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An Overview of Assembly Line Balancing

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Abstract: ***Assembly Line balancing is one of the widely used production systems. The problem of Assembly Line Balancing deals with the minimization of the number of workstations, minimization of cycle time, the maximization of workload smoothness, The maximization of work relatedness It is used to assemble quickly large numbers of a uniform product. Originally, assembly lines were developed for a cost efficient mass production of standardized products, designed to exploit a high specialization of labor and the associated learning effects .In the another hand when we used assembly line balancing (ALB) this makes efficient flow-line systems available for low volume assembly-to-order production and enables modern production strategies like mass customization. Assembly lines are traditional and still attractive means of large-scale production. Since the time of Henry Ford, many developments have been taken place in production systems which changed assembly lines from strictly paced and straight single-model lines to more flexible systems with intermediate buffers. In this paper a basic study is done on assembly line balancing methods.***

Key words: **Assembly line balancing, work station, line balancing procedures, line balancing classification.**

I. INTRODUCTION

Before the invention of the assembly line, when profitable goods were manufactured, it was regularly manufactured by hand, from separately fabricated parts. An assembly line is suitable for a type of industrial production in which prefabricated, interchangeable parts are used to assemble a finished product. The most assembly line consists of a simple conveyor belt (more complex one include feeder belts) which carries the product, through a series of work stations until it is finished. The improvement of the assembly line revolutionized manufacturing, and contributed to the higher level of Industrial Revolution.

Ford conceived of a production line, where the labor of workers would be divided into specific tasks which would contribute to the completion of products. The inspiration for this early assembly line likely came from several industries, but many historians credit the disassembly line at a Chicago slaughterhouse with the idea of dividing the labor.

Ever since Henry Ford's introduction of assembly lines, Line balancing has been an optimization problem of significant industrial importance: the efficiency difference between an optimal and a sub-optimal assignment can yield economies (or waste) reaching millions of dollars per year. Decreased costs of production allowed lower prices of manufactured goods, better competitiveness of enterprises, and better exploitation of the markets potential.

Assembly line defines that manufacturing technique in which a product is carried by some form of mechanized conveyor among stations at which the various operations necessary to its assembly are performed. It is used to assemble quickly large numbers of a uniform product. Originally, assembly lines were developed for a cost efficient mass production of standardized products, designed to exploit a high specialization of labor and the associated learning effects .In the another hand when we used assembly line balancing (ALB) this makes efficient flow-line systems available for low volume assembly-to-order production and enables modern production strategies like mass customization. This in turn ensures that the thorough planning and Implementation of assembly systems will remain of high practical relevance in the foreseeable future and also assembly line balancing problem involves an assignment of various tasks to the workstations, while optimizing one or more objectives without violating restrictions imposed on the line. Various objectives are considered in 2ALB problems. In practice, it is often desirable to smooth out the workload assignments, and assign related tasks to the same workstation if possible. Thus, we used line balancing technique to achieve:

(i) the minimization of the number of workstations;
(ii) the minimization of cycle time;
(iii) the maximization of workload smoothness;
(iv) The maximization of work relatedness.

An assembly line is a manufacturing process in which interchangeable parts are added to a product in a sequential manner to create a finished product. The assembly line was first used by Henry Ford and his engineers. Ford was also the very first to build factories around that concept.

Line balancing has been an optimization problem of significant industrial importance: the efficiency difference between an optimal and a sub-optimal assignment can yield economies (or waste) reaching millions of dollars per year. Decreased costs of production allowed lower prices of manufactured goods, better competitiveness of enterprises, and better exploitation of the markets potential. There are many different types of assembly line systems some common variations include the classic automated intermittent and lean manufacturing models. These assembly line systems are often used for making different types of products. Assembly lines have some shared characteristics.

II. LITERATURE SURVEY

MICIETA, B. & STOLLMANN,V. The development of the assembly line revolutionized manufacturing, and contributed to the higher level of Industrial Revolution. Assembly lines are designed for a sequential organization of workers, tools or machines, and parts. The motion of workers is minimized to the extent possible [1].

Naveen Kumar This paper presents the reviews of different works in the area of assembly line balancing and tries to find out latest developments and trends available in industries in order to minimize the total equipment cost and number of workstations [2].

Onc u Haz_r This survey paper serves to Identify and work on open problems that have wide practical applications. The conclusions Derived might give insights in developing decision support systems (DSS) in planning profitable or cost efficient assembly lines [4].

Vrittika.Pachghare This paper presents the reviews of assembly line balancing methods and tries to find out latest developments and trends available in industries in order to minimize production time[3].

Wenqiang Zhang The Assembly Line Balancing (ALB) problem is a well-known manufacturing optimization problem, which determines the assignment of various tasks to an ordered sequence of stations, while optimizing one or more objectives without violating restrictions imposed on the line. As Genetic Algorithms (GAs) have established themselves as a useful optimization technique in the manufacturing field, the application of GAs to ALB problem has expanded a lot. This paper describes a generalized Pareto-based scale-independent fitness function (gp-siffGA) for solving ALB problem with worker allocation (ALB-wa) to minimize the cycle time, the variation of workload and the total cost under the constraint of precedence relationships at the same time[5].

Christian Becker Assembly line balancing research has traditionally focused on the simple assembly line balancing problem (SALBP) which has some restricting assumptions. Recently, a lot of research work has been done in order to describe and solve more realistic generalized problems (GALBP). In this paper, we survey the developments in GALBP research [6].

Lucas K. *Abstract*—In this paper an Assembly Line Balance Optimization Model (ALBO) is proposed to solve the Assembly Line Balance problem (ALB). ALB is currently dependent on human experts. We employed an evolutionary algorithm based on Ant Colony Optimization technique. The efficiency records of three handbag styles having been running in the production lines for 2 months are used to test the ALBO model. It shows that the model can increase the efficiency by almost 13.88%. This is a great improvement as the efficiency of the actual production process is on average 15% below the current standard which could means millions of dollar in profitability [10].

Chorkaew.Jaturanonda This paper presents a heuristic procedure for assigning assembly tasks to workstations where both productivity and ergonomics issues are considered concurrently. The procedure uses Kilbridge and Wester's algorithm to obtain an initial task–workstation assignment solution which minimizes the balance delay of an assembly line. A task reassignment algorithm was applied to improve the initial solution by exchanging assembly tasks, which smooth postural load among workers, between workstations [7].

P. Sivasankaran In this paper, an attempt is made to present a comprehensive review of literature on the assembly line balancing. The assembly line balancing problems are classified into eight types based on three parameters, viz. the number of models (single-model and multi-model), and the nature of task times (deterministic and probabilistic), and the type of assembly line (straight-type and U-type)[8].

Nils Boysen In this paper Assembly lines are special flow-line production systems which are of great importance in the industrial production of high quantity standardized commodities. Recently, assembly lines even gained importance in low volume production of customized products (mass-customization). Due to high capital requirements when installing or redesigning a line, its configuration planning is of great relevance for practitioners [9].

III. DEFINITIONS OF RELATED TERMS

1) Assembly line: An Assembly is made up of a number of workstations, arranged serially. These stations are linked together by a transportation system that aims to supply materials and move the production item from one station to next one.

2) Line Balancing: Line Balancing is leveling the workload across all processes in a cell or value stream to remove bottlenecks and excess capacity. A constraint slows the process down and results if waiting for downstream operations and excess capacity results in waiting and absorption of fixed cost.

3) Cycle Time: Cycle time is the Maximum amount of time allowed at each station. This can be found by dividing required units to production time available per day.

4) Lead Time: Summation of production times along the assembly line or Total time required to manufacture an item or it is the time that elapses between when a process starts and when it is completed.

5) Idle Time: Idle time is the time specified as period when system is not in use but is fully functional at desired parameters.

6) Bottleneck: Delay in transmission that slow down the production rate. This can be overcome by balancing the line.

7) Precedence: The product can't be move to the next station if it doesn't complete at the previous station. The products flow from one station to the other station. In assembly line the products have to obey this rule. It can be represented by nodes or graph.

8) Smoothness Index: This is the index to indicate the relative smoothness of a given assembly line balance. Smoothness indeed is zero Indicates perfect balance.

IV. TYPES OF ASSEMBLY LINES

There are many types of assembly line systems, some common variations include the classic, automated, intermittent and lean manufacturing models. These assembly line systems are often used for making different types of

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products. Assembly lines have some shared characteristics. Figure 1 summarizes the kinds of assembly systems.

There are many different types of assembly line systems some common variations include the classic automated intermittent and lean manufacturing models. These assembly line systems are often used for making different types of products. Assembly lines have some shared characteristics.

Single model assembly line. Single model assembly line is a type of assembly line in which assemblers work on the same product.

Mixed Model assembly line. In mixed-model production is the practice of assembling several distinct models of a product on the same assembly line without changeovers and then sequencing those models in a way that smoothes the demand for upstream components. Setup times between models could be reduced sufficiently enough to be ignored, so that intermixed model sequences can be assembled on the same line. In spite of the tremendous efforts to make production systems more versatile, this usually requires very homogeneous production processes.

Multi Model Assembly lines. Multi-product production supports process manufacturers where multiple or single components are run through a processing line which delivers multiple end items or finished products, including waste or by-products. Serial/Lot control for components and end items is available, as is a variety of costing and yield methods.

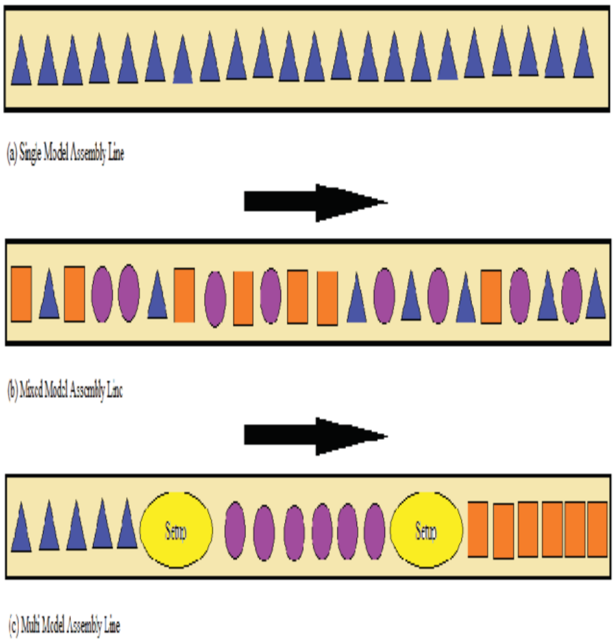

Fig. 1. Assembly lines for single and multiple products

Peaced and unpeaced assembly lines. In peaced assembly systems a fixed time value restricts the work content of stations (SALB further assumes that the cycle time of all stations is equal to the same value). Assembly lines with this attribute are called paced, as all stations can begin with their operations at the same point in time and also pass on work pieces at the same rate.

In unpaced lines, work pieces do not need to wait until a predetermined time span is elapsed, but are rather transferred when the required operations are finished. This type of line control is often implemented if stochastic variations influence processing times.

V. PROCEDURES TO SOLVE ASSEMBLY LINE BALANCING PROBLEMS

Numerous procedures have been developed to solve assembly line balancing problems. Due to the NP-hard nature of this type of combinatorial problem, few exact methods have been developed to solve SALBP, in particularly SALBP-1. Habitually, although guaranteeing an optimum so methods have a problem size limitation, measured in terms of computing time; therefore, they can only be applied to problem instances with small or medium number of assembly tasks. Approximate methods (i.e., heuristics and Meta heuristics) have been developed in order to overcome such a limitation, and aiming at providing good solutions that are as near as possible of the optimal solution.

Exact Procedures

Generally, (mixed) integer linear programming models have been used to formally describe assembly line balancing problems, which may facilitate designers and decision makers to have a better understanding of different assembly systems. However, most often solving such models optimally has not practical relevance because standard solvers proved to be inefficient when considering real-world scaled problems. Therefore, most exact method considered in the literature to solve ALBP are based on dynamic programming and branch-and-bound procedures. Dynamic Programming (DP) procedures basically transform the problem into a multi-stage decision process by breaking it into smaller sub problems, which in turn are solved recursively; then the optimal solutions of the sub problems are used to construct the optimal solution of the original problem. Branch-andbound (B&B) is an enumeration technique, which finds the optimal solution by exploring subsets of feasible solutions. Sub-regions are formed by branching the solution space. A bounding process is recursively used to find lower or upper bounds of the optimal solution within each sub-region, using different searching strategies (e.g. depth first search, minimal lower bound, best first search or minimal local lower bound). Some effective B&B methods developed to solve SALBP-1 include FABLE.

Heuristic Methods

A common methodology used is the greedy approach, where, at each step of the procedure, one element of the solution is chosen according to a given criteria until a complete solution is obtained. The simplest method randomly generates solutions, evaluates each one of them and keeps the best of all solutions obtained. Basically, constructive methods are based on priority rules, most of which are measured considering the number of predecessors and successors, and the task processing times. One of the first proposed heuristic

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was Ranked Positional Weight (RPW) in which tasks are ranked in descending order of the positional weight (the summation of the task time and the processing times of all its successors). Other well-known priority rules include maximum task time, maximum total number of successors, minimum earliest and latest workstation and minimum slack. Some heuristics combine several priority rules; such as, for example, TTS which considers the maximum task time divided by the total number of successors. Priority-rule based methods create a ranked list of the assignable tasks. A task is assignable if all of its predecessors have already been assigned and if its time plus the current workstation time does not exceed the cycle time. Then, tasks are selected and assigned to the workstations considering one of the two following strategies.

1. Station-oriented strategy starts with one workstation and then others are consecutively considered one at a time. With each iteration, tasks are orderly selected from the ranked list and assigned to the current workstation. Once the current workstation is fully loaded (the ranked list is empty) a new workstation is opened.

2. Task-oriented strategy, the first task in the rank list (the one with the highest priority) is selected and assigned to the earliest workstation to which the task can be assigned. Task-oriented methods are further divided into immediate-update-first or general-first-fit methods depending on whether the ranked list is immediately updated after a task has been assigned or after all tasks in the ranked list have already been assigned, respectively

Meta heuristics

Falling in a local optimum is a main drawback of classical heuristic methods. Therefore, in the last years a group of methods, referred to as metaheuristics have been developed to overcome such a limitation. The term metaheuristic was first introduced by Glover (1996). These procedures are based in constructive methods to find an initial solution (or a population of initial solutions) and local search algorithms to move to an improved neighbor solution. In contrast to local search approaches, metaheuristics do not stop when no improving neighbor solutions can be found. They allow movements to worsening solutions in order to avoid premature convergence to a local optimum solution. Metaheuristics use different concepts derived from artificial intelligence, evolutionary algorithms inspired from mechanisms of natural evolution. GRASP (Greedy Randomized Adaptive Search Procedure) is an iterative process in which each iteration consists of two phases the construction phase, which generates an initial solution; and the improving phase, which uses a local optimization procedure to find a local optimum. The initial solution is generated by probabilistically selecting the next element to be incorporated in a partial solution from a restricted candidate list (RCL). Tabu search (TS) is a local search metaheuristic based on memory structures that prevents returning and keeping trap in a local optimum solution. To escape from a local optimum moves to worse solutions are allowed. A tabu list is used to avoid cycling back to recently visited solutions. The size of the list, a key parameter, determines the number of iterations during which a given solution is prevented to reoccur. The procedure finishes, for example, when a number of search movements have been performed and no further improvement Ant colonies algorithms, basically model the behavior of ants searching an optimal path (e.g. for food or real ants) which connects two different positions. The selection of paths is stochastic and it is influenced by both the quantity of pheromone that other ants have put on a path (i.e. desirability) and the local values of the objective function that can be determined if the path is selected (i.e. visibility). Simulated Annealing (SA) is a technique inspired from the

VI. AIMS AND OBJECTIVES OF THE WORK

The aim of this is to minimizing workloads and Workers on the assembly line while meeting a required output. The aims and objectives of the present study are as follows:-

1) To reduce production cost and improve productivity
2) To determine number of feasible workstation.
3) To identify the location of bottleneck and eliminate them.
4) To determine machinery and equipment according to assembly mechanism.
5) To equally distribute the workloads among workmen to the assembly line.
6) To optimize the production functions through construction of mix form of automation assembly and manual assembly.
7) To minimize the total amount of idle time and equivalently minimizing the number of operators to do a given amount of work at a given assembly line speed.

VII. CONCLUSION

This paper highlights the brief details about assembly line balancing how and when it started, how it evolved. It is found that assembly lines are flow-line production systems, where a series of workstations, on which interchangeable parts are added to a product. The product is moved from one workstation to other through the line, and is complete when it leaves the last workstation. It has been also observed that equipment costs, cycle time, the correlation between task times and equipment costs and the flexibility ratio needs a great attention. This also gives detailed classification of assembly line balancing such as single model assembly line, multi model assembly line, mixed model assembly line and paced model assembly line balancing. it includes assembly line balancing problem solving procedures which guides industries to use suitable method for the problems available in industries.

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