MODELING OF THE OPTIMIZATION FOR DISTRIBUTED SQUENTIAL SCHEDULING IN SUSTAINABLE MANUFACTURING

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Abstract: logistics has a very important role in the distribution process, so that the strategic function of manufacturing logistics is planning, implementing, and controlling the effectiveness and efficiency of storage and flow of goods, to the consumption point to meet consumer needs. The problem that occurs in the distribution system is still not optimal which causes problems in the product distribution process. There are many requests from consumers to producers that cause the production and distribution process to experience difficulties in determining the availability of goods and the availability of the amount of production. This will cause a rigorous production process because there is no scheduling and cannot carry out distribution processes in sequence. The contribution of this study is that with the presence of a sequential distribution decision model that is scheduled to provide decisions about which distribution processes have been scheduled to be processed and the process will move in sequence. So it can be concluded that after optimizing the total cost if the number of each product to be produced (tons)> = 20000 can be distributed sequentially and so on. So that by finding this model the production distribution process will not be a problem in the future. The findings of the new optimization model are proven to be able to solve integrated problems from scheduling distribution of production products in sequence to meet consumer demand. Sequential scheduling is proven to be carried out sequentially in accordance with the flow of activities so that customer demand is fulfilled in the shortest possible time so that the total operational costs are minimal

Keywords: Optimization, Model, Production Distribution, Scheduled Sequential Distribution, Sustainable Manufacturing

1. Introduction

Distribution in the supply chain must be supported by professional technology to facilitate the process of shipping or storing goods. Currently, distribution logistics has a very important role in the distribution process, so the strategic function of logistics distribution must have a mature planner, good process, control effectiveness, storage efficiency, the flow of raw materials, services, and information, to arrive at the planned destination. to meet consumer needs. The problem that often occurs today is that the logistics distribution process has difficulty predicting the operational demand for the entry and exit of a product with a high level of demand from consumers. The lack of information and communication technology in developing countries, as well as poor infrastructure, causes the current logistics distribution problems to be so complex. So to overcome this problem, a decision-making process is needed to move sequentially which is related to the planning of the production cycle, labor usage, and machine usage capacity. according to (See, 2007) to get maximum results in logistics distribution, the distribution must be able to provide a decision, easy and fast, as well as accuracy in carrying out the logistics distribution process, and a decentralization. So that to create an efficient and fast logistics distribution, the current position of logistics requires the support of professional technology implementation to facilitate all processes of production and distribution processes both in terms of delivery or storage of raw materials and it is also necessary to reduce logistics costs. distribution has a very vital role in planning the production cycle which requires the production process to run smoothly so that it can facilitate the delivery of goods and services from the manufacturer to the customer on time (Trentesaux, 2009). So in this paper explain that there is a problem that occurs in the manufacturing distribution so as to resolve the problems that occur in manufacturing distribution, a model that can help manufacture in completing distribution in the future. When we talk about manufacturing distribution, it cannot be separated from transportation, sales, purchasing, storing, goods quality, and also the risk of damage to the production that will be distributed to consumers, so that good control of the manufacturing distribution process so that the product delivery process from the manufacturer Until consumers run smoothly, and there are no obstacles that can affect the distribution costs and time of production distribution (Paisley, Wangy, & Bleiz, 2012). In solving the problem of distribution in the future, it is necessary to optimize production costs and product delivery time and increase benefits. There are many studies related to distribution to optimize production and distribution time, costs, and possible constraints that must occur in the future. What happens is currently in the manufacturing distribution environment, namely the production process has not been scheduled which causes the distribution process. Sequential processes are needed in modeling the manufacturing distribution process so that the distribution process runs smoothly. If the order and production process are not sequential, the distribution process will be hampered. This is what causes the problem of distribution in the future and to overcome it the optimization model is needed to optimize the cost and time of distribution (Rauch, Dallinger, Dallasega, & Matt, 2015) (Leitão, 2009), (Rekersbrink, Makuschewitz, & Scholz-Reiter, 2009), (García-Flores, de Souza Filho, Martins, Martins, & Juliano, 2015). (Kamath et al., 2019) (Karageorgos, Mehandjiev, Weichhart, & Hämmerle, 2003). Based on the Statement (Shen, 2002) That Distribution Problems Are Very Complex, So To Solve Distribution Problems A Scheduled Distribution Is Needed To Integrate Into Production-Distribution Planning, Production Distribution Scheduling, And Control of Product Distribution. According to (Yao & Zheng, 1999) that optimization is needed to determine sequential quality control using a dynamic approach to quality control in batch manufacturing. From the description that has been explained by previous researchers, problems with distribution will continue to occur so that a decision model is needed so that the distribution can be scheduled sequentially resulting in the distribution process will not experience problems in the future. (Zhao & Nehorai, 2007) states that the application of the distributed sequential Bayes estimation method can reduce response time and save energy consumption of sensor networks. (Agrawal & Rao, 2014) states that reducing the excess energy consumption requires an update of the sequential scheduled distribution so that the total energy consumption accuracy value is reduced. So from the previous researcher's statement that has been described, a new model of scheduled sequential distribution is needed to solve problems in logistics distribution, to minimize the total cost of the process in the presence of limited resources, machine capacity, the amount of labor and also waste.

2. Literature Review

There are several approaches that have been carried out by previous researchers related to the permit of manufacturing distribution, some of these approaches included mathematical modeling and fuzzy logic-based methods. In the resolution of the integrated model production distribution can solve the problem of distribution system planning by applying a distributed generation as an interesting choice in the region of distribution utility. This model aims to minimize distributed generator investment and operating costs, total payment to compensate for system losses during periods of planning and different costs in accordance with the available alternative scenarios(El-Khattam, Hegazy, & Salama, 2005). It was not there, there was also a study stating that a new model for optimal energy storage placement to increase the minimization of energy loss through peak sinking with the presence of distributed plants. Storage size is modeled by considering the desired load and sinking profile. This storage is properly divided into several storage units and optimally allocated in several locations with the appropriate cargo release strategy. Renewable distributed generation (RDG) is modeled based on seasonal variations of renewable resources, for example, the sun or wind and RDG is placed in the appropriate location. The high-performance Gray Wolf Optimization (GWO) algorithm is applied to the proposed methodology (Kalkhambkar, Kumar, & Bhakar, 2016). And there are also research on saving the distribution of sensors. Previous researchers apply the sequential sequential estimation method by applying the mentode it can reduce the response time and save energy consumption of sensor networks (Zhao & Nehorai, 2007). The gene genetic algorithm has also been carried out to resolve the problem in the manufacturing distribution by applying several heuristic principles that have been added to improve the performance of the algorithm. The proposed algorithm can be applied and evaluated using the benchmark needed to resolve the problems possessed in time optimization. According to the results developed, it was found that the algorithm that had been developed had better results than the previous algorithm (Omara & Arafa, 2010).

3. Material and Method

This issue is propelled by the fish industry. The business intends to deliver K sorts of nearby conventional fish items from P plants. These plants are scattered in a few urban communities. The completed items will be pressed in bundling holder and afterward disseminated to a bunch of D appropriation places. Because of the perishability issue of the unpleasant fish material and the fish completed things, it is critical to plan the cutoff during the creation and spread endeavors, and from there on to organize detectable quality for the possibility of the things. The fish business wishes to design the creation and scattering framework with a legitimate saving for the K sort of fish things inside the time period s, s = 1…, S, to fulfill the market revenue. There are P plants available. To keep up the freshness of fish rough material, each plant has a confined cutoff cooled storeroom with a unit holding cost of $\rho_{ks}^{p}, k \in K, p \in P, s \in S$. These rough materials have a time period of practical convenience τ_r . On the off chance that the set aside unrefined materials are not totally used after their time period of practical convenience, they would be discarded. In like way, there would follow measures for the unpleasant fish, these crude fish ought to be disposed of on the off chance that they don't pass the quality norm. Hereafter the degree of supply of crude material at plant j of n sort of fish thing before their season of comfort would be inferred as $I_k^p, s < \tau_r$. There is a ton of D spread pivots organized around Kisaran Province satisfactorily close to each plant. Every development place d (d = 1, 2, ..., D) has a nonnegative and deterministic interest H_{ks}^d of k kind fish thing in getting sorted out period s of the engineering skyline. A bound extent of stock can be dealt with in a cooled room of stream focus d with unit holding cost of ρ_{ks}^p in each planning period s. Note that each completed thing has a period of the usability τ_f. We recognize that the interest for such a fish in the booked period at every development place is known. The sales have sure due dates. Excused interest for a period isn't permitted to be moved to the going with time span. The excused interest would be disposed of at costs. The issue for the fish affiliation is to plan creation and dispersing, so that will confine the immovable cost happened in the imaginative endeavors and stock at each plant and each stream neighborhood. For the numerical depiction of the model, the going with documentation is portrayed.

Sets and indices

S : Set of a time-frame with record *s*
O : Set of fish prepared items with record *o*
P : Set of plants with record *p*
I : Set of crude fish assets with record *i*
D : Set of distribution centers with record *d*

Variables

x_{op}^s : Amount of item *o* created to be followed in time span *s* from plant *p* (ton)
Z_{odp}^s : Amount of qualified item *o* conveyed to circulation focus *d* from plant *p* in time-frame *s* (ton)
u_{ip}^s : The extra measure of crude fish *i* to buy in time *s* for plant *p* (unit)
k_p^s : Number of laborers needed in time-frame *s* at plant *p* (man-period)
k_p^{s-} : Number of laborers laid-off in time span *s* at plant *p* (man-period)
k_p^{s+} : Number of extra laborers in time-frame *s* at plant *p* (man-period)
$I_{ip}^{s\le\tau_r}$: Stock degree of crude fish *i* at plant *p* in time-frame *s* considering time span of usability τ_r (units)
$I_{od}^{s\le\tau_f}$: Amount of item *o* to be put away in dissemination place *d* in time-frame *s* considering time span of usability τ_f (units)
B_{op}^s : Under-fulfillment of product *o* in period *s* at plant *p* (units)
Q_{od}^s : Neglected interest of item *o* in time span *s* at distribution center *d* (units)
y_{op}^s : Binary variable to state whether a sort of fish item *o* is set up to be dashed at plant *p* in time span *s*
v_{op}^s : Amount of item *o* to be dismissed at plant *p* in time-frame *s*

Parameters

CP_{op}^s : The expense related with creating *o* fish items at plant *p* in time span *s* (Rp.)
cr_{ip}^s : Cost to purchase extra crude fish *i* for plant *p* in time span *s* (Rp.)
cwr_p^s : The expense related with a standard specialist at plant *p* in time-frame *s* (Rp.)
cwa_p^s : The expense related with an extra laborer at plant *p* in time-frame *s* (Rp.)
cwl_p^s : The expense related with a laid-off specialist at plant *p* in time span *s* (Rp.)
cir_{ip}^s : Stock expense of crude fish *i* at plant *p* in time-frame *s* (Rp.)
cuf_{op}^s : The expense related with under satisfaction of fish item *o* at plant *p* in time span s (Rp.)
ct_{odp}^s : Transportation cost to convey fish item *o* from plant *p* to DC l d in time span *s* (Rp.)
$cid_{od}^{s\le\tau_f}$: The stock expense of fish item *o* at DC l *d* in time *s* considering time span of usability τ_f (Rp.)
cdp_{od}^s : The expense related with disposing of neglected nature of fish item *o* at DC l *d* in time span *s* (Rp.)
ctf_{op}^s : The expense related with following the cycle of fish item *o* at plant *p* in time span *s* (Rp.)
crf_{op}^s : The expense related with unloading the dismissed fish item *o* at plant *p* in time spa *s* (Rp.)
D_{op}^s : Interest for item *o* in period s from plant *j* (units)
U_{ip}^s : Upper bound on extra assets at plant *p* (units)
r_{iop}^s : Measure of asset *i* expected to deliver one unit of item *o* at plant *p*
f_{is}^p : Measure of asset *i* accessible at time *s* at plant *p* (units)
a_o : Number of laborers expected to deliver one unit of item *o* (man)

$UI_{op}^{s\leq\tau_r}$: Upper bound on the stock of item *o* at the plant *p* in period *s* before time span of usability (units)

$UI_{od}^{s\leq\tau_f}$:Upper bound on the stock of item *o* at the DC1 *d* in period *s* before timeframe of realistic usability (units)

4. Discussion and Models

The target of the issue is to limit the complete expense, numerically can be composed as follows.

$$\begin{aligned} minimize\ z = &\sum_{o\in O}\sum_{p\in P}\sum_{s\in S} cp_{op}^s x_{op}^s \\ &+ \sum_{i\in I}\sum_{p\in P}\sum_{s\in S} cr_{ip}^s u_{ip}^s \\ &+ \sum_{p\in P}\sum_{s\in S} cwr_p^s k_p^s \\ &+ \sum_{p\in p}\sum_{s\in S} cwa_p^s k_p^{s+} + \sum_{p\in p}\sum_{s\in S} cwl_p^s k_p^{s-} + \sum_{i\in I}\sum_{p\in P}\sum_{s\in S} cir_{ip}^s I_{ip}^{s\leq\tau_r} + \sum_{o\in O}\sum_{p\in P}\sum_{s\in S} cuf_{op}^s B_{op}^s \\ &+ \sum_{o\in O}\sum_{p\in P}\sum_{d\in D}\sum_{s\in S} ct_{odp}^s z_{odp}^s + \sum_{o\in O}\sum_{d\in D}\sum_{s\in S} cid_{od}^{s\leq\tau_f} I_{od}^{s\leq\tau_f} + \sum_{o\in O}\sum_{d\in D}\sum_{s\in S} cdp_{od}^s Q_{od}^s \\ &+ \sum_{o\in O}\sum_{p\in P}\sum_{s\in S} ctf_{op}^s x_{op}^s + \sum_{o\in O}\sum_{p\in P}\sum_{s\in S} crf_{op}^s v_{op}^s \qquad (1) \end{aligned}$$

Requirements to be met are as per the following.

$$\sum_{o\in O} r_{iop}^s x_{op}^s \leq f_{is}^p + u_{ip}^s \quad \forall i \in I, \forall s \in S, s \leq \tau_r, \forall p \in P \qquad (2)$$

Requirements (2) presents the quantity of fish asset *l* needed to deliver fish items o which ought to have similar measure of accessible crude fish assets at time *s* together with the extra crude assets required. Note that the crude fish assets are inside their time span of usability t_r, and have passed the following cycles.

$$x_{op}^s \leq C y_{op}^s \quad \forall o \in O, p \in P, s \in S \qquad (3)$$

Requirement (3) is to ensure that the creation of all sort of fish items happen at the planned plant

$$u_{ip}^s \leq U_{op}^s \quad \forall i \in I, \forall s \in S, p \in P \qquad (4)$$

Requirement (4) expresses that the extra crude assets have an upper bound.

$$\sum_{o\in O} a_o x_{op}^s \leq k_p^s \quad \forall s \in S, \forall p \in P \qquad (5)$$

Requirement (5) The amounts of standard experts required is conveyed in requirement 5

$$I_{op}^s = I_{op}^{s-1} + \sum_{d\in D} Z_{odp}^s - D_{op}^s \quad \forall o \in O, s \in S, l \in L, s < \tau_r \qquad (6)$$

$$I_{ip}^{s\leq\tau_r} \leq UI_{op}^{s\leq\tau_r} \quad \forall o \in O, s \in S, p \in P \qquad (7)$$

$$I_{od}^{s\leq\tau_f} \leq UI_{ns\leq t_f}^d \quad \forall o \in O, d \in D, s \in S \qquad (8)$$

Requirements (6) to (8) present the inventories at the plant and dissemination focus. The time span of usability is related with those articulations.

$$k_p^s = k_p^{s-1} + k_p^{s+} - k_p^{s-} \quad s = 2, \dots S, \forall p \in P \qquad (9)$$

Requirements (9) portray that the accessible laborers in any time span equivalent to the quantity of the past period in addition to any adjustment in the quantity of specialist types during the current time frame.

$$x_{op}^{s} + B_{op}^{s-1} + I_{op}^{s} - B_{op}^{s} = D_{op}^{s} \ \forall o \in O, \forall s \in S, \forall p \in P \qquad (10)$$

Requirements (10) decide either the created amount to be put away in the stock of the plant or to buy from different organizations to satisfy the setback of fulfilling the need.

$$\sum_{o \in O} Z_{odp}^{s} \leq \sum_{o \in O} UI_{op}^{s} \qquad \forall d \in D, \forall p \in P, s \in S \qquad (11)$$

Requirements (11) guarantee that the measure of a wide range of fish items from everything plants can be put away in the conveyance community inventories.

$$Z_{odp}^{s} + Q_{od}^{s} \geq D_{op}^{s} \qquad \forall o \in O, d \in D, p \in P, s \in S \qquad (12)$$

Requirements (12) expresses that the measure of conveyance from each plant in addition to the neglected interest ought to be in any event a similar measure of market interest.

$$x_{op}^{s}, u_{ip}^{s}, z_{opd}^{s}, v_{op}^{s}, I_{ip}^{s \leq \tau_r}, I_{od}^{s \leq \tau_f}, B_{op}^{s} \geq 0, \forall o \in O, \forall i \in I, \forall s \in S, \forall d \in D, \forall p \in P \qquad (13)$$

$$k_{p}^{s}, k_{p}^{s+}, k_{p}^{s-} \geq 0 \ and \ integer, \qquad \forall s \in S, p \in P \qquad (14)$$

$$Z_{odp}^{s}, y_{op}^{s} = \{0.1\} \qquad \forall o \in O, d \in D, p \in P, s \in S \qquad (15)$$

Requirements (13) – (15) express the idea of the factors utilized in the model.

5. Result

After resolving the scheduled sequential distribution problem on fish processed products located in the city kisaran by applying the proposed model we obtain results as shown in Table 17 to Table 24.

Table 1. Amount of each product to be produced (Ton)

Time Period	Prod 1	Prod 2	Prod 3	Prod 4	Prod 5
1	816	600	600	600	600
2	1050	1525	600	600	600

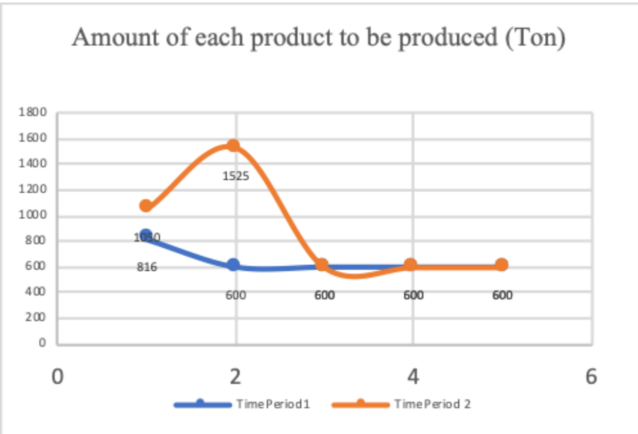

Figure 1. Experiment result amount of each product to be produced (Ton)

Based on the table above, the results obtained are the number of each product to be produced (tonnes), during period 1 the number of each product to be produced in product 1 is 816 tons and so on

Table 2. Quantity of resources to be used (ton)

Time Period	Resource 1	Resource 2	Resource 3
1	500	500	450
2	500	500	500

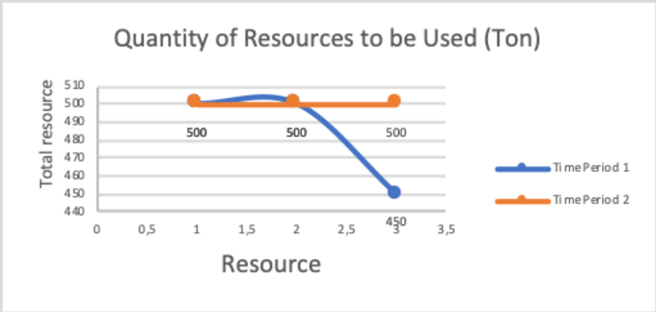

Figure 2. Experiment result quantity of resources to be used (ton)

Based on the table above, the results obtained are the amount of resources to be used (tonnes), in the period of time 1 the number of resources to be used (tons) the resources in product 1 are 500 tons and so on

Table 3. Number of workers needed

Time Period	Regular Worker	Lay-off Worker	Additional Worker
1	55300	0	0
2	55300	0	0

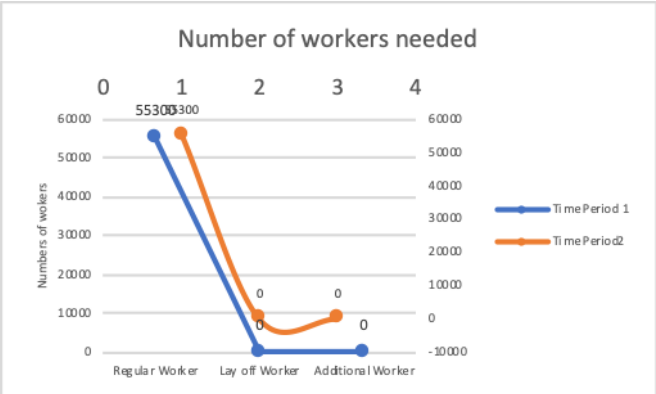

Figure 3. Experiment result number of workers needed

Based on the table above, the results obtained are the number of workers needed, during period 1 the number of regular workers is 55300, laid off workers 0, additional workers 0, and so on

Table 4. Number of Waste Produced (ton)

Time Period	Prod 1	Prod 2	Prod 3	Prod 4	Prod 5
1	163	120	120	120	120
2	210	305	120	120	120

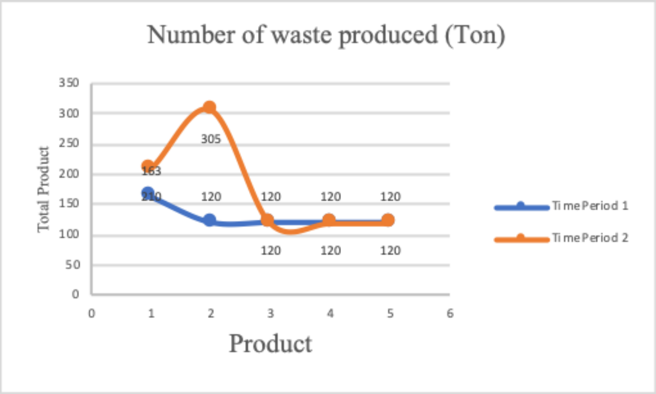

Figure 4. Experiment result number of waste produced (ton)

Based on the table above, the results obtained from the amount of waste in time period 1 and product 1 are 163 tons and so on

Table 5. Quantity of inventory at the manufacturing site (ton)

Time Period	Prod 1	Prod 2	Prod 3	Prod 4	Prod 5
1	20000	11500	4000	5000	3500
2	20000	11500	4000	5000	3500

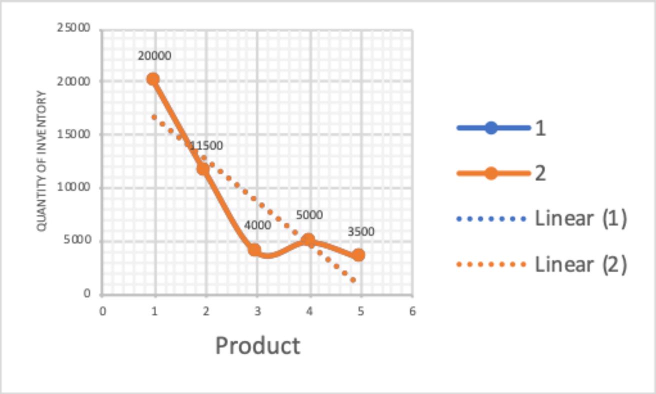

Figure 5. Experiment result Quantity of inventory at the manufacturing site (ton)

Based on the table above, the results obtained from the quantity of inventory at the production site (tons) in the period 1 production 1 is 20000 and so on

Table 6. Quantity of inventory at distribution center (ton)

Product	Distribusi Center	Time Period 1	Time Period 2
Product 1	DC 1	20000	20000
	DC 2	11500	11500
	DC 3	4000	4000
Product 2	DC 1	5000	5000
	DC 2	3500	3500
	DC 3	20000	20000
Product 3	DC 1	11500	11500
	DC 2	4000	4000
	DC 3	5000	5000
Product 4	DC 1	3500	3500
	DC 2	20000	20000
	DC 3	11500	11500
Product 5	DC 1	4000	4000
	DC 2	5000	5000

	DC 3	3500	3500

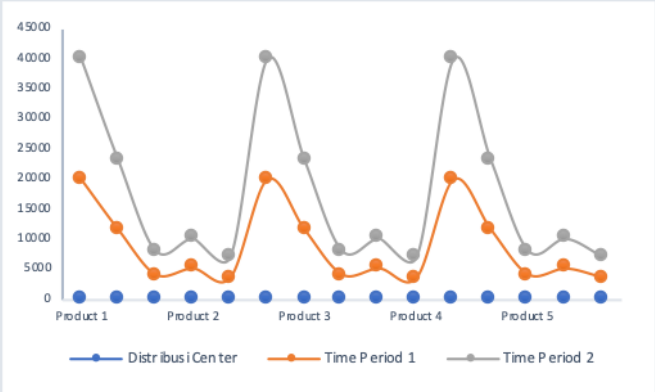

Figure 6. Experiment result quantity of inventory at distribution center (ton)

Based on the table above, the results obtained from the amount of inventory in the distribution center (tons) of product 1 DC 1 period 1 is 20000 and so on

Table 7. Production quantity to be delivered (ton)

Product	Vehicle	Distibusi Center	Period 1	Period 2
Product 1	Vehicle 1	DC1	0	0
		DC2	2500	0
		DC3	20000	0
	Vehicle 2	DC1	40000	6000
		DC2	0	20000
		DC3	0	20000
	Vehicle 3	DC1	0	14000
		DC2	14000	0
		DC3	4000	0
	Vehicle 4	DC 1	0	0
		DC 2	15000	0
		DC 3	0	0
Product 2	Vehicle 1	DC 1	0	0
		DC 2	0	11500
		DC 3	0	0
	Vehicle 2	DC 1	11000	0
		DC 2	15000	0
		DC 3	24000	0
	Vehicle 3	DC 1	5500	0
		DC 2	0	0
		DC 3	0	4000
	Vehicle 4	DC 1	0	11500
		DC 2	0	0
		DC 3	0	0
Product 3	Vehicle 1	DC 1	500	0
		DC 2	8000	0
		DC 3	0	0
	Vehicle 2	DC 1	0	4000
		DC 2	0	4000
		DC 3	0	0
	Vehicle 3	DC 1	0	0
		DC 2	0	0
		DC 3	9000	0
	Vehicle 4	DC 1	15000	0
		DC 2	0	0
		DC 3	0	4000

Product 4	Vehicle 1	DC 1	0	5000
		DC 2	0	0
		DC 3	0	5000
	Vehicle 2	DC 1	0	0
		DC 2	10000	0
		DC 3	15500	0
	Vehicle 3	DC 1	8500	0
		DC 2	0	0
		DC 3	1000	0
	Vehicle 4	DC 1	0	0
		DC 2	0	5000
		DC 3	0	0
Product 5	Vehicle 1	DC 1	0	3500
		DC 2	0	0
		DC 3	0	0
	Vehicle 2	DC 1	7500	0
		DC 2	8500	0
		DC 3	0	3500
	Vehicle 3	DC 1	0	0
		DC 2	0	3500
		DC 3	0	0
	Vehicle 4	DC 1	0	0
		DC 2	0	0
		DC 3	7000	0

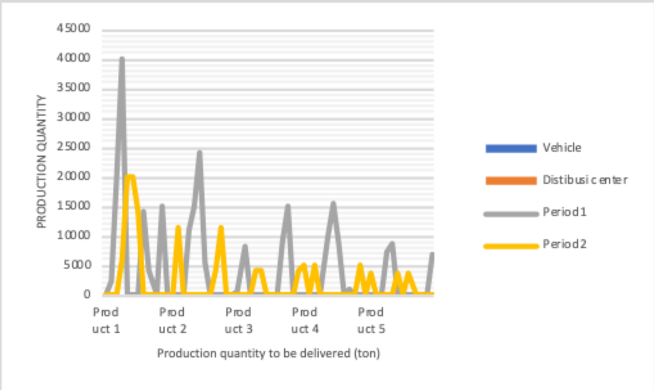

Figure 7. Experiment result production quantity to be delivered (ton)

Based on the table above, the results obtained from the amount of production to be shipped (tonnes), product 1, Vehicle 1, DC 1, time period 1 of 0 tons and so on

Table 8. under fulfillment of each product (ton)

Period	Prod. 1	Prod. 2	Prod. 3	Prod. 4	Prod. 5
1	816	1100	600	600	600
2	1866	3125	1200	1200	1200

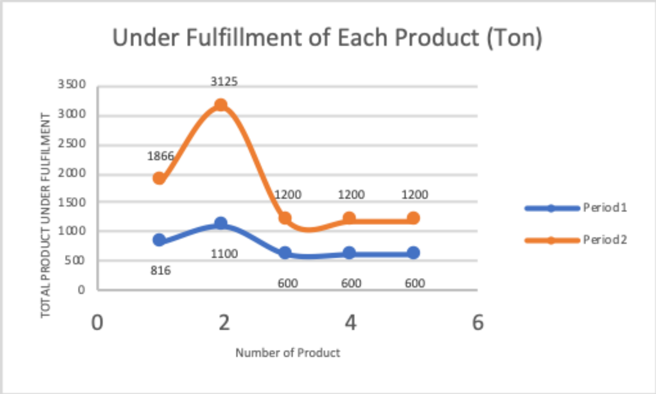

Figure 8. experiment result under fulfillment of each product (ton)

Based on the table above, the results obtained from under the fulfillment of each product (tons) during the period 1 product 1 amounted to 816 tons and so on

6. conclusion

As for the results of the research that has been done, it can be concluded that after optimizing the total cost, the criteria for the number of each product to be produced (tonnes)> = 20000 can be distributed sequentially on a scheduled basis and so on. The new optimization model is proven to solve the integrated problem of scheduling the distribution of production products sequentially to meet consumer demand. It is proven that scheduling can be carried out sequentially according to the flow of activities so that the fulfillment of consumer demand is fulfilled in the shortest possible time, up to a minimum total operational cost. This can assist current and future distribution.

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