Global Scientific JOURNALS

GSJ: Volume 6, Issue 6, June 2018, Online: ISSN 2320-9186
www.globalscientificjournal.com

MINIMIZATION OF THE MAKE-SPAN USING DYNAMIC PROGRAMMING APPROACH IN A MOUKA FOAM COMPANY

Oghoghorie Oghenekevwe, Ukwuaba Samuel Ifeanyi

Oghoghorie Oghenekevwe is presently with Benson Idahosa University, Benin City, Edo State, Nigeria. E-mail: ooghoghorie@biu.edu.ng
Ukwaba Samuel Ifeanyi is currently with Petroleum Training Institute, Effurun, Nigeria. E-mail: ukwuabasamuel@gmail.com

KeyWords
Flow shop, dynamic programming approach, Mouka Foam Company, competitive market

ABSTRACT
Generally in competitive markets the significance of good scheduling strategies in manufacturing companies is mainly central on the need of developing efficient methods to solving complex scheduling problems. In this present work, we investigated the minimization of the make-span using dynamic programming approach in a Mouka Foam Company. The setup times are one of the most common complications in scheduling problems, and are usually associated with cleaning operations and changing tools and shapes in machines. In this research work, the flow shop problem with make span criterion that was used is $n/m/F/c_{max}$ (n-job, m-machine), with make span criterion that can be defined as completion time at which all jobs complete processing or equivalently as maximum completion time of jobs. The results obtained reveal that the optimal sequence is job1—job2—job4—job6—job5—job3. In conclusion, the research work showed that the total elapsed time or make-span is 8657.5mins

INTRODUCTION

The optimal allocation of resources to activities overtime is the major concern of scheduling theory [1]. If factory that produces different sorts of jobs is considered, each job must first be processed by machine 1, then machine 2 and then machine 3 and so on, but different amount of processing time on different machines [2]. Each of the orders for batches of job in the factory has a time by which it must be completed. Question like; in what order should the machines work on different jobs in order to insure that the factory completes as many orders as possible on time, should be asked when scheduling is being considered [3-4]. Furthermore, how to schedule jobs on machines subject to certain constraints to optimize some objective functions is actually a scheduling problem. Specifying a schedule that specifies when and on which machine each job is to be executed is the major goal of scheduling [5].

The flow shop problem with make span criterion can be shown by $n/m/F/c_{max}$ or equivalently $F//c_{max}$, where both show a (n-job m-machine) flow shop problem with make span criterion that can be defined as completion time at which all jobs complete processing or equivalently as maximum completion time of jobs [6-7]. There are generally $(n!)^m$ different alternatives for sequencing jobs on machines [9-10]. However, most of research has focused on development of a permutation flow shop schedule, which can be considered as a classical flow shop, problem by adding the assumption: the jobs must be processed in the same sequence by each of the m machines.

Mouka foam as a family business was started by the Moukarim Family in 1972. They have always been a progressive and forward looking family and so adherence to the Montreal Protocol was just the right thing. At the time they were the first company apparently in Africa, the Middle East and the near east to adhere to the Montreal Protocol. They have been a very enlightened and forward looking company and they have in many times gone ahead of the legislation in ensuring compliance to the environmental regulations understanding that the foam is made out of chemicals and the process making means one needs to be very responsible about how it is manufactured. So, over and above that, the company has always had a series of "firsts". In 1999 it was the first company to receive ISO certification for the lab that shows a lot about how progressive the company has been. In 2002 the company received ISO certification for quality. In 2005 it received ISO certification for environmental management, and in 2005 it was the first company to introduce the fire retardant. Its ISO certifications are current and very proud of its environmental adherence and right now on the process of getting its occupational health and safety certification and again certainly will be the first company in Nigeria in any sector to get it. And certainly less than 10 companies in Nigeria in any sector have gotten this certification.

Internally the company is pursuing its own programmes to ensuring that it is environmentally compliant, it also looks at corporate governance and socially responsible. So it is not just the environment, it is the whole environmental social and governance aspect of the company. More especially from a family business background it's really trying to be a world class Nigeria company despite the fact that a lot of people think that anything from Nigeria is inferior or better substandard. The company wants to prove that Nigeria management team can be a world class management team though it's not there but on the journey. Mouka is unique because of the combination of all the things I have talked about. The fact that it is a family business which is transitioning on the internal side into a truly world class Nigeria run manufacturing organizations. In trying to develop a technique that can minimize the make-span of producing different jobs, we applied Branch and Bound technique to minimize the make-span of the flow shop in mouka foam Nigeria Limited

MATERIALS AND METHODS

The jobs is expected to flow from an initial machine, through several intermediate machines, and ultimately to a final machine before completing the tasks (Figure 1). The work in a job is broken down into separate tasks called operations, and each operation is performed at a different machine. Thus, each job requires a specific sequence of operations to be carried out for the job to be complete [10].

Foaming → Fork-lift truck → Curing → Slicing → Taping → Nyloning

Figure 1 Jobs flow chart

2.1 Method of Data Analysis

A dynamic programming method was adopted for analyzing flow shop scheduling problems in this research work.

2.2 Dynamic Programming Approach

The general idea behind dynamic programming is to iteratively find the optimal solution to a small part of the whole problem. Using the previous solution, enlarge the problem slightly and find the new optimum solution. Continue enlarging until you have solved the whole problem, then trace back to find the solution. The characteristics of a problem that can be solved using dynamic programming are the following:

i. Problem can be divided into stages.

ii. Each stage has one or more stage.
iii. You make a decision at each stage.
iv. The decision you make affects the state for the next stage.

There is a recursive relationship between the value of the decision at the stage and the previously found optima.
The recursive value relationship is expressed as follows.

$F_i (d_i) = \min \{ F_i (x_i) + F_i + 1(d_i – x_i) \}$

$X_i = 0, 1, 2, \ldots, n.$

where:

X_i = State at stage i to assign.
$N_i (x_i)$ = Number of stage i given x_i is assigned
d_i = State available at stage i
$F_i (d_i)$ = Best possible solution from stage i to end

2.3 Mathematical Development

Consider n jobs say i = 1, 2, 3,…n are processed on six machines A, B, C,D,E and F in the order ABCDEF. A job i (i = 1, 2, 3,…n) has processing time A_i, B_i, C_i, D_i, E_i and F_i on each machine respectively. The mathematical model of the problem in matrix form can be stated as:

Table 1 The matrix form of flow-shop problem.

Jobs	Machine A	Machine B	Machine C	Machine D	Machine E	Machine F
i	A_i	B_i	C_i	D_i	E_i	F_i
1	A_1	B_1	C_1	D_1	E_1	F_1
2	A_2	B_2	C_2	D_2	E_2	F_2
3	A_3	B_3	C_3	D_3	E_3	F_3
4	A_4	B_4	C_4	D_4	E_4	F_4
5	A_5	B_5	C_5	D_5	E_5	F_5
--	--	--	--	--	--	--
n	A_n	B_n	C_n	D_n	E_n	F_n

RESULTS AND DISCUSSION

The data collected on the study are the processing time of different sizes of foams which are clearly presented and analyzed. The researcher based his presentation on the major activities used in the stages of foam production. These are:

3.1 Machines

i. Foaming Area (Stage 1, Machine 1)
ii. Fork-lift truck (Stage 2, Machine 2)
iii. Curing Hall (Stage 3, Machine 3)
iv. Slicing (conversion) (Stage 4, Machine 4)
v. Tape edge Section (Stage 5, Machine 5)
vi. Nyloning Section (Stage 6, Machine 6)

3.2 Different Size (Jobs)

54 x 7” (Job 1)
54 x 8” (Job 2)
54 x 9” (Job 3)
54 x 10” (Job 4)
54 x 12” (Job 5)
54 x 20” (Job 6)

3.3.1 Processing Time for Job 1

P_1 = 1.5min
P_2 = 1.7min

P_3 = 1.9min
P_4 = 2.1min
P_5 =2.5min
P_6 = 4.2min

3.3.2 Processing Time for Job 2
P_1 = 2.0min
P_2 = 2.5min
P_3 = 2.8min
P_4 = 2.6min
P_5 = 3.2min
P_6 = 2.2min

3.3.3 Processing Time for Job 3
P_1 = 1440min
P_2 = 1440min
P_3 = 1440min
P_4 = 1440min
P_5 = 1440min
P_6 = 1440min

3.3.4 Processing Time for Job 4
P_1 = 3.0min
P_2 = 3.2min
P_3 = 3.5min
P_4 = 3.6min
P_5 = 3.8min
P_6 = 5.0min

3.3.5 Processing Time for Job 5
P_1 = 8.0min
P_2 = 12.0min
P_3 = 13.0min
P_4 = 13.5min
P_5 = 15.0min
P_6 = 20.0min

3.3.6 Processing time for Job 6
P_1 = 3.0min
P_2 = 3.2min
P_3 = 3.5min
P_4 = 3.8min
P_5 = 4.0min
P_6 = 5.0min

The data of six (6) jobs to six (machines) flow shop problem with the respective processing time of the jobs on each machine are presented in tabular form as shown in Table 2.

Table 2 Processing time of jobs on each machine

	Jobs					
Machines	**1**	**2**	**3**	**4**	**5**	**6**
M_1	1.5	2.0	1440	3.0	8.0	3.0
M_2	1.7	2.5	1440	3.2	12.0	3.2
M_3	1.9	2.8	1440	3.5	13.0	3.5
M_4	2.1	2.6	1440	3.6	13.5	3.8
M_5	2.5	3.2	1440	3.8	15.0	4.0
M_6	4.2	2.2	1440	5.0	20.0	5.0

Since there are a total of six (6) jobs, we have a possibility of having 0 to 6 available assignments. By using tableau to consider each stage, we have:

Stage 6: The recursive relationship for this stage is;

$F_6(d_6) = \text{Min } X_6 \{ F_6(X_6)\}$

Table 3 Stage Six

d_6	X_6=0	X_6=1	X_6=2	X_6=3	X_6=4	X_6=5	X_6=6	$F_6(d_6)$
0	0	-----	-----	-----	-----	-----	-----	0
1	0	3.0	-----	-----	-----	-----	-----	3.0
2	0	3.0	3.2	-----	-----	-----	-----	3.2
3	0	3.0	3.2	3.5	-----	-----	-----	3.5
4	0	3.0	3.2	3.5	3.8	-----	-----	3.8
5	0	3.0	3.2	3.5	3.8	4.0	-----	4.0
6	0	3.0	3.2	3.5	3.8	4.0	5.0	5.0

Stage 5: The recursive relationship at this stage is;

$F_5(d_5) = \text{Min}X_5\{F_5(X_5) + F_6(d_5 - X_5)\}$

Table 4 Stage Five

d_5	X_5=0	X_5=1	X_5=2	X_5=3	X_5=4	X_5=5	X_5=6	$F_5(d_5)$
0	0	-----	-----	-----	-----	-----	-----	0
1	3.0	8.0	-----	-----	-----	-----	-----	8.0
2	3.2	11.0	12.0	-----	-----	-----	-----	11.0
3	3.5	11.2	15.0	13.0	-----	-----	-----	11.2
4	3.8	11.5	15.2	16.0	13.5	-----	-----	11.5
5	4.0	11.8	15.5	16.2	16.5	15.0	-----	11.8
6	5.0	12.0	15.8	16.5	16.7	18.0	20.0	12.0

Stage4: The recursive relationship at this stage is;

$F_4(d_4) = \text{Min}X_4\{F_4(X_4) + F_5(d_4 - X_4)\}$

Table 5 Stage Four

d_4	X_4=0	X_4=1	X_4=2	X_4=3	X_4=4	X_4=5	X_4=6	$F_4(d_4)$
0	0	-----	-----	-----	-----	-----	-----	0
1	8.0	3.0	-----	-----	-----	-----	-----	3.0
2	11.0	11.0	3.2	-----	-----	-----	-----	3.2
3	11.2	14.0	11.2	3.5	-----	-----	-----	3.5
4	11.5	14.2	14.2	11.5	3.6	-----	-----	3.6
5	11.8	14.5	14.4	14.5	11.6	3.8	-----	3.8
6	12.0	14.8	14.7	14.7	14.6	11.8	5.0	5.0

Stage 3: The recursive relationship at this stage is;

$F_3(d_3) = \mathrm{Min}X_3\{F_3(X_3) + F_4(d_3 - X_3)\}$

Table 6 Stage Three

d_3	X_3=0	X_3=1	X_3=2	X_3=3	X_3=4	X_3=5	X_3=6	$F_3(d_3)$
0	0	-----	-----	-----	-----	-----	-----	0
1	3.0	1440	-----	-----	-----	-----	-----	1440
2	3.2	1443	1440	-----	-----	-----	-----	1440
3	3.5	1443.2	1443	1440	-----	-----	-----	1440
4	3.6	1443.5	1443.2	1443	1440	-----	-----	1440
5	3.8	1443.6	1443.5	1443.2	1443	1440	-----	1440
6	5.0	1443.8	1443.6	1443.5	1443.2	1443	1440	1440

Stage 2: The recursive relationship at this stage is;
$F_2(d_2) = \mathrm{Min}X_2\{F_2(X_2) + F_3(d_2 - X_2)\}$

Table 7 Stage Two

d_2	X_2=0	X_2=1	X_2=2	X_2=3	X_2=4	X_2=5	X_2=6	$F_2(d_2)$
0	0	-----	-----	-----	-----	-----	-----	0
1	1440	2.0	-----	-----	-----	-----	-----	2.0
2	1440	1442	2.5	-----	-----	-----	-----	2.5
3	1440	1442	1442.5	2.8	-----	-----	-----	2.8
4	1440	1442	1442.5	1442.8	2.6	-----	-----	2.6
5	1440	1442	1442.5	1442.8	1442.6	3.2	-----	3.2
6	1440	1442	1442.5	1442.8	1442.6	1443.2	2.2	2.2

Stage 1: The recursive relationship at this stage is;
$F_1(d_1) = \mathrm{Min}X_1\{F_1(X_1) + F_2(d_1 - X_1)\}$

Table 8 Stage One

d_1	X_1=0	X_1=1	X_1=2	X_1=3	X_1=4	X_1=5	X_1=6	$F_1(d_1)$
6	0	3.7	4.9	4.5	4.9	5.0	6.2	3.7

Total value of F_1 (d_1) in each stage:
Stage1: = 3.7
Stage2: 2 + 2.5 + 2.8 + 2.6 + 3.2 + 2.2 = 15.3
Stage3: 1440 + 1440 + 1440 + 1440 + 1440 + 1440 = 8640
Stage4: 3 + 3.2 + 3.5 + 3.6 + 3.8 + 5 = 22.1
Stage5: 8 + 11 + 11.2 + 11.5 + 11.8 + 12 = 65.5
Stage6: 3 + 3.2 + 3.5 + 3.8 +4 + 5 = 22.5
The sequence of the jobs to machines is therefore as follows;

Job1 → Job2 → Job4 → Job6 → Job5 → Job3

In this present study, we considered flow-shop problem with make-span criterion and the research data were obtained from Mouka Foam Nigeria Limited, Benin City, Nigeria. The data were presented and analyzed. The data included the processing time of six jobs (different sizes of foam) to six machines in the production processes of Mouka Foam. It was realized that the optimal sequence of the analyzed data is Job1-Job2-Job4-Job6-Job5-Job3. It was equally revealed from the research that the total elapsed time or make-span is 8657.5mins. The result of the dynamic programming approach showed that dynamic programming is an effective for solving jobs scheduling and flow shop problems.

CONCLUSION

In this present work, minimization of the make-span using dynamic programming approach in a Mouka Foam Company was investigated. The results analysis revealed that dynamic programming approach is an alternative and efficient tool for solving flow-shop problems. The evaluation has a great contribution to Mouka Foam Nigeria Limited in sequencing its jobs to machines for optimality.

REFERENCES

[1] B.L. Maccarthy and J. Liu J, "Addressing the gap in scheduling research: a review of optimization and heuristic methods in production scheduling,", *International Journal of Production Research*, 31 (1), pp. 59-79, 1993

[2] J.A., Hoogeveen, J.K., Lenstra and S.L. van de Velde, Sequencing and scheduling: an annotated bibliography, Memorandum COSOR 97-02, Eindhoven University of Technology, Eindhoven, The Nederlands

[3] S. Barman. Simple priority rule combinations: an approach to improve both flow time and tardiness, *International Journal of Production Research*, 35 (10), 2857-2870, 1997

[4] S.C. Kim, and P.M. Bobrowski, Impact of sequence-dependent setup time on job shop scheduling performance. *International Journal of Production Research*, 1503-1520, 1994

[5] J.K. Lenstra, A.H.G. Rinnooy, and P. Brucker, Complexity of machine scheduling problems, Annals of Discrete Mathematics, 1, 343-362, 1997

[6] A. Oduje, G. Oboh, J. Akinyemi, A. Adefegha, and A. Stephen, Assessment of the nutritional, anti-nutritional and antioxidant capacity of unripe, ripe and over ripe plantain (Musa paradisiacal) peels, *International Journal of advance research*. 3(2): 63 – 72, 2015

[7] A.J. Mason, and E.J. Anderson, Minimizing flow time on a single machine with job classes and setup times. *Naval Research Logistics*, 38, 333-350, 1991

[8] P.Y. Jiang, Y.B. Fu, Q.Q. Zhu, Event-driven graphical representative schema for job-shop-type material flows and data computing using automatic identification of radio frequency identification tags. *Proc IMechE*, *Part B: J Engineering Manufacture*, 226: 339–352, 2012

[9] B.J., Lageweg, J.K., Lenstra, A.H.G. and Rinnooy Kan, Minimizing maximum lateness on one machine: computacional experience and some applications, *Statistica Neerlandica* 30, 25-41, 1978

[10] C.L., Monma, and C.N. Potts, On the Complexity of Scheduling with Batch Setup Times. *Operations Research*, 37(5), 798-804, 1989