OPTIMIZATION OF COAL BLENDING PROCESS TO MEET DEMAND OF PLTU SURALAYA WITH MARKET BRAND BA-48 AT PT. BUKIT ASAM Tbk

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Abstract — Bukit Asam Ltd. provides coal grades that range from 4001 to 7001 kcal/kg calories. This company's customer is PLTU Suralaya, which has a market demand for the BA brand 48 and parameters such as 30% total moisture, 8% ash, 0.8% total sulfur, and 4800 kcal/kg calories. To optimize the desired blending results, optimization will be carried out using simplex method calculations with the help of the Pom-Qm application for Windows V3. This study aimed to find the percentage of coal blended using the simplex method according to consumer demand contracts and to recommend optimal proportions for blending. The research methodology employed qualitative and quantitative data. The results indicated that the percentages needed to meet the demand for PLTU Suralaya were mine brands MT 47 and AL 53 at 49%, MT 47 at 51%, and AL 53 at 63%. The results of the coal quality test were: total moisture of 29.99%, ash of 3.09%, sulfur of 0.57%, and calories of 4817 kcal/kg. All of them met the demand for PLTU Suralaya.

Keywords: blending, coal quality, simplex method

I. INTRODUCTION

PT. Bukit Asam is a state-owned company that produces coal. Coal is a mineral that has the potential and is much needed to meet the needs of the domestic industry and for export [1]. In addition, coal is also used to meet the heat needs of industrial processes [2]. Coal produced must be in accordance with the demand desired by consumers, especially the quality of coal which must comply with agreed standards. Coal at PT, Bukit Asam, sometimes does not match PT Bukit Asam's consumer demand, namely PLTU Suralaya, with market brand requests of 48 and the parameters requested, namely total moisture 30%, Ash 8%, total sulfur 0.8%, and calories 4800 kcal/kg. So that a mixing process (blending) is needed to adjust to consumer demand.

According to [3], mixing is carried out on coals with different calorific values, water content, ash content, and sulfur content, so that the quality of the mixed coal is a combination of the quality parameters of the mixed coal. To get the desired results with a homogeneous composition. There are several reasons for the need for a blending process, namely coal does not meet market specifications (lack of selling value), difficulties in obtaining coal according to market specifications without a blending process and increasingly stringent regulations requiring environmental emission thresholds [4].

However, in the blending process, sometimes the resulting results still do not fully meet market demand. So that the desired blending result is optimal and PT Bukit Asam is not subject to a penalty or rejection because it is not in accordance with the contract, optimization will be carried out. Previous studies have discussed optimizing the blending process using various methods [5]. This research will discuss the optimization of the blending process using simplex method calculations with the help of an application Pom-Qm for windows V3 in order to get the optimal blending proportions. The objective of this research is to determine the parameters of coal quality in the stockpile; find the percentage of blending using the simplex method according to consumer demand; and provide recommendations to obtain more optimal blending proportions [6].

II. METHODS

The research is located in the temporary stockpile area at the Air Laya Mine site, namely stockpile 1 and stockpile 2; and the Banko Barat site, namely stockpile 3 at PT. Bukit Asam, Tbk, in Tanjung Enim,

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Lawang Kidul District, Muara Enim District, South Sumatra. The research sites are included in the Kasal Formation, Muara Enim Formation and the Airbenakat Formation and are part of the South Sumatra Basin in the Regional Geology of Lembar Lahut, South Sumatra [7].

This research was conducted from June 6 to July 7, 2022 using combined research. In carrying out the research, there were 3 stages carried out, namely field observations to monitor all mining activities, collect data to be processed and compile research results with reference to the formulation of the problem with defined problem boundaries so that the research is detailed and can be used effectively [8]. The data used in this study are: data on coal contract specifications with consumers, coal stock data in each stockpile, data on the results of analysis of the company's coal quality and data on mine brands and market brands.

Figure 1. Map of the research location

A. Data Collection

The steps taken to process the research data, as follows :

1. Conduct coal sampling at stockpile 1, stockpile 2, and stockpile 3 with 12 different sampling points, and put it in a plastic sample and then bring it to the laboratory and let it stand for 24 hours to reduce the water content in the coal before preparation [9].
2. Do the preparation by dividing the sample into 6 parts, then reducing it using a jaw crusher to a size of 10 mm. Furthermore, the prepared samples were divided into 2 kg for each proximate and ultimate analysis. Then each sample is reduced again using a hammer mill so that it measures 2.36 mm and then put into a bottle for further processing [10].

B. Data Processing

In data processing, the applicable equations are used to obtain the results of calculations that will be used in the analysis. The processed data is as follows:

1. Total Moisture (TM); can be calculated using the equation, as follows:

$$\%\,\mathrm{TM} = \left(1 - \frac{\%\mathrm{RM}}{100}\right) \times \%\mathrm{adl} + \mathrm{RM} \quad (1)$$

2. Ash Content (AC); can be calculated using the equation, as follows:

$$\%\,\mathrm{AC} = \frac{A_3 - A_4}{A_2 - A_1} \times 100\% \quad (2)$$

3. Volatile Metter (VM); can be calculated using the equation, as follows:

$$\%\,\mathrm{VM} = \frac{m_2 - m_3}{m - m_1} \times 100\% \quad (3)$$

4. Fixed Carbine (FC); can be calculated using the equation, as follows:

$$\%FC = 100\% - (IM + AC + VM) \times 100\% \quad (4)$$

5. Blending Quality; can be calculated using the equation, as follows:

$$KB_c = \frac{(KB_1 \times PB_1) + (KB_2 \times PB_2) + \cdots + (KB_n \times PB_n)}{PBC} \quad (5)$$

C. Data Analysis

Data that has been processed in the laboratory in the form of total moisture test results, proximate analysis, sulfur test, and caloric test on coal will be further analyzed. In using the application, the parameters used are total moisture, ash, volatile matter, and coal calories which have different values, and are entered into the pom-qm for windows application to optimize the coal blending process so that the quality of the coal matches consumer demand. Then add the demand criteria that consumers want, so that applications can take into account more optimal mixing results, so that coal blending can be achieved according to consumer demand criteria.

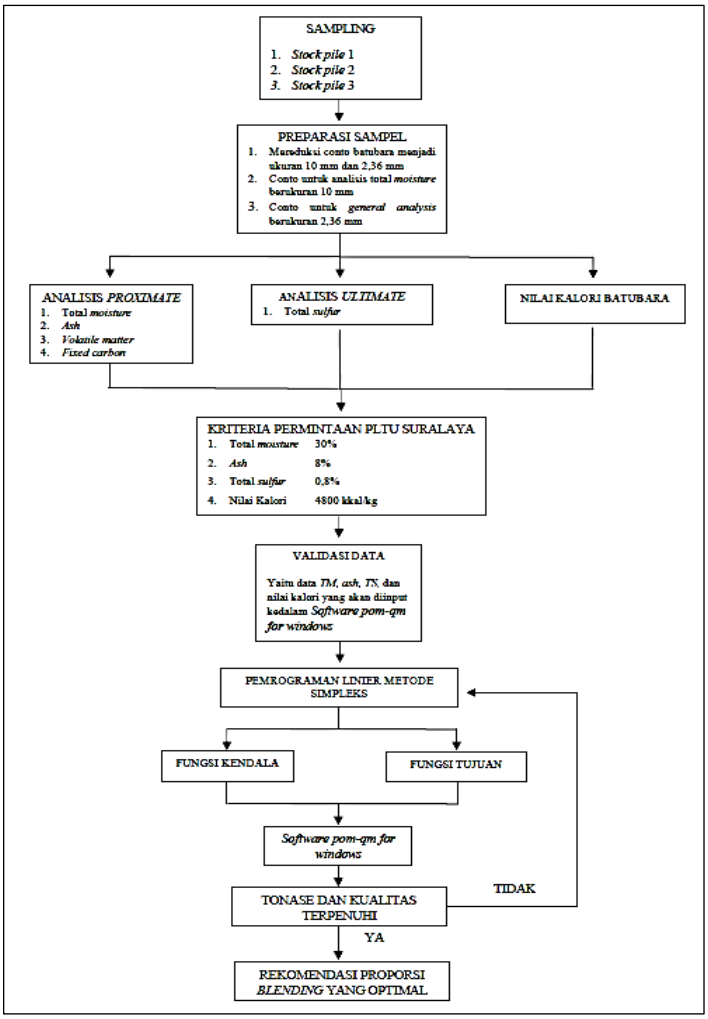


Figure 2. Data Processing Chart

III. Results and Discussion

A. Results

The quality value of coal is obtained from the results of sampling in the stockpile pile which is then tested in the laboratory with various quality parameters which include Total Moisture (TM) using ASTM D.3302 reference, inherent moisture (IM) using ASTM D.3302 reference, ash content (Ash) uses ASTM D.3174-12 reference, Volatile Matter (VM) uses ASTM D.3175 reference, Fixed Carbon (FC) uses ASTM D.3178 reference, Total Sulfur (TS) uses ASTM D.4239-17 reference and Calorie Value (CV) uses ASTM D.5865-13 [11]. From the results of laboratory tests obtained the quality of coal, as follows:

Table 1. Laboratory Test Results for Coal Quality Parameters

Mine Brand	Quality Parameter							
	TM	**IM**	**ASH**	**VM**	**FC**	**TS**	**CV**	**CV**
	%, ar	%. adb	%, ar	%, ar	% ar	% ar	Kkal/kg, adb	Kkal/kg, ar
STP 1 AL-49	27,36	11,99	3,33	33,91	35,40	0,21	6.064	5.004
STP 1 AL-51	27,59	12,38	3,62	33,61	35,19	0,36	6.085	5.028
STP 1 AL-53	25,64	1,78	3,12	34,67	36,58	0,70	6.237	5.256
STP 1 AL-55	22,10	9,05	5,26	35,31	37,33	2,38	6.388	5.464
STP 1 AL-59	18,60	8,71	2,66	37,33	41,43	0,39	6.706	5.979
STP 1 AL-61	15,84	6,79	3,89	37,76	42,52	0,25	6.724	6.071
STP 2 AL-63	15,00	6,36	3,39	37,99	43,50	0,27	6.908	6.271
STP 2 AL-65	12,87	6,66	3,09	39,28	44,78	0,26	6.959	6.494
STP 2 AL-67	11,21	5,13	2,85	39,55	46,48	0,32	7.201	6.740
STP 2 AL-69	9,28	4,57	2,59	39,15	48,97	0,37	7.375	7.010
STP 2 Al-71	3,55	1,28	5,06	26,87	64,53	1,28	7.898	7.738
STP 3 BB-49	29,89	12,37	1,72	32,54	35,87	0,36	6.154	4.924
STP 3 BB-51	27,70	11,74	2,95	33,73	35,63	0,46	6.221	5.097
STP 3 BB-53	26,52	11,07	2,28	34,05	37,23	0,75	6.421	5.306
STP 3 MT-47	30,69	12,92	3,28	32,76	33,28	0,45	5.935	4.723

Coal can experience a decrease in calories, one of which is due to rain which causes the water content in the coal to rise so that there will be a decrease in the quality of the calorific value of coal [12]. Therefore, it is necessary to make adjustments to the total moisture value of 3%. This aims to anticipate the occurrence of quality blending results that are not in accordance with the target due to a decrease in the quality of coal in the field. The results of calculating the average quality value of mine brand which has been adjusted by 3% and can be used for blending activities are as follows:

Table 2. Coal Quality After 3% Adjustment

Mine Brand	**Quality Parameters After 3% Adjustment on Total Moisture**							
	TM	**IM**	**ASH**	**VM**	**FC**	**TS**	**CV**	**CV**
	%, ar	**%. adb**	**%, ar**	**%, ar**	**% ar**	**% ar**	**Kkal/kg, adb**	**Kkal/kg, ar**
STP 1 AL-49	28,19	11,99	3,18	33,91	35,40	0,21	6.064	4.798
STP 1 AL-51	28,42	12,38	3,47	33,61	35,19	0,36	6.085	4.815
STP 1 AL-53	26,41	11,78	2,93	34,67	36,58	0,70	6.237	4.935
STP 1 AL-55	22,76	9,05	4,79	35,31	37,33	2,38	6.388	5.055
STP 1 AL-59	19,16	8,71	2,35	37,33	41,43	0,39	6.706	5.306
STP 1 AL-61	16,31	6,79	3,42	37,76	42,52	0,25	6.724	5.320
STP 2 AL-63	15,45	6,36	2,96	37,99	43,50	0,27	6.908	5.466
STP 2 AL-65	13,26	6,66	2,60	39,28	44,78	0,26	6.959	5.506
STP 2 AL-67	11,55	5,13	2,40	39,55	46,48	0,32	7.201	5.698
STP 2 AL-69	9,56	4,57	2,16	39,15	48,97	0,37	7.375	5.836
STP 2 AL-71	3,83	1,28	5,10	26,87	64,53	1,28	7.898	6.250
STP 3 BB-49	30,78	12,37	1,70	32,54	35,87	0,36	6.154	4.869
STP 3 BB-51	28,53	11,74	2,86	33,73	35,63	0,46	6.221	4.923
STP 3 BB-53	29,52	11,07	2,19	34,05	37,23	0,75	6.421	5.080
STP 3 MT-47	33,69	12,92	3,26	32,76	33,28	0,45	5.935	4.696

Coal demand by PLTU Suralaya for BA 48 is 338,000 tons, while the availability of mine brand at the research location is not in accordance with the quality and quantity of consumer demand, so it is necessary to carry out a coal blending process. Based on consumer demand, Total Moisture, Ash, Total Sulfur and Heat are ≤ 30% ar, ≤ 8% ar, ≤ 0.8% ar, and ≥ 4,800 kcal/kg respectively. Based on Table 2, the suitable mine brand for blending is MT-47 with AL-53 and MT-47 with BB 51. MT-47 stock in stockpile 3 was 925,000 tons, AL-53 stock in stockpile 1 was 567,000 tons, and BB-51 stock in stockpile 3 was 1,274,000 tons

In order to obtain the optimal blending of the market brand BA 48, a blending simulation was carried out using the pom-qm for windows application with the mine brand to be blended, namely MT 47 with AL 53. Then the blending proportion results were obtained, sequentially, as follows:

Table 3. MT-47 Calculation Results with AL-53 Using the Pom-Qm Application for Windows

Coal Type	Proportion	tonnage	TM	ASH	TS	CV
			(%, ar)	(%, ar)	(%, ar)	(Kkal/kg, ar)
MT 47	49.00%	165.620	33,69	3,26	0,45	4.696
AL 53	51.00%	172.380	26,41	2,93	0,70	4.935
Blending Result		338.000	29,9	4,35	0,57	4.817
Demand Criteria			≤ 30,00	≤ 8,00	≤ 0,80	≥ 4800

The results of optimizing blending using the pom-qm application in Table 3 yielded total moisture of 29.9%, ash 4.35%, total sulfur 0.57% and calories 4,817 kcal/kg. These results meet the standards of consumer demand so that it can be recommended to do blending of the two my brands.

Tabel 4. MT-47 Calculation Results with BB-51 Using the Pom-Qm Application for Windows

Coal Type	Proportion	tonnage	TM	ASH	TS	CV
			(%, ar)	(%, ar)	(%, ar)	(Kkal/kg, ar)
MT 47	29,00%	98.020	33,69	3,26	0,45	4.696
BB 51	71,00%	239.980	28,53	2,86	0,46	4.923
Blending Result		338.000	30,00	2,97	0,46	4858
Demand Criteria			≤ 30,00	≤ 8,00	≤ 0,80	≥ 4800

The results of optimizing the blending using the pom-qm application are shown in Table 3. The results obtained were 30% total moisture, 2.97% ash, 0.45% total sulfur and 4,858 kcal/kg calories. These results also meet the standards of consumer demand.

B. Discussion

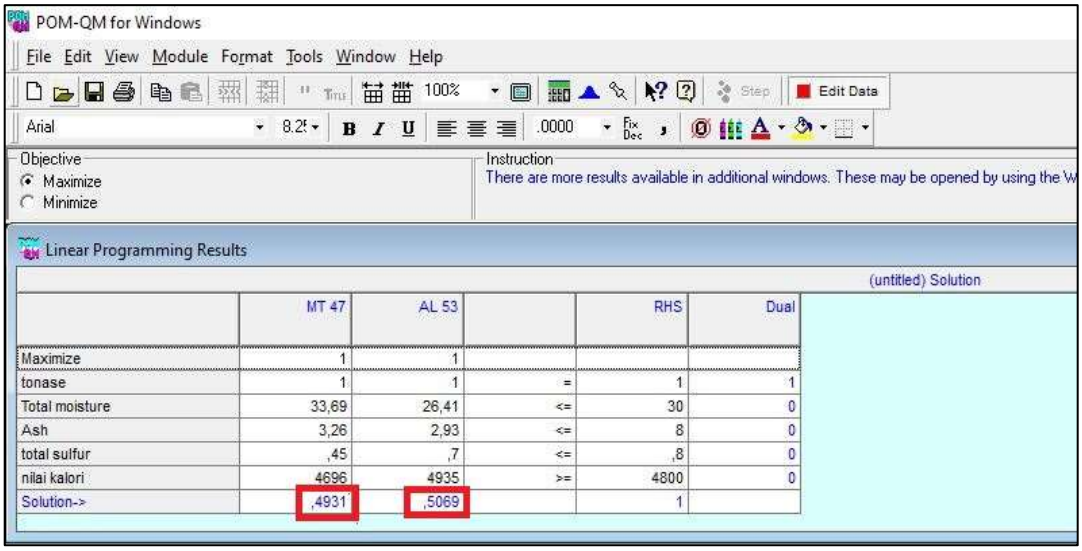
Coal quality in stockpile PT. Bukit Asam has different qualities, this is due to the condition of the open stockpile which causes coal to come into direct contact with environmental conditions, such as weather conditions when it rains, heat, dust, or other impurities due to the mobility of operational equipment can affect the quality of coal. Coal quality at PT. Bukit Asam has a total moisture value between 3% - 35%, Ash between 1% - 6%, volatile matter between 25% - 40%, fixed carbon between 30% - 65%, total sulfur between 0.2% - 1% and calorific value between 4,700 kcal/kg – 7,700 kcal/kg.

From the results of previous calculations, it is known that the proportion for blending coal using mine brand MT-47 is 165,620 tons and BB-51 is 172,380 tons to meet PLTU Suralaya's demand of 338,000 tons. With the desired coal quality parameters, namely the total moisture value ≤ 30% and fulfilling 29.9%; ash value ≤8% and fulfill that is 4.35%; total sulfur value ≤ 0.8% and fulfill 0.57%; as well as caloric value ≥ 4,800 kcal/kg and fulfilling 4817 kcal/kg. Thus, the results of a comparison of consumer demand with the results of calculations using software pom-qm for windows fulfills the requirements for PLTU Suralaya. Meanwhile, for calculations with mine brand MT-47 with BB-51, the proportion of MT-47 was 98,020 tons and BB-51 of 239,980 tons to meet the demand for PLTU Suralaya of 338,000 tons. With the quality parameters obtained, namely total moisture 30%, ash 2.97%, total sulfur 0.45% and a calorific value of 4858 kcal/kg, these results have fulfilled consumer demand.

The quality of mine brand coal in the stockpile has various results, so the process of optimizing coal blending is carried out to get the market brand quality that consumers want. This optimization was carried out using the help of Microsoft Excel and the pom-qm application for Windows V3. Thus, a simulation is

needed to obtain a more optimal proportion. The simulation results using the pom-qm application for Windows V3 are as follows:

1. Blending Simulation on Mine Brand MT-47 with AL-53



	MT 47	AL 53		RHS	Dual
Maximize	1	1			
tonase	1	1	=	1	1
Total moisture	33,69	26,41	<=	30	0
Ash	3,26	2,93	<=	8	0
total sulfur	,45	,7	<=	,8	0
nilai kalori	4696	4935	>=	4800	0
Solution->	,4931	,5069		1	

Gambar 3. Iteration Result *Pom-Qm For Windows* MT-47 with AL-53

In the software, the solution column shows the results MT-47 = 0.4931 and AL-53 = 0.5069. Because the mixing simulation uses the assumption that the desired tonnage is one ton, the calculation results above show that the optimal mixing proportions for BA-48 are MT-47 = 49.31% and AL-53 = 50.69%. As for the quality of blending results, as follows:

$$Total\ Moisture = \frac{(33{,}69 \text{ x } 0{,}4931)+(26{,}41 \text{ x } 0{,}5069)}{1} = 29{,}99\ \%$$

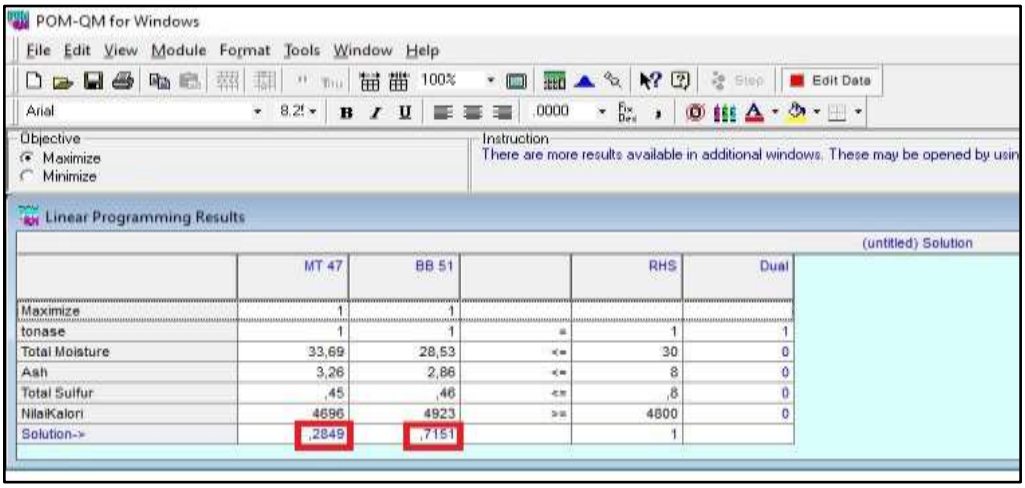
$$Ash = \frac{(3{,}26 \text{ x } 0{,}4931)+(2{,}93 \text{ x } 0{,}5069)}{1} = 3{,}09\ \%$$

$$Total\ Sulfur = \frac{(0{,}45 \text{ x } 0{,}4931)+(0{,}7 \text{ x } 0{,}5069)}{1} = 0{,}57\ \%$$

$$Caloric\ Value = \frac{(4.696 \text{ x } 0{,}4931)+(4.935 \text{ x } 0{,}5069)}{1} = 4817 \text{ kkal/kg}$$

From the blending calculation above, it is obtained that the proportion of coal MT 47 and AL 53 is 49.31%: 50.69%, with the result that the quality results are total moisture 29.99%, ash 3.09%, total sulfur 0.57% and caloric value 4817 kcal/kg.

2. Blending Simulation on Mine Brand MT-47 with BB-51



	MT 47	BB 51		RHS	Dual
Maximize	1	1			
tonase	1	1	=	1	1
Total Moisture	33,69	28,53	<=	30	0
Ash	3,26	2,86	<=	8	0
Total Sulfur	,45	,46	<=	,8	0
NilaiKalori	4696	4923	>=	4800	0
Solution->	,2849	,7151		1	

Gambar 4. Iteration Result *Pom-Qm For Windows* MT-47 with BB-51

In the software, the solution column shows the results MT-47 = 0.2849 and BB-51 = 0.7151, because the mixing simulation uses the assumption that the desired tonnage is one ton, then the calculation results above show the optimal proportion of mixing BA-48, namely MT-47 = 28.49% and AL 53 = 71.51%. As for the quality of blending results, as follows:

$$Total\ Moisture = \frac{(33{,}69 \text{ x } 0{,}2849)+(28{,}53 \text{ x } 0{,}7151)}{1} = 30{,}00\ \%$$

$$Ash = \frac{(3{,}26 \text{ x } 0{,}2849)+(2{,}86 \text{ x } 0{,}7151)}{1} = 2{,}97\ \%$$

$$Total\ Sulfur = \frac{(0{,}45 \text{ x } 0{,}2849)+(0{,}45 \text{ x } 0{,}7151)}{1} = 0{,}46\ \%$$

$$Caloric\ Value = \frac{(4.696 \text{ x } 0{,}2849)+(4.923 \text{ x } 0{,}7151)}{1} = 4858\ \text{kkal/kg}$$

From the blending calculation above, it is obtained that the proportion of coal MT 47 and BB 51 is 49.31%: 50.69%, with the result that the quality results are total moisture 30%, ash 2.97%, total sulfur 0.46% and caloric value 4858 kcal/ kg.

Based on the calculation results of the mine brands MT-47 with AL-53 and MT-47 with BB-51 that have been obtained, recommendations can be given to optimize the coal blending process, namely using mine brands MT-47 and AL-53 with a ratio of MT-47 and AL-53, namely 49.31% : 50.69%, because the proportions produced are more balanced than the proportions of MT-47 and BB-51, namely 28.49% : 71.51%. The results of the proportion of MT-47 with BB-51 using more mine brand BB-51 so that the resulting caloric value is greater than desired. This can be detrimental to the company because the selling price is set only for calories of 4800 kcal/kg.

IV. CONCLUSION

Based on the discussion of the blending simulation analysis using the simplex method, the following conclusions can be drawn:

1. The quality of coal at PT. Bukit Asam has a total moisture value between 3% - 35%, Ash between 1% - 6%, volatile matter between 25% - 40%, fixed carbon between 30% - 65%, total sulfur between 0.2% - 1% and calorific value between 4,700 kcal/kg – 7,700 kcal/kg.
2. The results of calculations using the pom-qm for windows application for mine brands MT 47 and AL 53 get the results of coal quality total moisture 29.99%, ash 3.09%, sulfur 0.57%, and calories 4817 kcal/kg with the blending proportion percentage of 49% MT 47: 51% AL 53 and the calculation results using mine brand MT 47 with BB 51 get the results of coal quality total moisture 30%, ash 2.97%, sulfur 0.46%, and calories 4858 kcal /kg with the percentage of blending proportion, namely 29% MT 47 : 71% BB 51.
3. Recommendations to meet market demand for brand BA 48 with a tonnage of 338,000 tons of coal for the most optimal proportions are to use mine brand MT 47 of 165,620 tons and mine brand AL 53 of 172,380 tons or with a percentage of 50.69% AL 53 and 49, 31% MT 47 with the quality of coal blending results, namely total moisture 29.99%, ash 3.09%, total sulfur 0.57%, and calories 4817 kcal/kg very close to the criteria for consumer demand contracts, namely a total moisture content of 30%, ash 8% sulfur 0.8% and calories 4800 kcal/kg.

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