as a progressive assembly. In assembly line the parts are holded at workstation and are assembled at each station with help of rope or belt driver for assembling complex items such as automobiles and other transportation equipment, household appliances and electronic goods. Rather quality that's addressed in the production process is taken into account. Furthermore technical and design issues for the automated robotic system were excluded but maintenance i.e. working of the robot was studied and considered. We moreover did not consider the changeover time and tasks between the products since moreover all the products follow a similar assembly process.

Engine assembly modelling is quite a large field with a plethora amount of knowledge available in literature. The main problem encountered is that the models are either too simple to allow the implementation of new control strategies or too specific as they were developed for a particular application. A process that has been found to be in need of improvement is the engine mapping and model calibration. The current use of mean-value engine models and mapping procedures result in data that cannot be used on other engines while some engine phenomena cannot be expressed at all.

Assuming that a mathematical model about a process or system of interest is available in the literature, it is most of the time unclear or difficult to implement it in a particular simulation package. This problem is either the outcome of missing information while sometimes it is due to the absence of a complete model structure which correctly represents the interaction of all presented equations. The mathematical models presented in this work have been developed in such a way so that they can form an autonomous engine sub-system which allows them to be clearly presented, understandable, and easily implemented by the reader. In addition, their sub-system format facilitates the complete engine model development or future editing. The sections that follow are a brief introduction to the mathematical modelling terminologies and their main applications for analysing engines assembly line.

Engine line assembly can be automated, manual operated or of mixed design. In recent years, instead of human labours, robots or automated guided vehicles have been widely begun to use in assembly systems and the systems are called Robotic Assembly Lines (RAL). In the especially automotive sector, more than 1 million industrial robots may be established until 2018. These advantages make robots a vital component of the Industry.

Number of serial stations consists in the robotic assembly operations are commonly performed on an engine assembly line. Therefore, in a production environment the efficiently designed and balanced robotic assembly lines (RAL) have a remarkable importance. However, different robot types may exist at the assembly facility, and for the various elements of assembly tasks they usually have different capabilities and efficiencies.Systems thinking begins with understanding the concept named "feedback" that is based on cause and effect of actions. In simple terms, it involves learning the structures that manifest an archetypal pattern of escalation. In order to develop these patterns which are based on cycle of events, there are mainly 2 types of feedback processes namely reinforcing and balancing processes.

Figure1. Automobile Automatic Engine Assembly Line

Robotic assembly lines blockage (RALB) problem includes two main works which are assigning tasks to stations and allocation robots in stations due to the fact that different robots perform different performance on the same task. In summary, the basic differences of between robotic and non-robotic engine assembly line problems are: (i) in robotic engine assembly line problem, robot must be considering while tasks are assigned to stations, (ii) task time can be different based on robot type and it causes problem to be difficult, (iii) the objective of the problem is usually preferred as minimization of the cycle time due to capital cost of robots.

Figure 2 Double line Assembly automatic guided vehicle for workers in workshop

1. According To Henry Ford

The Principles of Assembly Are These

- Place the tools and the men in the sequence of the operation so that each component part shall travel the least possible distance while in the process of finishing.
- Use work slides or some other form of the carrier so that when a workman completes his operation, he drops the part always in the same place—which place must always be the most convenient place to his hand—and if possible have gravity carry the part to the next workman for his own.
- Use sliding assembling lines by which the parts to be assembled are delivered at convenient distances

2. Mathematical Modelling

The mathematical representation of an actual system that is carried out by correlating input and output variables using equations is referred to "mathematical modelling". It is used on systems that need to be optimised, controlled or simulated. There is always a trade-off between the model accuracy, simplicity and simulation speed as more accurate models usually tend to be more complex the mathematical models are classified into different categories from which some are listed below.

2.1 Static Vs. Dynamic- Static models do not take into account the time variable. Sometimes,they describe a system at a particular moment in time or one that does not vary over time. On the other hand, dynamic models are mathematical expressions of a system over time and usually are represented by differential equations.

2.2 Continuous Vs. Discrete- The term"continuous"is used to refer to the model ability torepresent the system using a constant set of equations. On the other hand, "discrete models" variables and equations may switch when a system's process changes.

2.3 Linear Vs. Non-Linear- Linear models can be evaluated using the four fundamentalmathematical operations, addition, subtraction, multiplication and division. A non-linear model can have any mathematical operation and non-linearities.

2.4 Black-Box Vs. White-Box- The terminology"black-box"is used to describe a model thatcontains some unknown operations. There are cases which some experimental data are used within a model to replicate a physical phenomenon and because either the phenomenon is not needed to be further analysed or the knowledge is not available, then it is used as it is. An example of such a model is a trained neural network model which is representing a system. The system's mathematical model is not known but only its input-output relationships. On the other hand, a model is noted as "white-box" when everything is mathematically expressed and known.
Practically, every model falls in an imaginary category between these two.

3. Optimisation of Process

In his 1922 autobiography, Henry Ford mentions several benefits of the assembly line including:

- Workers do no heavy lifting.
- No stooping or bending over.
- No special training required.
- There are jobs that almost anyone can do.
- Provided employment to immigrants.

4. Assembly Line History

Before the Industrial Revolution, most manufactured products were made individually by hand. At that time, each part of a product would create by a single craftsman or team of craftsmen. To create the individual parts they would use their skills and tools such as files and knives . They would then assemble them into the final product, making cut-and-try changes in the parts until they fit and could work together (craft production).

5. Industrial Revolution

The Industrial Revolution led to a proliferation of manufacturing and invention. Many industries, notably textiles, firearms, clocks and watches, horse-drawn vehicles, railway locomotives, sewing machines, and bicycles, saw expeditious improvement in materials handling, machining, and assembly during the 19th century, although modern concepts such as industrial engineering and logistics had not yet been named.

7. Improved Working Conditions

In his 1922 autobiography, Henry Ford mentions several benefits of the assembly line including:

- Workers do no heavy lifting.
- No bending over.
- No special training required.
- There are jobs that almost anyone can do.
- Provided employment to immigrants.

8. Objectives

In this proposed study, a design process is presented to help controls engineers develop reconfigurable codes for reconfigurable machines and systems. Chapter 1 introduced the motivation for the design of a reconfigurable control system for an engine assembly line, and outlined objectives and motivation for the study. Chapter 2 presented a thorough literature survey investigating various academic methods and researches, but none of the methodologies were industry ready. Chapter 3 investigated systems engineering approach for control software design. Chapter 4 proposed a novel method to design and develop a reconfigurable and industry-applicable controls system. Chapter 5 contains conclusions and discusses the entire thesis while proposing continuations to this work. And Chapter 6 contains future work.

The main objectives of the study are as follows:

- To perform an extensive literature review to identify the research and development status of this technique and the current guidelines.
- To develop detailed studies of the system taking into account VE COMMERCIAL VEHICLES, Pithampur, Distt. Dhar (M.P.), India (A Volvo Group and Eicher Motors Joint Venture) engine line stations and analyze their working and to record working time and a number of workers to do work on each station.
- To study the assembly of various parts on engine line and to do a time study on each station. By observing various station processes, under the guidance of person working there and by finding the solutions to problems.
- In this task, a decision matrix including details about the investigated auxiliaries and the implementation effort has been collected.
- The decision matrix shows all the available components and the selected components for implementation. Along with this the individual function of some part of their specification has also described.
- The components of LCV or LD engines of 70kW includes engine parts, fuel injection pump setting, connecting rod tappet setting etc. described.

II. LITERATURE REVIEW

1. Theory

This section gives the reader the background information in the problem area from a theoretical point of view. The theory described was used both for establishing a current picture of the line as well as in the analysis phase. Further the choice of theorieswas based on the findings from pre-study conducted and alignment of the three research questions. The following Table2.1 provides information about the theories where they were applied during the project. We thereby begin by system thinking and further narrowing down to lean production and TPM.

Table 1 Selection of theory

SN	Theory	Section of the thesis where it is Applied
1	Systems thinking	Methodology, qualitative analysis
2	Organizational development (Porras' & Robertson's framework)	Qualitative data collection
3	Production Development	General background for lean Production
4	Box score	Quantitative data collection and Analysis
5	Lean production	Analysis for waste & recommendations
6	TPM	Recommendation

2. Organizational Development

Organizational development (OD) focuses on planned change and follows Kurt Lewis statement “In order to truly understand something, try changing it”(Porras, & Robertson 1992)[41]. Even if organizations know how to do things, like building automobiles, what does it really mean? (Dosi, Nelson & Winter, 2000)[14]. although many contributions have been established to OD the field still has its problems. The purpose of this section is to view the change associated with organizational development by the use of Porras and Robertson’s,(1992),[41] organizational framework that focuses on the technical and social aspects of the system. Porras and Robertson, (1992)[41] develop this framework because they believe that focusing on identifying the key factors influences the *on thejob* behaviour will give a picture how the current working conditions are in anorganization.

These work setting factors have been divided into four categories according to Porras, & Robertson (1992)[41] can be seen in Figure 2.1.

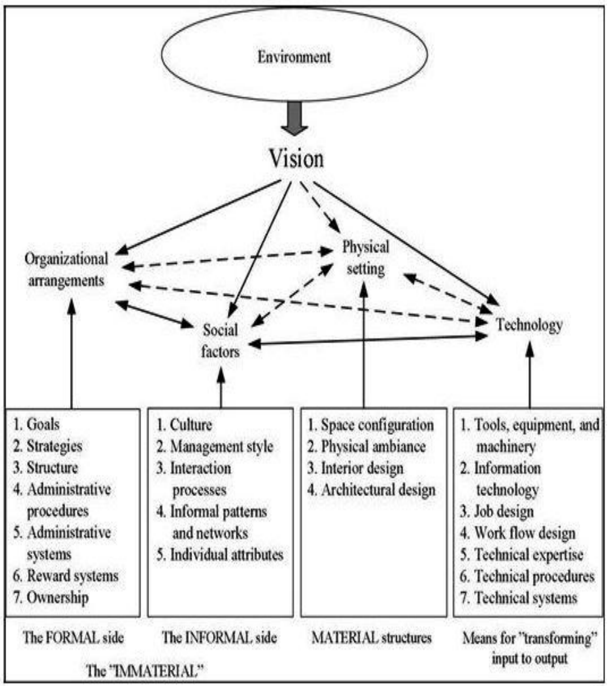

Figure 2. Factors Constituting the Organizational Work Setting Organizational arrangement

3. Production Development

Production development is a term more traditional than production engineering (Bellgran&Säfsten, 2005)[5] and it describes the need for long term actions in production system development. With the ongoing increasing competition, the focus on production has a more or less value for every manufacturing company, not only in Sweden but the rest of the Western world (Bellgran&Säfsten, 2005)[5]. One way of improving the current production system is by the use of tools and methods supporting the way of working within the production cell. The ongoing condition of industrial change on a regular basis and as the company is a major factor in the market it comes with opportunities as much as change of requirements (Bellgran&Säfsten, 2005)[5].

Nowadays, customer expects much more than low prices for e.g. high quality products and on time delivery. Factors such as delivery at right price along with requiring suppliers with continuous development of new products, companies tend to give more attention towards outsourcing and production is instead moved to low wages countries such as China. One main reason for this move is that companies in Sweden see the world as a big factory and are maximizing profit when facilities are located in a different place of the world (Bellgran&Säfsten, 2005)[5]. The accepted traditional concept of mass production practiced in the automotive industry was challenged by lean production in the 1990's and has led to changes in the manufacturing industry (Holweg, 2007)[24]. One aspect that has been historically separate is productivity and quality (Gunasekaran, Korukonda, Virtanen &Yli-Olli, 1993)[20].

4. Box Score

In visual management box score is an efficient tool for weekly measurements and keeping track of how the value stream is performing. Box score helps to monitor how a value stream is performing with measurement figures etc. As company works towards lean manufacturing and overlook the entire flow of the production instead of each single production cells, it has become more important for an organization to present the stream in a better way (Maskell&Baggaley, 2004)[36].

Box score enables one to present in a consistent way, different types of lean targets for example FTT (first time though), OEE (Overall Equipment Efficiency). It helps a team to keep a track on key information and keeps everyone informed about the current state, to keep tracks of the efforts being taken to improve the value stream in order to meet the long and short term goals. The benefit of box score is that it can be applied throughout the organization which makes it understandable for everyone (Maskell&Baggaley, 2004)[36]. Within a lean organization, all personal have a common view and language in order to talk about how the production line is performing.

5. TPM

In order to achieve high quality performance companies tend to improve productivity and reduce cost as much as possible. In order to do so, an efficient maintenance system is required. It will not only extend equipment lifetime but also produce right products at the first time (Swanson, 2001)[47]. Traditionally manufacturing companies tend to use reactive maintenance e.g. fixing machinery problems when it happens. Assembly lines consisting of machinery need attention to maintenance activities in order to prevent breakdowns and establishing high quality products.

Total productive maintenance (TPM) is one system that can increase the consistency of a line in order to maintain a high level of productivity (Borris, 2006)[7]. According to maintenance is defined as technical and administrative actions that include maintaining or restoring a unit to the condition where it allows the function desired. TPM consists of not only maintenance activities andmachineries but also leads the organization towards improvement activities of equipment. Moreover according to TPM has its base in three corner stone's namely follow up of operational disturbances e.g. by the means of measurement tools such as OEE which will help in finding the factors limiting the production.

III. RESEARCH MODEL & METHODOLOGY

1. Research Gap & Problem Formulation

In engine assembly line, the primary objective of this research is to design a time observatory control system. By the reason of the design complexity of such a manufacturing system, requires teams of engineers to work concurrently or simultaneously to create a reliable and effective production line which following multi-phase processing, an effective and systematic methodology remains greatly needed. To study engine line stations and analyze their working and to record working time and number of workers to do work on each station is the concerned research & methodology of this project in VE COMMERCIAL VECHILES, Pithampur, Distt. Dhar (M.P.) (A Volvo Group and Eicher Motors Joint Venture). To study the assembly of various parts on engine line and to do time study on each station by observing various station processes, by the guidance of person working there and by finding the solutions of problems.

2. Introduction To Ve Commercial Vehicles

An Indian automaker company based in Gurgaon, India is Eicher Motors Limited (BSE: 505200, NSE: EICHERMOTOR) (Registration number of Eicher Motors) which were incorporated in 1982. Eicher Motors Limited (EML) owns Royal Enfield (India). In the field of commercial vehicles, it is one of the leading manufacturers. Madhya Pradesh, Tamil Nadu, Maharashtra, and Haryana is the location where its manufacturing facilities locates. Eicher Motors is a commercial vehicle manufacturer in India.

In February 1990, in Enfield India Ltd, Eicher Good earth has been bought 26% stoken and and by 1993 in Royal Enfield India, Eicher has been acquired a majority stake (60% equity shareholding). In July 2008, VE Commercial Vehicles (VECV) designs, manufactures and markets commercial vehicles, engineering components and provides engineering design like categories are fall in EML and Volvo Group's 50:50 joint ventures.

3. Design Steps For Engine Assembly

Reaching a specific millstone with product design, prior to beginning the design of manufacturing system, manufacturing teams get involved in reviewing product design for manufacturability (DFM). Subsequently,to design an engine assembly line many teams join efforts and work concurrently.

4. Research and Validation Technique

Research: VE COMMERCIAL VEHICLES, PITHAMPUR, Distt. Dhar (M.P.) (A Volvo Group and Eicher Motors Joint Venture)

- Engine line stations and analyze their working
- To record number of workers to do work on each station and their working time.
- To study the assembly of various parts on engine line and
- To do time study on each station.
- By observing and noting the reading at various station processes, by the guidance of concerned supervising person working there and by finding the solutions of problems.

For validation, needs:

- To Investigate The Time Recording And Performance Characteristics Of An Unit.
- The Mathematical Design Study And Its Dimensions Of Previous Study.
- Time Recording Of VE COMMERCIAL VECHILES, PITHAMPUR, Distt. Dhar (M.P.) (A Volvo Group And Eicher Motors Joint Venture), To Plot The Result For Different Unit Variation During Workshop At Different Processes.
- For Validation, Will Further Compare The Results With Previous Research Studies And Our Established Report Research Standards.

IV.RESULTS & DISCUSSIONS

1. Detail of Various Sections contains VE Commercial Vehicles, Pithampur, Distt. Dhar (M.P.), India (A Volvo Group And Eicher Motors Joint Venture)

1. PDD (Product Development & Design)
2. QC (Quality Control)
3. PPC (Product Planning & Control)
4. PMO (Productive Manufacturing Operations)
5. EDC(Engine Development Centre)
6. VDC(Vehicle Development Centre)
7. Safety –
   - ME (Manufacturing Engineering) Engine Assembly Line
   - Transmission Assembly
   - Machine Shop
   - CT (Cab Trim)
   - HD (Heavy Duty) Chassis
   - LMD (Light Medium Duty) Chassis
   - Cab Weld
8. Paint Shop
9. TS (Technical Services)
10. Inventory

Detail of various station processes, by the guidance of person working there and by finding the solutions of problems.

2. Sop (Standard Operating Procedure) - A Standard operating procedure is a set of step-by-step instructions compiled by an organization to help workers carry out routine line operations. SOPs aim to achieve efficiency, quality output and uniformity and performance, while reducing miscommunication and failure to comply with industry regulations.

Engine Lines

1. PRB Line
2. AGV-1 (Automatic Guided Vehicle- 1)

3. AGV-2(Automatic Guided Vehicle-2)

3. Process Of Engine Assembly Line

3.1. Machine Shop

Drilling, trimming, machining etc machine works are being carried out

2. PRB line (Power Roller Belt)
3.AGV-1(Automatic Guided Vehicle- 1)
4. AGV-2(Automatic Guided Vehicle-2)
5. Pre Delivery Inspection (PDI)
6. Testing @ (LD 4V-2750-2850 RPM)
7.Pre Delivery Inspection
8. Transmission & coupling (Gear box connect)
9. Painting
10. Pre Delivery Inspection
11. LMD Line where engine drop on the chassis, cabin etc are to be assembled.

4. Types Of Models Manufactured:

- LD4V stands for LIGHT DUTY 4 VALVE, 4 CYLINDER
- HD4Vstands for HEAVY DUTY4VALVE, 4 CYLINDERS
- LD2V stands for LIGHT DUTY 2 VALVE, 4 CYLINDER
- HD2Vstands for HEAVY DUTY 2VALVE, 4 CYLINDER

V.CONCLUSIONS

Two-sided robotic assembly lines are used for flexible production and to reduce the total energy consumption.

In terms of modularity, in this proposed study, the proposed design method requires reconfigurability of mechanical system as a condition for use. For controls, a distributed architecture has also required. If mechanical hardware and controls are closely coordinated at the development stage, best results are obtained. In this proposed study, the methodology proposed offers several benefits, such as time savings for control software designs, retooling time minimization for machinery compared to current industrial practices, maintenance of actual tools and programming languages known on production floors. In the Axiomatic Design encourages minimization of information content in any design, and considers as best design that containing the least amount of information, or the simplest. The methodology presented herein is systematic and easy to use, and can conclusively be adapted to develop coding, using existing tools and programming methods, in a systematic manner geared to production configurability.

Future Works

Automating function block generation with Ladder logic can do but increase the value of the methodology presented in this thesis from a reconfigurability perspective. A machine can potentially generate its program each time a module is added. IEC64199 is another standard well perceived in research, and investigating its usability and easiness of implementation in the developed methodology appears promising. The company strives hard to satisfy their customer needs but the assembly line faces problem in meeting the output of planned target. We can say that the company is an anorexic organization having a strategy of downsizing with permanent personnel reductions. There is a constant debate going on about the advantages of downsizing. A further research study that could be carried out is how organizational effectiveness gets affected in “anorexic organizations” or how to strategically manage a downsizing process.

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