

# THE ANALYSIS OF COAL LIQUEFACTION WITH THE UTILIZATION OF LIMONITE CATALYST ON CENTRAL BANKO, TANJUNG ENIM SOUTH SUMATERA

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**Abstract.** Coal liquefaction process that often said as a hydrogenation degradation were direct conversion from solid structure of coal becoming liquid product was done. Catalyst on liquefaction of coal using to insert H atom from catalytic dissociation H<sub>2</sub> molecular into the coal or mixture of coal-solvent therefore could increase the availability active hydrogen. This research propose to know the comparison between coal liquefaction process using catalyst and without catalyst on liquefaction process of central Banko coal, South Sumatera by using the equipments such as, autoclave 500, soxhlet. Distillation installation, oven+exilator, of operation condition in this matter was % catalyst, temperature and time on anthracene solvent toward conversion resulted from liquefaction process of bankotengah coal, south Sumatera. From analysis and the measurement, resulting % conversion ( THF extraction result) highly on 96,988% on temperature 400<sup>o</sup> C, catalyst = 2 % and time on 75 minutes for coal liquefaction by using catalyst and the highest conversion for coal liquefaction without using catalyst were on operation condition at 425<sup>o</sup>C temperature and 75 minute operation time which reach 65.4695 % conversion result . This research on liquefaction of Central Banko coal with limonite catalyst and anthracene solvent on this variable and this operation condition , actually resulting high % conversion compare with previous research

**Keywords:** Coal Liquefaction, Catalyst, Conversion

## I. INTRODUCTION

Indonesia is a country that has enormous coal resources where the utilization is still very limited, namely for direct burning in power plants for the cement industry and other small industries. The utilization of coal can not be separated from various problems, specially on pollution. It can be answered with the use of clean coal technologies are constantly being developed and applied. one of these technologies is coal liquefaction

Another consideration is due to the characteristics of coal itself, such as the nature of combustion and fuel handling liquid or gas is more profitable than with solid fuel. Basically all rank of coals can be transformed into liquid by adding hydrogen atoms into the chemical structure. It is known that the enhancement of Indonesian coal varies from Peat, Lignite, subbituminous anthracite and bituminous was found even in small quantity

Realizing the majority of Indonesian coal is rated relatively low and marketshare for this area is very limited, it is important to applied a new valuable technology in order to increase the added value of coal utilization. It can be done

with coal liquefaction technology, which as one alternative substitute on petroleum, where this liquefaction technology are to produce liquid and gas that is equal to the petroleum processing [1].

Coal liquefaction process was developed in the laboratory on the center of Coal and Mineral Utilization and Processing Technology [2]. This process is often called as *degradative direct hydrogenation* of the solid structure of coal into liquid product. [3] [4]

The role of catalyst in the coal liquefaction is to enter the H atom from the molecular dissociation H<sub>2</sub> catalytic into coal. Thereby increasing the availability of active hydrogen. Hydrogen will serve to aromatic hydrogenate, promotes bonding and stabilizing the concentration of the reaction of free radicals and prevent [5].

The factors that affect to the coal liquefaction product was the catalyst as coal bond, the ratio of coal and solvent, the operation conditions (temperature, pressure and time), the type of catalyst and the catalyst particle size. The catalyst in the liquefaction of coal is a very important component because it will affect the products results [6].

According to research by *Gwathmey* and *Cunningham* (1960) catalyst is a compound that changes the speed of a chemical reaction, even at the end of the reaction, the catalyst remains there and does not undergo a permanent chemical change. However, the physical state of the catalyst can be changed.

Other catalytic reactions such as removal of heteroatoms, acid cracking and condensation. The activity and selectivity of the catalyst is strongly influenced by disperse catalyst. The catalyst dispersion increases due to higher catalyst surface area and surface particle size, while decreasing the catalyst particle size will make a high conversion of coal on liquefaction process. [7] [8] [9]. This study conduct to obtain the comparison on conversion results of synthetic oil between the liquefaction process without catalysts and using catalyst for Central Banko coal, South Sumatra [10].

## II. METHODOLOGY

### 1. Raw Materials and Equipment

#### A. Mineral

##### a. Coal

Coal that used and becomes sample in this study is the Banko Tengah coal, on Tanjung Enim South Sumatera.

##### b. solvent

Anthracene oil used as a solvent or solvent derived from KOBELCO, CO.Ltd.Japan (Appendix 5).

##### c. catalyst

The catalyst used in this study, is a byproduct of Soroakonickel mining, with spare  $\pm$  108.5 million tonnes (NEDO Study). Economically, catalysts have qualified and well used to process coal liquefaction (easily available, relatively cheap / reserves a lot, and the Fe content is quite large and most mineral-quartz due to relatively can improve conversion rate.

The catalyst material in the form of limonite ( $\gamma$ -FeOOH) which is a synthetic catalyst of Soroako, PT. International Nickel Indonesia and KOBELCO, Co.Ltd., Japan).

### 2. Coal Preparation and Analysis of Coal

Coal Characteristic analysis carried out by grinding the coal to pass 60 mesh size. Preparation of coal sample for melting experiments carried out by grinding the coal to pass the 200 mesh size.

Coal that become samples from Banko Tengah Coal, solvent (Anthracene) and a catalyst obtained from PPTM.

### 3. Equipment

- b. autoclave 500 ml Andreas Hoffer
- c. Soxhlet (a set of tools extraction)
- d. Distillation Equipment
- e. Oven + exicator

### f. Analytical balance equipment

## Coal Liquefaction Procedure

1. Coal that has been mashed dried for  $\pm$  24 hours
2. Oil solvent (Anthracene), catalyst and sulfur weighed with a certain weight, then it all put to the autoclave
3. Autoclave prepare on immaculate condition, enter the first balls of stainless steel (as stirrer) are weighed and then enter each of the coal, sulfur, catalyst, and antrasen.
4. Then, the hydrogen gas flow into the autoclave until ascertain pressure, followed by heating and stirring the initial start up, as well as other control devices such as temperature controllers, pressure 3 and recorder.
5. Temperatures starters between 24-25<sup>0</sup>C (room temperature), the temperature rise and the pressure continues to be observed every 10 minutes, when the operating temperature has been reached, the temperature is maintained for a specific operation and continued to be observed.
6. Furthermore, the autoclave was cooled and left at room temperature for 12 hours.
7. liquid product (slurry) was taken, and then cleaned then weighed.

- ### b. Product Analysis and Determination of Conversion
- Determination of the conversion products obtained from the sum of the results of calculations percent of the product. The equation for calculating the percent of products listed on the following formula:

$$\% \text{ Product} = \frac{EP}{BU - BA - BW} \times 100\%$$

### c. Operating Condition and Calculations

In this study, experiments on Central Banko coal samples is done by using a variation:

- a. The addition of the catalyst (Without a catalyst, 1%, 2% and 3%)
- b. Operating time 45, 60 and 75 minutes and
- c. Temperatures of 375, 400 and 425<sup>0</sup>C

the experiments calculated on:

1. Conversions% extraction: N-Hexana, toluene and THF
2. Conversions%<sub>solid-liquid</sub> coal products

## III. RESULTS AND DISCUSSION

### 1 Coal Analysis

Coal used in this study is the Banko Tengah coal because of its potential in the future. The result of coal proximate analysis and coal ash analysis as contained in the following table

:

TABLE I

PROXIMATE ANALYSIS AND ULTIMATE ANALYSIS RESULT ON  
CENTRAL BANKO COAL, SOUTH SUMATERA

Proximate analysis	Ultimate Analysis
Air Moisture (% adb) 10.87	Carbon (% adb) 02,98
Abu (% adb) 2.39	Hydrogen (% adb) 6,18
Volatile matter (% adb) 43.53	Nitrogen (% adb) 0.37
Solid carbon (% adb) 43.21	oxygen 27.11
Calorific value, cal / g, adb 5965	Total sulfur (% adb) 0.47

TABLE II

COAL DUSH COMPOSITION ANALYSIS RESULT

Analysis	Yield (% by weight)
S <sub>1</sub> O <sub>2</sub>	24.6
Al <sub>2</sub> O <sub>3</sub>	17,31
Fe <sub>2</sub> O <sub>3</sub>	12.78
TiO <sub>2</sub>	0.91
CaO	18.55
MgO	1.74

The analysis of coal as in table above. For Bankotengahcoal, the classification was on class subbituminus low rank coal.

## 2. Coal liquefaction

In this section we will discuss the liquefaction results that obtained from experiments on coal samples above.

For operating conditions with variations on time and the addition of the catalyst is done at 425 °C, which is the temperature apply on liquefaction process in this study. The results of calculations and analysis can be seen in Table IV.

### a. Effect of Variation Percent Against Time Conversion

The addition of the catalyst at the time variation showed increased liquid products from coal liquefaction process. This is because the catalyst can accelerate the reaction between free radicals (coal fragment warming that has free electrons) with a hydrogen donor solvent.

TABLE III

THE RESULTS OF CONVERSION PRODUCT ON COAL  
LIQUEFACTION AT 425° C TEMPERATURE

Catalytic %	Time (Min)	% Products				% Conversion		
		Oil + Gas + Water	Asphaltene	Preasphaltene	Residue	Extraction N-Hexane	Toluene extraction	Extraction THF
-	45	29.66	21.44	13.06	35.82	29.66	51.10	64.17
	60	30.70	9.74	13.61	45.94	30.70	40.44	54.06
	75	43.47	13.89	8.09	34.53	43.47	57.37	65.46
1	45	69.66	13.19	6.31	10.81	69.66	82.85	89.18
	60	69.01	14.85	4.47	11.65	69.01	83.86	88.34
	75	68.27	16.24	4.02	11.45	68.27	84.52	88.54

2	45	65.80	15.90	6.82	11.47	65.80	81.70	88.53
	60	77.43	13.54	5.01	4.00	77.43	90.97	95.99
	75	74.04	10.74	5.08	10.12	74.04	84.78	89.87
3	45	74.78	11.35	4.93	8.92	74.78	86.14	91.07
	60	76.26	9.97	5.20	11.37	76.26	86.24	88.62
	75	70.30	11.92	5.96	11.80	70.30	82.22	88.19

From the table, shows that the time reaction is not dominant, compared to the addition of the percent catalyst, the conversion results obtained in 45-75 minute variation times show the fluctuations, which with the addition of time will be able to increase or decrease the conversion. It means that the increase in time reaction will affect to the increase on value of the conversion, and then the research perform at the 75 minute operating time.

### b. Temperature Variations Against Percent of Product and Conversion

TABLE IV

THE RESULT ON THE EFFECT OF TEMPERATURE AND  
CONVERSION PRODUCT OF COAL LIQUEFACTION AT 400° C.

temp °C	Catalytic %	Time (Min)	% Products				% Conversion		
			Oil + Gas + Water	Asphaltene	Preasphaltene	Residue	Extraction N-Hexane	Toluene extraction	Extraction THF
400	-	75	27.83	9.05	10.66	52.45	27.83	36.88	47.54
	1	75	53.63	20.09	20.83	5.43	53.63	73.73	94.56
	2	75	59.77	25.12	14.45	0.64	59.77	84.97	96.88
	3	75	55.04	28.07	13.57	3.30	55.04	83.12	96.69

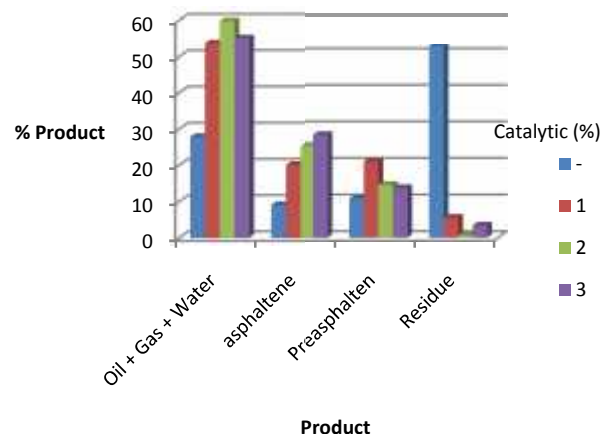


Fig. 1. The % Product on Liquefaction Process

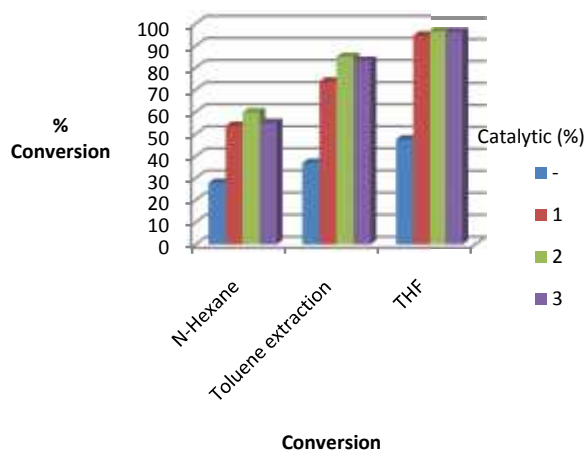


Fig. 2. The % Conversion on Liquefaction Process

From Table 4 and Figure 1 and 2, shows that the best conversion for the liquefaction using catalyst was at a temperature of 400 °C. At 400 °C, coal liquefaction process is expected to react to the fullest. As for the liquefaction process without catalyst was better at a temperature of 425 °C. Subsequent heating at 425 °C operating temperature will protect the reactive part of the process of coal liquefaction. The focus for further research aimed at temperatures of 400 °C

**c. The addition of catalyst variation Against Percent of Conversion**

TABLE V

OBSERVATION RESULTS ON THE EFFECT OF OPERATING CONDITION AGAINST COAL LIQUEFACTION CONVERSION PRODUCTS AT 400 °C TEMPERATURE

Catalytic (%)	Time (Min)	% Products				% Conversion		
		Oil + Gas + Water	Asphaltene	Pre asphaltene	Residue	Extraction N-Hexane	Toluene extraction	Extraction THF
-	75	27.83	9.050	10.66	52.45	27.83	36.88	47.54
1	75	53.63	20.09	20.83	5.43	53.63	73.73	94.56
2	75	59.77	25.12	14.45	2.64	59.77	84.90	96.88
3	75	55.04	26.07	13.57	3.30	55.04	83.12	96.69

For the liquefaction using catalysts known that the variation on catalyst percent and stayed the same time (75 minutes) obtained the highest conversion results in the addition of 2% of the catalyst, in the amount of 96.8889% (maximum reaction conditions) compared with the addition of 3% catalyst, wherein a decline in percent conversion was not so significant (large) so in terms of addition of the catalyst is best taken at 2%.

With the addition of the catalyst over 2%, the activity of the catalyst will be reduced. In the graph shown in the comparison of each conversion percentage rate for the extraction of N-

Hexane, Toluene and THF. While for coal liquefaction without catalysts known that a best conversion was at a temperature of 425 °C with operating time of 75 minutes resulted in a conversion of 65.4695%.

**IV. CONCLUSION**

Recommendations on the research results in the form of:

1. For coal liquefaction using catalyst, the results of conversion percent (extracted THF) by 96.8889% at the operating temperatures = 400 °C, Catalyst concentration = 2%, operating time 75 minutes. While the liquefaction of coal without catalyst, the best conversion results at a temperature of 425 °C with 75 minutes operating time resulting 65.4695% conversion.
2. Coal liquefaction better and more effective by the utilization of catalyst due to a high conversion rate that is equal to 96.8889% compared the coal liquefaction without catalyst in which the highest conversion rate only at 65.4695%.

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