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Integrated Decision Making in Production Department inside Internal Supply Chain

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Abstract The most important drawback of existing methods used to solve the sequencing problems is the sequence must have a few products and dependent setup time for single demand. The main advantage of this new methodology, it using two methods to determine optimum products sequences with many products and muti-demands and also applied in Wasit company, that has production line produce multi-products. First, modified assignment method (MAM) depends on fundamental of TSP and using it decision maker to determine optimum products sequences step by step or demand by demand to short planning. The second method genetic algorithm (GA) depend on fundamental of (TSPPCA) and using it decision maker to determine optimum products sequences as global optimal or optimal entirely or long planning.

Keywords: *products sequencing, modified assignment method, genetic algorithm*

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1. Introduction

The sequencing problem is a specialized scheduling problem in which an ordering of the products completely determines a schedule. Sequencing is the most impact factor inside demands that consist from muti-products [1].

Cheng et al. (2001) [2] studies scheduling with batching is an NP-hard problem, and heuristics are better suited at solving a scheduling problem when batching is present and show that single batch processor scheduling problems with multiple product families, setup times, and focusing on due date objectives, such as minimizing maximum lateness, is strongly NP-hard.

Pinedo (2002) [3] study scheduling problem involving sequence-dependent setups is well-known to be similar to that of the Traveling Salesperson problem (TSP), which is known in the literature to be NP-hard.

Kreipl and Pinedo (2004) [4] provide insights into the use of planning and scheduling models in supply chain management, as well as into the information sharing and interactions that occur between the different types of models that are embedded in one system.planning models have often been analyzed in detail; scheduling models, on the other hand, have been studied less often within a supply chain management framework.

Zhu and Wilhelm (2006) [5] studies scheduling problems with sequence-dependent setups. The most research considers the reduction of setup costs and inventory holding costs. This study shows that any scheduling problem that has sequence-dependent setups any performance objective (e.g., minimize makespan, minimize total flow time, minimize maximum lateness, etc.) is NP-hard.

Charnprasitphon (2007) [6] develop methodologies that are applied to two fundamental problems as batch production scheduling problem for perishable products with sequence-independent setup times (BPP-SI) and sequence-dependent setup times (BPP-SD).The new models for both problems by formulating them as a Mixed Integer Program (MIP) in discrete time.

Jingxu (2008) [7] study efficient production scheduling and sequencing are important to achieve the overall material supply, production, and distribution efficiency around the mixed-model assembly line in a supply chain, where production scheduling and finished goods distribution have been increasingly considered in an integrated manner to achieve an overall best efficiency.

Clark et al. (2010) [8] formulated sequencing and lot sizing with non-triangular setup times based on Asymmetric Travelling Salesman Problem (ATSP) at animal feed plant based on iterative subtour elimination

Salmasiet al. (2011) [9] developed a mathematical programming model in order to minimize the total flow time on the Flow-Shop Group Scheduling (FSGS) problem., together with a Tabu Search and a Hybrid Ant Colony Optimization (HACO) algorithm for solving large-size issues.

Celanoet al. (2013) [10] analyzed a flow shop sequence-dependent group scheduling problem with limited inter-operational buffer capacity truly observed in the inspection department of a company producing electronic devices. The authors proposed a matrix-encoding GA.

In this paper, we compare between (MAM) and GA depends on least setup time, the results discern that GA has a minimum setup time.

2. The Optimum Sequence of Products

A production line structured requires all products to pass through some workstations in the same sequence. Market required greater flexibility and variety of products together with the reduction of life cycles. This guides lead the companies to necessary utilizes from all available requirements, therefore manufacturer within internal supply chain work on interpret this direction and produce multi-products in the same production line to fulfill customer demands in a dynamic environment. The objective of decision maker in this department is reducing the setup time for all demands, the outline of the methodology is illustrated in the block diagram in Figure 1.

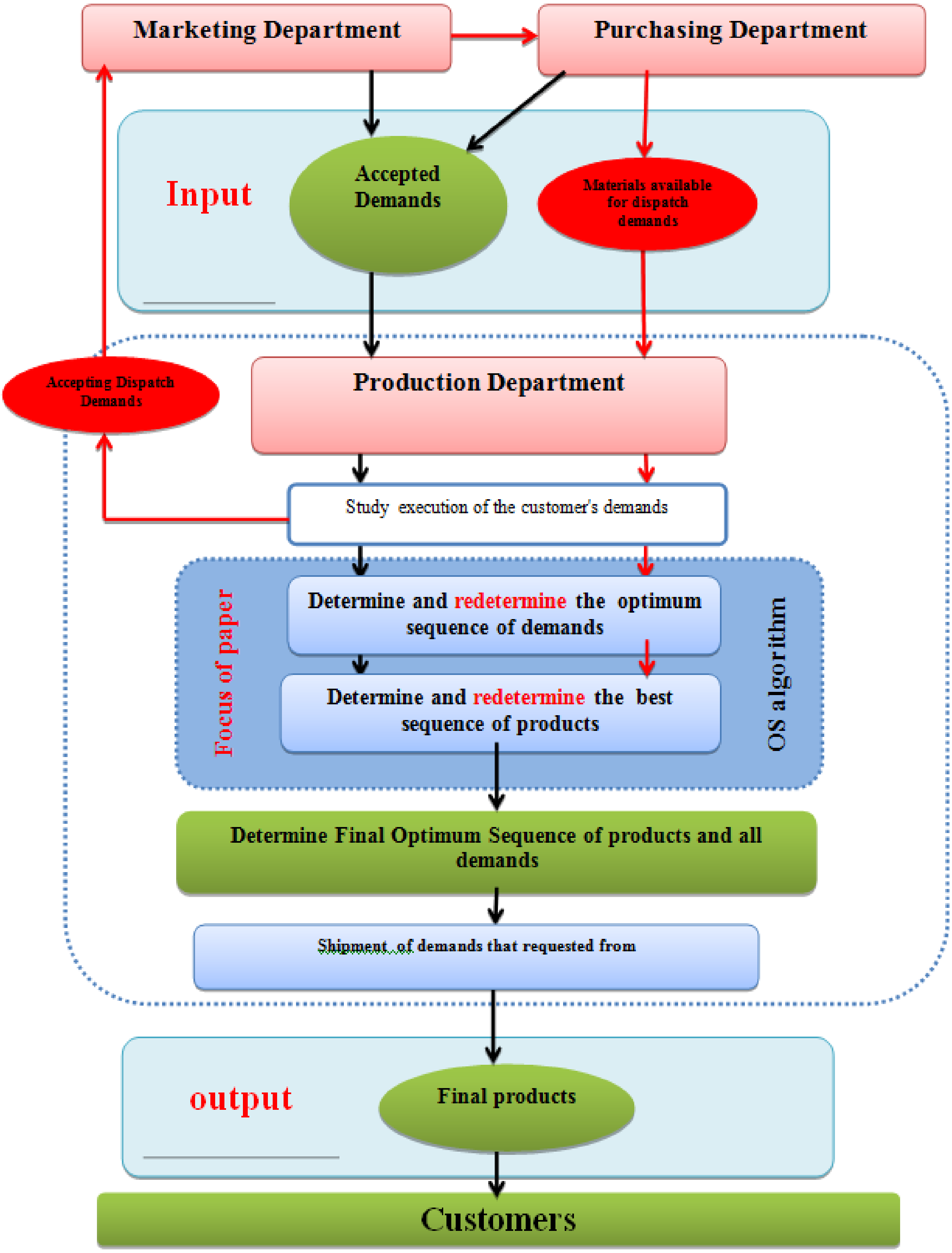

Figure 1. Block diagram for production department in proposed Methodology

2.1. Algorithm Optimum Sequence

The completion time consists of process time and setup time, assume that sequence of process is constant, therefore process time for products are constant for each product and setup time assume to an entire production line. The production department is that convert raw material and parts to finish product. The steps of this algorithm can be described as following:

Step 1. Accepted demands and dispatch demands with materials available will consider as an input to the production department.

Step 2. Production department will study execution accepted demands, while dispatch demands will study the ability of its execution depend on available for capacity, loading, and unloading.

Step 3. If the capacity available less than a capacity of dispatch demands then it rejects, while going to step 6, if capacity available more than the capacity of dispatch demands.

Step 4. The normal demands will determine the best sequence of demands depend on the due date, available material or any rule use.

Step 5. Determine the optimum sequence of products to all normal demands, that consider as output for OS algorithm.

Step 6. Redetermine the optimum sequence of products to all demands.

Step 7. Determine final optimum sequence of products and all demands.

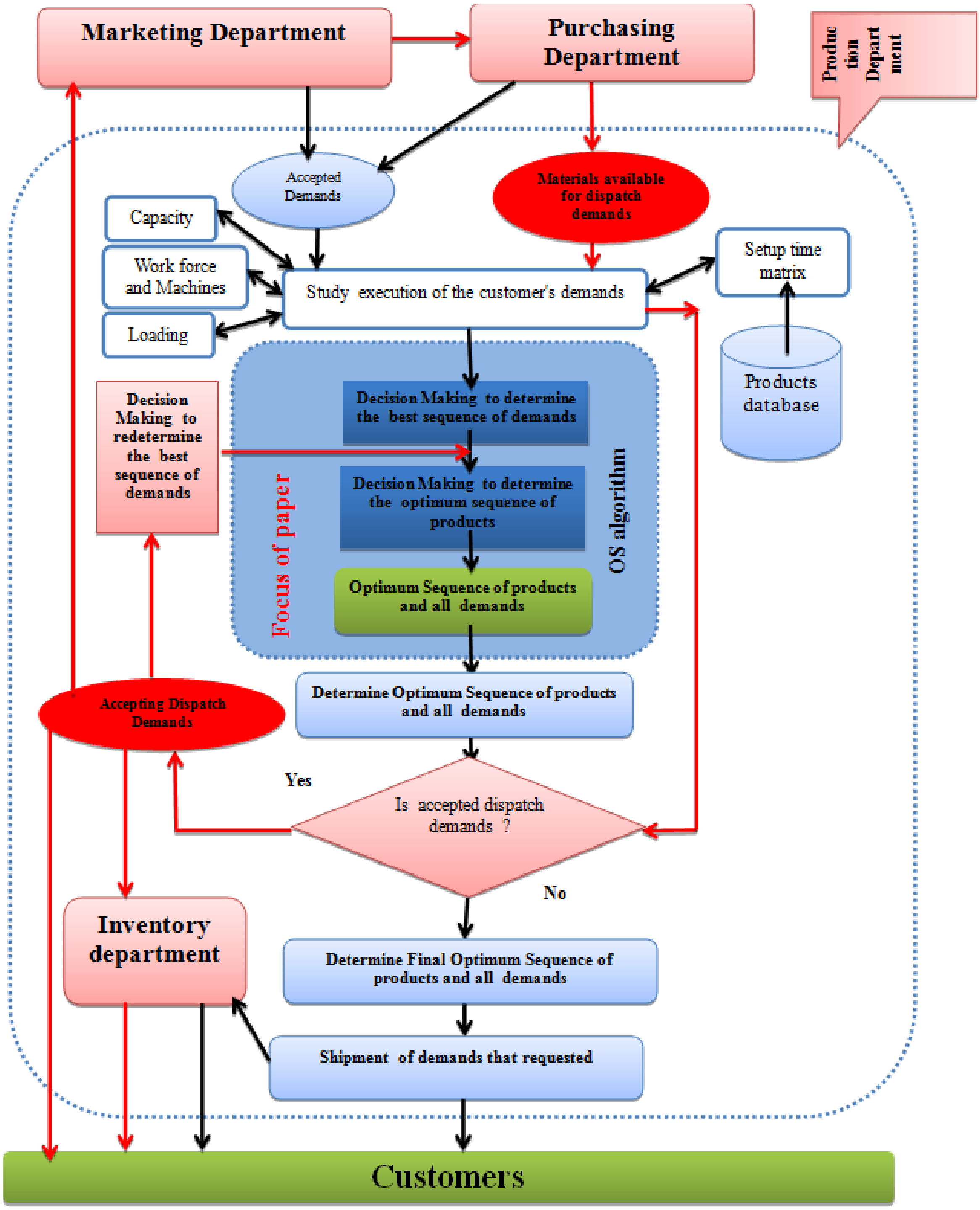

Figure 2. Production Department in proposed Methodology

Dispatch demands have special treatment because it order with short time and it needs to change policies production department and purchasing department, therefore described as red lines in proposed methodology. The detail of this algorithm is illustrated in Figure 2.

3. Application of Proposed Methodology

This paper applied in Wasit company for textile industries as a case study to integrate decision making inside production department in the textile factory under an umbrella of supply chain management.

The textile factory produces five products will making on the same production line inside a factory and need setup time to change arrangements this production line when altering the production to another product.

Fifth products for Textile factory as following:

1. Printed Striped weave, will representation to it with a symbol (A).
2. Poplin Weave, will representation to it with a symbol (B).
3. Plain Weave, will representation to it with the symbol (C).
4. Nuba Weave, will representation to it with a symbol (D).
5. Dyed Poplin weave, will representation to it with a symbol (E).

These products will vary in a number of warp's yarn or weft's yarn, quality of yarn, weave density and etc. this it leads to being setup time different from product to another product, can be illustrated setup time for product's factory in Table 1.

3.1. OS Algorithm

After the demands accepted decision maker start to determine the optimum sequence of products depends on setup time using travel sales methodology. Two methods are used to determine optimum products sequences.

First, MAM depends on fundamental of TSP and using it decision maker to determine optimum products sequences step by step or demand by demand and used to short planning, as used in 2015 by watheq [11].

The second method genetic algorithm (GA) depend on fundamental of (TSPPCA) and using it decision maker to determine optimum products sequences as global optimal or optimal entirely and used to long planning, as used in 2015 by watheq [12].

The optimum sequence of Products depends on setup time using travel sales methodology, where using two methods to determine optimum products sequences.

The market department order monthly set of demands as Table 2, all demand contain a different number of products.

The production department is that convert cotton and some chemical material to fifth products, the products within demands input to production department for study possible execution it demands then decision making to determine the best sequence of demands depend on opinion marketing department. The objective of decision maker in Production department is reducing the completion time for all demands. There are assumptions for products sequencing in this proposed algorithm as following:

1. The number of the products manufactured on a production line are known and specified.
2. Setup time between products is known.
3. Demands consist of one or more products.
4. Products within the same demand not to be repeated.
5. A product is manufactured within a single batch.

4. The Results of Product Sequencing Problem using MAM

Products sequencing for textile factory when demand contain on several products can be solved by MAM and repeat these several times approach to solve the problem with multiple demands, where posterior demand start with product that ended the previous demand as explained in four chapter, the sequence of this demand as following:

4.1. Product Sequencing for First Demand

First demand contains products (A, B, C) and product (A) ended previous demand, Setup time as shown in Table 3 and the goal is an optimum sequence of demands' products with minimum setup time.

Table 1. Setup Time (hours) Matrix

	To product j					
From product i	Products \ products	A	B	C	D	E
	A	0	58	50	50	62
	B	69	0	50	60	67
	C	85	70	0	57	67
	D	80	65	3	0	68
	E	85	4	50	57	0

Table 2. Sequence of Demands depends on order Marketing Department

Months	Products for each month
January	A, B, C
February	B, C, D, E
March	A, B
April	B
May	A, C, E
June	A, D
July	A, B, C
August	A, E
September	C
October	A, C
November	B, D
December	A

Table 3. Setup time (hour) matrix for First Demand

	To product j			
From product i	Products \ Product	A	B	C
	A	0	58	50
	B	69	0	50
	C	85	70	0

Table 4. Setup Time Matrix of MAM for First Demand

	To product j			
From product i	Products \ Products	A	B	C
	A	0	58	50
	B	∞	∞	50
	C	∞	70	∞

Since the previous demand finished product D so it will be the assignment matrix depend on the modified assignment method algorithm as Table 4.

The problem can be formulated using linear programming method. The infinite amount is replaced by the number (1000) or any large number, then the mathematical model will be as following:

$$\begin{aligned} MinZ1 &= 0X_{11} + 58X_{12} + 50X_{13} + 1000X_{21} + 1000X_{21} \\ &+ 1000X_{22} + 50X_{23} + 1000X_{31} + 70X_{32} + 1000X_{33} \end{aligned} \quad (1)$$

S.t.

$$\left.\begin{aligned} X11 + X12 + X13 &= 2 \\ X21 + X22 + X23 &\le 1 \\ X31 + X32 + X33 &\le 1 \end{aligned}\right\} \quad (2)$$

Note all row constraint is smaller than or equal to one; except first constraining equal to two depend on stepping (8-a) from the proposed algorithm to modified assignment method.

$$\left.\begin{aligned} X11 + X21 + X31 &\le 1 \\ X21 + X22 + X23 &\le 1 \\ X13 + X23 + X33 &\le 1 \end{aligned}\right\} \quad (3)$$

Note all column constraints is smaller than or equal to one depend on stepping (4) from the proposed algorithm.

$$\left.\begin{aligned} X12 + X21 &\le 1 \\ X13 + X31 &\le 1 \\ X23 + X32 &\le 1 \end{aligned}\right\} \quad (4)$$

Note all above constraints is smaller than or equal to one depend to step (6) from the proposed algorithm.

$$\begin{aligned} &X_{11} + X_{12} + X_{13} + X_{21} + X_{22} \\ &+ X_{23} + X_{31} + X_{32} + X_{33} = 3 \end{aligned} \quad (5)$$

06-04-2016 23:08:54	Decision Variable	Solution Value	Unit Cost or Profit C(j)	Total Contribution
1	X11	1.0000	0	0
2	X12	1.0000	58.0000	58.0000
3	X13	0	50.0000	0
4	X21	0	1,000.0000	0
5	X22	0	1,000.0000	0
6	X23	1.0000	50.0000	50.0000
7	X31	0	1,000.0000	0
8	X32	0	70.0000	0
9	X33	0	1,000.0000	0
	Objective	Function	(Min.) =	108.0000

Figure 3. Result of MAM for First Demand

Note the constrains is equal to three depend to step (9) from the proposed algorithm. From Figure 3 note the assignment variables are:

$$X_{11} = X_{12} = X_{23} = 1.$$

This means that the optimal sequence is:

$$A - A - B - C = 0 + 58 + 50 = 108\text{hour}$$

4.2. Product Sequencing for Second Demand

Second demand contain products (B, C, D, E) and product (C) ended previous demand, therefore the optimal sequence is:

$$C - C - D - E - B = 0 + 57 + 68 + 4 = 129\text{hour}.$$

4.3. Product Sequencing for Third Demand

Third demand contain products (A, B) and product (B) ended previous demand, therefore the optimal sequence is:

$$B - B - A = 0 + 69 = 69\text{hour}.$$

4.4. Product Sequencing for Fourth Demand

Fourth demand contain product (B) and product (A) ended previous demand, therefore the optimal sequence is:

$$A - B = 58\text{hour}.$$

4.5. Product Sequencing for Fifth Demand

Fifth demand contain products (A, C, E) and product (B) ended previous demand, therefore the optimal sequence is:

$$B - A - E - C = 69 + 62 + 50 = 181\text{hour}.$$

4.6. Product Sequencing for Sixth Demand:

Sixth demand contain products (A, D) and product (C) ended previous demand, therefore the optimal sequence is:

$$C - A - D = 85 + 50 = 135\text{hour}.$$

4.7. Product Sequencing for Seventh Demand

Seventh demand contain products (A, B, C) and product (D) ended previous demand, therefore the optimal sequence is:

$$D - C - B - A = 3 + 70 + 69 = 142\text{hour}.$$

4.8. Product Sequencing for Eighth Demand

Eighth demand contain products (A,E) and product (A) ended previous demand, therefore the optimal sequence is:

$$A - A - E = 0 + 67 = 62\text{hour}.$$

4.9. Product Sequencing for Ninth Demand

Ninth demand contain product (C) and product (E) ended previous demand, therefore the optimal sequence is:

$$E - C = 50\text{hour}.$$

4.10. Product Sequencing for Tenth Demand

Tenth demand contains products (A, C) and product (C) ended previous demand, therefore the optimal sequence is:

$$C-C-A=0+85=85\text{hour}.$$

4.11. Product Sequencing for Eleventh Demand

Eleventh demand contain products (B, D) and product (A) ended previous demand, therefore the optimal sequence is:

$$A-D-B=50+65=115\text{hour}.$$

4.12. Product Sequencing for Twelfth Demand

Twelfth demand contain products (A) and product (B) ended previous demand, therefore the optimal sequence is:

$$B-A=69\text{hour}.$$

Therefore the optimal sequence for all demands are:

AABCCDEBBABAECADCBAAECCADBA.

5. The Results of Product Sequencing Problem Using GA

Products sequencing for the textile factory when customers order multiple demands with several products can be solved by GA in Matlab program, where this approach take into account the product which ended the previous demand and which will begin in the later demand. GA consist from two matrices as explained in four chapter, where the first matrix is constraints matrix that represents the constraints that the relationships' constraint between the demands' products relies on the opinion of the marketing department.

Constraints matrix =[

1	0	0	0	0	0	0	0
2	0	1	0	0	0	0	0
3	0	1	0	0	0	0	0
4	0	1	0	0	0	0	0
5	0	2	3	4	0	0	0
6	0	2	3	4	0	0	0
7	0	2	3	4	0	0	0
8	0	2	3	4	0	0	0
9	0	5	6	7	8	0	0
10	0	5	6	7	8	0	0
11	0	9	10	0	0	0	0
12	0	11	0	0	0	0	0
13	0	11	0	0	0	0	0
14	0	11	0	0	0	0	0
15	0	12	13	14	0	0	0
16	0	12	13	14	0	0	0
17	0	15	16	0	0	0	0
18	0	15	16	0	0	0	0
19	0	15	16	0	0	0	0
20	0	17	18	19	0	0	0
21	0	17	18	19	0	0	0
22	0	20	21	0	0	0	0
23	0	22	0	0	0	0	0
24	0	22	0	0	0	0	0
25	0	23	24	0	0	0	0
26	0	23	24	0	0	0	0
27	0	25	26	0	0	0	0]

Figure 4. C- matrix for order marketing department in Textile Factory

Setup time =[

0	0	58	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1000	0	58	50	58	50	50	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1000	69	0	50	0	50	60	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1000	85	70	0	70	0	57	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	50	60	67	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	70	0	57	67	85	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	65	3	0	68	80	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	4	50	57	0	85	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	50	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	69	50	67	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	50	62	0	50	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	85	0	67	85	57	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	85	50	0	85	57	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	58	50	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	80	65	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	50	0	62	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69	0	50	69	67	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	70	0	85	67	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	50	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	0	50	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	58	50	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	0	70	57	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	69
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	80
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0];

Figure 5. S-Matrix for all demands in Textile Factory

Can be illustrated this matrix according to order marketing department and to period twelve months as Figure 4, where consist from twelve demands and twenty-seven row.

The first row of this matrix represents start the sequence of products that start by ended the previous demand and its product A, while the remain from rows represents products of this demands.

The second matrix is setup time matrix as shown in Figure 5, where this matrix is the square matrix and consist of twenty-seven rows and column that represent products of this demands and added to a product that ended the previous demand.

Figure 6 explain setup time and a number of generation and sixth generation will represent optimal sequence for this demands with minimum setup time that equal to 1139 hours.

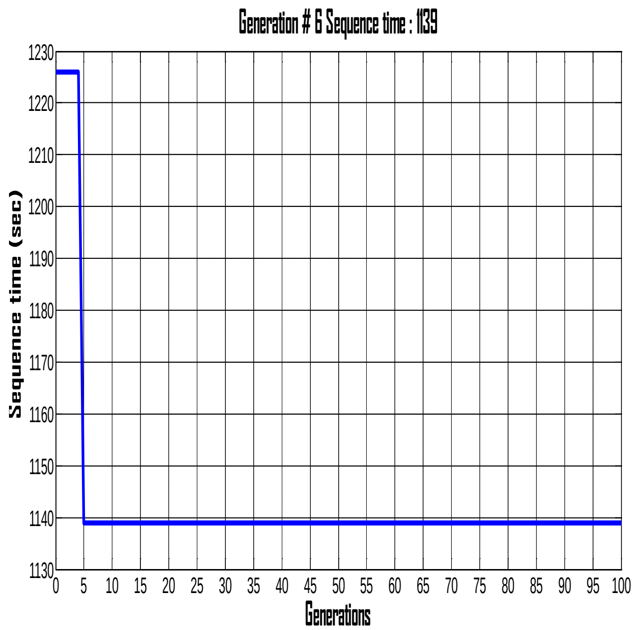

Figure 6. Setup Time and Number of Generation GA

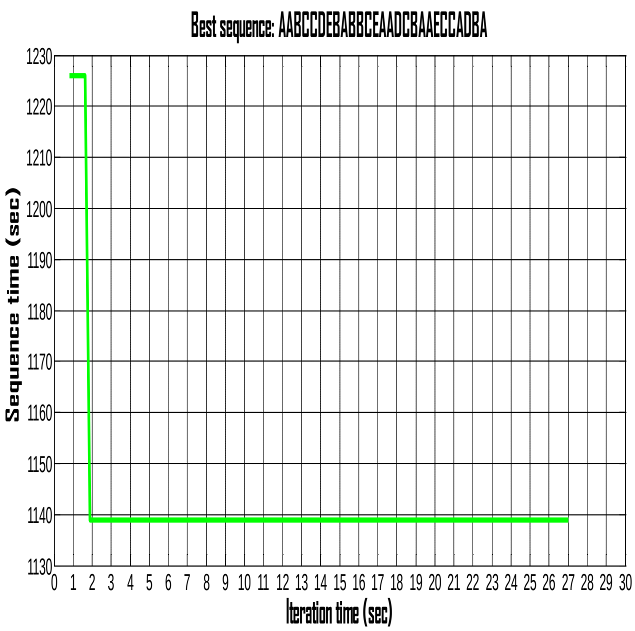

Figure 7. Optimum Products Sequencing for Multiple Demands

Figure 7 show the optimum products sequencing for this demands and elapsed time to run this program that equal to 27 seconds.

The optimum sequence for this demand using this method as following:

AABCCDEBABBCEAADCBAAECCADBA.

6. The Results Discussion for Optimum Products Sequences

Can be compared between two methods (MAM and GA) for determining the optimum products sequences in multiple demands, that all demand consists of multi-products dependent setup time, Table 5 shown the result of optimum products sequences.

Table 5. The result of optimum products sequences for MAM and GA

Number of demands	Optimum Sequence for MAM	Setup Time (hour)	Optimum Sequence for GA	Setup Time (hour)
1	ABC	108	ABC	108
2	CDEB	129	CDEB	129
3	BA	69	AB	127
4	B	58	B	0
5	AEC	181	CEA	202
6	AD	135	AD	50
7	CBA	142	CBA	142
8	AE	62	AE	62
9	C	50	C	50
10	CA	85	CA	85
11	DB	115	DB	115
12	A	69	A	69
Total Setup Time (hour)		1203		1139

7. Conclusions

The aim of any industrial organization is to reduce setup time. This aim is achieved by proposal methodology in this paper to integrate decision making in production department inside internal supply chain.

The main conclusions of this thesis are:

1. The implementation this proposed methodology can be used to help decision maker in Wasit company.

2. The production department is attempting execution of customer demands with minimum total setup time and it coordinates its decisions with other departments inside this company.

3. The short for setup time is consider necessity now a day in all industrial organizations and for this company especially to meet the competition and customer requirements.

4. GA take into account the product which ended the previous demand and which will begin in the later demand, either MAM depends on which ended the previous demand only.

5. According to the results, GA is the best of MAM in determining the sequence of several demands with multi-products for being the less setup time.

6. GA is an advantage in long planning and MAM is the advantage in short planning to determine a sequence of products.

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