Production Flow in Gas Cooker Assembly Line

Batool Ibrahim
University of Technology-Industrial Engineering Division

Abstract

Increasing the flow of parts under manufacturing in production and assembly lines one of the most important goals that administration is seeking to achieve them. Problems of balancing the production and assembly line created to uneven distribution of workloads on workstations along the production and assembly line, Which is usually measured in number of units produced in the unit of time (hours / day), and can be irregular flow of production and raised the achievement of balanced production line. research aims to study the problem of balancing single production lines and the most important methods adopted to solve it and try to apply that in the production line was chosen as the assembly line cookers in light Industrial Company and calculate the material flow or parts in the production line, where the parts moving between work stations by conveyor system , Software (Quantitative Methods ,Production and Operations Management POM-QM) has been used to solve the problem of balancing single production lines to calculate the actual number of workstations are (9) workstations and production flow (35) units / day, the efficiency of the line (% 78.24) By choosing the shortest task time method to increase the production flow to (37) units / day to increase efficiency (81.64%).

Keywords: Assembly Line Balancing, Production Flow.

الخلاصة

يعتبر رفع تدفق الأجزاء تحت التصنيع في خطوط الإنتاج والتجميع، واحده من أهم الأهداف التي تسعى الادارة لتحقيقها .مشاكل موازنة خط الإنتاج والتجميع تنشأ لتفاوت توزيع أعباء العمل على محطات العمل المختلفة على طول خط الإنتاج والتجميع. والتي تقاس عادة بعدد الوحدات المنتجة في الوحدة الزمنية (ساعة/يوم)، ويمكن انتظام تدفق الإنتاج ورفعه بتحقيق موازنة الخطط الانتاجيه .يهدف البحث إلى دراسة مشكلة موازنة الخطوط الانتاجيه الاحاديه واهم الطرق المعتمدة في حلها ومحاولة تطبيق ذلك في خط إنتاجي حيث تم اختيار خط تجميع الطباخات الغازية في شركة الصناعات الخفيفة وحساب تدفق المواد أو الأجزاء في خط الإنتاج، حيث تنتقل الأجزاء بين محطات العمل بواسطة نظام ناقل، تم استخدام (POM-QM) البرامجيه لحل مشكلة موازنة الخطوط الانتاجيه أحادية النموذج وحساب عدد محطات العمل الفعلية وهي (9) محطات عمل وتدفق الإنتاج (35) وحده/يوم، كفاءة الخط (78.24%) وباختيار طريقة اقصر وقت للنشاط تم زيادة تدفق الإنتاج إلى (37) وحدة/يوم، كفاءة الخط (81.64%).

الكلمات الدالة: موازنة خط التجميع, تدفق الإنتاج.

1. Introduction

The production lines are consist a group of stations Work pieces are moved along the line from station to other , while each one performs a number of repeated operations necessary to manufacture a desired final product .production line must be arranging the individual processing or assembly tasks at the workstations in a way that facilitates the flow materials or parts from a workstation to another. so that Assembly line is a flow oriented production system consists of a set of workstations arranged in a linear fashion, and each station connected by a material handling device .The basic movement of material through an assembly line begins with a part being fed into the first station at a predetermined feed rate **[Norman,2002]**. A station is considered any point on the assembly line in which a task is performed on the part. The time it takes to complete a task at each operation is known as the process time. The cycle time of an assembly line is predetermined by a desired production rate. This production rate is set so that the desired amount of end product is produced within a certain time period **[Grzechca,2008]**. the total time required at each workstation is approximately the same. Improper line balancing is defined on distribution of workloads are not equal along the production line , there will one station that has maximum time to perform a task so that the production flow different in one station to others . This station is called bottle neck station to preventing these problem , engineers should come out with a solution in order to fix these problems. One way to do so is using line balancing method[**Norman,2002, Nearchou,2006].** Balancing method is very essential to make the production flow almost smoother. Line balancing is a tool that can be used to optimize the workstation or production line throughput. This tool will assist in the reduction of the production time and maximizing the output or minimizing imbalance between station in order to achieve required run rate to max production flow. This can be done by equalizing the amount of work in each station[**Grzechca,2008, Slack ,2004].**

2. Classification of Assembly Line Balancing

Classification of Assembly Line Balancing problems is primarily based on objective functions and problem structure. Different versions of Assembly Line Balancing problems are:

2-1. <u>single Model Assembly Line</u>

A single – model line can be described as a line that produce a single model .This line produces many units of one product with no variation. The tasks performed at each station are same for all units. Products with high demand are intended to this line[**Nearchou,2006,Hapaz, 2008].**

Simple assembly line Balancing Problem(SALBP) problem is relevant for single product are:

A- problem deals with assigning tasks to work stations such that the number of stations *(n)* is minimized for a given production rate (fixed cycle time, *c*) and max flow material.

B-Problem is to minimize cycle time (maximize the production flow and production rate) for a given number of stations *(m).*

C- the most general problem version maximizing the line efficiency *(E)* , minimizing (C) and idle time.

2-2. <u>Multi Model Assembly Line</u>

This line produces each model in batches. Usually workstations are set up to produce required quantity of the first model then the stations are reconstructed to produce other model. Products are often assembled in batches when medium demand. It's more economical to use one assembly line to produce several products in batches [**Slack ,2004,Kriengkorakot,2007].**

2-3. <u>Mixed – Model Line</u>

Mixed – model line is producing more than one model. They are made simultaneously on the same line. Once one model is worked at one stations, the other product are made at the other stations. Thus, every station is equipped to perform various tasks needed to produce any model that moves through it. Many consumers product are assembled on mixed – model line[**Hapaz, 2008,Meyr,2004].**

3. Literature Review

In view of the importance of integrated line balancing, many researchers have worked on this problem such as.

[Liu, 2008] focused on the use of exact algorithms for solving simple assembly line balancing problem which is required an assignment of tasks to workstations in order to minimize the number of workstations needed for a given cycle time. precedence relations between tasks are not violated, and one or more objectives are optimized. using branch-and-bound algorithms for solving the simple assembly line balancing.

[Shumon, 2010] discussed and comparing the output and efficiency before and after applying the balancing technique. one production line is selected from the sewing floor and Comparing total output of each process then identified the bottleneck station ,Standard allowable minutes has been calculated of each station and then imbalance situation in the line and bottleneck condition has been identified . balancing process has shared the excess time after the benchmark production in the bottleneck process, Maximum outputs have been increased and line efficiency increased 58% line.

[Rashid , 2011] concludes the Assembly Sequence Planning (ASP) and Assembly Line Balancing (ALB) problems . Several soft computing approaches using different techniques have been developed to solve ASP and ALB. Although these approaches do not guarantee the optimum solution, they have been successfully applied in many ASP and ALB optimization works research .The current research trend shows that ASP and ALB are progressing to a more complicated problem by increment in the number of papers that works on multi objective optimization . Besides that, growth in usage of relatively new algorithm like Particle swarm optimization PSO shows that the researchers tend to explore and develop algorithm which manage to handle more complex problems. three soft computing algorithms that frequently used to solve ASP and ALB are Genetic Algorithm, Ant Colony Optimization and Particle Swarm Optimization.

4. Method To Solve The Problem

For solving line balancing problems Heuristic Methods are preferred . They are simple and involve less time in solving .They provide most Likely solution. The Heuristic Method involves drawing a precedence diagram in a particular way which indicates the flexibility available for transferring tasks' laterally from one column to another to arrive at the most promising balance**[Shumon,2010].**

five heuristic rules that can be chosen are :

1. Longest operation time.
2. Ranked positional weight.
3. Shortest task time.
4. Least number of following tasks.
5. Most following tasks. common way to choose tasks is by using the task with the most following tasks ,from the available tasks choose the task with the largest number of following tasks without violating the cycle time and precedence constraints.

5. The Suggested Steps To solve Problem

There are many steps to solve the problem of single assembly line balancing these are:

1-Specify the number of tasks, description each task and predecessor task, the time for each Task .

2- Specify the sequential relationships among tasks using a precedence diagram. The diagram

consists of circles and arrows. Circles represent individual tasks each task required time; arrows indicate the order of task performance. Precedence diagram needs to be drawn to show a connection between a workstation. There are many advantages of using precedence diagram such as the sequencing constraints. A single number can be assigned to identify each activity, Analytical solution is simpler, Certain process begins when previous process was done**[Soota,2011].**

3-Determine the required workstation cycle time (*Ct*) which is the time interval between parts coming off the line , in order to calculate needing The number of units of product to be produced in a working day , The amount of effective clock time available in a day, using the formula **[Eryuruk,2008].**

$$\text{Ct} = \frac{H}{Pd} \qquad (1)$$

Where:

H=Production time per period.

Pd=Required output in units.

4- Determine Actual number of workstations ,the total number of workstations required on the entire production line ,calculated as the next higher integer value of the number of workstations working (WS) using the following formula **[Fazlollahtabar,2010].**

$$\text{WS} = \frac{\sum_{i=1}^{n} ti}{Ct} \qquad (2)$$

Where:

WS= is the actual number of station.

ti= is the time of task i, i = 1….n

5- Evaluate the efficiency of the balance derived using the formula **[Khanna,1999].**

$$\text{LE}= \frac{\sum_{i=1}^{n} ti}{Ct * WS} \qquad (3)$$

6-Balance Delay(Balancing Loss) is measure of line inefficiency which results from idle time due to imperfect allocation of work among station **[Roya,2010].**

$$\text{B}= 100\% -\text{E} \qquad (4)$$

7- Idle Time (It) is unproductive time. The total idle time in assembly line is calculated as follows **[Roya,2010].**

$$\text{IT} =(\text{WS*Ct})-\sum_{i=1}^{n} ti \qquad (5)$$

6. Practical Application

To Applied the above Suggested Steps to the production line (single assembly line) in The Light Industries company . The line producing a gas cookers size(60*90),the production quantity in one day are(35) unit ,a production line operating (7 hours) per day .the total number of tasks are (24), gas cookers consist of many parts assembled to obtain the final product as illustrated in figure(1).

Figure(1) gas cooker parts.

1-The sequence of assembling processes, the task number and name with their times can be illustrated in table(1) .

Table(1)Task Times

Task Number	Task Name	Task Description	Tasks that must predecessor	Time (min)
1	A	Assembly upper roasting device for oven		1.5
2	B	Assembly lower roasting device for oven		2
3	C	Place oven frame on conveyor	A,B	0.5
4	D	Attach upper roasting device	C	1.5
5	E	Attach lower roasting device	D	2.5
6	F	Attach thermal insulator around oven frame	E	7
7	G	Put oven frame on oven die	F	0.5
8	H	Attach two sided and adjustable base to oven frame	G	5
9	I	place and attach the front panel and electrical system	H	2
10	J	attached Ignition System	I	3
11	K	Attach oven burners	J	1.5
12	L	Assembly and attached the lower oven door	K	2.5
13	M	Assembly and attach gas pipes	K	5
14	N	Preliminary inspection of the gas	M,L	5
15	O	Attach gas nozzle and upper panel	N	6
16	P	Final gas inspection	O	5
17	Q	Electrical inspection	P	5
18	R	Assembly and attach back	Q	4
19	S	assembling class cover	R	5
20	T	assembling the double class oven door	R	6
21	U	attach class cover	S	4
22	V	attach oven door	T	4
23	W	support the accessories	V,U	2
24	X	Packaging	W	4

2-The sequential relationships among tasks using a precedence diagram Shown in figure(2).

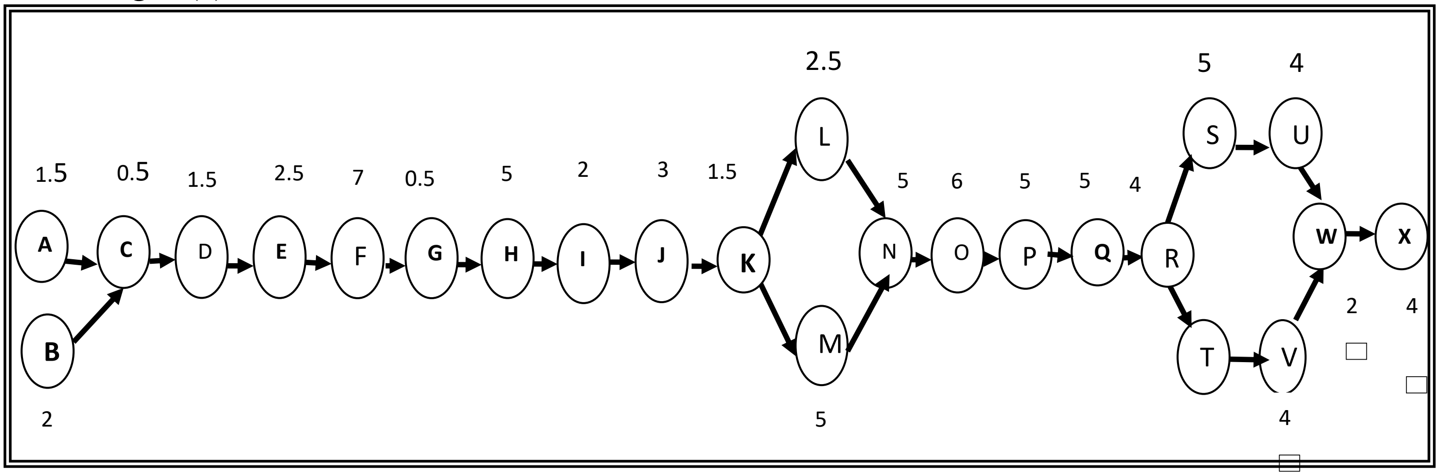


Figure (2) precedence diagram

The program named (POM-QM) is used to balance workloads on an assembly line stations. One of five heuristic rules named the shortest task time method can be used for performing the balance. The production rate can be given and the program will compute the cycle time , the program start with start screen for input the problem name ,the tasks symbols and numbers ,the time as shown in figure(3).

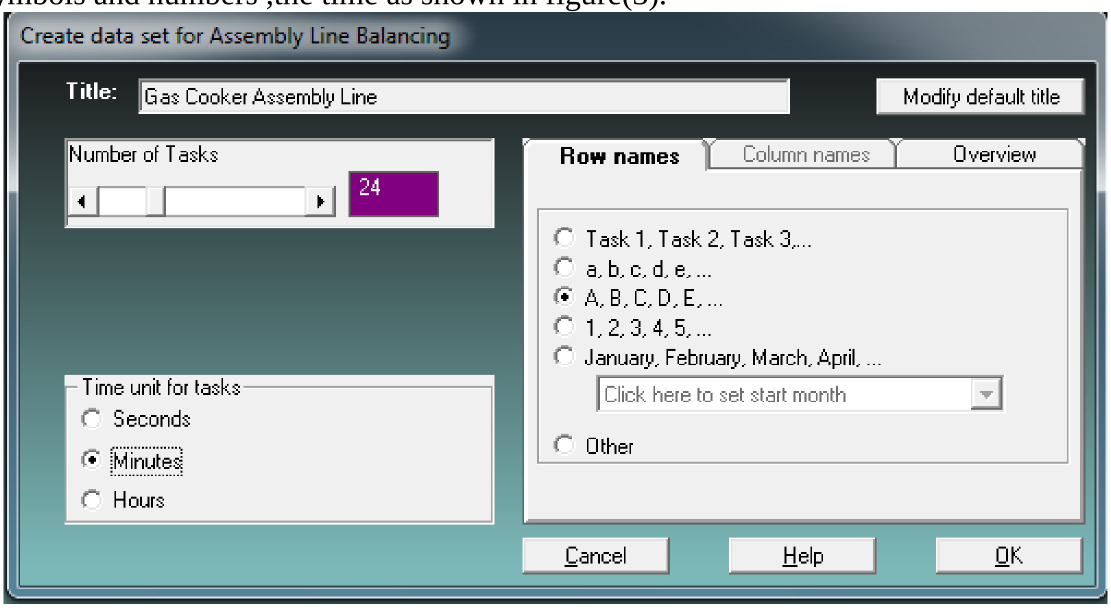


Figure (3) Input Screen of the System

3- By using the programe after input the data to the table presented in figure(4). Calculation of The time needed to make one unit. This is simply the sum of the task times which equal to

$\sum_{i=1}^{24} ti = 84.5$ minutes. In addition that, The cycle time and the actual number of workstation .

Assembly Line Balancing Results

(untitled) Solution

Station	Task	Time (minutes)	Time left (minutes)	Ready tasks (# followers)
	U	4	2	V(2)
9	V	4	8	W(1)
	W	2	6	X(0)
	X	4	2	
Summary Statistics				
Cycle time	12	minutes		
Min (theoretical) # of stations	8			
Actual # of stations	9			
Time allocated (cycle time * #	108	minutes/cycle		
Time needed (sum of task times)	84.5	minutes/unit		
Idle time (allocated-needed)	23.5	minutes/cycle		
Efficiency (needed/allocated)	78.24%			
Balance Delay (1-efficiency)	21.76%			

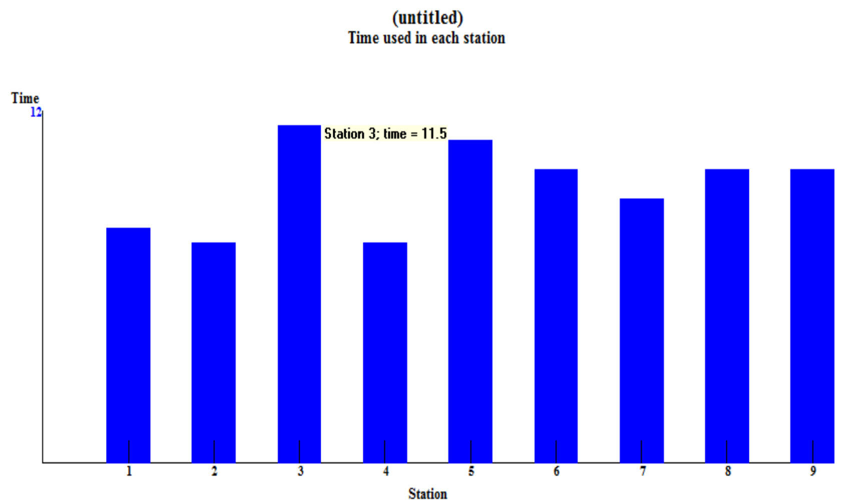
Figure(4) Input Data Table

4- Select the rule named most following task to solve the production line problem as shown in figure(5).

Station	Task	Time (minutes)	Time left (minutes)	Ready tasks
	O	6	0.5	P(8)
6	P	5	6.5	Q(7)
	Q	5	1.5	R(6)
7	R	4	7.5	S(3),T(3)
	S	5	2.5	T(3),U(2)
8	T	6	5.5	U(2),V(2)
	U	4	1.5	V(2)
9	V	4	7.5	W(1)
	W	2	5.5	X(0)
	X	4	1.5	
Summary Statistics				
Cycle time	11.5	minutes		
Time allocated (cyc*sta)	103.5	minutes/cycle		
Time needed (sum task)	84.5	minutes/unit		
Idle time (allocated-needed)	19	minutes/cycle		
Efficiency (needed/allocated)	81.64%			
Balance Delay (1-efficiency)	18.36%			
Min (theoretical) # of stations	8			

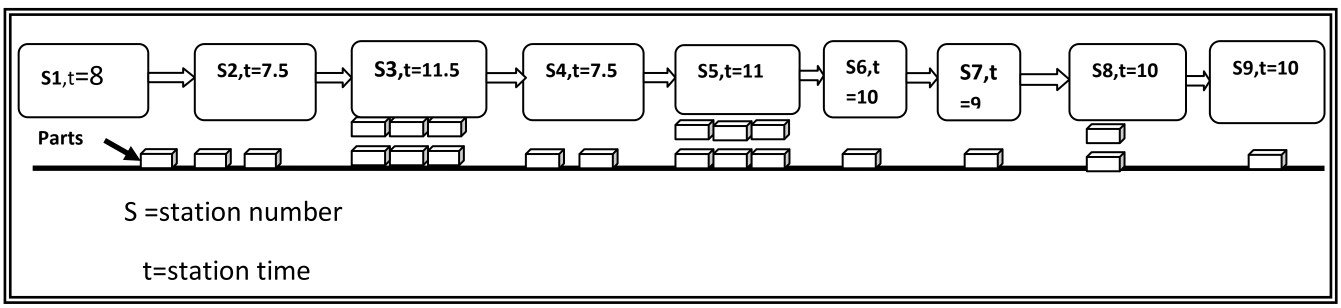
Figure (5) Better Balance for Production Line

Result of re-distribution of tasks on the workstations and the allocation of time for each station is noted that the method is used the solution helped to increase the efficiency of the production and assembly line Which assist to reduce the cycle time of actual production and increase the flow production line .as appears in the figure (6) .



Figure(6) time used in each station.

figure(7) shows the time of the stations and how the flow of production line.



Figure(7)Production Flow in Production Line

7. Conclusions

The aims of this study are trying to Solve of an single assembly line balancing problem which occurs in real production line of industrial company by compute efficiency, finding production flow in assembly line, rearrange the tasks in stations , and then improve the production flow efficiency and effectiveness by minimizing balancing loss and system loss. In addition to minimize idle time.

The results generated by the program were compared with themselves This last however, is an illustration, because there is a fundamental difference between the implemented model and the company production lines. the resulting achieve a desired production rate, will serve only to decrease the idle time of the assembly line.

On the other hand, an apparently trivial reduction in the time to complete a certain task may lead to a more efficiently balanced line, producing a much. The production flow quantity are (35) unit/day, Idle time was(23.5) minutes/cycle ,Efficiency (78.24) before solving the assembly line problem. The production flow quantity (37) unit/day , Idle time is (19) minutes/cycle , Efficiency (81.64%) after solving the assembly line problem.

8. References

Eryuruk S. H. , Kalaoglu. F and M. Baskak. (2008)," Assembly Line Balancing in a Clothing Company" Fibres & Textiles in Eastern Europe January Vol. 16, No. 1(66).

Fazlollahtabar. H , Hajmohammad i.H and Haghzadeh.A.(2010), " A heuristic methodology for assembly line balancing considering stochastic time and validity testing" Springer-Verlag London Limited.

Grzechca.w .(2008) "Estimation of Time and Cost Oriented Assembly Line Balancing Problem".

Hapaz .H;(2008)" Productivity Improvement Through Line Balancing" Faculty of Mechanical Engineering, University Malaysia Pahang.

Heizer .J and Render .B.(2011)," Operations Management" ,tenth edition, Prentice Hall.

Khanna.O.(1999)," Industrial Engineering and Management",MC Graw-Hill,Inc.

Kriengkorakot.N and Pianthong.N; (2007)" The Assembly Line Balancing Problem Review articles" KKU Engineering Journal Vol. 34 No .2 (133 – 140).

Liu.S and Ong.K. (2008), "Branch-and-bound algorithms for simple assembly line balancing problem" Springer-Verlag London Limited, 36:169–177.

Meyr,H.(2004) ,"Supply Chain Planning in the German Automotive Industry",OR Spectrum,26(4),447-470 .

Nearchou . A. (2006) ,"Balancing large assembly lines by a new heuristic based on differential evolution method" Springer-Verlag London Limited, 34:1016–1029.

Norman &Gaither .(2002);"Operations Management", Nine Edition, book, South-Western

Rashid.M ; Hutabarat .W and Tiwari.A. (2011), "A review on assembly sequence planning and assembly line balancing optimization using soft computing approaches" Springer-Verlag London Limited.

Roya .D and khan.D.(2010)" Integrated model for line balancing with workstation inventory management" International Journal of Industrial Engineering Computation139–146.

Shumon . R ; Zaman. k and Rahman, A. (2010), "Productivity Improvement through Line Balancing in Apparel Industries" International Conference on Industrial Engineering and Operations Management.

Slack, N; Chambers,S and Johnston ,R.(2004), "Operations Management" Book, Fourth Edition; Prentice Hall,2004.

Soota.T.(2011);"Modern Project Management" ,Second Edition ,New Age International(P) Ltd,Publishers.