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A PATH FOR HORIZING YOUR INNOVATIVE WORK

DEVELOPMENT OF ASSEMBLY LINE FOR AUTOFEEDER

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Abstract: The manufacturing industry mainly of small scale and medium scale provide wide range of product to fulfill the need of today's market to face the new challenges, these industries should increase their production rate with good quality and accuracy. Thus the time required for the production should be decrease to as small value as possible. The company is located in Nagpur, India. This industry manufacture ginning machine which separates the seeds from cotton. An auto feeder is subcomponent of ginning machine which feeds cotton continuously into ginning machine. Due to increase in demand of product, company need to change over production system from current existing assembly process to assembly line production system. This paper includes determination of number of workstation, allocation of activity to each workstation of each worker, selection of tool to each workstation.

Keywords: Development Of Assembly Line Balancing (ALB); Balancing; Problem; Methods; Determination Of Work Station; Allocation Of Activity.

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INTRODUCTION

Assembly line simply means "A set of sequential workstations, typically connected by a continuous material handling system. Designed to assemble component parts of a product and perform any related operation to produce finished product. An assembly line is a flow-oriented production system where the productive units performing the operations, referred to as stations, are aligned in a serial manner. The work pieces visit stations successively as they are moved along the line usually by some kind of transportation system, e.g. a conveyor belt. Each worker performs his/her assigned tasks on each product when it arrives to him/her. The key to making an assembly line as efficient as possible is to divide the time it takes to produce a product equally among the workers. 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. Since the times of Henry Ford and the famous model-T, however, product requirements and thereby the requirements of production systems have changed dramatically. In order to respond to diversified customer needs, companies have to allow for an individualization of their products. For example, German car manufacturer BMW offers a catalogue of optional features, theoretically, results in 1032different models.Multi-purpose Machines with automated tool facultative production sequences of varying models at negligible setup costs. This makes efficient flow line systems available for low volume assembly to-order production and enables modern production strategies like mass-customization which in turn ensures that the thorough planning and implementation of assembly systems will remain of high practical relevance in the foreseeable future[3].

ALB AND LEVEL OF AUTOMATION

On the basis of level of automation Assembly lines are mainly classified into two categories such as manual lines and automated lines which are explained as below.

Manual Assembly Lines

A manual assembly line is a production line that consists of a sequence of workstations where assembly tasks are performed by human workers. Products are assembled as they move along the line. At each station, a worker performs a portion of the total work o the unit. The common practice is to 'launch' base parts onto the beginning of the line at regular intervals. Each base part travels through successive station and workers add components that progressively build the product. A mechanized material transport system is typically used to move the base part along part along the line as they are gradually transformed into final products. The production rate of an assembly line is determined by its slowest station. Stations capable of working faster are ultimately limited by the slowest station. . Stations capable of working faster are ultimately limited by the slowest station. Procedure for calculating the number of workstations in manual assembly line is discussed below.

Determination of workstations in manual assembly lines

The assembly line must be designed to achieve a production rate (Rp) sufficient to satisfy demand for the product. Product demand is often expressed as an annual quantity, which can be reduced to an hourly rate. Management must decide how many shifts per week the line will operate and how many hours per shifts. Assuming the plant operates 50 week/yr., then required hourly production rate is given by

Rp = Da/ (50*S*H) ……. (1)

Where, Rp = Average production rate (units/hrs.)

Da = Annual demand for single product to be made on line (units/year).

S=No. of shifts per week

H=No. of hours per shifts

This production rate must be converted to a cycle time (Tc), which is the time interval at which the line will be operated. The cycle time must be taking into account the reality that some production time will be lost due to occasional equipment failures, the power outages, lack of certain component needed in assembly, quality problems, and other reasons. As a consequence of these losses, the line will be up and operating only a certain proportion of the total shift time available; this uptime proportion of time out of the total shift time available; this uptime proportion is referred as the line efficiency. The cycle time is determined as

Tc = (60*E)/Rp ….. (2)

Where, Tc=cycle time of the line, min/cycle.

Rp=required production rate units/hr.

E=Line efficiency.

The constant 60 in the above equation converts the hourly production rate to cycle time in minutes. Typical values of E for a manual assembly line is in the range 0.90 to 0.98.The cycle time establishes the ideal cycle rate for the line

$R_c = 60/T_c$ .... (3)

Where, R_c = cycle rate for the line in cycles/hr.

T_c is in minute/cycle

This rate R_c must be greater than the required production rate R_p because the line efficiency E is less than 100%.Line efficiency is therefore defined as

$E = R_p/R_c = T_c/T_p$ ...... (4)

Where, T_p=average production cycle time ($T_p=60/R_p$)

An assembled product requires a certain total amount of time to build, called the work content time (T_{wc}).This is the total time of all work elements that must be performed on the line to make one unit of product by the assembly line. It represents the total amount of work that is to be accomplished on the product by assembly line. It is useful to compute a theoretical minimum number of workers that will be required on the assembly line to produce the product with known T_{wc} and specified production rate R_p. The approach is basically same as while computing the minimum number of workstations required to achieve a specified production workload. So number of workers require on the assembly line:

$w=WL/AT$ ...... (5)

Where, w = No. of workers on the line.

WL = Workload to be accomplished in a given time period.

AT = Available time in the period.

The time period of interest will be 60 min. The workload is that period is the hourly production rate multiplied by the work content time of the product, that is,

$WL = R_p T_{wc}$ .... (6)

Where, R_p = Production rate, units/hr.

T_{wc} = work content time, min. /unit

Eq. (2) can be rearranged to the form $R_p = 60E/T_c$. Substituting this in Eq. (6) we get, WL = (60*E*Twc) /Tc ….. (7)

The available time AT = one hour (60 min.) multiplied by the proportion uptime on the line; that is,

AT = 60*E ….. (8)

Substituting these terms for WL and AT in Eq. (5) the equation reduces to the ratio Twc/Tc. Since the number of workers must be an integer, we can state

w* = Minimum Integer ≥Twc/Tc … (9)

Where w* = Theoretical minimum number of workers. If we assume one worker per station, then this ratio also gives the theoretical minimum number of workstations on the line.

Automated assembly lines

The term automated assembly refers to the use of mechanized and automated devices to perform various assembly tasks in an assembly line or cell. An automated assembly system performs a sequence of automated assembly operations to combine multiple components in single entity. The single entity may be the final product or a subassembly in a larger product.

CLASSIFICATION OF ALB PROBLEMS

Classification of ALB problem is primarily based on objective functions and problem structure. Different versions of ALB problems are introduced due to the variation of objectives.

Objective Function Dependent Problems

1) Type F: Objective dependent problem, it is associated with the feasibility of line balance for a given combination of number of stations and cycle time (time elapsed between two consecutive products at the end of the AL).

2) Type 1: This type of problem deals with minimizing number of stations, where cycle time is known.

3) Type 2: Reverse problem of type 1.

4) Type E: This type of problem is considered as the most general version of ALBP. It is associated with maximizing line efficiency by minimizing both cycle time and number of stations.

5) Type 3, 4 and 5: These corresponds to maximization of workload smoothness, maximization of work relatedness and multiple objectives with type 3 and 4 respectively.

STRUCTURE OF ALB PROBLEMS

1) SMALB: This refers to single model ALB problems, where only one product is produced.

2) MuMALBP: Multi model ALB problems, where more than one product is produced on the line in batches.

3) MMALBP: Mixed model ALB problems, various models of a generic product are produced on the line in an intermixed situation.

4) SALBP: Simple ALB balancing problems, simplest version of balancing problems, where the objective is to minimize the cycle time for a fixed number of workstation and vice versa.

5) GALBP: A general ALB problem includes those problems which are not included in SALBP. Those are for instance, mixed model line balancing, parallel stations, U-shaped and two sided lines with stochastic task time

METHODS OF ALB

There are four Assembly Line Balancing methods such as Largest Candidate Rule, Kilbridge and Wester method, Ranked Positional Weights Method. , COMSOAL method. Each method of Assembly Line Balancing is explained below in brief.

Largest Candidate Rule

In this method, work element are arranged in descending order according to their Tek values, The algorithm consists of the following steps: (1) assign elements to the worker at the first workstation by starting at top of the list and selecting the first elements that satisfies precedence requirements and does not cause the total sum of Tek at that station to exceed the allowable Ts; when an element is selected for assignment to the station, start back at the top of the list for subsequent assignments; (2) when no more elements can be assigned without exceeding Ts, then proceed to the next station; (3) repeat steps 1 and 2 for as many additional stations as necessary until all elements have been assigned.

Kilbridge and Wester Method

This method has received considerable attention since its introduction in 1961 and has been applied with apparent success to several complicated line balancing problems in industry. It is a heuristic procedure that selects work elements for assignment to stations according to their position in precedence diagram. This overcomes the one of the difficulties with largest candidate rule in which elements may be selected because of a high Ts (cycle time) value but irrespective of its position in the precedence diagram. In general, the Kilbridge and Wester method provides a superior line balance solution to that provided by the largest candidate rule.

Ranked Positional Weights Method

The Ranked positional weights method was introduced by Helgeson and Birnie. In this method, a ranked positional weight value (RPW) is computed for each element. The RPW takes into account both the Tek value and in the position in the precedence diagram. Specifically, RPW is calculated by summing Tek and all other times for elements that follow Tek in the arrow chain of the precedence diagram. Elements are compiled into list according to their RPW value, and the algorithm proceeds.

COMSOAL

The COMSOAL (Computer Method of Sequencing Operations for an Assembly Line) is procedure to assign work elements to stations. In this heuristic method, hundreds or thousands of calculations are quickly performed on the computer until the absolute best solution is found.

FACTORS TO BE CONSIDERED IN ASSEMBLY LINE BALANCING

Various factors to be considered in assembly line balancing are discussed as below

Line Efficiency

The line efficiency is a critical parameter in assembly line operations. When the entire assembly line goes down, all workers are idled. It is the responsibility of management to maintain a value of line efficiency (LE) as close to 100%. Steps that can be implemented to maintain the line efficiency at its maximum value are given below.

i) Implementing preventive maintenance program to minimize downtime occurrences.

ii) Employing well trained repair crews to quickly fix breakdowns when they occur.

iii) Managing the incoming components so that parts shortages do not cause line stoppages.

iv) Insisting on the highest quality of incoming part from suppliers so that downtime is not caused by poor quality components.

Methods Analysis

Methods analysis involves the study of human work activity to seek out ways in which the activity can be done with less effort, in less time, and with greater effect. Method analysis can be used after the line is in operation to examine workstations that turn out to be bottlenecks. The analysis may result in improved efficiency of workers hand and body motions, better workplace layout, design of special tools and/or fixtures to facilitate manual work elements, or even changes in product design for easier assembly.

Subdividing the work elements

Minimum rational work elements are defined as small tasks that cannot be subdivided further. It is reasonable to define such tasks in assembly of a given product, even though in some cases it may be technically possible to further subdivide the element.

Preassembly of Components

To reduce the total amount of work done on the regular assembly line, certain subassemblies can be prepared offline, either by another assembly cell in the plant, or by purchasing them from an outside vendor that specializes in the type of processes required.

Parallel workstation

Parallel stations are sometimes used to balance a production line. Their most obvious application is where a particular station has an unusually long task time that would cause the production rate offline to be less than that required to satisfy product demand. In this case two stations operating in parallel and both performing the same long task may eliminate the bottleneck.

LINE BALANCING CONSTRAINTS

It gives factors to be considered while solving line balancing problem. These factors are listed as below.

Precedence constraints: It indicates the task sequence required to accomplish the goal.

b) Cycle time constraint: It gives the maximum time allowed at any workstation

c) Location constraints: It indicates that some tasks must be placed close to or far from others

d) Technological constraints: It represents technical factors which are to be considered E.g. clean-room vs. standard tasks.

e) Positional constraints: It indicates the tasks that cannot be executed by the same operator due to their position on the product (E.g. opposite sides of an aircraft).

f) Layout constraints: It takes into account the available area for work station e.g. tasks take place in different places in the factory.

EXISTING PRODUCTION SYSTEM OF AUTO FEEDER

Existing technique assemble the auto-feeder in haphazard manner. The technique implies assembling one part at one time for the whole batch. After completion of one part for the whole batch then switching over to another part and hence completing the whole assembly. The component of product assembled in sequence.

TABLE I. Activities Performed in existing system

Sr. no.	Name of activities performed in existing system	Time (min)	Distance (meter)
1	Moving towards storage system	3	22
2	Keep the assembly device in assembly section	1	
3	Moving towards storage system	2	22
4	Keep the bottom round panel on device	1	
5	Moving towards storage system	30sec	22
6	Keep lock bush, bolt, washer on Bottom round panel	30sec	
7	Moving towards storage system	3	22
8	Insert the upper pipe into Bottom round panel	1	
9	Moving towards storage system	3	22
10	Insert the bearing pipe into Bottom round panel	1	
11	Tight, bolt, washer of bearing pipe	2	
12	Moving towards storage system	30sec	22
13	Keep the lock bush on upper pipe	30sec	
14	Moving towards storage system	3	22
15	Fix the belt	2	
16	Moving towards storage system	3	22

17	Keep the upper round panel	1	
18	Alignment of upper round panel hole with bearing pipe	2	
19	Moving towards storage system	30sec	22
20	Keeping the bolt washer on upper round panel	30sec	
21	Partial tighten of bolt washer of aligning bearing pipe	2	
22	Tighten of grub screw of bearing bracket	1	
23	Tight the bearing pipe with upper round panel	1	
24	Tight the bearing pipe with bottom round panel	1	
25	Moving towards storage system	30sec	22
26	Keep the 10'' pulley at each machine	30sec	
27	Tilting of semi assembled auto feeder	3	
28	Tight the grub screw of bracket on bottom round panel	1	
29	Moving towards storage system	3	22
30	Fitting of side panel to machine	3	
31	Fitting of 10'' pulley to upper pipe	1	
32	Moving towards storage system	30sec	22
33	Fitting of block on bottom round panel	30sec	
34	Moving towards storage system	30sec	22
35	Fitting of 4'' pulley to block	30sec	
36	Moving towards storage system	3	22
37	Fitting of side panel to machine	3	
38	Drilling the side panel	2	
39	tightening of side panel from upper side	2	
	Total time	60min.	308meter.

In this type of assembly practice work is stationary and workers are moving within working area.

The worker first pick up one part for the whole batch size and place it. The next objective of worker is to put the next meshing part. After the placement,3 workers start the assembling of batch one by one while the 4th one keep getting the part at places for other 3. The existing system consist of 12 worker for assembling the auto feeder i.e. two worker for front panel fitting, two worker for standing the auto feeder, two worker for side panel fitting, two worker for 4’’pulley and arm housing fitting, one worker for 10’’ pulley fitting and two worker for the fitting of glass frame.

After observing carefully all activities performed by workers at the shop floor for production of auto feeder we have recorded the different activities performed by the worker. There are 39 different activities and from the above table no.1, the existing system consist of fourteen transportation activities which requires 26min. and the total distance travelled by the worker is 308 meter because the storage system is far away from the assembly section i.e.22 meter and as it is a haphazard system, every time the worker has to travel the same distance, and it consist of twenty five operational activities which requires 34 minutes for completion. So after doing the time and method study of existing system, we proposed modified system for the assembly of auto-feeder. In modified system, first we eliminate the unnecessary activities from the existing system which are performed unnecessarily during an assembly of auto-feeder because these activities do not have any direct relation with assembly procedure. And we reduce the distance between storage system and the assembly section so that time required to travel the total distance by worker is reduced.

TABLE II. Activities and time of modified system with precedence

Sr.no.	Name of activities of modified system	Time (min)	Distance (meter)
i.	Moving towards storage	30sec	4
1	Keeping two front panels on stand	30sec	
ii.	Moving towards storage.	40sec	4
2	Fixing four bearing bracket.	2.20 sec	
iii.	Moving towards storage.	30sec	4
3	Inserting lock bush on top roller.	30sec	
4	Inserting two top rollers.	2min	
iv.	Moving towards storage.	1min	4
5	Fixing four wooden blocks.	3min	
v.	Moving towards storage.	30sec	4
6	Inserting lock bush on bottom roller.	30sec	
7	Fixing bottom roller.	4min	
vi.	Moving towards storage.	1min	4
8	Fixing belt on roller.	4min	
9	Adjusting grub screw.	1min	
vii.	Moving towards storage.	30sec	4
10	Fixing angle plate.	1.30 sec	

viii.	Moving towards storage.	1min	4
11	Fixing sub assembly (arm housing, 4’’pulley).	4min	
ix.	Moving towards storage.	30sec	4
12	Fixing 10’’ pulley on top roller.	1.30 sec	
x.	Moving towards storage.	1.30 sec	4
13	Fixing side panels.	4.30 sec	
xi.	Moving towards storage.	30sec	4
14	Drill the side panel on top side and fix it.	3.30 sec	
xii.	Moving towards storage.	30sec	4
15	Fixing the glass frame.	1.30 sec	
	Total time	43 min.	50meter

MODIFICATION OF PRODUCTION SYSTEM OF AUTOFEEDER

Determination of number of workstation

After the thorough analysis of existing method of production , time study and after reducing unnecessary activities we developed modified assembly system which reduces operational and transportation time from existing system but for developing the assembly line we need to calculated the no. of workstation and for that we calculate production rate and cycle time after doing the assembly of auto feeder according to modified system we determine the new time for assembling the auto feeder given in table.no.2. Then we applied the line balancing method i.e. Largest Candidate Rule to determine actual no. of workstation and to allocate the activities at different workstation. Sequence of activities with their working elemental time (Tek) and precedence of each activity is given in following tableno.3

Production rate (Rp):

= Da/(50*S*n)

=12000/(50*6*8)

=5units/hr.

Cycle time (Tc):

= (60*E)/Rp

= 60*0.95/5

=11.4min

Where, E(line efficiency)(assume)=0.95 , Da=annual demand, S=shift per week, n=working hour per shift

TABLE III. List of activities with time and their precedence

Sr.no	Operational plus transformational activities of modified system	Time Min.	precedence
01	Keeping two front panels on stand	1	-
02	Fixing four bearing bracket.	3	01
03	Inserting lock bush on top roller.	1	02
04	Inserting two top rollers.	2	03
05	Fixing four wooden blocks.	4	04
06	Inserting lock bush on bottom roller.	1	05
07	Fixing bottom roller.	4	06
08	Fixing belt on roller.	5	07
09	Adjusting grub screw.	1	02
10	Fixing angle plate.	2	08
11	Fixing sub assembly (arm housing, 4'' pulley).	5	10
12	Fixing 10'' pulley on top roller.	2	04
13	Fixing side panels.	6	12,09
14	Drill the side panel on top side and fix it.	4	13
15	Fixing the glass frame.	2	14
	Total time	43	

TABLE IV. Arrangement of work element according to as L.C.R

Work element	Working elemental time(min)	Preceded by
13	6	12,09
08	5	07
11	5	10
05	4	04
07	4	06
14	4	13
02	3	01
04	2	03

10	2	08
12	2	04
15	2	14
01	1	-
03	1	02
06	1	05
09	1	02
	43min.	

TABLE V. Assignment of work elements to work station according to L.C.R

Station no.	Work element	Working elemental time(min)	Station time (Tc=11.4 min)
1	01,02,03,04	1+1+3+2	7 min
2	05,06,07	4+1+4	9 min
3	08,09,10	5+1+2	8 min
4	11,13	5+6	11 min
5	12,14,15	2+4+2	8 min

RESULT AND COMPARISON

The following table shows results which is compared on the basis of different parameters of existing and proposed modified assembly model.

Sr no.	Parameters	Existing assembly system	Modified assembly system
1	Production rate	20 auto feeder per shift	34 auto feeder per shift
23	Assembly time	First-60 min. Then 1 per 19min	First-43min Then 1 per 11.4min
3	Number of worker	12	10
4	Cost of assembly per auto feeder	Rs.1000	Rs.833
5	Storage for spare parts	Storage is in random manner and also far from the working area	Separate for each workstation

TABLE VI. Comparison of different parameters

CONCLUSION

This paper provides solution to the problems faced by industry. Proposed method provides a better solution over the existing assembly method. The proposed method reduces the time required for assembly of product auto-feeder. Thus the overall production rate is increased. Also the proposed method allows the dispatching of the first product in 43 minutes and then the remaining products after interval of 11.4 minutes. Thus, time to time, the dispatching can be done and thus the industry can supply the product to the customers, even in between the day. Thus, this disadvantage of the existing assembly method is also rectified in this method. The paper mainly includes determination of sequence of operations, determination of work stations, operations to be carried out at each work station, the number of workers, the cycle time i.e. the time required at each work stations of the proposed method. In this paper we have used the largest candidate rule to determine the no. of workstations. The Method adopted shows saving of time from the calculations. The method thus increases the production as stated earlier. With the proposed method the auto-feeder assembled per day increases from 20 to 34. This much increased rate thus helps in earning higher profit. Thus the cost involved in setting up of the new assembly method is justified.

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