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INVENTORY CONTROL ANALYSIS OF FLOWLINE PIPE (CASE STUDY: PT. PERTAMINA HULU ROKAN FIELD LIMAU)

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Abstract
Flowline is a means of distributing oil and natural gas from drilling wells to the separation point or collection station. The need for this flowline is fast moving but the problem that often occurs in companies is that the flowline needs cannot be fulfilled. Stock out on the 4-inch flowline pipe can cause a loss of production opportunity. To overcome the stock out, it is necessary to do proper inventory control. Forecasting the demand for the 4-inch flowline pipe using the ARIMA model to determine the amount of demand in the future period. After getting the number of requests, the requests are analyzed using the ADI-CV technique to see the demand pattern. The characteristics of the demand pattern are used to determine the appropriate type of inventory control. The result of the ADI value is 1 and the CV value is 0.04, so the demand pattern is smooth moving and uses the continuous review method. The continuous review method resulted in a total cost of Rp. 17,780,325,626, while the actual cost was Rp. 18,247,993,200. These results indicate that with inventory control, the proposed condition using the continuous review method can reduce inventory costs by Rp. 467,667,574 compared to actual conditions, and there is a saving of 2.56%.

Keywords:
Flowline; inventory; ARIMA; continuous review

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1. Introduction

Spare part inventory is an important component in the company's supply chain flow [1]. The characteristics of demand for spare part materials are different from raw materials, where spare part materials are more difficult to predict than raw materials [2,3,4]. This is because the procurement of spare parts is related to the availability and reliability of a machine in its production process [2,3].

Flowline is a means of distributing oil and natural gas from drilling wells to the separation or collection station. Apart from being a means of distribution, flowlines are also used to replace leaky pipelines due to corrosiveness. The use of this flowline is much needed because the distance between the well and the collection station is around 8 km, and there is an annual program, namely the installation of new lines for newly opened production wells. So, from the needs that are really needed, the flowline pipe is fast moving. The following is the demand and issued data, as shown in Fig. 1.

Based on inventory data from 2017-2021, the number of flowline requests is always high when compared to issued or material expenditures. Its high material needs are caused by unexpected demand, causing this flowline demand to always be unfulfilled (stock out). if this flowline pipe cannot be met, it will cause a loss of production opportunity. Loss production opportunity is the loss opportunities because the operation of the well must be temporarily stopped, and the replacement of the leaking pipeline cannot be executed. The effect of loss production will certainly hamper the flow of the oil and gas process if the operation of the well is stopped.

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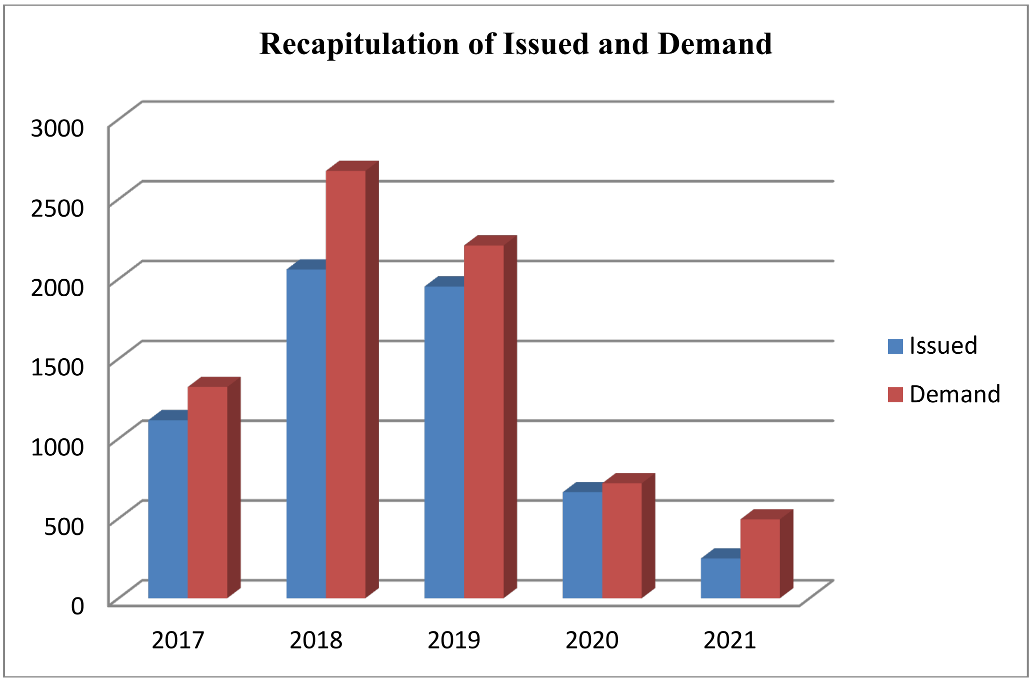

Figure 1. Recapitulation of Issued and Demand

Initial observations show that there is a need for inventory control for flowline pipe material needs. The ordering policy method used by the company is not correct because the number of orders made is only based on estimates obtained from the average demand for the previous period, so there is always a stock out of materials. User demand that fluctuates or is not constant and the information obtained is based on requests from history, then this problem needs to be solved by using a probabilistic model of supply approach [5].

2. Methods

A. Sliding Window

Sliding window as depicted in Fig. 2 is a technique for calculating the average value in the period of the actual value of a time series or time series [6]. Sliding window is done to make the actual value data smoother. The calculation of data smoothing is carried out in the first period, then the next period is selected from the end of the segment of the first period. The process is repeated until all-time series data are segmented thoroughly. This method can be used if fluctuating data is difficult to analyze in a time series model and is used to smooth the movement of data.

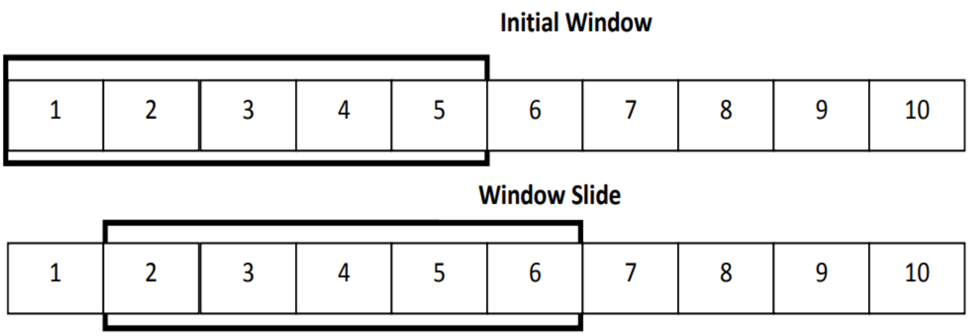

Figure 2. Sliding Window Process [6]

The initial step on the 4IN flowline pipe material request data is to perform a sliding window. Sliding window is done to smooth the movement of data to form the average value of the movement of demand within a certain period. This Sliding window technique is used to refine the data so that the forecasting data pattern is easy to analyze and to find out the trend pattern.

B. Autoregressive Integrated Moving Average (ARIMA)

Autoregressive Integrated Moving Average (ARIMA) is a forecasting model using a time series approach using a correlation technique between a time series. ARIMA model consists of autoregressive, integrated, and moving averages which are denoted as ARIMA (p, d, q) [7]. The data is stationary if the p-value < 0.05. If the data is not stationary, a differencing test will be performed on the data seen from the ACF and PACF correlograms. Next, estimate the data, then a validation test is required in the form of data testing to see the accuracy of the model.

C. Analysis of Average Demand Interval (ADI) and Coefficient of Variation (CV)

ADI-CV analysis was used to determine the right type of inventory control based on the characteristics of the movement pattern of the demand for a material. The characteristic of a material is classified through demand patterns [3,5,8]. Fig. 3 is a classification of demand data patterns in the ADI-CV.

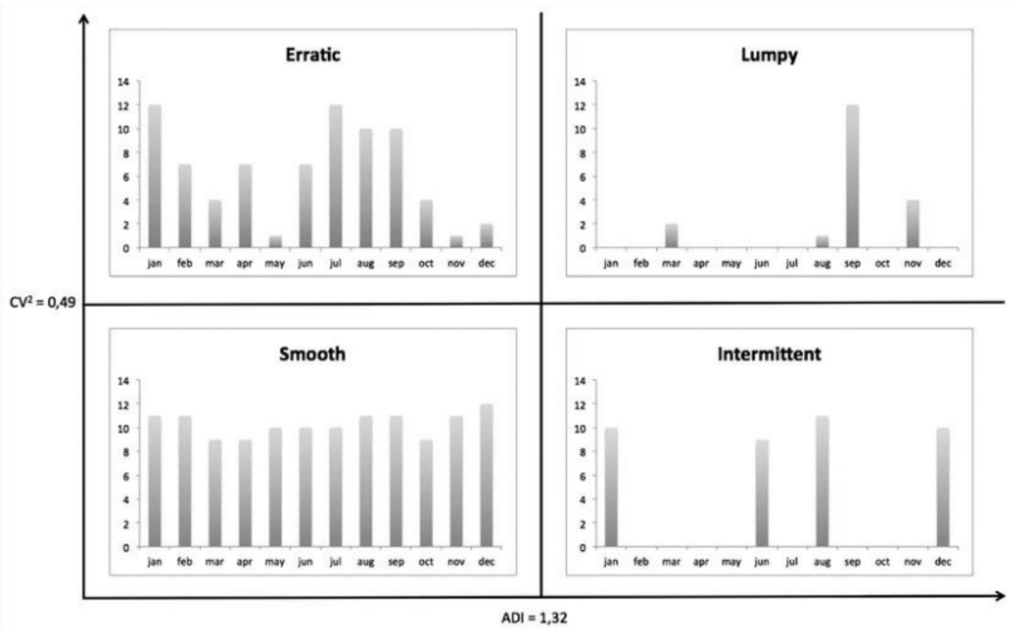

Figure 3. Demand Data Classification [9]

The demand interval for a material is divided into continuous material and intermittent material. This continuous material is a type of material that is fast moving, so it is suitable to use the continuous review order policy. Meanwhile, the intermittent data pattern for the demand period is large enough to be categorized as slow-moving material which can use the periodic review method [3]. The ADI and CV was calculated using equation (1) and (2) [11]

$$ADI = \frac{\sum_{i=1}^{N} t_i}{N} \quad (1)$$

$$CV = \frac{\sqrt{\frac{\sum_{i=1}^{N}(\varepsilon i-\varepsilon)^2}{N}}}{\varepsilon} \quad (2)$$

where:

t_i = number of periods
N in ADI = number of periods that have demand
N in CV = total period number
ε = average
ε_i = demand to i

Based on demand data classification [9,11] as shown in Fig. 4, the analysis of ADI-CV value can be divided as;
- ADI value < 1,39 dan CV value > 0,49 then the demand pattern is erratic demand
- ADI value < 1,32 dan CV value > 0,49 then the demand pattern is Smooth demand
- ADI value > 1,32 dan CV value > 1,32 then the demand pattern is Lumpy demand
- ADI value > 1,32 dan CV value < 0,49 the then demand pattern is Intermittent demand.

Moreover, based on the ADI value, we can determine the appropriate inventory control methods [11].
- ADI value <1,32 then continuous review method can be used.
- ADI value >1,32 then periodic review method can be used

D. Continuous Review

This control method will carry out continuous inventory checks [10]. Checking process will be imposed every time a transaction occurs, then it will be compared with the reorder point value. When the inventory has reached the reorder point or is less than the reorder point value, the order will be re-ordered for a fixed number of orders. This method is suitable to be used to prevent stock outs on materials, so the company can delay the fulfillment of its requests and immediately place an emergency order.

Continuous review system (CRS) is a method used to determine the number of orders on a regular basis [10,11,12]. This Q control method will carry out continuous inventory checks. This method is suitable to be used to prevent stock outs on materials, so the company can delay the fulfillment of its requests and immediately place an emergency order [12]. The following is the calculation of the continuous review system method [12]:

1. Calculating the value of q_{01} is equal to the value of q_0

$$q_{01} = \sqrt{\frac{2AD}{h}} \quad (3)$$

2. Find the total value of the shortage of inventory (α)

$$\alpha = \frac{hq_{01}}{C_u D} \quad (4)$$

$$r_1 = DL + Z_\alpha S\sqrt{L} \quad (5)$$

3. After getting the value of r_1, then the next step is to calculate the value of q_{02} as follows:

$$q_{02} = \sqrt{\frac{2D[A - C_u \int_r^\infty (x - r_1) f(x) dx}{h}} \quad (6)$$

$$N = \int_{r_1}^\infty (x - r_1) f(x) dx = S_L [f(Z\alpha) - Z\alpha\, \psi(Z\alpha)] \quad (7)$$

Where the value is obtained from the normal distribution table

4. Recalculate the values of α and r_2

$$r_2 = DL + Z_\alpha S\sqrt{L} \quad (8)$$

5. Comparing the values r_1 and r_2, if the values are relatively equal then the iteration is complete, if not then it is repeated to step 3 until the value of r_1 and r_2 is equal.
6. Calculating the value of safety stock

$$ss = Z_\alpha S\sqrt{L} \quad (9)$$

7. Calculating service level

$$\eta = 1 - \frac{N}{D_L} x\, 100\% \quad (10)$$

8. Calculating the total cost of inventory

$$O_T = D_P + h\left(\frac{1}{2}q_0 + r - DL\right) + C_u \frac{D}{q_0} \int_{r_1}^\infty (x - r) f(x) dx \quad (13)$$

where

$$O_T = D_P + h\left(\frac{1}{2}q_0 + r - DL\right) + C_u \frac{D}{q_0} N$$

where:

q_{01} = Quantity order
A = Order cost
D = Demand/month

h = Holding cost/unit/year
p = Purchase cost
C_u = Shortage cost/unit
Z_α = normal deviation
r_1 = reorder point
S = standard deviation

3. Results and Discussion

A. Historical Data Pattern

The following are the results of the plot on the actual 4-inch flowline pipe.

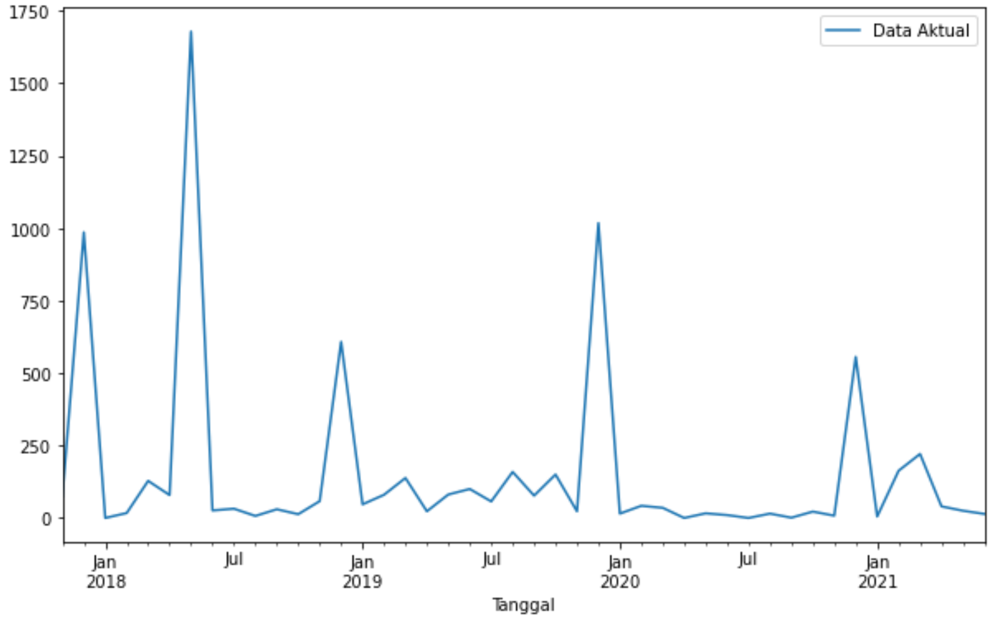

Figure 4. Actual Data Plot

From Fig. 4, it can be seen that in several months, the demand for material flowlines was always high. May 2018 there was a very high demand compared to other periods, as well as every December the demand was high due to end of project. Thus, the historical data pattern for 4-inch flowline pipe requests forms an erratic pattern or a random pattern. This random pattern is characterized by erratic fluctuations in demand. The random pattern is characterized by the existence of a long-term demand data pattern that cannot be described as a series of trend, seasonal, and cyclical fluctuations. The fluctuation of the demand data for this random pattern varies randomly, which can be caused by natural disasters, competitors, or other events that do not have a certain pattern. Random patterns on demand fluctuations can use the ARIMA method because ARIMA can accept all demand data patterns even though a stationary test must be required.

B. Sliding Windows

Sliding window is done by calculating the average in several periods. This is done to refine the existing data patterns. The technique used is the same as finding the moving average value. By doing this technique, it can produce smoothing on the data so that the average is not too large or not too small but remains within the fluctuations in the actual data demand. The results after the sliding window can reduce high demand fluctuations and the data can be easily processed using the ARIMA model, where the requirements of the ARIMA model data must be stationary or have a constant average. The comparison of actual data and sliding window is given in Fig. 5.

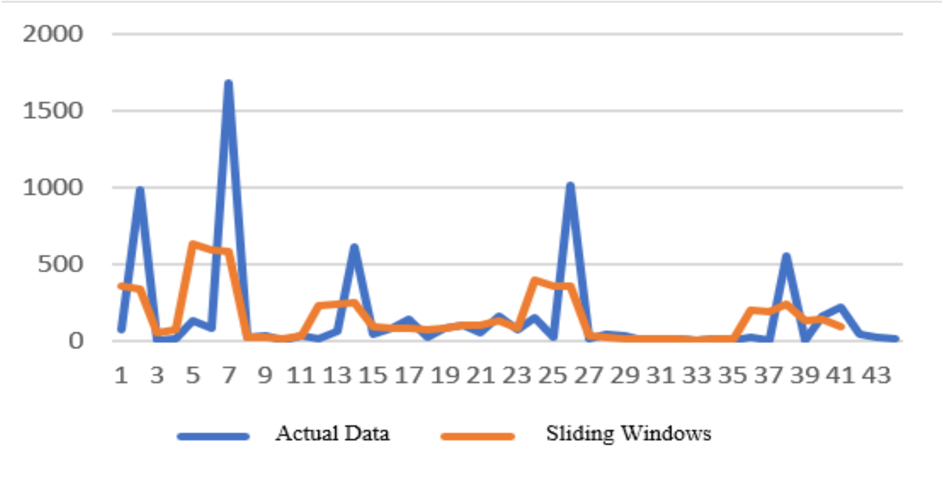

Figure 5. Comparison of Actual Data and Sliding Window

C. ARIMA Results

The data must be stationary first in forecasting using ARIMA, the condition is stationary on the data if the p-value <0.05. Results of the ADF test that has been obtained, the p-value obtained is 0.03. These results indicate that the p-value is less than 0.05. Data is stationary and does not need to be tested for differencing, then the value of parameter d is 0 because no differencing is performed.

Next is to find parameters p and q by plotting ACF and PACF. Parameter p is seen in the PACF plot, seen from the lag value plot that cuts 0 for the first time. The following result of the PACF plot can be seen in Fig. 6.

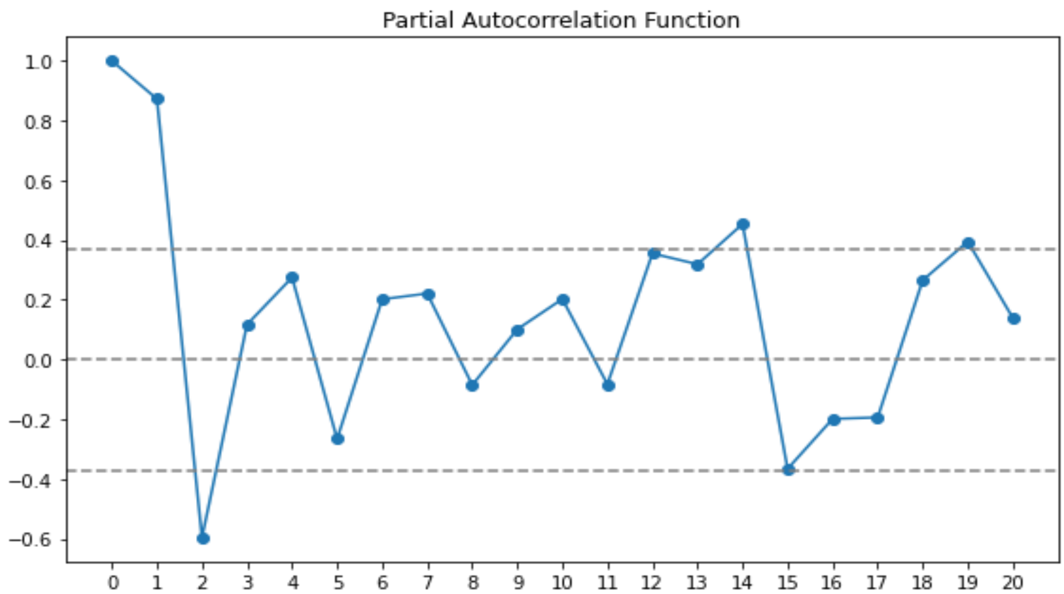

Figure 6. PACF Plot

The PACF plot was used to find the value of the p parameter, where the value that cuts the 0 lag value for the first time is 2, then the p parameter value is 2. The following is the result of the ACF plot, which can be seen in Fig. 7.

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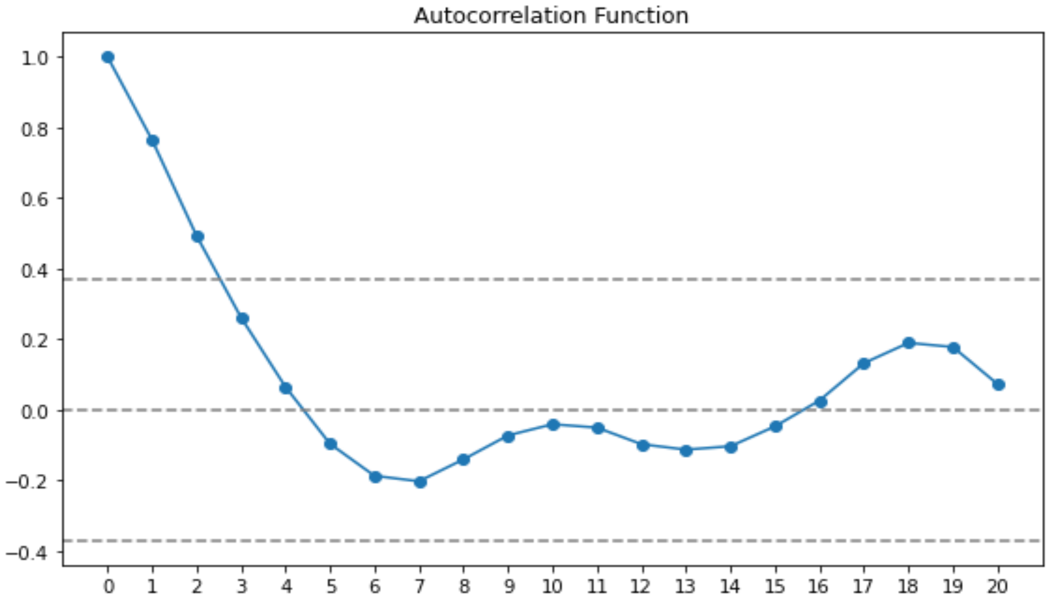

Figure 7. ACF Plot

The ACF plot was used to find the q parameter, where the lag value that crosses the upper confidence interval is 2, then the q parameter value is 2. After the p, d, q parameters are obtained, these parameters are implemented into the ARIMA model for forecasting. Thus, the suitable ARIMA model in this study is ARIMA (2, 0, 2).

The prediction plot of the forecast results with sliding window data is almost close. Next, make predictions using data testing to see the performance of the ARIMA model (2, 0, 2) which will be carried out in the testing stage. The results of error testing using Mean Squared Error (MSE) produce a value of 0.326 or 32.6%. furthermore, a walk forward validation is carried out to see the forecast results in a one-a-head forecasting manner. The MAPE value generated from walk forward validation is 24.9%, where the accuracy value is approximately 75.1%. The results of forecasting a 4-inch flowline pipe for the next 18 periods are provided in Table 1.

Table 1. Forecasting Results

Date	Demand	Date	Demand
Jul-21	155	Apr-22	185
Aug-21	164	Mei-22	184
Sep-21	172	Jun-22	183
Okt-21	178	Jul-22	181
Nov-21	182	Aug-22	180
Des-21	185	Sep-22	179
Jan-22	186	Okt-22	178
Feb-22	187	Nov-22	178
Mar-22	186	Des-22	177

D. ADI-CV Results

Through formula (1) and (2), the ADI value is 1 and CV value is 0,04. The results of the ADI value indicate that the ADI value < 1.32 then continuous review can be used to control inventory problem [11]. Furthermore CV value result indicate that the demand pattern of the 4 inch flowline pipe material is smooth moving. Smooth moving demand shows that the demand for a 4-inch flowline pipe has a pattern of demand data that is always there in each period, with the size of the demand which tends to be the same or constant in each period and does not fluctuate.

E. Continuous Review

A continuous review system or often referred to as the Q model is an inventory control that can overcome the problem of probabilistic inventory uncertainty. The pattern of probabilistic demand is fluctuating and is specified in probabilistic terms.

In the continuous review back-order model, the company can postpone the demand for goods that have not been fulfilled and immediately place an emergency order to meet the lack of demand [10]. In this condition the user wants to wait until the item is available again. In contrast to the condition of continuous review lost sales where the user does not want to wait for goods, so the user will fulfill his needs elsewhere. Seeing the actual condition, the problem at PT Pertamina Hulu Rokan Field Limau is more suitable to use a back-order system. This is because the user is an internal user of the company, so if the material is empty, the user waits for the material until it arrives again. Thus, continuous review of back orders is a solution to the inventory model to avoid stock out. The continuous review system method can provide a solution to this uncertainty, by determining the size of the order, determining when to do a reorder or reorder point, and the amount of safety stock to reduce stock outs and unstable demand [13].

Obtained continuous review inventory control with optimal inventory policy with lot orders (q_0) of 339 joints, reorder point of 722 joints. At the inventory policy level, the order will be made if the inventory has reached 722 joints, where the size in one order is always constant at 339 joints.

F. Comparison of Continuous Review and Existing Methods

Based on the calculation results that have been obtained, the following is a recapitulation in terms of actual costs using the continuous review and Existing methods.

Table 2. Comparison Method Results

Method	Total Inventory Cost	Cost Reduction	Efficiency
Exsisting	Rp 18.247.993.200	Rp 467.667.574	2,56%
Continuous Review	Rp 17.780.325.626		

Based on the calculation results in Table 2, it can be concluded that the cost of the existing condition is Rp. 18,247,993,200 and the cost of the proposed condition is Rp. 17,780,325,626. These results indicate that the proposed inventory control using the continuous review method can reduce inventory costs by Rp 467,667,574 compared to the actual condition and there is a saving of 2.56%. This result shows that the proposed condition is better in terms of costs because it can reduce costs compared to the existing conditions.

4. Conclusion

Based on the results that have been carried out in data processing and analysis, the results of forecasting demand for 4 inch flowline pipe materials using the ARIMA model (2, 0, 2) produce an error value or MAPE on walk forward validation of 24.9% with an accuracy value of 75 ,1%. The ADI-CV analysis shows that the ADI value is 1 and the CV value is 0.04. Then the type of 4-inch flowline pipe demand pattern is smooth demand. With the value of ADI < 1.32, the suitable inventory control is a continuous review system.

Using continuous review, the order lot size is 339 joints, the reorder point is 722 joints, and the safety stock is 6 joints. With a cost of Rp 17,780,325,626, while the actual cost calculation is Rp. 18,247,993,200. These results indicate that using the continuous review system method can save costs of inventory by Rp. 467,667,574 or 2.56%.

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