JOB SEQUENCING METHODS AND TOTAL ELAPSED TIME MANAGEMENT IN BLOCK PRODUCTION INDUSTRY

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Abstract

The study applied job sequencing algorithm model for total elapsed time management in Osun State. The study examined the significant impact of job sequencing system on total elapse time management and the nexus between job sequencing and on-time delivery. A survey research was employed and data were collected through observation and investigation to pre-production, production and post -production activities of the selected block industry in Odo - Otin Local Government in Osun State. The results revealed that job sequencing model has significant impact on total elapse time management. Also, the finding revealed that saved time will reduce the cycle time, on -time delivery, customer due date of delivery and the total elapse time will be at optimal and this will enhance and boost the buffer stock for unexpected future demand. However, the cost implication of the saved time will enhance the profit of the`organisation. Organisations should endeavor to integrate the strategies of job sequencing model into their operations and build a team work toward cost minimization in all their activities.

Keywords: Job sequencing, Johnson rule Algorithm, Production Cost minimization and Total Elapsed time Management.

Introduction

Job sequencing which mean the selection of an order for a series of jobs to be done on a number of service facilities (machines) to reduce the production cost has created need of concern to management scientists. Job sequencing is conceptually perceived by management scientists as the process of production management which involves the assigning jobs to workstations and employees to jobs for specified time periods. Different scheduling methods result in diffent job sequences, leading to difference waiting time of individual jobs (Nong, Xueping, Tony & Xiaoyun, 2005). Due to the dynamic environment faced by business organisations as an open system, several jobs can be processed at one or more workstation(s). If job sequences or flow of operations are not carefully planned and managed, lapses, time waste, bottlenecks and several jobs may hanged and waiting lines may developed.

In addition, new jobs can enter the process at any time, as a result of the unavoidable dynamic environment. Such complexity puts pressure on both managers of small-scale businesses such as food vendors, welders among others and managers of large scale businesses such as automobile companies, cement factories, saw mills, block industries among others sought for maximum production at minimum cost within a reasonable and profitable time. In spite of the variability of job sequencing among factories, the importance of job sequencing on production cost of block industry cannot be over emphasized because of its necessity and unavoidability. In production, the purpose of job sequencing is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. Job sequence aims to maximize the efficiency and free flow of the production at a minimum costs and minimum time.

The sole aim of a production manager is the maximum production of quality goods at a minimum cost, which has made worthy of note that the impact of sequencing jobs during operations cannot be ignored. Development and increase in the market for blocks and the number of block industries in Odo Otin Local Government area of Osun State has grown rapidly since the establishment of State. As a result, the managements of most block industry in this area experience the under-use and over-use of resources such as man, machine, and tools like spade,

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shovel, and the wastage of materials such as sand, water, cement, boards, among others. This creates unnecessary expenses and increases in the cost of production and consequently, affects the profit margin as a result of the avoidable increase in the cost of production.

Furthermore, a lot of time which is supposed to be utilized for the production of bricks are used in searching for labour, waiting for the late delivery of materials, repair of machines, among others therefore causing waiting lines and bottlenecks which will increase cost and lead to low sales and loss of customers if bricks are not available when demanded. All these problems stagnate the growth of block industries and contribute to late delivery of the product, high cost, poor quality and inability to meet customers' requirement and there can be no minimization of cost if jobs are not properly sequenced, therefore, there is need to establish the link between effective job sequencing and total elapse time management.

Objective of the Study

The objectives are to:

- examine the significant impact of job sequencing system on total elapsed time management .
- explain the relationship between job sequencing and on-time delivery.

Literature Review

To improve the production facilities, a set of jobs are executed on the set of machines. For better performance there are large numbers of constraints. Process scheduling theory has been developed to meet all side constraints (Merten & Muller, 1972). Process Schedule is done in such a way that the resulting solution minimizes the given objective function. Many variants of the basic scheduling problem can be formulated by differentiating between machine environments, side constraints and objective functions.

What is sequencing?

Sequencing gives the idea of the order in which things happen or come in event. Suppose there are *n* jobs (*1,2,3.....n*) each of which has to be processed one at a time at *m* machine (*A,B,C...)*. The arrangement of these flows is called job sequencing (Kalavathy, 2000). Sequencing can be defined as the selection of an order for a series of jobs to be done on a number of service facilities (machine). In sequencing, a systematic procedure is adopted in assigning priorities to waiting jobs thereby determining the sequence in which jobs will be processed.

Sequencing problem, thus arises when a few facilities (machines), each render a different kind of services (operations) are to be assigned a number of jobs in such a way that the order of performing operation by the machines on each job remains unaltered, as this order is predefined. For example, if a job requires an operation to be performed first on the machine a, then another operation on machine B, the order of performing operations should remain AB. The purpose of sequencing problems is to complete the job within the minimum possible time, keeping the minimum idle time of the machines (or services). Sequencing problem is by and large as allocation problem.

Principal assumptions of sequencing

While solving a sequencing problem, the following assumptions are made:

- One machine can process only one operation at a time.
- Each operation once started must be completed first.
- Preceding operation must be completed before the succeeding one can proceed.
- Processing time is known and fixed and the time taken in transfer of jobs between machines is neglected.
- Machines to be used are of different types.
- Jobs to be processed are known and ready for processing before the period under consideration begins.

Objectives of Job Sequencing

- **Minimizing work in Progress**: Optimal production management aims to minimize work in process. Work in process requires storage space, represents bound capital not available for investment and carries an inherent risk of earlier expiration of shelf life of the products. A queue leading to a production step shows that the step is well buffered for shortage in supplies from preceding steps, but may also indicate insufficient capacity to process the output from these preceding steps.
- **Maintaining minimum average flow time of production:** Task time is calculated on virtually every task in a business environment. It is used in manufacturing, however, most common in production lines that move a product along a line of stations that each performs a set of predefined tasks. The product moves along a line, so bottlenecks (stations that need more time than planned) are easily identified when the product does not move on in time. Correspondingly, stations that don't operate reliably (suffer frequent breakdown, etc.) are easily identified.
- **Maintaining minimize cost of production:** Cost reduction can result in significant product cost saving, manufacturing cost saving, and life cycle cost saving when companies interested in cutting cost implement
- **Maximizing utilization of production resources:** The available resources i.e machines, men, money and materials will be well utilized and arranged in optimal manner. Sequencing allows job flows in order of pre determined and achieved as speculated.
- **Targeted output achieved as specified:**, Supply chain management is involved, When your supplier supply materials needed per time and production is carried out within specification (scheduling) products supplied are more likely to meet customers expectation thereby allowing finished product, inventory without failing to meet their needs for volume and timeliness.

Classification of Job Sequencing Algorithms/ Models

Some of the algorithms /models for solving job sequencing problems are explained below;

TABU Search Algorithm

Eugeniusz and Czesl (2015) these authors explained TABU search algorithm for the job shop problem. It provided a new approximate algorithm that is based on the big valley phenomenon, and used some elements called path re linking technique as well as new theoretical properties of neighborhoods. The model provided a powerful tool to solve the job shop problem with the makespan criterion. It offered very good accuracy, in comparison to other best known approaches, obtainable in a short running time on a modern PC. The general idea of the algorithm could be applied to other scheduling problems, as an example, the flow shop and hybrid flow shop problem. (Rao, Raju, & Babu, 2013)

Fuzzy Topsis Method

Another scholars, Pragati and Manisha (2011) presented Fuzzy TOPSIS model in Job Sequencing Problems on machines of unequal efficiencies. Sequencing problems arise when there are more many jobs to done on series of machines with different time specification. In such problems, they determined an appropriate order or sequence for a series of jobs to be done on a different number of facilities. The processing time on theses machines for the jobs are assumed as imprecise processing time (Rao et al, 2013). Weights were given to each machine according to their efficiency. The gap distance will be defined and calculated, closeness coefficient of each job is ranked in order of their weight to minimize the overall total elapse time.

Payoff System / Model

Joss (2011) proposed a modification to the concept of the potential of Hart and Mas Colell to determine a payoff system for job scheduling problems. The basic understand of this model is the value attached to each job, the job should be assigned to production process or machines base on significant payoff of such job.

Johnson's Sequencing Rule

Punit and Rakesh (2012) In this study, they proposed an approach to find an optimal path from source to destination by taking advantage of job sequencing technique. They had used n jobs m machine sequencing technique and this was divided into n jobs 2 machine problems. Using Johnson's sequencing rule, they solved the problem and obtained the (n-1) sub sequences of the route. Using the proposed algorithm, they calculated the optimal sequence, which lead to the shortest path of the network. (Rao et al, 2013). This current study adopts the Johnson's rule algorithms to reveal the impact of job sequencing to production cost minimization.

Sequencing Model for N-Jobs through Two Machines (Johnson's rule algorithms)

This type of problem can be described as :

(i) Only two machines A and B, are involved :

(ii) Each job is processed in the order AB, and

(iii)Expected processing times $A_1, A_2, A_3 \ldots A_n$, $B_1, B_2, B_3 \ldots B_n$ are known as given below:

Job	1	2	3	…	n
A_i	A_1	A_2	A_3	...	A_n
B_i	B_1	B_2	B_3	…	B_n

Johnson's Rule

Since the procedure for solving such problems was developed by Johnson and Bellman (1953), this procedure as explained below is known as Johnson's Rule.

Step 1. Select the smallest processing time from $A_1, A_2, A_3 \ldots A_n$ and $B_1, B_2, B_3 \ldots B_n$. if there is a tie, select either of the smallest processing time.

Step 2. (i) If the smallest processing time is A_r, do the r^{th} job first and place it at the beginning of the sequence

(ii) If it is B_s, do the s^{th} job last of all and place it at the end of the sequence

(iii) If there is a tie for minimum $A_r = B_s$, process the r^{th} job first and the s^{th} job in the last

(iv) If there is a tie for the minimum among A_r's then do any one of them first.

(v) If there is a tie for minimum among B_S's then do any one of them in the last.

Step 3. Repeat step 1 and 2. Continue the process till all the jobs have been assigned a position known as 'optimal sequence'.

Sequencing of N- Jobs through three Machines

Johnson's method can be extended to the three machine case if any one of the following conditions is satisfied: Smallest time for a job on machine A is greater than or equal to the largest processing time on machine B or Smallest processing time for a job on machine c is greater than or equal to the largest processing time on machine B. For solving such problems, replace the equivalent problem involving n jobs and two machines. These two (fictitious) machines are donated as X and Y, and corresponding processsing time are defined by X_i and Y_i, where

$X_i = A_i + B_i$

$Y_i = B_i + C_i$

Sequencing of N-Jobs through M-Machines

In this type of problem, let expected processing times are represented by a Table of the type shown below:

Job	Machine times for n-jobs and m-machines				
	A_1	A_2	A_3	…	A_m
1	A_{11}	A_{12}	A_{13}	…	A_{1m}
2	A_{21}	A_{22}	A_{23}	…	A_{2m}
:	: :	: :	: :	: :	: :
N	A_{n1}	A_{n2}	A_{n3}	…	A_{nm}

Solution to this problem is possible only if any one of the following condition is satisfied. Smallest processing time on machine A_1 is greater than or equal maximum time on machines A_2, A_3…. $A_m – 1$or

Smallest processing time on machine A_m is greater than or equal to machine time on machine A_2, A_3, …, A_m -1.

Procedure for obtaining optimum sequence involved following steps:

Step 1: Check whether it satisfy the above mentioned condition.

Step 2: if condition is satisfied, proceed further. If not satisfied, method fails.

Step 3: convert the machine problem into an equivalent two machine problem says machine M and N, such that

$A_iM = A_i1 + A_i2 + ….. + A_im$ excluding the last machine time

$A_iN = A_i2 + A_i3 + ….. + A_im$ excluding the first machine time

Then determine the optimum sequence of m jobs through 2 machines by using the optimum sequence algorithm.

Elapsed Time Management

Elapsed time has to do with the time between starting the first job slated on the machine or a particular facility and the time of completing the last job on the machines. This includes the idle time that occurs on any of the machines during the process. The proper planning, scheduling and controlling of the time is referred to as total elapsed time management. Mathematically; Total Elapsed Time = $StJ_1\ M_A + tJ_1\ M_B + ……….. J_1\ M_N$ for Job 1. Also, for Job2 $StJ_2M_A + tJ_2\ M_B + ……….. J_2\ M_N$ and $J_3\ M_A + tJ_3\ M_B + ……….. J_3\ M_N$ for Job 3 assumed to be the last job + Idle time on the machines if occurs.

Empirical Review

To improve the production facilities, a set of jobs are executed on the set of machines. For better performance there are large numbers of constraints and objectives must be achieved. Process scheduling is vital and authors have done series of study to meet all side constraints and for maximum gain to be achieved. Process Schedule is done in such a way that the resulting solution minimizes the given objective function.

Comparison of Well-Known Scheduling Methodologies

Tadsanee and Jirarat (2010), in their study Comparison of Well-known Scheduling Methodologies explains the well-known scheduling methodologies including first come first serve, shortest processing time, EDD, and least slack time. Since the scheduling may be done by using the rules of jobs and orders, two types of scheduling methodologies are created namely job-based rule and order-based rule. The methodologies then turn to be double. The eight methodologies are applied in a case study of an electronic manufacturing company in

Thailand. It is found that job-based rules always gives better results than order-based rules, and EDD and shortest processing time are the best methodologies.

Nong, Toni and Xiaoyun Xu (2005) The authors examined job scheduling methods for reducing waiting time variance represents their local level work and considers a single resource on a computer and network system. The paper supports an overall effort to achieve end-to-end Quality of Service (QoS) assurance for individual high priority jobs on an information infrastructure (such as the Internet). They worked on QoS models at the local, regional, and global levels. A local level QoS model aims to provide service stability and dependability on individual resources, leading to standard parts, which enable predictable performance. This simplifies QoS assurance at the regional and global levels. Performance results showed that Verified Spiral gives the best performance for the scheduling methods and problems tested in the study. Balanced Spiral produces comparable results, but at less computational cost.

During their investigation they discovered a consistent pattern in the plot of WTV over mean of all possible sequences for a set of jobs, which can be used to evaluate the sacrifice of mean waiting time while pursuing WTV minimization. This study considered only a single resource and jobs with only information of their processing times. This paper focuses on the VS and BS algorithms. Minimizing Waiting Time Variance (WTV) is a job scheduling problem where schedules on batch of *n* jobs, for servicing on a single resource, in such a way that the variance of their waiting times is minimized. Minimizing WTV is a well-known scheduling problem, important in providing Quality of Service (QoS) in many industries. Minimizing the variance of job waiting times on computer networks can lead to stable and predictable network performance

METHODOLOGY

Research Design

The survey research method was used in this study . Observation and investigation was made to production of blocks industry in Okuku, Odo – Otin, Local Government Osun state. This observation affords the research to collect data on steps, time and cost of production of the three types of blocks which are: 6 inches, 9 inches and special block without manipulating any of the variables involved in the study. The study covered all the production activities of the selected block industry in Okuku, Odo – Otin, Osun state.

Sample and Sampling Techniques

Sampling techniques relate to the procedure or method of choosing representatives of study population. Therefore, the researcher adopted simple techniques. Proportionate random sampling technique was used to select the block industry based on the activities and population of the workforce in the selected block industry in Osun state.

Instrumentation

The research instrument for this study adopted is “observation and investigation method” which made the respondents and the activities of the block industry to be well known to the researcher.

Section A – observation The first section focused on information on the number of workers, time used up on each process, the process of production and the number of machines in the firm.

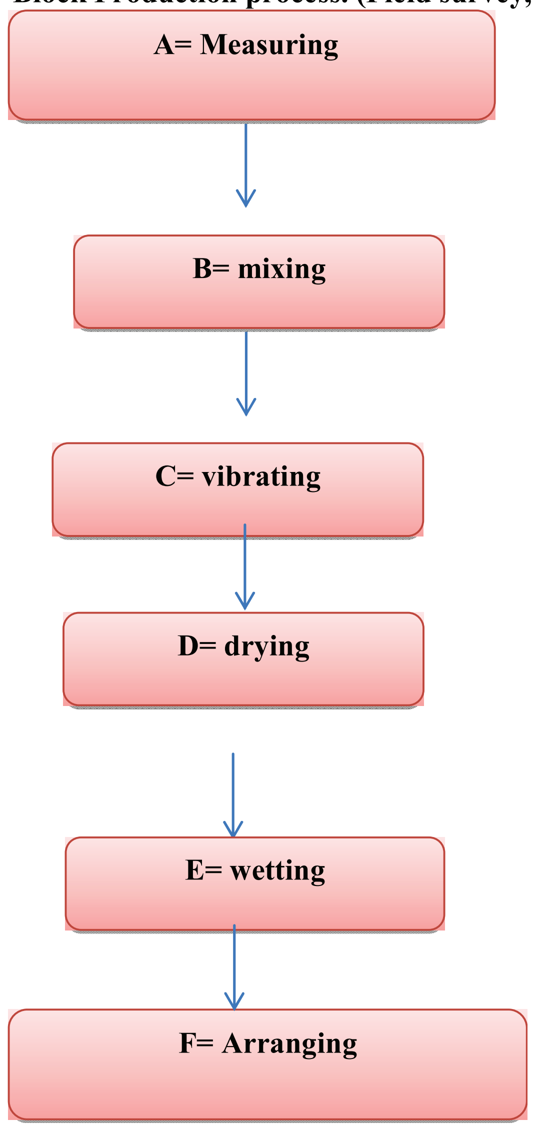
Section B – investigation: the second section focused on information on the cost of production. Cost of a bag of cement, sand, water, labour, fuel and other miscellaneous expenses.

Administration of the Instrument

A close observation was made by the members of the research group. The research consulted with the manager of the selected block industry for support and assistance in the observation and investigation on the subject matter. The managers assisted in justification of the observation made and in sustaining the interest and support by providing adequate information needed. All aspects of the investigation were explained to the respondents and the confidentiality of the information being supplied was guaranteed.

However, through the help of the manager, the researcher was able to ask questions with ease. It took the researcher three weeks to gather the information needed with average of 8 hours per day

Fig 1. Block Production process. (Field survey, 2015).



The block industry produces 6 inches blocks, 9 inches blocks and special blocks

Quantity produced per bag of cement

PRODUCT	QUANTITY PER BAG OF CEMENT
6 inches block	50
9 inches block	40
Special block	35

Source: Researcher's survey, (2015).

The estimated time used up by the firm per bag of cement on each type of block

Machine

Machine A represents measuring, Machine B represents mixing, Machine C represents vibrating, Machine D represents drying Machine, E represents wetting and Machine F represents arrangement.

MACHINES JOB	A	B	C	D	E	F	TOTAL TIME USED UP PER JOB
1	10	10	30	45	5	15	115
2	10	10	35	55	5	12	127
3	10	10	20	50	5	13	108
350							

Job

Job 1 represents 6 inches blocks, Job 2 represents 9 inches blocks and Job 3 represents Special Blocks.

Estimated time used up for Production

Total estimated time used up in the production of 6 inches block per bag of cement is 115 minutes.
Total estimated time used up in the production of 9 inches block per bag of cement is 127 minutes.
Total estimated time used up in the production of special blocks per bag of cement is 108 minutes.
Total estimated time used up in the three types of block per bag of cement each is 350 minutes.

Estimated Cost of Production

MATERIAL	COST
1 BAG OF CEMENT COST	₦1800
A LABOURER COST	₦200
SAND PER WHEEL BARROW COST	₦200
FUEL AND OTHER MISCELLANEOUS EXPENSES COST	₦300

Source: Researcher's survey, (2015).

Applying the processing of n-jobs through m-machines method

Cost of production for the three jobs with an estimated time of 350 minutes

3 Bags of cement = ₦5400

5 labourers = ₦3000

9 Wheel barrows of sand = ₦1800

Cost of fuel and other miscellaneous expenses = ₦900

Total cost for the three jobs for 350minutes = ₦11100

STEP 1: Comparism of time

First

Min MA ≥ Max MB√
Min MA ≥ Max MC×
Min MA ≥ Max MD×
Min MA ≥ Max ME√

Last

Min MF ≥ Max MB√
Min MF ≥ Max MC×
Min MF ≥ Max MD×

Min MF ≥ Max ME√
STEP 2: Compress
Mα –the last machine satisfied
Mβ –the first machine satisfied

JOB / MACHINE	1	2	3
M1	100	115	95
M2	105	117	98

STEP 3: Sequence
Job 3 has the least time of 95 minutes

3		

JOB / MACHINE	1	2
M1	100	115
M2	105	117

Job 1 has the least time of 100 minutes

J3	J1	J2

Therefore the job will be sequenced: JOB 3, JOB 1 and JOB 2
STEP 4:

MACHINE	A		B		C		D		E		F		IDLE TIME					
JOB	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**S**	**F**	**A**	**B**	**C**	**D**	**E**	**F**
3	0	10	10	20	20	40	40	90	90	95	95	108	-	10	20	40	90	95
1	10	20	20	30	40	70	90	135	135	140	140	155	-	-	-	-	40	32
2	20	30	30	40	70	105	105	160	160	165	165	177	-	-	-	-	20	10

S represents start time and **F** represents finish time
Total elapsed time = 177minutes (optimal time used for the production)
Idle time for Machine A = 147minutes
Idle time for Machine B= 137minutes
Idle time for Machine C = 72minutes
Idle time for Machine D = 17minutes
Idle time for Machine E = 12minutes
Idle time for Machine F = 137minutes

Time used up by the block industry is 350minutes
Time used up if proper Job sequencing is applied is 177minutes
Time saved if proper Job sequencing is applied is 173 minutes

Conclusion and Recommendations

From the study conducted, it takes the block industry about 350minutes to produce fifty 6inches blocks, forty 9inches blocks and thirty-five special blocks with one bag of cement allocated to each type of block. It was realized that the application of proper job sequencing takes about 177minutes for the block industry to produce fifty 6inches blocks, forty 9inches blocks and thirty-five special blocks with a bag of cement allocated to each type of blocks whereby machine A will be idle for about 147minutes, machine B will be idle for 137minutes, machine C will be idle for 72minutes, machine D will be idle for about 17minutes, machine E will be idle for about 12minutes and machine F will be idle for about 137minutes. Therefore about 173minutes is saved and can be utilized in making about forty-nine 6inches block, thirty-nine 9inches block and thirty-four special blocks extra.

Therefore, the selection of an order for a series of jobs to be done on a number of service facilities (machine) minimizes production time in block industry. Thus, has a positive impact on total elapse time minimization. The nexus between effective job sequencing and time minimization as revealed from the finding above shown that saving period of idle time and 173 minutes actual time saved will reduce the resources that ought to have been allocated to the period. Also, the time saved will reduce the cycle time or delivery time and customer due date of delivery will be met. From this finding, the total elapse time will be at optimal and this will enhance and boost the buffer stock for unexpected future demand. However, the cost implication of the saved time will enhance the profit of the`organisation. The finding supported the conclusion of Rao et al (2013) that sequencing job has the capacity to reduce and manage total elapsed time in production organisation. Organisations should endeavor to integrate the strategies of job sequencing model into their operations and build a team work toward cost minimization in all their activities.

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