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RESEARCH ARTICLE

A REVIEW ON ASSEMBLY LINE BALANCING.

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Abstract

An assembly line is one of the most intrinsic parts of manufacturing industry where the workstations are arranged systematically to obtain their final product. Balancing of an assembly line aims at reducing losses and increasing productivity. There are certain loopholes in the assembly lines of various industries which hampers its balance. This paper reviews some of the studies carried out in the field of assembly line balancing and puts forward recent trends and techniques available to optimize the assembly line of the company.

Introduction:-

Line balancing is a useful tool in the production field. Its main aim is to assign jobs to each worker or machine in such a way that each unit has the same amount of work to be done and can complete their task at approximately the same time.

An assembly line balancing is a production strategy of assigning tasks to workstations, in which parts are assembled and made into a final product as the unit progresses from station to station. A balanced assembly line improves productivity as a whole, reduces cycle time and improves the efficiency of the organization. Various techniques are available for developing an assembly line, but basic requirements for all are confined to breaking down of total job content into smaller tasks and decide which task to be performed before the next one begins or which task can be performed simultaneously.

Definitions of related terms-

Assembly line :-

An assembly line is a flow line of progressing workstations where parts are assembled to form a final product. If only one model of product is produced in the same line then such assembly lines are known as Single Model Assembly Line and if products of one similar model are assembled with batches then such assembly lines are called Multi-Model Assembly Line. On the other hand, if several distinct models of a product on the same assembly line are produced without any changeover, then such models are called as Mixed Model Assembly Line.

Non-Value Added Work:-

The work that consumes resources but does not add any value to the product or service is known as Non Value Added Work. These non value added work need to be identified and eliminated to optimize the total cost incurred by a company.

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Yamazumi Chart:-
'Yamazumi' is a Japanese word that means to stack up. So Yamazumi Chart is a stacked bar chart that shows the balance of cycle time workloads between several operations in assembly line or work cell. It can be used in both single product and multi product assembly line.

Genetic Algorithm (GA):-
Genetic algorithm is based on natural selection which is the process that derives the biological evolution. This method can be used for both constrained and unconstrained optimization problem. This algorithm modifies the population of individual solution repeatedly.

Lean Manufacturing:-
It is the manufacturing technique which is used to minimize the waste within the production system without sacrificing productivity.

Particle Swarm Optimization(PSO):-
PSO, developed by Kennedy and Eberhart is a population based stochastic optimization technique that optimizes the problem by iterative approach to improve a solution related to a given measure of quality. This technique was inspired by the social behaviour of animal species living in large colonies like birds, ants and fishes.

Definitions of terms related to line balancing-
Cycle time:-
It is the time taken to complete a specific task from start to finish. Generally stopwatch is used to measure the cycle time. The formula to determine the cycle time is-

$$Cycletime = \frac{Totalproducedparts}{Productionruntime}$$

Takt Time:-
The rate to which an industry or a company needs to produce the product to satisfy the customer demands is called as Takt Time. The formula for Takt Time is-

$$Takttime = \frac{Availablemachinetimepershift}{Customerdemandpershift}$$

Lead Time:-
The time from receiving the order to delivery of the product is termed as Lead Time.

$$Leadtime = \sum Productiontimealongassemblytime$$

Bottleneck:-
Bottleneck is the transmission delay that slows down the production rate. Line balancing is used to overcome this issue.

Idle Time:-
It is the period when system is not in use but is fully functional at desired parameters.

Productivity:-
It is the ratio of desired output to the input. Productivity depends on several factors such as labours, machines and methodologies used.

$$Productivity = \frac{Output}{Input}$$

Literature Review:-
A work on assembly line balancing using simulation technique in a garment manufacturing firm was done by Kitaw, Matebu, and Tadesse[1]. According to them typically problems facing garment manufacturing are long production lead time, bottlenecking, short product cycle and low productivity. In this paper to reduce or eliminate these problems they have proposed a simulation model which represent real production process of garment products that helps to identify the bottlenecks and enhance production system performance. According to them their model is advanced than existing line balancing techniques as those techniques are based on manual operations oriented system and do not gain significant results with the techniques and difficult to forecast future events when the industries want to change or modify the production system. But the simulation model for line balancing that they

proposed provides the planning managers with a simulation based optimization tool that helps to gain information without disturbing the real system and improves the performance of the system to maximize the productivity of the particular industry. Besides these, the managers can test new systems before implementing without any disturbance of the existing production system.

A paper on optimization of production line using simulation and lean techniques was presented by Enrique, Gustava, Luis, Deniel and Antonio[2]. In this paper their main aim and objective was to present the use of simulation to assist the process of decision making in order to implement lean manufacturing principle which was done in die carton box factory. They developed a simulation model for the existing assembly system as well as for new assembly system. Through this work they have found that the discrete event simulation has been proven robust as tool can help in quantifying the benefits of manufacturing. Using techniques suggested by them, a company can have savings of significant amount of running cost as impact of lean principles that effect in reduction of floor space and transportation time.

Aiming at production activity and assembly line at the company X, Abdul, Asyran, Eddi, Mohd[3], presented a work on optimizing assembly production line using line balancing. Both qualitative and quantitative methods were used to determine the layout is flexible or not. Qualitative method includes interviews to obtain data or information from production line and quantitative methods include secondary data collection needed for the assignment. Further, they entered the secondary data into a software POM and concluded that it can increase efficiency and reduce idle time. On the other hand, some solution procedures like optimum seeking procedure, heuristic simulation have many ways in details to solve mixed model assembly line balancing problems.

Sandip, Niranjan and Sanjay[4] presented a work on assembly line production improvement by optimization of cycle time. The main aim of their work was to reduce non value added work and to eliminate waste on resources of the manufacturing system. Here they have taken the problem of automobile manufacturing organizations as those organizations have to compete in a dynamic environment and must have to develop new methodologies allowing them to remain competitive and flexible because of changing demand. In this paper, a short problem description was presented and found that the line balancing tool can help to characterized the line capacity and take into account the dynamic behaviour of the system. Line balancing tool also can assist in flexibility and effective manner. They have proposed a solution for optimization of cycle time by both side weights balancing with safety side cylinders for up and down movement of chute. To get the solution they have done analysis of process, work and motions. For line balancing, they took help of Yamazumi chart. With these activities they have concluded that the optimization of cycle time is helpful for low cost automation and bench marking activity at industry production improvement level.
A novel assembly line balancing method based on PSO algorithm was presented by Xiaomei, Yangyang, Zhang and Dong[5]. Their main aim was to propose a better solution to overcome the problem in assembly line balancing. In this paper, they have taken multi objective optimization model considering the takt time and smoothness index and proposed a balance optimization scheme based on PSO algorithm. In their work , they used Matlab to simulate the PSO algorithm. They have found that the PSO algorithm can optimize assembly line balancing problem with the high rate of assembly balance and the smallest discrete condition.

A case study on optimizing assembly line production through line balancing was carried out by Adi, Lean and Nor Akramin [6] at an electrical accessories manufacturer in Malaysia. In this study the cycle time for each station was recorded, standard cycle time was estimated and eventually the productivity and efficiency of current assembly line were analysed. Through that analysis it was found that although 600units/worker/day was expected productivity of studied assembly line, yet only 500units/worker/day was its actual performance. Hence they proposed an assembly line setting based on line balancing method, which on implementation increased the productivity up to 671units/worker/day. In addition, by implementing their proposed setting, number of workers reduced by one person compared to ongoing setting.

A multi objective optimization in order to solve assembly line balancing problem using Genetic Algorithm approach was put forward by Michela and Gino[7]. A case study was considered keeping in mind two main parameters that are very important from economic point of view: first, number of highly skilled workers in order to accomplish the operations correctly and secondly, number of assembly equipments along the line. In this study, they proposed a software tool which is able to solve the Single Assembly Line Balancing Problem(SALBP-1) using multi objective genetic algorithm, named GenIAL (Genetic Iteration for Assembly Lines). The SALBP-1 considers following assumptions-

1. Mass production of one homogeneous product
2. Paced live with fixed cycle time
3. Deterministic execution time
4. Serial line layout, one sided stations
5. Fixed launch interval corresponding to cycle time

The results of their work present the capability of GenIAL to group the necessary resources needed to accomplish the assembly operations in few workstations, simultaneously reducing number of workstations, proper distributions of high skilled workers and number of assembly equipments within the workstations.

A research article on optimization of cycle time in an assembly line balancing problem was presented Vishnu, Jeeno, Peter and Gishnu[8]. They have mainly focussed on mixed assembly line system. Their main objective of the paper was to maximize the rate of production in assembly line system where numbers of operators are predefined and to decrease the number of workstations in mixed model assembly balancing problem. They proposed an approach to solve the mixed assembly line balancing problem by using meta heuristic method. According to them for mixed assembly line system, heuristic method may not give optimal solution as in this kind of assembly line more number of work elements are there and the solution becomes complex. Therefore they have developed a method called meta heuristic which is nothing but the genetic algorithm and proposed a genetic algorithm based procedure to solve the cycle time optimization problem.

A research on industrial assembly line balancing optimization based on genetic algorithm and witness was presented by Wang Y and Yang O[9]. They have mainly focussed on addressing the issues in balancing assembly lines for industrial production. In this paper, they have proposed a combinatorial optimization method for implementation and optimization of the assembly line by using genetic algorithm (GA) and system simulation. In their genetic algorithm (GA) they have used different techniques those are encoding design, decoding design, finding fitness function equation, population initialization, selections of operator and hybrid operator and then mutation of operators.

Using Largest Candidate Rule(LCR), Ayal, Tabish, and Malikah[10], performed a case study on line balancing of a manufacturing industry that assembles Pix Cassette Panels. Initially they collected data from the industry and then applied LCR and then applied LCR method. Later the compared the observations recorded before applying LCR and incurred that efficiency of the assembly line improved from 48.98% to 97.3%. Moreover, the cycle time decreases from 120 min to 100min to meet up given demand. Also number of workstations reduced to 7 from 6 and need for overtime also got removed even after completing demand of 100 panels per month with lesser labour. The balance delay of assembly line also decreased and the new designed assembly will save around PKR of 400000 as labour and operating cost per month. Thus on the application of LCR method, the authors concluded that the method improved the overall capabilities of assembly line drastically.

Sumit and Anulay [11], in their work presented an approach for developing assembly line simulation models generally used for optimizing assembly line. In this work, they gave importance to the process of locating and scheduling products in the line achieving best cycle time to fulfil orders in workstations. MATLAB was being used by them for simulation of production line and Particle of Swarm Optimization (POS) algorithm was implemented on models for optimizing productivity and economical costing products. The results of this work highlighted the problems faced during assembly line balancing process and provide guideline for future use as follows:

1. Operations that are object to be inappropriate for pre assembly line & readdressed to the sub assembly stations should be removed from the pre assembly line.
2. The line should be balanced for the minimum number of required operations at stations & on demand workforce should be provided by joker operators.
3. Sub assembly stations should be relocated in order to meet the requirements of new line layout.
4. Factory logistics should be informed about supplying the required parts in the desired sequence.

In today's global competitive world, if an organization does not concentrate on effective production process, then, in the long run, they are sure to be wiped off. K.Amarnath, P.Surendernath, M.Gangadhar[12], simulated and evaluated a real time system on a dies and tooling manufacturing company by implementing discrete event simulation to identify problems in manufacturing and assembly line delay. In this simulation and evaluation, they considered two

main factors (worker and machine performance) in a simulator software and identified the following problems that acts as barrier towards achieving high productivity:

1. Occurrence of bottleneck
2. Waiting time loss
3. Lack of utilization of worker and machine

Summary Of Literature Review:-

The research done by experts in the field of line balancing have been presented in Table 1 in the ascending order of year. Although, there are ample works that are being carried out in this field, the noted works of certain researchers within the period 2010 to 2019 have been reviewed.

Table 1:-

Reference no.	Author name (year)	Problem type	Solution proposed
1	Daniel Kitaw, Amare Matebu and Solomon Tadesse (2010)	Bottlenecking and low productivity in garment industry	Simulation model based on real production scenarios was developed
2	Dr Enrique Ares, Dr Gustavo Palaez, Dr Luis Pinto Ferreira and Mr Daniel Prieto (2012)	Shortfall in assembly line	A simulation model to optimize assembly line and support decision making for overall improvement
3	Abdul Talib Bon, Asyran Abdul Rahman, EddiAzharBolhassan and MohdAshadi Ali Nordin (2013)	Study production activity and the assembly line at a company	Suggested mixed model as better option for assembly line balancing problem
4	Sandip K. Kumbhar,Niranjan N. R and Sanjay T. Satpute (2014)	Various waste in manufacturing system of automobile industry	Used line balancing tool-Yamazumi chart that optimizes cycle time
5	Xiaomei Hu, Yangyang Zhang and Dong Wang (2014)	Assembly line balancing	PSO algorithm considering takt time and smoothness index
6	AdiSaptari, LeauJiaXin and Nor Akramin Mohammad (2015)	A case study on assembly line of an electrical accessories manufacturer was	An assembly line setting proposed that is based on the Line Balancing Method
7	MichelaDalle Mura and Gino Dini (2016)	Simple Assembly Line Balancing Problem (SALBP)	A multi-objective genetic algorithm was developed to solve SALDP
8	Vishnu Raj A S, Jeeno Mathew, Peter Jose and Gishnu Sivan(2016)	Shortfall in mixed model assembly line	Meta heuristic method by using genetic algorithm
9	Wang Y and Yang O (2017)	Assembly line balancing or industrial production	Combinatorial optimization method by using genetic algorithm and system simulation
10	Muhammad Ayat, TabishSarfraz and Malikah Ibrahim (2017)	Line balancing	Largest candidate rule algorithm to improve line balancing
11	Sunil and Anulay Kumar Anu (2018)	Optimization problem in assembly line	A simulation model using PSO technique
12	K. Amarnath, P. Surendernath and	Assembly line delays in a	Built simulation

	M.Gangadhar (2019)	dye manufacturing company	models to identified loopholes in assembly line and ways to increase productivity

Conclusion:-

From the study of the assembly line, it can be summarized that, through logical planning and proper distribution of total job between the work stations a balanced assembly line can be obtained. In order to, achieve that, certain factors like the number of work stations, cycle time, takt time, total cost imposed and productivity must be given special attention. Therefore, we have to arrange the work stations in such an optimal way that higher productivity can be achieved for an organization at a comparatively low cost. Following are some inferences observed:-

1. PSO technique can be used to develop a simulation model that is studied to improve productivity.
2. Largest Candidate Rule Algorithm is used to improve line balancing.
3. A combinatorial optimization method is used for optimization and implementation of the assembly line.
4. Meta-heuristic method can be used to balance Mixed Model Assembly Line.
5. Cycle time can be optimized by implementing Yamazumi Chart.

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