spark assist system.

iii) Spark assist system

This spark assist system is developed by Komatsu in Japan, where 100% methanol can be combusted. To obtain highest thermal efficiency, compression ratio is identical to that for the petroleum fuel. However, at the end of compression stage of stroke cycle, methanol is injected using the diesel method and one of sprays is ignited by spark, and then the combustion spreads to the rest of the fuel mist.

Fig. 8-4-5 shows the position of the spark plug in a combustion chamber. Since an ordinary spark plug in gasoline engine is designed for petroleum, it has a problem in igniting capability and durability, therefore the spark plug employed here have been tailor-made by welding platinum chips (Fig. 8-4-6).

Fig. 8-4-7 presents a drawing of the igniter and distributor.

The previous section depicted the measure against low cetane value of methanol. However, only with this, the use of methanol is not possible to diesel engines which have been designed for petroleum fuel. Table 8-4-3 illustrates methods actually taken in perfecting the system. A method of all these trouble predictions and measures is generally called as "FMEA".

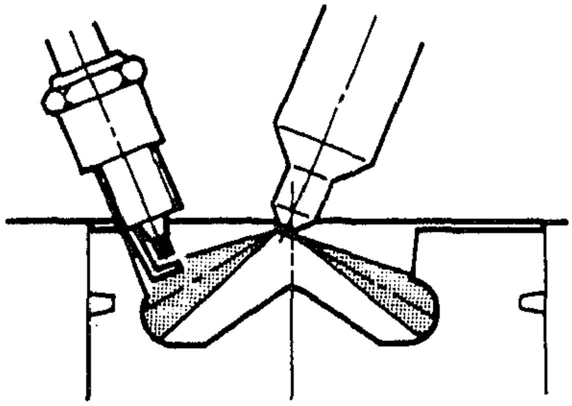
(4) Performance of Spark Assist Diesel Engine

1) Turbocharged diesel engine with spark assist

Table 8-4-4 shows an engine whose specifications are 4-cycle, turbo-charged, direct injection, water-cooled, piston displacement: 4.33 ltr., cylinder bore: 105 mm, stroke: 125 mm, and compression ratio: 16.0 because of use of turbocharger.

Though a diesel engine generally uses a smaller injection pump, an injection pump of one class larger capacity has been employed because of its lower

Fig. 8-4-5 **Schematic of spark plug installation**



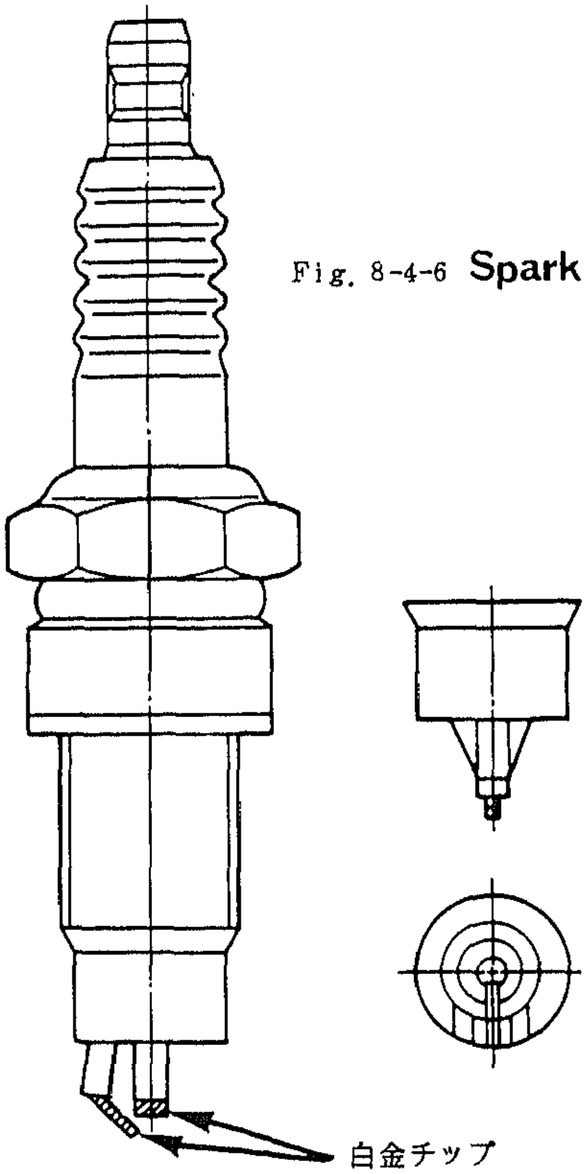


Fig. 8-4-6 Spark plug confiquration

Fig. 8-4-7 **SPARK ASSISTED DIESEL**

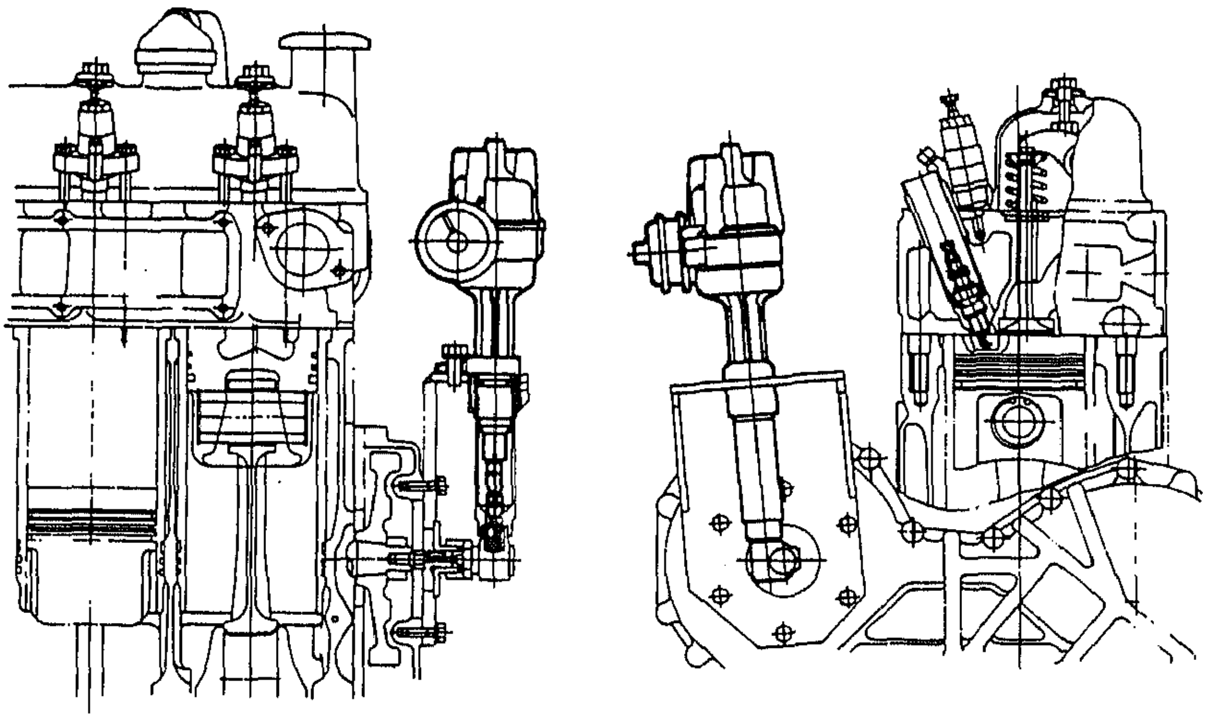
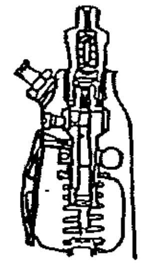


Table 8-4-3 FMEA of Fuel Injection System for Methanol Fuel

Fuel Properties			Failure Modes	Counter Measures
Viscosity	Methanol 0.7 cst	Diesel fuel 2.3 cst	Seizure of fuel system	Pressure lubrication of fuel pump → (Multi fuel type injection pump) 
Low specific gravity Low heating valve (Kcal/kg)	Methanol 0.76 Methanol 4800	Diesel fuel 0.83 Diesel fuel 103200	Injection quantity is too small in weight to get same power as that by diesel fuel	Bigger injection pump → (A Type → P Type)
Corrosion erosion	$CH_3OH \rightarrow HCOOH$ Strong affinity with water		Corrosion erosion oxidation	▪ Rubber hose → Nitric type rubber hose ▪ Steel pipe → *Stainless steel pipe* ▪ Steel fabricated tank → Ni-plating

engine type	4 cycle, turbocharged
number of cylinders	4
type of combustion	direct injection
cooling	water
displacement	4330cc
bore	105mm
stroke	125mm
compression ratio	16.0
injection pump	Bosch P
injection nozzle	hole type
number of injection hole	4
ignitor	commercial automotive CDI, multi-strike type

Table 8-4-4 Engine Specification

calorific value. Injection nozzle is the hole type, and includes four holes.

i) Fuel consumption

Fig. 8-4-8 shows a performance map where horizontal axis is an engine RPM and vertical axis is a mean effective pressure (kg/cm^2) and the pattern is made of constant-fuel-consumption lines (unit: g/ps.h). The minimum fuel consumption is 300 g/ps.h at around 1,800 RPM. This compared to diesel oil which consumes only 150 - 160 g/ps.h, seems to be badly inferior. However, it is reasonable because of low carolific value of methanol. Then what about thermal efficiency? As the Fig. 8-4-9 indicates, methanol marks values almost similar to diesel oil.

ii) Exhaust gas emission

The Fig. 8-4-10 is a NOx map, and shows a maximum of 500 PPM at a maximum PME. The Fig. 8-4-11 a HC map and Fig. 8-4-12 a CO map.

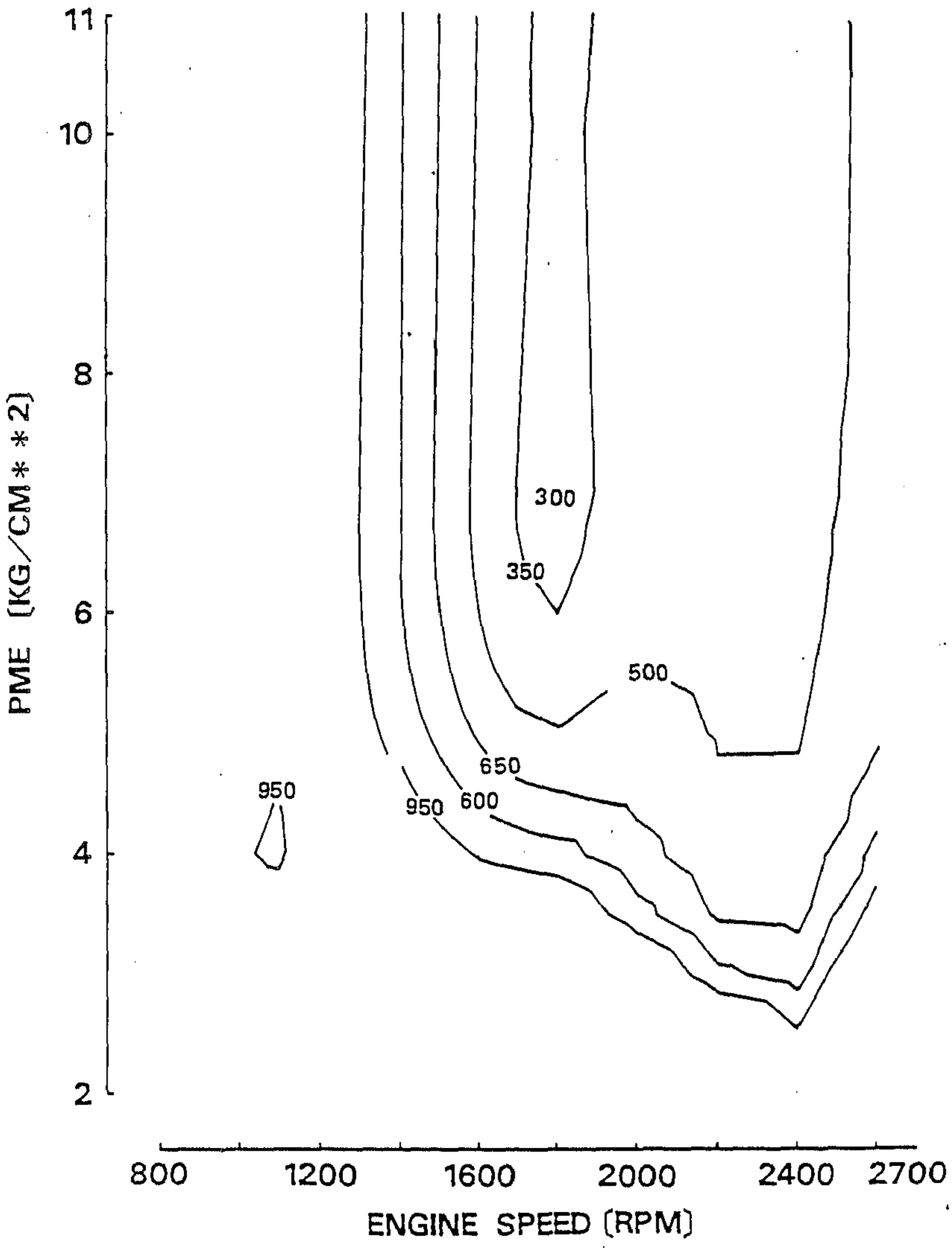
Table 8-4-5 shows the engine performance when it's applied to the PC120 hydraulic excavator. The performance in case of diesel oil includes flywheel, horsepower: 98.9 ps, rated engine speed: 2,400 RPM, fuel consumption ratio (with fan): 179 g/ps.h, exhaust color: B.S.U 2.4, exhaust temperature: 560°C, maximum torque: 37.6 kg.m/1,400 RPM, fuel consumption ratio: 168 g/ps.h, exhaust color: 3.8, and exhaust temperature: 610°C.

Though there are no emission gas regulations for construction machinery, california regulations for ON-HIGHWAY are shown for reference in Table 8-4-5. It gives 6 g/ps.h for diesel engine. If emission of diesel oil is adjusted to the regulated value, fuel consumption of diesel oil falls about 10%.

Quick acceleration characteristics are determined by how long it takes from low to high idle, from low to rated point and how much smoke is produced during the time. It was 1.0 sec and 3.9 BSU respectively in the

Fig. 8-4-8 S4D105 METHANOL BSFC (G/PSH)

CONTOUR CURVE



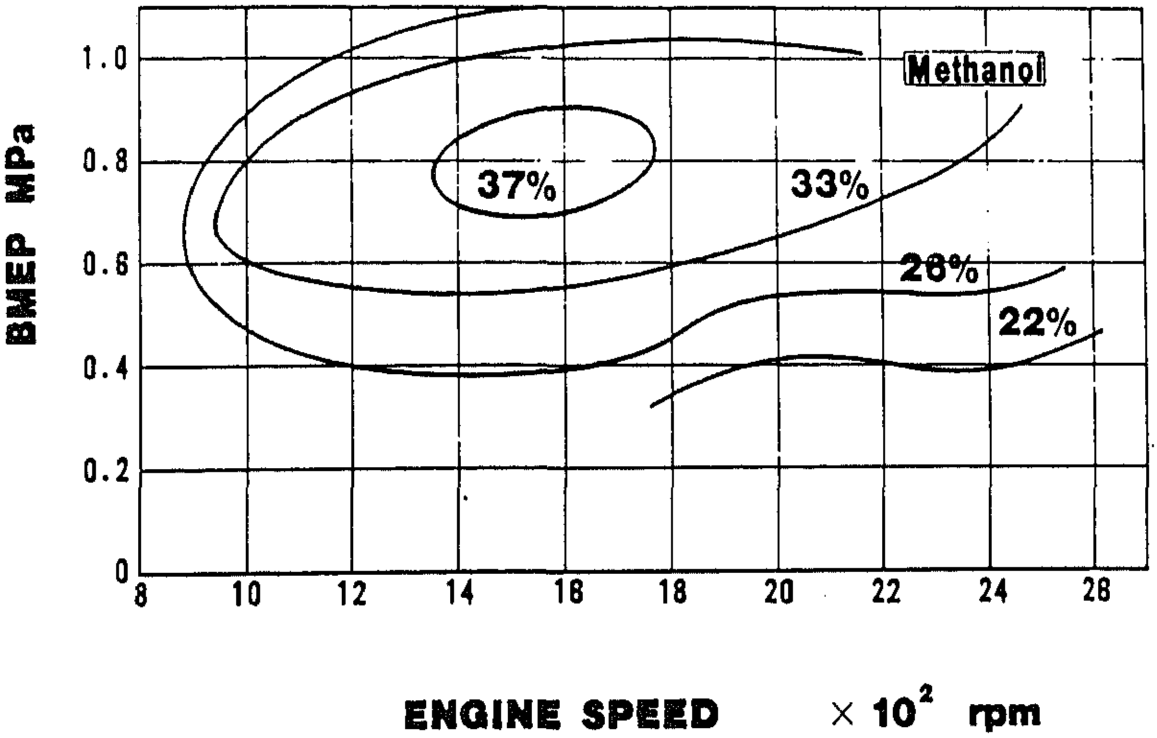


Fig. 8-4-9 **Brake thermal efficiency with neat methanol**

Fig.8-4-10 **S4D105 METHANOL NOX CONTOUR CURVE**

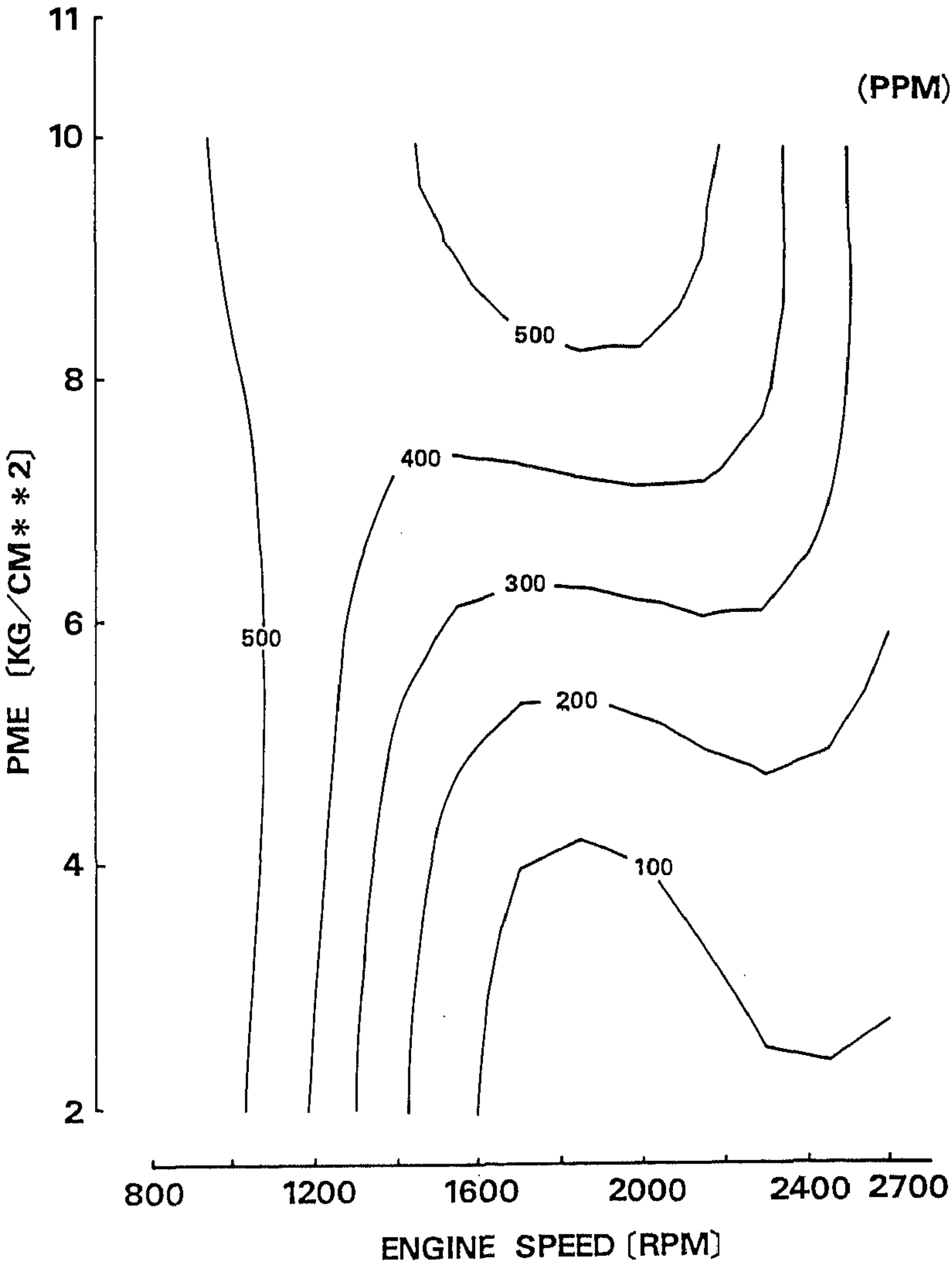


Fig 8-4-11 S4D105 METHANOL HC CONTOUR CURVE

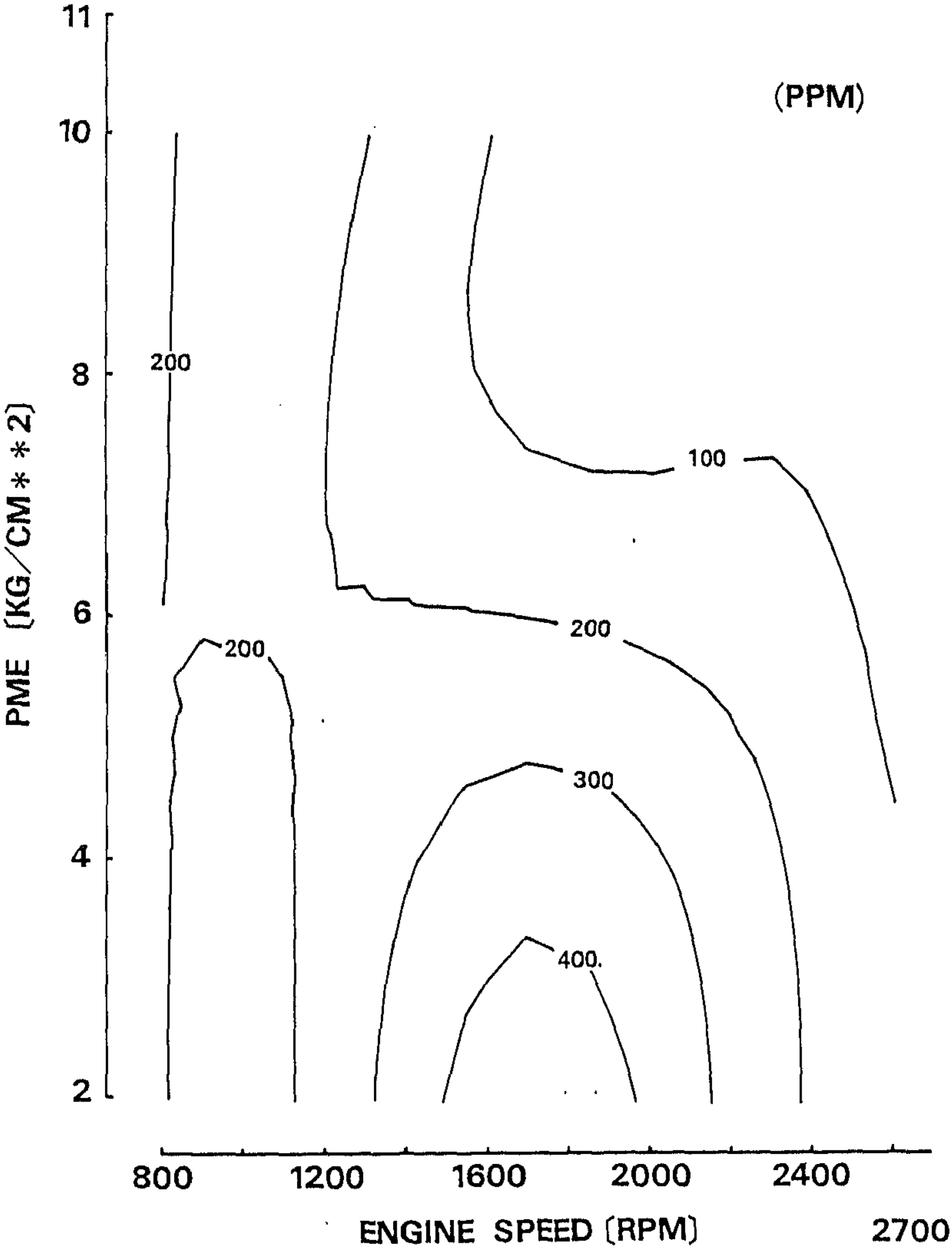


Fig.8-4-12 **S4D105 METHANOL CO CONTOUR CURVE**

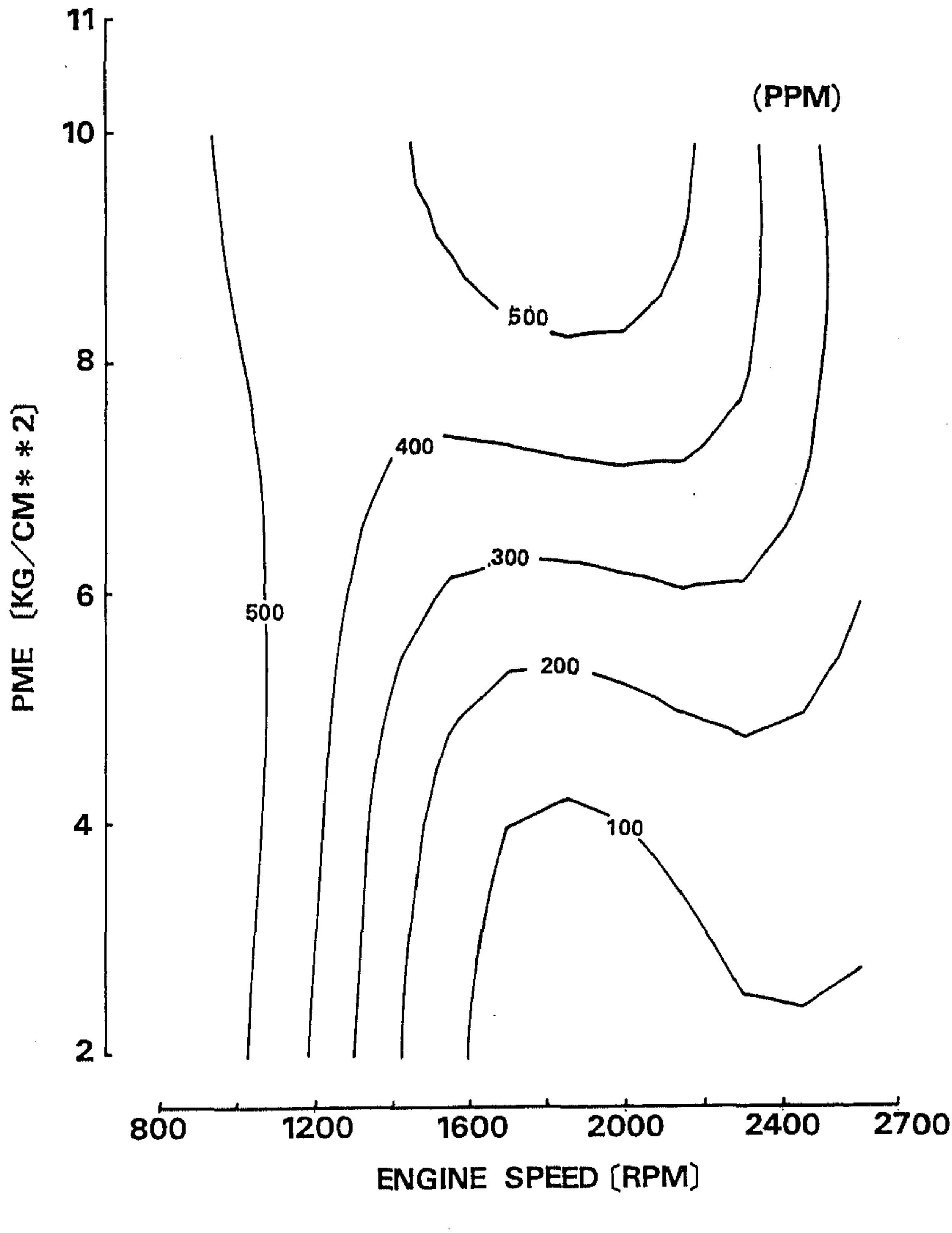


Table 8-4-5 Exhaust Gas Emissions of Turbocharged Spark Assisted Diesel Engine (S4D105)

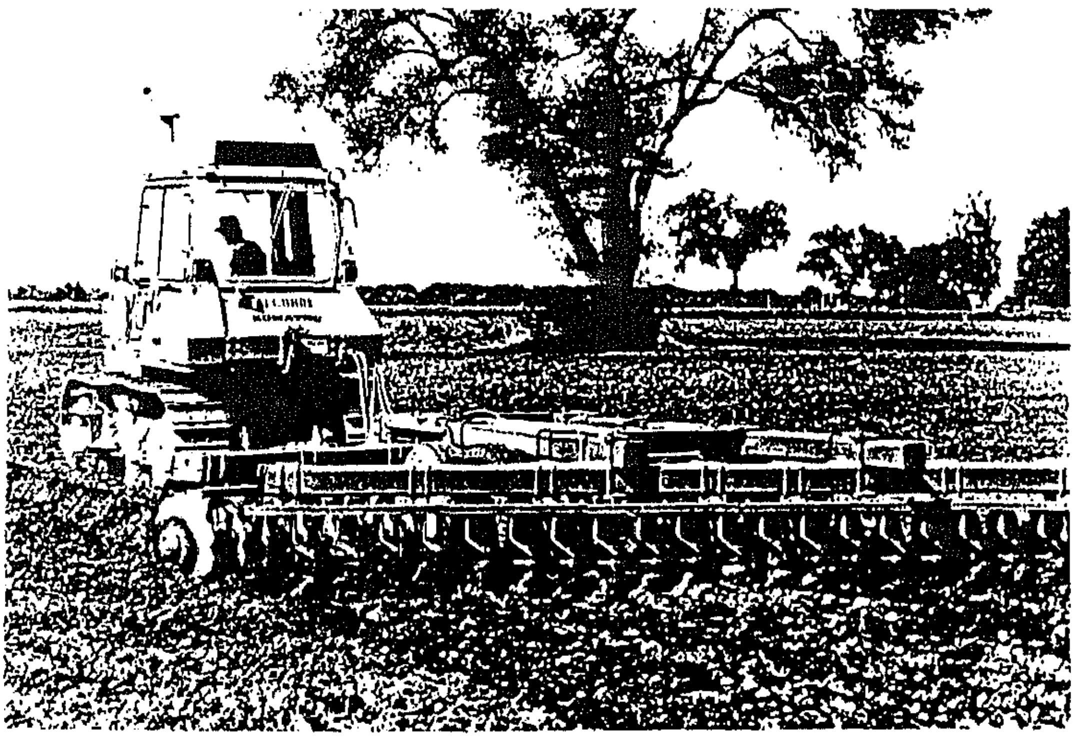
PC120 Excavator Specification	Measurement items	Unit	Spark assisted diesel-methanol	Diesel engine -diesel fuel	Reference (California regulator)
Rated HP/Rated rpm 98.9/2400	SFC	g/psh	396 (184)	179	
	Smoke density	B.S.U.	0	2.4	
	Exhaust temp.	°C	646	560	
Max. Torque 37.6 kg/1400 rpm	SFC	g/psh	451 (210)	168	
	Smoke density	B.S.U.	0	3.8	
	Exhaust temp.	°C	648	610	
13 mode Exhaust gas emissions	Nox + Hc	g/psh	1.99	11.47	6
	CO	↑	0.42	2.77	25
	HC	↑	0.97	0.72	1
Acceleration properties	L1 → H1	B.S.U./sec	0/0.95	3.9/1.0	–
	L1 → Rated HP	↑	0/3.2	–	–

case of diesel oil. By contrast to this, engine operation using methanol under the same conditions results in 396 g/ps.h fuel consumption ratio (if converted, corresponds to 184 g/ps.h of diesel oil). Thermal efficiency is about the same as diesel oil. Also during quick acceleration, it doesn't emit any black smoke. What shall be noted here is very low NOx and no black smoke.

2) Natural aspirated diesel engine with spark assist
Methanol fuel operation of natural aspirated diesel engine was applied to Komatsu's D40F-3 agricultural tractor of similar structure with a bulldozer. The tractor is presently in trial operation on a farm of Chico College, California, U.S.
As the Table 8-4-6 indicates, the engine is similar with turbocharged engine except number of cylinders and a little higher compression ratio of 17.5.
Fig. 8-4-13 is a SFC map of methanol fuel operation where the horizontal axis shows engine RPM, the vertical axis shows PME and a dot shows the optimum point. The bold line indicates power curve of diesel oil operation of typical D40F bulldozer.
Fig. 8-4-14 is a exhaust temperature map. For additional information, an excess air ratio map is given in Fig. 8-4-15 and NOx map in Fig. 8-4-16. Also, Fig. 8-4-17 shows a comparison of noise level where the vertical axis shows noise level under loaded conditions and the horizontal axis shows engine RPM. Methanol's curve is lower in profile in the map, and the difference is considered to stem from their combustion type.
Table 8-4-7 shows fuel consumption and exhaust gas emission of this engine. The performance of the spark assist methanol engine has been described in the above explanation. But to put it into a practical use, considerations should be given to durability. In the section below, the results of durability demonstration test conducted in Japan are described.

Table 8-4-6 Engine Specification

Engine type	4 cycle Natural Aspirated
Number of cyl.	6
Cooling	Water
Displacement	6,490 CC
Cyl. bore	105 mm
Stroke	125 mm
Piston compression ratio	17.5
Injection pump	Bosch P
Injection nozzle	Hole type
Number of injection hold	4



KOMATSU D40F-3 Running in the Field of Chico University. USA.

Fig. 8-4-13 **BSFC**

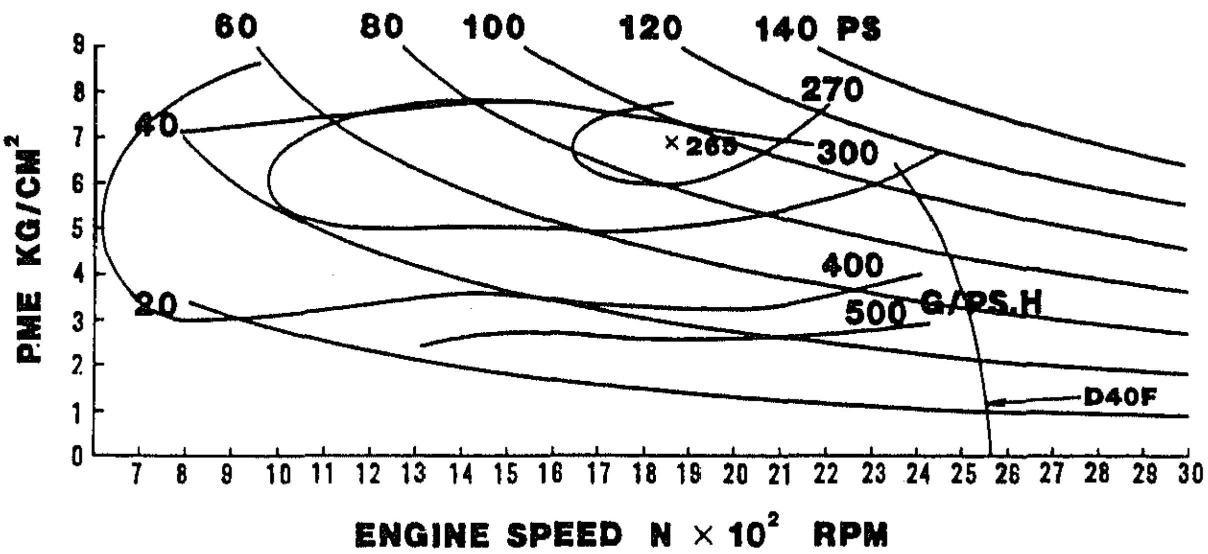


Fig.8-4-14 **EX. TEMP**

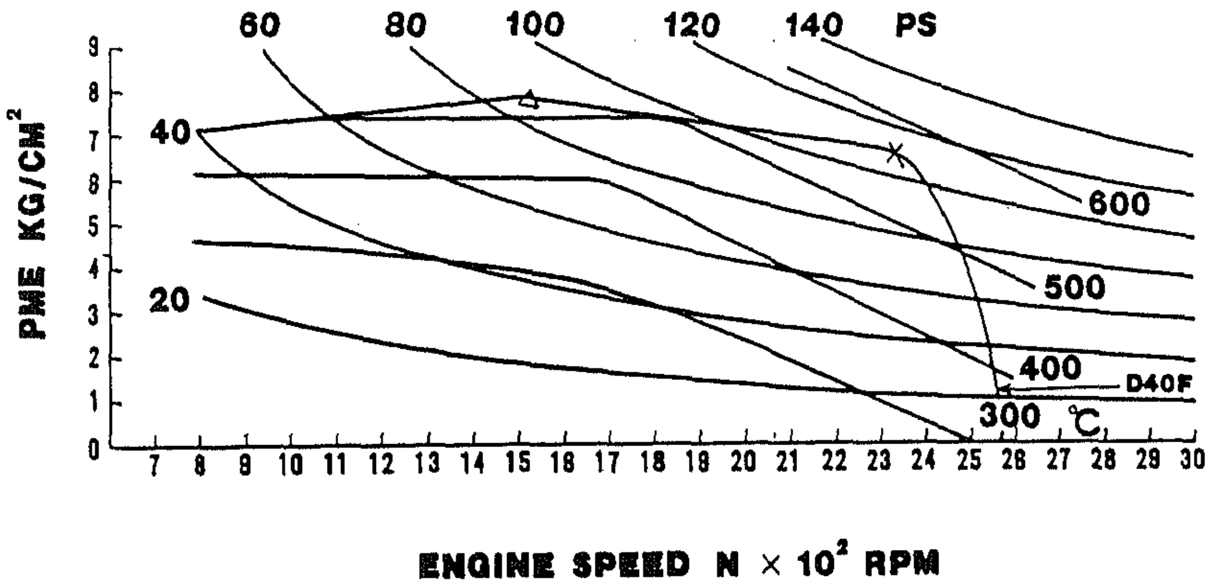


Fig.8-4-15 **EXCESS AIR PATIO**

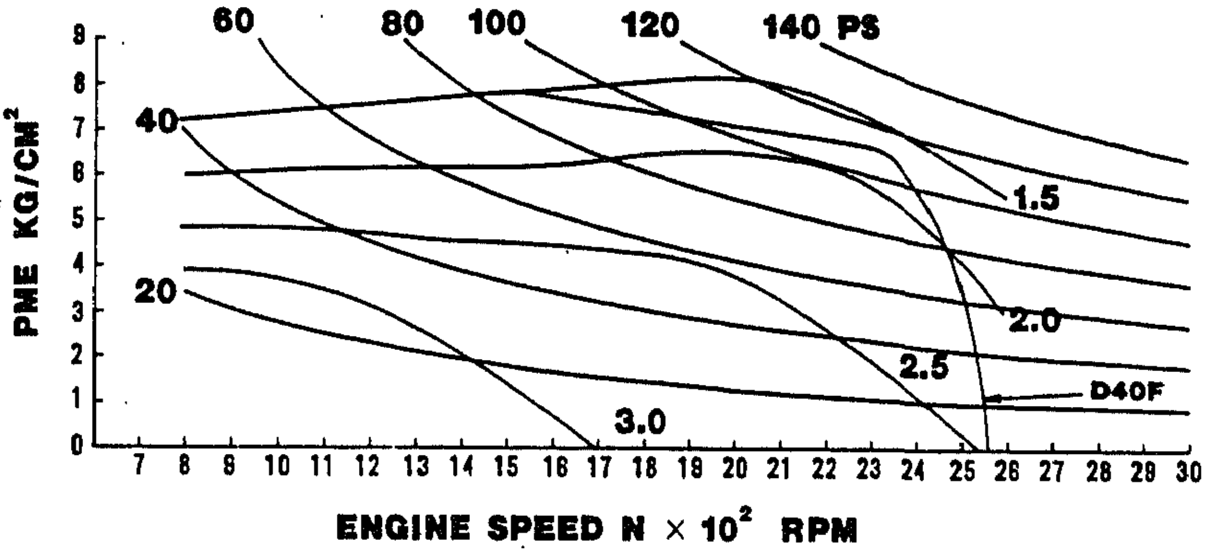


Fig.8-4-16 **NOX**

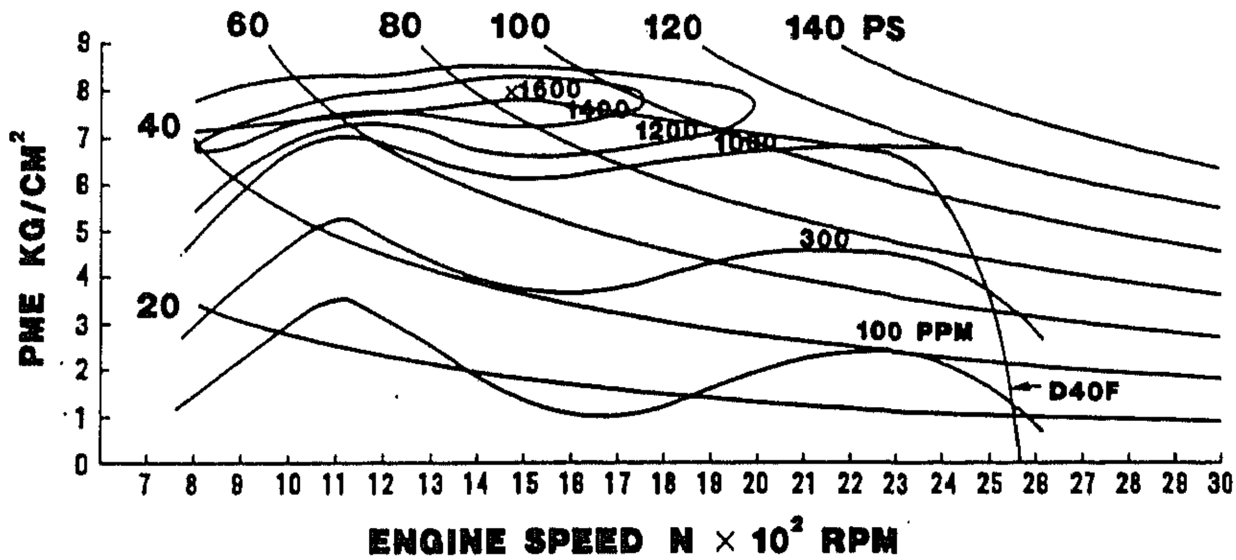


Table 8-4-7 Exhaust Gas Emissions and BSFC of KOMATSU 6D105

Spark Assisted Diesel Engine Comparison with Methanol and Diesel Fuel

	Methanol	Diesel Fuel	Ethanol
NOX (g/psh)	3.8	6.9	5.1
HC (g/psh)	0.2	1.2	0.13
CO (g/psh)	0.13	3.3	0.1
BSFC (g/psh) (Rated point)	*179	174	*179

- Rated point . . . . . < 103 ps 2350 rpm>
- Max. torque . . . . . < 40.2 kg·m 1500 rpm>

* Converted value to diesel fuel.

3) Durability of neat methanol engine

i) Cylinder pressure and temperature

Since there is a big difference in combustion type between spark-assist methanol engine and conventional diesel engine, pressure and temperature in combustion chamber were measured for confirmation. In the test, maximum cylinder pressure and temperatures at piston and intake/exhaust valves are measured for the turbo-charged diesel with higher thermal load.

Fig. 8-4-18, where the horizontal axis shows engine RPM and vertical axis shows PME, was made for illustrating the Pmax curve of neat methanol operation, adding above them the typical performance curves of the diesel engine which is actually driven by diesel oil. It was confirmed that the cylinder pressure show relatively low Pmax of 73 kg/cm^2 at rated point and generates no problems in the whole range of engine speed.

However, as the Table 8-4-8 and 8-4-9 show, the test also made clear that the thermal load is relatively higher in compared to when diesel oil is used. Theoretically, there are no reasons to explain about the pressure of interrelation between the use of methanol and temperature increase in the combustion chamber. It seems to be caused by the insufficient optimization of intake swirl, the number of nozzle used, nozzle diameter and spark timing.

ii) Durability test

In addition to low viscosity of fuel methanol, above unreasonable results of cylinder temperature made it necessary to confirm durability of neat methanol engine. The durability test was carried out using 6D105 engine.

Since the engine is scheduled to assemble on the D40F-3, a farm tractor, with power as shown in the Fig. 8-4-19, the conditions for the durability test were set as depicted in the Fig. 8-4-20. That is, 1

Fig.8-4-17 **NOISE**

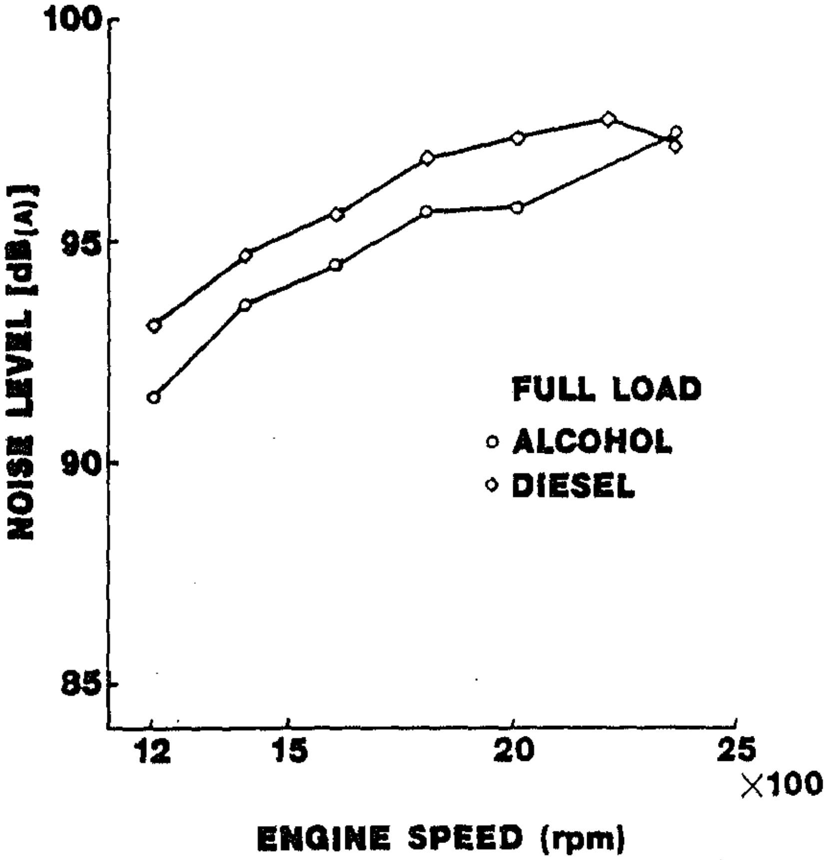


Fig.8-4-18 **Pmax**

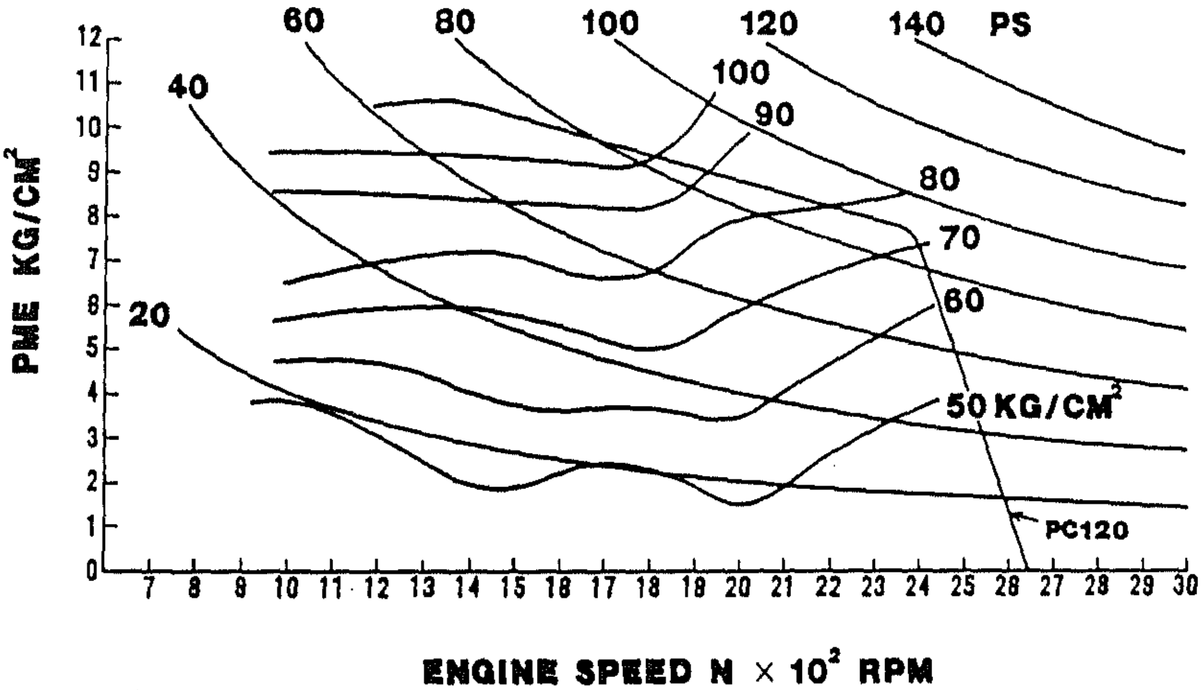


Table 8-4-8 **Temperature of Engine Valve Seat (°C)**

Engine valve	Fuel	#1 Cyl.	#3 Cyl.	Fuel	#1 Cyl.	#3 Cyl.	Fuel	S4D105
Intake valve	Methanol	355	400	Ethanol	320	300	Diesel Fuel	350
Exhaust valve		560	585		520	505		500

Table 8-4-9 **Piston Temperature (°C)**

Piston	Methanol	Ethanol	Diesel Fuel
Cavity	350 ~ 469	312 ~ 418	330 ~ 360
Topring groove	300	210	219

Fig.8-4-19 **D40F3-ALCOHOL**
6D105

RATED	103± 3ps/2350 rpm
P.TORQUE	40.2± 1.2kgm/1500rpm
HIGH IDLE	2570± 50rpm

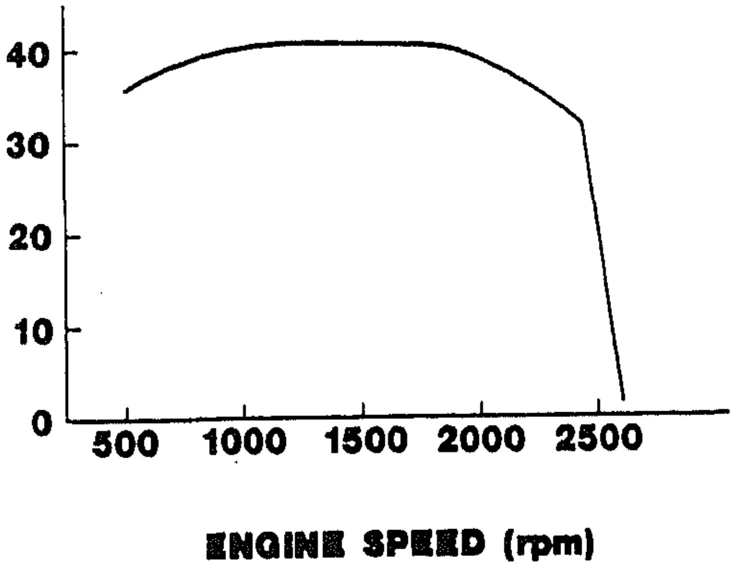
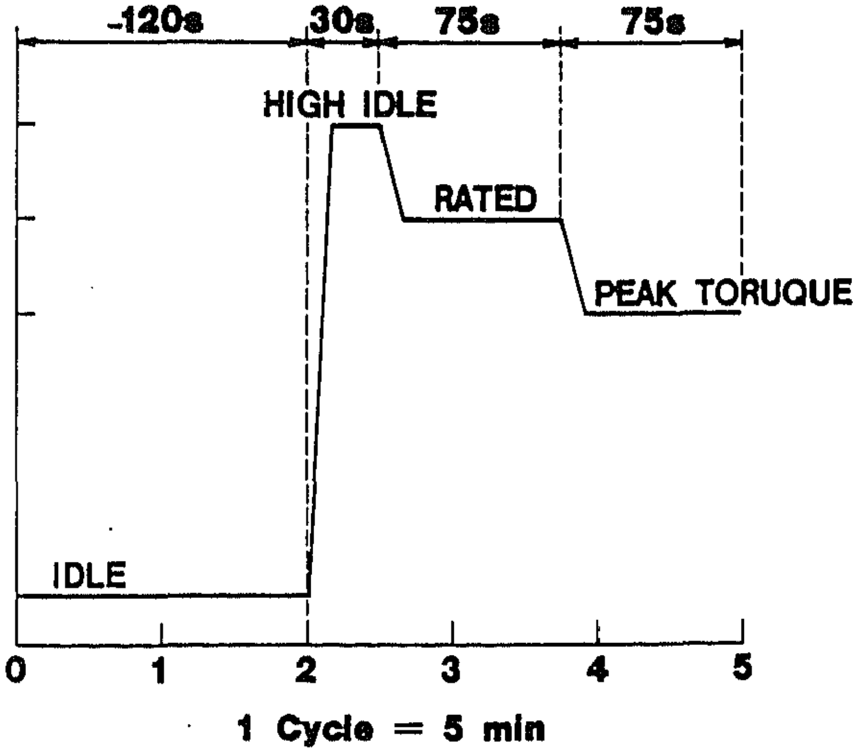


Fig.8-4-20 **6D105**



cycle: 5 min, idle: 2 min, high idle: 30 sec. The cycle was specially designed to create severe thermal load and strong stress on engine, for the range from rated to peak torque, including intermittent run of ON for 22 hours and OFF for 2 hours, which the plugs are imposed on severe conditions. The results of run for a total of 1,000 hours proved sufficient wear resistance of valves and stems. Wear of valve seat was a maximum 5/1000" on the intake side, and 1/1000" on the exhaust side, and any problem was not found on engine. It was initially anticipated that the cylinder liner may be affected much by the fuel methanol, but the obtained value, less than that of diesel oil, turned out such an opinion completely. The analysis of lubricant oil where Cu and Pb indicates bearing conditions, Si and Al indicates piston, Cr indicates piston ring and Fe indicates liner, shows typical values in which no problems were found. Examination of engine oil deterioration also shows that it is sufficiently capable of 250 hours replacement interval.

Also, there was no problems with injection pump and nozzle.

Based on all these data it was concluded that the 6D105 spark assist diesel using methanol was sufficiently applied to the D40F-3. Photo 1 through 3 show the engine and the tractor of neat methanol engine which is used for demonstration run. The tractor is still a work on the farm of the Chico College, California, and its service meter indicate now near 1,000 hours.

4) Commercial application of spark assist diesel engine

As pointed out in general, security for supply and construction of the delivery system of fuel methanol are troublesome problem economically and technically for

commercial application of neat methanol engine.
However, it is important to note that spark assist diesel engine designed for neat methanol as fuel can be operated with diesel oil by minor adjustments, such as injection timing, maximum stroke of injection pump and turn-off of spark switch.

Above metnioned adjustments of spark assist diesel engine will be easily carried out by gasoline stand or driver. By other word, spark assist diesel engine designed for neat methanol has flexibility for selection of fuel time by time, diesel oil or neat methanol. Otto cycle-gasoline engine designed for neat methanol seams to have same flexibility for fuel, gasoline or neat methanol, though this flexibility must be confirmed through further studies.

All things taken into consideration, it is recommended that neat methanol engine will be applied commercially for special-purpose-engines such as electricity generation, city bus and truck, agricultural equipment, and mining equipment, which run routine route only.

5) Conclusion on Performance of Spark Assist Diesel Engine

i) Ordinary diesel engine is unsuitable engine for neat methanol because methanol is low in its cetane value. However spark assist diesel engine developed by Komatsu in Japan can be applied for neat methanol as well as diesel oil.
It is notable that spark assist diesel engine designed for neat methanol has flexibility for fuel selection, neat methanol or diesel oil.

ii) It is understood that methanol is sufficiently effective as a fuel for internal combustion engines, and that neat methanol engine can be manufactured applying the existing technology.
However, further studies for such a turbocharged after-cooled engine and the engines with a large

cylinder bore (which presumably requires multiple spark plugs) must be continued.

Furthermore, there are many elemental research subjects left untouched for attaining more effective methanol combustion, such as the study into relation between intake swirl, combustion chamber and nozzles, and optimization of injection pattern.

It is believed that above subjects will be shortly studied and resolved, because it was confirmed that most of 100 years' accumulation of internal combustion technology for petroleum engine can be available for neat methanol engine.

8-5 Preliminary evaluation of coal gasification technology

(1) Technology for synthesis gas production

All taking into the consideration, overall evaluation shows that oxygen blow-molten iron bath gasifier is superior for production of synthesis gas from Banko coal. Pressurized molten iron bath gasifier will be more better, if such a technology will be developed.

Evaluation of Coal Gasification Technology for Synthesis Gas Production

	Fixed bed (dry ash)	Fludizied bed (oxygen blow)	Entrained flow (oxygen blow)	Molten iron bath (oxygen blow)
Gas composition	5	4	2	1
Impurity	4	3	2	1
Flexibility for coal quality	4	3	2	1
Overall thermal efficiency	3	2	3	1
Gas pressure	1	1	1	3
Operatability and safety	1	1	3	1
Construction cost	3	2	2	1
Commercial experience	1	1	1	2
Total	22	17	16	11
Overall evaluation (ranking)	4	2	2	1

i) Gas composition

Product gas come from coal gasifier contains hydrogen carbon monoxide, carbon dioxide, steam, methane, ethane, nitrogen and small amount of impurities. For production of derivatives, product gas will be treated to remove undesirable materials for synthesis reaction such as carbon dioxide and impurities. However, methane, ethane and nitrogen are difficult to remove, and therefore accumulated gas in synthesis reactor must be purged from the synthesis process. As obvious from above discussion, the most desirable gas composition of product gas is a mixture of hydrogen and carbon monoxide, and other materials are undesirable components. In view of product gas composition, an oxygen blow-molten iron bath gasifier is the most superior for synthesis gas production and an oxygen blow-entrained flow gasifier follows. An oxygen blow-fixed bed gasifier and a fluidized gasifier as well as an air blow gasifier are not suitable for the purpose of synthesis gas production, because the product gas contains much undesirable materials.

ii) Impurity

Product gas contains a small amount of impurities such as hydrogen sulphide (H_2S), carbonyl sulphide (COS) and ammonia (NH_3) which are catalyst poison. Therefore these impurities must be completely removed by chemical treatment.
In view of impurities, a molten iron bath gasifier has better performance, because 95% of sulfur contained in coal is absorbed into slag in gasifier.

iii) Flexibility for coal quality

Banko coal has a wide variety of its quality, sodium content in ash and ash fusion temperature (1,150°C - more than 1,500°C). A molten iron bath gasifier has an enough flexibility for such a wide variety of coal. Other type of gasifier has some kinds of restriction in coal quality.

iv) Energy efficiency
If outlet temperature of product gas from heat recovery system is assumed to be same level, energy efficiency of gasifier depends on each carbon conversion efficiency and amount of effluent steam. A molten iron bath gasifier is the most superior because of the highest carbon conversion efficiency, and less effluent steam.

v) Gas pressure
Required gas pressure in synthesis reaction is generally higher than 30 kg/cm^2G.
In view of gas pressure, a molten iron bath gasifier is inferior to other gasifiers.

vi) Operatability and safety
An entrained flow gasifier has no surplus carbon inside of gasifier. Therefore steady operation may be easily disturbed by minor deviation of feed rate of oxygen and coal. Also there is a possibility of such a dangerous condition as oxygen surplus.

vii) Construction cost
It is difficult to evaluate the construction cost, because concrete cost data are not investigated at the present. However, in view of process flow scheme a molten iron bath process and an entrained flow process seem to be superior to other processes. Because of low pressure operation and simplified process flow scheme, the construction cost of a molten iron bath process is expected to be cheeper, though the maintenance cost of a firebrick lining of the gasifier may be expensive.

viii) Commercial experience
A molten iron bath process has no commercial experience, though many of similar type of commercial plants are operated in steel industry.

(2) Technology for coal gasification combined cycle power generation

Overall evaluation shows that air blow-pressurized type of fluidized bed gasifier is superior for CGCC power generation, providing that the technical development of hot gas clean-up system will be completed at the level of proposed objective.

Evaluation of Coal Gasification
Technology for CGCC Power Generation

	Fixed bed (dry ash. air blow)	Fluidized bed (pressurized. air blow)	Entrained flow (pressurized. oxygen blow)	Molten iron bath (atm. pressure. oxygen blow)
Gas pressure	1	1	1	10
Oxygen-steam consumption	2	1	3	2
Tar content	3	1	1	1
Impurity	3	2	2	1
Gas calorific value	1	1	1	1
Carbon conversion	1	2	1	1
Operatability and safety	2	1	4	1
Construction cost (including air separation)	5	1	4	3
Commercial experience	1	1	1	2
Flexibility for coal quality	4	3	2	1
Total	23	14	20	23
Overall evaluation (ranking)	3	1	2	3

Note: CGCC technology should be evaluated not only coal gasification technology but also hot clean gas system and high temperature gas turbine. However, the following major technologies are still under development work, and no performances are grasped and demonstrated at present time.

a) Hot dry type desulfurizer

b) Hot dry type dust removal equipment

c) High temperature gas turbine (1,300°C)

Therefore the evaluation of coal gasifier for CGCC was carried out on the basis of assumptions that above a) - c) will be well developed in near future:

i) Gas pressure

The gas pressure for CGCC must be higher than 10 kg/cm^2G. A molten iron bath gasifier gives atmospheric pressure gas, and therefore such a atmospheric pressure gas must be cooled down and then pressurized by a compressor, resulting very low energy efficiency as total CGCC system.

Other gasifiers provide 20 kg/cm^2G or higher pressure gas and such a gas can be sent to a gas turbine at hot-dry conditions without cooling down, resulting very high energy efficiency as total CGCC system.

ii) Oxygen steam consumption

Oxygen and steam used as oxidizing agent consume much energy for production. In view of oxidizing agent, an air blow gasifier is superior to an oxygen blow type.

iii) Tar content

Tar must be removed to avoid fouling of hot dry type desulfurizer and dust removal equipment.

To remove tar from product gas, high temperature product gas must be cooled down to 200 - 300°C, resulting loss of energy. Therefore a gasifier which does not produce tar is preferable for CGCC system.

iv) Impurity

Sulfur compounds (H_2S, COS) produce sulfur dioxide at the gas turbine and cause air pollution. Therefore such a sulfur compound must be removed until at reasonable level to avoid air pollution by hot dry type desulfurizer.

In case of a molten iron bath gasifier desulfurizer is not required, because 95% of sulfur is removed in gasifier.

v) Calorific value

There is no difference in evaluation, because a gas turbine can accept low calorific gas of 1,000 $kcal/Nm^3$.

vi) Carbon conversion

Higher carbon conversion is effective because higher energy efficiency can be achieved.

A fluidized bed gasifier has a subject on carbon recycle system, because the amount of effluent carbon is higher than other gasifiers.

vii) Operatability and safety

Electricity can not be stored.

Therefore steady operation and safety are especially important in evaluation. As mentioned in 8-5-(1)-vi), a fluidized bed gasifier and a molten iron bath gasifier in which hold much surplus carbon show more steady and safety operation for deviation of feed rate of carbon and oxidizing agent.

viii) Construction cost

An air blow fluidized bed gasifier seems to be superior to other oxygen blow gasifier because an air separation plant is not required.

ix) Commercial experience

A molten iron bath gasifier is inferior to other gasifier.

x) Flexibility for coal quality
A molten iron bath gasifier is superior to other gasifier (see 8-5-(1)-iii)).

(3) Technology for Coal Gasification Test Plant in PUSPIPTEK

1) Summary

	Entrained Flow	Molten Iron Bath
Synthesis Gas Production		
CO and H2	o	o
Sulfur compounds	x	o
Flexibility for coal quality	x	o
Tested with Banko coal	x	o
Experience	o	x
Operatability	x	o
Maintenability	o	x
Technology transfer	x	o
Conclusion	x	o

Legend : o = good
x = average

2) Discussion

i) Synthesis gas production
According to the results on preliminary survey on market the most propective markets of produced gas are feedstock for synthetic fuel oil, fuel methanol and urea, which are derived from synthesis gas, though some will be used as fuel for electric power generation. According to the discussion of 8-5-(1), the best technology for above requirement is entrained flow gasifier or molten iron bath gasifier.

ii) Impurity in produced gas
Molten iron bath process produces less sulfur compounds than entrained flow process.

iii) Flexibility for coal quality
According to the results of survey on Banko coal quality, the coal gasification test plant must be able to gasify a wide variety of Banko coals, which feature high total moisture, low calorific value, high Na_2O content in ash and a wide range of ash fusion temperature.
Generally speaking, both the entrained flow gasifier and molten iron bath gasifier can gasify a wide range of coals, because of their high reaction temperatures and slagging ash removal systems.

iv) Acceptability of Banko coal
Banko coal has been tested successfully by the molten iron bath process using a 60 t/d pilot plant.
Furthermore, the molten iron bath gasifier has also tested successfully residue from coal direct liquefaction, which has lower calorific value and higher ash content.

v) Commercial experience
Entrained flow process has been commercialized, while molten iron bath process is in the stage of demonstration operation.

vi) Operatability
Because the coal gasification test plant in PUSPIPTEK is small, with a capacity of 20 kg coal per hour, there may be some difference in test data compared with a large scale test plant.
However, the test plant is required to provide reliable and reproducible data. At this point, molten iron bath gasifier may be better because it holds molten iron which acts as a big heat reservoir and reaction buffer to absorb carbon.

vii) Maintenability

The test plant is required to have good maintenability by using standard materials available from ordinary market.

At this point, entrained flow process seems to be better.

viii) Technology transfer

Process owner shall be required to dispatch operation and other engineers to Jakarta during the coal gasification testing period and also provide detailed operation manuals for the counterpart. From this view point, it is better employing one of Japan's technologies for coal gasification test plant in Indonesia.

8-6 Conclusion and Recommendation Obtained from Survey on Banko Coal Utilization Technology

(1) Conclusion

1) Molten iron bath gasifier for synthesis gas production and fluidized bed gasifier of air blow-pressurized type for electricity generation are evaluated as the most superior technology at present time.
However the evaluation of coal gasification technology shall be reviewed at the feasibility study stage on the basis of up-to-date information.

2) Molten iron bath process was selected for coal gasification test facilities in PUSPIPTEK.

3) Technology for derivatives production is well established.

4) Technology for CGCC electricity generation shall be evaluated in due course, watching the technical development of high temperature gas turbine and hot gas clean-up system.

5) Banko coal is "problem coal" for conventional pulverized coal firing boiler because of high sodium-in-ash.

6) Spark assist diesel engine newly developed in Japan can be applied for neat methanol, and has flexibility for fuel selection, neat methanol or diesel oil.

(2) Recommendation

1) Detailed market survey on fuel methanol for gas turbine generator and diesel engine generator as well as city bus in Indonesia will be carried out.

2) Preliminary feasibility study on high voltage-direct current transmission line between Banko area and Java will be carried out to evaluate mine mouth electricity generation.

9-1 Economic Possibility of Banko Coal Utilization

(1) Method of Study

Generally speaking, economic possibility of coal utilization depends on energy policy of government, price level of competitive energy and production cost of coal and its derivatives, and therefore must be studied individually for each project based on concrete local conditions.

For Banko coal utilization, as described in previous sections, many of important factors were clarified through stratigic investigation stage carried out in FY 1984.

However some of principal factors for financial and economic analysis such as capital cost, operation cost, and basis of financial study are not yet studied at present.

Therefore, in this section, the economic possibility of Banko coal utilization is discussed on the basis of published literatures using the estimated selling price of Banko coal.

(2) Estimated Selling Price of Banko Coal

The selling price of Banko coal for this project was estimated by the following formula.

$$\text{Selling price (dry base)} = \frac{A}{(1 - B)} \times (1 + C) \times (1 + D)$$

Here A : mining cost (wet base)
B : weight loss by drying (% of A)
C : drying cost (% of A)
D : profit (% of dry coal cost)

Banko coal is non-transportable coal and contains high sodium-in-ash, which denies to sale for out of South Sumatra and other existing market. Therefore, the selling price of Banko coal will not be affected by the world market price like crude oil, natural gas and other exportable coal.

Considering these conditions, the above formula was arranged to estimate the selling price based on "cost and profit" for coal mining.

According to the preliminary estimation of coal mining cost, the mining cost (A) of non-continuous mining method is approximately 14 $/t (wet base).

Weight loss by drying (B) will be about 25% of wet coal, assuming that 30 - 35% of water in coal is decreased to 5 - 10% by drying. Drying cost (C) is assumed as 10% of the mining cost, considering effective heat recovery from hot synthesis gas. Profit of coal mining (D) is assumed as 20% of cost of dry coal.

According to above formula and assumption, the estimated selling price is approximately 25 $/t (dry coal).

(3) Methanol Production

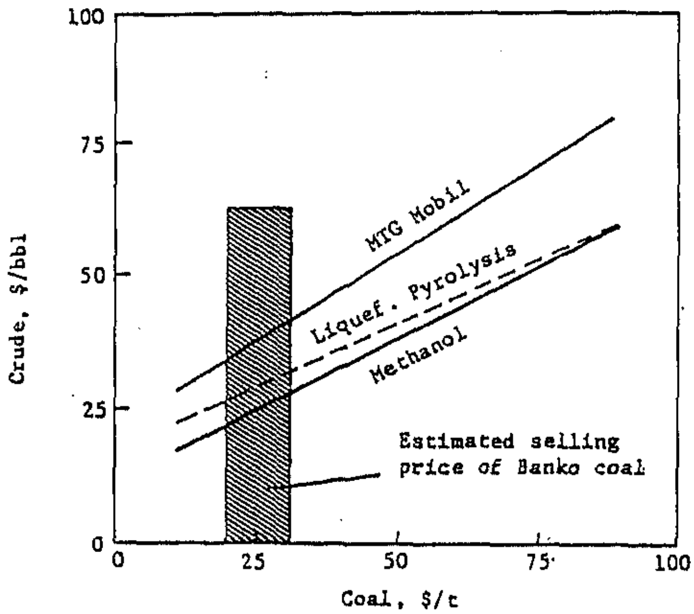
Fig. 9-1-1 shows correlation between coal price and production cost of methanol and synthetic gasoline (MTG process), which is taken from in Hydrocarbon Processing Aug. 1984.

The literature does not explain the basis of cost calculation. Therefore applicability for Banko coal can not be judged. However, to obtain economic prospects of rough guess, the estimated selling price of Banko coal (dry base) is shown in the Fig. 9-1-1.

As illustrated in Fig. 9-1-1, the production cost of fuel methanol is equivalent to 25 $/bbl of crude oil and MTG is equivalent to 36 $/bbl.

At present time, the market price of crude oil is FOB 27 - 29 $/bbl.

Therefore, economic possibility of methanol production as fuel seems to be high. On the other hand, that of MTG depends on future price of crude oil as well as Government price policy for petroleum gasoline.



The Source: Hydrocarbon Procersing. Aug., 1984.

Fig. 9-1-1 Crude Oil/Synthetic Gasoline Equivalence (Coal)

(4) Synthesis Gasoline (MTG) Production

As is mentioned above, synthesis gasoline seems less competitive unless the price of crude oil goes up higher than 35 $/bbl. On the other hand, synthesis gasoline has some advantages such as;

1) Compatibility with petroleum gasoline at any rate
2) Utilization of ordinary gas stations and automobiles without modification
3) Less toxicity than methanol

Therefore, there is a possibility to utilize synthesis gasoline with the crude oil price soaring up to 35 $/bbl.

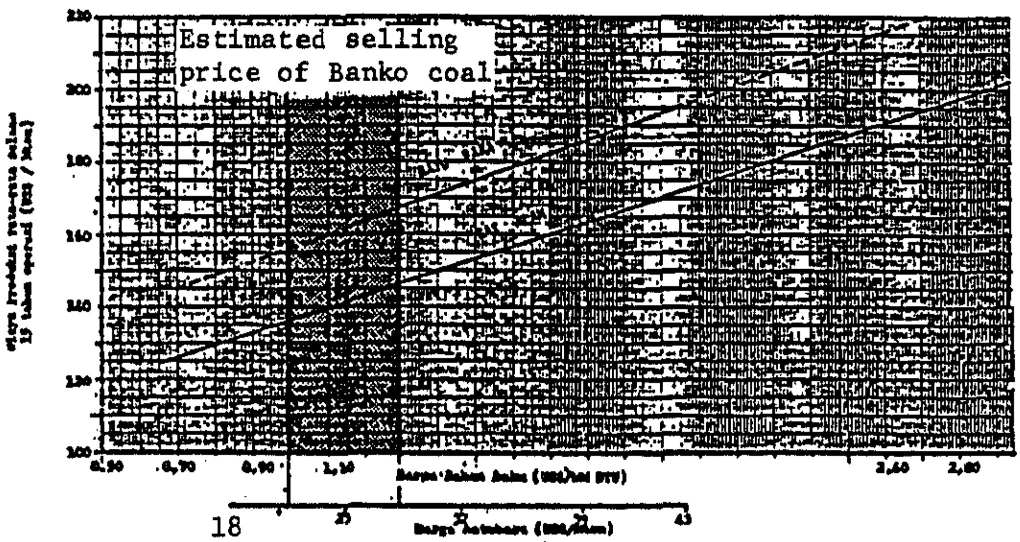
(5) Urea Production

Fig. 9-1-2 shows correlation between coal price and production cost of urea, which is reported in "Coal gasification for Ammonia/urea plant in Palembang" by Ir Kresno Sunarto and P.T. PUPUK SRIWIDJAJA in May, 1983. 25 $/ton of coal price gives approximately 160 $/ton of urea production cost, which is equivalent to 1.7 $/MMBTU of natural gas.

The price of natural gas for ammonia/urea production is 1.0 $/MMBTU in Indonesia at the end of 1984. Therefore, economic possibility of urea production from Banko coal is less viable, if the price of natural gas is kept cheaper than about 1.7 $/MMBTU, and such a natural gas can be supplied for a new project. The otherhand, the recent FOB price of urea for export is around 170 - 180 $/ton, which is hopeful for Banko coal. As conclusion, the economic possibility of urea production from Banko coal must be investigated in details in further study, watching FOB price of urea and Government policy for price and supply of natural gas for urea production.

Fig.9-1-2

Sensitivity of feedstock price to the production cost



(6) Electricity Generation

Fig. 9-1-3 shows transitions of net thermal efficiency of conventional coal-firing steam cycle power generation. Fig. 9-1-4 illustrates correlation between gas turbine inlet temperature and net thermal efficiency of CGCC power generation.

As shown on above figures, the CGCC power plant is expected to have higher thermal efficiency, 43 percent for 1,300°C gas turbine, comparing with 37 - 38 percent of conventional coal-firing steam cycle power plant.

Further comparison between expected Coal Gasification Combined-Cycle and coal firing steam cycle power plant are summarized on Table 9-1-1.

However, the concrete cost comparison of both technology is difficult at present time because following technical matters are still under development.

a) Modification of coal firing steam cycle power plant for utilization of Banko coal with 12% of Na_2O in ash.

b) Development of CGCC, especially advanced gas turbine of 1,300°C class and dry clean-up system of produced gas.

For reference, an example of cost comparison, on the basis of coal prices in Japan, between CGCC and pulverized coal firing power plant is illustrated in Fig. 9-1-5.

It will be noted that the estimation by mine mouth prices will give different figures, because of different coal price and construction cost.

The main point of this economical evaluation lies in the relation between the decrease of fuel cost by efficient power generation and the cost increase of construction such as coal gasification plant.

In other words, as shown in Fig. 9-1-5, if the technological development is so achieved that CGCC composed of advanced gas turbine of 1,300°C class and dry clean-up system of product gas can be realized with the construction cost of less than 10% higher than that in pulverized coal firing power plant, CGCC will be regarded, even in an economical sense, as competitive power generation system.

In case of Banko coal, economic possibility of electricity generation by CGCC at mine mouth (Banko area) and supply of electricity to Java by high voltage direct current transmission line seems to be high, because price of Banko coal is enough cheap compared with other Indonesian exportable coal and the cost of HVDC transmission line, about 400 km, is estimated about 0.1 $/KWH.

Fig. 9-1-3

Transitions in thermal efficiency

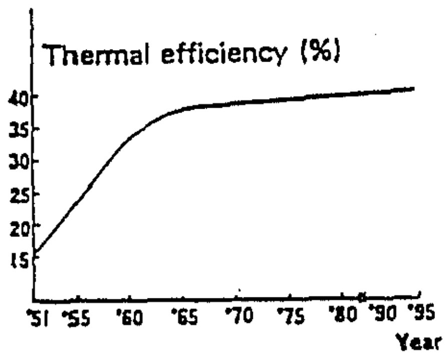


Fig. 9-1-4

Thermal efficiency of combined cycle power generation

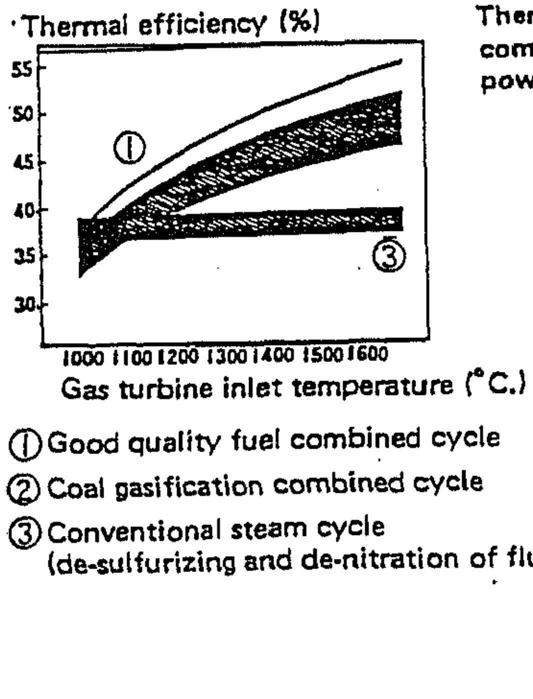
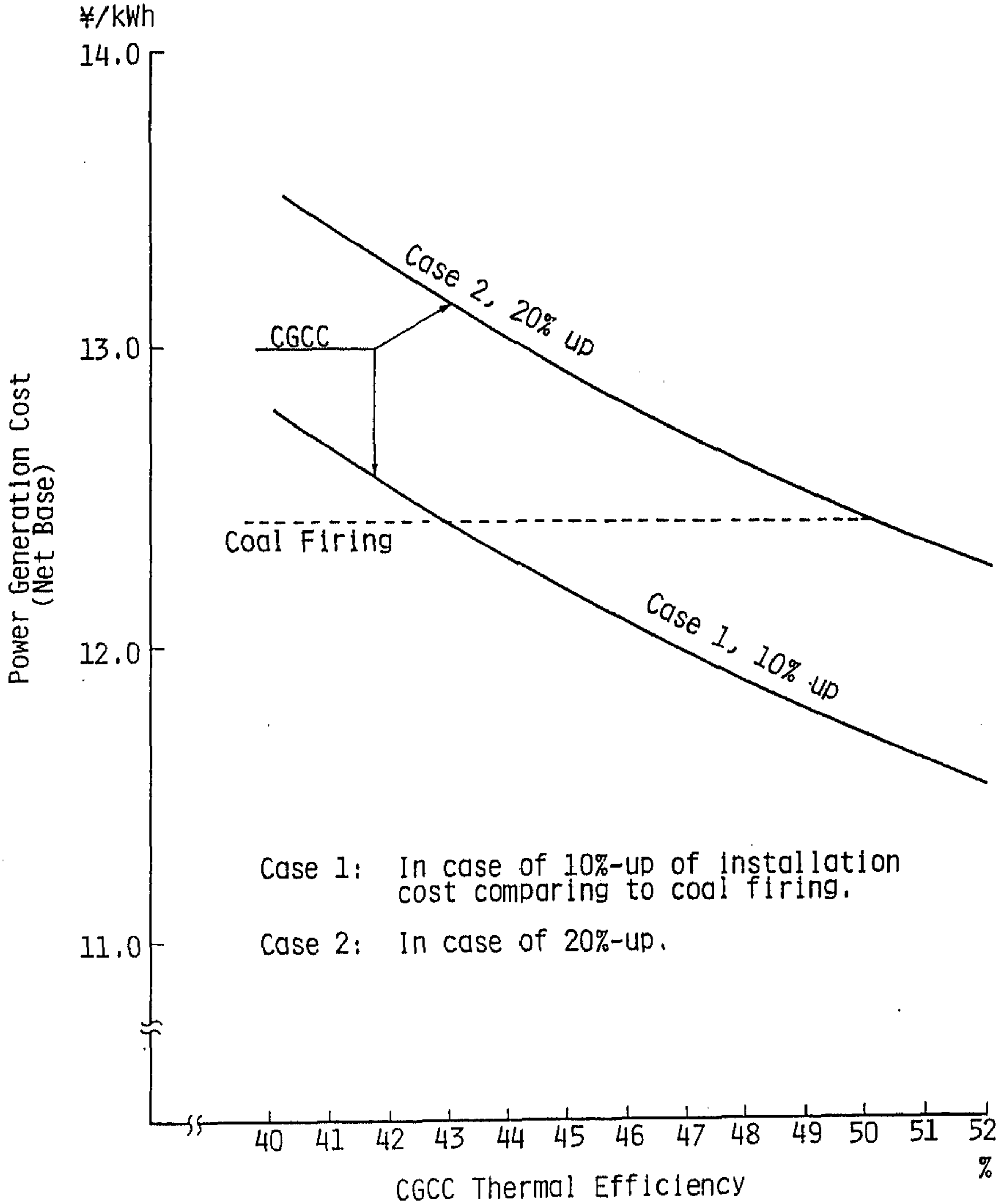


Table 9-1-1 COMPARISON BETWEEN COAL GASIFICATION COMBINED-CYCLE AND COAL-FIRING STEAM CYCLE POWER PLANT

	CGCC Power Plant 1,000 MW	Coal Firing Power Plant 1,000 MW
Thermal Efficiency (Net)	43 %	37 %
Environmental Affect		
Dust	Dust removal from raw fuel gas	EP for flue gas
SOx	Desulphation of raw fuel gas	De-SOx for flue gas
Circulating water	80 %	(Base)
Ash	Even	Even
Arrangement Space		
Power Plant	80 %	(Base)
Ash Yard	Even	Even
Operability		
Min. Load	30 % (1 train)	25 - 30 %
Load Change	1 - 2 %/min.	3 %/min.
Startup Time	Slightly longer (Temp. rise of refractory)	(Base)
Operation	Base load	Base load and peak load

Fig. 9-1-5

POWER GENERATION COST AND
CGCC THERMAL EFFICIENCY



9-2 Master Plan

(1) Basis for Master Plan

1) Product

As the possible chemical products for this project,

a) Methanol

b) Single cell protein

c) Gasoline

d) Urea

have been taken up for the Master Plan reflecting the study results for market investigation and technology development. Although, as mentioned in Subsection 8-2, there are so many possible products directly processed from synthesis gas or indirectly through methanol, we have not taken up products of which demand in Indonesia will be rather small even a decade later or of which processing technologies are still premature.

Methanol is the most prospective product, since it can be used as chemical, as feed stock for other chemicals and as fuel in the form of neat and blending stock to other fuel oil, such as gasoline, kerosene and diesel oil.

Single cell protein can take over a position of fish meal for animals, which Indonesia has imported about 72,000 tons or about US$39,000,000 in 1982.

Although it is needless to explain about gasoline and urea, Indonesia consumed 4,500,000 Kl of gasoline and 1,979,000 tons of urea in 1982, and is estimated to consumed 10,400,000 Kl of gasoline in 1995 and 5,365,000 tons of urea in 1990.

Also electric power is one of the most prospective products, since Indonesia will require much more electric power in the future and diversify energy source of electric power from fuel oil to coal, and a Banko coal is adequate for the mine mouth electric power generatino due to its non-transportable nature.

As for electric power, the two cases of the electric power generation methods will be considered, i.e., the first is so-called CGCC (Coal Gasification Combined Cycle) and another is fluidized bed combustion or pulverized coal firing boiler, since those technologies have not yet been commercialized or have some technical uncertainties.

Fig. 9-2-1 shows these possible products.

2) Plant Capacity

Plant capacity for each unit is selected based on that;

a) Coal mining capacity should be about three to six million tons per year, since it is not so difficult to attain such capacity even at the earliest stage of the operation.

b) Chemical processing plant capacity should be commercially proven one and good enough for Indonesian Market.

c) Two cases of capacities for electric power generation plant should be considered, i.e., one is to generate an enough amount of electric power for this project, coal mining facilities and their infrastructure as well as a certain amount of electric power to be supplied to South Sumatra area, and another is to generate an enough amount of electric power for this project, coal mining facilities and their infrastructure as well as a certain amount of electric power to be supplied to Java area.

d) Cooling water requirement should be enough below the dry season discharge of River Enim or River Lematang.

After these consideration, plant capacities below are selected for the time being, although these may be changed after the further detailed studies;

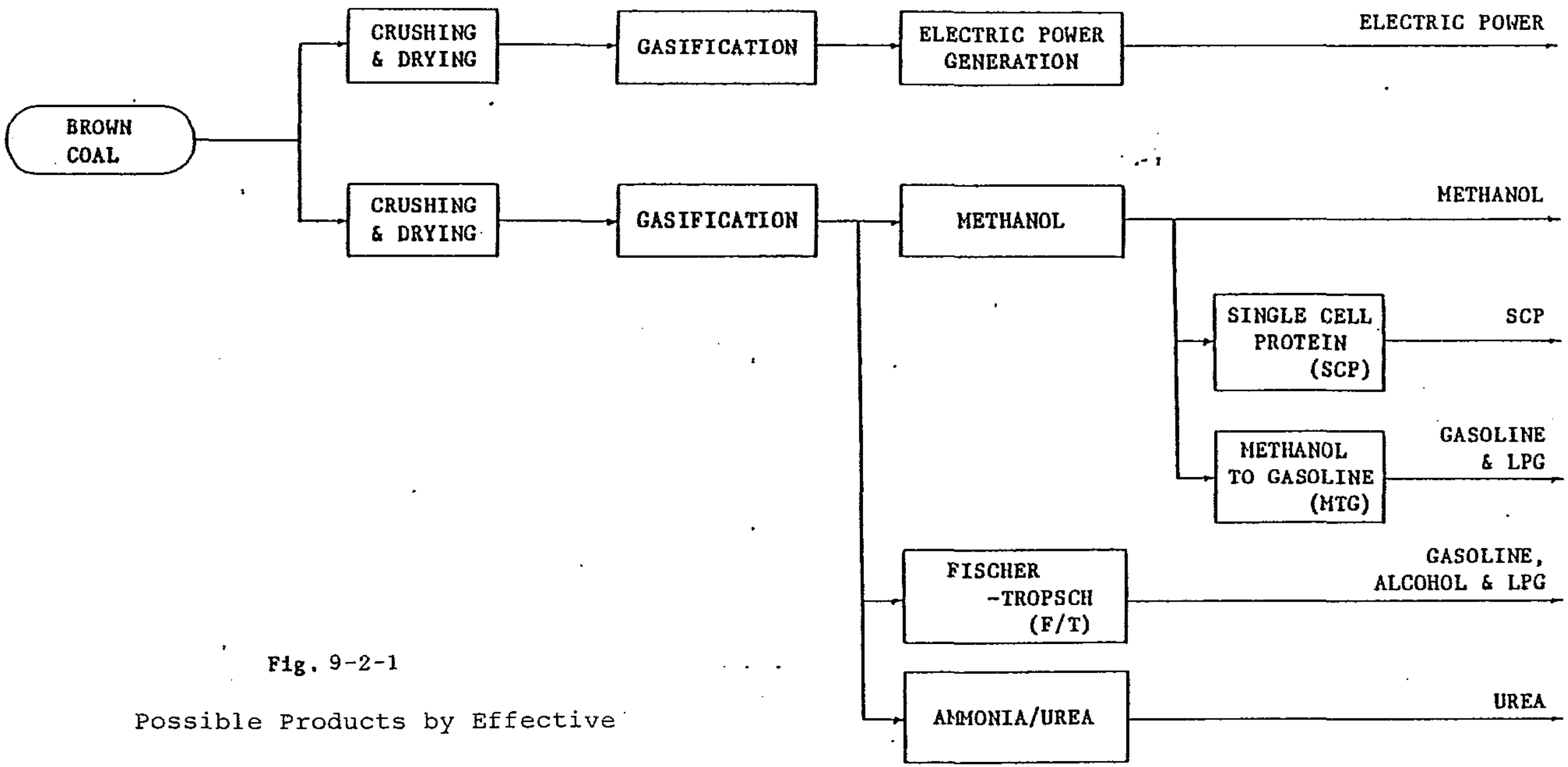


Fig. 9-2-1

Possible Products by Effective Utilization of Banko Coal.

a) Coal mining ; 4.0 to 6.2 million ton/year

b) Gasification Plant for chemical processing ;
504,000 Nm^3/Hr

c) Methanol Plant ; 5,000 ton/day

d) Other Chemicals Plant ; Synthesis gas requirement is the same as for 5,000 ton/day Methanol Plant,

i.e., Methanol 4,500 ton/day + SCP 300 ton/day
Methanol 4,060 ton/day + Urea 1,750 ton/day
MTG 13,190 BPD
F/T oil 6,900 BPD

e) Electric Power Generation Plant ; 300 MW or 1,000 MW

3) Mining Area

Coal reserves in Banko Area estimated by Shell are summerized in Table 9-2-1.

On the other hand, a coal requirement for this project is estimated as 6.2 million tons per year at the maximum.

Therefore, North West Banko (Block A), and West and Central Banko (Block B) are proposed as the mining area, since at least 30 years of the mine life must be secured.

TABLE 9-2-1

COAL RESERVES IN BANKO AREA

Area	Measured Reserves 10^6 tons	Strip Ratio m^3/t coal	Coal Quality
Block A	129.5	2.0	Total Moisture
(North West Banko)			28 - 35%
Block B	178.5	1.5	Ash
(West & Central Banko)			4 - 16% (dry base)
Block C	127.5	2.5	Volatile Matter
(Central Banko)			40.5-48.5% (dry base)
Total	435.5	-	Total Sulfur
			0.15-2.4% (dry base)
	-		Calorific value
			6100 - 7100 (dry base)

4) Design Coal

During the preparation of the Master Plan, the coal quality listed in Table 9-2-2 has been assumed as the design basis.

This has been mainly taken from the report titled "Technical Study of the North-West Banko Coal Project" prepared by Shell, dated April 1983, and some unlisted data have been assumed by the study team based on the coal analysis data in the same report and the coal analysis made by the team in August, 1984.

This design coal will also be used for the further study and establishment of the Proposed Project.

Table 9-2-2 DESIGN COAL

	As received	After drying
Total Moisture	35.0 %	10.0 %
Ash Content	4.84%	6.7 %
Volatile Matter	32.79%	45.4 %
Fixed Carbon	27.37%	37.9 %
Calorific Value-Gross	4,430Kcal/Kg	6,820Kcal/Kg
Carbon		70.06%
Hydrogen		5.67%
Nitrogen		1.10%
Oxygen		22.95%
Sulfur		0.22%
SiO_2 in ash		33.65%
CaO in ash		18.45%
Na_2O in ash		12 %

5) Plant Site

Although the further study will be required, possible plant sites are as follows.

i) Banko site
ii) Lematang River site
iii) Musi River site

(2) Case Study for Master Plan

In order to establish the Master Plan, we have prepared six cases of the preliminary Master Plans as per Fig. 9-2-3 through Fig. 9-2-8.

1) Chemical Production Plant

During a study for possible products, the five cases of chemical processing plants are selected, i.e.;

a) Methanol production plant
b) Single Cell Protein Production plant
c) Urea production plant
d) Fuel oil production plant by Fischer Tropsch Process
e) Fuel oil production plant through methanol by MTG Process

However, in the preliminary Master Plan, three cases as followings are put aside for a time being;

a) Single Cell Protein (SCP)
b) Fuel oil by Fischer Tropsch Process
c) Fuel oil through methanol MTG Process

Because, SCP and MTG processes are the downstreams of the methanol plant, can be constructed at the place where the site conditions are much better than in Banko area, such as distance to the major market, easiness of plant construction, and should be studied by the other party as an independent project.

A product selectivity of Fischer Tropsch process is not so good and rather small amount of various by-products are produced by the present technology. So it seems to be rather difficult or uneconomical to sell such small amount of various by-products from the remote area such as Banko area. Therefore,

a) Methanol production
b) Methanol and urea production

are taken up for the preliminary Proposed Project.

TABLE 9-2-3 COAL & UTILITIES REQUIREMENT (METHANOL PRODUCTION COMPLEX)

CASE NO.1-A

CGCC 300 MW
METHANOL 5,000 T/D

COAL AND UTILITIES	CONDITIONS	COAL GASIFICATION (MOLTEN IRON)	METHANOL & UTILITY	ELECT. POWER GEN'TN. INCL. GASIFICAT'N.	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	396 T/H		128 T/H	524 T/H (3,940,000 T/Y)	
ELECTRICITY		71.4 MW	49.7 MW	-252 MW	-130 MW	
IW		100 T/H	2,384 T/H	25 T/H	2,409 T/H *	* INCL.
CW	30 - 37°C	6,200 T/H	32,800 T/H	30,000 T/H	69,000 T/H	BFW MAKE-UP 214 T/H
BFW		385 T/H	375 T/H	69 T/H	829 T/H	CW MAKE-UP 2,070 T/H
HP STEAM	350°C 40Kg/cm^{2}G	-385 T/H	385 T/H	0	0	
HP STEAM	250°C 40Kg/cm^{2}G	0	0	0	0	
LP STEAM	156°C 3.5Kg/cm^{2}G	144 T/H	-124 T/H	-20 T/H	0	
STEAM COND.		-144 T/H	-427 T/H	-44 T/H	-615 T/H	
FUEL GAS		0	0	0	0	
LIMESTONE		11.4 T/H	0	0	11.4 T/H	
IRON SCRAP		5.7 T/H	0	0	5.7 T/H	
WASTE WATER	DIRTY	-94 T/H	-100 T/H	-28 T/H	-222 T/H	
WASTE WATER	CLEAN	0	-748 T/H	-6 T/H	-754 T/H **	** INCL.
CHAR		0	0	-6 T/H	-6 T/H	BFW BLOW-DOWN 9 T/H
SLAG		-25.7 T/H	0	0	-25.7 T/H	CW BLOW-DOWN 690 T/H

TABLE 9-2-4 COAL & UTILITIES REQUIREMENT (METHANOL PRODUCTION COMPLEX)

CASE NO.1-B

CGCC 1,000 MW
METHANOL 5,000 T/D

COAL AND UTILITIES	CONDITIONS	COAL GASIFICATION (MOLTEN IRON)	METHANOL & UTILITY	ELECT. POWER GEN'TN. INCL. GASIFICAT'N.	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	396 T/H		500 T/H	896 T/H	
COAL (DRY)	MOISTURE: 10%				(5,980,000 T/Y)	
ELECTRICITY		71.4 MW	74.6 MW	-1,013 MW	-867 MW	
IW		0 T/H	5,000 T/H	100 T/H	5,100 T/H *	* INCL.
CW	30 - 37°C	6,200 T/H	32,800 T/H	116,700 T/H	155,700 T/H	BFW MAKE-UP 230 T/H
BFW		385 T/H	375 T/H	214 T/H	974 T/H	CW MAKE-UP 4,670 T/H
HP STEAM	350°C 40Kg/cm^{2}G	-385 T/H	385 T/H	0	0	
HP STEAM	250°C 40Kg/cm^{2}G	0	0	0	0	
LP STEAM	156°C 3.5Kg/cm^{2}G	144 T/H	-124 T/H	-20 T/H	0	
STEAM COND.		-144 T/H	-427 T/H	-173 T/H	-744 T/H	
FUEL GAS		0	0	0	0	
LIMESTONE		11.4 T/H	0	0	11.4 T/H	
IRON SCRAP		5.7 T/H	0	0	5.7 T/H	
WASTE WATER	DIRTY	-94 T/H	-100 T/H	-113 T/H	-307 T/H	
WASTE WATER	CLEAN	0	-1,615 T/H	-21 T/H	-1,636 T/H **	** INCL.
CHAR		0	0	-24 T/H	-24 T/H	BFW BLOW-DOWN 27 T/H
SLAG		-25.7 T/H	0	0	-25.7 T/H	CW BLOW-DOWN 1,557 T/H

TABLE 9-2-5 COAL & UTILITIES REQUIREMENT (METHANOL PRODUCTION COMPLEX)

CASE NO.1-C

PULVERIZED COAL FIRING 1,000 MW
METHANOL 5,000 T/D

COAL AND UTILITIES	CONDITIONS	COAL GASIFICATION (MOLTEN IRON)	METHANOL & UTILITY	ELECT. POWER GEN'TN.	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	396 T/H		550 T/H	946 T/H (6,250,000 T/Y)	
ELECTRICITY		71.4 MW	83.2 MW	-1,015 MW	-860 MW	
IW		100 T/H	5,810 T/H	100 T/H	6,010 T/H *	* INCL.
CW	30 - 37°C	6,200 T/H	32,800 T/H	146,700 T/H	185,700 T/H	BFW MAKE-UP 240 T/H
BFW		385 T/H	375 T/H	225 T/H	985 T/H	CW MAKE-UP 5,570 T/H
HP STEAM	350°C 40Kg/cm^2G	-385 T/H	385 T/H	0	0	
HP STEAM	250°C 40Kg/cm^2G	0	0	0	0	
LP STEAM	156°C 3.5Kg/cm^2G	144 T/H	-124 T/H	-20 T/H	0	
STEAM COND.		-144 T/H	-427 T/H	-175 T/H	-746 T/H	
FUEL GAS		0	0	0	0	
LIMESTONE		11.4 T/H	0	0	11.4 T/H	
IRON SCRAP		5.7 T/H	0	0	5.7 T/H	
WASTE WATER	DIRTY	-94 T/H	-100 T/H	-124 T/H	-318 T/H	
WASTE WATER	CLEAN	0	-1,915 T/H	-31 T/H	-1,946 T/H **	** INCL.
ASH		0	0	-29 T/H	-29 T/H	BFW BLOW-DOWN 34 T/H
SLAG		-25.7 T/H	0	0	-25.7 T/H	CW BLOW-DOWN 1,857 T/H

TABLE 9-2-6 COAL AND UTILITY REQUIREMENT (METHANOL AND UREA PRODUCTION COMPLEX)

CASE NO.2-A C.G.C.C 300 MW
METHANOL / UREA 4,060 T/D / 1,750 T/D

COAL AND UTILITIES	CONDITIONS	COAL GASIFICATION (MOLTEN IRON)	METHANOL/UREA & UTILITY	ELECT. POWER GEN'TN. INCL. GASIFICAT'N.	TOTAL	REMARKS
COAL	MOISTURE : 35%	396 T/H		143 T/H	539 T/H	(4,140,700 T/Y)
ELECTRICITY		71.4 MW	105.0 MW	-252 MW	-75 MW	
IW		0	2,849 T/H	25 T/H	2,874 T/H *	* INCL.
CW		6,200 T/H	42,700 T/H	30,000 T/H	78,900 T/H	BFW MAKE-UP :274 T/H
BFW	30－37℃	385 T/H	332 T/H	184 T/H	901 T/H	CW MAKE-UP:2,367 T/H
HP STEAM	350℃ 40Kg/cm²G	-385 T/H	385 T/H	0	0	
HP STEAM	250℃ 40Kg/cm²G	0	0	0	0	
LP STEAM	156℃ 3.5Kg/cm²G	144 T/H	-13 T/H	-131 T/H	0	
STEAM COND.		-144 T/H	-439 T/H	-44 T/H	-627 T/H	
FUEL GAS		0	0	0	0	
LIMESTONE		11.4 T/H	0	0	11.4 T/H	
IRON SCRAP		5.7 T/H	0	0	5.7 T/H	
WASTE WATER	DIRTY	-94 T/H	-100 T/H	-28 T/H	-222 T/H	
WASTE WATER	CLEAN		-837 T/H	-9 T/H	-846 T/H **	** INCL.
CHAR		0	0	-6 T/H	-6 T/H	BFW BLOW-DOWN:13 T/H
SLAG		-25.7 T/H	0	0	-25.7 T/H	CW BLOW-DOWN :790 T/H

TABLE 9-2-7 COAL AND UTILITY REQUIREMENT (METHANOL AND UREA PRODUCTION COMPLEX)

CASE NO.2-B C.G.C.C 1,000 MW
METHANOL / UREA 4,060 T/D / 1,750 T/D

COAL AND UTILITIES	CONDITIONS	COAL GASIFICATION (MOLTEN IRON)	METHANOL/UREA & UTILITY	ELECT.POWER GEN'TN. INCL.GASIFICAT'N.	TOTAL	REMARKS
COAL	MOISTURE : 35%	396 T/H		515 T/H	911 T/H	(6,186,200 T/Y)
ELECTRICITY		71.4 MW	130 T/H	-1,1013 MW	-812 MW	
IW		0	5,464 T/H	100 T/H	5,564 T/H *	* INCL.
CW		6,200 T/H	42,700 T/H	116,700 T/H	165,600 T/H	BFW MAKE-UP:288 T/H
BFW	30—37℃	385 T/H	332 T/H	328 T/H	1,045 T/H	CW MAKE-UP:4,968 T/H
HP STEAM	350℃ 40Kg/㎠G	-385 T/H	385 T/H	0	0	
HP STEAM	250℃ 40Kg/㎠G	0	0	0	0	
LP STEAM	156℃ 3.5Kg/㎠G	144 T/H	-13 T/H	-131 T/H	0	
STEAM COND.		-144 T/H	-439 T/H	-173 T/H	-756 T/H	
FUEL GAS		0	0	0	0	
LIMESTONE		11.4 T/H	0	0	11.4 T/H	
IRON SCRAP		5.7 T/H	0	0	5.7 T/H	
WASTE WATER	DIRTY	-94 T/H	-100 T/H	-113 T/H	-307 T/H	
WASTE WATER	CLEAN		-1,703 T/H	-23 T/H	-1,726 T/H **	** INCL.
CHAR		0	0	-24 T/H	-24 T/H	BFW BLOW-DOWN:28 T/H
SLAG		-25.7 T/H	0	0	-25.7 T/H	CW BLOW-DOWN:1,656 T/H

TABLE 9-2-8 COAL & UTILITIES REQUIREMENT (METHANOL AND UREA PRODUCTION COMPLEX)

CASE NO.2-C

Pulv. Coal Combustion 1,000 MW
Methanol/Urea 4,060 T/D / 1,750 T/D

COAL AND UTILITIES	CONDITIONS	COAL GASIFICATION (MOLTEN IRON)	METHANOL & UTILITY	ELECT. POWER GEN'TN. INCL. GASIFICAT'N.	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	396 T/H		565 T/H	961 T/H	(6,467,100 T/Y)
ELECTRICITY		71.4 MW	139 MW	-1,015 MW	-805 MW	
IW		0	6,374 T/H	100 T/H	6,474 T/H *	* INCL.
CW	30 - 37°C	6,200 T/H	42,700 T/H	146,700 T/H	195,600 T/H	BFW MAKE-UP 298 T/H
BFW		385 T/H	332 T/H	339 T/H	1,056 T/H	CW MAKE-UP 5,868 T/H
HP STEAM	350°C 40Kg	-385 T/H	385 T/H	0	0	
HP STEAM	250°C 40Kg	0	0	0	0	
LP STEAM	156°C 3.5Kg	144 T/H	-13 T/H	-131 T/H	0	
STEAM COND.		-144 T/H	-439 T/H	-175 T/H	-758 T/H	
FUEL GAS		0	0	0	0	
LIMESTONE		11.4 T/H	0	0	11.4 T/H	
IRON SCRAP		5.7 T/H	0	0	5.7 T/H	
WASTE WATER	DIRTY	-94 T/H	-100 T/H	-114 T/H	-308 T/H	
WASTE WATER	CLEAN		-2,003 T/H	-33 T/H	-2,036 T/H **	** INCL.
ASH		0	0	-24 T/H	-24 T/H	BFW BLOW-DOWN 38 T/H
SLAG		-25.7 T/H	0	0	-25.7 T/H	CW BLOW-DOWN 1,956 T/H

TABLE 9-2-9 COAL & UTILITIES REQUIREMENT (OVER-ALL)

CASE NO.1-A — CGCC 300 MW; METHANOL 5,000 T/D

COAL AND UTILITIES	CONDITIONS	COAL MINING	GASIFICATION COMPLEX	INFRASTRUCTURE	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	-524 T/H	524 T/H		0	(3,940,000 T/Y)
METHANOL		8 T/H	-208 T/H		-200 T/H	(1,625,000 T/Y)
ELECTRICITY		25 MW	-130 MW	20 MW	-85 MW	
IW		500 T/H	2,410 T/H	90 T/H *	3,000 T/H	* FOR POTABLE WATER
CW	30 - 37°C				0	
BFW					0	
HP STEAM	350°C 40Kg/cm^{2}G				0	
HP STEAM	250°C 40Kg/cm^{2}G				0	
LP STEAM	156°C 3.5Kg/cm^{2}G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			11.4 T/H		11.4 T/H	
IRON SCRAP			5.7 T/H		5.7 T/H	
WASTE WATER	DIRTY		-222 T/H		-222 T/H	
WASTE WATER	CLEAN		-754 T/H		-754 T/H **	** EXCL. RAIN WATER, SANITARY WASTE & WASTE WATER FROM MINING
CHAR					-6 T/H	
SLAG					-25.7 T/H	
OVERBURDEN		-3,700 m^3/H			-3,700 m^3/H	(11.1 x 10^6 m^3/Y)

TABLE 9-2-10 COAL & UTILITIES REQUIREMENT (OVER-ALL)

CASE NO.1-B

CGCC 1,000 MW
METHANOL 5,000 T/D

COAL AND UTILITIES	CONDITIONS	COAL MINING	GASIFICATION COMPLEX	INFRASTRUCTURE	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	-896 T/H	896 T/H	0	0	(5,980,000 T/Y)
METHANOL		13 T/H	-208 T/H		-195 T/H	(1,610,000 T/Y)
ELECTRICITY		30 MW	-867 MW	30 MW	-807 MW	
IW		500 T/H	5,100 T/H	100 T/H *	5,700 T/H	* FOR POTABLE WATER
CW	30 - 37°C				0	
BFW					0	
HP STEAM	350°C 40Kg/cm^2G				0	
HP STEAM	250°C 40Kg/cm^2G				0	
LP STEAM	156°C 3.5Kg/cm^2G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			11.4 T/H		11.4 T/H	
IRON SCRAP			5.7 T/H		5.7 T/H	
WASTE WATER	DIRTY		-307 T/H		-307 T/H	
WASTE WATER	CLEAN		-1,636 T/H		-1,636 T/H	EXCL. RAIN WATER, WASTE WATER FROM COAL MINE & SANITARY WASTES
CHAR			-24 T/H		-24 T/H	
SLAG			-25.7 T/H		-25.7 T/H	
OVERBURDEN		-5,600 m^3/H			-5,600 m^3/H	(16.8 x 10^6 m^3/H)

TABLE 9-2-11 COAL & UTILITIES REQUIREMENT (OVER-ALL)

CASE NO.1-C PULVERIZED COAL FIRING 1,000 MW
METHANOL 5,000 T/D

COAL AND UTILITIES	CONDITIONS	COAL MINING	GASIFICATION COMPLEX	INFRASTRUCTURE	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	-946 T/H	946 T/H		0	(6,250,000 T/Y)
METHANOL		-13 T/H	-208 T/H		-195 T/H	(1,610,000 T/Y)
ELECTRICITY		30 MW	-860 MW	30 MW	-800 MW	
IW		500 T/H	6,010 T/H	90 T/H *	6,600 T/H	* FOR POTABLE WATER
CW	30 - 37°C				0	
BFW					0	
HP STEAM	350°C 40Kg/cm^2G				0	
HP STEAM	250°C 40Kg/cm^2G				0	
LP STEAM	156°C 3.5Kg/cm^2G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			11.4 T/H		11.4 T/H	
IRON SCRAP			5.7 T/H		5.7 T/H	
WASTE WATER	DIRTY		-318 T/H		-318 T/H	
WASTE WATER	CLEAN		-1,946 T/H		-1,946 T/H**	** EXCL. RAIN WATER, WASTE WATER FROM COAL MINE & SANITARY WASTES
ASH			-29 T/H		-29 T/H	
SLAG			-25.7 T/H		-25.7 T/H	
OVERBURDEN		-5,800 m^3/H			-5,800 m^3/H	(17.6 x 10^6 m^3/H)

TABLE 9-2-12 COAL & UTILITIES REQUIREMENT (OVER-ALL)

CASE NO.2-A CGCC 300 MW
METHANOL 4,060 T/D & UREA 1,750 T/D

COAL AND UTILITIES	CONDITIONS	COAL MINING	GASIFICATION COMPLEX	INFRASTRUCTURE	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	-539 T/H	539 T/H		0	(4,140,700 T/Y)
UREA			-72.9 T/H		-72.9 T/H	(577,500 T/Y)
METHANOL		8 T/H	-169.2 T/H		-161.2 T/H	(1,314,800 T/Y)
ELECTRICITY		25 MW	-75 MW	20 MW	-30 MW	
IW		500 T/H	2,880 T/H	90 T/H *	3,500 T/H	* FOR POTABLE WATER
CW	30 ~ 37°C				0	
BFW					0	
HP STEAM	350°C 40Kg/cm^{2}G				0	
HP STEAM	250°C 40Kg/cm^{2}G				0	
LP STEAM	156°C 3.5Kg/cm^{2}G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			11.4 T/H		11.4 T/H	
IRON SCRAP			5.7 T/H		5.7 T/H	
WASTE WATER	DIRTY		-222 T/H		-222 T/H	
WASTE WATER	CLEAN		-846 T/H		-846 T/H	** EXCL. RAIN WATER,
CHAR			-6 T/H		-6 T/H	WASTE WATER FROM
SLAG			-25.7 T/H		-25.7 T/H	MINE & SANITARY WASTES
OVERBURDEN		-3,900 m^3/H			-3,900 m^3/H	(11.7 x 10^6 m^3/Y)

TABLE 9-2-13 COAL & UTILITIES REQUIREMENT (OVER-ALL)

CASE NO.2-B CGCC 1,000 MW
METHANOL 4,060 T/D & UREA 1,750 T/D

COAL AND UTILITIES	CONDITIONS	COAL MINING	GASIFICATION COMPLEX	INFRASTRUCTURE	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	-911 T/H	911 T/H		0	(6,186,200 T/Y)
UREA			-72.9 T/H		-72.9 T/H	(577,500 T/Y)
METHANOL		13 T/H	-169.2 T/H		-156.2 T/H	(1,299,800 T/Y)
ELECTRICITY		30 MW	-812 MW	30 MW	-752 MW	
IW		500 T/H	5,564 T/H	90 T/H *	6,200 T/H	* FOR POTABLE WATER
CW	30 - 37°C				0	
BFW					0	
HP STEAM	350°C 40Kg/cm^{2}G				0	
HP STEAM	250°C 40Kg/cm^{2}G				0	
LP STEAM	156°C 3.5Kg/cm^{2}G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			11.4 T/H		11.4 T/H	
IRON SCRAP			5.7 T/H		5.7 T/H	
WASTE WATER	DIRTY		-307 T/H		-307 T/H	
WASTE WATER	CLEAN		-1,726 T/H		-1,726 T/H	** EXCL. RAIN WATER, WASTE WATER FROM MINE & SANITARY WASTES
CHAR			-24 T/H		-24 T/H	
SLAG			-25.7 T/H		-25.7 T/H	
OVERBURDEN		-5,800 m^3/H			-5,800 m^3/H	(17.5 x 10^6 m^3/Y)

TABLE 9-2-14 COAL & UTILITIES REQUIREMENT (OVER-ALL)

CASE NO.2-C

PULVERIZED COAL FIRING 1,000 MW
METHANOL 4,060 T/D & UREA 1,750 T/D

COAL AND UTILITIES	CONDITIONS	COAL MINING	GASIFICATION COMPLEX	INFRASTRUCTURE	TOTAL	REMARKS
COAL (WET)	MOISTURE: 35%	-961 T/H	961 T/H		0	(6,467,100 T/Y)
UREA			-72.9 T/H		-72.9 T/H	(577,500 T/Y)
METHANOL		13 T/H	-169.2 T/H		-156.2 T/H	(1,299,800 T/Y)
ELECTRICITY		30 MW	-805 MW	30 MW	-745 MW	
IW		500 T/H	6,474 T/H	90 T/H *	7,100 T/H	* FOR POTABLE WATER
CW	30 - 37°C				0	
BFW					0	
HP STEAM	350°C 40Kg/cm^{2}G				0	
HP STEAM	250°C 40Kg/cm^{2}G				0	
LP STEAM	156°C 3.5Kg/cm^{2}G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			11.4 T/H		11.4 T/H	
IRON SCRAP			5.7 T/H		5.7 T/H	
WASTE WATER	DIRTY		-308 T/H		-308 T/H	
WASTE WATER	CLEAN		-2,036 T/H		-2,036 T/H	** EXCL. RAIN WATER, WASTE WATER FROM MINE & SANITARY WASTES
ASH			-24 T/H		-24 T/H	
SLAG			-25.7 T/H		-25.7 T/H	
OVERBURDEN		-6,100 m^3/H			-6,100 m^3/H	(18.2×10^6 m^3/Y)

Case 1 is to produce only methanol of which plant capacity is two trains of 2,500 ton per day and can be defined as a base case, since methanol is expected as one of basic chemicals to be used as fuel and raw material for other chemical as described in the relevant Section. However, since a demand of methanol as raw material for other chemicals would be small in Indonesia even after a decade, methanol shall be mainly consumed as fuel. Therefore the commercialization of technologies for utilization of methanol as fuel shall be carefully watched and studied. Also a distribution net work for methanol shall be studied.

Case 2 is to produce 4,060 ton per day of methanol as well as 1,750 ton per day of urea through ammonia. Since a demand of urea in Indonesia will still grow up, this case is selected. However, a viability of this case will mainly depend on a production cost of urea and possibility of natural gas supply for new project, since PUSRI has urea production facilities starting from natural gas in Palembang and there is enough amount of natural gas resources to produce urea but not enough for export, as discussed in Subsection 6-4.

It is needless to say that we will be prepared to take up such put-aside-processes into the final Proposed Project, when a progress of research and development work or a marketability allows us to do so.

2) Electric Power Generation Plant

For a electric power generation plant, three cases are selected for the preliminary Master Plan.

Case A (300 MW) is to generate a required amount of electricity for a gasification plant complex, coal mining facility and infrastructures as well as some amount of electric power to be supplied to South

Sumatra, utilizing CGCC (Coal Gasification Combined Cycle).

Case B (1,000 MW) is to generate a required amount of electricity for a gasification complex, coal mining facility and infrastructure as well as considerable amount of electric power to be supplied to Java area utilizing CGCC.

Case C (1,000 MW) covers the same capacity of electric power generation plant with Case B but utilizing pulverized coal firing boiler.

Since a high efficiency combined cycle power plant technology is still under development, the future study for this point will be required.

Also, in case of pulverized coal firing power plant, high content of Na_2O in Banko coal seems to be problem. The future study for it as well as for fluidized bed combustion boiler will be necessary. This is also a reason why 300 MW pulverized coal firing case is omitted from the preliminary Master Plan.

In Case B and C the study for a high voltage direct current transmission system will be necessary as a part of the future study.

3) Coal Gasification Plant

For chemical processing, Molten Iron Bath Process has been taken up for the convenience of the future study taking the process evaluation made by the study team and the Counterpart into consideration. In this case the only one study is to be carried out since the required volume of synthesis gas is the same with Case 1 (only methanol production) and Case 2 (methanol and urea production), as mentioned before.

For electric power generation utilizing the CGCC, Fluidized Bed/Entrained Flow Processes of air blow type have been taken up without distinction, since CGCC is still premature in the stage of commercial development, and there is no significant difference in material balance between these two process at this moment. In this case two cases of the plant capacity are to be studied, namely one for Case A (300 MW) and another for Case B (1,000 MW).

The coal gasification processes for chemical processing and CGCC electricity generation shall be reviewed and selected again on the basis of the up-to-date information at the final stage of feasibility study.

4) Material Balance

As mentioned before, six cases of the preliminary Master Plans have been established as per Fig. 9-2-2 through Fig. 9-2-7.

Material balances for these six cases covering Coal Gasification Plant, Chemical Production Plant and Electric Power Generation Plant (Coal Gasification Complex) have been estimated and shown in Table 9-2-3 through Table 9-2-8.

Also over-all material balances for these six cases covering Coal Mining Facility, Coal Gasification Complex and their infrastructure have been estimated and shown in Table 9-2-9 through Table 9-2-14.

According to these over-all material balances,

a) the annual coal requirement is ranging from 3,940,000 tons to 6,470,000 tons, and

b) the raw water requirement is 2.0 tons per second at the maximum, although the dry season discharge of River Enim is estimated as 22.5 tons per second.

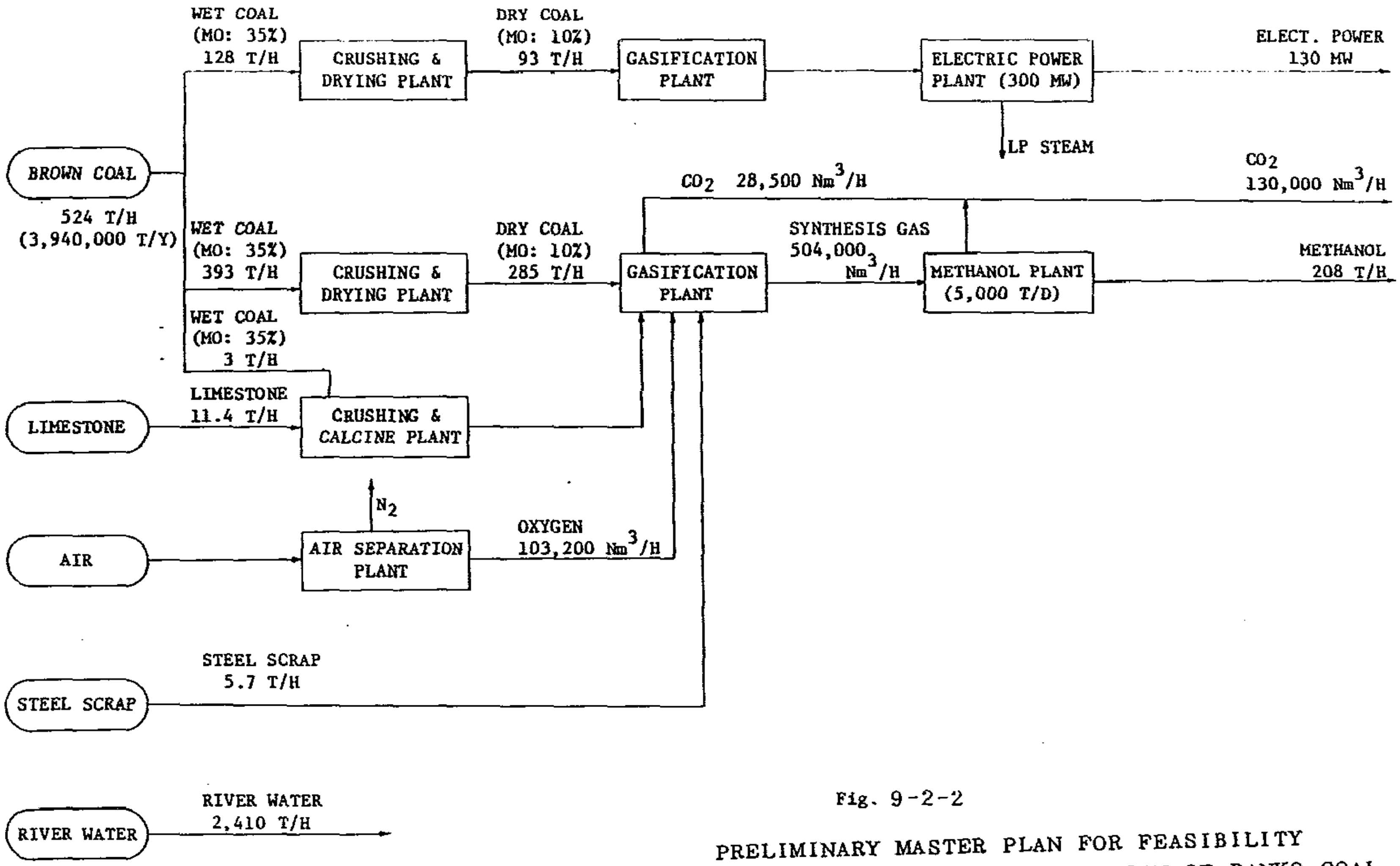


Fig. 9-2-2

PRELIMINARY MASTER PLAN FOR FEASIBILITY STUDY ON EFFECTIVE·UTILIZATION OF BANKO COAL

CASE 1-A

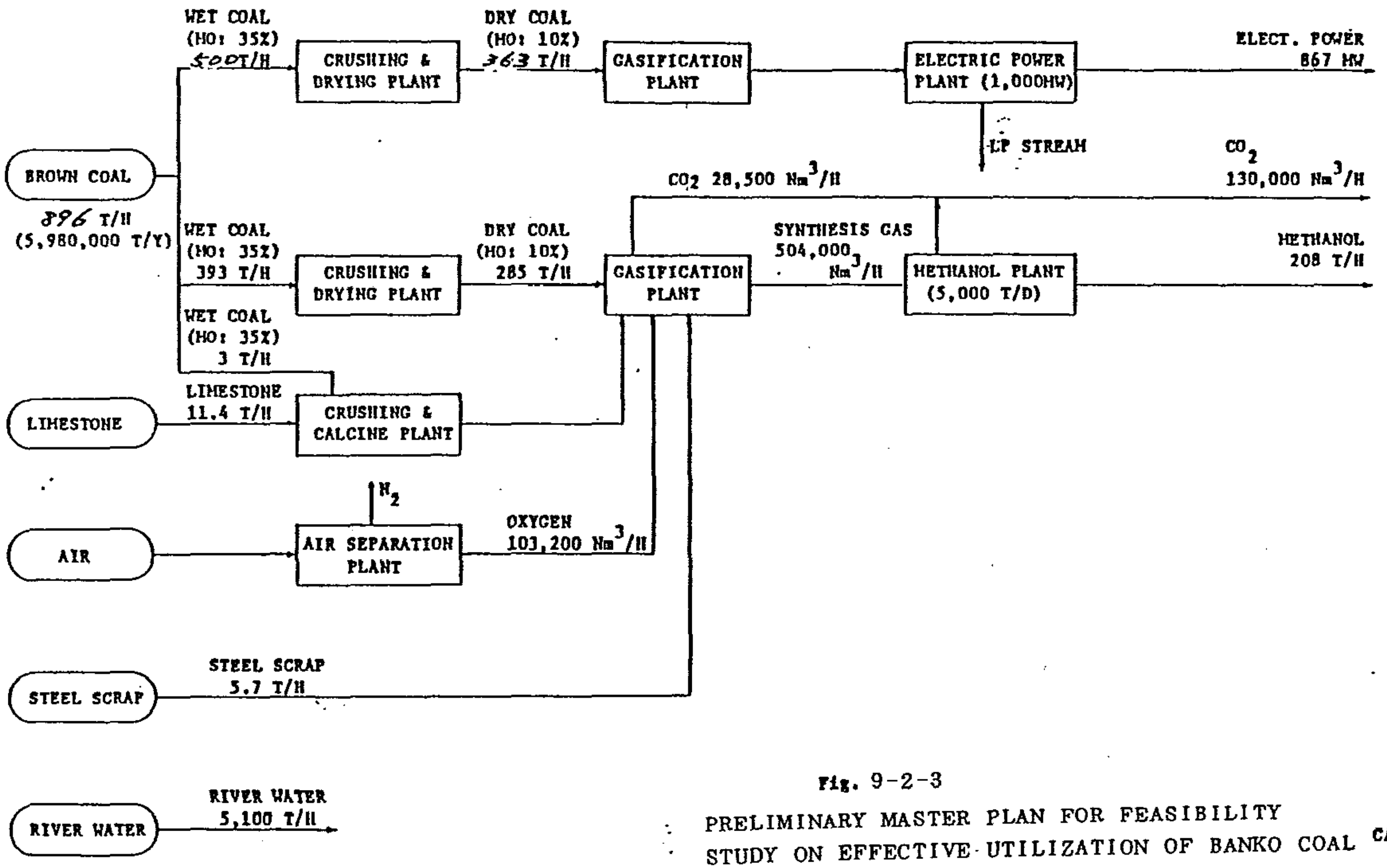


Fig. 9-2-3

PRELIMINARY MASTER PLAN FOR FEASIBILITY
STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL CASE 1-B

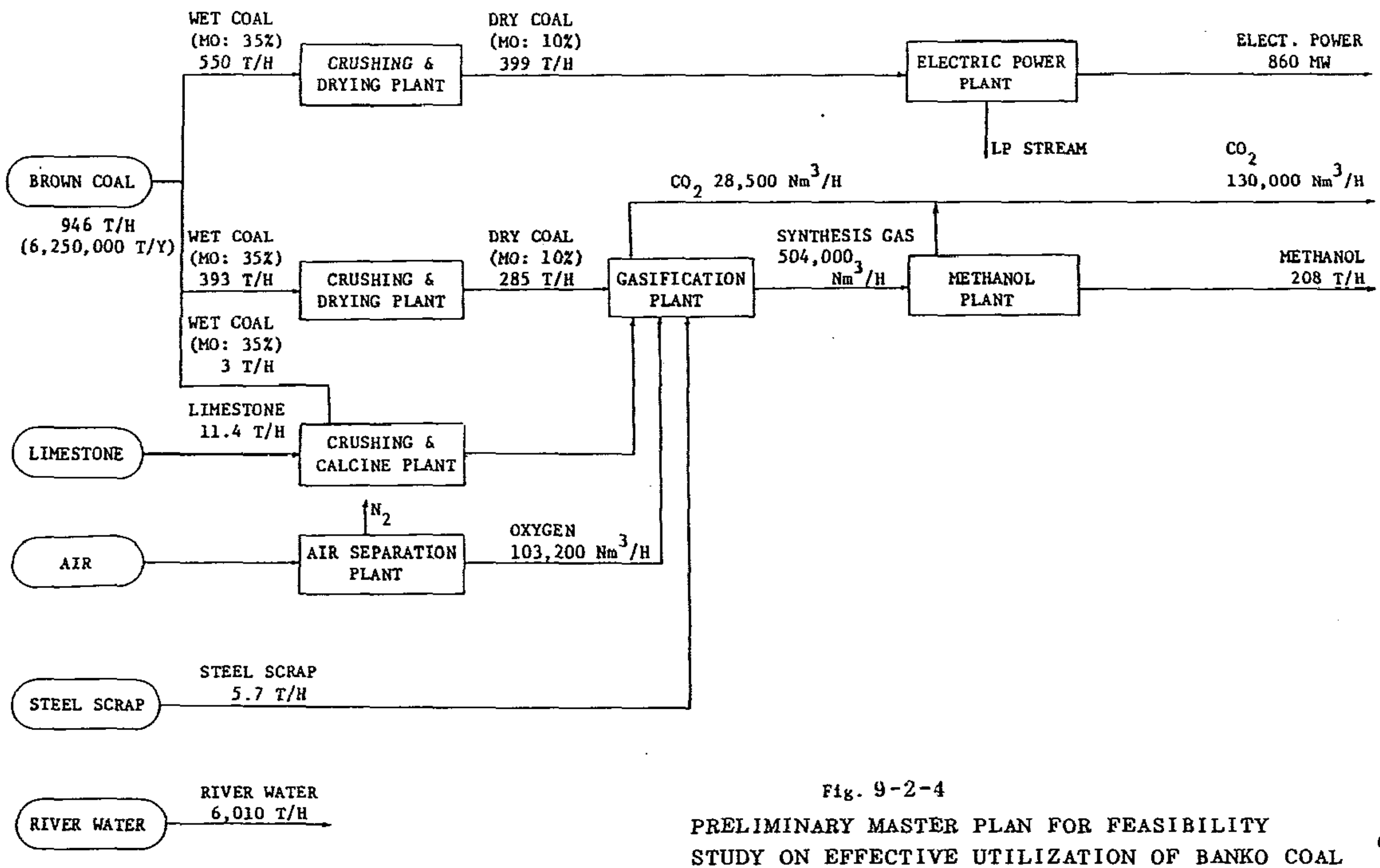


Fig. 9-2-4

PRELIMINARY MASTER PLAN FOR FEASIBILITY
STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL

CASE 1-C

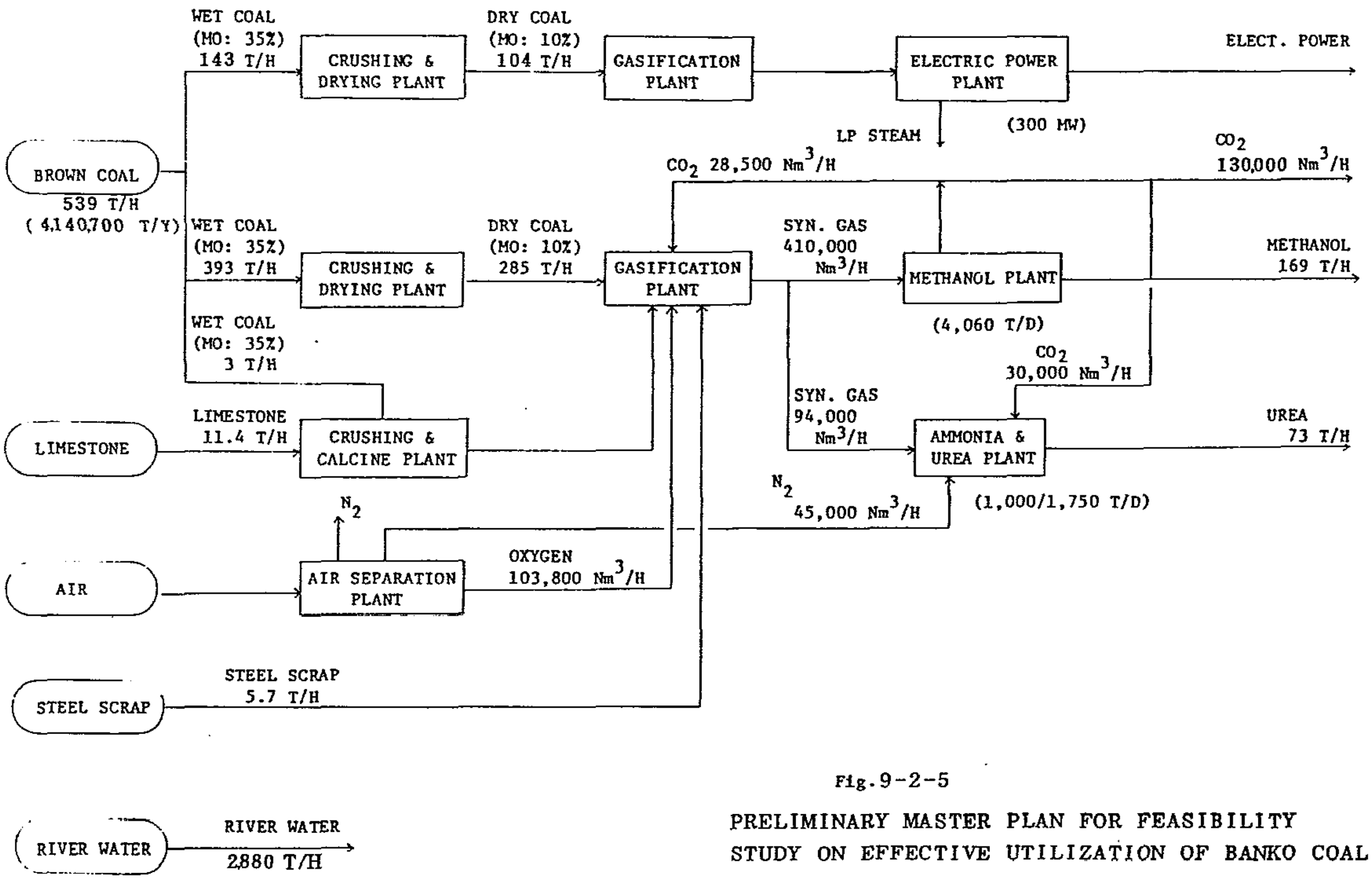


Fig. 9-2-5

PRELIMINARY MASTER PLAN FOR FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL

CASE 2-A

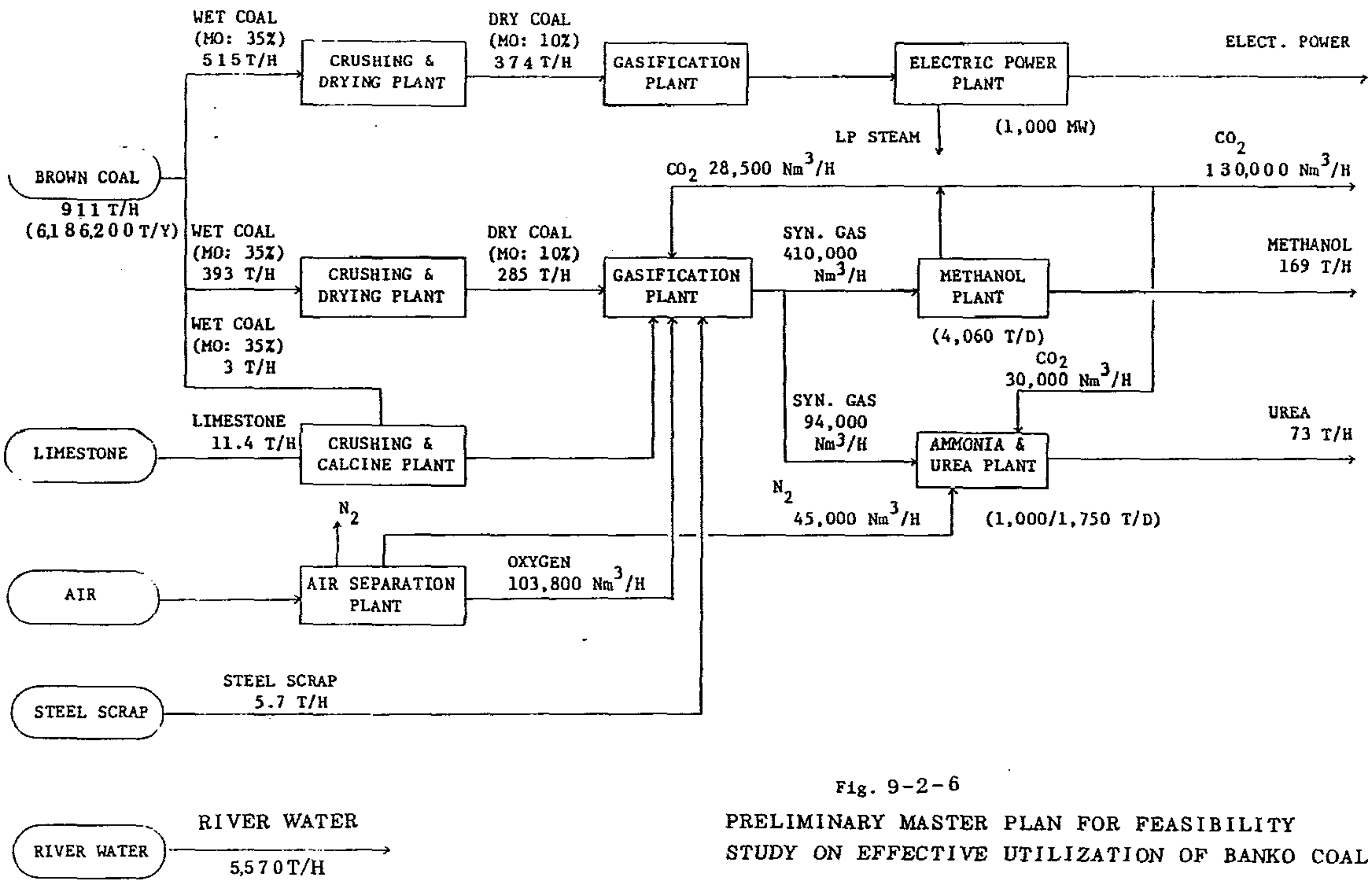


Fig. 9-2-6

PRELIMINARY MASTER PLAN FOR FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL

CASE 2-B

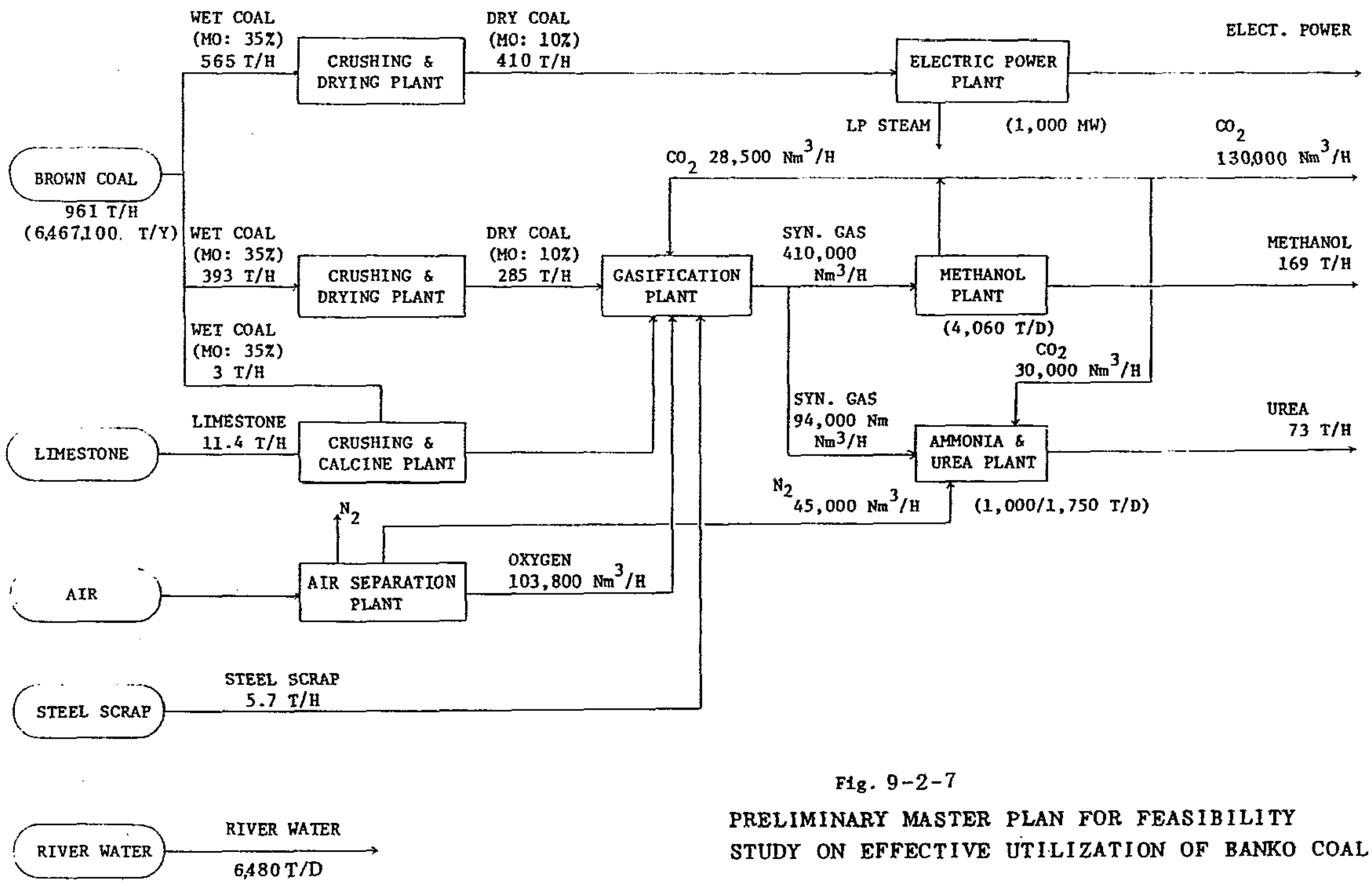


Fig. 9-2-7

PRELIMINARY MASTER PLAN FOR FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL

CASE 2-C

Therefore, the these cases seem to be viable only from these technical view points.

(3) Establishment of Master Plan

We have further studied as follows in order to establish the Master Plan.

1) Chemical Production Plant

a) *Conformity with Indonesian Policy*

Both methanol and urea production with conform with;

- Energy policy
- Industrialization policy
- Transmigration poilcy

b) Prospect for Demand

As in Subsection 6-4, a demand of methanol as chemical will not be increased so much. However, it would be drastically increased, if methanol with be accepted as fuel in Indonesia. In this sense methanol is advantageous to produce. For export, a prospect for demand will depend on a production cost, since methanol from this project must compete with it from Middle East and Oceania of which feed stock is cheap natural gas.

A demand for urea will be increased gradually. However, since Indonesia has enough natural gas reserves, the competitiveness of urea from coal will depend on its production cost.

c) Distribution Network

Methanol is planned to be consumed at small stationary electric power generation facilities and automobiles of which service route is limited such as buses, at this moment. However a completely new distribution network will have to be established. It will be quite difficult from financial and technical view point.

On the other hand, in principle, an existing distribution network can be used for urea, even though it might be required to enforce.

d) Transportation
Pipeline and shipping/loading facilities including tankages for methanol must be constructed. Also methanol tanker fleet, tank trucks, etc. must be prepared for the transportation of methanol. Those will cause a big additional investment.
Although an existing transportation system could be used after Palembang, an improvement of existing railway or a newly construction of railway between Banko and Palembang would be necessary for urea.

e) Competitive Plant
Although the methanol plant at Bunyu Island will be put into operation from this year, this plant will not be a competitive plant considering its plant capacity and location.
On the other hand, there are urea production facilities in Palembang where the plant site condition is much better than in Banko.
So urea from this project will be theoritically discussed against it in Palembang.

f) Technology Development
There are so many methanol and urea plants in the world. Although their feed stock is natural gas, we do not see the difference of difficulties between them to switch the feed stock to synthesis gas.

g) Construction
Equipment and materials will be unloaded at Palembang and hauled to the plant site for 200 Km. So the construction of the plant will not be so easy for both processes. However, when the both processes will be constructed at the same time,

such difficulty will be significantly increased due to large volume of cargoes.

h) Operation and Maintenance
Since there are both methanol and urea plants in Indonesia, we do not see the difficulties in operation and maintenance of the plants. However, the difficulties will be significaulty increased when the two processes will be constructed at the same time.

i) Number of Employees
When both methanol and urea plants will be constructed, a number of employees will be naturally increased. It will provide a big opportunity for employment.

j) Investment Cost
When a high pressure plant such as urea plant will be constructed in addition of methanol plant, an investment cost will be significantly increased, even if the methanol plant capacity will be decreased. So the difficulty to arrange an investment cost will be increased.

k) Prospect for Viability
It is difficult to predict a viability of these Master Plan at this moment, since no economic study has been carried out. However, judging from literatures, only methanol production case seems to be advantageous.

2) Electric Power Generation Plant

a) Prospect for Demand
A demand for electric power will be increased, as a whole. However, the study for demands in Java area and South Sumatra area has not yet been conducted during the first stage.

b) Transmission

A transmission line between Bukit Asam Power Station and Palembang, which is under construction, could be used for supplying electric power to South Sumatra. However we have not yet studied this transmission line. An additional study for a transmission line to Java will be newly necessary.

c) Development of Technologies

Technologies for Coal Gasification Combined Cycle (CGCC) and large fluidized bed combustion boiler are under development. The effect of Na_2O on pulverized coal firing has not yet studied in detail.

3) Evaluation

The evaluation on chemical production plants are summerized in Table 9-2-15. According to this table, it seems to be advantageous to construct only methanol plant. However it also seems to be better not to discard the case for methanol and urea production.

It is very difficult at this moment to select the one for electric power generation plants, since technologies for them are still under development and the further studies will be required.

Therefore we would like to propose the following four cases of the Master Plan at this moment.

a) Base Case

- Case 1-A (Fig. 9-2-2)
  5,000 T/D Methanol Plant and 300 MW CGCC
- Case 1-B (Fig. 9-2-3)
  5,000 T/D Methanol Plant and 1,000 MW CGCC

b) Alternative

- Case 2-A (Fig. 9-2-5)
  4,060 T/D Methanol Plant, 1,750 T/D Urea Plant and 300 MW CGCC

Table 9-2-15 Evaluation on Chemical Production Plant

	Fuel Methanol	Fuel Methanol and Urea	Remarks
1. Conformity with Indonesian Policy	o	o	
2. Prospect for Demand - Domestic	o	o and Δ	
- Export	Δ	Δ and Δ	
3. Distribution Network	x	x and o	
4. *Transportation*	o	o and x	
5. Competitive Plant	o	o and x	
6. Technology Development	o	o and o	
7. Construction	Δ	x	
8. Operation and Maintenance	Δ	x	
9. Number of Employees	Δ	o	
10. Investment Cost	Δ	x	
11. Prospect for Viability	o ∿ Δ	Δ ∿ x	
12. Total Evaluation	o ∿ Δ	Δ ∿ x	

o : Good   Δ : Average   x : Poor

- Case 2-B (Fig. 9-2-6)
  4,060 T/D Methanol Plant, 1,750 T/D Urea plant and 1,000 MW CGCC

Beside these on-site facilities, off-site facilities and infrastructure shown in Table 9-2-16 are included in the Master Plan.

TABLE 9-2-16

OFFSITE FACILITIES AND INFRASTRUCTURE

1) Utilities

- 1-1) Cooling water system
- 1-2) Potable water system
- 1-3) Boiler feed water system
- 1-4) Industrial water system
- 1-5) Fuel gas system
- 1-6) Fuel oil system
- 1-7) Nitrogen system
- 1-8) Instrument air system
- 1-9) Plant air system
- 1-10) Steam system
- 1-11) Steam condensate recovery system
- 1-12) Electricity receiving and distribution system

2) Offsite

- 2-1) Stock piles
  - a) Brown coal
  - b) Limestone
  - c) Steel scrap
- 2-2) Gas holder
- 2-3) Tankage
- 2-4) Water intake system
- 2-5) Product shipping facility
- 2-6) High voltage direct current transmission system
- 2-7) Slug disposal facility
- 2-8) Dust disposal facility
- 2-9) Waste water treatment facility
- 2-10) Flare
- 2-11) Fire fighting facilities

3) Auxiliary facilities

- 3-1) Offices
- 3-2) Laboratory
- 3-3) Workshop
- 3-4) Warehouse
- 3-5) Training center
- 3-6) Mess hall
- 3-7) Guard house
- 3-8) Fire engine house
- 3-9) Airport or Heliport
- 3-10) Telecommunication facilities

4) Infrastructures

- 4-1) Housing complex
- 4-2) Guest house
- 4-3) Club house
- 4-4) Hospital
- 4-5) School
- 4-6) Mosque and Church
- 4-7) Market
- 4-8) Recreation facilities
- 4-9) Access roads

10. Implementation Plan of Coal Gasification Test

(1) Coal gasification experiment plan

1) Principle and features of coal gasification process using a molten iron bath

A number of coal gasification processes have been developed from diverse ideas of reactor structures for coal gasification and for the use of gases produced. Those processes can be classified into four groups by characteristics of reactions taken place in a reactor; the fixed bed, the fluidized bed, the entrained flow and the molten bath. The coal gasification process using a molten iron bath is classified into a group of molten bath method.

Schematic drawing of this process is shown in Fig. 10-1. It has been developed by applying a highly refined technology of steelmaking converter and consists of a gasification reactor storing high-temperature molten iron which acts an important role in acceleration of gasification reaction.

Process of oxidation reaction in a top-blown converter is schematized in Fig.10-2. In the early stage of blowing, an amount of oxygen consumed for oxidation of Si, Mn and P is greater than that for decarburization. In the middle stage, most part of the oxygen is used for decarburization. More than 98% of gases produced in this period is carbon monoxide, which suggests that decarburizing efficiency of oxygen is almost 100%. In the late stage of blowing, since the amount of carbon in molten iron bath has already reduced, oxygen is increasingly consumed for oxidation of iron and generation of carbon dioxide and, as a result, reduces generation of carbon monoxide.

In molten iron coal gasification process, an adequate amount of coal is added to a molten iron bath during the middle stage of blowing, where decarburization reaction proceeds at the highest rate, in such a way as to compensate the reducing carbon content in the molten iron and to maintain its level at about 1% or higher, and coal is thus gasified continuously.

Coal is blown through a non-submersion-type lance onto the surface of this molten iron at a high speed together with gasification agents (oxygen gas and steam). Only a small amount of coal is gasified before it arrives the molten iron surface, but most amount of coal is efficiently gasified in the molten iron bath which provides the following benefits;

a) The molten iron bath completely cracks the blown coal in a short period of time and not only generates hydrogen gas but dissolves and absorbs the carbon produced by cracking.
b) The molten iron reacts with blown oxygen and with carbon dioxide generated in the bath and becomes FeO, but this FeO is immediately reduced by carbon contained in the molten iron and becomes Fe while generating carbon monoxide gas.

c) Even if an excessive amount of coal is fed into the molten iron bath, the molten iron dissolves and absorbs an excessive amount of carbon preventing unoxidized carbon to escape from the gasifier.

d) Even if an excessive amount of oxygen is supplied, carbon contained in the molten iron bath reacts with excess oxygen preventing the generation of carbon dioxide gas.

e) Coal ash is melted in the molten iron bath and floats on the surface due to its low specific-gravity characteristic.

f) The molten iron dissolves and absorbs the sulfur contained in the coal and then transform into the molten slag.

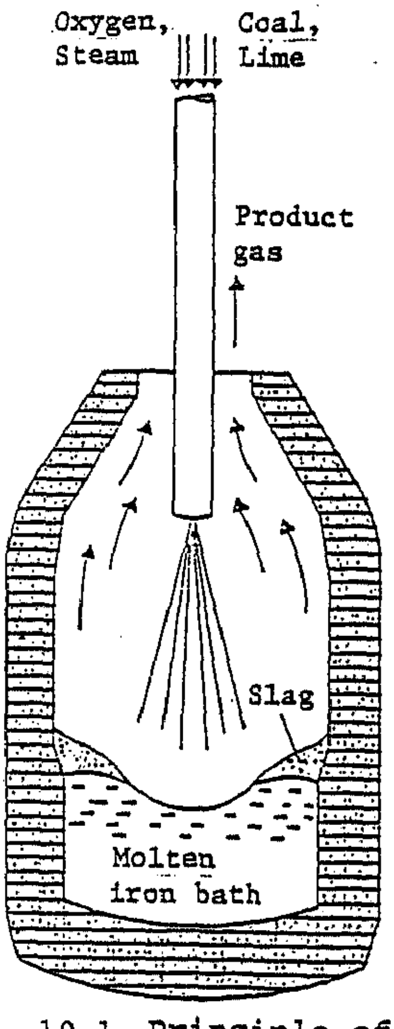


Fig. 10-1 Principle of molten iron coal gasification process

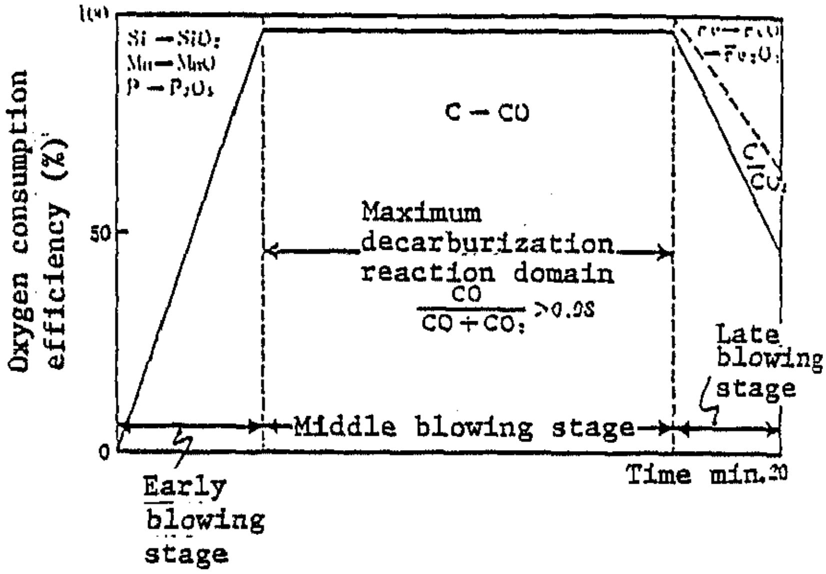


Fig. 10-2 Process of oxidation reaction in a top-blown converter

2) Purpose of experiments

In gasification of coal, characteristics of gasification operation (amount of product gas, components, contents of impurities, characteristics of slag, etc.) vary with properties of coal (moisture, ash, C,H,O,S contents, etc.).

Especially, coal reserved in the district of Banko, Indonesia, has a wide variety of qualities depending on area and coal seam. Therefore, before working out a plan for Banko coal gasification project, it is necessary to have a good knowledge of the properties of each coal produced in this district from the viewpoint of gasification.

Therefore, the purpose of experiments are;

a) Different kinds of brown coal produced in Banko district in Indonesia are gasified in a molten iron coal gasification testing plant to obtain necessary information about them for understanding each aspect of gasification operation.

b) The data obtained through conduction of gasification experiments are analyzed and studied by referring to our accumulated information by basic researches and experiments on pilot plants, and are summarized into a basic information needed for further feasibility study of coal gasification. Accordingly, the purpose of this experiment is not for development of new technology nor collection of engineering data.

3) Plan for installation of experimental equipment

The basic idea in making plan for installation of experimental equipment is as follows;

i) The experimental equipment must have a proper scale and function for understanding and evaluation of characteristics of coal gasification operation.

a) In order to make an accurate analysis of product gas components by minimizing the external disturbances (such as inclusion of N_2 gas used for sealing), the experimental equipment must have a capacity to generate about 40 Nm^3/h of product gas (Feeding rate of coal: about 20 kg/h).

b) The experimental equipment must be capable of producing a necessary amount of slag for analysis of components. A sufficient amount of slag for analysis will be produced when the coal is blown at a rate of about 20 kg/h.

ii) The equipment must be capable of keeping the molten iron bath at a constant temperature.

A small-scale experimental equipment has a greater heat loss causing the molten iron temperature to drop. To compensate such heat loss by giving heat from outside, this experimental equipment has an induction coil surrounding a gasifier to maintain the molten iron bath at a constant temperature.

iii) The molten iron required for coal gasification is produced by a medium-frequency induction furnace from iron scraps.

The basic specifications and the main components of the experimental equipment for coal gasification process designed on the basis of above-mentioned idea are indicated in Table 10-1 and Fig. 10-3.

Table 10-1 Basic specifications required for the experimental equipment

Item	Amount required	Remarks
Molten iron bath	300 kg	
Coal feeding rate	20 kg/h	Dry coal
Blowing oxygen	575 Nm^3/coal-t, 12 Nm^3/h	Standard value, varies with kind of coal.
Carrier gas	150 Nm^3/coal-t, 3 Nm^3/h	N_2
Product gas	2000 Nm^3/coal-t, 40 Nm^3/h	Standard value, varies with kind of coal.
Calcined lime	30 kg/coal-t, 0.6 kg/h	Standard value, varies with kind of coal.
Slag production	78 kg/coal-t, 1.6 kg/h	

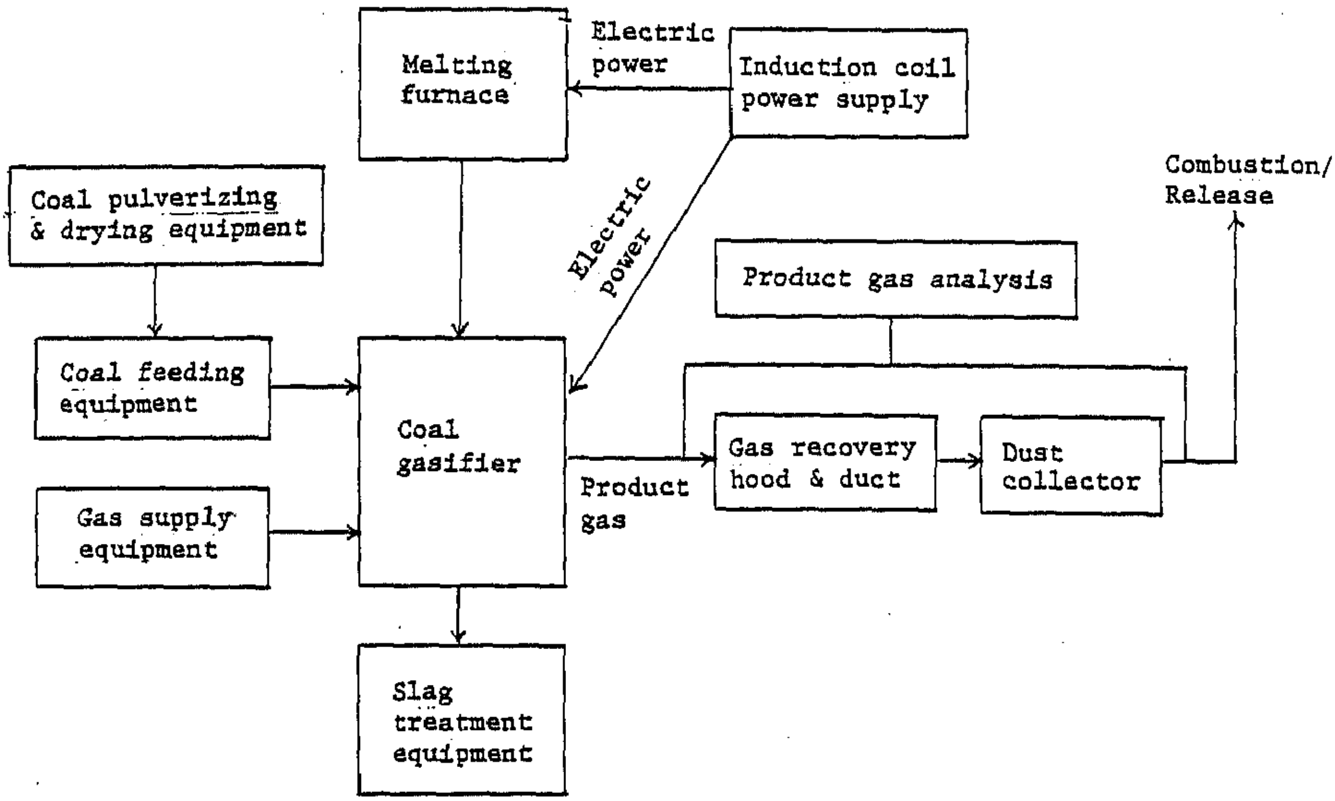


Fig. 10-3 Main components of experimental equipment

4) Considerations on experimental method

As a result of preliminary investigations made on Banko coal in 1984, common properties of Banko coal have been reported as follow;

a) Total moisture is as high as 28 to 38%.

b) Ash content is generally low but fluctuates between 4% and 16% depending on coal seam.

c) Oxygen content is as high as 23 to 26% according to the result of ultimate analysis.

d) Total content of sulfur is 0.2 to 1.8% and a large amount of sodium oxide (Na_2O) is included in ash.

A large fluctuation is recognized in the above-mentioned values among locations of coal area from NW Banko to Central Banko and also among depths of seam. Accordingly, the experimental method was so designed that the characteristics of coal gasification could be distinguished by properties of coal under the constant experimental conditions (proper values of the results obtained from past experiments) such as reaction temperature, feeding and blowing conditions of coal and oxygen, particle size of pulverized coal and basicity of slag, etc.

i) Experimental conditions

The experimental conditions were discussed considering the results of past experiments. The main items of the experimental conditions are as follow;

a) Temperature of molten iron bath

In a large-sized reactor, coal gasification can be performed to almost 100% of decarburizing efficiency when the molten iron temperature is 1400°C or higher. But, in a small-seze reactor, a little higher temperature of the molten iron bath is needed for decarburization. Therefore, we took a range of 1500 to 1550°C for the target of molten iron temperature.

b) Carbon content in molten iron bath

In order to maintain the carbon content in the molten iron bath at a level of 1% or higher, the ratio of coal to oxygen to be blown onto the molten iron bath is adjusted. The target of carbon content for practical operation is usually 2 to 3%.

c) Slag basicity

For maintaining the basicity of slag (CaO/SiO_2) between 1.5 to 2.0, an adding amount of calcined lime is controlled in consideration of fluidity, reaction with refractory bricks and desulfurization reaction of slag.

d) Pulverized coal feeding method

Both pulverized coal and oxygen are blown onto a hot spot on the surface of molten iron bath through a non-submersion type lance.

e) Particle size of pulverized coal

Pulverized coal of -200 mesh (more than 70%) is used, considering the efficiency of gasification.

ii) Sampling of Banko coal for gasification experiments

After examining the results of proximate and ultimate analyses conducted on samples of coal collected from each area and each seam of area spread over from NW Banko to Central Banko districts, some kinds of coal which are particularly characterized by total moisture, ash content, O content, S content and sodium content in ash are selected out of them and used for the coal gasification experiment.

iii) Time and procedure of experiment

Taking the following points into consideration that it was predicted to take 20 to 30 minutes for stabilization of gasification and one more hour for normalization of the process from which the reliable samples could be collected for analysis, a maximum period of time for one experiment was decided to be two hours. Table 10-2 indicates the standard time schedule for one experiment.

A 300 kg molten iron is prepared in a melting furnace (medium-frequency induction furnace)

In the morning, a 300 kgs of molten iron is produced from iron scraps in a medium-frequency induction furnace (melting furnace). In the afternoon of the same day, the molten iron is transferred into a gasifier in which a 2-hours gasification experiment is conducted at a prescribed temperature. Considering the necessary jobs to be done before and after an experiment including the arrangement of collected data, a cycle of two experiments in a week will be suitable.

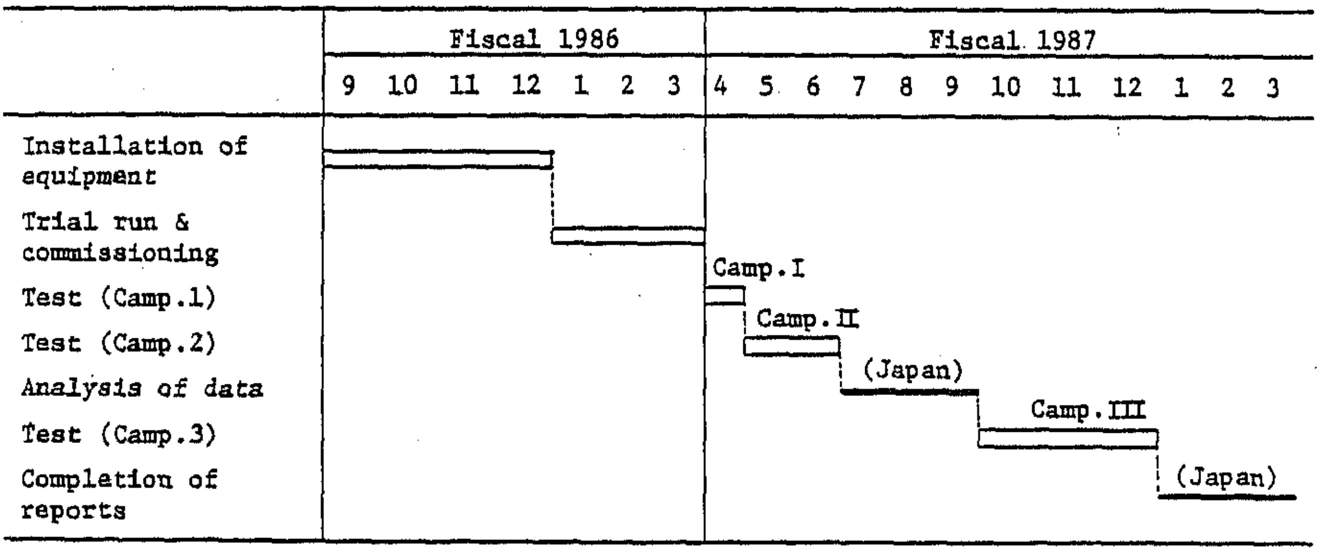
Table 10-2 Standard time schedule for an experiment

Hour	9	10	11	12	1	2	3	4	5
Melting furnace	Molten iron preparation				Tapping				
Gasifier	Gasifier preparation & preheating				Charging	Experiment		Finishing job	

5) Schedule

Table 10-3 indicates an overall schedule of Banko coal gasification experiment.

Table 10-3 Overall schedule of Banko coal gasification experiment



It is so scheduled that installation, trial run and commissioning of the experimental equipment and also a cold test (drying, pulverizing and feeding of the actual Banko coal) are to be completed at or before the end of March, 1987. The gasification experiment is to be conducted in a period of one year, from April, 1987 to March, 1988, and is divided into 3 steps of Campaign I to Campaign III by the purposes of experiment as indicated in Table 10-4.

During Campaign I, preparatory experiment is conducted to examine and understand the characteristics of the experimental equipment.

During Campaign II, essential experiment is conducted to understand the characteristics of Banko coal being a raw coal for gasification.

During Campaign III, supplementary experiment is conducted in consideration of the results of analyzed data.

Table 10-4 Experiment by 3-step Campaign

	Main purpose
Trial run and commissioning	1. Non-load test of the equipment 2. Drying, pulverizing and feeding tests using the actual Banko coal
Campaign I	1. Experiments to understand the characteristics of equipment 1) Heat loss of gasifier 2) Examination of gasifier temperature holding condition that can keep the molten iron bath at a constant temperature 3) Study of furnace repair intervals 4) Establishment of an optimum testing condition 2. Number of heats for experiment: About 8 heats
Campaign II	1. Experiment to understand the characteristics of Banko brown coal being a raw material for gasification 1) Influence of moisture and ash 2) Influence of C, H, O and S contents 2. Number of heats for experiment: About 15 heats
Campaign III	Supplementary tests to the results of analyzed data collected during Campaign II

(2) Basic Design of the Coal Gasification Test Facilities

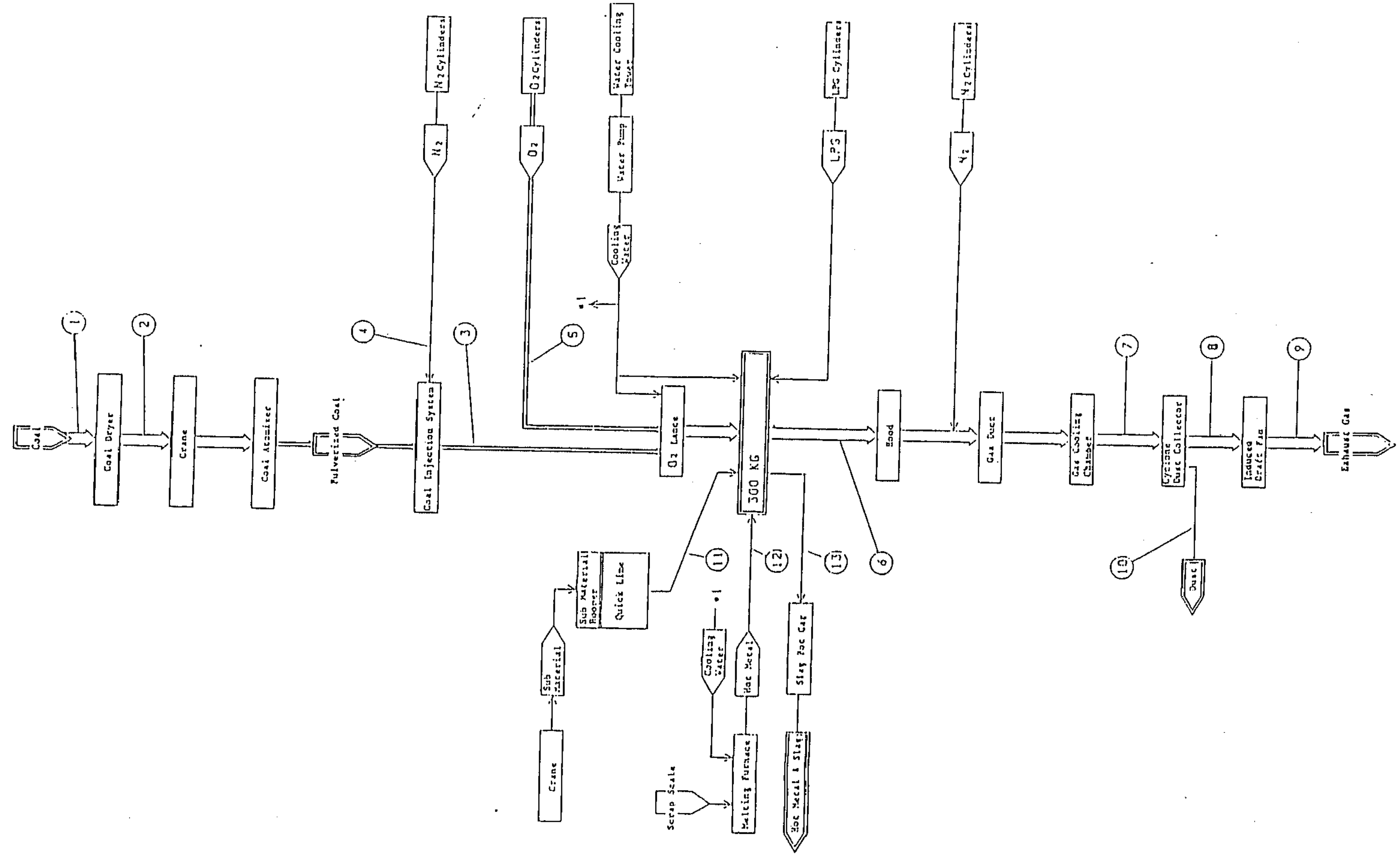
On the basis of the implementation plan of coal gasification test, as described in 10-(1), basic design of the coal gasification test facilities was carried out.

The outlines are as follows;

Note: The details are illustrated on the separated report "the interim report for the feasibility study on effective utilization of Banko coal in the Republic of Indonesia (Basic design on coal gasification test facilities)"

1) Process flow diagram

Fig. 10-6 shows process flow diagram of the test facilities.



Item		TAG. NO. / Materials	Unit	(1) Coal	(2) Coal	(3) Coal	(4) Nitrogen	(5) Oxygen	(6) Produced Gas	(7) Produced Gas	(8) Produced Gas	(9) Produced Gas	(10) Produced Dust	(11) Quick Lime	(12) Hot Metal	(13) Slag	Remarks
Molten Iron Process	Solidity	Flow Rate	Kg/H	60 Kg/ch	40 Kg/ch	20							2	0.6	300 Kg/heat	1.6	
		Temperature	°C	Ambient Temp	100	100							150	Ambient Temp	1500~1600	1600~1650	
		Water Content	%	35	5	5							—	—	—	—	
		Grain Size	—	-25 mm	-25 mm	-74 μm >70 %							-63 μm 100%	-30 mm	—	—	
	Gravity	Flow Rate	Nm³/H				3	12	40	40	40	40					
		Temperature	°C				Ambient Temp	Ambient Temp	1300~1500	150	150	150					
		Pressure	Kg/cm² / mmAq				4~4.5 K	10~12 K	±100 M	-300~-100M	-500~-300M	100~300 M					K: Kg/cm² M: mmAq
		Dust Content	g/Nm³				—	—	50	50	0.05	0.05					

Fig. 10-6 Process Flow Diagram

2) Descriptions of coal gasification process

The coal gasification equipment is composed of a coal drying and pulverizing unit, a coal blowing unit, a molten iron production unit, a gasifier and a product gas dedusting unit.

i) Coal drying and pulverizing unit

Raw coal is dried in a drying unit until its moisture content is reduced down to a prescribed level and pulverized into a particle size of about 74 μm in a pulverizing unit.

ii) Coal blowing unit

The pulverized coal is gathered in a rock hopper, pressurized, fed out in a predetermined amount by a rotary feeder and then transported pneumatically to a coal blowing lance by means of a carrier gas (N_2).

iii) Molten iron production unit

The molten iron required for operation of gasifier is produced in a medium-frequency induction furnace from iron scraps. The molten iron produced in this furnace is carried to the gasifier after being adjusted for its chemical composition (mainly carbon content) and for temperature.

iv) The gasifier is lined with refractory bricks on internal walls and equipped with a lance through which both coal and oxygen are blown and an induction coil to maintain the temperature of molten iron constant. The gasifier stores molten iron and instantaneously gasifies the coal blown at a high speed with oxygen on to the surface of molten iron bath. Through a sub-lance, temperature and carbon content of the molten iron bath in the gasifier is measured.

v) Product gas filtration unit

The gas produced in the gasifier is recovered through a hood directly connected to the gasifier and a joining duct. The recovered product gas is cooled, dedusted, burnt and released.

3) Piping and instrument diagram

See Fig. 10-7.

The details will be decided by the detailed design.

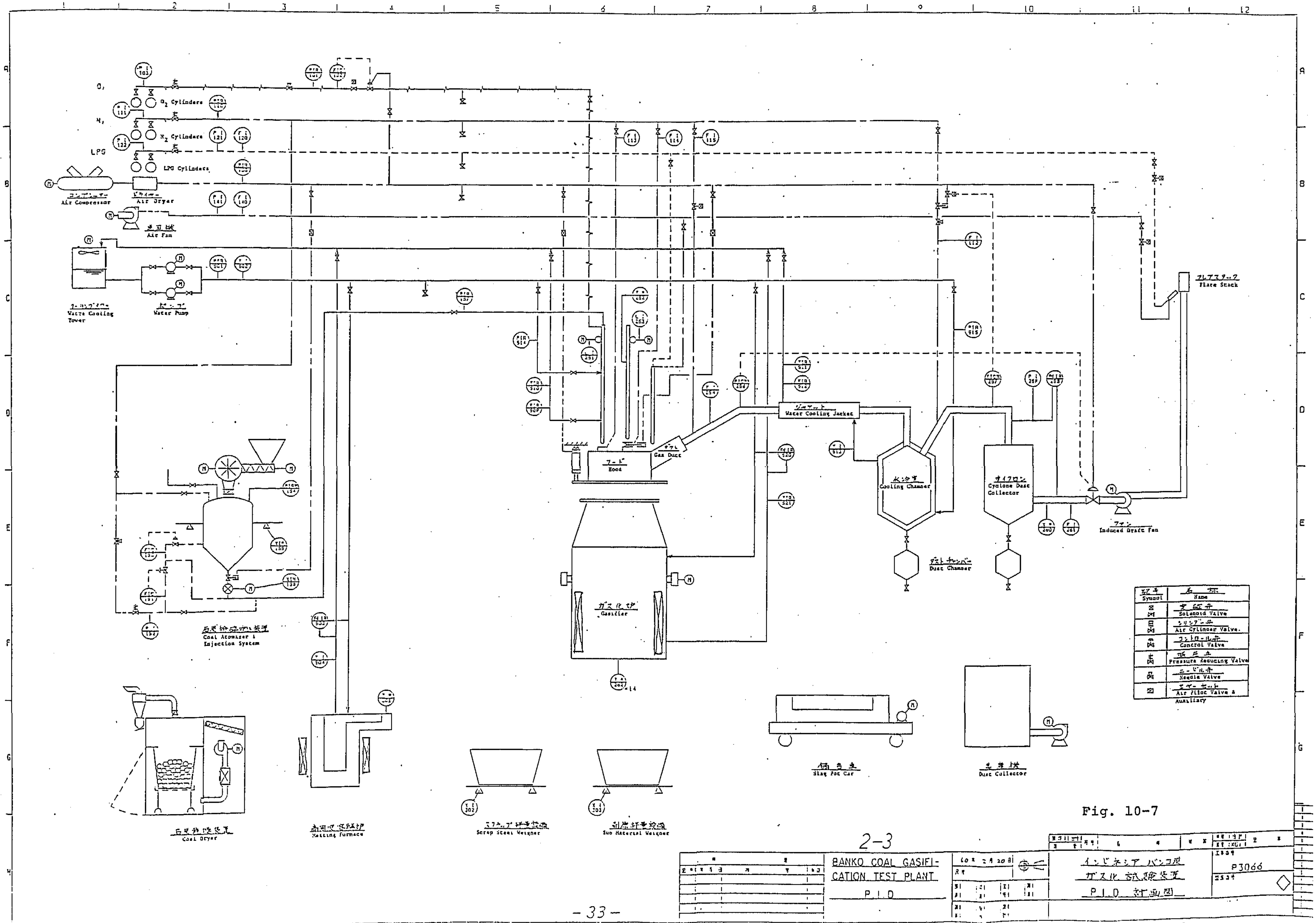

O2 Cylinders
N2 Cylinders
LPG Cylinders
LPG
Air Compressor
Air Dryer
Air Fan
Water Cooling Tower
Water Pump
Flare Stack
Water Cooling Jacket
Gas Duct
Hood
Cooling Chamber
Cyclone Dust Collector
Induced Draft Fan
Dust Chamber
Gasifier
Coal Atomizer & Injection System
Symbol
Name
Solenoid Valve
Air Cylinder Valve
Control Valve
Pressure Reducing Valve
Needle Valve
Air Pilot Valve & Auxiliary
Slag Pot Car
Dust Collector
Coal Dryer
Melting Furnace
Scrap Steel Weigher
Sub Material Weigher
2-3
BANKO COAL GASIFICATION TEST PLANT
P.I.D
インドネシア バンコ炭
ガス化試験装置
P.I.D 計画図
P3066

Fig. 10-7

-33-

4) Mechanical equipment list

i) Coal preparation system

a) Coal dryer 1 set

Type	: Multi tray type
Heater	: Electric heater
Raw coal/Drying time	: 117 kg/1.5 hr
Raw coal moisture/ Dry coal moisture	: 35%/5%
Electrical accessories	: Motor for fan and Electric heater

b) Coal atomizer 1 set

Type	: Special Hammer Mill
Coal/Atomizing time	: 80 kg/1.5 hr
Inlet grain size/ Outlet grain size	: - 25 mm/ - 74 µm over 70%
Electrical accessories	: Motor for screw feeder and atomizer

c) Coal injection system 1 set

Type	: Rotary feeder feeding with Rock hopper
Flow rate x time	: 40 kg/hr x 2 hrs
Electrical accessories	: Motor for rotary feeder

ii) Gasifier system

a) Gasifier vessel — 1 set

Type	: Molten iron process gasifier
Inner size	: 400ø x 950 mm H
Molten iron	: 300 kg
Refractories	: Electrical fused MgO-Cr bricks and MgO stump refractories
Electrical accessories	: Induction heating coil

b) Vessel tilter — 1 set

Electrical accessories	: Gear motor

c) Structure, deck and stairs — 1 set

d) Calcined lime feeder

Type	: Double seal valves with rock hopper
Feed rate	: 300 g/one time/0.5 hr

e) Melting furnace — 1 set

Type	: Crucible shaped middle frequency induction melting furnace
Melting rate/ Melting time	: 300 kg/2 hrs
Refractories	: Mg-O stump refractories
Electrical accessories	: Induction heating coil

f) Slag pan and car — 1 set

- Pan : Steel made with castable refractories
- Car : Driven with gear motor

g) Lance and driving unit — 1 set

- Lance : Water cooled lance
- Driving Unit : Gear motor drive

h) Sub-lance and driving unit — 1 set

- Sub-lance : non water cooled lance
- Driving Unit : Gear motor drive

iii) Gas treatment system

a) Hood and duct — 1 set

- Hood : Vessel mouth seal type with rise and fall mechanics
- Duct : Duct with water cooled jacket

b) Cooling chamber — 1 set

Chamber with water cooled jacket

c) Dust collector — 1 set

- Type : Linden type cyclone
- Gas flow rate : 80 Nm^3/h
- Outlet dust content : ~ 50 mmg/Nm^3 (not guaranteed)

d) Induced draft fan 1 set

Flow rate x pressure : 80 Nm^3/h x 600 mm Aq.

e) Flare stack 1 set

Ignition torch : LPG by compressed air

iv) Dust collection for gasifier mouth and others

a) Hood, duct and dampers 1 set

b) Bag filter 1 set

Flow rate : 1000 m^3/hr

Outlet dust content : 50 mmg/Nm^3 under

Electrical accessories: Motor for fan

5) Electrical equipment list

i) Induction gasification furnace and induction melting furance

a) Transformer 1

Oil-filled, self cooling, indoor use

Capacity	: 260 kVA
Input/output	3 phase, 380V, 50 Hz / 3 phase, 480V, 50 Hz

b) Thyristor inverter 1

Indoor use, self-supporting

Input	: 3 phase, 480V, 50 Hz
Output	: single phase, 1000V, 300 Hz
Capacity	: 200 kW (Maximum continuous rating)

c) Operating console 1

Desk type

Devices	: Display lamps, push-button switches, voltage meter, ampere meter, command switches

ii) Auxiliary AC equipment

a) Distributing panel

for 380V (indoor use, self-supporting) 1

for 220V (indoor use, wall-mounting) 1

for 110V (indoor use, wall-mounting) 1

b) Transformer

50 kVA, 380V/220V, 3 phase, 50 Hz	1
10 kVA, 380V/110V, single phase, 50 Hz	1

c) Control panel

Indoor use, self-supporting

Controlled equipment

· Induction motors	12
· Electric heater	1
· Solenoid valves	4

Operation

Manual operation

d) Operation console (installed in the pulpit) 1

Desk type

Controlled equipment

Rotary feeder, gasification furnace, induced draft fan

e) Operation boxes (installed around machines) 1

Indoor use, wall-mount type

Controlled equipment

All machines except for item (d) listed above

6) Single line diagram

See Fig. 10-8.

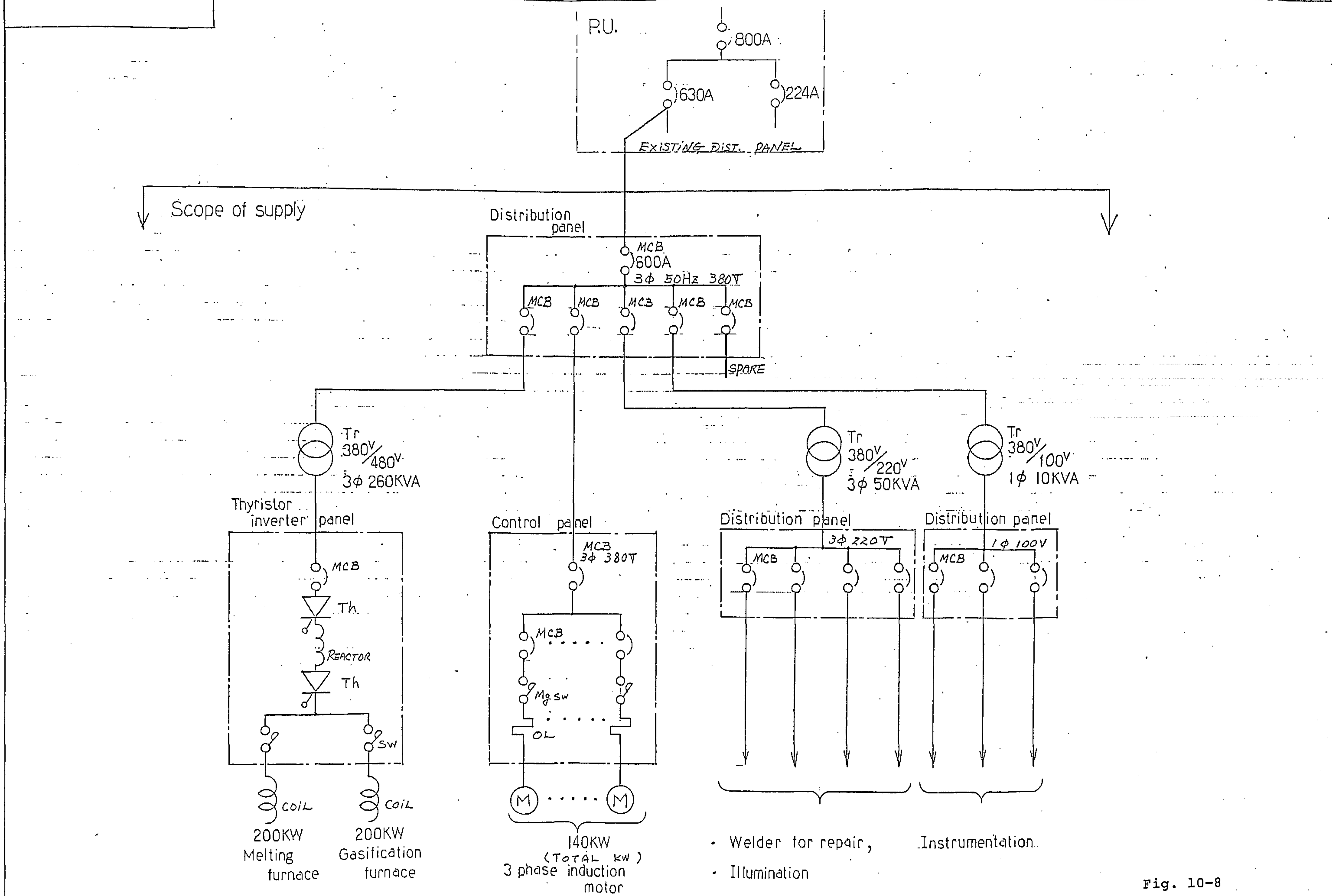


Fig. 10-8

APPROVED BY	TITLE	DRAWING No.
CHECKED BY	2-6 SINGLE LINE DIAGRAM	
DRAWN BY Komeda		

7) Gas analyzer

i) On-line analyzer — 1 set

a) CO/CO_2 (Infrared analyzer)

b) H_2 (Thermal conductivity analyzer)

c) O_2 (Magnetic oxygen analyzer)

d) N_2 (Gas chro.)

e) COS/H_2S (Gas chro.)

ii) Off-line analyzer

a) Slag analyzer — 1 set

Analyzer : CaO, SiO_2, $A\ell_2O_3$, MgO, Fe_2O_3

Accessory

b) Melting plant analyzer — 1 set

Analyzer : C or (C, S)

d) Off-line common parts — 1 set

Desiccator

Magnetic bowl

Spoon, scale, saucer

Sieve

Tongs

Sample keeping case

Precision spring balance

Sample bottle

Spare parts

8) General layout

See Fig. 10-9.

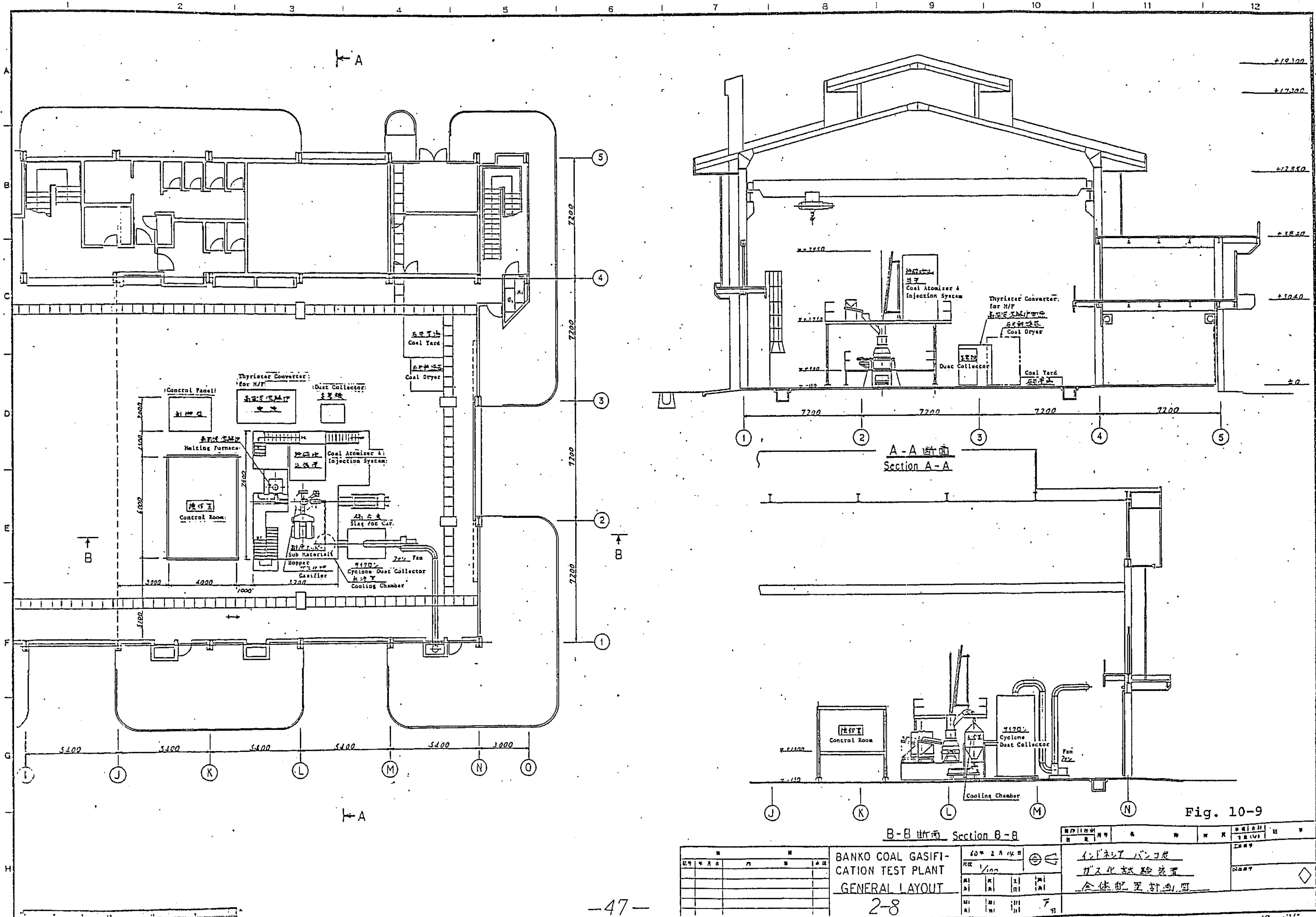

A-A 断面
Section A-A
B-B 断面
Section B-B
Control Room
Control Panel
Thyrister Converter for M/F
Dust Collector
Melting Furnace
Coal Atomizer & Injection System
Slag Pot Car
Sub Material Hopper
Gasifier
Cyclone Dust Collector
Cooling Chamber
Fan
Coal Yard
Coal Dryer
BANKO COAL GASIFICATION TEST PLANT
GENERAL LAYOUT
2-8
インドネシア バンコ炭
ガス化試験装置
全体配置計画図

Fig. 10-9

(3) Job Assignment Program with Counterpart

The outline of the undetaking of the counterpart is as follows:

1) Materials & sub-materials

a) Coal

Properties	: Various coals
Size	: -50 mm
Total consumption	: 6 tons

b) Scrap

Chemical compositions	: Fe 93∿96%
	C 3∿3.5%
	Si 1∿2%
Size	: About 110ø
Total consumption	: 15 tons

c) Calcined lime

Chemical compositions	: CaO over 90%
	CO_2 4∿8%
Size	: -30 mm
Total consumption	: 150 kgs

2) Utilities

a) Oxygen

Supply condition	: Cylinders (Inner volume 46.7ℓ) (Pressure 150 kg/cm^2g)
Supply rate	: 10 cylinders/heat

b) Nitrogen

Supply condition	: Same as oxygen
Supply rate	: 8 cylinders/heat

c) Electrical power

Frequency	: 50 Hz 3ø
Voltage	: 380V ± 10%
Electrical power	: Max. 350 kVA

d) Compressed air

Supply condition	: Flange contact Contact point and size will be prescribed on another print.
Supply temperature	: Ambient temperature
Supply pressure	: Min. 6 kg/cm^2g
Supply rate	Max. 60 Nm^3/h

e) Cooling water (Supply water/waste water)

Supply condition	: Flange contact Contact point and size will be prescribed on another print.
Water analysis	: Ref. (Indonesian Basic Design Data) There will be no quality change between supply water and waste water.

Supply temperature/waste temperature : 25∿27°C/35∿37°C

Supply pressure/waste pressure: Min. 10 kg/cm^2g/This will be decided at detailed engineering stage.

Supply rate/waste rate : Max. 30 t/h / max. 30 t/h

3) Consumables for chemical analysis

. Standard gas

. Reagent

. Others (consumables for gas chromatography, etc.)

4) Safety and first aid equipment

. Stretchers

5) Maintenance tools and materials

. Steel materials for general maintenance (Steel sheets, pipe)

. Valves for general maintenance

. Piping materials for general maintenance (Flanges, Unions, Elbows, etc.)

. Bolts and nuts for general maintenance

. Paint, brushes, brooms

6) Transfer and storage containers

Drums, Cans containable 4.765 U.S. gallon, Desiccator, Sample sorting cases, Cart

7) Administration requisites

Sink, Hot water facility, Thermal pots, Kitchen cabinet, Cups and spoons, etc., Waste baskets, Electric washing machines, Electric refrigerators, VTR, Office desks and chairs, Conference table and chairs, Blackboard, etc.

11. Conclusion and Recommendation

(1) Conclusion

1) The stratigic investigation for effective utilization of Banko coal was carried out through FY 1984. The study includes the principal fields as follows:

   a) Preliminary market survey of Banko coal and its derivatives

   b) Survey on Banko coal resources and preliminary estimation of coal mining cost

   c) Survey on effective utilization technology

   d) Stratigic study for Banko coal effective utilization

   e) Study for coal gasification test

2) The most possible utilization of Banko coal is production of fuel mathanol, urea and electricity generation by coal gasification in view of market, technology, economics and Indonesian Government policy.

3) The measured reserves of Banko coal is enough for commercialization, 435 million tons. However the quality of Banko coal is "non-transportable-problem coal" because of spontaneous combustion and fragility during transportation and stock as well as high sodium-in-ash.

4) The preliminary mining cost of Banko coal is estimated as 14 $/t (wet base) by non-continuous mining method. The selling price is estimated as approximately 25 $/t (dry base) on the basis of "cost and profit" for coal mining.

5) Molten iron bath gasifier for synthesis gas production and fluidized bed gasifier for electricity generation are evaluated as the most superior technology for the time being.

6) It was revealed that spark assist diesel engine designed for neat methanol as fuel is ready for commercialization and has flexibility for fuel selection, diesel oil or neat methanol.

7) Master plan and preliminary proposed projects for Banko coal effective utilization were proposed.

   However such a plan and projects must be studied furthermore in due course.

8) Economic possibility of Banko coal utilization was studied on the basis of the estimated selling price of Banko coal and production cost data obtained from published literatures.

   Production of fuel methal is "hopeful", but MTG (mobil) and urea depend on price of crude oil in future and Government price policy for petroleum gasoline and natural gas.

   Possibility of electricity generation by CGCC depends on future's technical development.

9) As conclusion of the stratigic investigation, the effective utilization of Banko coal seems to be feasible in technical and economic stand point.

   Therefore it is recommended that the coal gasification test stage shall be proceeded as scheduled on Scope of Work.

(2) Recommendation

As the results of the stratigic investigation of effective utilization of Banko coal, the following subsidary subjects are proposed to be carried out in further study period.

1) Maps of Banko area will be prepared for the further study of coal sampling spot and method.

2) Water resources data and soil data will be additionally required for selection of plant site.

3) Market survey on fuel methanol for gas turbine generator and diesel engine generator as well as city bus in Indonesia will be carried out to grasp practical specified demand of fuel methanol.

4) Preliminary feasibility study on high voltage-direct current transmission line between Banko area and Java will be carried out to evaluate mine mouth electricity generation.

APPENDIX - 1 Minutes of Meeting

APPENDIX - 1 Minutes of Meeting

In accordance with the strategic survey of 1983, Minutes of Meeting, which the team leader and the representative of the counterpart confirmed and singed each other, are as follows.

THE DATE OF SIGN	THE ITEM OF MINUTES OF MEETING
May 20, 1984	Inception Report
ditto	The Pilot-Plant Building
ditto	Site Report
ditto	Preparation for the 2nd Study Team
July 26, 1984	Site Report
ditto	The Pilot-Plant Building
ditto	Progress Report by the No. 1 Study Team
ditto	Training for the Counterpart
ditto	Preparation for the 3rd Study Team
Nov. 1, 1984	Progress Report by the No. 2 Study Team
ditto	Field Report
ditto	Preparation for the No. 4 Study Team
Feb. 21, 1985	Progress Report by the No. 3 Study Team
ditto	Field Report
ditto	Preparation for the Study Team (No. 4-B)

March 27, 1985	Basic Design of Coal Gasification Test Plant
ditto	Implementation Plan of the Coal Gasification
ditto	Field Report

Minutes of Meeting

Inception Report

In accordance with the Scope of Work for the Feasibility Study the Study on Effective Utilization of BANKO Coal in the Republic of Indonesia, Japan International Cooperation Agency (JICA) sent the first study team (the No.1 study team) headed by Mr Takehiko Sato to the Republic of Indonesia on May 9, 1984 and started the study for the Strategic Investigation Stage.
According to the prepared program the team has met with counter-part team in BPPT, and has discussion on the program.
The No.1 study team has prepared the Inception Report on the Study with emphasis on the Strategic Investigation Stage.
BPPT submitted the organization and personnel of the counterpart and other information to be included into the Inception Report.
After discussion, BPPT and the JICA Team agreed on the Inception Report on May 25, 1984.
28 copies of the Inception Report were submitted to Badan Pengkajian dan Penerapan Teknologi (BPPT) and the following relevant organizations.

BAPPENAS
DGM
DGP
MIGAS
DGBCI
PERTAMINA
PLN
PNTB
PTBA
LEMIGAS
PUSPIPTEK

BPPT will also send the Inception Report to MTDC, LIPI and ITB.

5) BPPT has also the approved budget of 160 million rupiah in FY 1983 and is expected to gain the same level of budget for civil and architecture in FY 1984 and 1985, respectively. The budget of BPPT shall be used for inside modification of the Building for coal gasification test facilities.

6) The Counterpart requested to provide the necessary detailed information, in relation with the coal gasification test facilities, as soon as possible.

7) The No. 1 study team submitted general comments on the Building (see Attachment - 3) and will prepare principal information until the visit of the 2nd study team, on July of 1984 and detailed information until the end of December, 1984.

Attachment - 1: Questionnaire
2: Minutes of the Visit (BPPT/PUSPIPTEK)
3: General comments on the Building

For Japan International Cooperation Agency	For the Agency for the Assessment for Application of Technology
T. Sato	Wardiman 30.5.84
TAKEHIKO SATO Leader of the No. 1 study team Japan International Cooperation Agency	WARDIMAN DJOJONEGORO Deputy Chairman for Administration The Agency for the Assessment and Application of Technology

For Japan International
Cooperation Agency

TAKEHIKO SATO
Leader of the No. 1
Study Team
Japan International
Cooperation Agency

For the Agency for the Assessment
for Application of Technology

30.5.84

WARDIMAN DJOJONEGORO
Deputy Chairman for
Administration
The Agency for the Assessment and
Application of Technology

MINUTES OF MEETING

THE PILOT-PLANT BUILDING

1. The No. 1 study team of JICA submitted the Questionnaire for the Pilot-Plant Building (the Building) of Laboratory for Energy and Energy Resources in PUSPIPTEK on May 10, 1984 (see Attachment - 1).

2. The meetings between BPPT, PUSPIPTEK and the first study team were held on 21, 25 and 28 of May, 1984.
   The necessary data and information, including drawings of the Building - Stage I were submitted by the Counterpart (see Attachment - 2).

3. Special notes of the meetings are as follows:
   1) The design and construction of the Building is in charge of PUSPIPTEK.

   2) The coal gasification test facility shall be installed in the Building - Stage I.

   3) The budget for the Building - Stage I, about 0.8-1.2 billion Rupiah, was already approved by Government, and shall be managed by PUSPIPTEK.

   4) The construction schedule of the Building is:

Design and engineering	:	Finished by PUSPIPTEK, using ARCHITEN as consultant.
Start of field work	:	August of 1984.
Completion of the Building	:	Dec. of 1985

Minutes of Meeting

Site Report

1. The No.1 study team of JICA prepared the site report (see Attachment-I) summarizing the results of the visits to BPPT and relevant organizations in Indonesia.

2. The collected data and information described in the site report shall be analyzed and synthesized as the Progress Report at the Home Office in Japan.

3. After discussions, BPPT and JICA agreed on the Site Report on May 30, 1984.

4. 15 copies of the Site Report were submitted to BPPT.

5. The Progress Report will be submitted to BPPT and relevant organizations by the No.2 study team of JICA, on July, 1984.

for Japan International Cooperation Agency

T. Sato

TAKEHIKO SATO
Leader of the No.1 study team
Japan International Cooperation Agency

For the Agency for the Assessment for Application of Technology

Wardiman 30.5.84

WARDIMAN DJOJONEGORO
Deputy Chairman for
The Agency for the Assessment and Application of Technology

MINUTES OF MEETING

PREPARATION FOR THE 2ND STUDY TEAM

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of BANKO Coal in the Republic of Indonesia, Japan International Cooperation Agency (JICA) will send the second study team (the No. 2 study team) headed by Mr. Takehiko Sato to the Republic of Indonesia on July 10, 1984.

2. The objective of the No. 2 study team is survey on BANKO coal resources and basic design of civil and architecture as described on the Inception Report.

3. Preliminary schedule and member list of the No. 2 study team were submitted to Badan Pengkajian dan Penerapan Teknologi (BPPT) by Mr. T. Sato, Team Leader of the Japanese study team. (see Attachment 1).

4. BPPT agreed and accepted the visit of the No. 2 study team, from July 10, 1984 until July 26, 1984, and will make the necessary arrangement.

5. Questionnaires for PN. BATUBARA (cc. to DGM and MTDC) and PT. BUKIT ASAM (cc. to DGM) were also submitted to BPPT. (see Attachment 2).

6. BPPT will send the Questionnaire to the each organization with BPPT's official letter requesting data, drawing and other necessary information.

For Japan International Cooperation Agency

For the Agency for the Assessment for Application of Technology

T. Sato

TAKEHIKO SATO
Leader of the No. 1 study team
Japan International Cooperation Agency

Wardiman 30.5.84

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
The Agency for the Assessment and Application of Technology

Minutes of Meeting

Site Report

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of BANKO Coal in the Republic of Indonesia, Japan International Cooperation Agency (JICA) sent the No.2 study team, headed by Mr. Takehiko Sato to the Republic of Indonesia on July 10, 1984 and started survey on Banko Coal resources. According to the prepared program the team has met with counterpart team in BPPT, and has discussion on Banko Coal resources and coal mining method as well as effective utilization of Banko Coal.

2. The No. 2 study team of JICA prepared the site report (draft) summarizing the results of the visits to BPPT and relevant organizations as well as Bukit Asam and Banko area in Indonesia.

3. The collected data and coal samples described in the site report shall be analyzed and synthesized as the Progress Report at the Home Office in Japan.

4. After discussions, BPPT and JICA agreed on the Site Report on July 26, 1984.

5. 15 copies of the Site Report were submitted to BPPT.

6. The Progress Report will be submitted to BPPT and relevant organizations by the No.3 study team of JICA, on October, 1984.

for Japan International Cooperation Agency

July 26. 1984

T. Sato.

TAKEHIKO SATO
Leader of the No.2 study team
Japan International Cooperation Agency

for the Agency for the Asses[illegible]
and Application of Technolo[illegible]

Wardiman

WARDIMAN DJOJONEGORO
Deputy Chairman for
The Agency for the As
and Application of Te

MINUTES OF MEETING

THE PILOT - PLANT BUILDING

1. According to the mutual consent of last meeting held in May 1984. The 2nd study team of JICA submitted the Information on the Pilot-Plant Building on 12 July, 1984.

2. The meetings between BPPT., PUSPIPTEK and the 2nd study team were held at BPPT on 12 and 13 of July, 1984. Through the discussion that was done based on the above information, both parties recognized and confirmed the intention of each other concerning the installation of the gasification pilot-plant equipment.

3. Special notes of the meetings are as follows:

   1) The layout of the coal gasification pilot-plant and its regarding facilities will be redesigned by JICA taking into account the intention of the counterpart.

   2) The exhaust of the combustion gas will be done basically through the planned chimney, therefore JICA will inform of the temperature of the gas to the counterpart. The counterpart will reconsider the installation of PVC pipe in the chimney.

   3) All the electric power supply facilities will be installed within the existing substation and the planned electric room of the Pilot-Plant Building. If there might be no room to install the required facilities, the substation will be extended by the counterpart. According to the counterpart's opinion there will not be necessary to provide airconditioning.

   4) JICA informed of the required amount of power supply to be 350 KVA in total. The counterpart explained their basic intention for the power supply. JICA will inform of each capacity of required electric facilities to the counterpart.

   5) JICA recommended the counterpart to provide an elevated water tank of enough capacity for the operation of all pilot-plants, outside of the building. Water used for the coal gasification pilot-plant is mainly of cooling purpose, therefore the recirculation system would be desirable for the sake of water saving. The counterpart agreed basically with the concept.
   The design and construction of the said water tank will be done by the counterpart.
   JICA will inform of the necessary data for that to the counterpart.

6) The coal analysis room will be provided within the existing chemical laboratory building by the counterpart. JICA submitted the basic data of the coal analysing apparatus to the counterpart.

For Japan International Cooperation Agency

July 26.1984

T. Sato

TAKEHIKO SATO
Leader of the No. 2 Study Team
Japan International Cooperation Agency

For the Agency for the Assessment and Application of Technology

Wardiman 26.7.84

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
The Agency for the Assessment and Application of Technology

Minutes of Meeting

Progress Report by the No. 1 Study Team

1. The No. 2 study team of JICA submitted 15 copies of the Progress Report on the Feasibility Study on Effective Utilization of Banko Coal prepared by the No. 1 study team.

2. BPPT and the No. 2 study team of JICA discussed on the Progress Report. Through the discussion, both parties recognized and confirmed the principle of the Study, which is effective utilization of non-transportable coal and production of liquid fuel as alternative energy.

3. After discussion, BPPT and the JICA team agreed on that the conclusion of preliminary survey on markets of brown coal and its derivatives and the recommendation for the further study in the second stage shall be prepared in the Interim Report which is scheduled to issue at the end of FY 1984

For Japan International Cooperation Agency

July 26. 1984

T. Sato

TAKEHIKO SATO
Leader of the No. 2 Study Team
Japan International Cooperation Agency

For the Agency for the Assessment and Application of Technology

Wardiman 26.7.84

WARDIMAN. DJOJONEGORO
Deputy Chairman for Administration
The Agency for the Assessment and Application of Technology

Minutes of Meeting

Training for the Counterpart

1. JICA explained the program of training for the counterpart.

Number of personnel	:	Three (3)
Schedule	:	Aug. 16 - Oct. 13, 1984
Place of training	:	The Institute of Energy Economics, Japan
Subject of training	:	Coal Gasification Technology

2. BPPT agreed on the program with deep appreciation and decided to dispatch the following engineers,

Ir. Subagio Imam Bakri	:	Team leader of the Counterpart (BPPT)
Drs. Basyani	:	Technical group (MTDC)
Ir. Bambang Suwondo	:	Technical group (BPPT)

3. It was mutually confirmed that urgent formalities (A2, A3 Form) shall be proceeded because the time is pressing.

for Japan International Cooperation Agency	for the Agency for the Assessment and Application of Technology
July 26. 1984	
T. Sato	Wardiman 26.7.84
TAKEHIKO SATO Leader of the No.2 study team Japan International Cooperation Agency	WARDIMAN DJOJONEGORO Deputy Chairman for The Agency for the Assessment and Application of Technology

MINUTES OF MEETING

PREPARATION FOR THE 3RD STUDY TEAM

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of BANKO Coal in the Republic of Indonesia, Japan International Cooperation Agency (JICA) will send the No. 3 study team headed by Mr. Takehiko Sato to the Republic of Indonesia at the end of October, 1984.

2. The objective of the No. 3 study team is survey on brown coal utilization technology and selection of coal gasification technology to be employed in the 2nd stage as described on the Inception Report.

3. Preliminary schedule of the No. 3 study team were submitted to Badan Pengkajian dan Penerapan Teknologi (BPPT) by Mr. T. Sato, Team Leader of the Japanese study team. (see Attachment 1).

4. BPPT agreed and accepted the visit of the No. 3 study team, from October 23, 1984 until November 3, 1984, and will make the necessary arrangement.

5. Member list of the No. 3 study team will be informed to BPPT until the middle of September, 1984.

For Japan International

Cooperation Agency

July 26. 1984

TAKEHIKO SATO
Leader of the No. 2
study team
Japan Internatinal
Cooperation Agency

For the Agency for the Assessment

and Application of Technology

26.7.84.

WARDIMAN DJOJONEGORO
Deputy Chairman for
Administration
The Agency for the Assessment and
Application of Technology

MINUTES OF MEETING

PROGRESS REPORT

BY THE NO.2 STUDY TEAM

1. The No. 3 Study Team of JICA provided 15 copies of the Progress Report on the Banko coal resources and its preliminary estimation of mining cost, which was prepared by the No. 2 study team.

2. BPPT (the counterpart) and the No. 3 study team of JICA discussed on the Progress Report.

   Through the discussion, both parties recognized and agreed on:

   a) The Banko Coal resource is abundant and the mining condition is good regarding certain parameter, while Banko coal is classified into a nontransportable brown coal and contains high Na_2O in ash.

   b) The comparison of two kinds of mining method is reasonable and shall be studied in details in due course, considering the operation results of the Bukit Asam expansion project.

   c) The sampling spots and method for coal gasification test, proposed in Section 4-3-3 (page 44 and 47), is reasonable. Further study for selection of sampling spots and method will be carried out in FY 1985 and 1986.

   It was also confirmed that in accordance with the Scope of Work a small boring machine and its operators will be prepared by the counterpart, while JICA will dispatch an expert on coal exploration, coal sampling and analysis.

d) Water resources data and preparation of detailed maps for Banko area will be required for the further study.

BPPT requested above study in the 2nd stage because of no available existing data in Indonesia. JICA team will convey the BPPT's request to JICA Head Qaurter.

3. After discussion, BPPT and the JICA team agreed on the Progress Report.

The recommendation for the further study in the 2nd stage shall be prepared in the interim Report which is scheduled to issue at the end of FY 1984.

For Japan International Cooperation Agency	For the Agency for the Assessment and Application of Technology
T. Sato nov 1. 1984	Wardiman 1.11.84
TAKEHIKO SATO Leader of the No. 3 Study Team/ Japan International Cooperation Agency	WARDIMAN DJOJONEGORO Deputy Chairman for Administration Agency for the Assessment and Application of Technology.

MINUTES OF MEETING

FIELD REPORT

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia, JICA sent the third study team (the No. 3 study team) headed by Mr. Takehiko Sato to the Republic of Indonesia from October 23 to November 2, 1984.

   According to the prepared program BPPT (the counterpart team) and the No. 3 study team have presented and discussed on brown coal utilization technology.

2. The No. 3 study team prepared the field report (draft) summurizing the results of discussions.

3. After discussions BPPT and the No. 3 study team agreed on the field Report on November 1, 1984.

4. 15 Copies of the Field Report were provided to BPPT.

5. The Progress Report of the No. 3 study team will be provided to BPPT and relevant organizations by the No. 4 study team of JICA.

For Japan International
Cooperation Agency

T. Sato nov. 1. 1984

TAKEHIKO SATO
Leader of the No. 3
Study Team
Japan International
Cooperation Agency

For the Agency for the
Assessment and Application
of Technology

Wardiman 1. 11. 84

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
Agency for the Assessment
and Application of
Technology.

MINUTES OF MEETING

PREPARATION FOR THE NO.4 STUDY TEAM

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia. JICA will send the No. 4 study team headed by Mr. Takehiko Sato to the Republic of Indonesia.

2. The objective of the No. 4 study team is

   a) Preliminary evaluation of the Banko coal effective utilization in view of technical, economic and strategic aspects.

   b) Implementation plan of the coal gasification test stage, including the results of basic design of the coal gasification test facilities.

   c) Preparation of the Interim Report.

3. The visit of the No. 4 study team was originally scheduled in February, 1985. However the actual schedule will be discussed and decided later by both team leaders, considering schedule of each home office work.

4. BPPT agreed and accepted the visit of the No. 4 study team and will make necessary arrangement in accordance with schedule and program settled later.

Signatures /2 ....

For Japan International Cooperation Agency

For the Agency for the Assessment and Application of Technology

T. Sato Nov. 1. 1984

TAKEHIKO SATO
Leader of the No. 3 Study Team
Japan International Cooperation Agency

Wardiman 1. 11. 84

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
Agency for the Assessment and Application of Technology.

MINUTES OF MEETING
PROGRESS REPORT
by the No. 3 STUDY TEAM

1. The study team (No. 4-A) of JICA provided 15 copies of the Progress Report on Survey on coal utilization technology, which was prepared by the No. 3 study team.

2. BPPT (The Counterpart) and the study team of JICA discussed on the Progress Report. Through the discussions, both parties recognized and agreed on :

   a) the results of the study of economic possibility of Banko Coal utilization will be understood as "only for reference", because reference literatures are not describing the preconditions and basic data for calculation of product cost.

   b) It is desired that the preliminary cost estimation of synthesis gas and methanol from Banko Coal will be studied at earliest program.

3. After discussion, BPPT and the JICA team agreed on the Progress Report.

The recommendation for the further study in the 2nd stage shall be prepared in the Interim Report which is scheduled to issue at the end of FY 1984.

For Japan International Cooperation Agency

Feb 21. 1985

T. Sato

TAKEHIKO SATO
Leader of the Study Team
Japan International Cooperation Agency

For the Agency for the Assessment and Application of Technology

Wardiman 21.2.85

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
Agency for the Assessment and Application of Technology.

MINUTES OF MEETING
FIELD REPORT

1. In accordance with the Scope of Work for the feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia, JICA sent the study team (No. 4-A) headed by Mr. Takehiko Sato to the Republic of Indonesia from February 13 to February 21, 1985.

   According to the prepared program BPPT (the counterpart team) and the study team have discussed on subjects related to Banko Coal effective utilization.

2. The study team prepared the field report (draft) summarizing the results of discussions.

3. After discussions BPPT and the study team agreed on the field Report on February 21, 1985.

4. 15 Copies of the Field Report were provided to BPPT.

5. The Progress Report of the study team will be provided to BPPT and relevant organization by the study team (No. 5) of JICA.

For Japan International Cooperation Agency

Feb 21. 1985

T. Sato

TAKEHIKO SATO
Leader of the Study Team
Japan International
Cooperation Agency

For the Agency for the Assessment and Application of Technology

Wardiman 21.2.85

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
Agency for the Assessment
and Application of
Technology.

MINUTES OF MEETING

PREPARATION FOR THE STUDY TEAM (No. 4-B)

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia. JICA will send the study team (No. 4-B) headed by Mr. Takehiko Sato to the Republic of Indonesia.

2. The objective of the Study Team (No. 4-B) is :

   a) Explanation and discussion on the result of the basic design of the coal gasification test facilities.
   b) Discussion on the Interim Report (Revised Draft)
   c) Discussion on coal sampling in FY 1985.

3. Preliminary schedule of the study team (No. 4-B) was submitted to BPPT by Mr. T. Sato, Team Leader of the study team (No. 4-A) (See Attachment I).

4. BPPT agreed and accepted the visit of the Study Team (No. 4-B) and will make necessary arrangement in accordance with schedule and program settled.

For Japan International Cooperation Agency	For the Agency for the Assessment and Application of Technology
T. Sato Feb 21, 1985	Wardiman 21.2.85
TAKEHIKO SATO	WARDIMAN DJOJONEGORO
Leader of the Study Team Japan International Cooperation Agency	Deputy Chairman for Administration Agency for the Assessment and Application of Technology

TENTATIVE SCHEDULE

of

THE STUDY TEAM (NO. 4-B)

19/March	(Tues.)	NARITA - JAKARTA
20/	(Wed.)	JICA, EMBASSY, BPPT
21/	(Thu.)	BPPT, PUSPIPTEK
22/	(Fri.)	(National Holiday)
		JAKARTA - BANDUNG
23/	(Sat.)	DMR, MTDC
24/	(Sun.)	
25/	(Mon.)	MTDC, BANDUNG - JAKARTA
26/	(Tues.)	BPPT, PUSPIPTEK, JICA
27/	(Wed.)	BPPT, JICA
28/	(Thur.)	Av NARITA

MINUTES OF MEETING

BASIC DESIGN OF COAL GASIFICATION TEST PLANT

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia, JICA sent the study team (No.4-B) headed by Mr. Takehiko Sato to the Republic of Indonesia from March 19 to March 27, 1985. The study team prepared the "Basic Design of Coal Gasification Test Facilities", including basic plan for coal gasification test.

2. According to the program, BPPT (the counterpart team) and the study team have discussed and agreed on the Basic Design and Basic Plan for Coal Gasification Test.

3. Furthermore, both teams have discussed utilities supply system for the coal gasification test plant in PUSPIPTEK and agreed that the design and engineering of utilities supply system will be carried out by JICA team.

4. BPPT requested the provision of the coal gasification test facilities according to the Scope of Work. The study team will convey the BPPT's request to JICA Head quarters.

5. When above mentioned gasification test facilities will be provided, JICA will be responsible for all the expenses until the port of JAKARTA, and BPPT will undertake the expenses of custom clearance, handling of equipment and materials, from the port of JAKARTA to the Project site at PUSPIPTEK.

Jakarta, March 27, 1985

For Japan International Cooperation Agency

For the Agency for the Assessment and Application of Technology

T. Sato

TAKEHIKO SATO
Leader of the
Study Team
Japan International
Cooperation Agency

Wardiman 27.3.85

WARDIMAN DJOJONEGORO
Deputy Chairman for
Administration
The Agency for the
Assessment and Application
of Technology

MINUTES OF MEETING

Implementation plan of the coal gasification test stage

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia, JICA sent the study team (No.4-B) headed by Mr. Takehiko Sato to the Republic of Indonesia from March 19 to 27, 1985.

2. According to the result of the strategic investigation stage, BPPT and the study team discussed the necessity to step forward to the coal gasification test stage as well as Scope of the Study for the coal gasification test stage.

3. Both sides agreed on the necessity and Scope of the study described on the Scope of Work.

4. Furthermore, BPPT requested to carry out the following additional works.

   a) Preliminary study on production cost of fuel methanol from Banko coal.

   b) Study on the marketing and distribution system of methanol as fuel in Indonesia.

   The study team will convey the BPPT's request to JICA Head quarters.

5. When above mentioned additional works will be carried out, JICA and BPPT will modify the Scope of Work and sign in "the modified Scope of Work".

Jakarta, March 27, 1985

For Japan International Cooperation Agency

TAKEHIKO SATO
Leader of the Study Team
Japan International Cooperation Agency

For the Agency for the Assessment and Application of Technology

27.3.85

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
Agency for the Assessment and Application of Technology

MINUTES OF MEETING

FIELD REPORT

1. In accordance with the Scope of Work for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia, JICA sent the study team (No.4-B) headed by Mr. Takehiko Sato to the Republic of Indonesia from March 19 to 27, 1984.

   According to the prepared program BPPT (the counterpart team) and the study team have discussed implementation plan of the coal gasification test stage, including the results of basic design on the coal gasification test facilities.

2. The study team prepared the field report (draft) summarizing the results of discussions.

3. After discussions BPPT and the study team agreed on the field Report on March 27, 1985.

4. 15 Copies of the Field Report were provided to BPPT.

5. The Interim Report will be provided to BPPT and relevant organizations by JICA.

Jakarta, March 27, 1985

For Japan International Cooperation Agency

T. Sato

TAKEHIKO SATO
Leader of the Study Team
Japan International Cooperation Agency

For the Agency for the Assessment and Application of Technology

Wardiman 27.3.85

WARDIMAN DJOJONEGORO
Deputy Chairman for Administration
Agency for the Assessment and Application of Technology

APPENDIX-2 List of Schedule, Organization and Personnel Visted

APPENDIX-2 List of Schedule, Organization and Personnel Visted

Schedule, organization and personnel visited by the No. 1 study team

Date	Time	Name of Organization	Name of Attendant
May 10 (Thu.)	10:00 - 11:00	JICA Jakarta Office	Mr. Yamamura, Mr. Sugihara
	11:00 - 11:30	The Embassy of Japan	Mr. Sugawara
	14:00 - 16:00	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Imam Bakri Mr. Bambang Suwondo Miss Indyah
May 11 (Fri.)	08:00 - 12:00	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Iman Bakri Mr. Maskan Abdullah Mr. Bambang Suwondo Miss Indyah
	12:30 - 13:30	BAPPENAS	Mr. Rezy
May 15 (Tue.)	08:00 - 09:00	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Iman Bakri Mr. Bambang Suwondo
	09:50 - 12:00	MIGAS	Mr. Marzuan Mr. Siti Djuharmi
	14:00 - 15:30	Directorate General of Electric Power and New Energy (DGP)	Mr. T. Roesad Mr. M. Pandjaitan Mr. Supriyo Mr. Agus Martono
May 16 (Wed.)	09:00 - 09:15	Directorate General of Basic Chemical Industries (DGBCI)	Mr. Soenario
	11:00 - 12:00	PLN	Mr. Mengah Sudja
	14:00 - 16:00	PT Bukit Asam (PTBA)	Mr. Omar Hassan Mr. Abdillar M. Mr. A. Hakim M. Mr. Andi Masso Mr. Andi Massalagka
May 17 (Thu.)	11:00 - 12:40	DGBCI (BPPT office)	Mr. Sunario Mr. J. Purba Mr. S. Sinambela Mr. Finayati Mr. Soemarni
	14:00 - 16:00	PN Tambang Batubara (PNTB)	Mr. Kusna Mr. Sunardi Mr. Ridwan

Date	Time	Name of Organization	Name of Attendant
May 18 (Fri.)	09:00 - 11:00	LEMIGAS	Mr. Hendro Prawoto Mr. Effendi Husin Mr. Hirwan Effendi Mr. Pangkat S. Mr. A. S. Hastion
May 21 (Mon.)	(Group A) 07:30 - 10:00	PT Bukit Asam (Tg. Enim)	Mr. Soetjipto Wijadi Mr. Japran Mr. Soebastedjo
	(Group B) 08:00 - 12:00	BPPT	Mr. Maskan Abdullah
	(Group B) 14:00 - 16:00	PUSPIPTEK (Serpong)	Mr. Gunawan Sakri
May 22 (Tue.)	14:00 - 15:00	PERTAMINA (Plaju)	Mr. Sumantri Mr. Surjanto
May 23 (Wed.)	(Group A) 09:00 - 12:00	PT Pupuk Sriwidjaja (PUSRI)	Mr. Suyatho Mr. Nasli N. Mr. Kusno Sunarto Mr. S.P.M. Simandjuntak Mr. Sutarto B.
	(Group A) 12:30 - 13:00	KERTAPATI Coal Terminal of PT Bukit Asam	Mr. Anwar Hassan Mr. Nasibi
	(Group B) 08:30 - 09:00	BPPT	Miss Indyah
May 24 (Thu.)	(Group A) 09:00 - 11:00 14:00 - 14:30	PERTAMINA	Mr. Soedarno Martosewojo Mr. Emir Siregar Mr. Indraman Akman
	(Group B) 08:00 - 16:00	PUSPIPTEK (FRW)	Mr. Sutaeman Koerdi
May 25 (Fri.)	(Group A) 08:30 - 09:00	Ministry of Transmigration	Mr. Rofiq Ahmad, Es Mr. Buyung Syafei Mr. Harry H. Saleh Mr. Siswanto Mr. Margono
	(Group A) 09:30 - 10:30	Ministry of Communication	Mr. G. Soedjantoko Mr. Yunus

Date	Time	Name of Organization	Name of Attendant
	(Group B) 09:00 - 10:30	DGBCI	Mr. Sunario Mr. J. Purba Mr. S. Sinambela Mr. Finayati Mr. Soemarni
	11:00 - 12:00	Directorate General of Mining (DGM)	Mr. Johannes
May 26 (Sat.)	09:00 - 10:15	MIGAS	Mr. Harzun Mr. Siti Djuharmi
May 28 (Mon.)	(Group A) 10:00 - 12:00	PT Petrokimia Gresik	Mr. Sutrisno Mr. A. Budiono Mr. H.H. Gaol Mr. Agus Ismail Mr. B. Setiobroto Mr. Bandung Djoko W. Mr. Bowo L.
	(Group B) 08:00 - 12:00	BPPT	Mr. Wardiman Djojonegoro
	13:00 - 16:00	JICA Jakarta Office	Mr. Sugihara
May 29 (Tue.)	09:30 - 10:30	PERTAMINA	Mr. R. Siregar Mr. Parmono Mr. P. Agus Budiarto
	10:45 - 12:00	BAPPENAS	Mr. Sudradjat Djiwandono Mr. Eko
May 30 (Wed.)	08:00 - 12:00	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio I.B. Mr. Bamban Imam Bakri
	14:00 - 15:00	JICA Jakarta Office	Mr. Sugihara

Schedule, Organization and Personnel Visited by

the No. 2 Study Team

Date	Time	Name of Organization	Name of Attendant
July 11 (Wed.)	10:00 - 11:00	JICA Jakarta office	Mr. Yamamura
	13:30 - 16:00	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Imam Bakri Mr. Bambang Suwondo
July 12 (Thur.)	(Group - A) 09:00 - 16:00	BPPT	Mr. Maskan Abdullah Mr. Sulaiman Kurdi
	(Group - B) 09:00 - 10:00	DGM	Mr. Johannes
	13:30 - 15:00	PNTB	Mr. Senosoendjojo Mr. Adeng Sunardi
July 13 (Fri.)	(Group - A) 08:30 - 11:00	PTBA	Mr. Omar Hassan Mr. Sufatri Arief Mr. Ahdma Marian Mr. Andi Massalanga
	(Group - B) 09:00 - 15:30	BPPT	Mr. Maskan Abdullah Mr. Sulaiman Kurdi
JUly 14 (Sat.)	08:30 - 12:00	BPPT	Mr. Subagio Imam Bakri Mr. Bambang Suwondo
July 16 (Mon.)	(Group - A) 08:00 -10:00	ITB	Mr. Ambyo Mr. Maide Mr. Alwi Mr. Theopilus
	(Group - B) 14:30 - 15:30	LEMIGAS	Mr. Hendro Prawoto Mr. A.S. Nastion
July 17 (Tue.)	(Group - A) 09:00 - 12:00	MTDC(Bandung)	Mr. Bambang Sulasmoro Mr. Mohamad Adnan Mr. Bathoni
	13:00 - 15:00	DMR(Bandung)	Mr. Hardjono
	(Group -B) 09:15 - 10:00	DGBCI	Mr. Sunario Mr. J. Purba
	13:00 -15:00	MIGAS	Mr. Widartomo

Date	Time	Name of Organization	Name of Attendant
July 18 (Wed.)	09:00 - 11:00	BPPT	Mr. Wardiman Djojonegoro Mr. Maskan Abdullah Mr. Sulaiman Kurdi
July 19 (Thur.)	08:00 -17:00	PTBA(Tg. Enim)	Mr. Soetjipto Wijad Mr. Japran Mr. Benyamin
July 20 (Fri.)	(Group - A) 08:00 - 17:00	PTBA(Tg. Enim)	Mr. Benyamin Mr. Airidelle
July 21 (Sat.)	(Group - A) 08:00 - 14:00	PTBA(Tg. Enim)	Mr. Benyamin
	(Group - B) 09:00 - 09:30	DPU(Prabumulih)	Mr. Said Kadir
	13:00 - 13:30	PLN(Palembang)	Mr. Edi Trisna
	17:00 - 17:30	DPU(Palembang)	Mr. Hasan Nuh
July 23 (Mon.)	(Group - A) 08:00 - 08:30	DGM	Mr. Johannes
	11:00 - 12:00	PLN	Mr. Mangah Sudja
	(Group - B) 11:00 - 16:00	PUSPIPTEK	Mr. Sulaiman Kurdi
July 24 (Tue.)	(Group - A) 09:00 - 10:00	PNTB	Mr. Kusna
	(Group - B) 11:30 - 13:30	PLN	Mr. C. S. Hutasoit
	14:15 - 15:00	DGBCI	Mr. Sunario Mr. Sjafar B. Sinambela Ms. Finayati Mr. J. Purba
July 26 (Thur.)	09:00 - 11:00	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Imam Bakri Mr. Bambang Suwondo
	15:00 - 16:00	JICA	Mr. Yamamura Mr. Aoki

Schedule, Organization and Personnel Visited by
the No. 3 Study Team

Date	Time	Name of Organization	Name of Attendant
Oct. 24 (Wed.)	10:00 - 11:00	JICA Jakarta Office	Mr. Yamamura Mr. Aoki
	13:30 - 16:00	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Imam Bakri Mr. Bambang Suwondo
Oct. 25 (Thu.)	08:30 - 16:00	BPPT	Mr. Wardiman and others (35 persons)
Oct. 26 (Fri.)	08:30 - 14:00	BPPT	Ditto
Oct. 27 (Sat.)			-
Oct. 28 (Sun.)			-
Oct. 29 (Mon.)	09:00 - 17:00	MTDC	Mr. Bambang Sulasmoro and others (40 persons)
Oct. 30 (Tue.)	08:30 - 13:00	MTDC	Ditto
Oct. 31 (Wed.)	13:00 - 17:00	BPPT	Mr. Wardiman Djojonegoro Dr. Harsono Mr. Subagio Imam Bakri Mr. Bambang Suwondo
Nov. 1 (Thu.)	09:30 - 10:30	The Embassy of Japan	Mr. Sugawara
	13:00 - 16:00	BPPT	Dr. Harsono Mr. Zuhar
Nov. 2 (Fri.)	09:30 - 11:00	JICA Jakarta Office	Mr. Aoki

SCHEDULE, ORGANIZATION AND PERSONNEL VISITED BY THE STUDY TEAM (NO. 4-A)

DATE	TIME	NAME OF ORGANIZATION	NAME OF ATTENDANTS
Feb. 14 (Thurs.)	11.00 - 14.30	BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Iman Bakri Mr. Bambang Suwondo Mr. Achmad Setiadi Mr. Kunarso
Feb. 15 (Fri.)	09.00 - 11.30 13.30 - 15.30	) BPPT)	Mr. Subagio Iman Bakri Mr. Bambang Suwondo Mr. Achmad Setiadi Mr. Kunarso Mr. Harsono (Part time) Mr. Djoko (Part time)
Feb. 16 (Sat.)	09.00 - 11.15	MIGAS	Mr. Marzuan Ms. Siti Djuharmi
Feb. 18 (Mon.)	09.00 - 11.00	PERTAMINA	Mr. Ruslan Siregar Mr. Parmono
Feb. 19 (Tues.)	09.00 - 11.20	P.L.N.	Mr. Nengah Sudja Mr. Sudjahadi Mr. Sjahroels Mr. Sitompul S.
	12.00 - 15.30	PUSPIPTEK	Mr. Sulaiman Kurdi Mr. Chandra Prawiro
	15.30 - 16.00	BPPT	Dr. Lolo M. Panggabean

DATE	TIME	NAME OF ORGANIZATION	NAME OF ATTENDANTS
Feb. 20 (Wed.)	09.00 - 12.10	MIGAS	Mr. Marzuan Ms. Siti Djuharmi Ms. Woro RH. Ms. Etty S. Ms. Tobing

SCHEDULE, ORGANIZATION AND PERSONNEL VISITED BY THE STUDY TEAM (NO. 4-B)

DATE	TIME	NAME OF ORGANIZATION	NAME OF ATTENDANTS
March 20 (Wed)	14.00-16.00	BPPT	Mr. Subagio Iman Bakri Mr. Bambang Suwondo Mr. Achmad Setiadi Mr. Kunarso
March 21 (Thurs)	09.00-15.00 15.00-17.00	PUSPIPTEK BPPT	Mr. Wardiman Djojonegoro Mr. Subagio Iman Bakri Mr. Bambang Suwondo Mr. Achmad Setiadi Mr. Kunarso Mr. Sulaiman Kurdi
March 25 (mon)	09.00-14.00	MTDC	Mr. Bambang Sulasmoro Mr. Komar P.A Mr. D. Wejaongarjja Mr. Y. Basyuni Mr. Samza Mr. Hadi Nursaya Mr. Subagio Iman Bakri Mr. Kunarso Mr. Achmad Setiadi

DATE	TIME	NAME OF ORGANIZATION	NAME OF ATTENDANTS
March 26	9.00-12.00	BPPT	Mr. Subagio I.B.
			Mr. Achmad Setiadi
			Mr. Bambang Suwondo
			Mr. Djoko Sulaksono
			Mr. Suharjono
			Mr. Hasnedi
	13.30-16.00	PUSPIPTEK (JAKARTA)	Mr. Sulaiman Kurdi
			Mr. Rustamadji
			Mr. Chandra Prawira
			Mr. Bambang Suwondo
			Mr. Achmad Setiadi
	14.00-15.00	P L N	Mr. Mengah Sudja
March 27	9.00-	PUSPIPTEK (SERPONG)	Mr. Achmad Setiadi
			Mr. Bambang Suwondo
			Mr. Sulaiman Kurdi
	14.00-16.00	BPPT	Mr. Wardiman Djojonegoro
			Mr. Subagio Iman Bakri

APPENDIX - 3 List of the Documents

APPENDIX-3 List of the Documents

List of documents, DWG, and data submitted by the counterpart

(1) By MIGAS

1) STATISTIK PERMINYAKAN INDONESIA 1982
(OIL STATISTICS OF INDONESIA 1982)
2) STATISTIK PERMINYAKAN INDONESIA TRIWULAN IV-1983
(83/10,11,12)
3) PETROLEUM & NATURAL GAS INDUSTRY OF INDONESIA
DECEMBER 1983 (MONTHLY REPORT)
4) FUEL DEMAND & PRODUCTION IN INDONESIA
5) DWG: PENGOLAHAN & PEMURNIAN MINYAK DAN GAS BUMI
6) DWG: KAPASITAS TIMBUN TANGKI BAHAN BAKAR MINYAK

(2) By PLN

1) Commercial Statistics, April 1, 1981 - March 31, 1982.
2) PLN Fuel Consumption Projection 1983/84 - 2003/4
3) Cost Reference
4) Busbar Cost Data
5) Energy Balance
6) Capative Power Compares with PLN's Installed Capacity
7) Tariff Schedule 1984
8) Peak Load Production and Installed Capacity
9) Installed Capacity, Selected Years
10) Existing Unit and Installed Capacity of Each PLN Wilayah as of 1983
11) Pattern of Oil Consumption
12) List of Enim River Water Level
Jan. '82 - July '83

(3) By GDBCI

1) Information from Directorat General of Basic Chemicals

(4) By PERTAMINA

1) Angka Penjualan Nyata BBM Dalam Negeri
2) Perkiraan Kebutuhan BBM Pertamina PDM Dalam PELITA IV
3) Pemakaian BBM Seluruh Indonesia menurut Sektor Pemakai Tahun '83/'84
4) Volume Penjualan Elpiji UPMS
5) Hasil Penjualan Pertamina PDM
6) Supply Elpiji Versus Thruput

(5) By PUSRI

1) P.T. Dupuk Sriwidjaja, 1982 (Pamphlet)

(6) By Ministry of Transmigration

1) RENCANA PENELITIAN DAN PENGEMBANGAN TRANSMIGRASI DALAM REPELITA IV

(7) By PETROKIMIA GRESIK

1) PT PETROKIMIA GRESIK (Pamphlet)

(8) By DGP

1) Organization of DGP
2) PROSPEK PERANSERTA SWASTA NATIONAL DALAM SEKTOR TENAGA LISTRIK
3) Table
    (1) KONSUMSI ENERGI KOMERSIAL 1984/1985 - 1988/1989
    (2) PERKIRAAN JUMLAN KONSUMSI ENERGI PADA AKHIR REPELITA IV
    (3) PENCANA KEGIATAN PENGEMBAGAN SUMBER-SUMBER ENERGI BARU DALAM REPELITA IV

(4) JADWAL PEMBANGUNAN PROYEK-PROYEKD PERCONTOHAN PEMANFAATAN SUMBER-SUMBER ENERGI BARU DALAM REPELITA IV

(9) By DGM

1) South Sumatra Coal Exploration Project (Review Report, May 1984)
2) Geotechnical Assessment and Enclosures, Part 1 and Part 2
3) Computer Summary Lithological and Coal Quality Data, Part 1 and Part 2
4) South Sumatra Computer Tapes and COGEO Manual
5) Mining Appendices

(10) By PTBA

1) Maps for Bukit Asam and Banko area, 28 sheets
2) List of mining equipment
3) List of manpower allocation
4) Climate data in 1983

(11) By DMR

1) Coal Geological Map, South Sumatra, scale 1:250,000
2) The Banko Coal Prospect, a Geological Evaluation

(12) By BPPT

1) Technical Study of the North West Banko coal project

List of the documents procured by the study team

1. REPELITA-IV 1984/85 - 1988/89 (Vol. 1 - 4)

2. STATISTICAL YEARBOOK OF INDONESIA 1982

3. IMPORT STATISTICS 1982 (Vol. 1 - 2)

4. EXPORT STATISTICS 1982

5. IMPORT STATISTICS OCTOBER 1983

6. EXPORT STATISTICS OCTOBER 1983

7. Indikator Ekonomi (Economic Indicators) February 1984

8. INDUSTRIAL STATISTICS 1981 (Vol. 1 - 2)

9. DAMPAK LISTRIK MASUK DESA DAN PERUSAHAAN LISTRIK NON PLN

10. STATISTIK ANGKUTAN KERETA API 1982 (RAILWAYS STATISTICS)

11. STRUKTUR BIAYA BUS DAN TRUK UMUM 1982

12. PLN in 1979/80 (ELECTRICITY SUPPLY BY PLN IN INDONESIA 1981/1982, 1982/1983)

13. ENERGY STATISTICS 1981

APPENDIX - 4 Reference List

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In accordance with the strategic survey of 1983, we made the following reports and handed them in to JICA and the counterpart.

May, 1983	1)	Inception Report for The Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia
July, 1983	1)	Progress Report on the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia by the No.1 Study Team
Aug., 1983	1)	Progress Report on the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia by the No.2 Study Team
Sep., 1983	1)	Pamphlet of the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia (English, Indonesian)
Dec., 1983	1)	Preliminary Report on Brown Coal Utilization Technology for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia
	2)	Progress Report on the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia by the No.3 Study Team
March, 1984	1)	The Interim Report for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia (draft)
	2)	The Interim Report for the Feasibility Study on Effective Utilization of Banko Coal in the Republic of Indonesia (Basic Design on Coal Gasification Test Facilities) (draft)

APPENDIX - 5 Members List

APPENDIX - 5 Members List

No.1 Study Team

Preliminary survey on markets of products

Name	Undertaking	Area of Expertise
Takehiko SATO	Team Leader	Registered Consulting Engineer in Mechanical Engineering
Yoshio HARA	Assistant Leader Chief, Market Group	Energy Economist
Yoshitaka ARAKI	Chief, Technical Group	Project Manager in Process Industries
Osamu HONGO	Energy Demand/ Supply for Electric Generation	Utilization of Energy
Taizo HAYASHI	Energy Demand/ Supply for Transportation	Evaluation of Alternative Energy
Ryoji SUZUKI	Basic Design of Civil and Architecture	Design and Engineering of Civil and Architecture

No.2 Study Team

Survey on Banko coal resources

Name	Undertaking	Area of Expertise
Takehiko SATO	Team Leader	Registered Consulting Engineer in Mechanical Engineering
Kunihiko MUTA	Assistant Leader Chief, Resources Group	Doctor, Geologist
Hiroshi TAKAHASHI	Mining Technology and Cost	Mining Engineering

Name	Undertaking	Area of Expertise
Koji SATO	Coal Reservoir	Evaluation of Coal Reservoir
Terumi ODA	Coal Quality	Evaluation of Coal Quality
Yoshitaka ARAKI	Chief, Technical Group	Project Management in Process Industries
Ryoji SUZUKI	Pilot Plant Building	Authorized Building Engineer
Yoshio HARA	Chief, Market Group	Energy Economist

No.3 Study Team

Survey on effective utilization of Banko coal

Name	Undertaking	Area of Expertise
Takehiko SATO	Team Leader	Registered Consulting Engineer in Mechanical Engineering
Yoshitaka ARAKI	Master Plan	Project Manager in Process Industries
Takeshi TAKAKURA	Coal Gasification	Manager in Research and Development for New Energy
Kohji WATANABE	Derivatives Production	Manager for Process Engineering
Takashi OKA	Neat Methanol Engine	Manager for Development Planning for Internal Combustion Engine
Kazuki HAITANI	Electricity Generation	Principal Engineer for Electricity Generation

No.4-A Study Team

Study on basic design of effective utilization of Banko coal

Name	Undertaking	Area of Expertise
Takehiko SATO	Team Leader	Registered Consulting Engineer in Mechanical Engineering
Yoshio HARA	Assistant Leader Chief, Market Group	Energy Economist
Taizo HAYASHI	Energy Demand/ Supply for Transportation	Evaluation of Alternative Energy
Yoshitaka ARAKI	Chief, Technical Group	Project Manager in Process Industries

No.4-B Study Team

Study on basic design of effective utilization of Banko coal

Name	Undertaking	Area of Expertise
Takehiko SATO	Team Leader	Registered Consulting Engineer in Mechanical Engineering
Shozo IDA	Coal Sampling	Mining Engineer
Ken ISHIHARA	Pilot Plant Building	Authorized Building Engineer
Ryoji SUZUKI	Pilot Plant Building	Authorized Building Engineer
Naomichi NIRE	Pilot Plant Building	Authorized Building Engineer
Toshitaka YANAGI	Pilot Plant Building	Authorized Building Engineer

JICA