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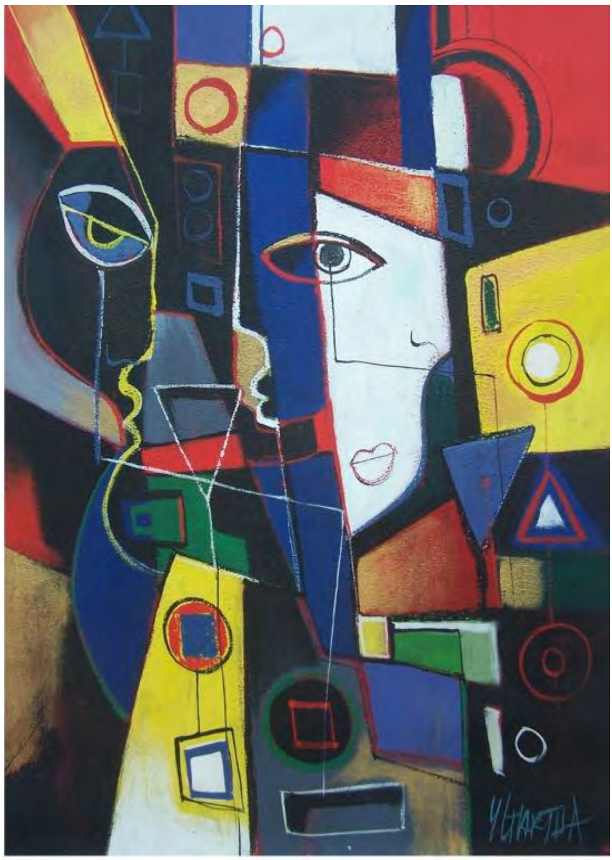

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Determination of optimal lot size using the Silver-Meal and Wagner-Whitin algorithms under the theory of constraints / Case study at Diyala Public Company

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Abstract

International companies are striving to reduce their costs in order to increase their profits, and these trends have produced many methods and techniques to achieve these goals. Of these methods what is judgmental and the other analog. The research seeks to adapt some of these techniques in Iraqi companies, and these techniques are to determine the optimal size of the batch using the algorithms of Silver-Meal and Wagner-Whitin under the theory of constraints. The study adopted the case study methodology to objectively determine the size of the optimal batch of each of the products of the electronic scales laboratory in Diyala Company and in light of the bottlenecks in the work stations or restrictions that limit the energy. The results showed the ability to apply the theory of constraints by identifying the optimal mix that achieves the highest profit according to priority and its contribution to the treatment of the bottleneck by scheduling the production in light of the energy available in each workstation per month. The results also indicated the advantage of the Silver-Meal algorithm on the Wagner- Optimize the batch by adopting cost standards. Taking into account the recommendations of the research, which is the adoption of scientific methods in determining the size of the batch and the application of the theory of restrictions and re-internal arrangement of the laboratory and training employees to use these techniques to achieve the company the ability to reduce the cost and thus increase profits.

Determinación del tamaño óptimo del lote utilizando los algoritmos Silver-Meal y Wagner-Whitin bajo la teoría de restricciones / Estudio de caso en Diyala Public Company

Resumen

Las compañías internacionales se esfuerzan por reducir sus costos para aumentar sus ganancias, y estas tendencias han producido muchos métodos y técnicas para lograr estos objetivos. De estos métodos, lo que es crítico y el otro análogo. La investigación busca adaptar algunas de estas técnicas en compañías iraquíes, y estas técnicas son para determinar el tamaño óptimo del lote utilizando los algoritmos de Silver-Meal y Wagner-Whitin bajo la teoría de las restricciones. El estudio adoptó la metodología del estudio de caso para determinar objetivamente el tamaño del lote óptimo de cada uno de los productos del laboratorio de balanzas electrónicas en la empresa Diyala y a la luz de los cuellos de botella en las estaciones de trabajo o las restricciones que limitan la energía. Los resultados mostraron la capacidad de aplicar la teoría de las restricciones al identificar la combinación óptima que logra el mayor beneficio según la prioridad y su contribución al tratamiento del cuello de botella al programar la producción a la luz de la energía disponible en cada estación de trabajo por mes. Los resultados también indicaron la ventaja del algoritmo Silver-Meal en Wagner- Optimizar el lote mediante la adopción de estándares de costos. Teniendo en cuenta las recomendaciones de la investigación, que es la adopción de métodos científicos para determinar el tamaño del lote y la aplicación de la teoría de restricciones y la disposición interna del laboratorio y la capacitación de los empleados para usar estas técnicas para lograr la empresa la capacidad de reducir el costo y así aumentar las ganancias.

Introduction

Electrical industries are one of the most important industries in Iraq, which contribute to enhancing national income and provide many job opportunities. Diyala General Company is one of the formations of the Ministry of Industry and Minerals, one of the strategic companies in Iraq and the region. The company is located in Diyala Governorate. The site includes the distribution and power distribution plant, electrical and electronic measuring laboratory and photovoltaic laboratory. Which includes a set of production plants that opened in 1978 (the start of experimental operation). The company seeks to provide a combination of high quality products that are competitive in the market and meet the needs of customers through continuous work to develop their resources (physical and human) efficiently and effectively. The Iraqi government depends on meeting all the needs of the Ministry of Electricity on this company. The researcher found that the research sample does not rely on scientific methods to identify and treat bottlenecks, but rather depends on experience and personal experience, which caused accumulation of stock between the work stations and the overlap between the responsibilities of workers in the work stations, This is what makes the workers in some stations that do not suffer from suffocation from stopping work waiting for the arrival of the piece from the previous station. The researcher also noted that the laboratory does not adopt scientific techniques in determining the size of the batch.

The limitation theory can be used to identify the bottleneck and to work on it. The electronic measuring laboratory produces four similar products. The process of handling the bottlenecks starts from the principle of determining the best mix of the four products according to priority, which depends on the margin of the highest contribution per unit per minute. The batch size of the mix determined by the restriction theory is then determined. The size of the payments is determined according to the Silver-Meal and Wagner-Whitin algorithms and then the trade-off between these two algorithms according to the cost criterion.

Theoretical framework

In the 1970s, an Israeli physicist, Eliy M. M. Goldratt, responded with an intuitive approach to scheduling problems. Developed a program that uses mathematical programming The program produced good schedules and managed to market them in the United States. After more than 100 companies succeeded in using the scheduling system, the originator sold his approach to the Theory of Constraints (TOC). (Russell and Taylor, 2011: 774). Eliyahu M. Goldrat holds a PhD in Physics. Work began on moving his ideas to his target groups and plant managers (Pongsart, 2015: 17).

Constraint theory is the philosophy of management work on ecosystems that have been implemented for sustainable development (Sanjica, 2010:

3). (Bosworth and Hundfield, 2008: 228) or is the thing that limits the performance of the process or order to achieve its objectives. Constraint theory is considered as an administrative philosophy in the preparation of an idealization scheduling program for production and then in a set of integrated management tools that include three interrelated areas: logistics / production, performance measurement, and problem solving / thinking tools (Watson et al., 2007: 387). (Brown, et al., 2001, 232), the operating system and optimal production (OPT), based on Goldratt's theory of constraints, or almost MRP functions can not be greater Ever, where it could be bigger than ever. At the beginning of the assembly line, the theory of constraints is an administrative approach Silver-Meal (S-M)

The batch size refers to the number of units for an order. The batch size model is a design for production situations where supply starts and then demand. During the display the demand will decrease from the stock while the supply will increase inventory. That the rate of supply exceeding the demand rate gradually leads to the accumulation of inventory during the supply period, while the continued demand will lead to a gradual reduction of inventory (Owusu, 2013: 39-40). The SM algorithm is one of the Heuristic methods for determining the least expensive batch size. This method depends on calculating the cost of the period instead of calculating the unit cost of the planned order. This is different from other methods used for the same purpose. Many companies have adapted this method with the system MRP, which has great benefit in reducing costs and avoid accumulation of raw materials inventory on the one hand and ease of use on the other, many of the studies reviewed by the researcher proved the effectiveness of this technique because of its suitability with changing demand situations and at different periods. The Silver-Meal algorithm was developed in 1973 by Harlan Meal & Edward Silver and refers to production planning in the manufacturing process and is intended to determine production quantities to meet minimum transaction costs. This is an important way to calculate the volumes of variable payments, which are considered to be very complex arithmetic methods. Sarwosri (2011: 10) considers that the S-M method is the ideal way to reduce the total cost of production due to the reduction in the number of times the orders are launched, and that this method works under certain conditions such as the constant cost of inventory and for similar periods. Prima et al., 2014: 902 proved that many companies are working to reduce costs by adopting certain techniques to determine the optimal size of the batch to avoid accumulation of inventory, but these techniques are not optimal. The study proved that the Wagner-Within and Silver-Meal algorithms are The best because of the ability of these algorithms to deal with changing demand at different periods. To find solutions to realistic problems of batch size, this guidance system has been developed, which calculates the average cost of the application and its retention. This method reduces the average cost of purchase, demand, transportation, storage and re-ordering (Alfares & Turnadi, 2016: 201-203). According to this algorithm, the average cost of retention and preparation for each period is determined if the current demand extends for future periods (T), which is called the planning horizon. This application should cover those periods. In this case the cost of preparation is calculated. The Silver-Meal method uses the average cost per period rather than the average unit cost. As the cost decreases, the batch size is expanded similarly to the unit cost method (Ivanov, et al, 2017: 377). This algorithm is based on several procedures: (Silver & Meal, 1973: 66-67).

Suppose the following symbols have been designed. F(j) is the demand rate (assumed Constant) during the j-th period (where period I is the period immediately following the present moment at which a replenishment decision has to be made).

T = I, 2, 3, ... is the decision variable, the time duration that the current replenishment quantity is to last.

R and G(*j*) are quantities to be used in the algorithm,

S is the ordering cost in the unit of currency,

C is the unit variable cost in the unit of currency per piece,

I is the inventory carrying charge expressed as a decimal fraction per period,

$M = \frac{S}{CI}$

Algorithm

The algorithm is as follows:

Step 1: Initialization

Set $T = I$,

$R = F(I)$, and

G(I)=M.

Step 2

Is $T^2 F(T+l) > G(1)$?

NO - go to Step 3

Yes - go to Step 4

Step 3

Set $T = T+l$

Evaluate $R = R + F(l)$, and

$G(1) = G(T-l) + (T-l)\, F(1)$

go to Step 2

Step 4: Calculation of replenishment quantity

Q = current value of R (because R is defined in such a way that it has accumulated total demand through the end of period 1).

$\sum_{j=1}^{T} f(j)$

The most complicated operation in the algorithm is seen to be straight multiplication of two terms or the squaring of a number.

Algorithm of Wagner-Whitin (W-W)

After the advent of computers and the development of software for the MRP system, the issue of optimal size of the batch has become an important issue for companies, and began to find the most appropriate way to find the economic quantity of the order EOQ and thus reduce the total costs. The study (Saydam & Evans, 1990: 91), a classic in the field of batch size determination, indicates that there are approximately 200 studies arguing the advantages and disadvantages of the Wagner-Whitin algorithm. The researcher believes that this study is the cornerstone of the current research because this algorithm has provided a methodology and mechanism of action is clear, as well as this study proved the effectiveness of this method and superiority on other methods, and pointed out that this method works under certain circumstances. The W-W algorithm is best suited to produce optimal policy for dynamic batch size and variable time scales (Saydam & Mcknew, 1987: 15). Instead of assuming a continuous and unlimited period of time, W-W makes the time horizon limited and divided into several separate time periods and demand changes over time but is known and constant (Hoogen, 2010: 17). Many researchers have pointed out that using the "square root formula" to determine the economic quantity of the batch size is not appropriate and assuming the stability of the demand. On this basis, Wagner-Whitin developed a forward-forward algorithm in 1958 based on dynamic programming principles to make optimal batch size decisions. The problem considered by Wagner-Whitin is the problem of periods without any delay when the assumption of a fixed demand is excluded - if the costs required in each known period are different but moreover, when inventory costs vary from period to period. (Gonzalez & Tullou, 2004: 3).

Similarly, Sadjadi et al. (2009) presented two models of the WW algorithm. The first model assumes the stability of the costs of retention and preparation / preparation. The second model assumes the instability of the cost of storage and configuration in order to facilitate calculation of the economic quantity of the batch size. Each of these models depends on the timeline for planning. Rachmawati & Siregar (2013: 1103) considered that the W-W method is a strategy aimed at achieving optimal demand by reducing the cost of the order and the cost of storage. All possible options are usually calculated. It's best to calculate an additional cost or cost instead of incorrectly setting the size of the payment. If we want to calculate the costs for the next period, we not only start with the fixed demand cost in this period but must add the cost of the application for this period and the total cost of the previous request period. Below are the formulas for this algorithm in which the number and timing of releases will be made: (Wagner & Whitin, 1958: 90-94).

Mathematical Model

As in the standard lot size formulation, one assumption is that the buying (or manufacturing) cost and selling price of an item are constant throughout all time periods, and consequently only the costs of inventory management are of concern. In the t-th period, t = 1, 2, ... , H, we let

d, = amount demanded,
hi = holding cost per unit of inventory carried forward to period t + 1,
s = ordering (or setup) cost,
Xt = amount ordered (or manufactured or size ofthe lot), and
Ct = unit variable cost, which can vary from period to period.

Let all period demands and costs are non-negative. The problem IS to find a programme $x_1 \geq 0$, t = 1,2, ... ,H, such that all demands are met at a minimum total cost; any such program will be termed optimal.

Of course, one method of solving the optimization problem is to enumerate 2^{H-1} combinations of either ordering or not ordering in each period (it has been assumed that an order is placed in the first period). A more efficient algorithm evolves from a dynamic programming characterization of an optimal policy.

Let I denote the inventory entering a period and I_0 initial inventory; for period t

$$I = I_0 \sum_{j=1}^{t-1} xj - \sum_{j=1}^{t-1} dj \geq 0 \qquad (1)$$

The functional equation representing the minimal cost policy for periods t through H, given incoming inventory I, as

$$F_t(I) = \min\left[i_{t-1} I + S(x_t)st + f_{t+1}(I + x_t - d_t)\right] \qquad (2)$$

Where

$$\delta(x_t) = \begin{cases} 0 & \text{if } x_t = 0 \\ 1 & \text{if } x_t > 0 \end{cases} \qquad (3)$$

In period H

$$f_N(I) = \min\left[i_{N-1} I + S(x_N) S_N\right]. \qquad (4)$$

$X_N \geq 0$

$1 + X_N = d_N$

Thereby obtaining an optimal solution as I for period 1 is specified..

Research Methods

The theory of constraints to deal with bottlenecks requires several procedures to identify bottlenecks and then exploit those bottlenecks and work to address them. The process of determining bottlenecks in the case of single production requires a single product, the number of units processed at each workstation and the time available for such treatment. Therefore, the bottleneck point is the longest time of the path. In the case of multiple products, the identification of bottlenecks requires several procedures as follows:

Select available power

The power available to all workstations can be determined by the number of working hours per day and the number of lips. The Electronic Standards Lab operates five days a week, an average of 22 days a month and 7 hours a day with one per day per month. Through the data here, we can determine the energy available in minutes per month through the following formula:

Available energy = 22 days / month x 1 x 7 hours x 60 minutes = 9240 minutes / month

Available power = 22 days / month x 1 x 7 x 60 x min = 9240 min / h
These data are as stated in the work orders issued by the company when the production orders are sent to the laboratory. The time is calculated monthly on the basis that the demand per month and not daily or weekly or annually. Determination of bottlenecks for work stations If there is a mix of products, the time available for each work station is required to determine the time needed to produce the required quantity. If the time required to produce what is required is exceeded, this indicates a bottleneck. This means that the plant is the bottleneck or the bottleneck station

Identifying Bottlenecks

This step is to identify the bottlenecks of the work stations. Since there are several products (mix), the bottleneck point is determined on the basis of the load per workstation and in light of the available power per month for each work station. The load exceeds the available time. In Table (2) showing the loading per workstation for the four products and each month and the bottleneck points. The load shall be based on the number of units required for each month. These units shown in Table (1) refer to the application submitted to the Company on a monthly basis.

Table (1) Quantities required

month	Scale I 1 (10-40)	Scale I 1 (10-40)	Scale I 3 (10-60)	Scale I 3 (30-90)	Scale I 3 (50-150)
1	220	220	291	300	180
2	120	120	121	230	160
3	729	729	129	900	280
4	578	578	120	870	265
5	980	980	78	300	132
6	815	815	452	290	234
7	729	729	235	120	389
8	590	590	560	200	235
9	625	625	125	420	243
10	993	993	125	290	200
11	1080	1080	654	170	291
12	750	750	100	290	299

Table (2) shows the energy required in minutes per month to meet the demand for each month shown in Table (1) for each work station and according to the cycle time per unit. The loading of the workstations is determined by multiplying the demand for each product at the time required for processing at each station. The first stop of the first month is the turning of the product (1-10-40) 770 minutes (220 units x 3.5 minutes = 770 minutes / unit). The product load (scale 30-30) was 1164 minutes (291 units x 4 minutes = 1164 minutes / min / unit). The loading of the product (scale 30-390) was 1200 minutes (300 units x 4 minutes = 1200 minutes). While the total load of the product (scale 3 50-150) was 936 minutes (180 units x 4 minutes = 720 units / min). The total load is the collection of the loading of the four products in the first station (3854 minutes) It is not a bottleneck point that does not exceed the available energy (9240 minutes). And so on for the rest of the workstations and for all periods of research.

Table (2) Determination of the bottleneck point for work stations for periods of 1-12 months

Download for 1 month					
product / Workstation	Download Product Scale (10-40)	Download Product Scale (10-60)	Download Product Scale (30-90)	Download Product Scale (50-150)	Total Download
Lathing	770	1164	1200	720	3854
Cables	286	873	900	540	2599
Plastic	616	873	900	576	2965
Paint	1100	1455	1500	900	4955
Winding and insulation	1540	2415.3	2490	1494	7939.3
Assembly	1320	2037	2100	1260	6717
Examination	902	1193.1	1230	738	4063.1
Packing	308	407.4	420	252	1387.4

After counting the time required to produce the required quantity at each station, we can identify the choke points by specifying the stations which exceed the total load time available power, ie the stations which exceed the total load of 9240 minutes per month, are considered a bottleneck point. It is clear that the first month and the second month there are no bottlenecks, because of the lack of units required and so the company is able to produce all the required units without the presence of problems at the work stations. Demand has increased significantly in the months of (3) and (11), which led to bottlenecks in three work stations (paint, winding, insulation, assembly). For the rest of the months there were bottlenecks in only two stations (roll, insulation and assembly) because they exceeded the available energy (9240 minutes / month). Therefore, the monthly scheduling of production of the plant that requires a longer time of treatment is the station and roll and isolation for all months except the first month and the second.

Since the mix of products requires a total load of (14285 minutes) for the month (3) for completion in the station and roll and isolation (13537 minutes) in the assembly station and (10190 minutes) in the paint station, and the maximum available power (9240 minutes) Work station so the process of treatment of the bottleneck depends on the station that suffers from the biggest bottleneck and in the same way for all months is the station roll and isolation.

Determine the marginal contribution

The aim of this process is to identify which products are most profitable down to less profitable products and to reduce the number of units produced in the light of the available energy, ie the production of less profitable units as much time available in stations or station suffering from suffocation. The marginal contribution of each product is extracted to determine the priority of production of priority products in production as in Table (3). The cost of the raw materials and the purchased part of the selling price and each of the products approved in the current study are subtracted to obtain the margin of marginal contribution for each of the four products.

Table (3) marginal contribution

Product Scale (50-150)	Product Scale (30-90)	Product Scale (10-60)	Product Scale (10-40)	Products data
120000	112000	110000	34250	selling price
87730	82511	81688	30471	Cost of raw materials + parts purchased
32270	29489	28312	3779	Marginal contribution

Based on the results in Table (3), which indicates the marginal contribution of each product, the production of the highest profitable products is started (product 3-150-150), product (scale 30-390), product (scale 3-10-60) , Product scale i 10-40) respectively. This priority sequence depends on the traditional method of prioritization. In the method of bottlenecks, the results of the marginal contribution in Table (3) are divided by the time at the choke station as shown in Table 4.

Table (4) marginal contribution per minute

Product Scale (50-150)	Product Scale (30-90)	Product Scale (10-60)	Product Scale (10-40)	Products / data
32270	29489	28312	3779	Marginal contribution
8.3 minutes	8.3 دقيقة	8.3 minutes	7 minutes	Time at the bottleneck point
3888	3553	3411	540	Marginal contribution per minute

The marginal contribution per minute is extracted through the results in Table (3) for the marginal contribution to time at the bottleneck point for each product. It is clear from the results obtained in Table 4 that the product of scale 3 (50-150) achieves the higher marginal contribution followed by the measures 3 (30-90), 3 (10-60) and 1 (10-40) Respectively.

Determine the optimal mix of products

Table (5) shows the optimal mix according to the choke points identified in order to address these bottlenecks. At this stage, the available resources are distributed to the eight workstations to produce the products according to the sequence determined to find the most profitable mix within the power limits available in the choke station (coating, winding, insulation, assembly) for monthly (3) and (11) . First, the required quantity of the maximum product is produced by a marginal contribution per minute (scale 3 50-150) at the most stifling station, the turning station and the insulation and for all periods and products. The third period requires an energy of 8.3 minutes x 280 units = 2324 minutes. Since the required quantity of the product (30-90) is (900 units / month) and requires a capacity of (8.3 × 900 = 7470 minutes) and the remaining available energy after the coverage of the product (50-150) is (9240-2324 = 6916 minutes) Which is not enough to produce (900 units), we calculate the amount that can be produced within the available energy per month (833 units) b = (8.3 × 8336913.9 minutes). 833 units were extracted through (6913.9 min / 8.3 min at the choke station = 833 units). Calculate the available time to cover the required quantity (6916 minutes - 6913.9 minutes = 2.1 minutes). The remaining energy is not enough to produce the required amount of other products because of the lack of energy (2.1 minutes per month), and the energy covers only the first product and the second after reducing the quantity required. Here are several options available to the company:

Work on two lips instead of one lip.
1 - Exploitation of surplus time in the first and second month to produce the required quantities in the third month, and storage because the cost of storage less than the cost of loss of opportunity.
2 - working overtime system.
3. Redesign the process to reduce initialization and setup time.
4- Increasing the number of machines and equipment used in the work.
5- Increasing the number of employees.
6 - Adding a working day so that the working days become six days instead of five days.

The fourth period calls for the supply of 265 units (8.3 x 20 minutes / 2199.5 min / unit) of the product (50-150) on the suffocation station. While the product (30-90) requires a capacity of (870 units x 8.3 minutes = 7221 minutes, since the time required to produce one unit of the product (scale 3 30-80) is (8.3 minutes) in the suffocation station, thus producing (848) Unit B (7038.4 minutes) (7038.4 minutes / 8.3 minutes at the choke station = 848 units), and in the same way for all other periods.

Table (5) Determine the optimal mix of products

Month (3)					
Time remaining after production (0) Of scale i 1 (10-40)	Time remaining after production (0) Of scale i 3 (10-60)	Time remaining after production (833) Of scale I 3 (30-90)	Time left after production (280) Of scale i 3 (50-150)	Energy available per month	Workstation
0	0	4788	8120	9240	Lathing
0	0	5901	8400	9240	Cables
0	0	5845	8344	9240	Plastic
0	0	3675	7840	9240	Paint
0	0	2.1	6916	9240	Winding and insulation
0	0	1449	7280	9240	Assembly
0	0	4676.7	8092	9240	Examination
0	0	7681.8	8848	9240	Packing

Profitability calculation

After changing the mix of products according to the constraints theory, profitability can be calculated by calculating the cost of raw materials, purchased parts, labor, indirect cost and subtracting from revenue and for each of the four products. Return in the first month amounted to (2461472), the return is a multiplication of the number of units at the sale price per unit. The calculation of profitability requires the calculation of the cost of work per hour. Thus, this cost is extracted per hour and is multiplied by the daily working hours of 7 hours, multiplied by twenty-two working days per month. The cost of materials represented by the sub-parts constitutes the bulk of the cost of the product, amounting to (76%) of the total cost.

Specify batch size using algorithm Silver-Meal

The demand determined in light of the available energy is determined by the constraints theory shown in Table (6), which shows these quantities with the cost of storage per unit, according to the product, in addition to the cost of the single order to balance the cost of preparation and the cost of storage for the periods approved in the current research .

The cost of preparing the order	Storage cost per unit	Month 12	Month 11	Month 10	Month 9	Month 8	Month 7	Month 6	Month 5	Month 4	Month 3	Month 2	Month 1	demand product
360000	175	503	0	591	386	140	438	163	715	0	0	120	220	(40-10)
450000	500	100	652	125	125	560	120	452	78	0	0	121	291	(60-10)
500000	500	290	1170	290	420	200	120	290	300	848	833	230	300	(60-30)
550000	575	2199	291	200	243	235	389	234	132	265	280	160	180	(150-50)

The working mechanism of this method is based on different periods of demand for the calculation of the total cumulative cost of storage. Table (7) indicates the accumulation of the cost of storage according to the net needs of product (3-10-60). After the calculation of the algorithm of this method, (490) units of the lowest rate of costs (133300), which will cover the period from the first month to the fifth month, and here we stopped adding the sixth period because the cost increased, and this makes us stop and calculate the size of the batch for five One release interval, followed by batch size (687) for the period of the sixth and seventh month at the cost rate (283750), then the size of the payment (810) to cover the eighth and ninth and tenth and then the last installment (752) and as shown in table (7) below.

Table (7) Calculation of the batch size according to the Silver-Meal algorithm for product 3 (10-60)

Total rate of costs	Batch size (cumulative)	Net period requirement	Length of storage	Period
$\frac{450000}{1} = 450000$	291	291	0	1
$\frac{450000 + (1 * 500 * 121)}{2} = 255250$	412	121	1	2-1
255250	412	0	2	3-1
255250	412	0	3	4-1
$\frac{510500 + (4 * 500 * 78)}{5} = 133300$	490	78	4	5-1
$\frac{666500 + (5 * 500 * 452)}{6} = 299416$	942	452	5	6-1
450000	425	452	0	6
$\frac{450000 + (1 * 500 * 235)}{2} = 283750$	687	235	1	6-7
$\frac{567500 + (2 * 500 * 560)}{3} = 375833$	1247	560	2	6-8
450	560	560	0	8
$\frac{450000 + (1 * 500 * 125)}{2} = 256250$	685	125	1	9-8
$\frac{512500 + (2 * 500 * 125)}{3} = 212500$	810	125	2	10-8
$\frac{637500 + (3 * 500 * 652)}{4} = 403875$	1462	652	3	11-8
450000	652	652	0	11
$\frac{450000 + (1 * 500 * 100)}{2} = 250000$	752	100	1	11-12

After making special calculations for product I3 (10-60), payment volumes are now released according to the results approved above. Table (37) shows the launch dates, the number of releases and the quantities of storage for each period of the planning horizon in the first month, covering up to the fifth month with an equal amount of 490, followed by the payment in the sixth month and then the payment in the eighth month, Month period in quantities (587), (810) and (752), respectively. Thus for the rest of the products.
For the purpose of calculating the total costs of storage including the cost of keeping the storage and the cost of issuing the orders, the quantities stored and the length of the planning period of twelve months and the number of releases should be calculated in the same period.

Total cost of storage = (total number of units stored for each period * storage cost) + (number of releases * cost of issuing the order)
= (1143 * 500) + (4 * 450000) = 2371500 dinars

Wagner-Whiten Specify batch size using algorithm
Table (8) presents the initial solution of this method, where the demand for product I 3 (10-60) and the cumulative cost of storage with the cost of issuing the order per month, to calculate the cost of the request and the cost of storage for each month in other words, (500) dinars per unit is being started from the first period to the end of the planning period and the experience of all possible alternatives to meet the needs of the period, for example, one order is issued to meet the needs of the first period only (291) units here is the total cost for this month Is equal to the cost of issuing the order only (450000) dinars without the cost of keeping The second alternative is to issue one order in the first period to meet the requirements of the first period. In addition to the cost of storage as much as the requirements of the second month (121) units multiplied by the monthly storage cost (500) dinars will show us that it is equal to (60500) dinars and the cost of Total (510500) dinars, the table shows The first of this method is accumulation of storage costs during the planning period and for each period.

The demand shown in all tables is the result of the outputs obtained when applying the constraint theory when determining the best mix. The months of March and April have no demand due to the lack of energy to produce this product during these months. The cost of storage for the first month is zero based on the assumption that there is no stock during the first period at the beginning of production, and here we bear only the cost of launching the order of purchase (450000) dinars for each purchase order, which represents the average cost of issuing orders for each product. The method of calculating the cumulative costs of the treasury to facilitate calculations and shortening instead of adopting the detailed method, which requires many complex and lengthy calculations. The cost of 60500 refers to the cost of storage for the month of February, which was obtained by multiplying the number of units required for this month in the cost of storage per unit (500 * 121 = 60500) .

December	November	October	September	August	July	June	May	April	March	February	January	the month
100	652	125	125	560	235	452	78	0	0	121	291	the demand
5500	5000	4500	4000	3500	3000	2500	2000	1500	1000	500	0	Accumulated storage cost
550000	3260000	562500	500000	1960000	705000	1130000	156000	0	0	60500	450000	January
500000	2934000	500000	437500	1680000	587500	904000	117000	0	0	450000	February	
450000	2608000	437500	375000	1400000	470000	678000	78000	0	450000	March		
400000	2282000	375000	312500	1120000	352500	452000	39000	450000	April			
350000	1956000	312500	250000	840000	235000	226000	450000	May				
300000	1630000	250000	187500	560000	117500	450000	June					
250000	1304000	187500	125000	280000	450000	July						
200000	978000	125000	62500	450000	August							
150000	652000	62500	450000	September								
100000	326000	450000	October									
50000	450000	November										
450000	December											

Table (8) The cost of storage for each period of product I 3 (10-60)

After calculating the cost of storage for each month, the cumulative calculation of the cost of storage and each of the months of the planning period is calculated based on the results calculated in Table (8) of the cost of storage. For example we note that the cost of storage for the month of January consists of the cost of issuing the order only 450000 dinars, and for the accumulation of the month of February (510500) dinars, which consisted of the cost of the month of January (450000) dinars plus the cost of storage for the month of February (60500) dinars. As for the months of March and April, there is no change in cost due to the absence of a request during these periods and therefore there is no need to issue orders to issue purchase orders. We note that for the rest of the months, this cost is increasing as a result of increased demand during these periods. Thus, the same process is carried out for all months. After calculating the total costs for each period by accumulating the costs shown in the costing table for each period, the total cost of each injection is now calculated by adding the lowest cumulative cost in a given column to the next row, on the basis of which the number of releases For example, in January, data are transferred from table (9) for the accumulation of costs to table (10). Then we move to the calculations of February. Note that the column preceded by the column of January has only one cell worth (450000) It is added to the grade for the month of February, but in the month of March we notice that The pillar which is preceded by the column of the month of February consists of two cells the first value (510500) dinars and the cell below the value (900000) dinars. In this case we choose the lowest value (510500) dinars and add them to the row cost of the month of March cumulative, and so for the rest of the months.

The results presented in Table (10) show that the first launch in January covers the requirements until May, and the second in June to cover the needs and needs of July, followed by the third launch in August to cover the needs of three periods of the month of August (8) The cost of storage for each period and the quantities of demand, we note that the volume of the first batch of (490) units and the second batch (687) Unit and the third batch (810) units and finally the size of the fourth installment (752)

Table (9) Cumulative Storage Cost for Product I 3 (10-60)

December	November	October	September	August	July	June	May	April	March	February	January	mounth
9334000	8784000	5524000	4961500	4461500	2501500	1796500	666500	510500	510500	510500	450000	gan
8110000	7610000	4676000	4176000	3738500	2058500	1471000	567000	450000	450000	450000	fep	
6946500	6496500	3888500	3451000	3076000	1676000	1206000	528000	450000	450000	march		
5783000	5383000	3101000	2726000	2413500	1293500	941000	489000	450000	February			
4619500	4269500	2313500	2001000	1751000	911000	676000	450000	March				
3495000	3195000	1565000	1315000	1127500	567500	450000	April					
2596500	2346500	1042500	855000	730000	450000	May						
1815500	1615500	637500	512500	450000	June							
1314500	1164500	512500	450000	July								
876000	776000	450000	Augus									
500000	450000	September										
450000	October											

November	October	September	August	July	June	May	April	March	February	January	ك 2	الشهر
9334000	8784000	5524000	4961500	4461500	2501500	1796500	666500	510500	510500	510500	450000	ك 2
8560000	8060000	5126000	4626000	4188500	2508500	1921000	1017000	900000	900000	900000	شباط	
7457000	7007000	4399000	3961500	3586500	2186500	1716500	1038500	960500	960500	march		
6293500	5893500	3611500	3236500	2924000	1804000	1451500	999500	960500	April			
5286000	4936000	2980000	2667500	2417500	1577500	1342500	1116500	may				
4161500	3861500	2231500	1981500	1794000	1234000	1116500	June					
3713000	3463000	2159000	1971500	1846500	1566500	July						
3049500	2849500	1871500	1746500	1684000	ogest							
2998500	2848500	2196500	2134000	sep								
2622500	2522500	2196500	oct									
2371500	2321500	nov										
2771500	dec											

The first launch during the planning period in January was 490 units, followed by the second in June, 687 units, followed by the month of August, which reached 810 units, and the last in November, with a size of (752) units.

Comparison algorithm Silver-Meal وWagner-Whitin

Table (11) shows the comparison of the total storage costs of four products according to the Silver-Meal and Wagner-Whitin methods. The display shows that the cost of storing (2371500) dinars for product 3 (10-60) according to the two methods, The lowest total (1802575) dinars of the Silver-Mill style (2079775) dinars for the product 1 (10-40), for the product I 3 (30-90) has achieved the style of Silver-mile the least cost (3914000) dinars of the Waknar - At a total cost of JD (4179000). Finally, the Silver-Milf method achieved the lowest total cost (3927025) dinars of the Waknar style, and at a total cost of JD (45,90025) for product 3 (50-150).

Table (11) Comparison of total costs

Total	50-150	30-90	10-40	10-60	product / Total cost
12292650	3927025	3914000	2079775	2371500	(S-M) Algorithm
According to the method (S-M)			According to company style		
12943100	4590025	4179000	1802575	2371500	(W-W) Algorithm

Table (11) shows the advantage of the S-M algorithm in general, and in two respects the lower cost due to the low number of releases during periods, while the second was the lack of required calculations. More importantly, the use of these methods by the company achieves a significant cost savings when compared to the current situation in the company. Table (12) shows the number of production orders for the laboratory electronic standards for the year 2018.

The number of releases of the product (10-60) and (30-90) was 11 for each product, while the product (10-40) was 13 productive. While the product (50-150) was 8 releases during the year according to company style. When comparing the number of releases in the company with those identified using the SM algorithm in Table 14, there is a significant decrease in the number of these releases, which in turn reduces the total cost of the production orders. Table 14 compares the cost Carried by the company as a result of repeated releases and those provided using the Silver-Mill algorithm being better than the Kneer-Wynn algorithm.

Table (14): Comparison of the costs of the demand release according to the company method and the method (S-M)

Conclusions

Company management is not based on identifying bottlenecks and addressing them to the theory of constraints due to their lack of knowledge of this theory and the tools it provides to

According to the method (S-M)			According to company style			
Total	The cost of a single injection	Number of releases	Total	The cost of a single injection	Number of releases	
2000000	500000	4	5500000	500000	11	Product (10-60)
1080000	360000	3	4680000	360000	13	Product (10-40)
2500000	500000	5	5500000	500000	11	Product (30-90)
2750000	5500000	5	4400000	5500000	8	Product (50-150)
8330000			20080000			Total

address these problems. The results also show the limited production capacity of the work stations in the electronic measurement laboratory, due to lack of Daily working hours as well as the adoption of the work system one working meal per working day and the difference in energy available to products due to the difference in the processing time required for each of the four products, as well as the adoption of the company in determining the priority of production of products on the basis of the request submitted, Firstly. There were also three three and eleven stoppage stations due to the increase in quantities required, namely the turning station, insulation, assembly and coating, while the rest of the periods suffered two bottlenecks, namely the turning station, insulation and assembly, respectively. By determining the priority of production of the most profitable product in the light of the product, the maximum yield per minute, the best product is the meter i 3 (50-150), the meter i 3 (30-90), the meter i 3 (10-60) 10-40) respectively. The results show that the best way to reduce overhead costs is to rely on storage instead of orders as an average of five months, because the cost of storage is less than the cost of launching the order. The results show that the use of the Silver-Meal algorithm is best for producers I3 (30-90) and 3 (50-150). What is product 1 (10-40)? The use of the Wagner-Whitin algorithm is best. While the total cost was equal in accordance with the algorithms for product i 3 (10-60). The results suggest that the use of the Silver-Meal algorithm is the best in reducing the overall cost of the four products compared to the Wagner-Whitin algorithm, due to the low number of releases and that these releases cost less than the cost of storage. Clearly, there is a significant reduction in the total cost when applying the S-M algorithm, due to the decrease in the number of releases. The cost reduction for the product (10-60) was 64%. Products (10-40), (30-90) and (50-150) were 77%, 55% and 38%, respectively. This indicator is good for the use of this algorithm, which reduced costs by a total of 59%.

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