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Decision-Making Optimization Model Sequential Production Planning In Sustainable Manufacturing Industries

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Abstract

Production planning models in the manufacturing industry are needed to minimize production costs. A company can have a competitive advantage if it has a mature production plan to offer products or services of the same or higher quality to customers. However, at a lower cost than its competitors, it must be considered in the preparation of production planning. Production optimization needs to be considered to achieve the lowest cost level to implement the production process itself. Sequential production planning optimization model in the sustainable manufacturing industry can solve the problem of integrated sequential production planning to minimize the total costs incurred in the production process. The sequential production planning model is proven to be able to minimize the total cost of production, and the production process 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 so that the total production cost is minimum.

Keywords Models, Optimization, Production Planning, Sustainable Manufacturing Industry.

Introduction

The rapid development of science and technology forces companies to innovate on the goods and services offered. In this case, the company innovates on existing products and issues new products by maintaining product quality and providing competitive prices in the market. A company is said to have a competitive advantage if it can offer products or services to customers with the same or higher quality but lower cost than its competitors (Varol & Zureck, 2020). This is done to maintain business continuity considering the increasing number of competitors due to technological developments that make it easier for business actors to enter the market and offer quality products. To overcome the intense competition due to globalization and technological developments, every industry player strives to improve its best quality. The main thing that industry players do is increase productivity in their production activities by improving product quality to get optimal results. Good, effective, and efficient planning is carried for each production operation.

Production planning is a plan about what and how many products will be produced by the company concerned in one period to come. Production planning is part of operational planning within the company. Aggregate planning is usually carried out by operations managers concerned with determining production, inventory, and labor levels to meet fluctuating demand (Eneyo & Ph, 2019). Aggregate planning provides the best way to meet forecasted demand within the next 3-18 months by adjusting regular and overtime production levels, inventory levels, labor levels, subcontract and backorder rates, and other controlled variables (Gansterer, 2015). In the preparation of production planning, the thing that needs to be considered is the optimization of production so that the lowest cost level for the implementation of the production process can be achieved. Production planning can also be defined as producing goods in a certain period according to what is predicted or scheduled through organizing resources such as labor, raw materials, machinery, and other equipment. Production planning requires an estimate of the demand for products or services that the company is expected to provide in the future. Thus, forecasting is an integral part of production planning (Wen, Hou, Liu, & Liu, 2017).

According to Brauner et al., in making a production plan, three elements must be considered: consumers, products, and manufacturing processes. This production activity plan includes the amount of production, production time, production costs, the number of production machines used, and the availability of raw materials. The availability of raw materials is optimal if the company can minimize production costs. Every aspect of the production process is interconnected so that scheduling planning in the production process becomes complex. In addition to the production process, the planning must also pay attention to the availability of raw materials before the production process is carried out. The shortage of raw materials when the production process is running will disrupt the production process and cause higher unexpected costs. In order to reduce production costs, increase productivity, and improve the quality of the products produced, it is very important to work in optimal conditions (Brauner, Finke, & Queyranne, 2014).

Production scheduling and raw material inventory are important things that are interrelated in a production process to find out the amount of production and types of products to be produced, the time of order, and the number of orders for raw materials (Akbar & Irohara, 2018). Production planning is very important to do in order to achieve the production function properly and precisely. Good inventory management must accompany production planning (Rácz-Szabó et al., 2020). The amount of inventory must always be adequate to hamper the production rate so that the company can always meet customer demands. The planning will prevent the company from producing goods at the wrong time, the price is not appropriate, and the number of goods in excess or shortage when finished. The problem often found in manufacturing companies, especially those of small and medium scale, is inefficient production planning due to the lack of human resource capabilities in implementing these plans (May, Schmidt, Kuhnle, Stricker, & Lanza, 2020).Good production planning begins with predicting consumer demand to know how many goods must be produced in a period. The optimal production planning strategy can control good warehouse stock inventory and avoid unnecessary raw material stock procurement. Ensure inventory is always at an adequate level, keep the good inventory, and keep the right inventory following consumer demand. The company gets notifications when the inventory stock is near the minimum level with a good inventory management system.

Material and Mathematics Model

This problem is motivated by production planning in the meat industry. The processed meat industry P has a plan to produce processed meat products I at factory P. With an increasing demand for processed foods from meat, a 1 M machine is needed to produce processed food products from meat with a planned completion time of W. The researcher assumes that the demand for processed meat products for each type of processed food from meat in the scheduled time period in each machine is known and has a certain maturity date. Any requests that cannot be fulfilled will not be processed to the next period. Furthermore, any requests that cannot be fulfilled will be discarded at a cost. The problem for meat companies is planning production to minimize the total costs incurred in the production process and the inventory in each factory and in each machine.

W : Declare the period of time with w□W
I : Declare processed meat products with i□I
P : Declare factory with p□P
S : Declare raw meat resources s□S
M : Declare machine with m□M

Variable

: Total product produced to be tracked in time period w at factory p(tons).

: Total products that qualify for production on a machine 1 m at factoryp in the time period w(tons).

: Total additional raw meat resources that must be purchased at time w for the factory p (units).

: Total workers needed in the time period w in factory p(man-period).

: Total workers fired in the time period w at factory p(man-period).

: The total addition of workers in the time period w in the factory p(man-period).

: Amount of raw meat stock s at factory p in time period wconsiderthe shelf life (unit).

: Amount of products s to be produced on a machine 1 in the time period w consider the shelf life (unit).

: Insufficient fulfillment of processed meat products i in time period w at factory p (units) (unit).

: The demand for a processed fish product i is not fulfilled in the time periodw in machine 1 m (unit).

: A binary variable denoting whether a type of processed meat product i is set to track at factory p in the time period w

: the level of processed meat product i will be rejected at factory p in the time period w (units).

1, if the processed fish product i is produced on time at factory 1 and machine 1 then sequential, and = 0, otherwise

Parameter

: The expense of producing processed meat products at factory p in time period w (Rp.)

: The expenseof purchasing additional raw meat s at factory p in time period w (Rp.)

: The expense of permanent employees at factory p in time period w(Rp.)

: The expense of additional employees at factoryp in time period w(Rp.)

: The expense with fired workers at the factory i in time period w (Rp.)

: The expense of raw meat stocks at factory p in time period w (Rp.)

: The expense of fulfilling processed meat product i at factory p in time period w(Rp.)

: The expense of using machine 1 m for processed fish i from factory 1 p in time period w(Rp.)

: Production cost of processed fish i in machine 1 m at time w considering shelf life

: Costs associated with disposing of unfulfilled quality of processed fish product i in machine1m in time period w(Rp.)

: The expense of tracing processed meat product i at factory p in time period w(Rp.)

: Disposal expense of rejected meat products at factory p in the time period w(Rp.)

: Demand for processed meat products i at factory p in time period w(Unit)

:Upper limit of additional resource of processed fish i in factory 1 p in time period w(Unit)

: Amount Resources needed to produce 1 unit of processed meat product i at factory 1p in time period w(Unit)

: Amount resourcess available at time w in factory 1 p (Units)(Unit)

: Amount workers needed to produce one unit of processed meat product i

: Upper limit of raw meat resource supply s at factory p in time period w before the shelf life (Unit)

: production cost related to scheduling raw meat processing i at factoryp in time w.

Discussion and Model

The object of this problem is to minimize the total cost of production mathematically so that all costs can be minimized. So it can be systematically written as follows;

The constraints that must be met are as follows:

(2)

Constraint (2) presents the number of raw meat resources needed to produce processed meat products i which must have the same total raw meat resources at the same time as the additional raw meat resources needed. Note that raw meat resources are in storage and have undergone a traceability process.

(3)

Constraint (3) ensure that all types of production for processed fish products i occur at the factoryp within the scheduled time w.

(4)

Constraint (4) represents that the additional amount of raw fish resources s has an upper limit on processed fish sources i.

(5)

Constraint (5) represents the number of permanent workers required expressed in the constraint.

(6)

(7)

(8)

Constraint(6)-(8)presents inventory at factoryp and machine 1m associated shelf life in the expression.

(9)

Constraint(9)represents that the amount of workers available in any time period w is equal to the amount of the previous period plus the change in the numberof types of workers during the current period.

(10)

Constraint(10)establishes the quantity produced to be stored in factory inventories or purchased from other firms to meet shortages in meeting demand.

(11)

Constraint(11)ensures that all types of processed fish products from all factories can be processed on machine 1.

(12)

Constraint(12)represents that the number of products produced on machines at the factory for each additional unfulfilled demand must be equal to the total market demand.

(14)

(15)

Constraint(13)(14)(15)state the nature of the variables used in the model

Result

After solving problems in production planning for processed fish products by applying the proposed sequential optimization model, the results of the model are as follows:

Table 1. Quantity Of Every Product To Be Produced (Tons)

w	i 1	i2	i 3	i 4	i 5
1	705	500	500	500	500
2	1141	1347	500	500	500

Figure 1. Quantity of every product to be produced (Tons)

Figure 1. Based on Figure 1, using a sequential optimization model, the amount of products produced in period 1 of product 1 is 705 tons, and period 2 of product 1 is 1141 tons.

Table 2. Number Of Raw Meat Resources To Be Used (Tons)

(w)	s1	s2	s 3
1	550	550	500
2	550	550	450

Figure 2. Number Of Raw Meat Resources To Be Used (Tons)

Figure 2. Based on Figure 2, using the sequential optimization model, the total quantity of raw meat resources obtained in period 1 is 550 tons of resource, and period 2 of fish resource 1 is 550 tons.

Table 3. Amount Of Workers Required

w	Regular	Lay-off	Additional

	Worker	Worker	Worker
1	54200	0	0
2	54200	0	0

Figure 3. Amount Of Workers Required

Figure 3. Based on Figure 3, using the sequential optimization model, the number of workers needed in period 1 is 54200 ordinary workers, 0 laid-off workers and 0 additional workers.

Table 4. Amount of Production Waste Produced (Ton)

w	i 1	i 2	i 3	i 4	i 5
1	152	110	110	110	110
2	222	311	110	110	110

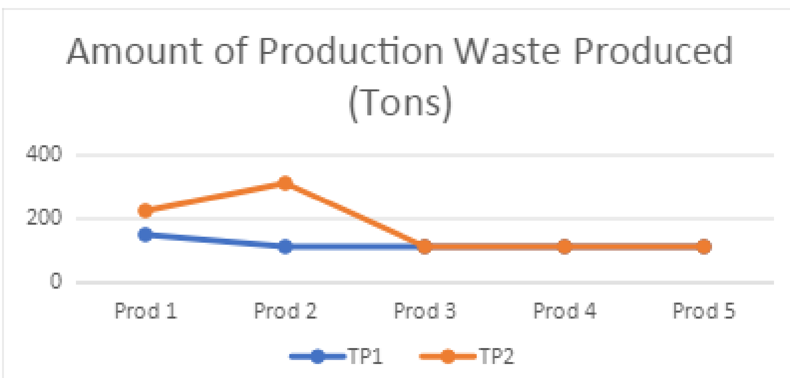

Figure 4. Amount of Production Waste Produced

Figure 4. Based on Figure 4,using the sequential optimization model, the amount of production waste produced in period 1 of product 1 is 152 tons and period 2 of product 1 is 222 tons.

Table 5. Total Inventory At The Factory Site (Tons)

w	i1	i2	i3	i4	i5
1	21212	10400	3999	4999	3450
2	21212	10400	3999	4999	3450

Figure 5. Total Inventory At The Factory Site (Tons)

Figure 5. Based on Figure 5, using the sequential optimization model, the total inventory at the factory site in period 1 of product 1 is 21212 tons and period 2 of product 1 is 21212 tons.

Table 6. Quantity Of Products To Be Produced At The Factory (Tons)

i	**p**	**m**	w1	w 2
Product 1	P1	M 1	0	0
		M 2	2501	0
		M 3	20002	0
	P 2	M 1	40001	6003
		M 2	0	20010
		M 3	0	20002
	P 3	M 1	0	14000
		M 2	14003	0
		M 3	4005	0
	P 4	M 1	0	0
		M 2	15005	0
		M 3	0	0
Product 2	P 1	M 1	0	0
		M 2	0	11503
		M 3	0	0
	P 2	M 1	11011	0
		M 2	15022	0

		M 3	24012	0
	P 3	M 1	5503	0
		M 2	0	0
		M 3	0	4002
	P 4	M 1	0	11511
		M 2	0	0
		M 3	0	0
Product 3	P 1	M 1	502	0
		M 2	8004	0
		M 3	0	0
	P 2	M 1	0	4007
		M 2	0	4007
		M 3	0	0
	P 3	M 1	0	0
		M 2	0	0
		M 3	9008	0
	P 4	M 1	15022	0
		M 2	0	0
		M 3	0	4007
Product 4	P 1	M 1	0	5008
		M 2	0	0
		M 3	0	5008
	P 2	M 1	0	0
		M 2	10001	0
		M 3	15511	0
	P 3	M 1	8503	0
		M 2	0	0
		M 3	1001	0
	P 4	M 1	0	0
		M 2	0	5008
		M 3	0	0
Product 5	P 1	M 1	0	3501
		M 2	0	0
		M 3	0	0
	P 2	M 1	7509	0
		M 2	8508	0
		M 3	0	3501
	P 3	M 1	0	0
		M 2	0	3501

		M 3	0	0
	P 4	M 1	0	0
		M 2	0	0
		M 3	7001	0

Figure 6. Quantity Of Products To Be Produced At The Factory (Tons)

Figure 6. Based on Figure 6,using the sequential optimization model, the number of products produced in machine 1, product 1, is 19999 tons, and product 1 on machine 2 is 11500 tons.

Table 7. Under Fulfillment Each Product (Tons)

w	i 1	i 2	i 3	i 4	i 5
1	818	1102	601	601	601
2	1855	3128	1203	1203	1203

Figure 7. Table 7. Under Fulfillment Each Product (Tons)

Figure 7. Based on Figure 7, using the sequential optimization model, it is obtained below the fulfillment of each product in period 1 product 1 818 tons and period 2 product 1 1855 tons and so on.

Conclusion

The sequential production planning optimization model in the sustainable manufacturing industry is proven to be able to solve the problem of sequentially integrated production results to meet consumer demand. The sequential production planning model is proven to be carried out based on the flow of activities in production planning to achieve consumer demands fulfilled in the shortest possible time so that the total production operational costs are minimal.

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