Green inventory controlling analysis of coal using the lot sizing technique: Lesson learned form nickel mining industry

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Green inventory controlling analysis of coal using the lot sizing technique: Lesson learned form nickel mining industry

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Abstract. Companies, including PT Vale Indonesia (PTVI), generally should implement inventory control. PTVI use approximately 32,077 tons per month coal as a heating catalyst on the reducing furnace. There were several periods in 2017 and 2018 where the coal inventory exceed the safety stock and maximum stock level with the total cost of IDR 616,059,680.00 in 2017 and IDR 669,720,480.00 in 2018. In order to analyze and solve that stock problems, this research used the Lot-Sizing technique with Lot for Lot (LFL), Economic Order Quantity (EOQ), Part Period Balancing (PPB), and the Silver-Meal Algorithm (SMA) methods to obtain the demand and appropriate order time, by considering the lead time factor, safety stock, and reorder point to obtain the efficient costs. As a result, the safety stock value was 7,922 tons with reorder point 18,674 tons. The PPB and SMA methods gave the most minimum total inventory cost of IDR 437,021,589,280 and efficiency of 34.74%.

1. Introduction

Basically, every company will always set policy about how big of safety stock of each material needed, lead time, and order price that must be spent. The amount of safety stock owned will be used to calculate how long the stock can cover (stock covering) ordering material in the event of an unwanted problem. Inventory control is a planned approach to determining what is ordered, when to order, how much is ordered, and how much inventory must be held so that the costs associated with purchasing and storage remain optimal without disrupting production and sales. Inventory control basically deals with two problems: (i) When should the order be placed (order level)?, and (ii) How much must be ordered? (order quantity) [1].

PT Vale Indonesia (PTVI) is a company that produces nickel product in matte form. In one of their processing stage needs, PTVI needs coal as the fuel catalyst. Coal inventories must always be sufficient to meet the company's performance. The stock is expected to meet the demand for unstable use of coal by calculating the cost and time of ordering. PTVI needs coal about 32.077 tons per month. However, between 2017 and 2018, PTVI ordered up to 902,348 tons of coal, but the consumption at the same period was only 769,845 (overstocked). This paper reviewed that problem and tried to seek a fit solution with some methods such as Lot for Lot (LFL), Economic Order Quantity (EOQ), Part Period Balancing (PPB), and the Silver-Meal Algorithm (SMA).

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2. Methods

This study conducted at PTVI using January 2016 – December 2017 coal inventory data as the object. The data then were analyzed using LFL, EOQ, PPB, and SMA methods.

Lot for lot is a lot size determination technique that produces what is needed to fulfill the plan precisely. The LFL method, also known as the minimum inventory method, is based on the idea of providing supplies (or producing) as needed [2]. The amount of inventory is kept to a minimum or even no inventory (zero inventory). The number of orders in accordance with the actual required amount (lot-for-lot) results in no inventory being stored. Thus, costs incurred only in the form of booking fees only. The assumption behind this method is that the supplier (from outside or from the factory floor) does not require a certain lot size. That means any size of the ordered lot will be able to be fulfilled by the supplier [3].

The EOQ technique is that the size of a lot is fixed, involving the cost of ordering and storage costs. Orders are made if the amount of inventory can not meet the needs needed [4]. This technique is usually used for planning horizons for one year (12 months), while the effectiveness of the method will be good if the pattern of needs is continuous and the level of need is constant. The EOQ model is used to determine the number of inventory orders that minimizes direct inventory storage costs and inventory ordering costs [5]. The order quantity will be optimal if the storage costs with the order cost reach a minimum value. The optimal order quantity occurs at point Q when the order fee is the same as the storage cost, which is the intersection of both.

PPB is an inventory ordering technique that balances setup and storage costs by changing lot sizes to reflect future lot size requirements in the future [6]. Balancing a part of the period creates a partial economic period (EPP), which is a comparison of setup costs with storage costs.

One of the heuristic methods in inventory control is the SMA method [7]. This method is an easy method to use, and the results of the iteration will get good results when compared with other heuristics. The use of the SMA method has similarities with the calculation of EOQ, which is used as a basis for the repetition of variables in subsequent periods. This method tries to find a minimum average cost for each period for several planned periods [8]. This SMA method is used for problems where the variation in demand from one time period to the next is quite high.

3. Result and discussion

3.1. Master production schedule

The nickel ore processing by PTVI involves coal as one of the forming material for nickel matte. In that process, nickel ore, coal, silica, and sulfur are blended together in reduce furnace. The production data of nickel matte during January 2017 – December 2018 are presented in table 1.

Table 1. Demand of nickel matte

Period	Production	
	2016	**2017**
January	4,898	7,870
February	4,979	5,800
March	5,298	5,827
April	7,234	6,665
May	5,390	4,733
June	6,211	6,563
July	7,687	5,599
August	6,671	5,808
September	8,025	7,127

October	7,402	6,003
November	6,493	6,974
December	7,460	7,251

3.2. *The coal demand data*

The demand and the actual usage of coal at PTVI between January 2017 – December 2018 are presented in table 2.

Table 2. The demand data of coal

Year	Period	Demand (ton)	Usage (ton)	Deviation (ton)
2016	January	34,350	24,491	9,859
	February	30,602	24.896	5,706
	March	40,592	26,489	14,103
	April	27,955	36,172	-8,217
	May	30,414	26,949	3,465
	June	39,455	31,053	8,402
	July	36,855	38,433	-1,578
	August	43,289	33,356	9,933
	September	42,228	40,126	2,102
	October	40,750	37,009	3,741
	November	42,730	32,467	10,263
	December	41,718	37,299	4,419
2017	January	42,284	39,352	2,932
	February	28,830	28,999	-169
	March	30,432	29,135	1,297
	April	41,384	33,324	8,060
	May	42,828	23,667	19,161
	June	41,199	32,815	8,384
	July	42,650	27,994	14,656
	August	40,481	29,040	11,441
	September	40,178	35,635	4,543
	October	30,015	30,015	0
	November	34,872	34,872	0
	December	36,257	36,257	0
Total		**902,348**	**769,845**	**132,503**
Average/period		**37,598**	**32,077**	**5,521**

3.3. PTVI policy for coal stock

During 2017 and 2018, PTVI determined the safety stock amount up to 4,000 tons with the assumption that the delay of coal distribution was rarely. Besides using the safety stock, the safety cover also used as the parameter of material demand satisfy in a weekly period (figure 1 and figure 2).

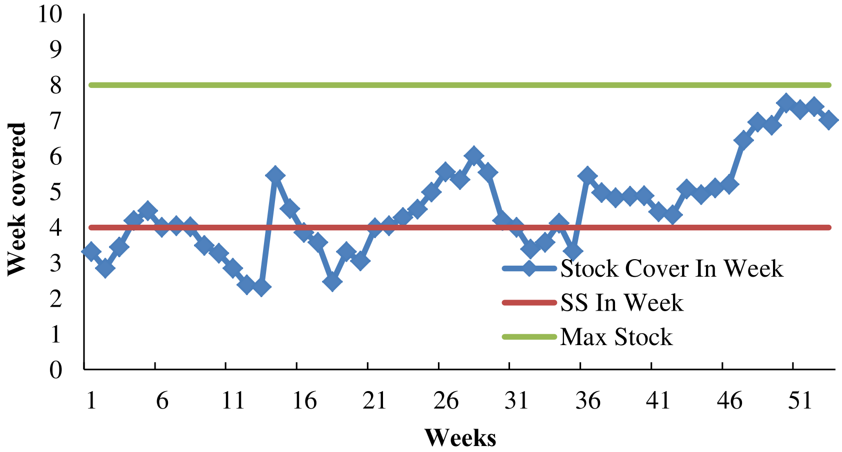

Figure 1. Safety cover of coal in 2017

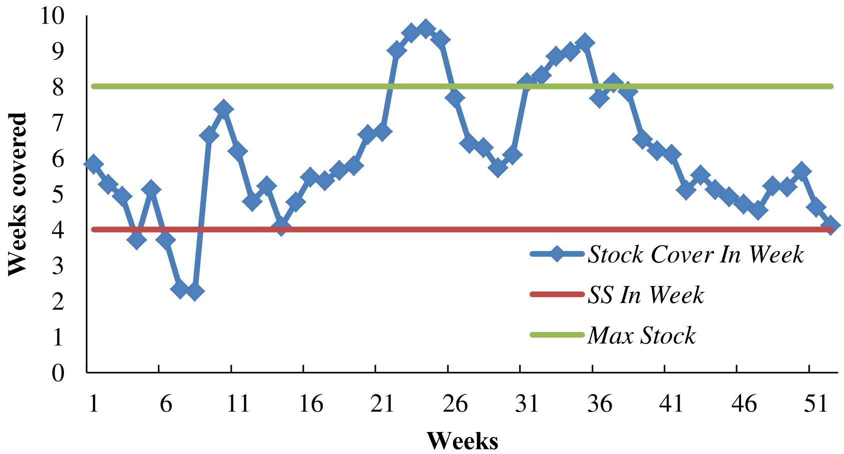

Figure 2. Safety cover of coal in 2018

3.4. Forecasting of the nickel production

The most optimal forecasting method obtain by analyzing the failure of actual demand in 2016 and 2017 with the forecasting by using the Mean Absolute Deviation (MAD), Mean Standard Error (MSE), and Mean Forecast Error (MFE). The comparison of the result is presented in table 3.

Table 3. The comparison of forecasting method

Method	MSE	MAD	MFE
SMA (3)	7,902	652	152
SMA (5)	776,180	625	130
WMA (3)	725,996	634	171
WMA (5)	1,035,478	722	173
SES (1)	1,366,345	928	611
SES (0,5)	930,824	764	169

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SES (0,9)	1,218,731	924	107

3.5. The comparison of lot sizing method

Table 4 presents a comparison of the total costs that must be incurred by PTVI for each inventory control method.

Table 4. The comparison of total cost

Method	Total Cost (IDR)
LFL	443,106,003,680
EOQ	662,627,080,960
PPB	437,021,589,280
SMA	437,021,589,280

4. Conclusion

The optimal safety stock amount for the coal demand was 7,922 tons. The optimal reorder point amount applies if the demand for coal within ten days was 18,674 tons. The most minimum total inventory cost could be obtained by implementing PPB or SMA method.

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