Standard Time Scenario in the Production System Dynamics [1]

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Abstract

The standard time gives a measure of how long it takes a process or workpiece to pass through each operation. It is mainly established by work measurement methodology giving the time allowed to an operator to carry out a specified task under specified conditions and defined level of performance. This definition may be with respect to a task (a job element or an activity) or a product (consisting of many tasks). In the latter case, which is the main thrust of this work, as one job element passes through different resource (work) centres, another job element of subsequent ones will immediately follow and this will continue until the last job element is completed as a whole, this means value added at each work centre. This scenario will affect the level of inventory in the system and the level of inventory in the system depends on the type of production system and configuration (series, parallel or a combination of both) adopted. This too will affect the standard time for a single product (one-off), single product (mass produced), mixed or different products which may utilize assembly line philosophy and products in batches even with back-tracking. Different examples have been used to highlight this scenario with different approaches developed which have gone a long way to improve on the solution techniques of the existing models.

Keywords: Assembly line balancing, inventory random activity selection, production line, sstandard time, work measurement.

1. Introduction

The primary goal of a production system is to convert one type of raw material into a finished product (also known as inventory) that customers or consumers can use. Manufacturing systems are dynamic and fast-paced (Cavalcanty, Kovacs and Ko, 2022). One finished product may become a raw material for another consumer, such as a nail for a carpenter. The production system is a process in which value is added at each stage (workstation), which in this case are the various work-in-progress (WIPs) until the process is completed. According to Sawyer, the level of inventory (which includes WIPs) is dependent on capacity availability, and capacity availability

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is heavily influenced by the type of production system in use. A product (continuous or line/process) layout system would be good for high-volume products with little or no variety, while a jobbing (project) production system would be good for low-volume products with a lot of variety.

Capacity availability versus capacity planned must be based on some units of measurement that are common to the product mix, and tonnes, metres, and standard hours are sometimes used. The reasons why one unit of measurement is preferred over another are determined by the nature of the product. Tons or any weight measurement is most appropriate in processing industries, whereas metres are most appropriate in industries concerned with work-piece size, such as textile mills, rolling mills, and so on. These industries are sometimes designed for a single product in a section or an entire plant. Because many operations, sometimes involving many components, are normally carried out using the same facility, the standard hour is mostly used in batch manufacturing industries. As a result, standard hours provide a measure of how long it takes a process or a workpiece to complete each operation. The math explanations in this study are kept to a minimum, and the different topics are based on what other authors have already said about those topics, with only minor changes as needed.

2.Literature Review

2.1. Types of Production System

In order to complement our discussion so far, it is important to review the type of production (sometimes called facility or workshop) layouts and their characteristics. Manufacturing facilities are basically arranged in four different ways. These are line (sometimes called flow, process or continuous), batch or intermittent production, jobbing or one-off production and lastly cellular manufacture or Group Technology (G.T.). The first three are the classical forms of production system and the last is a hybrid of these three. Jobbing production is not necessarily a facility layout system but only an arrangement to suit a particular situation at a time which is not permanent. It is a system where the nature of the job is for one lot, single or multiple of the same design and specification e.g. a flats of houses on a building site built concurrently and here facilities and labour are brought to the location only when they are needed.

2.1.1. Line Production System

This is sometimes termed product system (Sawyer, 1970) because emphasis is placed more on the product. It is a kind of system where series of operations are carried out using series of machines or manual operations and sometimes designed for a single product e.g. beer, steel or a batch of product which follow the same sequence of operation e.g. car assembly. This second type is sometimes called mass production and is typical of assembly line operations. This layout is very suitable where the product(s) is/are of sufficiently large volume to occupy the facilities full-time and as subassembly moves through the plant, the required operations are performed in a selected sequence. This is why it is sometimes called a flow system although it may not necessarily be in a straight line but ought to be progressive with no backtracking.

To maintain a perfect balance for full capacity utilization, the work content of one station must be in complete balance with all the others. Where this is not possible, a support service may be provided to feed those workstations with a shortfall in order to maintain the continuity of flow along the line. Alternatively, a buffer stock could be kept to take care of this and also to absorb the imbalance which is very likely to arise due to machine breakdown, workers' performance and variability and other contingencies.

2.1.2. Batch Production System.

This type of production system is sometimes called process or functional layout system because emphasis is centred on the different processes involved before a particular product finally leaves the system. It is characterized by the machines of the same kind being grouped together, the lathe in one area, the presses in another, etc. Here components move between the work centres usually in batches for processing and the sequence of operations are in many cases not the same and may require a new set-up before processing.

Batches are sometimes produced in lots which will minimize both the carrying as well as the set-up cost of machines. In order to keep the facilities fully utilized (effectiveness), the components should always be made available, and this will very likely result in a higher in-process inventory and higher storage cost as a result of tying up cost in excess inventory.

2.1.3. Group Technology and its associates

Group Technology, being a hybrid of the basic types of production system is a production technique whereby families of components are manufactured in machine groups (Sinha, etc. (1984)). It is a technique which codes and classifies individual components into families based on similarities as to form, size, material and degree of precision, with the objectives of simplifying, systemizing chains of activities from the initial design to the finished stage. In majority of cases, components have certain design features in common. The machine cells are grouped in such a way that all the machines and tools that can produce a composite component, a part which combines in its design the features of other parts are made available. It does not mean that all the components to process within the cell should have all the features as the composite but most of it to qualify being routed through the cell in question. The beauty of this technique is that the desired component goes into the cell as raw input and comes out as a finished product without having to visit one centre after the other for the various operations to be performed. If properly implemented, benefits are inevitable and include among others, the reduction in set-up time and cost due to similar tooling arrangement, reduction in work-in-progress, reduction in throughput time, more job satisfaction to workers, few progress chasers, less scrap since responsibilities are defined, material standardization, improved production methods and flexibility of the system to accept more components.

After the birth of G.T. and during the period of its nurturing, other systems also emerged which benefitted immensely from its principles. These associates include among others, Computer Aided Design/Computer Aided Manufacture (CAD/CAM), Material Requirement Planning (MRP1) and Manufacturing Resource Planning (MRP11), Just in Time (JIT), Flexible Manufacturing System (FMS), Computer Aided Manufacture (CIM), just to mention a few.

2.1.4. Inventory Management and Control

Inventory is like the blood which flows through any production system and without it, the system may cease to exist. The level of inventory on any production system is demand dependent and this depends on the scheduling technique used, the facility layout in use and above all, the production requirement, that is whether it is for stock to meet customers' demand as they arise or to meet anticipated customers' orders. If the production requirement is for stock, the shop load will consist mainly of internally generated shop orders depending on demand forecast for the different planning periods and if mainly for customers' orders, then the shop load will consist of these orders taking into consideration their due dates and cost of doing so. Production for stock is characterized by high inventory level especially if management is always out to satisfy all the demand as they arise. This will require a higher capacity to be maintained.

In order to cut down on cost (too low inventory resulting in a lot of set-up times or too high levels as result of cost tied up in inventory, storage and insurance), a certain inventory level has to be maintained and for production system, this is normally termed the Economic Batch Quantity (EBQ) and this is given as:

$$\mathbf{EB}\boldsymbol{Q} = \sqrt{\frac{2C_cD}{C_h\left(1-\frac{D}{R}\right)}} \qquad \mathbf{(1)}$$

where C_c is the setting up cost

D is the demand of the component per year

C_h is the cost of holding stock

R is the replenishment stock at each set-up

Under this scenario, it is assumed that the annual rate of replenishment is greater than the annual rate of demand, that is R is greater than D ((R>D).

Nwekpa (2013) discussed this issue with the objective of finding whether the First Come First Served (FCFS) job scheduling method adopted by Innoson Industrial and Technical Plastic Company has any significant influence on timely delivery of customers' orders. He supplied the data for the different types of inventory and their processing times for a whole year but failed to provide the data for the unit cost, the set-up cost as well as the carrying cost which should have enabled one to calculate the EBQ as given above as companies do not generally produce each component only once in a year but lots to minimize the overall cost of production. He neither provided the different times at the different stages of production (work-centres) towards the final end product and given only the overall production time may pose a problem in job sequencing (see Akpan (2016). Ever since the model of EBQ was developed by Ford W. Harris in 1913, a lot of refinements have been going on and Eilon (1964) in particular has reviewed some of the objections to the classical models of EBQ especially in areas of multi-product situations and because of this brought in other tools to enhance the model so also Goyal et al. (1994) in the determination of economic production quality in multi-stage production system. Aldurgam et al. (2019) added other issues with respect to variable machining rates and product quality while Chan et.al. (2013) carried a comprehensive study on what they term to be the recent research trend of economic lot-size scheduling problems, but one thing is certain, that all the authors accepting the original model only with minor modifications to accommodate some situations.

2.1.5. Cycle Time and Standard Time/Hour Determination

Establishing cycle time and thereafter the standard time of doing a job is at the core of production system and this is mainly anchored on work measurement methodology. These two terms are subject to different interpretations depending on the type of production system in use. The common definition of cycle time is the duration of time from starting point of a task to the starting point of another job. This cycle time normally consists of total machine time and material handling time. Without necessarily going into full details of work measurement methodology, in order to obtain the standard time, the basic time has to be obtained by multiplying the rating factor with the cycle time to have what is normally termed the observed time and the standard time is then derived when the different allowances such as personal, contingency, etc. are added to the observed time.

On the other hand, the cycle time is defined differently in line balancing problems, it is the highest time available among the workstations, the times at the different workstations being called station times which might have been derived based on work measurement methodology. The cycle time is then used for the different workstations to calculate the efficiency of the line with respect to the station time.

3. Standard Time Scenarios and the Production Output

Assembly line balancing problems have come to dominate this area under discussion. One noticeable issue that has arisen over the years is that of clearly distinguishing between multi-product assembly line balancing problems and that of the mixed. Various terms have been used for this purpose, Asadi et al. (2015) coming out with mixed-product assembly line (MPALs) and mixed-models assembly lines (MMALs) even within mixed assembly line balancing and Pooya et al, (2017) with Multi-job Production (MJP) which seems to resemble the original mixed-product assembly line balancing.

Multi-product (or job) seems to operate on the basis of unlimited capacity availability after the workstations have been established using such techniques as that of Helgerson et al. (1961) or Kilbridge et al. (1962) but that of mixed is on the basis of constrained capacity (or resource) model. For the purpose of this work, the multi-product model is restricted to single product passing through the different workstations while the mixed is mainly of products with different specifications (durations, mode of processing) which can be accommodated within the line. This has mainly been approached using job-sequencing methodology and the work of Nwekpa (2010) has much relevance here.

In order to marry the different scenarios, we need to look at some examples in relation to the determination of standard time and production system in general. Material from Industrial Engineering and Production Management by Telsang (1998) has been found to be useful for this purpose.

The following data refer to the study conducted for an operation. The table shows the actual times in minutes as follows: -

Table 1. Table showing actual time in minutes

	Cycle				
Element	1	2	3	4	5
1	2.50	2.10	2.20	5.40	2.50
2	6.20	6.00	6.10	5.90	5.90
3	2.30	2.00	2.10	2.10	2.20
4	2.40	2.10	2.80	3.00	2.30

(i) Element 2 is a machine element
(ii) Consider the observation as abnormal and delete the same if they are more than 25%
(iii) Take the performance rating as 120
(iv) The following allowances; personal allowance of 30 minutes in a shift of 8 hours, fatigue allowance – 15%, contingency allowance – 2%. Estimate the standard time of operation and production per 8-hour shift.

Solution: On observation, for element no. 1, cycle no.4, the cycle time is 5.4 minutes, which is more than 25% of the average time for that element. The cycle time is therefore neglected.

Table 2. Calculation of the cycle times of the different job elements

Element	Cycle					Average
Number	1	2	3	4	5	Time
1	2.50	2.10	2.20	5.40	2.50	2.325
2	6.20	6.00	6.10	5.90	5.90	6.020
3	2.30	2.00	2.10	2.10	2.20	2.140
4	2.40	2.10	2.80	3.00	2.30	2;520
Total observed cycle time						13.005

Element 2 is a machine element

Normal time for the cycle = Observed time/cycle x Rating

13.005 x 1.2 = 15.606 minutes

Total allowance = Fatigue allowance + contingency allowance

15.606 (1 + 0.15 +0.02) = 18.259 minutes

(ii) Production Rate Per Shift

Total time per shift of 8 hours = 8 x 60 = 480 minutes

Less personal allowance 30 minutes

Effective production time 450 minutes

Production in 8 hours shift = Time available for production/Standard Time

450/18.259 =24.64 = 25 jobs approx.\

While effort here is not to go into the accuracy of the calculations as given above, it is pertinent to note that fatigue allowance and rating performance may not be applicable to job element 2 which is machine element and for the fact that processing may take different types of production system and configuration–jobbing or one-off (series, parallel or a combination of both) and line (mass produced).

Based on this reasoning we have:

Element 1; 2.325 (1.20 + 0.15 + 0.02) = 3.26

Element 2; 6.020 (1.102) = 6.14

Element 3; 2.140 (1.20 + 0.15 + 0.02) =3.00

Element 4; 2.52 (1.20 + 0.15 + 0.02) = 3.54

Looking at this on the basis of types of production system, we have for:

3.2. One-off job

The presentation could be done:

(i) In series, then multiples of the completed unit
1-2, 2-3, 3-4, 4-5

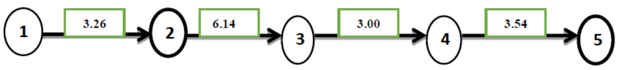

Fig. 1. Presentation in series

3.26 + 6.14 + 3.00 + 3.54 = 15.94 and in multiples (i.e. the number of units), we have 450/15.94 = 28 units approx. This can equally be given as the effective time over the total operation times

$$m / \sum_{1=1}^{i=n} \text{ti} \qquad (2)$$

(ii) Using a combination of series and parallel (many other combinations are possible) but two are considered here based on A on A presentation.

(a) 1-2, 2-4 and 1-3, 3-4 (that is 3.26 and 6.14; 3.00 and 3.54) and based on critical path methodology, 9.40 minutes is taken, and the number of units produced is given as 450/9.4 = 48 units approx.

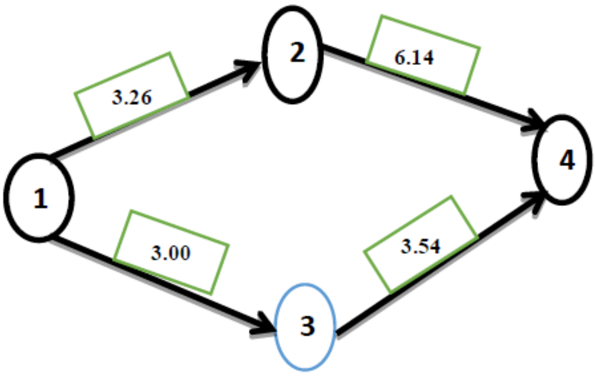

Figure 2: (a). Presentation in series and parallel

(a) 1-2, 2- 3, 3 - 4 and 1- 4 (that is 9.8 and 6.14) and similar to (a) above, 9.8 minutes is taken and for the number of units, we have 450/9.80 = 46 units approx.

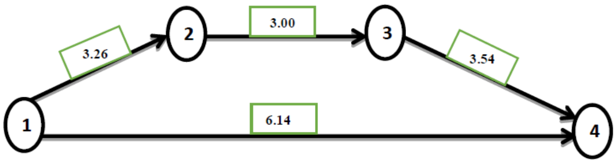

Figure 2: (b). Presentation in series and parallel

3.3. Line production

(a) This is of continuous nature, which gives us 450/6.14 = 73 units approx. This is in line with assembly line methodology. A modified formula with respect to production output (J) is given as

$$J = \left(\frac{m - \sum_{i=1}^{i=n} t_i}{K}\right) + 1 \qquad (3)$$

where *i* is the number of job elements

t_i is the job element time

K is the highest element time among the set

m is the effective production time

The first unit coming out from the production system will be at the elapsed time of the total element times, that is the standard time and the subsequent ones at the time of the highest element time; that is the cycle time as often the case in assembly line balancing problems although this aspect of the first unit is always ignored.

Using the equation in (3) above, we have:

(450 -15.94)/6.14 = 70.70 +1 =72 units approx. which is very close to (a) above.

To justify the above calculation with respect to the number of units produced at a given time, we can look at a case study earlier undertaken by Akpan (2000). A company running a basic week of 40 hours produces a component which passes through five machine centres in strict sequence with standard performance per hour of 80 units, 120units, 60units, 40units and 100units. The departmental and operators' performance (productivity) indices are 80% and 100% respectively and the cost of using each machine is $2.00 per hour while 20% of the work content is for loading and unloading with no idle time on the part of the operators. Based on this information, we have the information given in table 3.

Table 3. Evaluation of component flow

	1	2	3	4	5
Standard performance	80/hour	120/hour	60/hour	40/hour	100/hour
Processing Time/Unit (secs)	45	30	60	90	36
M/c Running Time (secs)	36	24	48	72	28.8
Loading/Unloading (secs)	9	6	12	18	7.2
M/c Capacity/ Week	2560	3840	1920	1280	3200
M/c Idle Time (sec)	-	15	-	-	54
Component waiting time (sec)	-	-	30	30	-
Machine Utilization	100%	66.67%	100%	100%	40%

From the information given above, machine 4 is the critical machine (sometimes called key or bottleneck) and determines the output of the final (finished) product coming out from the system. It is also the machine with the highest processing time which is 90secs and the output of 1280 units in a week of 32 working hours (80% of 40). Based on equation 3, we have

(32x60x60) – (45 +30 +60 +90 +36) = 115200 – 261;

114936/90 = 1277.1 + 1 = 1278 units approx.

The first unit will take 261seconds (4.35 minutes) to leave the system while the other ones will take 90 seconds (1.50 minutes).

3.4. Repetitive Jobs/Activities

Sometimes a lot of job elements may be carried out at the same time, that is, one job passing unto the other. It is not unusual to encounter this kind of repetitive tasks in projects such as building construction, ship building, etc. The method of presentation is sometimes difficult so also the determination of the duration of such subprojects. If the activities are not well coordinated, it is bound to cause a lot of problems during the period of project implementation. This kind of problem falls under this category of our discussion.

Several attempts have been made to provide the needed solution to the problem, one by trying to present the information in the form of a ladder diagram as shown in Fig.4 which result failed in its entirety and the second attempt by modelling it using the network diagram (Fig.5) which also suffered the same fate even though the critical path derived follows the job element with the highest processing time in line with the cycle time of line balancing problem which the solution to this problem is relied on. Due to these difficulties, Line-of-balance (LOB) method was introduced but it also came with its own difficulties. Chitkara (2011) sounded some words of caution when using this model with Turban (1968) and Levitt (1968) in their separate research proposing the integration of PERT model with LOB which led to the emergence of a modified technique called PERT/LOB for an improved solution.

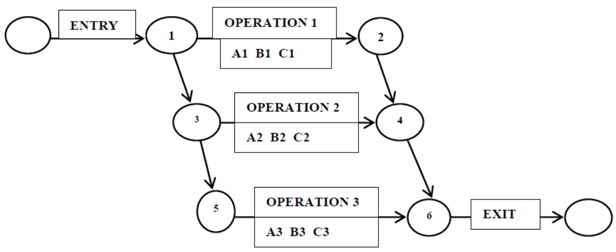

Figure 3: Ladder diagram

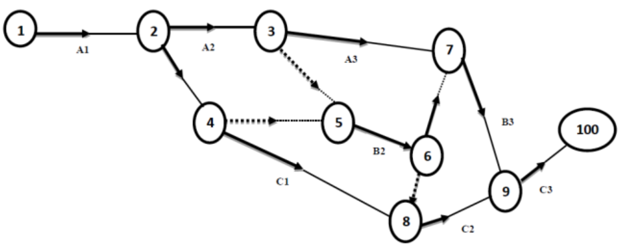

Figure 4: Ladder diagram (in line with network diagram)

Let us take for an example, the block laying in a housing project which involves sand and cement mixing, block moulding, allowing the block to dry and then laying. Four activities are clearly distinguishable with their respective time requirements. If there is no intermittent stop for the next stage of operation to be completed, then the third activity may be ignored as this will only be applicable in the initial stage. Considering a situation where the three activities are carried out for three consecutive times and designating them as A1, A2, A3, B1, B2, B3 and C1, C2, C3. Supposing A takes 30 minutes for 3 bags of cement, B takes 45 minutes, C takes 80 minutes and 48 hours for the period of drying. The cycle time (or to be more precise, the standard time for one unit or block) for A, B and C are 0.3333 minutes, 0.5000minutes and 0.8889 minutes respectively. Going by the effective time of 450 minutes as in the case of example one, we have:

450 – (0.3333+ 0.5000+ 0.889) = 448.333 minutes and the number of blocks is

(448.278/0.889) +1 = 505 blocks approx.

Examining this in line with Fig. 3, A is capable of working towards the production of 1350 blocks in a day which will require 45 bags of cement and B capable of 900 blocks requiring 30 bags of cement. In one week therefore, the organization can lay 2525 blocks even though there would be no block laying in the first two days (48 hours) where the blocks would be kept to dry. The project would still be completed within the seven days' duration. Alternatively, the moulding can be carried out for 4 days in order to minimize the inventory holding cost. If there could be no further use for the remaining blocks, the block moulding could just be carried out for 3 days using 88 bags of cement excluding the cement for the mixture for block laying. In order to increase the production rate, the crew size must be increased in proportion to one another or adjusted in such a way that no working station will be left idle.

3.5. Mixed products

This area has received a lot of attention as it relates to job sequencing with arrays of both mathematical and heuristic approaches to find an optimal solution with respect to minimum make span which is always the main objective. Heuristics of various forms and shapes have been fashioned over the years with Genetic Algorithm (GA) being highly favoured by Chen et, al (2011) and Kyriklidis et, al. (2016) but random activity (or job) selection seems to have an edge over some of these heuristics as proven by Akpan (2016) and for the fact that it can handle problems with multi-objectives (see Akpan (1987)). It should be noted that if the standard times for the different products at the different stages of production are not reliable, the whole task of carrying out the job priority (sequencing) for the determination of the minimum make span would be a futile exercise. This too will affect the level of inventory of the different products in the system and the total overall cost and their composition.

3.5.1. Batch production system including backtracking

The peculiar feature of this production system is that components are processed in batches rather than units and can even involve the batches revisiting some machine centres before the final exit. This poses a problem of how long the batches will stay in the system as those batches which may revisit some machine centres may have to queue up if another batch is being processed even for the first processing or subsequent ones. The objective is the same as that of mixed product assembly balancing problem, that of minimizing the mark span. However various attempts have been made by different researchers to fashion out different approaches to that aspect dealing with backtracking and similar ones. These include among others, Sadeh (1995) where he uses depth-first back-track search. He focused on the development of consistency enforcing technique and variable/value ordering heuristics that improve the efficiency of the search procedure and combines this technique with new look-back schemes that help recover from the so-called dead-end search state procedure (i.e. partial solutions that cannot be completed without violating some constraints). His approach is very much similar to Genetic Algorithm. Purdon (1983) probed the area of backtracking and found out that the average running time is much faster than the previously analyzed algorithm under conditions where the solution are common while Decter (1983) in his paper defines and compares the performance of such schemes of back-jumping, learning and cycle-cut set with one another. Akpan (1987) approached this problem using the network scheduling technique and considers it as acyclic in nature if one ignores the resource precedence in the network presentation. Based on this analogy, any of the resource allocation heuristics can conveniently be used to solve this kind of problem and it may be appropriate use an example to demonstrate this approach.

Without going into much detail, the problems posed by Lockyer (1983) are now used for this purpose. A small machine shop has four machines – A, B, C, D. Four jobs – W, X, Y, Z are taken on by this department. The times are in hours are the sequence of operations as shown in Table 4.

Table 4. Jobs and sequence of operations

	Operation sequences				
Jobs	1	2	3	4	5
W	C-5	B-3	C-3	B-3	-
X	A-6	C-4	B-5	D-5	C-6
Y	B-3	A-5	C-3	D-4	C-6
Z	D-4	B-5	D-6	A-5	C-3

Displaying the above information in the form of network diagram, the total number of activities or job elements will be 19. The minimum makes span or job completion time of 28 hours using random activity selection as the priority rule is realized with the ranking of jobs as Y, Z, W and X (3, 4, 1, 2). Further examination gives more insight as given in Tables 3 and 4 with an average m/c utilization of 72.32% and the different completion times and that of job waiting times.

Table 5. Sequence of operations, indicating total processing time, completion time and job waiting

Sequence	Jobs	Total Processing Time	Completion Time	Job Waiting Time
3	Y	21	25	4
4	Z	23	28	5

1	W	14	20	6
2	X	23	27	4

Table 6. Total processing time of each machine and their machine utilisation

Sequence	Operations in the different machines centres			
	A	B	C	D
Y	5	3	9	4
			(3+6)	
Z	5	5		
			3	10(6+4)
W	-		8	-
		6	(5+3)	
		(3+3)		
X		5		5
	9		4	
	(6+3)			
Total m/c time	19	19	24	19
M/c utilization %	67.86	67.86	85.71	67.86

4. Discussion

There are a lot of decisions which could be made in the case of material presented in Fig.3 depending on one's objective. With the arrangement, the average machine (m/c) utilization is 81.33% if the organization is willing to fully feed the line by supplying enough materials for the 2560 units of Machine 1 which this machine is capable of producing and also willing to hold in-process inventory or Work-in-progress (WIP) as it is sometimes called. This will equally affect the unit cost of production, $1.80 when the WIP is kept and $2.50 and 58% average m/c utilization without the WIP which means that only 1280 units are produced. In order to increase the finished output level, one more of Machine 4 is needed and the critical machine now shifts to Machine 3 with an output level of 1920 units, average m/c utilization of 79.45%, unit cost of $1.83 and without the WIP being kept, an average m/c utilization of 72.50% and $2.00 per unit. Further output level will mean increasing the number of machines to seven and that would entail an increase of Machine 4with and output of 2560 units, a m/c utilization of 87.67%, when WIP is kept and cost per unit of $1.75 and 82.86% and a cost per unit of $1.75 when WIP is not kept. A higher average m/c utilization would result in lower cost per unit and vice versa. It could be seen that as m/c utilization on average increases, the cost per unit comes down.

Looking also as it concerns the block laying in the housing project, the above analysis may not hold completely with respect to WIP because of the nature of the product. A mixture of sand/cement for block moulding must be used up immediately after the exercise is completed or the mixture would not be good for the moulding. However, the block can be kept for long if the succeeding stage is not ready, that is the block laying stage.

5. Conclusion

The study examines the types of production systems and the level of inventory with standard time as the main focus as this affects these variables. It has evidently been proven that the type of production system has an impact on the level of inventory (finished and in-process) in the system and the cost thereof. Input in the different workstations is seen to be demand and time dependent and in precise terms not stochastic unlike the independent demand, which is of continuous and of random nature, a pull system as it is normally called. Based on the above analysis, inventory can properly be managed to minimize cost within an acceptable limit. This can be noticed in the case of repetitive tasks in which an appropriate model has been fashioned out for easy analysis and resolution. In all these, it is the standard time which has the impact on capacity availability with concomitant effect on the level of inventory and the cost in general.

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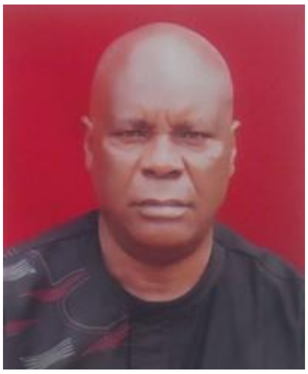

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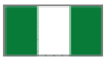

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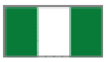

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