

CARBON MONOXIDE AS A FUEL

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The purpose of this talk is twofold. First, to familiarize you with a process for the separation of CO from gaseous mixtures which is called COSORB. COSORB cheaply and efficiently produces pure carbon monoxide from an ambient temperature and pressure gaseous mixture. Second, to discuss a coal gasification process which would produce pure CO for transmission and use as a fuel. This coal gasification process consists of (1) a slagging-ash gas producer using compressed air as oxidant, (2) gas processing units to extract the sensible heat of the producer gas as steam, isolate the tar and benzols produced and separate the sulfur, dust, and nitrogen containing compound from the gas, (3) COSORB which separates the CO from the rest of the purified producer gas (mostly nitrogen).

R. M. Jameson, at the recent Dallas meeting of this division, outlined at length why a coal refining industry needs to evolve in the immediate future. 85% of the total chemical fuel reserves of this country are coal. Yet coal is dirty. In addition to smoke problems, the sulfur and nitrogen content of coal go out the stack during its combustion in a boiler plant. Environmental problems will not allow future expansion of raw coal burning. Yet scrubbing stack gases for environmental clean-up is very expensive and only partially effective. The proposed process to be discussed here hopefully is an economically sensible way to use coal as an energy source. It refines the coal by gasification near the mine, purifies the gas, removes sulfur and nitrogen containing impurities, and then transports the pure CO by pipeline to the energy consumer. Pollution problems faced by the consumer would be practically nil.

It is to be emphasized that this process is completely unthinkable without an efficient, cheap separation of CO from nitrogen by a process such as Tenneco's COSORB. No such process has even been proposed before because COSORB did not exist before.

On the first slide, a diagram of COSORB is shown. The process has two packed towers, an absorber and a stripper. A copper containing solvent is circulated through the absorber where the solvent is contacted with a gaseous mixture, for illustrative purposes, a mixture of N_2 and CO. The copper cation in the solvent "coordinately" complexes the CO and absorbs it into the solvent. N_2 is untouched and dissolves in the solvent only by physical forces. It is quite easy to get the CO content of the nitrogen down to less than 1000 ppm. The CO rich solvent flows from the bottom of the absorber to a heat exchanger where it gives up a large fraction of the dissolved CO to the gas phase. In the stripper, a boiling aromatic compound drives the CO quantitatively out of the solvent. The hot lean solvent flows through the heat exchanger where it is cooled and then fed into the absorber to complete the circuit. A turbine compressor is shown in the diagram that may be used to compress the CO by letting down the nitrogen from its pressure in the absorber to one atmosphere. The stripper is run at some 5 psig or so pressure.

The entire apparatus for COSORB is built of simple mild steel. No corrosion problems exist.

Packed towers no taller than thirty feet are more than adequate to allow the quantitative separation at million lb/day carbon monoxide rates. The only utilities necessary are cooling water, low pressure steam, and electricity sufficient to pump the solvent from the stripper column to the absorber.

Having acquainted you with the COSORB process, I now turn to discuss a coal to CO energy complex.

Figure 5 is a diagram of a slagging-ash producer. The coal entering the top is mixed with a flux (limestone) and the residual ash from burning the coal exits the producer as a liquid. These producers can be built in very large units (the blast furnace, a prototype of this producer, is built in standard sizes of 1000 tons coke

per day). Under pressure, they also can be run at very high specific rates of production. These producers have a specific production rate fourfold that of the Lurgi process oxygen gasifiers. With pure carbon, the gas exit temperature is from 1000 to 1200C. The gases exiting a coal fed producer will be at a lower temperature because part of the sensible heat arising from the reaction of C to CO will be used to distill the tar, benzol, and moisture in the coal out of the coal on top of the very hot reaction zone. 72% of the energy of the carbon reacted will exit the producer as latent heat of combustion of CO while the remaining 28% will be sensible heat in the gas.

On slide 2, a line diagram of the coal to CO complex is shown. The heated producer gas goes to a steam generation unit where all possible sensible heat is transformed to steam. This steam is used as the driver in the succeeding units and also in the COSORB process to separate CO from the producer gas.

Tar and benzol are made in quantities similar to those obtained by low temperature coking of the coal in question.

One of the several developed efficient processes is then used to desulfurize the gas.

An activated carbon unit is then used for final clean-up to remove all heavier organics and nitrogen and sulfur from the gas.

A drying step (very probably a glycol-solvent absorber and stripper) is then used to finally prepare the gas for feed to COSORB. At this stage, the dry producer gas will be 33% CO with small amounts of H₂, CH₄, and CO₂ and the balance nitrogen.

This dry gas is then fed to COSORB (Fig. 1). In the absorber at 100 psig and ambient temperature, the CO is quantitatively absorbed in the solvent while the nitrogen goes overhead. A turbine lets down the pressurized nitrogen and compresses the pure CO. Considerable excess energy is available here and would be used to compress part of the air needed in Fig. 2 for the gas producer.

This energy complex would be at the mine. The product CO could be transported up to 400 miles to power generation stations or industrial complexes for use as fuel.

On slide 3, I have put down some salient points of interest about CO as a fuel. Its fuel value per unit volume is only 1/3 that of methane. This is a disadvantage for transport by pipeline, but not a severe one as long as the distances are reasonable. CO may be transported 400 miles by pipeline at an energy cost of only 13% of its fuel value.

As fuel, CO is superior to methane. It contains no water in its combustion gas. Its gross and net heat of combustion are the same. Methane uses only 90% of its gross heat of combustion in almost all of its fuel uses. CO has a higher octane number than methane. In a gas engine, fully 25% more horsepower can be delivered with CO than with methane as fuel.

CO can produce a completely dry hot gas if the combustion air is dried. This might be of great practical use in places where a very hot, but completely dry gas product is needed.

Engineering estimates for a COSORB based process and summarized on Fig. 4 for a very large CO producing complex, the complex size is 668 x 10⁶ SCF/day CO. This is equivalent in delivered BTU's to a 250 million SCF/day rate of methane.

The unit gasifies 10,800 tons of carbon per day. The tons coal would be larger than this by the amount of tar and benzol distilled in the gas producer. Twenty-eight percent of the heat value of carbon would appear as sensible heat in the producer gas upon oxidation to CO. This heat is equivalent to 3.5 million pounds of steam per hour. About 2.2 million pounds of steam is enough to drive all the purification units for the gas feed and also to operate a COSORB unit for the separation of CO from nitrogen.

One primary process driver (100,000 H.P.) operates from exhausting nitrogen. A second process driver is used (112,000 H.P.) for air compressing. Only the latter would need fuel. This fuel in a turbine would be about 14% of the heating value of the CO produced.

It is my opinion that the process discussed is a much more promising economical method of coal gasification than any method which uses oxygen as oxidant and which synthesizes methane as product.

CO does not have the BTU per SCF to substitute for methane in the present gas network. However, it needs emphasis that two-thirds of the present use of methane is in industrial or electricity use. Only 1/3 of the methane presently used goes to homes or other non-industrial usage.

Industrial and electrical generating uses of methane could be switched from methane to CO without great problems. This would conserve methane, so that an ample supply could be assured to continue home heating.

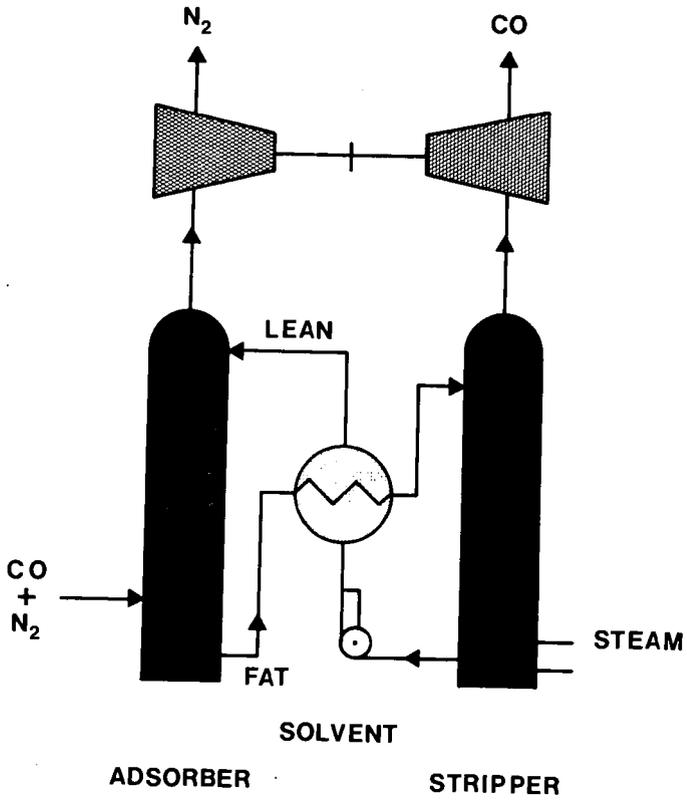


FIG. 1 - COSORB UNIT

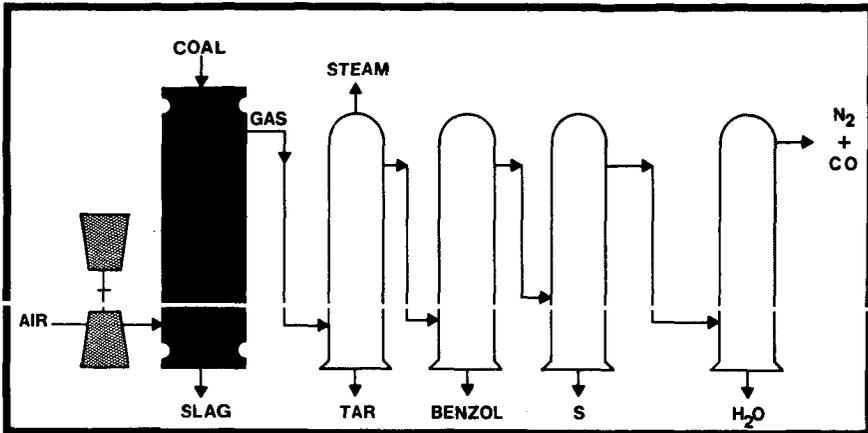


FIG. 2 - ENERGY COMPLEX: COAL - CO

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HEATING VALUE: 340 BTU/SCF

COMBUSTION EQN: $\text{CO} + \frac{1}{2}\text{O}_2 + 2\text{N}_2 \rightarrow \text{CO}_2 + 2\text{N}_2$

CO/CH₄ RELATIVE ENERGY DENSITY: 1.25/1

USEABLE COMPRESSION RATIO
IN OTTO CYCLE ENGINE: >9

COAL-CO ENERGY COMPLEX

- SIZE: 668×10^6 SCF CO/DAY
- GASIFIER P: 115 PSIG
- CO P: 100 PSIG
- CARBON GASIFIED: 10,800 TONS/DAY
- DRIVE: TRANSFER TURBINE 100,000 H.P.
AIR COMPRESSION 112,000 H.P.
- COSORB SOLVENT: 67,000 GPM
- STEAM USED: 2.23×10^6 #/HR.
- STEAM EQUIVALENT
OF GAS SENSIBLE HEAT: 3.56×10^6 #/H.R.

