Material Inventory Control of Al-Oxide in the Division Part Repair GMF Power Services

Finda A. Mahardika, Yuniaristanto, Muh. Hisjam, and Ria Asyrofa

***Abstract*—Stockout of Al-Oxide material is the main problem in the GMF Power Services' Part Repair Division. To identify the causes of the problem, we can use a Fishbone diagram. From the Fishbone diagram, we explored further by using ABC analysis. We proposed an inventory control using Q Method (Continuous Review Method) to find optimal supply and company spending for booking, storage and financial reserving for materials that the company cannot provide. Determining optimal stock is very urgent to the company in order to avoid the stockout.**

***Index Terms*—inventory control, fishbone diagram, ABC analysis, Continuous review method**

I. Introduction

GMF Power Services is a sub-business unit of PT Garuda Maintenance Facility AeroAsia [1]. It is the only sub-business unit of GMF AeroAsia which does not concern on aircraft maintenance. Rather, GMF Power Services is a business unit of GMF AeroAsia which focuses more on maintaining industrial turbine gas machines [1]. It is established to provide more options on maintaining industrial turbine gas machines, which is technically similar as maintaining airplane engines [2]. In MRO process (Maintenace Repair and Overhaul) conducted by GMF Power Services, It requires several material such as rotary, air macro grinder, powder stellite, angle head air die grinder, welding rod, ceramic blasting nozzle, aluminium oxide (Al-oxide), hydrogen gas, and many more [2]. Aluminium oxide (Al-Oxide) is a material used in the process of blasting. It is a chemical compound consists of aluminium and oxygen, with the chemical formula is Al_2O_3. In mining, ceramics, and engineering, it is well-known as alumina. It also plays an important role to make aluminium metal more durable in dealing with rust [3]. Its function is to clean the rust, oil, grease and the other particles that attached to the parts of turbine. Meanwhile, blasting is a process of cleaning the surface of the material using high-pressured air device. It uses sand, water, and other similar material as the media to clean a material [4]. It can be classified as a surface treatment, and it can be applied in engineering field, such as ship-making, pipping maintenance, tools maintenance, fluid machines maintenance, and many more [4]. Then, there are many factors that determine the success of sandblasting such as the operator's ability, air pressure for spraying, the amount of the sand, spraying time, and spraying range [5]. Blasting in GMF Power Services is often interrupted by stockout, and it makes the process stops.

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II. Method

Considering the problems in GMF Power Services, this paper will use Fishbone diagram for analyzing factors that cause of stockout of Al-Oxide. Then, this paper will apply ABC analysis to analyze Al-Oxide material. This paper will also use Q Method (Continuous Review Method) to conduct inventory control.

The fishbone analyse is a tool for analyzing the business process and its effectiveness [12]. It is also commonly referred as "Ishikawa Diagram" because it was invented and incorporated by Mr. Kaoru Ishikawa, a Japanese quality control statistician [12]. It is defined as a fishbone because of its structural outlook and appearance. In normal stature it looks like a skeleton of a fish [12]. The fishbone diagram is used to identify causes of a problem without using statistical methods [6]. ABC method of categorization of inventory items allows to focus on most expensive items (or other items strategic to the enterprise) [7]. The obtained results aim to indicate items whose purchase and storage in the warehouse is the most or the least beneficial for companies. The results of analysis might help identify these machines and equipment which are most prone to failure. ABC Method assumes that 20% of products covers 80% of share in general demand for goods [8]. This method provides focus on the materials whose supply takes higher positions in total value of material consumption and total value of turnover in companies [9]. It divides warehouse product range into three categories. First category is a group of 20% of goods marked A, including items of highest (80%) share in general supply. Second group is formed by the goods whose share in total supply amounts to more than 80%, marked B. Third group, marked C, encompasses the rest of goods, that share in total supply amounts more than 90% [8].

Generally, inventory generates income and future cash

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inflow to firms, thus, it plays a pivotal role for firm financial performance and position [13]. Traditional inventory models assume that depletion from stock is caused only by the arrival of demands [14]. However, in reality, many physical products like volatile liquids, agricultural items, films, blood, drugs, fashion goods, electrical components etc. undergo deterioration through evaporation, spoilage, dryness etc. during their normal storage period [14]. As a result, while developing inventory policies for such products, the loss due to deterioration cannot be ignored [14]. So, this paper used Continuous Review system to resolve GMF's problem. Continuous Review system is a system of the inventory control with fix quantity but change time [10]. The continuous review, where depending on the inventory level, orders can happen at any time, and next the periodic review, where orders can only be placed at the beginning of each period [15]. In a Continuous Review (Q) system, an organization perpetually monitors its inventory levels and places an order for a fixed quantity (Q) when the inventory drops below a predetermined reorder point. In this kind of system, orders can be placed at any time because they are dependent on the actual demand [11].

III. Result And Discussion

Before discussing inventory control, it is better to create Fishbone diagram for knowing the cause of Al-Oxide stockout. Interviewing the workers and conducting direct observation can be used to figure out the cause of Al-Oxide stockout.

When it is found, the next step is solving the problems. This paper does not solve all of the problems, rather the solution will be limited on material storage system of inventory control. It will be attached to Q method, since the company does not have the data record about the use of material. Thus, it is hardly to use deterministic models. Before conducting inventory control, it is better for conducting ABC analysis.

ABC analysis is a method of inventory that is used to control certain high-value and high-investment products. But, it cannot be merely conducted based on money value due to the price of all Al-Oxide is the same, IDR 660,000 each bag, when each bag is about 25 kilogram. It is better to conduct ABC analysis based on the need of Al-Oxide, the intensity of activity, and re-used Al-Oxide.

Table I shows he results of ABC analysis. Based on the ABC analysis, it can be assumed that the A-class Al-Oxide is Al-Oxide #16. It is because Al-Oxide #16 is used in *stripping*. *Stripping* is a part of repairing process, so if it does not exist, repairing will not work. Besides, the used Al-Oxide #16 can be re-used or re-cycled to form Al-Oxide #60. Al-Oxide #60 is very beneficial material for *activating* and *cleaning*.

Then, material that can be classified into B-class is Al-Oxide #36. It is because repairing needs Al-Oxide #36 in a very significant amount. Besides, it can be very beneficial material in coating 9954.

Meanwhile, materials that can be considered as C-class material are Al-Oxide #60 and Al-Oxide #20. It is because the function of both materials can be replaced by Al-Oxide #16.

The next step is conducting inventory control uses Q method. It is also known as Continuous Review system or Continuous Review Fixed-Order Quantity (FOQ) system. This method is applied to anticipate random demand or probabilistic caused by lack of supply data and recording. Thus, it contains standard deviation. Table II shows the value of standard deviation. The value of standard deviation based on lead time for seven days can be shown in Table III. From the standard deviation in Table III, it can be assumed the value of inventory based on continuous review method.

The following is the example of calculation of inventory Al-Oxide #60 uses Continuous Review (s,S) System. Demand (D) = 918 Kg; Standard Deviation (σDL) = 1390 Kg; Lead time (L) = 7 days; Booking Fees (A) = IDR 500,000 for 1 booking; Save Cost (h) = IDR 46.667/Kg; Shortage Cost (Cu) = IDR 7,920/Kg.

TABLE I
Analysis Abc

Al-Oxide	Recycle	Needed/Month	Work Activity	Class
#60	No	26%	Activating & Cleaning	C
#36	No	26%	Activating & Cleaning	B
#16	Yes	48%	Activating & Stripping	A
#20	No	0%	-	C

TABLE II
STANDARD DEVIATION

Al-Oxide	(Σx)^2	σD
#60	13,483,584	525.477
#36	13,483,584	525.477
#16	0	0
#20	45,037,521	837.734

σD = standart deviation
(Σx)^2 = sum of quantity Al-Oxide

TABLE III
STANDARD DEVIATION WITH LEAD TIME

SD With Lead Time	
Al-Oxide 60	1,390 (Kg)
Al-Oxide 36	1,390 (Kg)
Al-Oxide 16	2,216 (Kg)
Al-Oxide 20	0 (Kg)

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TABLE IV
INVENTORY ON WAREHOUSE

Material		Order Quantity (kg)	Order Quantity (bag)
AL-OXIDE 60	Q optimal	6,632	266
	Reorder Point	8,846	354
	Safety Stock	2,420	97
AL-OXIDE 36	Q optimal	6,632	266
	Reorder Point	8,846	354
	Safety Stock	2,420	97
AL-OXIDE 16	Q optimal	9,370	375
	Reorder Point	15,847	634
	Safety Stock	4,101	165

Holding Cost (h) = $\frac{20\% \; x \; (Labor \; cost + maintenance \; cost)}{max \; capacity}$

$= \frac{20\% \text{ x (IDR 500,000 + IDR 3,000,000)}}{600 \; x \; 25}$

= IDR 46.67 / Kg

Shortage Cost (Cu) = 30% x Cost per Kilogram

= 30 % x $\frac{IDR600{,}000}{25}$

= IDR 7,920/Kg

ITERATION

1. The Calculation of qo1* uses Wilson formulation

$qo_1^* = \sqrt{\frac{2.A.D}{h}}$

$qo_1^* = \sqrt{\frac{2 \text{ x (IDR 500,000) x (918)}}{IDR \; 46.667}}$

qo_1^* = 4,435.25 Kg

2. Based on the value of the value of qo_1^*, it will be able to find out the shortage of supplies α using the following equation:

$\alpha = \frac{h.qo1*}{Cu.D+h.qo1*}$

$\alpha = \frac{IDR \; 46.667 \; x \; 4{,}435.25}{\text{IDR 7,920 x 918} + IDR \; 46.667 \; x \; 4{,}435.25}$

α = 0.0278 So Zα = 1.9 (from normal table)

Then the value of r_1^* can be searched using the following equation:

$r_1^* = D.L + Z\alpha.\sigma D_L\sqrt{L}$

r_1^* = 918 x 7 + 1.9 x 1,390$\sqrt{7}$

r_1^* = 9,067.53 Kg

3. When the value of r_1^* is found, then the value of qo_2^* can be found either using the following equation:

$q_{02}^* = \sqrt{\frac{2.D \; [A+Cu \int_{r1^\wedge}^{\infty} (x-r1)f(x)\,dx]}{h}}$

With:

$N = \int_{r1^\wedge}^{\infty} (x - r1)f(x)\,dx$

$= SL \; [\; f \; Z\alpha - Z\alpha \; \psi \; Z\alpha \;]$

For the value of f and $\psi \; Z\alpha$, it can be found using an excel formula of normal distribution.
Zα = 1.9 → f (Zα) = 0.0656 and ψ (Zα) = 0.011

So:

$N = \sigma D_L \; L \; [f \; Z\alpha - Z\alpha \; \psi \; Z\alpha]$

N = (1,390 x 7) x [0.0656 – 1.9 x (0.011)]

N = 62.02

N ≈ 63 Kg

The value of qo_2^* are:

$q_{o2}^* = \sqrt{\frac{2.D \; [A+Cu \int_{r1^\wedge}^{\infty} (x-r1)f(x)\,dx]}{h}}$

$q_{o2}^* = \sqrt{\frac{2 \text{ x 918 [IDR 500,000 +(IDR 7,920 x 63)}}{\text{IDR 46.667}}}$

q_{o2}^* = 6,269.13 kg

The iteration is conducted until the value of r (i) * has an equal value. For Al-Oxide #60, it requires three times iteration, so does for Al-Oxide #36 and Al-Oxide #16. The proposed inventory control uses Q model probabilistic control system, since the company does not have the data record of material. Thus, it is hardly to use deterministic models. Besides, Q method is very useful to be used, considering it makes Al-Oxide stock controlling routinely conducted. Moreover, it makes the amount of Al-Oxide stock in warehouse is well registered. It can prevent the delay in demanding process also.

From the calculation, it is assumed that the reorder point (ROP) of each Al-Oxide is: 354 bags for Al-Oxide #60, 354 bags for Al-Oxide #36, and 634 bags for Al-Oxide #60. Thus, the company should make demands when the amount of Al-Oxide in warehouse are equal or less than each reorder point (ROP) for each Al-Oxide.

From the calculation also, it can be figured out that the company should have *safety stock* for Al-Oxide #16 is 165 bags, Al-Oxide #36 is 97 bags, and Al-Oxide #60 is also 97 bags. *Safety stock* will significantly help to handle the increase of sudden demand.

Besides, the Q method can determine the economic quantity order for each Al-Oxide per order. It is 266 bags for Al-Oxide #60 and Al-Oxide #36, meanwhile for Al-Oxide #16 is 375 bags. Thus, it can be assumed that the amount of each Al-Oxide in a material order, is the same as the Q value that has been calculated.

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IV. Conclusion

Based on fishbone diagrams, the stockout of Al-Oxide is caused by workers that do not make a clear recording about the usage of Al-Oxide. The other cause is the company does not set the right and proper *safety stock* and *reorder point* (ROP). Based on ABC analysis, it is concluded that the A-class Al-Oxide is Al-Oxide #16, the B-class is Al-Oxide #36, and the C-class are Al-Oxide #60 and #20.

Meanwhile, based on probabilistic control method or Q method, order will be placed when stock is less than Al-Oxide ROP value. The ROP values are 634 bags for Al-Oxide #16, 354 bags for Al-Oxide #36 and #60. The amount of economic order quantity are 375 for Al-Oxide #16, 265 bags for Al-Oxide #36 and #60. The number of safety stock are 97 for Al-Oxide #60 and #36, 164 bags for Al-Oxide #16.

Further research can be conducted in inventory with periodic review and comparing with the current model. Further research can also be condusted in inventory model that considering uncertainty.

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