INCREASING PRODUCTION CAPACITY WITH THE CUT AND TRY METHOD IN ANDESITE MINING

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ABSTRACT

The andesite mining industry in Cilegon needs help in meeting the increasing market demand, especially in the Split 1-2 product, which has an annual production capacity of 349,418 tons compared to the demand of 454,238 tons. This research aims to increase production capacity through the application of the cut-and-try method. This method identifies the optimal solution through repeated experiments on various operational strategies. The analysis uses the Simple Moving Average, Exponential Moving Average, and Mean Absolute Percentage Error (MAPE) approaches for demand forecasting, as well as aggregate planning evaluation, to align capacity with market demand. The results show that the cut-and-try method provides flexibility in adjusting production strategies in real-time, allowing for increased productivity, reduced downtime, and more efficient inventory management. Two production planning scenarios were tested, namely Production Plan 1, with variations in inventory and stock depletion, and Production Plan 2, which uses constant labour and overtime. Of these two scenarios, Production Plan 2 proved to be more cost-effective, with a total expenditure of IDR 1,413,258,340 compared to IDR 2,357,596,694 in Production Plan 1.

Introduction

One of the largest distributors in Cilegon that collaborates with various local and international factories and manufacturers that focus on the andesite production process in the form of Split 1-2, Split 2-3, Split 3-5, Split 5-7, Base Course A, Base Course B and Abu Batu. The practical activities include marketing, engineering, and customer service. The activity taken in this writing is an Engineering activity due to the production lead time of making Split 1-2, which is currently only able to complete as much as 349,418 tons per year. With a market demand of 454,238 tons per year, the company faces production challenges to be able to meet these needs.

The average market demand received in one year, namely from January 2022 to December 2022,

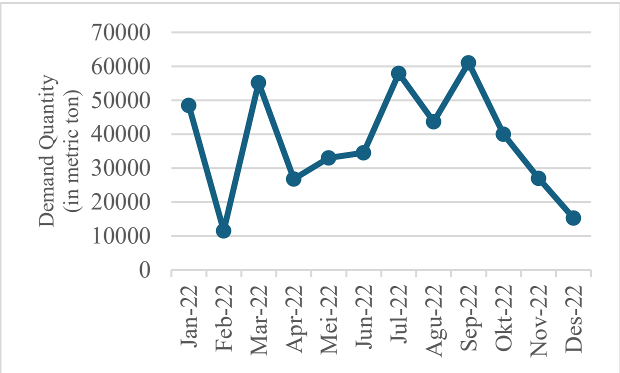

Figure 1. Material Demand Period January 2022 – December 2022

Source: Internal company (2022)

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reached 454,238 tons per year (Figure 1). Meanwhile, the total production capacity in 2022 will reach 349,418 tons per year (Figure 2).

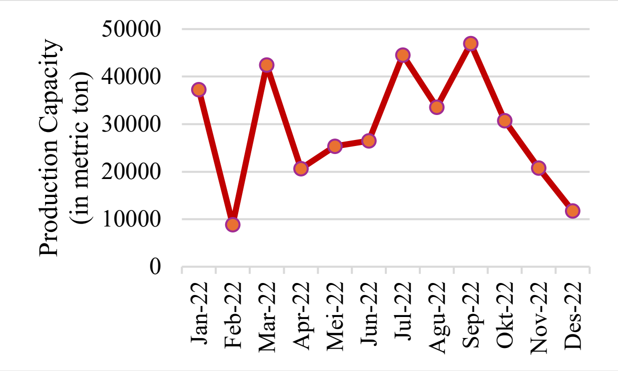

Figure 2. Production Capacity for the Period January 2022 – December 2022

Source: Internal company (2022)

From the Figure 1 and Figure 2, companies often need help managing the supply of andesite stones, so the stock is often low. Lack of stock leads to lost sales opportunities. This mismatch between supply and demand leads to financial losses, reduces customer satisfaction, and encourages customers to switch to other companies that have sufficient stock. Based on these problems, solutions are needed to increase efficiency and productivity in mining activities. One of the methods used is the cut-and-try method. This method has proven to be better than other methods. The cut-and-try method is a calculation that is carried out in advance of various production planning costs and the selection of the best alternatives. The cut-and-try method is used to find a solution or make a decision by conducting various experiments and then evaluating the results to find the most effective approach. This approach is often used in a variety of fields, including engineering and management when analytical calculations are impractical or impossible [1], [2]

Methods

The data analysis technique was carried out after all the data was collected, followed by processing using the Simple Moving Average, Exponential Moving Average, Mape and Cut and Try methods in order to identify Production Capacity Increase in Andesite Mining and determine production policies that are in accordance with the challenges currently faced by manufacturing service companies. [3], [4] The details of the process sequence are as follows (Figure 3):

1. Calculating a Simple Moving Average

It is a simple averaging method of a series of data over some time to identify trends more clearly. The calculation of the Simple Moving Average can be seen in the equation [5], [6], [7]

$$F_t = \frac{A_{t-1} + A_{t-2} \dots . + A_{t-n}}{n} \quad (1)$$

Explaination:

F_t : Forecast for the upcoming period
n : Number of periods to be averaged
A_{t-1} : Actual events in the past period
A_{t-2} and A_{t-n} : Actual events from the previous two periods, the previous three periods, and so on up to the previous n periods.

2. Calculating Exponential Moving Average

A forecasting method that gives more weight to the latest data, making it more responsive to price changes compared to the Simple Moving Average (SMA). The EMA can be seen in Equation 2 [8], [9], [10]

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \quad (2)$$

Explaination:

F_t : Exponentially smoothed approximation for period *t*
F_{t-1} : Exponentially smoothed estimates made for the previous period
A_{t-1}: Actual demand of the previous period
α : Expected response rate or smoothing constant

3. Calculating MAPE

Mean Absolute Percentage Error (MAPE) is a measure of the accuracy of a forecasting model that calculates the mean absolute percentage error between the predicted value and the actual value, expressed as a percentage, which is described in equation 3. [11], [12], [13]

$$MAPE = \frac{100\%}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right| \quad (3)$$

Explaination:

A_t : Actual value
F_t : Predicted value
n : Total number of observations

4. Aggregate Planning

Aims to optimize the use of available workforce and production equipment to formulate an overall plan to adjust production capacity in the face of uncertain market demand so that the total production cost can be minimized [14], [15]

5. Cut and Try

Cut and Try is a problem-solving method that involves experimenting with various solutions or approaches in practice until finding the most effective solution, often used in the design and development process [16], [17]

Results and Discussions

The andesite mining industry often faces challenges in optimizing production capacity to meet increased demand while minimizing costs and inefficiencies. One approach to achieve this balance is to use the cut-and-try method, a systematic process of gradual adjustment and evaluation. Unlike rigid strategies, this method allows for customizable experiments in the extraction and production phases, allowing for adjustments in the field that reflect real-time conditions. By iteratively testing various configurations of mining operations, including equipment usage, blasting methods, and extraction rates, companies can identify effective strategies to increase productivity, reduce downtime, and maintain resource sustainability. This direct and iterative approach offers practical benefits and innovative pathways to expanding production capacity in the competitive field of andesite mining.

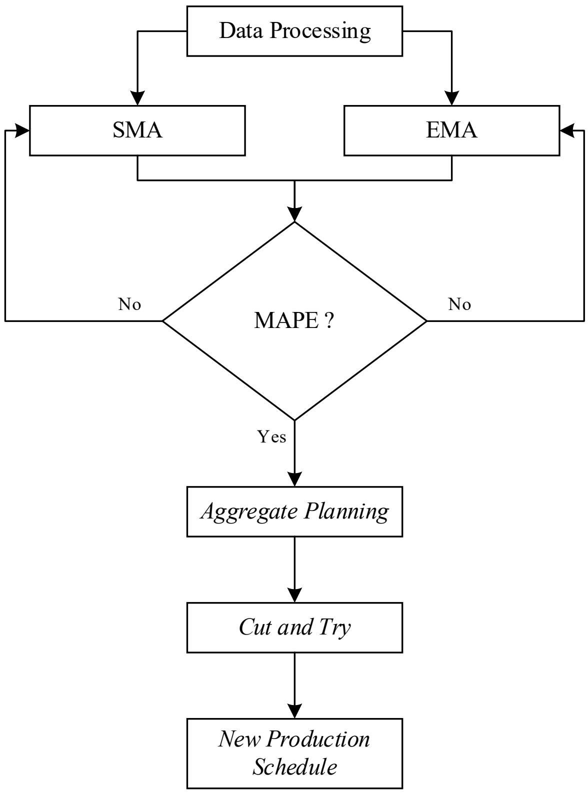

Figure 3. Flow Research

The Company's sales data for 2022 reveals comprehensive quarterly and monthly product sales figures for various types of crushed stone and aggregates, namely Split 1-2, Split 2-3, Split 3-5, Split 5-7, and Stone Dust. The data shows the sales volume for each category in cubic meters (m³) across all quarters. For example, in the first quarter (Q1) of 2022, Split 1-2 recorded a total sales volume of 26,581 m³, while Split 5-7 achieved a modest total sales of 4,430 m³. In comparison, Stone Dust recorded the highest sales in Q1, which was 35,441 m³. This pattern reflects fluctuations in demand for each product throughout the year, as Split and Stone Dust sales vary greatly based on industry needs, projects, and market demand.

A comparison of quarterly data shows that Q3 was the most active period in terms of sales, with Split 1-2 reaching 37,508 m³, Split 2-3 reaching a total of 18,754 m³, and Stone Dust leading with 50,011 m³. This peak in Q3 highlights a possible surge in demand during this timeframe, possibly due to an increase in construction activity or the completion of certain projects. In contrast, Q4 showed a significant decline in sales, as evidenced by lower volumes across all products, with Split 1-2 at 18,981 m³ and Stone Dust at 25,308 m³. This decline may reflect a year-end slowdown that is common in construction projects and related activities, which led to a decline in sales volume.

Warehouse capacity plays an important role in managing the Company's operations. With a

Table 1. Simple Moving Average Forecasting Method

Year	Months	Product									
		Split 1-2		Split 2-3		Split 3-5		Split 5-7		Ash Stone	
		Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast
	(a)	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h)*	*(i)*	*(j)*	*(k)*
2022	1	11.175,11		5.587,55		3.725,04		1.862,52		14.900,14	
	2	2.666,51	5.588	1.333,26	2.794	888,84	1.863	444,42	931	3.555,35	7.450
	3	12.739,00	6.921	6.369,50	3.460	4.246,33	2.307	2.123,17	1.153	16.985,34	9.228
	4	6.185,90	7.703	3.092,95	3.851	2.061,97	2.568	1.030,98	1.284	8.247,87	10.270
	5	7.613,44	9.462	3.806,72	4.731	2.537,81	3.154	1.268,91	1.577	10.151,25	12.617
	6	7.956,19	6.900	3.978,09	3.450	2.652,06	2.300	1.326,03	1.150	10.608,25	9.200
	7	13.355,38	7.785	6.677,69	3.892	4.451,79	2.595	2.225,90	1.297	17.807,18	10.380
	8	10.068,24	10.656	5.034,12	5.328	3.356,08	3.552	1.678,04	1.776	13.424,32	14.208
	9	14.084,60	11.712	7.042,30	5.856	4.694,87	3.904	2.347,43	1.952	18.779,47	15.616
	10	9.227,04	12.076	4.613,52	6.038	3.075,68	4.025	1.537,84	2.013	12.302,72	16.102
	11	6.227,04	11.656	3.113,52	5.828	2.075,68	3.885	1.037,84	1.943	8.302,72	15.541
	12	3.527,10	7.727	1.763,55	3.864	1.175,70	2.576	587,85	1.288	4.702,80	10.303

maximum storage capacity of 18,000 m³ for each type of product, effective inventory management is essential to avoid oversftocking or running out of stock. The storage fee is calculated at Rp 1,300 per cubic meter, while the ordering fee is Rp 2,070 per cubic meter, so careful planning is required to maintain cost efficiency while meeting demand. This balance is important for minimizing storage costs and optimizing stock levels, especially given the variability of monthly and quarterly sales figures. Ensuring that production is in line with market demand prevents wasteful expenditure and improves operational agility.

Pricing for the Company's products further affects its competitive position and market strategy. Split products are sold at a price of IDR 175,000 per cubic meter, while Stone Dust is priced at IDR 150,000 per cubic meter. This pricing strategy may reflect the value each product offers and the market's willingness to pay, with Stone Dust being a lower-priced option, perhaps due to wider availability or different usage contexts. The combination of sales trends, storage capacity constraints, and cost considerations forms the Company's operational and strategic planning throughout the year, helping the company respond to market dynamics while maintaining efficiency in the production and distribution process.

The Simple Moving Average (SMA) forecasting method applied to the Company's 2022 sales data provides a way to smooth fluctuations in product demand over time. This approach uses past actual data to generate predictions or forecasts for the coming months. For example, for Split 1-2 products, actual sales in January were 11,175.11 m³, with the next prediction calculated based on the average movement of the previous period. This methodology helps identify trends by averaging demand patterns over a given number of months. Although this approach cannot predict sharp changes in demand, it allows the Company to manage better expectations and plan inventory, production, and sales strategies accordingly. [18], [19]

The predicted value illustrates how the SMA smooths out the monthly variation. In particular, the predictions for Split 2-3 show significant alignment with actual data over time. For example, while February's actual sales for Split 2-3 are 1,333.26 m³, the prediction is around 2,794 m³. This method takes into account the gradual fluctuations seen in other months. The nature of SMA that follows this trend is reflected in similar patterns for other product categories, such as Split 3-5, Split 5-7, and Stone Dust. Predictions are generated by averaging data from recent months, making it a simple but effective tool for managing medium-term expectations and responding to shifts in general demand.

One important consideration for Companies when using the SMA method is the potential for the lagging effect. This is evident in the forecast value for Stone Dust, where actual demand often fluctuates beyond predictions. For example, in September, the actual sales volume was 18,779.47 m³, while the forecast value was 15,616 m³. This lag can lead to underestimating sudden spikes or dips in demand, so it is important to supplement the SMA approach with additional forecasting tools or qualitative insights. By utilizing these tools, companies can adapt to market shifts, manage storage capacity, and optimize supply chain operations more effectively.

The Exponential Smoothing (ES) method is used here to forecast the company's monthly sales data with a smoothing constant of $\alpha = 0.05$. This method gives more weight to recent observations, making it suitable for time series data whose current trends may reflect current market conditions. Initially, for Split 1-2, actual sales for January 2022 were 11,175.11 m³. Given that this is the first month, the predictions correspond to the actual values. In the future, the forecast will begin to be adjusted gradually based on the smoothing parameters. For February, with actual sales falling to 2,666.51 m³, the predicted sales value was only slightly reduced, reflecting the weight of previous data and slow reaction to sudden changes. [20], [21]

The gradual adaptation of this method is also seen throughout the rest of the product line. For example, in Split 2-3, the forecast for March, after actual sales of 1,333.26 m³ in February, was revised to 5,375 m³, reflecting a cautious approach to changes in demand. This gradual update feature ensures that predictions are not too sensitive to one-month fluctuations, thus providing stable, albeit somewhat conservative, estimates. Similarly, for Split 3-5, the March forecast stands at 3,583 m³ compared to actual sales of 4,246.33 m³ in the previous month, which illustrates the smoothing effect of this method.

Table 2. Comparison of SMA and ES

	SMA	ES
Produk A Produk B Produk C Produk D Produk E	47,17%	73,87%

While ES effectively smoothed out fluctuations, ES may have lagged behind more volatile demand shifts, as shown by the Abu Batu sell-off. In August, actual sales of 13,424.32 m³ contrasted with an estimated value of 13,988 m³, which shows how forecasts can deviate during significant spikes or declines. Options α = 0.05 make adjustments gradually and may not efficiently capture rapid market dynamics. However, ES remains valuable for managing stable demand trends, inventory planning, and aligning production schedules with market needs. As α increases, forecasts will adapt faster but with the risk of overreacting to temporary changes.

Average (SMA) and Exponential Smoothing (ES) methods for forecasting company sales data shows a striking difference in performance efficiency. On all products A through E, the percentage of forecasting accuracy obtained from the ES method consistently outperformed the SMA approach. Specifically, although the SMA maintains an accuracy level of 47.17% for all products, the ES achieves a much higher level of accuracy of 73.87%. This striking contrast suggests that ES is better suited for capturing demand patterns, especially when there are recent changes or trends in the data, thanks to its ability to give more weight to recent observations.

In contrast, the SMA method averages past data evenly over a given period, making it less responsive to sudden changes in demand or market behaviour. This SMA characteristic can lead to predictions that fail to adapt quickly, resulting in relatively lower forecast accuracy. The higher level of ES accuracy across all product lines indicates that this method is more effective for dynamic markets, where fluctuations and ever-evolving demand trends are common. This makes ES particularly advantageous for inventory management and demand planning in scenarios where current trends greatly affect future sales projections.

Cut and try is a method often used in production planning to experiment with different approaches and identify the most effective solution based on trials. In this context, Production Plan 1, which involves constant labour, inventory variation, and inventory depletion, aims to balance production efficiency with fluctuating inventory levels. The plan calculates regular working hours based on efficiency and workdays, with actual production in thousands of units determined by machine capacity and efficiency. The final inventory is tracked to determine excess or deficiencies, and the cost of storing inventory is assessed based on any surplus inventory.

In contrast, Production Plan 2, which uses constant labour and constant inventory over time, stabilizes the initial inventory and adjusts available units before overtime. By maintaining higher inventories at the beginning of each month, the plan reduces the need for overtime, which allows production to meet demand without significant shortages. However, excess inventory can accumulate in certain months, leading to additional inventory storage costs. The plan also incorporates overtime labour costs to meet production goals, although there are no major production shortages in most months.

Both production plans take into account total costs, including routine labour costs and inventory storage costs for Production Plan 1, as well as routine labour and overtime costs for Production Plan 2. The total cost for Production Plan 1 is 62.522%, which amounts to 2,357,596,694 rupiahs, while Production Plan 2 is 37.478% or amounts to 1,413,258,340 rupiahs. Production Plan 2 proved to be more cost-effective at 944,338,353 rupiah, although there may be some instability in inventory levels that require further adjustments.

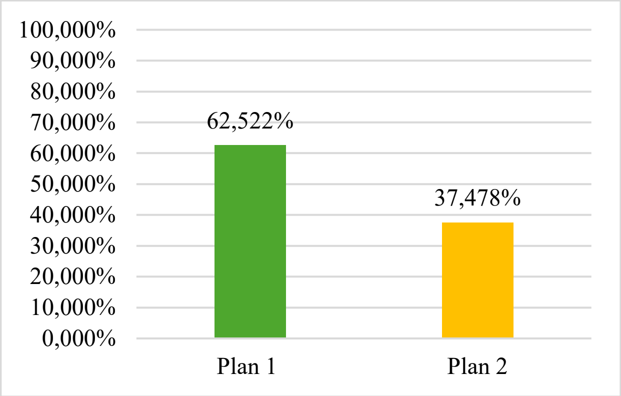

Figure 4. Cut and Try Planning

Production Plan 1, with constant labour, inventory variation, and inventory depletion, puts machine efficiency and capacity first in production. While inventory storage costs can increase due to excess stock in certain months, this plan provides flexibility in managing production and stock. However, higher total costs represent challenges in managing inventory more efficiently. Therefore, although this method can meet varying demands, its efficiency needs to be improved for better cost management.

On the other hand, Production Plan 2, which involves constant labour, constant inventory, and overtime, demonstrates better cost efficiency by reducing the need for overtime and stabilizing inventory. This plan avoids production shortages and has a lower total cost compared to Production Plan 1. While there may be an excess of inventory in a few months, more stable inventory management and controlled overtime use make Production Plan 2 more profitable in terms of cost efficiency. However, attention must still be paid to adjusting inventory levels to prevent excessive buildup.

Conclusions

In conclusion, increasing production capacity in andesite mining through the cut-and-try method offers a flexible approach to identifying the most effective production strategies. Experimenting with different techniques and measuring results allows for adjustments based on real-time performance. This trial and error process can help optimize mining operations by testing various factors such as labour, equipment, and inventory management, ultimately leading to increased efficiency and productivity. However, the results may vary depending on external factors such as market demand, resource availability, and operational constraints, which require constant monitoring and adaptation.

Despite its potential benefits, the cut-and-try method in andesite mining also has its challenges, especially in terms of cost management and resource allocation. While it provides valuable insights into production optimization, this method can lead to increased costs due to experimentation and inefficiencies during trial periods. Therefore, while this method can result in a significant increase in production capacity, it requires a balance between flexibility and cost control. A more systematic approach, using data collected from the cut-and-try process, can further improve decision-making for sustainable growth and long-term operational success.

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Author Contributions

For research articles with several authors, a short paragraph specifying their contributions must be provided. The following statements should be used "Conceptualization, Eka Irawanti and Saiful Hendra; methodology, Saiful Hendra; software, Singgih Juniawan; validation, Zaenal Muttaqien, Daruki; formal analysis, Saiful Hendra, Mutia Shaza Fita; investigation, Singgih Juniawan; resources, Eka Irawanti; data curation, Eka Irawanti; writing—original draft preparation, Eka Irawanti; writing—review and editing, Mutia Shaza Fita; visualization, Daruki; supervision, Saiful Hendra; project administration, Mutia Shaza Fita; funding acquisition, Eka Irawanti. All authors have read and agreed to the published version of the manuscript." Please turn to the CRediT taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

Conflicts of Interest

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