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The Application of Inventory Model in Material Planning Department atCompany of XYZ

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Abstract---*Company of XYZ is the first company in Indonesia to produce airplanes. Materials needed to produce the airplanes consist of metal, non-metal, and others. In the production process, there is condition where materials of metals are not available or run out. The unavailable materials are then substituted with other materials of metals. The problem is there are several substituted materials that are more expensive than the initial materials. On average, the difference or the price gap between the substituted materials and the initial materials is 105.78%. This gap shows that the Company of XYZ needs to control their inventory more effectively. An inventory model is applicated to the real system which is Material Planning Department to decrease this gap. That inventory model is simple probabilistic model. The result shows that the simple probabilistic model is able to decrease the gap to become 32.81%.*

Keyword--*Inventory model, Planning.*

I. INTRODUCTION

Company of XYZ is the first company in Indonesia to produce airplanes. Materials needed to produce the airplanes consist of metal, non-metal, and others. In the production process, there is condition where materials of metals are not available or run out. The unavailable materials are then substituted with other materials of metals. The problem is there are several substituted materials that are more expensive than the initial materials. Table 1 shows the difference between the prices of substituted materials and initial materials. On average, the difference or the price gap between the initial materials and the substituted materials is 105.78%. This gap shows that the Company of XYZ needs to control their inventory more effectively.

Table 1:*Price gap between the substituted materials and the initial materials*

No.	Prices of initial materials (USD/mm)	Prices of substituted materials (USD/mm)	The price gap
1	0.733	0.795	8.46%
2	0.01745	0.06472	270.96%
3	0.00004	0.00005	26.41%
4	0.00131	0.0018	37.43%
5	0.00246	0.00269	9.08%
6	0.04918	0.18873	283.76%
7	0.03415	0.05801	69.86%
8	0.44854	0.725	61.63%
9	0.00125	0.00139	11.09%
10	0.02161	0.14292	561.31%
11	0.00069	0.00079	14.88%

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12	0.03067	0.02864	-6.62%
13	0.00012	0.00024	104.94%
14	0.02864	0.02972	3.80%
15	0.00040	0.00131	223.89%
16	0.02177	0.05917	171.83%
17	0.00043	0.00059	39.55%
18	0.00820	0.01230	50.00%
19	0.02175	0.05855	169.21%
20	0.66800	1.14708	71.72%
21	0.04283	0.04320	0.87%
22	0.02892	0.03268	1299%
23	0.03500	0.11753	235.79%
The average			105.78%

To decrease this gap, an inventory model is applicated to the real system which is Material Planning Department (Slusarczyk, 2019). That inventory model is simple probabilistic model. According to Bahagia (2006), simple probabilistic model is an inventory model which service level is given. There are papers that applied inventory models to real systems. Iwu et al. (2014) applied EOQ (economic order quantity) model in a supermarket. The EOQ model was applied for multi-product and it was solved using heuristic method. Pulungan and Fatma (2018) applied simple probabilistic model, continuous review model, and periodic review model in a manufacture company. The models were applied for single product and they were solved using heuristic method. Margono and Lestari (2015) applied simple probabilistic model in a textile company. Similar to Iwu et al. (2014), Margono and Lestari (2015) applied the model for multi-product and the model was solved using heuristic method. Sukanta (2017) applied continuous review model in a toy company. The model in Sukanta (2017) was applied for single product and it was solved using heuristic method. Anggraini et al. (2013) applied continuous review model in a company of drinking water. Similar to Sukanta (2017), the model was applied also for single product and it was solved using heuristic method. Maskun (2016) applied periodic review model in an airplane company. The model in Maskun (2016) was applied for single product and it was solved using heuristic method. Nanaware and Saharkar (2017) applied EOQ model in a cement company. Similar to Margono and Lestari (2015), the model in Nanaware and Saharkar (2017) was applied for multi-product and the model was solved using heuristic method.

II. METHODOLOGY

The references used in this paper to develop the models are Bahagia (2006) and Saragih et al. (2018). Bahagia (2006) developed simple probabilistic model but the model was only for single product. As it can be seen in Table 1, the model needed in this paper is for multi-product. Saragih et al. (2018) is used to complete the model of Bahagia (2006) since Saragih et al. (2018) developed an inventory model for multi-product. To solve the model, this paper uses LINGO 12.0.

III. THE INVENTORY MODEL

3.1. Index sets

P set of products

3.2. Parameters and notations

μ_p mean of demand for product p (mm/year) ($\forall p \in P$)
σ_p^2 variance of demand for product p ($mm^2/year^2$) ($\forall p \in P$)
h_p holding cost for product p (USD/mm/year) ($\forall p \in P$)
a_p ordering cost for product p (USD /order) ($\forall p \in P$)
b_p buying cost for product p (USD /order) ($\forall p \in P$)
s_p shortage cost for product p (USD /mm) ($\forall p \in P$)
lt_p lead time at for product p (year) ($\forall p \in P$)

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α service level that should be satisfied
z_α standard normal deviate such that $P(Z \leq z_\alpha) = \alpha$
$f(z_\alpha)$ ordinate of z_α
$\Psi(z_\alpha)$ partial expectations of z_α
OT total cost (USD/year)

3.3. Decision variables
Q_p order size for product p (mm) ($\forall p \in P$)
MK_p amount of shortage for product p (mm) ($\forall p \in P$)
SS_p safety stock for product p (mm) ($\forall p \in P$)

3.4. Objective function

Objective function of simple probabilistic model consists of buying, holding, ordering, and shortage costs. Simple probabilistic model is as follows:

$$\min OT = \sum_{p\in P} \mu_p b_p + \sum_{p\in P} {}^{a_p \mu_p}/_{Q_p} + \sum_{p\in P} h_p \left({}^{Q_p}/_{2} + SS_p \right) + \sum_{p\in P} s_p MK_p \, {}^{\mu_p}/_{Q_p} \quad (1)$$

Subject to

$$SS_p = z_\alpha \sqrt{lt_p \sigma_p^2}, \qquad \forall p \in P \quad (2)$$

$$MK_p = \sqrt{lt_p \sigma_p^2}[f(z_\alpha) - z_\alpha \Psi(z_\alpha)], \qquad \forall p \in P \quad (3)$$

$$Q_p, SS_p, MK_p \geq 0, \qquad \forall p \in P \quad (4)$$

Equation (1) is the objective function of simple probabilistic model which is the sum of buying, holding, ordering, and shortage costs. Equation (2) is the formulation to calculate the safety stock. Equation (3) is the formulation to calculate the amount of shortage. Constraints (4) are the decision variables constraints.

IV. APPLICATION AT COMPANY OF XYZ

IV.I Data

From historical data, distributions of demands are normal distribution. Data of mean and standard deviation of demands for 14 products from Company of XYZ is given in Table 2.

Table 2: *Mean and standard deviation of demands*

No.	Mean of demand (mm)	Standard deviation of demand (mm)	Type of distribution
1	9,550	14,143	Normal
2	2,131,135	1,389,262	Normal
3	53,245,75	3,353,731	Normal
4	5,137	5,468	Normal
5	21,744	2,018	Normal
6	5,053	4,692	Normal
7	3,122	1,636	Normal
8	25,835	29,413	Normal
9	811,055	747,564	Normal
10	20,692	26,674	Normal
11	37,631	31,857	Normal
12	43,566	38,748	Normal
13	16,248	8,846	Normal
14	53,661	45,565	Normal

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Table 2 shows data for ordering, holding, and shortage costs.

Table 3:*Ordering, holding, and shortage costs*

No.	Ordering cost (USD/oder)	Holding cost (USD/mm/year)	Shortage cost (USD/mm)
1	0.00174	0.00454	0.02617
2	0.00000	0.00001	0.00006
3	0.00013	0.00034	0.00197
4	0.00492	0.01279	0.07377
5	0.00024	0.00063	0.00361
6	0.00342	0.00888	0.05123
7	0.04485	0.11662	0.67281
8	0.00216	0.00562	0.03242
9	0.00007	0.00018	0.00103
10	0.00286	0.00745	0.04295
11	0.00218	0.00566	0.03265
12	0.00217	0.00565	0.03262
13	0.00428	0.01114	0.06424
14	0.00289	0.00752	0.04338

As for service level, it is decided by 95%. That makes z_α =1.65.

IV.II Results

As it was mentioned before, this paper uses LINGO 12.0 to obtain the optimal solution. The result of LINGO 12.0 is given in Fig. 1.

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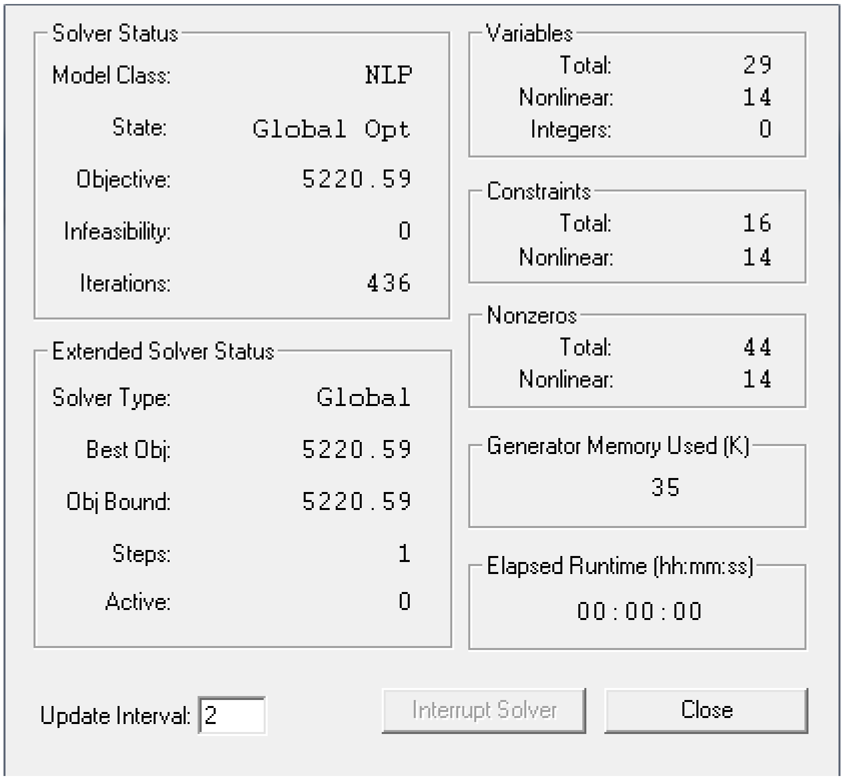

Figure 1:*The result of LINGO 12.0*

The optimal solutions for decision variables are given in Table 3.

Table 4:*Optimal solutions for decision variables*

No.	Order size (mm)	Safety stock (mm)	Amount of shortage (mm)
1	8,113.264	14,441.918	597.808
2	1,225,457.426	1,418,624.605	58,722.460
3	2,957,504.307	3,424,613.438	141,758.241
4	3,701.360	5,583.568	231.126
5	4,612.197	2,060.651	85.298
6	3,401.007	4,791.167	198.325
7	1,579.072	1,670.577	69.152
8	19,250.81	30,034.655	1,243.253
9	541,573.3	763,364.062	31,598.646
10	16,401.62	27,237.766	1,127.478
11	24,179.34	32,530.310	1,346.558
12	28,704.51	39,566.954	1,637.832
13	8,371.385	9,032.964	373.910
14	34,531.34	46,528.034	1,925.979

V. CONCLUSION

As it can be seen in Table 4, the price gap before and after the application of the inventory model is down by 72.97%. Afer the application of the model, the price gap is only 32.81%. It means that the model is able to improve the effectiveness of inventory of materials of metals in Material Planning Department at Company of XYZ.

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Table 5:*Before and after the application of the inventory model*

No.	Before the application			After the application		
	Prices of initial materials (USD/mm)	Prices of substituted materials (USD/mm)	The price gap	Prices of initial materials (USD/mm)	Prices of substituted materials (USD/mm)	The price gap
1	0.73300	0.79500	8.46%	0.73300	0.79500	8.46%
2	0.01745	0.06472	270.96%	0.01745	0.01745	0.00%
3	0.00004	0.00005	26.41%	0.00004	0.00004	0.00%
4	0.00131	0.00180	37.43%	0.00131	0.00131	0.00%
5	0.00246	0.00269	9.08%	0.00246	0.00269	9.08%
6	0.04918	0.18873	283.76%	0.04918	0.04918	0.00%
7	0.03415	0.05801	69.86%	0.03415	0.03415	0.00%
8	0.44854	0.72500	61.63%	0.44854	0.44854	0.00%
9	0.00125	0.00139	11.09%	0.00125	0.00139	11.09%
10	0.02161	0.14292	561.31%	0.02161	0.02161	0.00%
11	0.00069	0.00079	14.88%	0.00069	0.00069	0.00%
12	0.03067	0.02864	-6.62%	0.03067	0.03067	0.00%
13	0.00012	0.00024	104.94%	0.00012	0.00024	104.94%
14	0.02864	0.02972	3.80%	0.02864	0.02864	0.00%
15	0.00040	0.00131	223.89%	0.00040	0.00131	223.89%
16	0.02177	0.05917	171.83%	0.02177	0.02177	0.00%
17	0.00043	0.00059	39.55%	0.00043	0.00059	39.55%
18	0.00820	0.01230	50.00%	0.00820	0.01230	50.00%
19	0.02175	0.05855	169.21%	0.02175	0.02175	0.00%
20	0.66800	1.14708	71.72%	0.66800	1.14708	71.72%
21	0.04283	0.04320	0.87%	0.04283	0.04283	0.00%
22	0.02892	0.03268	12.99%	0.02892	0.02892	0.00%
23	0.03500	0.11753	235.79%	0.03500	0.11753	235.79%
		The average	105.78%		The average	32.81%

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