GASIFICATION OF BRAZILIAN COALS
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Introduction

The balance of Brazil's energy consumption shows that nearly 39% of the national energy demand is supplied from oil products, only 4% from coal. Looking for the domestic energy resources the disproportion is obvious. (Figure 1). Furthermore, in view to the necessity to import the largest part of crude oil with payment in foreign currency, the oil should be substituted as far as possible by other kinds of energy, especially by coal derived products.

In the states Santa Catarina and Rio Grande do Sul more than 98% of all Brazilian coal deposits, estimated to about 23 billion tons, are located. From the existing coal mines, three of hard coal can be taken in consideration for the proven coal gasification processes (Figure 2):

- Candiota r.o.m. coal with more than 50% of ash. This coal can not be beneficiated with sufficient yield. In view of the high ash-fusion temperature and the high content of fines, Candiota coal can be fed only for fluidized bed gasification processes. For fixed bed gasifiers the fines must be agglomerated.

- Leão and Charqueadas coal have nearly the same properties. From these high-volatile coals fractions with ash contents of 20-45% are beneficiated. Course coal should be used in fixed bed gasifiers for the production heating gas or for coproduction. The fines are a suitable feedstock to produce synthesis gas in fluidized bed gasifier. In view of the ash quantities and properties entrained processes should not be used.

- From the central washing plant Capivari, steam coal with ash contents of 35-42% are available. The Barro Branco coal has some caking properties, therefore some difficulties may occur, if the feed coal for fixed bed gasifiers contains partly lumps with lower ash contents. In principle this coal can also be used for fluidized bed systems.

Summary of the Brazilian Gasification Activities

In accordance with the demand of industrial heating gas in the late seventies several proposals were made, to deliver coal derived heating gas to distribute in industrial centres, e.g. ceramic factories, metallurgical and paper industries.

Of these projects only the CRN- and ELECTROSUL-project will be realized in the next future.

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CRN - Project

Nearby to the port of Rio Grande there was scheduled to build one fertilizer plant to produce ammonia, based on coal. Firstly the Koppers-Totzek process was selected for the production of synthesis gas for 2000 tons ammonia daily. After reducing the capacity to 600 t/d the aims were changed and the produced gas now should be used for heating purposes in the neighbouring industrial area. For the process the well-proven rotating grate double shaft gasifier, licensed by Lurgi and constructed through NORDON will be installed. The plant capacity is designed for the production of 5 Mio. m³/d lean gas, calorific value 1400 kcal/m³ (5,9 MJ/m³), with 6 gasifiers. Running with full load, these gasifiers need 2000 t coal/day. As feedstock a mixture of Leão, Charqueadas and Recreio steam coal with 35% ash is foreseen. In addition, to distribute the detared gas, the construction of one 4 km gas grid must be undertaken. The start of test runs was in August of this year and full operating can be expected at the beginning of '83.

ELECTROSUL - project

Originally the aim of this project was to substitute oil, which is burned for stand-by firing in the boilers of the Jorge Lacerda's power station in Tubarão, S.C.. The coal should be delivered from the nearby Capivari central washing plant. It is also taken in consideration, to distribute the produced lean gas to industrial consumers in the vicinity of Tubarão. The plant should produce about 220.000 m³ gas/d with a calorific value of 1500 kcal/m³ (6,2 MJ/m³). For the process the pressureless working fixed bed gasifier, type IGI, was selected and a contract, to build one 4,6 m gasifier to TECHINT, was awarded. It is scheduled to finish construction work till the end of this year and full operating with a daily coal consumption of about 70 tons can be expected in the first quarter of 1983. The air-blown gasifier has two gas outlets (Figure 3). At the top of the gasifier one part of the gasification gas will be tapped with the carbonization gas. The expected temperatures are 200-250°C for the top gas and about 700°C for the so-called clear gas. The main advantage of this two-stage gasifier is that only the top gas must be detared if the gas is transported over certain distances. For the hot gas stream only a cyclone as dustcatcher is necessary. The ash will be discharged from the gasifier by the rotating grate, through which the gasification agents air/steam or oxygen/steam are introduced.
For the extension a second two-stage gasifier is scheduled. The same gasifier before was proposed for the now canceled USIVAL project. In addition to the first mentioned gasifier the OTTO type is equipped with a central stirrer to prevent clinkering in the carbonization zone and to increase the gasifier's capacity.

Proposals for the production of medium c.v.-gas

To substitute naphtha, which is used as feedstock for the production of town gas in Rio de Janeiro and São Paulo, it was proposed by CEG, Rio de Janeiro and COMGAS, São Paulo, to substitute the existing plants against coal gasification units. In view to the heating value of the town gas the Lurgi fixed bed gasifier were selected for these projects. The capacity of the coal based gasification plant, which should be installed for CEG in Itaguai near the port Sepetiba is planned to about 2,7 Mio. m³ town gas/day. As feedstock roughly 1,3 Mio tons coal/year are necessary. Till now it is not decided which type of coal should be gasified. Therefore the feasibility study for the project could not be finished. It is also taken in consideration, to convert the gas to SNG in an additional methanization unit.

At the time, when the PETROBRAS contracts, to deliver natural gas from the Campos fields will come to an end, the new coal gasification plant should be in function. For COMGAS one coal gasification plant with nearly the same capacity than for CEG is under discussions. Further proceedings are depending e.g. from the America-Sul natural gas project and the availability of Brazilian coals.

Research and development by CIENTEC

In view to Rio Grande do Sul's coal properties CIENTEC investigated the fluidized bed gasification of Leão, Charqueadas and Candiota coals in bench-scale units and pilot plants.

Project CIVOCAS

After the successfully operated 5 kg/h bench-scale unit in july 1980 CIENTEC took in operation one 500 kg/h pilot plant at their campus in Cachoeirinha, R.S.. The gasifier works under atmospheric pressure with run-of-mine coal, 0 - 6 mm size, from Candiota and Leão pits, producing a lean gas with 1200 kcal/m³ (5 MJ/m³) heating value. The project is financed by CAEEB and CIENTEC. The obtained results should be scale up for the construction of one commercial plant with the target, to substitute about 15000 - 20000 tons fuel oil/year.
which is fired in the boilers of unit A in the power plant Presidente Mediei in Candiota, R.S.

Project CIGAS

To produce medium btu-gas, the construction of one bench-scale unit for fluidized bed gasification up to 20 bars, oxygen-blown, with a coal throughput of 10-30 kg/h was initiated in 1981 and the start of operation should be in the second half of this year. From the results the enlarged type CIGAS II with a capacity of 100-200 kg coal/h will be designed. For demonstration purpose in the third phase CIGAS III with about 5 tons/h coal throughput is scheduled. The CIGAS project is sponsored by FINEP, the government of Rio Grande do Sul and CIENTEC. The produced gas from the CIGAS process can be used for ammonia- and methanol synthesis or for the production of SNG and liquid fuels.

Oil substitutes from coal

In principle oil can be substituted totally by coal derived products, if coal is available in sufficient quantities and qualities for the coal conversion processes and the prices for these products are able to compete with those from oil. The question must be answered, in which fields of oil depending consumers coal derived fuels can be introduced to a reasonable price. As markets should be considered industrial consumers, e.g. ceramic factories, power plants, municipal distributors and the chemical industry. As shown in Figure 4, low calorific value industrial heating gas can be produced by gasification of coal with air and steam in pressureless working gasifiers, which are producing with efficiencies up to 75%. If the gasifiers are operated under pressure, the lean gas should be burned in one combined cycle to produce electricity. The main advantage in comparison to one conventionally fired boiler plant is the possibility to desulfurize the feedstock. For the production of synthesis gas and medium calorific value gas normally oxygen-blown and under pressure working gasifiers are used. In view to the optimum size of the necessary air separation unit, the gasification plant should have an annual throughput of more than 500,000 tons coal/year.

To produce gas with town gas quality the well proven LURGI fixed bed gasifier is available. If SNG should be delivered, synthesis gas must be methanized. From the economy also the coproduction was investigated. Coproduction means, that the methane containing gas is passing through the methanol synthesis unit and the
remaining purge gas can be distributed directly as SNG. This route of coal conversion works with higher efficiency than to convert all gases to only one final product.

By fluidized bed or entrained gasification processes synthesis gas can be obtained as feedstock for ammonia-, methanol-synthesis and Fischer-Tropsch products. With the methanol and Fischer-Tropsch syntheses coals are indirectly liquefied. By using the MOBIL process methanol can be converted with high efficiency to high octane number gasoline. From the crude Fischer-Tropsch product Diesel fuel is distilled as the main product.

In special cases the synthesis gas can be used as reduction gas in the metallurgical industry.

Outlook

Regarding to the current Brazilian coal price situation, only from Candiota coal oil substitutes can be produced under competitive conditions. Unfortunately, as already mentioned, it is impossible, to reduce the ash content of Candiota coal with conventional beneficitation processes. Investigations are running, to upgrade the r.o.m. coal partially. If these tests will be successfully the following conversion route should be taken in consideration (Figure 5): The fraction I with 35-40% ash contents is introduced to the gasification plant. Fraction II, containing more than 60% of ash is burned in one conventional boiler unit or by fluidized bed combustion to produce the necessary steam for the gasification and to deliver the needed electric power, e.g. for the air separation unit, compressors and pumps. The surplus of power should be delivered to public distributors.

For the gasification two alternative processes should be investigated, depending on the target of the project. Of SNG and liquids are the final products, than the fixed bed gasifier has some advantages. But in view to the grain size of the coal, the fines must be agglomerated in one additional unit. The obtained gas is delivered to the Fischer-Tropsch synthesis or to the methanol plant. In both cases the remaining purge gas can be distributed as high calorific value gas SNG.

If only liquid products are desired, the under pressure working fluidized bed process is suitable to produce the feed gas for Fischer-Tropsch- or methanol synthesis. From the obtained purge gas - probably together with the LPG fraction from the Fischer-Tropsch plant - additional synthesis gas can be obtained from one steam reforming unit.
It was reported, that two plants for the production of low calorific value industrial heating gas to substitute fuel oil will be in operation in 1983. The introduction of coal derived SNG and liquid fuels depends beside the price situation of the oil market on the tremendous demand of investments for commercial coal conversion plants. In view to the expected increasing of crude oil prices and to be more independent from foreign imports, powerful financial and technical efforts must be undertaken to substitute partly oil through coal-derived products.

References

2. LURGI DO BRASIL. Private Communications.
3. OTTO DO BRASIL. Private Communications.
FIGURE 1 - BRAZILIAN ENERGY RESERVES AND PRIMARY ENERGY CONSUMPTION.

RESERVES - $10^3$ tep

- OIL: 4,270,000
- URANIUM: 1,646,000
- NATURAL GAS: 565,000
- OIL-SHALE: 47,815
- HARD COAL

CONSUMPTION - $10^3$ tep/year

- OIL: 54.319
- URANIUM: 37.086
- HYDROELECTRIC POWER: 1,112
- NATURAL GAS: 28.319
- SUGAR-CANE: 12.471
- FIRE WOOD: 3.274
- STEAM COAL: 1,430
- COKING COAL

SOURCE: BEN - 1981

FIGURE 2 - BRAZILIAN COAL QUALITIES

<table>
<thead>
<tr>
<th>NINE</th>
<th>CANDIOTA (R.O.M.)</th>
<th>LEÃO</th>
<th>CHARQUINHAS</th>
<th>RADO BRANCO (STEAM COAL)</th>
</tr>
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<tbody>
<tr>
<td>ASH CONTENT, %</td>
<td>50</td>
<td>20 - 40</td>
<td>30 - 45</td>
<td>35 - 42</td>
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<tr>
<td>VOLATILE MATTER (d.b.), %</td>
<td>23</td>
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<td>28 - 33</td>
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<td>SULPHUR (d.b.), %</td>
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<td>ASH SOFTENING POINT TEMPERATURE, °C</td>
<td>1,590</td>
<td>1,490</td>
<td>1,450</td>
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SOURCE: CETEM E CIENTEC
Fig. 3 - Techint Two Stage Gasifier

- Coal Feed
- Mixed Gas
- Drying Zone
- Clear Gas
- Distillation Zone
- Gasification and Combustion Zone
- Water Jacket
- Ash
- Air
- Steam
FIGURE 5 - CANDIOTA COAL - CONVERSION ROUTE

CANDIOTA ROM

FRACTION I
ASH 35-40%

FRACTION II
ASH > 60%

BENEFICATION

A

B

FLUIDIZED BED GASIFIER

AGGLOMERATION

FRACTION I

FRACTION II

STEAM TO GASIFICATION

BOILER PLANT

STEAM TO GASIFICATION

FLUIDIZED BED COMBUSTION

ELECTRICITY

POWER PLANT

ELECTRICITY

POWER PLANT

METH

F.T.

V.METH

F.T.

SNG

METHANE

LPG

NAPHTHA

METH

F.T.

V.METH

F.T.

SNG

METHANE

LPG

NAPHTHA

DIESEL