Coal Potential for Underground Gasification

Aventi, Ir. MT
Madya Engineer, Directorate Technical Development Housing Settlements – Ministry Public Works and Housing Settlements

ABSTRACT (11 Bold):
Abstract: *Based on coal criteria for UCG, Macang Sakti Village, Sanga Village, Musi Banyuasin Regency, South Sumatera Province was chosen with an area around 50 ha. The purpose of this activity is to find out coal modeling to develop UCG as a new energy source.1)*
Data processing uses Research Surface Methodology (RSM).
In the six UCG locations, namely UCG-02 (01), UCG-05 (02A), UCG-7, UCG-9, UCG-11, and UCG-12, found that D layer coal relatively continuous and constant, with different contours. The coal layer on the six locations has been eligible to be used as a UCG coal.
Keywords: *UCG, Coal, RSM.*

INTRODUCTION

UCG is a coal utilization technology carried out through coal conversion in-situ by injecting air or oxygen through injection wells to burn coal layers, which is then produced by gas to be flowed through production wells. The resulting gas then processed into fuel and materials use for other chemical industry (Burton et al, 2006). Partially gasification gas can be used as fuel for power stations and some can be used as synthetic material (syngas) chemicals, such as hydrogen, methanol or other gas chemicals. UCG has advantages because it produces more environmentally friendly gas fuel besides utilizing under surface coal which is currently not economical to mining. The disadvantages, the UCG process has the potential to cause subsidies and pollution of chemical material on groundwater. To avoid the negative impact this application method in the field must be carried out with carefully and through careful AMDAL planning.

Basic parameter in the assessment of coal potential for UCG include coal depth (> 200 m), coal thickness (5 m -10 m), coal characteristics (low ranking, ash + water content < 60 %), coal seam rock (have low permeability) and coal resources (in accordance with the utilization target and operating period) (Burton et al, 2006; Shafirovich et al, 2008, 2009; Imran et al, 2012; Madiutomo, 2014).

In Indonesia this time, UCG is still in research and testing phase and has not been developed at the commercial stage. To support the development of UCG in Indomesia, Resource Center Coal Mineralogy and Geothermal (PSDMBP) has conducted an early study of the potential of the Indonesian under surface coal in 64 locations, with one of the aim to be converted into gas through the UCG method. The results of the evaluation show that in Indonesia UCG should be applied to the subbituminous coal layer which is at a depth of 200 m - 300 m, thickness > 1 m, the best between 5 m - 10 m.

The results of the PSDMBP study in 64 locations in Indonesian under surface coal, recorded the potential of coal resources for UCG is in 54 locations with total resources of 12.7 billion tons (7.8 billion tons on the island of Sumatra and 4.9 billion tons on the island of Kalimantan). The amount of the coal resource can still continue to grow if evaluation and exploration activities continue to be carried out.
Based on coal criteria for UCG, Macang Sakti Village, Sanga Village, Musi Banyuasin Regency, South Sumatera Province was chosen with an area around 50 ha. The purpose of this activity is to find out coal modeling to develop UCG as a new energy source.[1)]

Literature Study
Resource and reserve classes:
a. Hypothetical coal resource: is the number of coal in the inquiry area or part of the inquiry area, which is calculated based on data that meets the conditions set for the stage of investigation of the review survey.
b. Inferred coal resource: is the number of coal in the inquiry area or part of the inquiry area, which is calculated based on data that meets the conditions set for the stage of prospective investigation.
c. Indicated coal resource: is the number of coal in the inquiry area or part of the inquiry area, which is calculated based on data that meets the conditions set for the preliminary exploration phase.
d. Measured coal resoured: is the number of coal in the field of investigation or part of the inquiry area, which is

calculated based on data that meets the conditions set for detailed exploration phases.

e. Probable coal reserve: is indicated coal resource and partly measured coal resources, but based on feasibility study of all related factors have been fulfilled so that the results of the study are acceptable.
f. Proved coal reserve: is measured coal resource based on feasibility study of all related factors have been fulfilled so that the results of the study are acceptable.

Blake (1989) mention that South Sumatera has a coal basin area which is a tertiary-aged bow basin which is formed as a result of the interaction between Sundanese exposure (as part of the Asian continental plate) and the Indian oceanic plate.
The basin area includes an area of 330 x 510 km^2, where the southwest is limited by Bukit Barisan pre-tertiary outcrop, the east by Sundanese exposure (Sunda Shield), the west is limited by the Tigapuluh mountains and southeast is limited by Lampung's height.
Geologically, the formation of coal carrier in the South Sumatra basin is the formation of Talang Roots, Benakat Water, Muara Enim and Kasai, but who have the potential to be the Muara Enim formation. In general, Shell (1978) has separated the Muara Enim formation into 4 based on certain coal layers, namely M1, M2, M3, and M4 (from bottom to top).
Stratigraphy formation Muara Enim, South Sumatera Basin (Shell Mijnbow, 1976):

a. The quarter-aged aluvial formation, terrestrial deposits, generally rucks results, Kasai formation.
b. Kasai formation, green blue clay, glauconitan green sandstone, pumice, coal lens.
c. M-, tufa clay, blue green and clay patches, fine-rough sand, gray white, slight glauconite, thick 120 m - 200 m.
d. M-3, sand and silt by turns, green blue, green gray and brown clay. Horizon sand 3 m - 6 m located 40 m above seam Manggus and there are thick gas pockets between 100 m - 280 m.
e. M-2, clay and clay patches, gray chocolate. Medium fine sand, gray chocolate at the bottom of gray green, thick between 40 m - 120 m.
f. M-1, sand, silt, and brown gray clay with a little glucoitan sand, thick 100 m - 250 m.
g. Benakat, clay and sand patches, gray chocolate and gray blue, some of napalan, fine sand, gray green containing glauconite.

RSM is a collection of statistical and mathematical techniques useful for developing, improving, and optimizing processes. It also has important applications in the design, development, and formulation of new products, as well as in the improvement of existing product designs.

The most extensive applications of RSM are in the industrial world, particularly in situations where several input variables potentially influence some performance measure or quality characteristic of the product or process. This performance measure or quality characteristic is called the response. It is typically measured on a continuous scale, although attribute responses, ranks, and sensory responses are not unusual. Most real world applications of RSM will involve more than one response. The input variables are sometimes called independent variables, and they are subject to the control of the engineer or scientist, at least for purposes of a test or an experiment.

Clearly, if could easily construct the graphical, optimization of this process would be very straight forward. By inspection of the plot, that yield is maximized. Unfortunately, in most practical situations, the true response function is unknown. The field of RSM consists of the experimental strategy for exploring the space of the process or independent variables, empirical statistical modeling to develop an appropriate approximating relationship between the yield and the process variables, and optimization methods for finding the levels or values of the process variables that produce desirable values of the responses (in this case that maximize yield).

Most applications of RSM are sequential in nature. That is, at first some ideas are generated concerning which factors or variables are likely to be important in the response surface study. This usually leads to an experiment designed to investigate these factors with a view toward eliminating the unimportant ones. This type of experiment is usually called a screening experiment. Often at the outset of a response surface study there is a rather long list of variables that could be important in explaining the response. The objective of factor screening is to reduce this list of candidate variables to a relative few so that subsequent experiments will be more efficient and require fewer runs or test.

RSM is useful in the solution of many types of industrial problems. Generally, these problems fall into three categories:

a. Mapping a response surface over a particular region of interest.
b. Optimization of the response. In the industrial world, a very important problem is determining the conditions that optimize the process.
c. Selection of operating conditions to achieve specifications or customer requirements. In most response surface problems there are several responses that must in some sense be simultaneously considered.

RSM is an important branch of experimental design in this regard. RSM is a critical technology in developing new processes, optimizing their performance, and improving the design and /or formulation of new products. It is often an important concurrent engineering tool, in that product design, process development, quality, manufacturing engineering, and operations personnel often work together in a team environment to apply RSM. The objectives of quality improvement, including reduction of variability and improved product and process performance, can often be accomplished directly using RSM.

METHODOLOGY

In general, suppose that the scientist or engineer (whom will refer to as the experimenter) is concerned with a product, process, or system involving a response y that depends on the controllable input variables ξ1, ξ2, ... , ξk. The relationship is

$$y = f(\xi 1, \xi 2, ..., \xi k) + \varepsilon \quad (1)$$

where the form of the true response function f is unknown and perhaps very complicated, and ε is a term that represents other sources of variability not accounted for in f. Thus ε includes effects such as measurement error on the response, other sources of variation that are inherent in the process or system (background noise, or common /special cause variation in the language of statistical process control), the effect of other (possibly unknown) variables, and so on. We will treat ε as a statistical error, often assuming it to have a normal distribution with mean zero and variance σ^2 . If the mean of ε is zero, then

$$E(y) = \eta = E[f(\xi 1, \xi 2, ..., \xi k)] + E(\varepsilon)$$
$$= f(\xi 1, \xi 2, ..., \xi k) \quad (2)$$

The variables ξ1, ξ2, ... , ξk in Equation 2 are usually called the natural variables, because they are expressed in the natural units of measurement, such as degrees Celsius (°C), pounds per square inch (psi), or grams per liter for concentration. In much RSM work it is convenient to transform the natural variables to coded variables x1, x2, ... , xk,
The practical application of RSM requires developing an approximating model for the true response surface. The underlying true response surface is typically driven by some unknown physical mechanism. The approximating model is based on observed data from the process or system and is an empirical model. Multiple regression is a collection of statistical techniques useful for building the types of empirical models required in RSM.

To develop an empirical model relating the effective life of a cutting tool to the cutting speed and the tool angle. A first-order response surface model that might describe this relationship is

$$y = \beta 0 + \beta 1x1 + \beta 2x2 + \beta 3x3 + \beta 4x4 + \varepsilon \quad (3)$$

where y represents the tool life, x1 represents the total moisture, x2 represents the ash, x3 represents the volatile matter, and x4 represents fixed carbon. This is a multiple linear regression model with four independent variables. We often call the independent variables predictor variables or regression. The term "linear" is used because Equation 3 is a linear function of the unknown parameters b0, b1, b2, b3, and b4. The model describes a plane in the two-dimensional x1, x2, x3, and x4 space. The parameter b0 fixes the intercept of the plane. We sometimes call b1, b2, b3 and b4 partial regression coefficients, because b1 measures the expected change in y per unit change in x1 when x2 is held constant, b2 measures the expected change in y per unit change in x2 when x1 is held constant, b3 measures the expected change in y per unit change in x3 when x2 is held constant, and b4 measures the expected change in y per unit change in x4 when x3 is held constant.

In general, the response variable y may be related to k regression variables. The model

$$y = \beta 0 + \beta 1x1 + \beta 2x2 + \dots + \beta kxk + \varepsilon \quad (4)$$

is called a multiple linear regression model with k regresses variables. The parameters βj, j = 0, 1, ... , k, are called the regression coefficients. This model describes a hyper plane in the k-dimensional space of the regression variables {xj}. The parameter βj represents the expected change in response y per unit change in xj when all the remaining independent variables xi (i ≠ j) are held constant.

Models that are more complex in appearance than Equation 4 may often still be analyzed by multiple linear regression techniques.

In general, any regression model that is linear in the parameters (the β-values) is a linear regression model, regardless of the shape of the response surface that it generates.
This method for estimating the parameter in multiple linear regression model. This is often called model fitting.
This coding scheme is widely used in fitting linear regression models, and it results in all the values of x1, x2, x3, and x4.

$$x_{i1} = \frac{\xi_{i1} - [max(\xi_{i1}) + min(\xi_{i1})]}{[max(\xi_{i1}) - min(\xi_{i1})]}$$

$$x_{i2} = \frac{\xi_{i2} - [max(\xi_{i2}) + min(\xi_{i2})]}{[max(\xi_{i2}) - min(\xi_{i2})]}$$

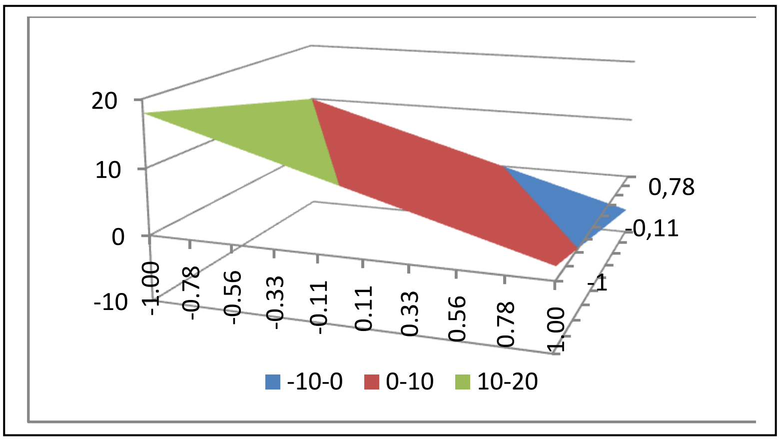
$$x_{i3} = \frac{\xi_{i3} - [max(\xi_{i3}) + min(\xi_{i3})]}{[max(\xi_{i3}) - min(\xi_{i3})]}$$

$$x_{i4} = \frac{\xi_{i4} - [max(\xi_{i4}) + min(\xi_{i4})]}{[max(\xi_{i4}) - min(\xi_{i4})]}$$

RESULTS AND DISCUSSIONS

The following tables presents the data resulting from an investigation into the effect of four variables, total moisture (ξ_1), ash (ξ_2), volatile matter (ξ_3), and fixed carbon (ξ_4), on the percentage conversion of calorific value (y). The process engineers had used an approach to improving this process based on designed experiments. The first experiment was screening experiment involving several factors that total moisture, ash, volatile matter, and fixed carbon, as the four most important variables.

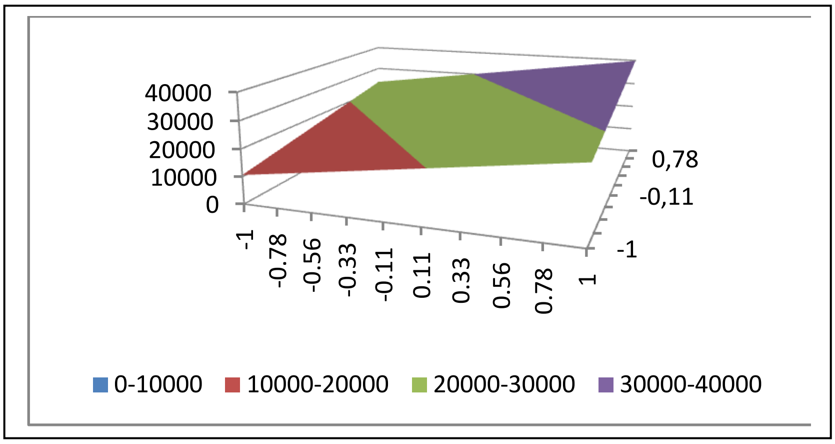
The following figures shows the fitted response surface for this model.
The first portion of the display is a plot of the values of the observed response y versus the predicted values ^yi. The pairs (yi, ^yi) lie closely along a straight line (the straight line in the graph is a result of a least squares fit). This is usually a good indication that the model is a satisfactory fit to the data.



UCG-02 (01)	Total Moisture (%)	Ash (%)	Proximate Volatile Matter (%)	Fixed Carbon (%)					Calorific Value (cal/g)
No	ξ_1	ξ_2	ξ_3	ξ_4	X_1	X2	X3	X4	Y
1	31,8	2,11	41,68	42,76	0,25	0,068	0,25	-0,25	6,098
2	31,05	2,15	39,99	44,68	0,017	0,25	-0,25	0,25	6,124
3	30,19	2,04	41,47	43,54	-0,25	-0,25	0,188	-0,047	6,275
Rata^2	31,01	2,1	41,05	43,66					6,166
Maks	31,8	2,15	41,68	44,68					
Min	30,19	2,04	39,99	42,76					

Source: Asep et al, 2017, Coal Potential for Underground Gasification Development: Case Study Macang Sakti Village, South Sumatera Province.

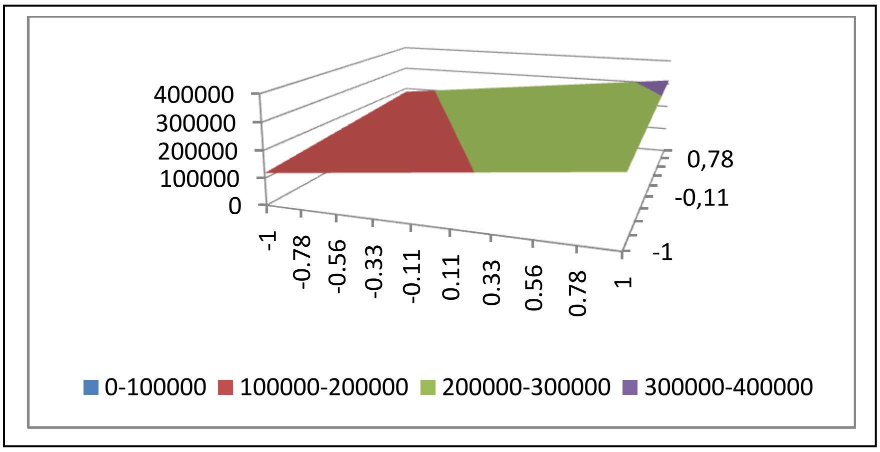
At the UCG-02 (01) location, found that D layer coal relatively continuous with thickness relatively constant. In terms of quality, this coal layer is included in the subbituminous, the calorific value of 6,166 kcal/kg, average total water content of 31.01 %, average ash content 2.1 %, average volatile matter of 41.05 %, average fixed carbon content of 43.66 %, water content + ash content < 60 %. Then the coal layer at this location has been eligible to be used as a UCG coal.



UCG-05 (02A)	Total Moisture (%)	Ash (%)	Proximate Total Moisture (%)	Ash (%)					Calorific Value (cal/g) Total Moisture (%)
No	ξ_1	ξ_2	ξ_3	ξ_4	X_1	**X2**	**X3**	**X4**	**y**
1	31,44	2,1	40,46	43,43	0,07	0,03	-0,18	0,14	5,993
2	31,53	1,88	40,33	43,48	0,25	-0,25	-0,25	0,25	6,078
3	31,28	2,27	41,21	43,26	-0,25	0,25	0,25	-0,25	6,212
Rata^2	31,42	2,08	40,67	43,39					6,094
Maks	31,53	2,27	41,21	43,48					
Min	31,28	1,88	40,33	43,26					

Source: Asep et al, 2017, Coal Potential for Underground Gasification Development: Case Study Macang Sakti Village, South Sumatera Province.

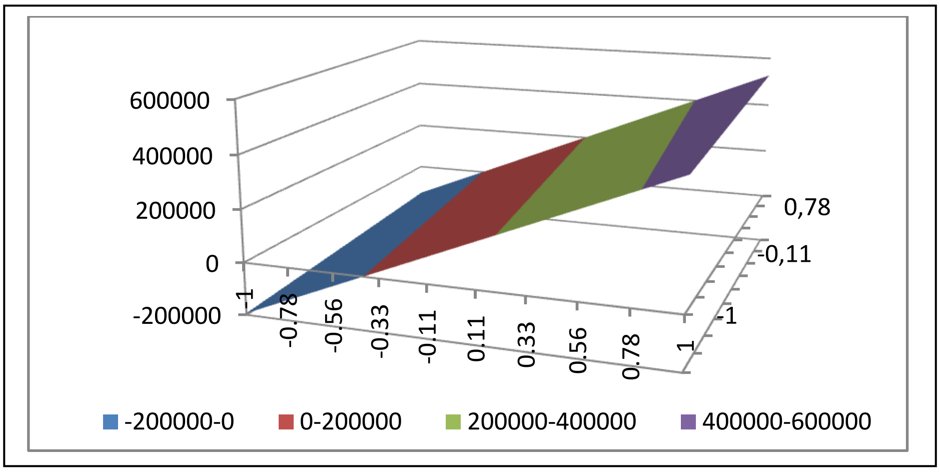
At the UCG-05 (02A) location, found that D layer coal relatively continuous with thickness two times the thickness at location of UCG-02 (01), relatively constant, with different contours. In terms of quality, this coal layer is included in the subbituminous, the calorific value of 6,094 kcal/kg, average total water content of 31.42 %, average ash content 2.08 %, average volatile matter of 40.67 %, average fixed carbon content of 43.39 %, water content + ash content < 60 %. Then the coal layer at this location has been eligible to be used as a UCG coal.



UCG-07			Proximate						Calorific Value (cal/g) Total Moisture (%)
	Total Moisture (%)	Ash (%)	Total Moisture (%)	Ash (%)					
No	ξ_1	ξ_2	ξ_3	ξ_4	X_1	X2	X3	X4	Y
1	34,92	1,57	38,41	45,1	-0,151	-0,25	-0,133	0,229	5,961
2	33,55	1,61	39,49	45,35	-0,25	-0,208	0,25	0,25	6,053
3	40,44	2,05	38,08	39,43	0,25	0,25	-0,25	-0,25	5,619
Rata^2	36,3	1,74	38,66	43,29					5,878
Maks	40,44	2,05	39,49	45,35					
Min	33,55	1,57	38,08	39,43					

Source: Asep et al, 2017, Coal Potential for Underground Gasification Development: Case Study Macang Sakti Village, South Sumatera Province.

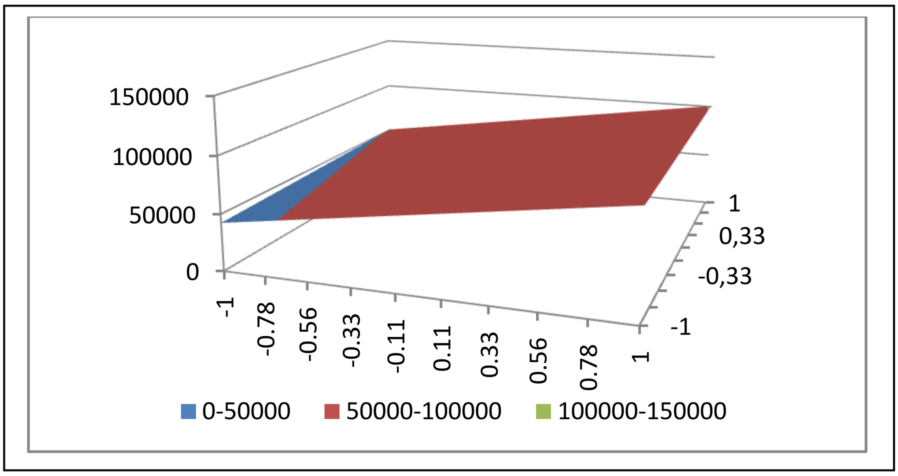
At the UCG-07 location, found that D layer coal relatively continuous with thickness relatively same at the location of UCG-05 (02A), with different contours. In terms of quality, this coal layer is included in the subbituminous, the calorific value of 5,878 kcal/kg, average total water content of 36.3 %, average ash content 1.74 %, average volatile matter of 38.66 %, average fixed carbon content of 43.29 %, water content + ash content < 60 %. Then the coal layer at this location has been eligible to be used as a UCG coal.



UCG-09			Proximate						Calorific Value (cal/g) Total Moisture (%)
	Total Moisture (%)	Ash (%)	Total Moisture (%)	Ash (%)					
No	ξ_1	ξ_2	ξ_3	ξ_4	X_1	X2	X3	X4	y
1	30,69	5,31	40,05	41,5	-0,247	0,25	-0,189	-0,25	5.850
2	44,6	2,83	40,63	43,09	0,25	-0,201	0,25	0,25	5.957
3	30,61	2,56	39,97	42,57	-0,25	-0,25	-0,25	0,086	5.980
Rata^2	13,24	1,34	15,08	15,9					5.929
Maks	44,6	5,31	40,63	43,09					
Min	30,61	2,56	39,97	41,5					

Source: Asep et al, 2017, Coal Potential for Underground Gasification Development: Case Study Macang Sakti Village, South Sumatera Province.

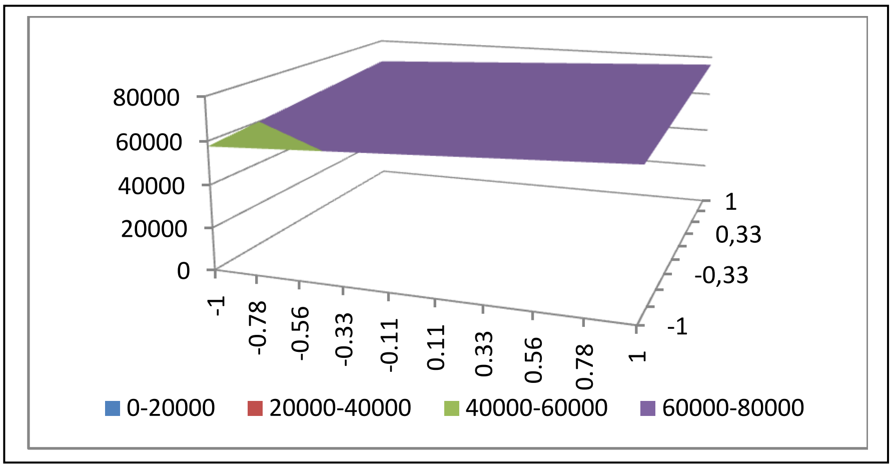
At the UCG-09 location, found that D layer coal relatively continuous with thickness relatively three times the thickness at location UCG-02 (01), relatively constant, with different contours. In terms of quality, this coal layer is included in the subbituminous, the calorific value of 5,929 kcal/kg, average total water content of 13.24 %, average ash content 1.34 %, average volatile matter of 15.08 %, average fixed carbon content of 15.9 %, water content + ash content < 60 %. Then the coal layer at this location has been eligible to be used as a UCG coal.



UCG-11	Total Moisture (%)	Ash (%)	Proximate Total Moisture (%)	Ash (%)					Calorific Value (cal/g) Total Moisture (%)
No	**ξ_1**	**ξ_2**	**ξ_3**	**ξ_4**	**X_1**	**X2**	**X3**	**X4**	**y**
1	35,38	2,41	41,66	40,55	-0,25	-0,166	0,25	-0,006	5.902
2	38,29	4,88	37,75	39,08	0,25	0,25	-0,25	-0,25	5.651
3	37,28	1,91	38,72	42,09	0,076	-0,25	-0,126	0,25	5.961
Rata²	36,98	3,07	39,38	40,57					5.838
Maks	38,29	4,88	41,66	42,09					
Min	35,38	1,91	37,75	39,08					

Source: Asep et al, 2017, Coal Potential for Underground Gasification Development: Case Study Macang Sakti Village, South Sumatera Province.

At the UCG-11 location, found that D layer coal relatively continuous with thickness relatively one-third the thickness at location UCG-05 (02A), relatively constant, with different contours. In terms of quality, this coal layer is included in the subbituminous, the calorific value of 5,838 kcal/kg, average total water content of 36.98 %, average ash content 3.07 %, average volatile matter of 39.38 %, average fixed carbon content of 40.57 %, water content + ash content < 60 %. Then the coal layer at this location has been eligible to be used as a UCG coal.



UCG-12			Proximate						Calorific Value (cal/g) Total Moisture (%)
	Total Moisture (%)	Ash (%)	Total Moisture (%)	Ash (%)					
No	**ξ_1**	**ξ_2**	**ξ_3**	**ξ_4**	**X_1**	**X2**	**X3**	**X4**	**y**
1	36,85	2,48	39,56	41,11	0,25	-0,25	0,064	-0,25	5.829
2	34,31	3,51	40,62	41,56	-0,25	0,08	0,25	0,009	5.941
3	35,05	4,04	38,93	41,98	0,104	0,25	-0,25	0,25	5.948
Rata^2	35,4	3,34	39,7	41,55					5.906
Maks	36,85	4,04	40,62	41,98					
Min	34,31	2,48	38,93	41,11					

Source: Asep et al, 2017, Coal Potential for Underground Gasification Development: Case Study Macang Sakti Village, South Sumatera Province.

At the UCG-12 location, found that D layer coal relatively continuous with thickness relatively same at the location of UCG-11, relatively constant and flat, with different contours. In terms of quality, this coal layer is included in the subbituminous, the calorific value of 5,906 kcal/kg, average total water content of 35.4 %, average ash content 3.34 %, average volatile matter of 39.7 %, average fixed carbon content of 41.55 %, water content + ash content < 60 %. Then the coal layer at this location has been eligible to be used as a UCG coal.

Coal is modeled and calculated is coal that qualifies to be exploited with the UCG method, namely having thickness > 5 m and coal depth between 200 m - 300 m, ranked lignit - subbituminous and the amount of moist water content and ash content < 60 % (Khadse et all, 2007; Friedmann et all, 2009; Kreynin, 2012; Bhutto et al, 2013; Imran et al, 2014; Santoso, 2015) (Asep et al, 2017).

Based on BSN (2011), the geological conditions at this coal location are considered moderate, so the area of coal influence follows moderate geological conditions, with an area of influence for measurable resources of 250 m, indicated resources of 250 m - 500 m, and inferred resources 500 m - 1000 m. After being compiled with 200 m - 300 m depth contour, found the deliniated area of D layer coal resource, with the amount of measured resources of 3,446,166 m^3, indicated resources of 1,468,892.6 m^3, and inferred resources of 2,551,214 m^3. With the results of coal density test of 1.29, the coal is converted to tonnage by multiplying a density factor of 1.29, thus getting D layer of coal to be measured resources of 4,479,951 tons, indicated resources of 1,909,560 tons, and inferred resources of 3,316,578 tons (Asep et al, 2017).

CONCLUSION

The coal resources the Formation of Muara Enim the basin of South Sumatera have a great opportunity to be used as an activity area for UCG research. Coal resources in this basin are relatively large, so they are chosen to be a research location conducted by the UCG team of Research and Development Center of Mineral and Coal Technology. Based on the detailed coal drilling activities that have been carried out, found D layer coal resources as follows: measured resources of 4,479,951 tons, indicated resources of 1,909,560 tons, and inferred resources of 3,316,578 tons and fulfill the aspect of the thickness parameter more than 5 m which is 9 m with depth between 200 m - 300 m (Asep et al, 2017). In the six UCG locations, namely UCG-02 (01), UCG-05 (02a), UCG-7, UCG-9, UCG-11, and UCG-12, found that D layer coal relatively continuous and constant, with different contours. The coal layer on the six locations has been eligible to be used as a UCG coal.

REFERENCES

[1] *Asep. B. P, Yudha. S. S, Yoga. A. S, Budi. M, Binarko. S, January 30, 2017, Coal Potential for Under Surface Gasification Development: Case Study Macang Sakti Village, South Sumatera Province, Journal of Mineral Technology and Coal Road.*

[2] *Geological Agency, Underground Coal Gasification (UCG), Another Alternative to The Utilization of Subsurface Coal, Ministry of Energy and Mineral Resources. https://r.search.yahoo.com/_ylt=Awr9DtgRx1Fiz6sAKkxXNyoA;_ylu=Y29sbwNncTEEcG9zAzEEdnRpZAMEc2VjA3Ny/RV=2/RE=1649555346/RO=10/RU=http%3a%2f%2fpsdg.geologi.esdm.go.id%2findex.php%3foption%3dcom_content%26view%3darticle%26id%3d1230%26Itemid%3d610/RK=2/RS=6uOmh7hQIn6CCRF9kGrXK.xrZJU-.*

[3] *Fyoe Tech, South Sumatera Coal Basin. https://r.search.yahoo.com/_ylt=Awr9ImMH0VFiWzMAvW9XNyoA;_ylu=Y29sbwNncTEEcG9zAzMEdnRpZAMEc2VjA3Ny/RV=2/RE=1649557896/RO=10/RU=https%3a%2f%2ffyofa.blogspot.com%2f2012%2f10%2fcekungan-batubara-sumatera-selatan.html/RK=2/RS=erdnniowGxRvrSg_m_ULWh92fto-.*

[4] *Raymond. H. M, Douglas. C. M, Christine. M. A, Response Surface Methodology, Process and Product Optimization Using Designed Experiments, Wiley Series in Probability and Statistics, Third Edition.*

[5] *SNI Amendment 1 - SNI 13-5014-1998, Classification of Resources and Coal Reserves, ICS 73,020, National Standardization Agency. https://r.search.yahoo.com/_ylt=Awr9Ilojy1FifHcAoOpXNyoA;_ylu=Y29sbwNncTEEcG9zAzIEdnRpZAMEc2VjA3Ny/RV=2/RE=1649556388/RO=10/RU=http%3a%2f%2fpsdg.geologi.esdm.go.id%2fkepmen_pp_uu%2fSNI_13-5104-1998.pdf/RK=2/RS=AYdTjL6dHd7Yr3Mz7SwLdqlDjHg-.*

