

Calculation of Coal Resources Using the Circular Method at PT Manggala Alam Lestari Bayung Lencir

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Abstract. PT. Manggala Alam Lestari (PT. MAL) is a private national company that operates in the coal mining industry. PT. Manggala Alam Lestari is located in Musi Banyuasin, Bayung Lencir district. As a coal-mining company, you must meet coal requirements to conduct resource calculations at the exploration stage before moving on to the mining preparation stage. The territory of IUP PT Manggala Alam Lestari is divided into V (five) mining blocks. However, Block IV, with an area of 150 hectares is currently not being calculated for coal resources, overburden, and stripping ratio since drilling activities are taking place on Block IV to sample coal thickness, overburden, and stripping ratio. The measured resource calculation for this coal is performed using the Circular method of block IV with a 100-meter radius, with data such as geological conditions on the ground and drilling data, and then the data is applied with supporting programs such as Software Surpac 6.6.2. Based on the data processing results, 1.579.428,13 tons of coal were measured using the circular method, as well as 1.067.573,57 m³ of overburden, or 1.708.117,71 tons.

Keywords: coal, low-calorie, sawdust, waste of sawdust, fuel

1 Introduction

PT. Manggala Alam Lestari (PT. MAL) is a national private company engaged in the coal mining business. PT. Manggala Alam Lestari is located in Bayung Lencir District, Musi Banyuasin Regency. As a company that operates in coal, to meet coal needs, resource calculation activities are required which are carried out at the exploration stage before the mining preparation stage.

Based on initial observations and interviews conducted in the field at PT. Manggala Alam Lestari Bayung Lencir. In the IUP area of PT. Manggala Alam Lestari is divided into V (five) mining block areas. However, in block IV with an area of 150 ha, we have not yet calculated coal resources, overburden, and stripping ratio, this is because block IV is currently carrying out drilling activities to take samples of coal thickness, overburden, and stripping ratio.

In the case of mining businesses, the number of resources to be mined is a factor in determining whether a company will continue to carry out mining activities or not. Based on this, it is necessary to consider the extraction, namely thickness, grade, or quality, as well as depth that meets legal and economic requirements at the time.

In the current era of computerization, resource and reserve calculations can not only be done manually but can also be done with the help of software designed to

carry out calculation operations quickly. There are many choices of software that can be used for mining work, namely Surpac software, Minescape software, Rockworks software, Autodesk Land Desktop 2005 software, and others. Several methods are used for calculating resources and reserves, such as the circular method, polygon method (area influence), mean area method, cross-section method, contour method (isoline), and kriging method.

The circular method is a development of the block system and ordinary volume calculations. This system is considered suitable for use in coal resource calculations because this system is aimed at measuring minerals in the form of layers (spreads) that have relatively consistent layer thickness and slope.

The principle of resource calculation is based on the results of a range and resource model created, calculations are carried out based on the results of an approach to actual conditions obtained from exploration activities with the help of Surpac 6.6.2 software based on the shape of layers that have been recorded through coal position, coordinate points, elevation, layer thickness, and the depth of each drilling based on the prospect area. The results of these calculations still contain uncertainty, therefore researchers are interested in raising the title Calculation of Coal Resources Using Circular Methods at PT. Manggala Alam Lestari Bayung Lencir

2 Literature Review

2.1 Exploration

Exploration is part of mining activities, where activities start from a review survey, prospection, preliminary exploration, and detailed exploration. Based on Law No. 3 of 2020, exploration is a stage of mining business activities to obtain detailed and thorough information about the location, shape, dimensions, distribution, quality, and resources of excavated materials, as well as information about the social and natural environment.

2.2 Resources and Reserves

Mineral Resources Mineral resources are mineral deposits that are expected to be put to real use. Mineral resources with certain geological beliefs can be converted into reserves after a mine feasibility assessment has been carried out and they meet the mineability criteria.

Reserves are mineral deposits whose size, shape, distribution, quantity, and quality are known and which are economically, technically, legally, environmentally, and socially mineable at the time the calculation is carried out.

2.3 Resource Calculation Method

The resource calculation method used must be appropriate to the type of excavated material to be calculated. The vertical section method is more appropriate for homogeneous rocks such as coal, andesite, or limestone. Meanwhile, for metallic minerals whose distribution is uneven, the area of influence method is more appropriate to use. Several reserve calculation methods include the Circular USGS method, truncated curve method, cross-section method, polygon method, contour line method, triangle method, and kriging method.

The circular method is a method with a circle shape with the radius of the circle being the outer information distance as the boundary (area of influence) by the provisions of SNI 5015:2011. So it can be interpreted that the circular method is a development of the block system and ordinary volume calculations. This system is considered suitable for application in coal resource calculations because this system is aimed at measuring minerals in the form of layers (tabular) which have relatively consistent thickness and slope of layers. The procedure or calculation technique in the USGS system is to make circles (half circles) at each coal deposit information point.

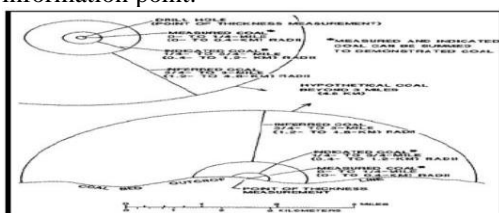


Fig 1. Coal Resource Calculation Rules circular method

Calculations to determine the quantity (tonnage) of coal resources after obtaining the value of the resource area, average coal thickness, and coal density, the quantity (tonnage) of the resource can be estimated. Estimation or estimation of tonnage can be done using the following formula:

$$(T) = (L/\cos \alpha) \times t \times D$$

Information:

T = Coal Tonnage (tons) t = Coal thickness (m)

D = Weight of coal per volume (density)

L = Luas area batubara (m²)

α = Coal seam dip(°)

The slope of the coal seam also influences calculating coal resources. If the coal seams have different slopes, the calculations are carried out separately:

Slope 0 – 10

Tonnage calculations are carried out directly using the Tonnage formula, namely coal thickness x coal specific gravity x coal area.

Slope 10 – 30

For slopes of 10 – 30, the coal tonnage must be divided by the cosine value of the coal seam slope

Slope > 30

For slopes > 30, the coal tonnage is multiplied by the cosine value of the coal seam slope.

Coal resource estimation using the USGS circular method has the advantage that it is easy to apply, easy to communicate easy to understand, and can be adjusted easily, but requires good geological interpretation. This calculation method is widely used in interpreting the size of coal resource calculations. The rules for calculating using the circular method are adjusted to the type of resource used.

According to Anis Millayanti et al in the Padjadjaran Geoscience Journal, the circular method forms a circle by making the outer radius based on the SNI boundary provisions as the area of influence. This method was started based on USGS 1983, but because it does not consider the actual thickness in the calculations, this circular method is not based on USGS instead uses SNI standards which do not explain the modeling method. The calculation procedure or technique is to make circles at each coal deposit information point, namely coal outcrops and/or drilling points. After justifying the geological conditions (simple, moderate, complex) it can then be seen that the radius of the circle used is the outer information distance from SNI 5015 – 2011 which is based on the 3-point problem.

The USGS circular method is a classification system designed to determine the total amount of coal in the ground before the mining process begins. The USGS circular method states that the calculation of measured resources is carried out at a radius of 400 meters from the Batubara outcrop towards the Batubara dip or slope. Induced resources are measured in a radius of 1200 to 4800 meters from the Batubara outcrop towards the entry of the Batubara dip (Wood, et al. 1983).

2.4 Definition of Overburden

The overburden layer is the rock that is above and directly covers the layer of valuable minerals so it needs

to be removed first before the valuable minerals can be excavated. The formula for calculating overburden using the circular method is:

$$Vob = A \times T$$

Information :

Vob = Volume overburden

A = Luas area overburden

T = Overburden thickness

2.5 Surpac Software 6.6.2

According to Yohanes Pamudi: 2018. Surpac is one of the most popular, best mining analysis software, especially in the world of the mining industry, which can competently handle the scope of work in the field of exploration and mining engineering and is the largest in almost 90 countries using it. This software provides efficiency and accuracy through easy-to-use 3-D, good graphics, and automatic workflow and can be adapted to work processes, especially for companies operating in the mining industry

Surpac is almost a basic requirement for geologists, surveyors, and mining engineers, in other fields or resource sectors, surpac is flexible enough for every commodity, many methods can be applied, then multilingual capabilities enable global companies to use it as a general solution in their operations.

Surpac 6.6.2 is integrated mine planning software specifically designed for the mining industry covering all aspects of mining technical information, from exploration data to mine production scheduling. The basis of Surpac is an open system feature and extensibility. The Surpac process supports a variety of special application software that allows us to provide a reliable and dynamic 3D CAD graphics system which is the core of the Surpac 6.6.2 system. Surpac is designed for use by all mining professionals including surveyors, geologists, and mine engineers.

Surpac's flexibility ensures that the software can be used in the short and long term of coal mines and minerals. One of the functions of Surpac software is to determine the form of reserves and calculate the amount of reserves based on the required data. To calculate surpac reserves, several data are needed, including drill log data, topographic data, and other data that support the modeling of a deposit.

2.6 Data - Coal Resource Calculation Data

In the process of calculating coal resources, the completeness of the data greatly influences the accuracy of the calculation results. The data required. Outcrop or outcrop data, drilling or drilling data, coal thickness, and maps of the area that can support future reserve calculations, such as geological maps, topography, drill logs, and others

a. Drilling data

Drilling is carried out using a Jarco 175-type drilling machine. The drilling technique is carried out vertically with a maximum depth of 45 meters or until it penetrates a coal layer of known thickness and position.

b. Topographic data

The data obtained is in the form of points that have coordinates and elevations, which will later be processed into contour lines that have more accurate elevation values compared to topographic contour data. The function of topographic mapping is to:

1) Know the shape and appearance of the earth's surface in the area where the mapping is carried out, such as the shape of the hills, the shape of the plains, and the shape of the flow patterns (rivers).

2) Detailed drill point planning.

3) Basic data in modeling coal deposits and calculating coal resources.

2.7 Definition of Coal

According to Ahlul Nazar: 2020, coal is a combustible organic rock sediment (with the main composition of carbon, hydrogen, and oxygen), formed from plant remains over a long period (tens to hundreds of millions of years). Plant remains can come from, among others, moss, algae, wood, fruit, and leaves which are organic compounds (cellulose, carbohydrates, lignite, protein, and fat). Apart from being formed from organic compounds, it is also accompanied by inorganic compounds, especially mineral elements originating from clay, quartz sand, limestone, and so on. Due to the influence of pressure and microbes accompanied by several chemical and physical events or geological conditions, these plant remains will disintegrate, clump together, and unite with each other to form layers of coal.

2.8 Coal Forming Process

The process of coal formation is classified according to ASTM (American Society for Testing and Material).

a. Peat

This stage is the initial stage of coal formation (coalification). Peat comes from dead plants and accumulates on top of the soil, which becomes thicker and thicker, causing the bottom of the swamp to sink slowly. The plant material is broken down by bacteria and fungi under anaerobic conditions into CO₂, water, and ammonia, and as a result, is peat/humus. C: 61.7%; H: 0.3%; O: 38%

b. Lignite

With changes in topography and surroundings, the peat becomes buried under layers of slits and sand which causes the pressure and temperature in the peat layer to increase. Closing peat swamps provide an opportunity for bacteria to actively decompose in alkaline conditions causing the release of CO₂, and deoxygenation of ulmin, so that the hydrogen and carbon content increases. C: 80.4%; H: 0.5%; O: 19.1%

c. Sub-bituminous

The next stage of coal formation is the conversion of bituminous coal with a low geological history into coal with a medium and high geological history. During this stage, the hydrogen content will remain constant and oxygen will decrease.

d. Bituminous

In the fourth stage or bituminous coal formation stage, the hydrogen content decreases with the gradual

decrease in oxygen. The by-products of the third and fourth stages are CH₄, CO₂, and H₂O.

e. Antrasit

The fifth stage is anthracite. In this stage, oxygen is almost constant while hydrogen decreases faster than in previous stages.

Coal genesis based on where it occurs is divided into 2, namely:

a) Teori Insitu

The materials that form coal seams occur in places where the plants are located (occur in that place too) and have characteristics, including wide distribution and good quality (because the ash content is low).

b) Teori Drift

The materials that form coal seams occur in other places where the original plants are located because they have been transported and have characteristics, including they are not widely distributed but are plentiful and the quality is not good because they contain many impurities.

3. Research Methodology

3.1 Types of Research

The method used in this research is the circular method. The circular method is a method that is carried out by making circles (semi-circles) at each coal deposit information point. This method is generally applied to sediment deposits that are relatively homogeneous and have simple geometry. The researchers used data processing using the software Surpac 6.6.2.

3.2 Research Data

The research subjects or samples were drilling coordinate points and drill log data on block IV of PT Manggala Alam Lestari Bayung Lencir to obtain the amount of coal resources, overburden value, and stripping ratio value on block IV so that mining could be carried out. The samples from this research are drilling coordinates and drill log data

1. Sample drilling coordinates
2. Sample drill log data

3.3 Research Sites

The location of this research was carried out at PT. Manggala Alam Lestari. Bayung Lencir District, Musi Banyuasin Regency, South Sumatra Province.

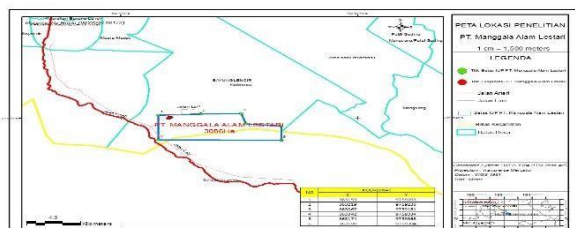


Fig 2. Research Sites

3.4 Research Procedures

The procedure is a way of conducting research. The procedures in this research were carried out in stages with sequential activity steps. The procedures in this research are as follows:

- a. Retrieval of drill data coordinate points
- b. Retrieval of drill log data
- c. Process data using a circular model with the help of Surpac 6.6.2 software.
- d. Obtained the results of the calculation of coal resources, overburden value, and stripping ratio value.

3.5 Operational Definition of Research Variables

Research variables are anything in any form that is determined by the researcher to be studied so that information about it is obtained, then conclusions are drawn. The variables in this research are drill log samples obtained in block IV to obtain calculations of the amount of coal resources, overburden values, and stripping ratio values. So that mining can be carried out in the block IV area at PT. Manggala Alam Lestari Bayung Lencir.

3.6 Instrumentation and Data Collection Techniques

Data collection activities are carried out using certain techniques and using certain tools which are often called research instruments. In carrying out research, techniques for collecting data are used. The activities in collecting research data are:

a. Literature Study

Literature studies are carried out by looking for supporting library materials, both as a basis for research and as support and related references. Literature studies can also be taken from journals related to calculating coal resources using the circular method with the help of software Surpac 6.6.2.

b. Field Observation

The purpose of field observation is to make direct observations of the processes that occur and look for supporting information related to the research that will be discussed.

c. Collecting data

Data collection was carried out after studying the literature and field orientation. The data taken is primary data and secondary data. Primary data taken in the form of data:

1. Primary data is data collected directly in the field such as:

Drilling log data is useful for knowing lithology. The coordinates for this drilling point include easting, northing, and elevation.

2. Secondary data, namely data collection without direct access, such as:

- a. Topographic maps PT. Manggala Alam Lestari.
- b. Geological Map PT. Manggala Alam Lestari.
- c. Exploration Map PT. Manggala Alam Lestari.
- d. Iup Coordinate Data PT. Manggala Alam Lestari.

3.7 Data Analysis Techniques

Data analysis techniques are the most decisive step in research because data analysis functions to conclude research results. The data analysis technique used in this research is collecting primary data and secondary data, primary data in the form of drilling point coordinate data using GPS (Global Positioning System), and secondary data in the form of topographic maps, geological maps of the research area, and regional achievement maps. Researchers used the Circular method assisted by Software Surpac 6.6.2.

4. Results and Discussion

4.1 Data Collection

There were two types of data collection carried out in this research, namely primary data and secondary data. The data obtained by researchers in the field is as follows:

1. Primary data

Primary data in this research includes:

1). Drilling Point Coordinates.

Retrieval of drilling point coordinates data at PT. Manggala Alam Lestari uses Garmin GPS. The drilling point coordinates are useful for knowing the position of the drilling point so that it can be mapped. The coordinates for this drilling point include easting, northing, and elevation.



Fig3. Retrieving drilling point coordinates using Garmin GPS

2). Dip coal outcrop

Measuring the dip position of coal outcrops at PT. Manggala Alam Lestari using Garmin GPS, with the outcrop coordinates easting (X) 363219 northing (Y) 9759233, position measurements were taken, namely strike (N) 164° dip (E) 19°



Fig 4. Retrieval of Coal Outcrop Coordinate Data and Dip Position using Garmin GPS

2. Secondary Data

Secondary data in this research includes:

1). Topographic Map of PT. Manggala Alam Lestari.

A topographic map is a contour map that depicts the height or elevation of the earth's surface, which can be seen in Appendix 1.

2). Geological Map of PT. Manggala Alam Lestari.

A geological map is a description of the geological condition of an area, which includes the composition of the existing rocks and the structural forms of each rock, which can be seen in Appendix II.

3). PT Exploration Map. Manggala Alam Lestari The exploration map illustrates the existence of coal outcrops in the PT. Manggala Alam Lestari can be seen in Appendix III.

4). Data Coordinates iup PT. Manggala Alam Lestari (data not yet attached)

4.2 Data Processing

From the drill point coordinate data, 5 points were obtained, importing the drill point coordinate data includes importing easting (x), northing (y), and elevation (z) coordinates from the results of data input using Surpac 6.6.2 software which can be seen in Fig.

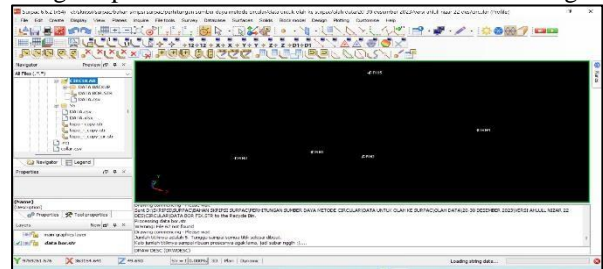


Fig 5. results of data input using surpac 6.6.2 software

1. Coal Resource Calculation Circular Method

The Circular USGS method is a method that is carried out by making circles (half circles) at each coal deposit information point. Making circles using the circular method is done by clicking on the drill holes one by one and entering data according to the geological conditions at PT. Manggala Alam Lestari.

Judging from the geological map, the geological conditions at PT. Manggala Alam Lestari is in a moderate geological condition where this moderate geological condition is according to SNI 5015:2011 guidelines for reporting mineral resources and reserves, the distance to information points for inferred resources is 500-1000 m, indicated resources are 250-500 m and measured resources are 0-250m, from this data researchers can calculate the amount of overburden and coal volume.

The steps for processing data from the circular method with the help of Surpac 6.6.2 software are as follows:

1) Save drill coordinate data in CSV (comma delimited) format with the help of Microsoft Excel.

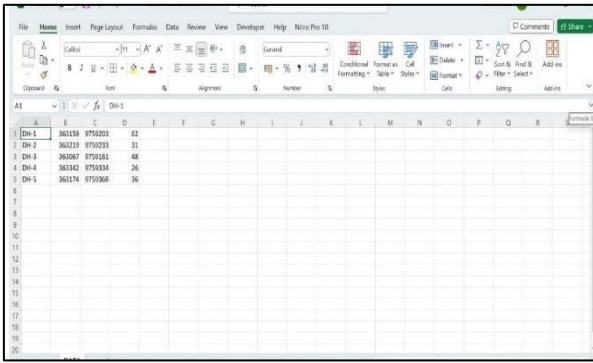


Fig 6. CSV format in Excel

- 2) Open the Surpac software and look for the file that has been saved in CSV (Comma Delimited) format.
- 3) Right-click on the folder where the file is stored and set it as a work Directory.

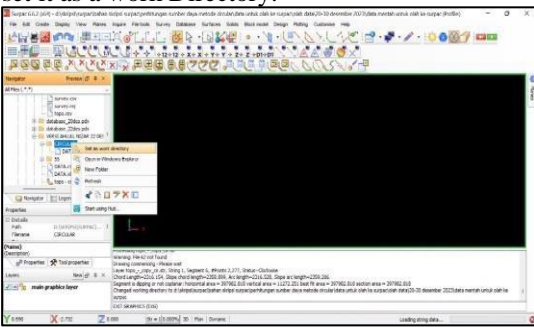


Fig 7. Set As Work Directory display

The function of clicking set as a work directory is so that the files that will be saved will be saved in that folder.

- 4) To display the drill hole, click the Excel file which is already in CSV format on the surpac menu, click the data file then change the CSV to STR by typing.

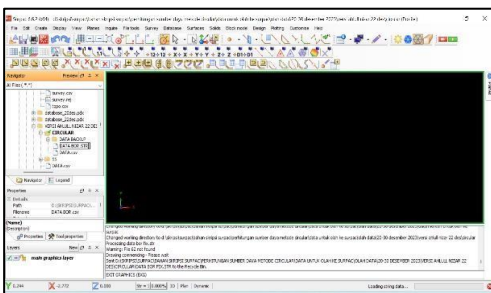


Fig 8. Converting CSV data to str

- 5) Click the finished drill hole file in str format then drag it to the screen.

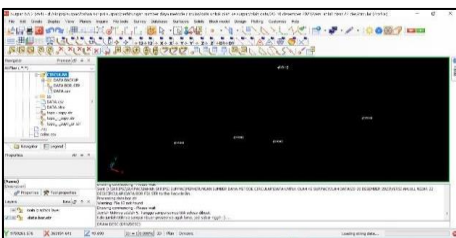


Fig 9. Drill Hole View

- 6) After the drill hole is displayed on the surpac screen, click Create on the menu, and click the circle by the selection, which can be seen in Fig 10.

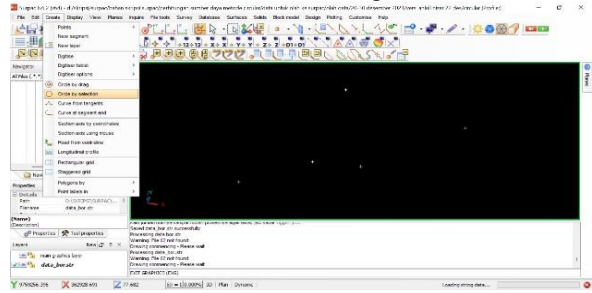


Fig 10. Proses of Making a Circle

- 8) Click on one drill hole point and fill in the radius distance according to the geological conditions in the company which can be seen on the geological map, click apply and apply to all drill hole points.

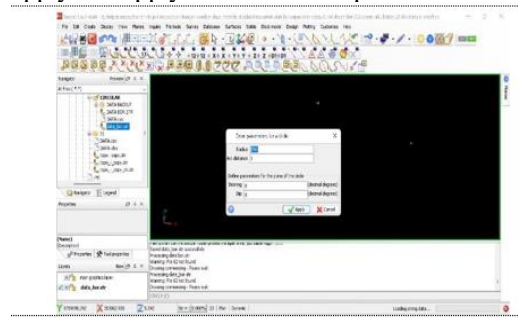


Fig 11. Entering Radius Distance Data

- 9) Geological conditions are geological symptoms that exist on geological maps such as folds, faults, faults, intrusions, and slopes.

- 10) After all the circles are finished, cut the part of the outer circle that is tangent by typing CBT (Clip by Temp Segment) at the bottom of the screen then enter, then click clip segment inside the boundary.

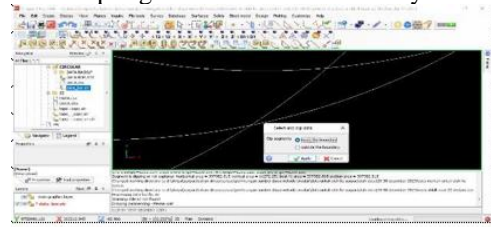


Fig12. Clips Segment

- 11) Click on the circle that is intersecting with 3 clicks to form a triangle. After that, a redo is done on all the circles that are intersecting.



Fig 13. Cutting the Outer Circle

12) After all the intersecting circles have been cut, click the delete segment tool in the Surpac menu to delete the innermost circle.

13) To connect the points that have been cut, click the join the end of one segment tool. When connecting the last point, click the close segment tool. After everything is connected, save the file.

14) Drag the finished circular cropline file to the screen to find out the area, click inquire in the menu, click segment properties, click in the middle of the circular cropline, and then at the bottom of the screen the horizontal area results will appear.

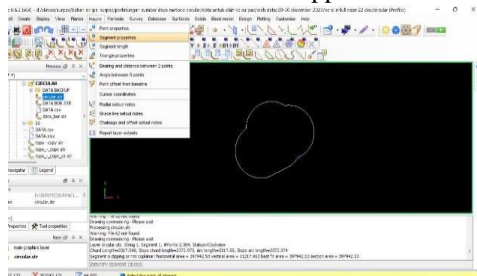


Fig 14. Cropline Circular

15) To calculate Coal tonnage and overburden volume using the circular method, use formulas such as Table 1 and Table 2

2. Calculation of Total Tonnage and Overburden Volume using the Circular Method

Table 1. Total coal tonnage using the circular method

No	Dipp ^o	Cos dip	Ketebalan rata-rata BB (m)	Jarak Radius (m)	Luas (m ²)	Volume (m ³)
1	19	0,94	2,87	100	397.942,53	1.214.994,72
Tonase sumberdaya terukur (ρ = 1,3 ton)					1.579.428,13 ton	

Table 2. Total overburden volume

No	Overburden	Ketebalan rata-rata overburden (m)	Luas (m ²)	Volume (m ³)
1	Sumberdaya Terukur	10,9	397.942,53	1.067.573,57

3. Calculation of stripping ratio / SR

From the calculation of resources, coal volume, and overburden, we can find out the stripping ratio, namely: SR = or 1: 1.08.

From the results of using the circular method with the help of Surpac 6.6.2 circle 100 m software in the resource calculation boundary area of 397,942.53 m², the measured coal resource is obtained at 1,579,428.13 tonnes and an overburden volume of 1,067,573.57 m³ or the equivalent of 1,708,117.71 tons, and a stripping ratio value of 1: 1.08, which means that 1 ton of coal requires 1.08 tons of overburden to be removed.

4. Analysis of data processing results using the circular method

In terms of calculating the measured coal resource tonnage and overburden volume with the help of Surpac 6.6.2 software, has advantages and disadvantages. The disadvantage is that if you make resource croplines from both drill data and survey data you get less accurate calculation results, this circular method does not take into account thickness. coal one by one because to calculate volume, the thickness of the coal is averaged so this is what becomes the loser when calculating coal tonnage and overburden volume, while the advantage of this circular method is that it creates a resource cropline that is easy to apply in the surpac 6.6.2 software.

5. Conclusions and Suggestions

5.1 Conclusion

- 1) Coal resources using the circular method in the PT IUP area. Manggala Alam Lestari in block IV obtained coal tonnage calculation results of 1,579,428.13 tons.
- 2) Overburden volume in block IV at PT. Manggala Alam Lestari using the circular method is 1,067,573.57 m³ or the equivalent of 1,708,117.71 tonnes.
- 3) Capacity stripping ratio value in block IV at PT. Manggala Alam Lestari using the circular method is 1: 1.08, which means that 1 ton of coal requires 1.08 tons of overburden to be removed.

5.2 Suggestions

- 1) The estimation results obtained by researchers can be used as a reference for companies to carry out more accurate calculations.
- 2) Before carrying out data processing, be careful when importing data because even the smallest error can result in less accurate calculation results.
- 3) From the resource calculation method, the author proposes the most appropriate circular method as a material for evaluating resource calculations by PT. Manggala Alam Lestari.

References

- [1] Agus Ardianto Budiman, Ricky Dwi Akhsanul, Sri Widodo. 2018. Estimasi Sumberdaya Batubara dengan Metode Circular usgs pada PT Tuah Globe Kalimantan Tengah. Jurnal Geomine, Vol 6, No. 1: April 2018
- [2] Ahlul Nazar. 2020. Analisis Sumberdaya Terukur Batubara dan Overburden Menggunakan Metode Circular dan Metode Poligon Pada Pt. Inti Bara Nusalima.
- [3] Akhsanul,R.D., Budiman, A. A., & Widodo, S. 2018. Estimasi Sumberdaya Batubara Dengan Metode Circular Usgs Pada PT. Tuah Globe Mining Kalimantan Tengah. Jurnal Geomine. Vol 6. No:1, April 2018.
- [4] Anis Millayanti, Nurdrajat, M.Kurniawan Alfadli,

- Ririn Hindra Fidiarini., 2020. Estimasi sumberdaya Batubara menggunakan metode circular pada seam KS01 dan seam KS02 PIT Kasetu Kalimantan Selatan PT Adaro Indonesia. *Padjadjaran Geoscience Journal*. Vol 4 No 3 Juni 2020. I-ISSN: 2597-4033.
- [5] Arikunto, Suharsimi. 2013. *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: PT Rineka Cipta.
- [6] Aziz, A. 2018. About SR, Density. Tonase. <https://www.scribd.com/doc/67977189/About-SR-Density-Tonase>.
- [7] Badan Standarisasi Nasional. 2015. *Standar Nasional Indonesia (SNI) 5015-2011 pedoman pelaporan sumberdaya dan Cadangan Batubara*. Jakarta.
- [8] Danu Tri Wuryadi, Sunaryo, Dedi Kurniawan Sunaryo, Jasmani. *Permodelan dan Perhitungan Peredeksi Umur Volume Cadangan Batubara pada satu PIT Studi Kasus : Kecamatan Pengaron, Kabupaten Banjar*.
- [9] Dumilah, Retna., Syamsuddin & Aswad, Sabrianto. 2015. Penentuan Cadangan Batubara Dari Data Bor Menggunakan Metode Area Of Influence. *Jurnal Provided by Hasanuddin University Repository*.
- [10] Faris Tirasonjaya. 2018. Batubara Sebagai Sedimen Organik. <http://ilmubatubara.wordpress/diakses> (07/07/2022).
- [11] Ferry Fernando, Uyu Saismana, Riswan, 2022. Perhitungan Sumberdaya Batubara Menggunakan Metode Circular Studi Kasus CV Akbar, desa Keramat Jati. *Jurnal Himasapta*. Vol. 7, No. 3 Desember 2022.
- [12] Gerry T. 2014. Metode-Metode dalam Perhitungan Cadangan Batubara. <https://gerrytri.blogspot.com/2014/10/normal-0-false-false-false-in-xnone-x.html>. (10/07/2022).
- [13] Juli Chandra Teruna dan Kartion. 2016. Perhitungan Cadangan Batubara Dengan Menggunakan Program Surpac 6.2 Berdasarkan Data Pemboran Pada Pit VI di PT. Unirich Mega Persada (UMP) Site Hajak Kabupaten Barito Utara. *Jurnal Geolgi Pertambangan*. Vol. 2 No. 20 September 2016.
- [14] Li Zhilin, Zhu Qing dan Gold. 2018. *Digital Terrain Model Principe and Methodology*. New York: CRC Press.
- [15] Mheea nck. 2018. Seputar Informasi tentang tambang. <https://mheeanck.blogspot.com/2018/12/perhitung-an-cadangan.html> (11/07/2022).
- [16] M.H. Wakila, Anshariah, A.F. Heriansyah, K.Idris. 2023. Estimasi sumberdaya Batubara menggunakan metode circular studi kasus daerah tanjung palas Tengah Kalimantan utara. *Jurnal pertambangan*., Vol 7 No 3.
- [17] Muhammad Dahlan Balfas, Heriyanto, Iswan Arsidi, Human Hanafi. 2018. Estimasi sumberdaya Batubara seam 4 PT. YUF Kalimantan kecamatan Kenohan, kabupaten Kutai Kartanegara provinsi Kalimantan Timur. *Jurnal Teknik Geologi*., Vol. 1 No. 1, hal 4-15, 15 Juli 2018.
- [18] Narebdra Saputra, Dr.Ir. Eddy Winarno, S.Si.,M.T.,. Estimasi Cadangan Batubara dengan menggunakan metode cross section pada daerah bencana penambangan PIT F, Blok III, site air kotok di PT. Ratu Samban Mining, Kabupaten Bengkulu Tengah, Bengkulu.
- [19] Redy M. 2018. Karakteristik overburden batubara <https://tentangbatubara.blogspot.com/2018/10/karakteristikoverburdenbatubara.html> (12/07/2022).
- [20] Rozali, M. R., Saismana, U., Dwiatmoko, M. U., Triantoro. A., & Nuzuliansyah, F. 2015. Perhitungan Cadangan Batubara Dan Permodelan Pit Pada PT Global Indonesia Mandiri, Kabupaten Tapin, Kalimantan Selatan. *Jurnal Geosapta*, Vol 1, No: 1, Juli 2015.
- [21] Triono, Mitra Wardhana. 2014. Perhitungan Cadangan Batubara Terbukti Dengan Menggunakan Metode Cross Section dan Blok Model di Software Surpac Vision V4.0-L Pada CV. Mine Tech Consultant Jobsite PT. Welarco Subur Jaya Kalimantan Timur. *Jurnal Geologi Pertambangan (JPG)*. Vol 1 NO. 14 Tahun 2014.
- [22] Teruna, J.C. 2016. Perhitungan Cadangan Batubara Dengan Menggunakan Program Surpac 6.2 Berdasarkan Data Pemboran Pada Pit VI Di PT. Unirich Mega Persada (UMP) Site Hajak Kabupaten Barito Utara. *Jurnal Geologi Pertambangan (JGP)*. Vol 2, No:20. September 2016.
- [23] SNI 4726-2011. (2011). *Pedoman Pelaporan Sumberdaya dan Cadangan Mineral*. Jakarta : Badan Standarisasi Nasional.
- [24] Sudaryono. 2017. *Metodologi Penelitian*. Jakarta: Rajawali pers.
- [25] Sugiman. 2014. Perhitungan Volume Surface Batu Granit Secara Teristris di PT Mandiri Karya Makmur, dalam penelitian ini menghitung cadangan batu granit dengan cara membandingkan metode pengukuran cadangan menggunakan Software Surpac 6.3 dengan metode manual.
- [26] UU No 3 Tahun 2020 tentang Eksplorasi
- [27] Wandy Marty, Uyu Saismana, & Riswan dkk. Perhitungan Cadangan Batubara Dan Perancangan PIT PT Anugrah Karya Raya Desa Penain Kec Teweh Tengah Kabupaten Barito Utara Kalimantan Tengah. *Jurnal Geosapta*. Vol, No: 1 Juli 2015.
- [28] Wood, G.H., Kehn, T.,M., Carter, M.D. and Culbertson, W, C.,. 1983. Coal resource classification system of the U.S. geological survey.
- [29] Al-Haadi,M. (2022). Estimasi Sumberdaya Batubara Blok C2 PT.Tebo Prima, Site Desa Kunangan, Kecamatan Tebo Ilir, Kabupaten Tebo, Provinsi Jambi (Doctoral dissertation, Universitas Negeri Padang)
- [30] Habibie, M. D., & Prabowo, H. (2020). Estimasi Sumberdaya Batubara Menggunakan Perbandingan Metode Polygon dan Cross Section Di Pit I PT.Atoz Nusantara Mining, Pesisir Selatan, Sumatera Barat. *Bina Tambang*, 5(2), 125- 135.