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Analysis of Fabrication Material Inventory Control Strategy Using AHP, MUSIC-3D and MIN-MAX STOCK approaches at PT. Bangun Teknik

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A B S T R A C T

PT Bangun Teknik Baja is a manufacturing company engaged in Fabrication, Repairing, and Machining for heavy mining equipment. The company does not yet have a basic strategy in carrying out inventory planning actions, so the amount of material ordered is only based on the estimated number of production product needs. Therefore, excessive amounts of inventory (overstock), lack of inventory (out of Stock) and frequent occurrence of Deadstock often occur. Order data, usage data and stock data on 50 types of fabrication materials with an average of 25 materials experiencing overstock, 4 materials out of stock and there are 221 Deadstock materials from August 2021 to July 2023 are used as the basis of this research. To determine the most suitable inventory control strategy according to the needs of PT Bangun Teknik Baja, processing is carried out with AHP, Music-3D with ABC, FSN and SDE Classification, and Min-Max Stock. AHP produces the most important priority classification dimension criteria, namely ABC, FSN and SDE with the most important sub-criteria being A,B,C,F,S,N,D,E,S. These results are used as a reference for Music-3D processing which produces 9 groups of material categories according to their respective characteristics of importance, namely AFD, AFE, ASE, BFE, BSE, CFD, CFE, CSD, and CSE, the 9 categories obtained their respective policy solutions by applying Min-Max Stock, by obtaining minimum and maximum limits on each material to minimize waste. ROP and Safety Stock calculations are used to minimize Overstock in minimizing Deadstock and Out Of Stock to minimize losses, so it is proven that the application of Min-Max Stock can save Total Inventory Cost by 1.45% from the company's actual policy.

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1. INTRODUCTION

Strategy in determining inventory is an important aspect for the company, because the existence of optimal inventory is able to make the company increase the smoothness of the process. optimal inventory is able to make the company improve the smooth running of its operational processes. However, if there is excessive inventory procurement or overstock, this situation can be considered a waste due to the storage costs that must be incurred by the company. situation can be considered a waste

because the storage costs that must be incurred by the company will increase. company will increase. In addition, this condition has the potential to affect the company's cash flow because a large amount of money is tied up in inventory. This kind of situation can also cause additional costs such as ordering costs and unwanted storage costs. Moreover, excess inventory or overstock can have a negative impact by causing damage or loss of loss of goods because they are too long stacked in the warehouse or referred to as material Deadstock (Afriliansyah, Nababan and Situmorang, 2020). Therefore, it is very important for manufacturing companies to manage their inventory as well as possible to ensure the efficiency of their total inventory. to ensure total inventory cost efficiency and optimized order planning. planning that is more optimal. The need for optimal inventory is to prepare the raw materials required during the production stage to ensure the smooth running of the process and prevent stock-outs with the out of stock at the minimum possible cost (Fadilah and Aryanny, 2021).

From the information obtained, PT Bangun Teknik Baja has problems in determining a structured inventory control strategy. a structured inventory control strategy, the material procurement process is carried out based on the the amount needed in the production product which is then placed an order with the supplier. So that the company does not know the ideal number of orders so that resulting in swelling of the company's total inventory costs. Currently PT. Bangun Teknik Baja does not yet have a good material inventory planning system, in terms of quantity that does not yet have a basis for total orders and also when to reorder materials. There is no basis for the total order and also when to reorder the material that is used as stock. used as stock. Figure 1 explains that the overall average material overstock occurs, which consists of 25 average materials overstocked and 4 materials out of stock in the material procurement process carried out by PT. material procurement carried out by PT Bangun Teknik Baja, especially in 2021-2023. For example for the data for April 2022 which can be seen in Figure 2 which explains that obtained 50 types of materials, there are 20 materials that experience excessive storage in inventory (overstock) and 19 materials that experience excessive storage in inventory (overstock). (overstock) and 19 materials are out of stock. Overstock on inventory can have an impact on swelling the company's cash flow and result in waste when the item is stored for too long resulting in deadstock, while if there is Out Of Stock, it will impact the production process and deadstock, while if Out Of Stock occurs, it will have an impact on the production process that is production process is hampered due to the working time used to wait for material suppliers to fulfill material orders that run out. material orders that run out. Therefore, to anticipate these problems, it is necessary to treat a special strategy in inventory prioritization by classifying the materials into categories of urgency for and must also control the minimum and maximum limits and determine the optimal quantity in ordering materials. maximum and determining the optimal quantity in ordering materials in the reorder point in material inventory to avoid overstocking. in material inventory to avoid overstock and out of stock at PT Bangun Teknik Baja.

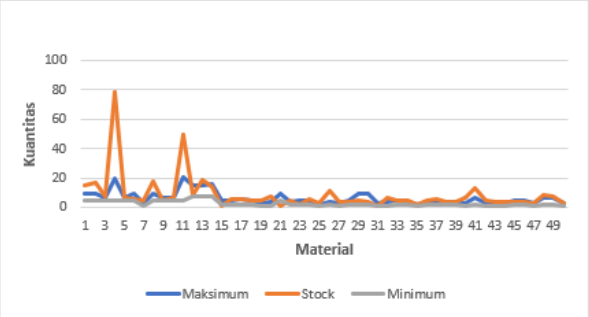

Figure 1. 2021-2023 inventory
Source: Company data, 2023

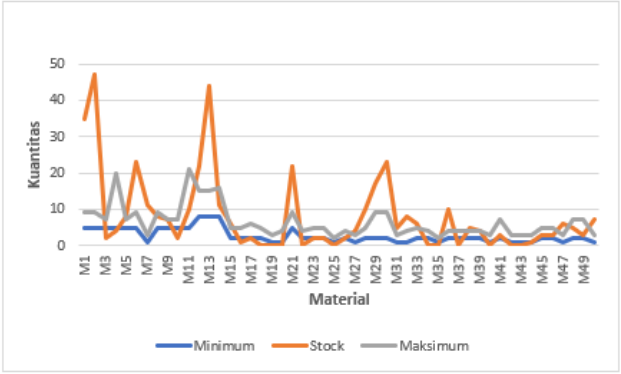

Figure 2. April 2022 supplies
Source: Company data, 2023

In this study, PT Bangun Teknik Baja does not have a basic concept in placing orders, therefore in solving this problem, it can apply the Multi Unit Spares Inventory Control-Three Dimensional approach (Music-3D) in categorizing inventory priorities according to dimensions that are in accordance with company needs with the help of AHP in applying priorities to these dimensions and Min-Max Stock is used in determining Safety Stock, minimum and maximum quantity limits in storage and also the level of storage frequency up to Total Cost Inventory. Based on the explanation of the three previous studies, this study uses 3 inventory planning methods, namely AHP as a determinant of priorities between criteria and classification sub-criteria, Music-3D is used to form material groups based on their characteristics and make it easier to set control strategies and Min-Max Stock to produce minimum and maximum limits in storage to minimize overstock and Out of Stock, so that companies are expected to carry out long-term planning in carrying out inventory plans. (Afriliansyah, Nababan and Situmorang, 2020) As well as producing the optimal order quantity and frequency value in minimizing Total Cost Inventory in avoiding waste at PT. Bangun Teknik Baja.

2. RESEARCH METHOD

2.1 Triangulation

The way to eliminate doubts about answers is to use the Triangulation method. Triangulation can be put into the same category as a method of checking the validity of data using something else (Listania, 2020). There are 3 ways of triangulation used in this study, namely: (1) Triangulation Technique. Triangulation techniques are used to test the trustworthiness of data by finding out and seeking the truth of data from the same source through different techniques. The techniques used in this research are questionnaires, interviews and documentation (Alfansyur and Mariyani, 2020). (2) Source Triangulation. Source triangulation is a data collection technique that is carried out by obtaining information from several sources (Alfansyur and Mariyani, 2020), which is measured for the harmony of the answers to inventory control problems at PT Bangun Teknik Baja. Source triangulation can sharpen the trustworthiness of data if it is done by checking the data obtained during research through several sources or informants. The informants in this study were the President Director, Chief Logistics Officer, and Operations Manager of PT Bangun Teknik Baja. (3) Time Triangulation. Time Triangulation is used to produce reliable data by collecting data on different days. This time triangulation is carried out at different times or situations. At October 27, 2023, October 28, 2023, and October 30, 2023

2.2 ***Analytic Hierarky Proces***

The Analytical Hierarchy Process (AHP) model was created by Thomas L. Saaty and requires the selection of alternative values in pairwise comparisons due to its uncertain nature. AHP must also be reconsidered in many pairwise comparison assessments (Afriliansyah, Nababan and Situmorang, 2020). AHP in this study is used to determine the priority ranking order of 3 types of classifications used in Music-3D which are sorted based on criteria and sub-criteria. The problem solving process using the AHP method is described as follows:

1. Relative priority value of each element
   Pij : Cij × Wji
   Where:
   Pij : The multiplication of the comparison value of the i-th criterion against the j-th criterion.
   Cij : The comparison value of the i-th criterion against the jth criterion
   Wj : Weight of the jth criterion.
   i : 1,2,3, ...,n.
   j : 1,2,3,...,m.
2. Line Addition
   $T_i = \sum_j^n = P_{ij}$
   Where :
   Ti = Addition
   Pij= On the i-th row
3. Priority Value
   $A_i = \frac{T_i}{W_i}$
   Where :
   Ai : priority value between criteria
4. *Eigen Value*
   $\lambda Maks = \frac{\sum_i^n A_i}{n}$
   Dimana:
   n = Sum of Criteria
   Consistency Index Value (CI)

$$CI = \frac{(\lambda Maks - n)}{n - 1}$$

Where:
Max = max*igen value*
n = Number of criteria

5. *Consistency Ratio* (CR)

$$CR = \frac{CI}{RI}$$

Where :
CR = *Consistency Ratio*
CI = *Consistency Index*
RI = *Random Index Consistency*

2.3 Music-3D

Multi Unit Spares Inventory Control - Three Dimensional Approach or MUSIC-3D is a technique or strategy for conducting inventory control to organize spare parts or production support materials that are reviewed from various aspects according to company needs. MUSIC-3D combines a three-dimensional approach (classification) to group inventory units into various classes (Ni'mah and Farida, 2019). In this study using 3 types of classification based on company needs, namely: (1) ABC classification. ABC analysis is an inventory control technique that has a high usage value, items from class A have a high usage value, which accounts for 70% of the inventory usage value; items from class B have a medium usage value, which accounts for 20% of the inventory usage value; and items from class C have a low usage value, which accounts for 10% of the inventory usage value (Noviani, Nasution and Rizki, 2017). (2) Classification of FSN. FSN classifications are fast moving (F), slow moving (S), and non-moving (N). The FSN classification, organizes inventory based on its speed of movement. TOR, which is the ratio of the level of expenditure, usage, or sales of goods during the observation period to the average inventory level in the warehouse, is used to determine how to see the movement of goods (Hudori and Tarigan, 2019). Grouping goods with FSN Analysis based on TOR, in making decisions can be divided by criteria which can be seen in Table 1.

Table 1. FSN classification categories

Category	Criteria
Fast Moving	TOR > 3
Slow Moving	3 ≤ TOR ≤ 1
Non Moving	TOR < 1

Source : Hudori and Tarigan, 2019

(3) SDE Classification. SDE classification is a classification that groups materials based on the length of lead time a material arrives at the company's warehouse There are three categories in the SDE classification (Sodikin, Asih and Rahmanto, 2019). The levels for each category can be found in Table 2.

Table 2. SDE category

Category	Criteria
S	≥ 6 month or 180 days
D	≥ 14 days ≤ 180 days
E	≥ 0 days

Source: Sodikin, 2019

1.4 Min-Max Stock

The Min-Max Stock method is a way to control inventory, as well as the safety stock that must exist and the minimum and maximum inventory policies as inventory limits (Ronatio Dinauli Lubis, 2020). This Min-Max analysis method controls the minimum and maximum amount of inventory by setting up an inventory ordering plan. This is done to avoid inventory shortages (stockout) or excess inventory (overstock) (Abdus Salam, 2019). The stages in using the min-max method are as follows:

1. *Safety Stock*
   SS = (Maksimum Usage - T) × L
   Explain :
   SS : *Safety Stock*
   T : Average Usage
   L : *Lead Time*
2. Minimum *Stock* (*Reorder Point*)
   Min Stock = (T× L) × SS
   Explain :
   Min *Stock* : Minimum *Inventory*
   SS : *Safety Stock*
   T : Average Usage
   L : *Lead Time*
3. Maksimum *Stock*
   Max *Stock* = 2 × (T × L) +SS
   Max *Stock : Inventory Maximal*
   SS : *Safety Stock*
   T : Average Usage
   L : *Lead Time*
4. Order Quantity
   Q= *Max Stock - Min Stock*
   Explain :
   Q : Order Quantity
   Max *Stock* : Maksimum *Inventory*
   Min *Stock* : Minimum *Inventory*
5. Order Frequency

Frequency is the number of times raw materials must be ordered to meet demand inventory (Audina and Bakhtiar, 2021).

$F = D/Q$

Explain :

D : *demand*

F : Frequency

Q : Total Order Inventory

6. Total *Inventory Cost*

Total Inventory Cost (TIC) includes ordering costs, namely the cost of purchasing goods or ordering costs from suppliers and holding costs, namely costs related to storage (Audina and Bakhtiar, 2021).

$TIC = DQ \times S + (D \times H)$

Explain :

S : *ordering cost*

H : *holding cost*

3. RESULT AND DISCUSSION

Triangulation

The results of validating the company's needs in the strategy to be proposed, using 3 triangulation approaches with the results of each triangulation are: (1) Triangulation Technique. Techniques used to strengthen the results of data obtained in various ways. The interview technique conducted states that the classifications with the highest priority are ABC, FSN and SDE classifications, then followed by multiple pair selection questionnaires with the help of SuperDecision Software resulting in the most important order of ABC, FSN and SDE classifications. Then, the observation technique produces data and events that are similar and support the classification order. (2) Source Triangulation.Different sources, consisting of the General Department, Logistics Head and Operations Manager resulted in the most important classification order being ABC, FSN and SDE Classification. Each source produced the same order of results as evidenced by the questionnaire. (3) Time Triangulation. The same questionnaire, but filled out at different times at each source still resulted in the same order of classification, namely ABC, FSN and SDE Classification which has been proven by the questionnaire.and society. Results and findings must be able to answer the research questions or hypotheses in the introduction.

Analytic Hierarcy Process (AHP)

This research has a function to determine the criteria and sub-criteria of each type of classification in data processing with the Music-3D method, namely ABC Classification, FSN Classification and SDE and each sub-criteria. After processing the model on Super Decision Software in an effort to obtain the highest priority classification, the weight ranking is obtained based on the results of Normalized By Cluster contained in the priorites of the Super Decision application, the results obtained in Table 3.

Table 3. Priority ranking

Name	Normalized By Cluster	Ranking
Inventory Management Strategy	Goals	Goals
ABC Classification	0.76079	1
FSN Classification	0.15760	2
SDE Classification	0.08161	3
Category A	0.76079	1
Category B	0.15760	2
Category C	0.08162	3
Category F	0.77859	1
Category S	0.14282	2
Category N	0.07859	3
Category Scarce	0.07859	3
Category Difficult	0.77859	1
Category Easy	0.14282	2

Source : Data processing, 2023

Music-3D

Processing with AHP results in the prioritization of weight criteria in determining the priority order of classification as needed in inventory control at PT Bangun Teknik Baja.

The results obtained from AHP processing in a row according to priority are ABC, FSN, and SED classifications which then the three classifications aim to group inventory units into several. The Music-3D processing is as follows (Table 4).

ABC Classification

ABC classification describes the priority of inventory control based on the size of the company's investment absorption costs in the material procurement process (Guslan and Saputra, 2020). The value of investment absorption in each material can be seen in Table 4.

Table 4. Cumulative percentage value

Raw Material Group	Investment Value (units)	Investment Presentation	Number of Raw Material Types	Percentage of Raw Material Type
Group A	10,682,446,770	70%	12	14%
Group B	2,872,834,250	19%	10	13%
Group C	1,714,799,259	11%	28	73%
Total	15,270,080,279	100%	50	100%

Source : Data processing, 2023

Based on the ABC classification calculation, the number of groupings and percentage of categories in Table 4 are obtained.

The percentage of the number of materials of the 50 types of fabrication materials and the y-axis explains the total investment absorption of funds in the 50 types of fabrication materials. The pareto diagram explains the division of the plot of the position of the type of material that belongs to Category A, B or C. For example, in Category A material, it can be explained that the x-axis explains the percentage level of the material with a total of 24% and the y-axis explains the percentage of investment absorption of funds worth 70% and categories B and C are then the cumulative of each previous category both the x and y axes, so it can be stated that the pareto diagram can interpret the division of the plot of material results against the absorption of investment funds at PT. Bangun Teknik Baja.

FSN Classification

The FSN classification carried out in this study uses the Turn Over Ratio (TOR) calculation which aims to calculate the rate of use of inventory materials based on order turnover in inventory (Hudori and Tarigan, 2019). The material grouping can be seen in Figure 5.

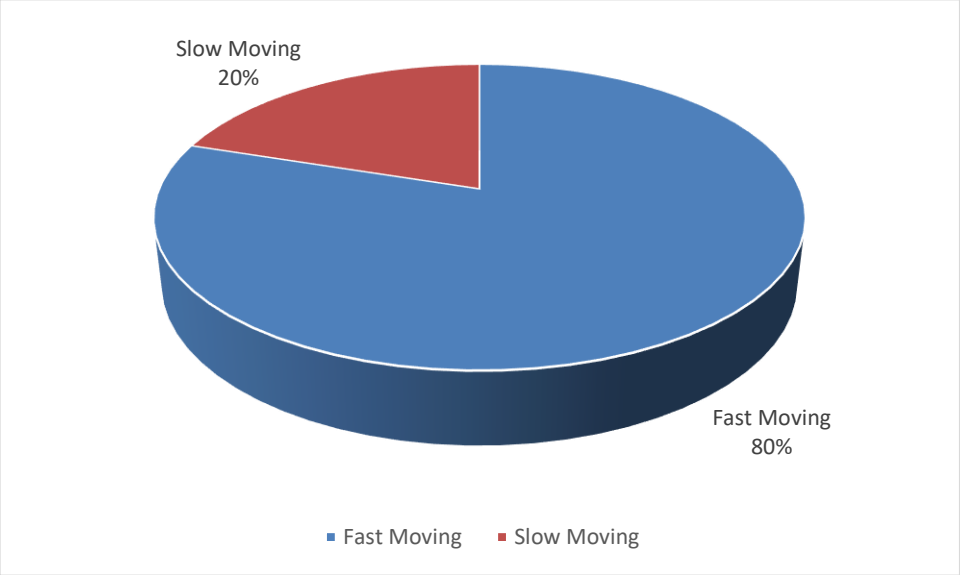

Figure 4. Percentage of FSN classification
Source : Data processing, 2023

Based on the results of the TOR calculation, it is obtained that the FSN classification based on the turnover or rate of use of fabrication materials consists of Fast Moving (F) which consists of 40 materials and Slow Moving (S) which consists of 10 materials, while the Non Moving criteria do not occur in the fabrication department material at PT Bangun Teknik Baja. And in Figure 5 it is obtained that the type of usage rate of 50 fabrication materials is 80% Fast Moving with an average Turn Over Ratio ≥3 Therefore, if inventory control is not carried out in a structured manner, there is a potential for material shortages or Out Of Stock (Rachmawati and Lentari, 2022).

SDE Classification

SDE classification is used to categorize the priority of fabrication materials based on the lead time in the fabrication material procurement process. This classification aims to group materials based on their lead time which is divided into 3 categories, namely, Scarce, Difficult, and Easy categories (Janari, Rahman and Angerah, 2020). The material grouping can be seen in Figure 6.

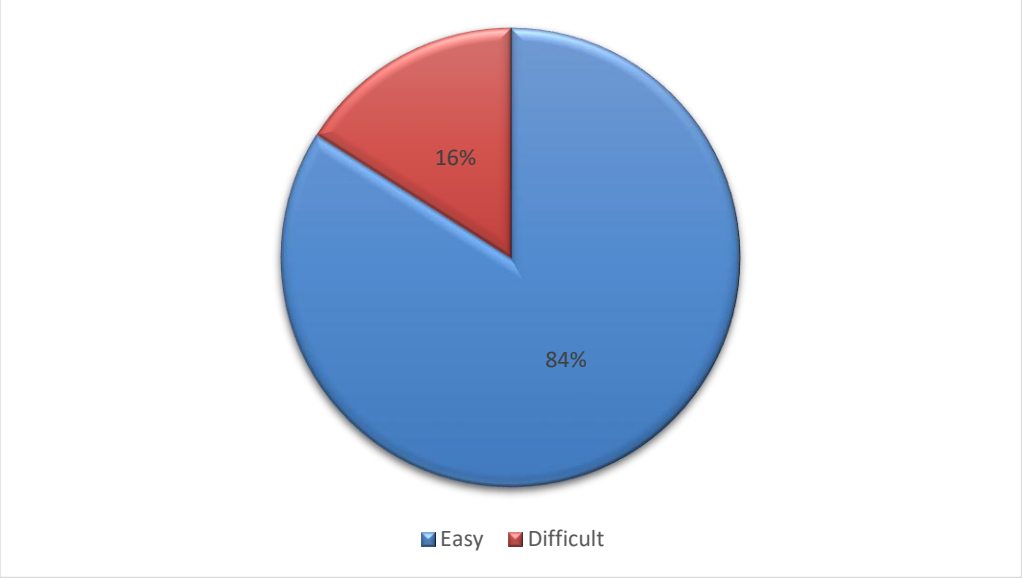

Figure 5. Percentage of SDE classification
Source: Data processing, 2023

Based on Figure 6, it is obtained that 16% of materials have a Difficult Lead Time ≥15 days and 84% have an Easy Lead Time ≥0 days, and the scarce category does not occur in the material procurement process at PT Bangun Teknik Baja, because there are no materials that have a Lead Time ≥180 days due to regular suppliers of PT Bangun Teknik Baja having domiciles only around Kalimantan. Therefore, in the SDE Classification, the highest level of material obtained is the Easy Category, and this category has a level of opportunity for Over Stock if it does not carry out an optimal planning strategy in the material procurement process due to the fast procurement Lead Time level (Ni'mah and Farida, 2019).

Music-3D Integration

Music-3D integration is done by merging using a matrix of only a few that need inventory control. Inventory control is carried out only on the 2 highest priority classifications, namely the ABC classification and the FSN classification obtained from AHP testing. After getting a combination of the first and second 2 (two) priority classifications, then the third priority classification is combined, namely the SDE classification (Budiman and Ariapramuda, 2020). The matrix can be seen in 5.

Table 5. Music-3D integration

Cost and Usage Rate	Lead Time		
	S	D	E
AF	AFS	**AFD**	**AFE**
AS	ASS	ASD	**ASE**
AN	ANS	AND	ANE
BF	BFS	BFD	**BFE**
BS	BSS	BSD	**BSE**
BN	BNS	BND	BNE
CF	CFS	**CFD**	**CFE**
CS	CSS	**CSD**	**CSE**
CN	CNS	CND	CNE

Source: Data processing, 2023

The results of the integration of each classification in Music-3D obtained a total of 9 types of materials with the same classification dimension category. The integration results have materials with priority levels that have an order from the most important scale to the material category that has the lowest priority level. The grouping of Music-3D results can be seen in Figure 7.

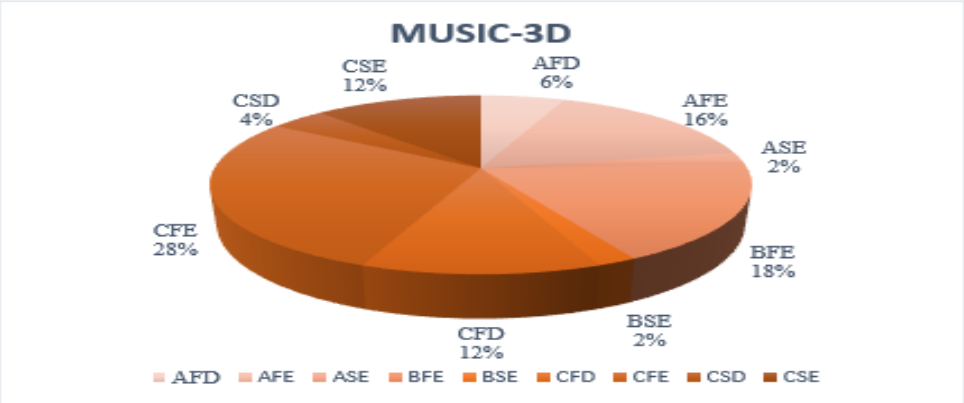

Figure 6. 3D music grouping percentage
Source: Data processing, 2023

From the integration results, the total material with the highest percentage is CFE with 28% and the material that has the highest priority is AFD with a percentage of 6% and AFE with 16%. Thus, the results of policies that can be applied in the company based on these categories can be seen in Table 6.

Table 6. Music-3D analysis results

Category	Policy Control Analysis
AFD	Materials included in this category have the most important priority for the company so that the main strict control is needed for the company and supervision must be carried out regularly.
AFE	Materials that fall into this category have the most important priority for the company but are not the top priority.
ASE	Materials included in this category need to be supervised on a scale but not routinely but periodically.
BFE	Materials in this category do not need direct supervision but only the need for scale calculation of maximum, minimum, ROP and SS limits with Min-Max Stock calculations.
BSE	Materials with this category only need to be procured at the minimum inventory level at Min-Max Stock.
CFD	Materials with this category only need to be procured on a scaled basis based on the ROP level at Min-Max Stock.
CFE	Materials in this category only need to be procured on a scaled basis based on the minimum level without Safety Stock at Min-Max Stock.
CSD	Material with this category only needs to be procured at the very low stock level. So there is no need for scheduled inventory control.
CSE	Materials with this category only need to be ordered if conditions are needed. So there is no need for inventory control

Source: Data processing, 2023

Min-Max Stock

Strategies to carry out a more optimal inventory control policy strategy, obtained results based on Music-3D integration there are categories that must be monitored with the Min-Max Stock strategy. . And the overall results of the calculation with the Min-Max Stock method have been carried out on all types of materials, the results of these calculations can be seen in Table 7.

Table 7. Min-max stock result

Material	SS	Min (ROP)	Max	Order Quantity
M1	58	114	170	56
M2	80	181	283	101
M3	4	5	7	2
M4	27	40	53	13
M5	7	11	15	4
M6	5	9	14	4
M7	1	2	4	2
M8	3	5	8	3
M9	4	5	7	2
M10	4	5	7	1
M11	8	17	26	9
M12	7	13	20	6
M13	7	12	18	5
M14	26	41	57	15
M15	9	13	17	4
M16	1	2	3	1
M17	2	3	4	1
M18	1	2	3	1
M19	1	2	3	1
M20	1	2	2	1
M21	6	8	9	1
M22	1	2	4	2
M23	13	18	22	5
M24	6	9	13	4
M25	2	3	5	2
M26	1	2	4	1
M27	1	1	3	1
M28	1	2	2	1
M29	38	78	118	40
M30	14	21	29	7
M31	3	4	6	3
M32	22	37	52	15
M33	1	2	3	2
M34	1	2	2	1
M35	1	2	3	1
M36	1	1	2	1
M37	1	2	2	1
M38	1	4	8	4
M39	1	4	6	2
M40	1	3	5	2
M41	3	5	10	5
M42	1	3	4	1
M43	2	3	4	2
M44	1	3	4	2
M45	1	2	3	1
M46	9	16	24	8
M47	8	17	25	8
M48	7	14	21	7
M49	21	33	45	12
M50	1	3	5	3

Source : Data processing, 2023

After Calculating Min Max Method , the next step is calculate the TIC reduction percentage. This Function is used to know how this method give an impact to the inventory management. The result of TIC Reduction Percentage in Table 8.

Table 8. TIC calculation

Company Policy	*Min-Max Stock Methods*	Differences
IDR 1,756,168,897.58	IDR 1,730,729,659.38	IDR 25,439,238.19

Source : Data processing, 2023

TIC Reduction Percentage

$$TIC\ Reduction\ Percentage = \frac{(TIC\ Company\ Policy - TIC\ Min - Max\ Stock)}{TIC\ Company\ Policy}\ x\ 100\ \%$$

$$TIC\ Reduction\ Percentage = \frac{\text{IDR } 25{,}439{,}238.19}{\text{IDR } 1{,}756{,}168{,}897.58}\ x\ 100\ \%$$

$$TIC\ Reduction\ Percentage = 1.45\ \%$$

Therefore, it can be stated that the Min-Max Stock method can be applied to PT Bangun Teknik Baja by obtaining a minimum TIC rather than the application of company policy by obtaining a TIC cost reduction result of 1.45% with a difference of Rp. 25,439,238.19.

4. CONCLUSION

After all data processing, there are conclusions that contain a summary of the core of all the desired research outputs to realize the objectives of this study, namely, as follows: (1) Music-3D aims to describe the desired needs of the company, namely ABC Classification as the first ranking criterion, FSN Classification ranking 2 and SDE Classification ranking 3. Then the sub-criteria in ABC Classification are Category A, B and C, respectively. FSN sub-criteria consecutively the main priorities are Categories F, S and N. And SDE sub-criteria consecutively the main priorities are Difficult, Easy and Scarce. (2) Music-3D with the processing order of ABC Classification, FSN Classification, and SDE Classification with the order of sub-criteria in each classification respectively Tururt A, B, C, F, S, N, D, E, S, obtained 9 category groups based on the main priority level of inventory control based on each classification respectively AFD, AFE, ASE, BFE, BSE, CFD, CFE, CSD, and CSE. (3) Min-Max Stock is done to obtain the minimum and maximum limits on each material to minimize waste. ROP and Safety Stock calculations are used to minimize the occurrence of Overstock in minimizing Deadstock and Out Of Stock to minimize losses. And the last stage is to calculate the order quantity to determine the frequency of materials to avoid waste in repeated orders that result in swelling the cast flow. For example, material M1 obtained a Safety Stock value of 58 units, minimum stock (ROP) worth 114 units, maximum stock 170 units and an order quantity of 56 units which resulted in an order frequency of 15 times a year and resulted in a TIC of IDR. 1,832,757.03. The application of Min-Max Stock resulted in savings of 1.45% from company policy with a difference of IDR. 25,439,238.19.

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