

Coal Resources Calculations Using Block Model And Cross Section Method, In Pt. Natural Earth Regency Of Kutai Kartanegara East Kalimantan, Indonesia

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Abstract: In the world of mining, calculation of reserves was the most decisive in exploration activities. The results of the calculation of coal reserves were needed to evaluate the economic value of a mining operation to be planned. Observation of fundamental data in the calculation of reserves was in accordance with the level and accuracy in retrieving the data. Therefore, so that mining activities can be done easily then the required supporting software that can simplify the calculation and modeling. The purpose of this research was to calculate the reserves of coal by using two methods include methods of block model and cross-section method. In this study, the acquisition of the coal obtained from the comparison between the methods of block model and cross-section method. Calculation of coal reserves by stripping ratio was not more than 7: 1. The block method model the obtained results 13,646,218.25 MT of coal reserves and overburden volume of 91,472,579.44 BCM. While the section method the results obtained by 14,540,371.3 MT of coal reserves and overburden volume of 92,547,132 BCM. Comparison of the two methods produce different amount of coal reserves in the same mining pit design. because the accuracy of the calculation was not the same. Factors that lead to differences in methods of calculation of reserve block model of the method was calculated based on the volume of blocks with dimensions adapted to the conditions of the sediment in the area. While the cross-sectional method was that the volume was calculated based on a model that can represent a cross-section model of sediment in the area

Index Terms: Block Model, Cross-section, Stripping Ratio.

INTRODUCTION

• Background

One of the most vital stages of coal mining activity is exploration activities, which cover many things from the outcrop to reserve calculations. The calculation of reserves is the stage that most affect the overall exploration activities, where the data obtained from the exploration stage in the field greatly affect the form of sediment and value of reserves contained in the research area. Another thing that most influential in the calculation phase of coal reserves is the basis of economic evaluation, whether the mining activities in the area of research can be said to be feasible or not feasible mine. There are various methods in the calculation of coal reserves, including the model block method and the cross section method. The model block method is performed by dividing the ore body or mineral deposits into blocks with dimensions adjusted for the mineralized type of trap encountered. While the cross section method is done by making a representative cross-section so that it can represent the model of coal deposits in the area. Along with technological developments, the coal-resources calculation method has been greatly developed computerized by using software that already exists today without changing the philosophy of calculation. The principle of reserve calculation is based on the results of a range. The backup model made is the result of the approach of the actual conditions resulting from the exploration activities.

uncertainty by doing a simulation of modeling and calculation of coal reserves with the help of software and to know the amount of coal reserve potential contained in Pit A Block I and Block II at PT. Bumi Alam Raya, in East Kalimantan, Indonesia. The benefits of this research are to produce coal deposits model, to know the amount of coal reserve potential in the research area, and to produce the potential location and pit limit that can be used as the basis in mining planning stage for coal production.

RESEARCH PURPOSES

The purpose of this research were :

- Calculate the coal reserves by the model block method and the cross-section method.
- Comparing the calculation of coal reserves between the two modeling methods ie block model and cross section methods.

SCOPE OF PROBLEM

Limitations of the problem in this study were as follows:

- The reserve calculation was done by using block model and cross section method using 4,118 mescape software.
- Limitation The value of stripping ratio refers to the criteria desired by the firm that is not more than 1: 7.
- The calculation was did in the PT. Bumi Alam Raya concession on the design plan of pit A in block I and block II.

THEORETICAL BASIS

• Coal

Coal has been mostly defined by many authors, but essentially coal is a type of sedimentary rock, an organoclastic in nature, composed of plant remains that have undergone a lithification process, which ultimately has the privilege of being one of the fuel sources. (Thomas

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2013). Rapid plant growth and deposition in water with low oxygen content, shallow swamps or swamps in temperate or tropical regions are necessary environments to allow for coal precipitation processes. The abundant particles of decomposition of plant material will use any oxygen in the swamp water, so that the decay stops and the remaining organic material is preserved. Buried by sedimentation pressing the plants, which gradually repel water and other volatile compounds, the change of coal from brown becomes increasingly black resulting in increased amount of carbon in it. (Plummer et al. 2013). In Indonesia based on government regulation article 1 number 27 in the year of 1980, coal is classified as strategic excavation material, where in Article 3 paragraph (1) in explanation of strategic drilling material means is strategic material for defense / security of state or for economy of country. (Saleng 2004)

- **Theory of coal formation (Sukandarrumidi 1995)**
- **Insitu theory**

This theory says that the materials forming the coal seam, the formation of the place where the origin of the plants are located. So after the plant died, has not undergone a process of transportation immediately covered by a layer of sediment and coalification process. The type of coal formed in this way has widespread and even distribution, the quality is better because the ash content is relatively smaller.

- **Drift theory**

This theory suggests that coal-forming materials occur in different places premises where the original plants live and thrive. Thus the dead plants are transported by aqueous media and accumulate in one place, enclosed by sedimentary rock and undergo a process of coalification. The type of coal formed in this way has a widespread spread, but is found in some places, the quality is relatively poor because it contains many impurities which are transported together during transport from the place of origin to the sedimentation site.

- **Resources and Coal Reserves (BSN, 1999)**

According to the National Standardization Agency (1999) the term "coal resources" was part of the coal deposits expected to be utilized. Coal resources were divided into resource classes based on the geological confidence level determined qualitatively by geological conditions / degree of complexity and quantitatively by the distance of the information point. This resource may increase its status to a reserve if after a feasibility study was declared feasible. The geological confidence level that determines the classes of coal resources is obtained based on the exploration stage which includes:

- Survey review (Reconnaissance)
- Prospecting
- Preliminary Exploration
- Detailed Exploration.

- **CLASSIFICATION OF COAL RESOURCES**

Classification of coal resources is a grouping based on the level of geological belief and economic feasibility, so that in the end obtained the classes of coal resources as follows (BSN, 1999):

- Hypothetical coal resources are coal in the area of investigation or part of the area of inquiry, which is calculated based on data that meets the requirements set for the survey review stage.
- Inferred coal resources are the amount of coal in the investigation area or part of the inquiry area, calculated on the basis of data that meets the requirements set for the prospecting probe stage.
- The indicated coal resource is the amount of coal in the investigation area or part of the investigation area, calculated on the basis of data that meets the requirements set for the preliminary exploration stage.
- The measured coal resources are the amount of coal in the investigation area or part of the inquiry area, calculated on the basis of data that meets the requirements specified for the detailed exploration stage.

In addition to the above classification Sukandarrumidi (2009) also added:

- Sumerdaya speculative level (speculative resource)
Is the potential of mineral resources that may be produced from a prospect area of mineral materials and field research where the data used as the basis of calculation mainly refers to the results of literature studies h at a glance (recognize).
- Hypothetical resource level
the potential of mineral resources that may be produced by an excavation prospecting area where the data used as the basis is a field review of the region and the results of laboratory analysis. Thus the resource speculative rate is a relatively very rough calculation rate compared to the hypothesis level resource.

COAL RESERVES

Coal reserves are part of the known coal resource dimensions, quantity distribution, and quality, which at the feasibility assessment are eligible to be mined taking into account the current conditions (BSN, 1999).

The following conditions are considered:

- Technology, related to the size of the mining area, the degree of difficulty in coal removal used, the Environmental conditions, relating to residential, agricultural, protected forest, roads and other facilities that are highly unlikely to be mine land, so reserve calculation should be outside this location, and consideration should also be given to the determination of disposal, roads, And the location of coal deposits as well as the determination of coal quality specifications in selling or in marketing.
- Government regulations, which relate to mining permits, environmental and reclamation laws and other binding regulations to mining companies that will ultimately affect stripping ratios.

Coal reserve itself is grouped into two categories namely (BSN, 1999):

- The probable reserve is the source of the indicated coal and some of the measured coal resources

whose geologic confidence level is still lower, based on the feasibility study of all related factors have been met, so that mining can be done economically.

- Proved reserve is measurable coal resources based on a feasibility study of all related factors that have been met, so that mining can be done economically.

In addition to 2 reserves above Kaiser (2013) add also :

- planned to be mined on mining operations that are underway, are pending or which permits have been filed and plans for development of mining operations. Fixed reserves are reserves to be mined in the future but have no specific mining designs. Non-current reserves are reserves that require significant investment (such as new mineshaft, mining equipment and factory facilities) before operations can begin.
- Leased reserves and owned reserves. Coal companies generally do not own land where their mining operations are carried out, but they are rented from third party landholders. State and private tenants have various terms and conditions for extension, but generally are the exchange cost per ton or royalty of a percentage of the gross sales price,

or the minimum payment for the economic life of the production.

- Basic Classification of Resources and Coal Reserves (BSN, 1999)

The classification of coal resources and reserves is based on the level of geological confidence and feasibility study. The grouping consists of two aspects, namely the geological aspect and the economic aspect.

GEOLOGICAL ASPECTS

Based on the level of geological confidence, measured resources must have a greater degree of confidence than the designated resources, as well as the designated resources should have a higher level of confidence than the inferred resources. The measured and designated resources can be upgraded to proven and proven reserves if they meet the eligible criteria (in Table 2.1). The degree of geological belief is quantitatively reflected by the distance of the information point (outcrop, drill hole). The Feasibility Study Based on Factors include : Economy, Mining, Processing, Marketing, Government Policy, Regulation / Legislation, Environment and social.

Table 2.1 Classification of coal resources and reserves (BSN, 1999)

Exploration stage	Reconnaissance	Prospecting	Preliminary Exploration	Detailed Exploration
Status of Study Result				
Not Yet Feasible	Hypothetical Resources	Inferred Resources	Indicated Resources	Measured Resources
Feasible	Probable Reserves			
	Proved Reserves			

Classification of coal resources was an effort to group coal resources based on geological beliefs and economic feasibility. Distance information requirements for each geological condition and resource class was shown in Table 2.2

Table 2.2 Distance of information points by geological conditions (BSN, 1999)

Geological conditions	Criteria	Resources			
		Measured	Indicated	Inferred	Hypothetical
Simple	Distance of information points (meter/m)	$x \leq 500$ m	$500 < x \leq 1000$ m	$1000 < x \leq 1500$ m	unlimited
Moderate		$x \leq 250$ m	$250 < x \leq 500$ m	$500 < x \leq 1000$ m	unlimited
Complex		$x \leq 100$ m	$100 < x \leq 200$ m	$200 < x \leq 400$ m	unlimited

A description of the general limits for each geological conditions above are as follows (BSN, 1999):

- Simple Geological Condition
With the following characteristics as follows :
- Coal deposits are generally not affected by tectonic activity such as cesarean, folds and intrusions.
- Coal layers are generally sloping, continuously lateral to thousands of meters, and barely have branches.
- Coal layer thickness is lateral and its quality does not show any significant variation.
- Examples of coal in South Bangko and Estuary Big Three (South Sumatra), West Senakin (South Kalimantan), and Cerenti (Riau).

- Moderate geological conditions

With the following characteristics as follows :

- Deposition of coal to some degree has undergone tectonic deformation effect.
- In some places, the intrusion of igneous rocks affects the lining structure and quality of the coal.
- Characterized by lateral slope and variation of lateral thickness or in usual the thickness not so thick
- The distribution of coal branching can still be followed for hundreds of meters.
- Contoh batubara di Senakin, Formasi Tanjung (Kalsel), Loa Janan – Loa Kulu, Petanggis (Kaltim), Suban dan Air Laya (Sumsel), serta Gunung Batu Besar (Kalsel).
- Coal samples in Senakin, Tanjung (South Kalimantan) Formation, Loa Janan - Loa Kulu, Petanggis (East Kalimantan)), Suban and Air Laya (South Sumatra), and Great Batu (South Kalimantan).

- Complex geological conditions.

With the following characteristics as follows :

- Generally have undergone intensive tectonic deformation..
- Shifting and folding due to tectonic activity makes coal seams difficult to correlate.
- Strong folding also leads to a steep slope.
- Lateral coal seam distribution is limited and can only be followed up to tens of meters
- Examples of coal in Ambakiang, Warukin Formation, Ninian, Belahiang and Upau (South Kalimantan), Sawahlung (West Sumatra), Water Kotok (Bengkulu), Bojongmanik (Manik), and coal areas undergoing frozen rock intrusions in North Bunian (South Sumatra).
- Economic Aspects

A feasibility study is a detailed review of all technical and economic aspects of a mining project plan. The results of this study can be used as a basis for determining investment decisions and as a bankable document for project financing. This study covers all aspects of economics, mining, processing, marketing, government policy, regulations / legislation, environment, and social. The projected cost budget should be accurate and grounded and no further investigation is needed to make an investment decision. The minimum thickness of the mined coal layer and the maximum thickness of the impurity layer or "dirt parting" which can not be separated at the time of mining, which causes the quality of the coal to decrease due to the increased ash content, are some elements

related to the economic aspects and need to be considered in classifying the resources Coal of low energy coal (brown coal) shows relatively low heat content compared to coal of high energy coal type (hard coal). Because essentially heat content is the main parameter of coal quality, minimum requirement of mined coal thickness and maximum limit of impurity coating that can not be separated at the time of the mine for coal type coal of low energy (brown coal) and coal type of high energy coal (hard Coal) will show different numbers. These requirements are shown in Table 2.3.

Table 2.3 Quantitative requirements of coal seam thickness and impurity coating (BSN, 1999)

Coal thickness	Coal Type	
	Brown Coal	Hard Coal
Minimum Coal Coating (m)	≥ 1,00 m	≥ 0.40 m
Maximum impurity layer (m)	≤ 0,30 m	≤ 0,30 m

- Calculation of Reserve Profil Method / Cross section method. (Popoff 1966)

The first step in applying a cross-section method is to divide the mineral body into blocks by making a geologic cross section at intervals along a transverse line or at different levels according to the exploration work, calculation objectives, and nature of the reserve. Distance or interval between sections can be made constantly or may vary, but at different calculations the distance will be more complicated.

Based on the block construction there are 3 modifications of the cross section method.

- The standard method, based on the rule of gradual change guidelines. Where each block interval is limited by two cross sections, and each end of block is limited by 1 cross section.
- Linear method, based on the rule of nearest points guidelines. Where each block is defined by a cross section and the distance is equal to half the distance to the next section.
- The isoline method, based on the rule of gradual change guidelines.

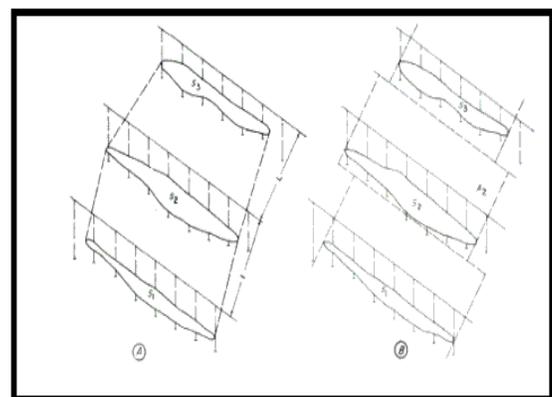


Figure 2.1

Block layout of the cross-section method, A sample cross-sectional method; B. Examples of cross-sectional linear

methods. (Popoff 1966) Volume calculation can be done by mean-area method. Where the volume between two sections can be calculated by the following formula:

$$V = \frac{S1 + S2}{2} \times L \text{ m}^3 \dots (2.1)$$

With

V = Volume (m³)

S1 = Area of cross section 1 (m²)

S2 = Sectional area 2 (m²)

L = Distance between cross section (m)

- Calculation of Reserve Method Block model (Hustrulid.W, & M.Kuchta 1995)

The basics of applying computer engineering to the value and calculation of tonnase is the visualization of a deposit or reserve as a set of blocks. The block model as shown in Figure 2.2

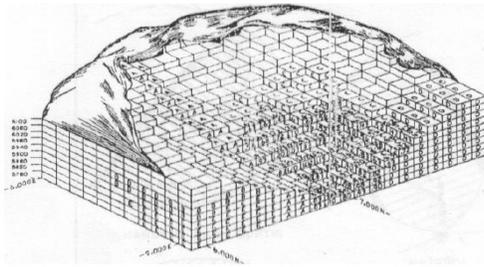


Figure 2.2

Example of the model block method (Hustrulid & Kuchta, 1995)

Some guidelines for the selected block size have been set by David (1997). Usually in mining jobs, people want to know how much their reserves are likely and as a result they ask for a detailed estimate of the smallest possible blocks. This tendency, in addition to allowing do not require a high cost but can menimbulakan disappointing results. People will find that the blocks around them are rated the same. It should be remembered that as the block size diminishes, the error of the block estimate increases. Also, divide the linear dimension of the block into 2, multiplying the number of blocks to be calculated and allowing the calculation system to be completed. As a rule of thumb, the smallest size of a block should not be less than ¼ the average of the borehole interval. Sperti 50 ft block size for 200 ft. Drilling grid or 200 ft for 800 ft grid of drilling.. The elevation of the block is usually adjusted to the level to be used in mining. In addition, the location of the blocks depends on several factors. For example, the main elevation is based on contact between oberburden and ore. Some techniques are used to set the value of the blocks. The tonnage of each block can be easily calculated from the block's volume (applicable to other blocks) and the factors affecting tonnage (which may vary). All these values are based on the concept's 'impact area' where the value of the specified block is based on consideration of the value of the surrounding blocks.

- Stripping Ratio and Pit Limit (Hartman, Howard L. 1987)

This is based on the calculation of the stripping ratio we use to determine the pit limit and to express the volume of the overburden moved per unit weight of the ore, coal, or rocks found. We can distinguish between two stripping ratios (unit: yd³ / ton, or m³ / ton)

- Maximum stripping ratio considered (SRmax) = Volume of overburden / weight of ore at economic limit pit
= V / w

- Overall stripping ratio (SRo) = Volume of overburden / total weight of ore or cross-section
= V / W

In an example SRmax does not specify a limit pit or may exceed SRo, and it can occur if the shape of the surface is flat, and the reserve is flat and has a constant thickness. In such cases SRmax is less significant, and the limit lies in the concession line. In long-term planning, it is known that SRmax, having a temporary quantity of physical, is determined solely by economic value. SRo on the other hand, has a significant physical virtue. This is because the economic basis for which we can use SRmax to determine the pit limits of the reserves in the general case, ie the ore body of various thicknesses, dips, or values that occur under a sloping or horizontal surface.

• RESEARCH METHODOLOGY

The study was conducted by conducting literature study and direct observation in the field taken at one of the mining companies in East Kalimantan. Data taken in this research are:

- Topographic data
- Data concession area boundary research
- Drillhole data
- Coal quality data

The data is ultimately useful for calculating reserve values in the research area. The results of the calculation of such reserves will be compared to determine which method is expected to have the value closest to the reserve value of the research area to be used as a consideration of the subsequent dimensional stage.

ANALYSIS

- Geological Condition of Research Areas

Coal formed in research area at KP PT. Bumi Alam Raya is in Balikpapan formation and Ritan Limit Member, Haloq formation. In the research area there is almost no geological structure. Both layers of rock and coal coating have a uniform direction.

The sequence of rock formations from the old to the young in this area are as follows:

- Formation of Balikpapan, Central Miocene to Late Miocene, Balikpapan Formation is characterized by quartz sandstone constellation with batulanau inset, limestone and coal. The thickness of the formation is 1800 m and is deposited in a delta litoral environment to shallow seas.

- Members of the Ritan Limestone, Haloq Formation, Eocene-aged, consist of bioclastic limestone, solid and containing foraminifera Thickness of 500 m formation and deposited in shallow marine environments.
- Coal found in this research area on average has a sloping slope that ranges between 40-60 degree. So in this case coal is included in moderate geological conditions, which is characterized also apart from dip with a slope of less than 100 is also of thickness of coal which is sometimes thickened and thinning, so that sometimes in one seam can be found seam coal with uneven thickness . In such conditions for the calculation of reserves using a distance measurement ≤ 200 meters.

Based on the quality aspect, the coal from the research area is included in the Bituminous class with the following details as follows :

- The calorific value under Air Dry Base (ADB) conditions ranges from 5000-5400 cal / gr.
- Content of ash content (ADB) between 4.41-7.73%
- Sulfur content (ADB) between 0.18 - 0.21%
- Total humidity (AR) between 36.99 - 39.35%
- Humidity (ADB) between 15.34 - 18.76%
- Flying substances (ADB) between 37.96 - 40.12%
- Carbon tethered (ADB) between 37.94 - 40.52%
- Exploration drilling activities

In conducting exploration drilling activities of PT. Bumi Alam Raya in pit A blocks I and II with an area of more than 800 Ha, using a Jack row type drilling machine with a maximum drilling depth of more than 80 meters with Wing Bit drill bit. The method of drilling is rotary percussion drilling. The drilling orientation is usually done in two ways, ie following the direction of the coal strike and the second is following the down dip direction of coal. The purpose of the drilling follows the direction of coal strike is to know the direction of kemenerusan and the pattern of dispersal of coal while drilling by following the dip down direction aims to see the value of coal slope as well as know the stratigraphy of the layer and also the number of seam of coal available. In this study used the drill point data which is the result of survey and drilling activities conducted by PT. Bumi Alam Raya. Data required for calculation include data in the form of coordinates of drill points (easting, northing, elevation, obtained from drilling survey activities), total drilling depth, rock lithology and thickness data. The thickness of coal obtained from this drilling activity is apparent thickness obtained by conducting core drilling (coring). In the coring process the thickness is obtained by measuring the length of the coal core contained in the core barrel. To know the actual thickness can be sought by multiplying the apparent thickness of the coal dip coin.

• Modeling of Coal Deposition

Coal sediment modeling aims to determine the pattern of coal layer spread, both geometry in general, layers or layers position, depth, thickness, slope, and dispersion pattern of covering soil layer Construction of coal precipitate model is represented in the form of maps, which is done by using minescape software. The basic data required are topographic data and drill hole data. From these data can

be made derived data for the calculation of the contours of the contours of the structure of the roof or roof and floor or floor of coal.

• Making structural contours

Contour structure map made on minescape software is useful to know how the form of coal seams that exist beneath the surface of the earth. In addition, from the contours of the structure can also be seen dip slope (dip) coal and at research sites in PT. Bumi Alam Raya has a slope ranging from 40-60. It can be concluded that coal in the study site has a sloping slope Making contours of this structure is made based on drilling result coordinate data using minescape software. Where the coordinate data is then plotted into the topographic map. After all information data is obtained which includes coordinate data, top and bottom elevation of coal, and description (naming of drill point), then begin to make data for coal structure contours ie data for top and bottom each seam. In making pit design in this research use contour of seam A structure which is bottom seam or seam target. The result of making contour structure map can be seen in figure 4.2.

• Cropline making

Cropline is made using the help of minescape software using the same data to create structural contours. Cropline is used to describe the position of coal deployment that is in one seam. From cropline can also be used as the initial boundary of mining and as a limitation in the calculation of reserves. In this research to make pit design is used subcropline, that is cropline which is connected under ground surface. Subcropline used is subcropline seam A which is the lowest sea

• Making Block-Solid and Resgraphic

Resgraphic is a menu in minescape to describe the values in a table on each block which is the result of measurable resource calculation with a solid baterrblock model into a gradual gradation graphic form, resgraphic can be made for stiping ratio, waste, tonnage and other values -other. Resgraphic can make it easy to restrict areas that have an exposed stripping ratio. From the resgraphic modeling results with the exposed stripping ratio of 1: 7 ton / bcm, area blocks having stripping ratios of more than 1: 7 ton / bcm are shown in red.

RESGRAPHIC MAP

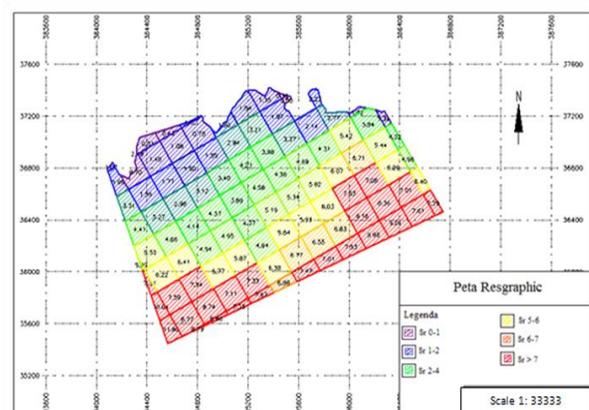


Figure 4.3 Map of Resgraphic

- **Potential Pit Boundary Determination**
Making pit design was done with the help of minescape software, where the resgraphic results made can be seen the desired pit limit in accordance with the company's requirements. Where the desired limit is at the value of cumulative SR no more 1: 7. Blocks bounded in red are blocks that have a cumulative value of SR greater than 1: 7 so that the pits to be set will be limited by red area blocks From this research is obtained pit design with pit limit -5 meters below the surface. From the design also obtained a description of the ladder at the pit and also the boundary (boundary) pit. After obtaining the appropriate design form with the desired SR requirement, which has the pit limit and also the boundary pit required for the calculation process, then the amount of mined reserves in that location is also calculated by the model block method and the cross section method.

low wall and height of 10 m and distance of 5 m, according to criteria desired by company. Here is a slope design for pit design where data used comes from the standard used in PT.Bumi Alam Raya, as shown in Figure 4.12.

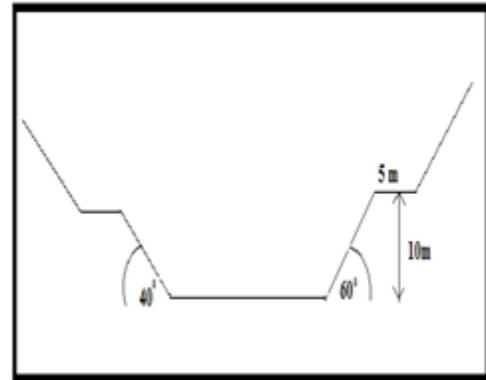


Figure 4.2 Slope design

The calculation of coal reserves is done with 100% recovery and minimum thickness of 2.4 m. Here is a manual calculation on one of the blocks in the 4.118 minescape software (figure 4.13). Blocks in the count is a block with the name SG_075

- **Calculation of Reserve With Model Block.**
For the calculation of reserves is done by dividing the potential pit area into blocks of mine. In this case the block size is made 200 x 200 m. This size is adjusted to the size of the short term design used by the company and also based on the initial distance between the drill point (both strike direction and dip are equally spaced 200 m) expected in a block can represent a drill point so that the calculation results are obtained close reality. These blocks of mining will result in the amount of coal reserves, overburden, and quality. In the calculation of coal reserves with minescape software 4.118 angle of slope used for hanging wall and for

Below was a table of calculation of resources of coal using software on one block that is block SG_075

Seam	Area	True Thickness	Density	Volume	Reserves
	M ²	M	Ton/ M ³	M ³	MT
A	40,002.86	3.720	1.3	148,810.639	193,453.831
B	13,627,02	1.308	1.3	17,824.142	23,171.385

As for overburden volume calculation for block SG_075 as follows :

Overburden	Area	True Thickness	Volume
	M ²	M	BCM
Overburden	12.501,95	1.973	24,666.347
interburden 1	40.002,86	28.224	1,129,063.7

So the total reserves and burden on SG_075 block are as follows:

- Total Reserve = 216,625,216 MT
- Total burden = 1,153,730.047 BCM
- SR = 5.33

Using the same method, calculations are made for all blocks. The results of the calculation of reserves on all seam (appendix B) and all blocks in the block minescape model obtained the following results:

- Total Reserve = 13.646.218,25 MT
- Total overburden = 91.472.579,44 BCM
- SR = 6,70.

- **Calculation of Reserves With Sectional Methods**

The calculation of coal reserves by using vertical cross-sectional method can describe the condition of sediment, overburden in each cross section. In this research, the calculation using cross-sectional method is done on all Seam as comparison from the calculation of backup using software minescape 4.118. in the calculation of reserves using this cross-section, the distance between cross-sections in use is 100 m, and the pit slope is assumed to be as large as 1.3 kg of coal, and does not include losses and weathering zones. Calculations are performed on the pits that have been generated in the 4.118 minescape software. An example calculation is taken from section E and section F (figure 4.). From each section will be obtained the area of coal and overburden, then calculated so as to obtain the following results: Used equations for two cross-section (mean area). Known:

Table 4.3 Calculation of reserves between cross section E and cross section F

Seam	Area		Distance	Volume	Density	Reserves
	Section E	Section F				
	M ²		M	M ³	Ton/ M ³	Ton
A	4,552.41	5,055.52	100	480,396.5	1.3	624,515.45
B	1,436.01	1,406.74	200	142,137.5	1.3	184,778.75

And for the overburden calculation between the two sections and the three sections are as follows:

Table 4.4 Overburden calculation between cross section E and cross section F

Section	Area	Distance (M)	Volume (BCM)
Section E	56.316,3	100	5.368.212
section F	51.047,94		

So the total reserves and overburden between section E and section F are as follows:

- Reserve = 809,294.2 Ton
- Total burden = 5,368,212 BCM
- SR = 6.6

And by using the same method, the calculation as a whole (appendix D) in the section in the results can be as follows:

- Number of coal = 14,540,371.3 MT
- Total overburden = 92,547,132 BCM
- SR = 6.36

Table 4.5 Comparison of calculation of model block reserves and cross-sectional methods

	Volume of Reserves	Reserves in Tonnage	Volume of Overburden	SR
Blok model	10.497.091	13.646.218,25 MT	91.472.579,44 BCM	6,70
Cross section Method	11.184.901	14.540.371,3 MT	92.547.132 BCM	6,36

Based on the calculation, there are differences in the amount of coal reserves of both methods, ie different 894.152, 95 MT on the pit that has been constructed. Differences generated by both methods are caused by different ways of calculating them. The vertical cross-sectional method in the calculation uses the area of influence of each cross-section. In this case calculations are made using two cross sections, where the volume of coal and overburden between the two cross sections is the average of the area of coal and overburden at each cross section of the cross section of the two cross sections. This means that the variation in coal thickness as well as overburden between the two cross sections is assumed to be equal to the average of coal thickness and overburden at each cross section. If there is significant variation between two cross sections, then an additional cross section should be constructed between the two cross sections. It is also one that causes the difference of calculation results with the software. The calculation of proven reserves with software basically uses the principle of calculating the model block method where the method of calculation using floor area and roof is then multiplied by the actual thickness of the coal deposits (vertically and unlike the cross-sectional method whose way of multiplying

by the distance between the cross section horizontally) . Calculations on the software that is by calculating the surface to surface that is projecting the topography to the structure of group seam group A roof, then projected to the structure of the floor group of seam A. The calculation of backup with this software is very effective for the variation of topography and variation of coal thickness.

CONCLUSIONS

- The calculation of coal reserves from the model block method with tonnage of 13,646,218.25 MT, while the tonnage of the cross-sectional method is 14,540,371.3 MT. Basically the result of both methods of calculation of this reserve can not be compared because it is not known the actual value of the reserves in the area of research, but from the calculation can be known the value of the reserve method is larger 894.152,95 MT. This is because the accuracy of the two method so calculation is not the same.

SUGGESTION

- Drilling should be done in detail, so as not to have difficulty in processing the data.
- To calculate coal reserves by cross-sectional method, it is necessary to have a high accuracy in calculating the area of sediment and overburden which determines the volume calculation.
- The distance between incisions in the cross-sectional method should be noted because of the distance of the incision will be obtained by the volume of the calculation process with a more detailed cross-sectional method considering the closer spacing of the incision will be able to better describe the detail of the existing coal deposits.
- Drilling results should not be wrong, as they are very influential in coal modeling. For mining design, coal mining should be prioritized first, in order to avoid the difference of mining position to the location of coal.

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