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THE TVA AMMONIA FROM COAL PROJECT

By

D. A. Waitzman
Division of Chemical Development
Tennessee Valley Authority
Muscle Shoals, Alabama 35660

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THE TVA AMMONIA FROM COAL PROJECT

The TVA Ammonia from Coal Project consists of retrofitting an 8 ton/hour coal gasification and gas purification facility onto the front end of a small, but modern, natural gas-steam reforming ammonia plant at the National Fertilizer Development Center in Muscle Shoals, Alabama.

The simple facts are that at least one-third of the food and fiber produced in this country is attributed to fertilizer, of which nitrogen is the main nutrient. Practically all nitrogen fertilizer produced is made from ammonia. Ninety-five percent of ammonia produced is made from natural gas. If we lose the natural gas, we lose the ammonia, the fertilizer, and one-third of the food and fiber produced. Neither this country nor the world can stand such a situation.

While there is much debate in various quarters as to the extent of natural gas reserves and resources, most experts agree that within the next two or three decades petroleum and natural gas in the United States will be depleted. The substitutes for natural gas that can be considered are naphtha, fuel oil, and coal. Availability and cost considerations are such that coal is the only viable alternative.

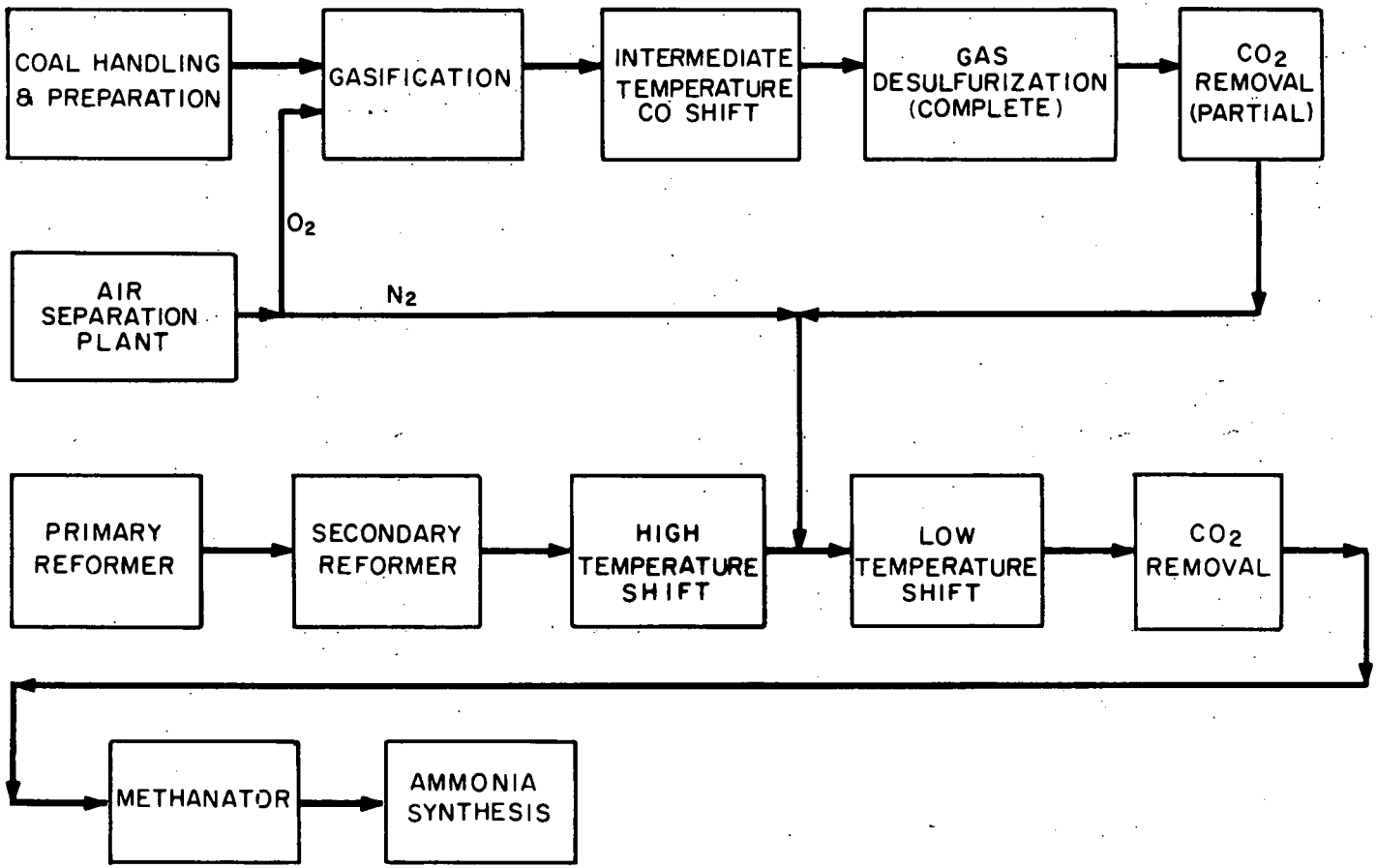
The main objective of the TVA project is to provide technical and economic information to the U.S. fertilizer industry for the substitution of coal for natural gas as a feedstock for producing ammonia. The TVA demonstration facility should provide a basis for retrofitting existing plants. There are about one hundred natural gas-steam reforming plants in the U.S. and about thirty of these are large 1000 ton/day plants. If these plants can be retrofitted so that they can use coal, the present investments in these

plants can be protected. Many of the problems involved in retrofitting are different from those with grass-roots plants. Others, such as the W. R. Grace Company, are pursuing grass-roots ammonia from coal technology, and we believe grass-roots and retrofit approaches supplement each other and both approaches should be pursued. Much of the data from the TVA project will be applicable to grass-roots plants.

The Texaco process was selected for the TVA project, but it is apparent that a number of coal gasification processes are entirely adequate for use in ammonia from coal plants. These are the German coal-based processes and those U.S. processes being funded by DOE and by private companies. Each coal gasification process has certain advantages in given situations and should be given serious consideration before a final selection is made. All of the process developing firms are continuing to advance their process technology and are anxious to have their processes put into operation in the U.S.

Basically the TVA project will consist of producing from coal a gas that matches--in composition, temperature, and pressure--the gas that exists near the front end of the ammonia plant, that is, before the low-temperature shift converter as shown in Figure 1. In the existing ammonia plant, natural gas is reformed to a gas containing hydrogen, carbon monoxide, carbon dioxide, nitrogen, and moisture. The high-temperature shift converter by a catalytic reaction converts most of the carbon monoxide and steam to hydrogen and carbon dioxide. At the point upstream of the existing low-temperature shift converter, the pressure is about 335 psig and the temperature is about 670° F. It is our intention to duplicate the process conditions of this gas with the gas produced in the Texaco gasifier, after particulate removal, shift conversion, and acid gas removal. This arrangement should make the greatest

FIGURE 1
COAL GASIFICATION RETROFIT TO EXISTING NH_3 PLANT



use of the existing plant and minimize the amount and size of new equipment required.

The existing TVA ammonia plant has a capacity of 225 tons/day of ammonia. It can be turned down to 60 percent of capacity by operating one of the two 60-percent-capacity reciprocating compressors. The least cost installation, therefore, would be a coal gasification facility that would produce 60 percent of the gas needed by the ammonia plant. This would give a capacity from coal feed of 135 tons of ammonia per day. In a coal only operation any adverse effects, such as poisoning of catalysts in the existing ammonia plant, could be determined. If we do match the process gas conditions at the selected point of entry, the ammonia plant could be operated on a 60-40 mode; that is, we could run our reformers and high-temperature shift converter so that 40 percent of the feed would come from natural gas for the full 225 ton/day capacity. Even though it will be necessary to make some modifications to the ammonia plant, the capability of operating with 100 percent natural gas will be retained. The new gasification, desulfurization, and purification section is being designed so that it can also be operated independently of the ammonia plant and the gas produced from coal could be burned in an existing steam boiler. In such an event, the nitrogen needed for ammonia production would not have been added to the synthesis gas. During the times the gas would not be suitable for burning in the boiler, it would be flared or incinerated.

It is recognized that differences from plant to plant will require special consideration. A case in point is high-pressure steam generation for steam turbines driving centrifugal compressors. TVA's compressors are electric-motor driven. The typical 1000 ton/day ammonia plant has high-pressure steam

generation in the reformers and waste heat boilers. If this steam were not produced because the reformers were eliminated, the steam would have to be raised either by waste heat recovery or in coal, coal gas, or fuel oil fired steam boilers. This requirement could be about 400,000 pounds of 1500 psig steam/hour for a 1000 ton/day ammonia plant. It is unlikely that this total amount could be produced as waste heat at the gasifier, and additional boiler capacity probably would have to be provided.

Waste heat recovery from the raw gases from the gasifier presents difficult problems due to slag deposition on tubes, erosion, and metallurgy. For this reason, a waste heat boiler will not be installed initally in the TVA project. Provisions will be made for possible future installation.

The plant is being designed for using Illinois No. 6 coal. Pilot-plant tests were run with this coal to determine the design conditions. This coal was selected because it has the largest reserve in the U.S. and is located in the Midwest where there is the greatest consumption of fertilizer. Sufficient flexibility is being designed into the plant to allow for test operation using coals with different heat, ash, and sulfur contents, and with different grinding characteristics.

Close attention has been given to the environmental, occupational health, and safety aspects of the plant. Emissions to the atmosphere have been limited to 500 ppm carbon monoxide, 160 ppm H_2S plus COS and 270 pounds/day solid particulate matter. Emissions in the wastewater have been limited to 30 mg/l total suspended solids, a pH range of 6 to 9, and other limitations on extraneous chemical pollutants. Composite noise levels have been specified at 85 decibels. Suitable devices for the monitoring of toxic fumes

will be installed at appropriate points throughout the plant. A medical program will be instituted for monitoring the plant workers for any adverse effects from possible carcinogens.

After the physical plant is complete in early 1980, a 3-year operational period is planned to determine the technical and economic data from this retrofit ammonia from coal plant. As far as possible within proprietary limitations, this information will be disseminated to the U.S. industry.

Two major contracts have been awarded--one to Air Products and Chemicals, Inc., Allentown, Pennsylvania, for about $5 million, for an air separation plant to produce 180 tons of oxygen per day; and the other to Brown and Root Development, Inc., for about $25.6 million, for a coal gasification and gas purification unit. These are lump sum, turnkey contracts with full process performance guarantees covered by the contractors; the gasification process is guaranteed by Texaco. The engineering, procurement, and construction of the remaining four areas will be done by TVA forces. These areas consist of the coal handling and preparation, modifications to the existing ammonia plant, slag disposal, and services and utilities needed for the entire complex. The total plant cost will be about $42 million. This cost is not believed to be amenable to scale-up for costs of commercial plants because the plant contains developmental and first-time-out design features. A percentage breakdown of these costs is shown in Table 1. It is interesting to note that the gasification and particulate removal facilities represent only 10 percent of the total cost. Shift conversion, acid gas removal and its associated heat exchange equipment, and the sulfur recovery system represent 39 percent of the total plant cost. A major factor in the cost of the acid gas removal system and sulfur recovery system is the presence of COS in the process gas. The lack of selectivity of available solvents for this specie

TABLE I

	PERCENT OF FACILITIES COST
COAL HANDLING AND PREPARATION	5.7
WET GRINDING	2.8
COAL GASIFICATION	10.0
ACID GAS REMOVAL, SHIFT CONVERSION, ASSOCIATED HEAT EXCHANGE, SULFUR RECOVERY EQUIPMENT	39.0
WASTEWATER TREATMENT	10.7
CONTROL ROOM, MISCELLANEOUS	8.5
AIR SEPARATION PLANT	14.2
MODIFICATIONS TO EXISTING AMMONIA PLANT	0.7
SLAG DISPOSAL	1.3
SERVICES AND UTILITIES	5.5
COMMON COSTS, ADMINISTRATION, ETC.	1.6
TOTAL	100.0

requires elaborate and costly solvent regeneration schemes and added steps in the sulfur recovery process.

As shown in Table II, we have recently estimated the production cost for 1000 ton/day plants, for both retrofit and grass-roots plants. There is a degree of uncertainty in these costs as they are estimated from conceptual designs rather than operating plants. After the TVA plant is completed and operated, we will either confirm or revise these estimates. The estimated 1978 cost for a natural gas-steam reforming plant is about $75.6 million, and a grass-roots coal partial-oxidation ammonia plant is about $140.8 million. Retrofitting an existing 1000 ton/day plant would cost about $89.0 million.

We have estimated ammonia sales price, f.o.b. plant, for 1000 ton/day plants. The sales price includes the cost of raw materials and chemicals, operating labor and supervision, utilities, maintenance, simple depreciation at 15 years, insurance, plant and administrative overheads, a 40-60 debt-equity capital structure, interest at 10 percent on borrowed capital, marketing, and a 15 percent after-tax return on owner's equity. Ammonia could be produced in a natural gas-steam reforming ammonia plant built in 1978 at a sales price of about $131/ton, using $2/MCF natural gas. Using $25/ton coal, the sales price would be about $176/ton for a 1000 ton/day grass-roots, coal-based plant and about $148/ton for a retrofit to a fully depreciated plant. With a cost of $25/ton, coal would be competitive with about $3.45/MCF natural gas for a grass-roots plant and about $2.55/MCF natural gas for a retrofitted fully depreciated existing ammonia plant. Other ammonia sales prices for partially depreciated plants are also shown. Ammonia prices delivered to retail dealers in the Midwest are currently about $118-$125/ton, about $84/ton on the Gulf Coast, and less for spot prices on small shipments. These ammonia prices

TABLE II

ESTIMATED AMMONIA SALES PRICE FOR NATURAL GAS AND COAL BASED AMMONIA PLANTS[a]

	EXISTING AMMONIA PLANT			TOTAL CAPITAL INVESTMENT,[c] $MM	AMMONIA SALES PRICE FOB PLANT $/TON NH_3	EQUIVALENT NATURAL GAS PRICE, $/MM Btu
	YEAR CONST.	ORIGINAL INVESTMENT $MM	REMAINING BOOK VALUE[b]			
NATURAL GAS FEED	1978	75.6	75.6	75.6	131	2.00
NEW COAL FEED[d]	--	--	--	140.8	176	3.45
RETROFIT COAL FEED[d]	1974	57.5	43.1	132.1	174	3.40
RETROFIT COAL FEED[d]	1971	46.1	23.5	112.5	162	3.00
RETROFIT COAL FEED[d]	1967	37.0	9.3	98.3	154	2.75
RETROFIT COAL FEED[d]	1963	35.5	0	89.0	148	2.55

[a] BASIS: 1000 SHORT TON/DAY AMMONIA PLANT.

[b] DEPRECIATED OVER 15 YEARS.

[c] TOTAL CAPITAL INVESTMENT IS THE SUM OF COST OF RETROFIT FACILITY, $89.0MM PLUS BOOK VALUE OF EXISTING AMMONIA PLANT.

[d] COAL AT $25/TON

reflect a current depressed market for ammonia. Coal costs at Muscle Shoals are currently about $28/ton. The cost would be about $17-$23/ton for a coal-based plant located at the coal mine (high-sulfur, bituminous).

The conclusion reached at this point is that both the technical and economic aspects of coal-based ammonia production are unclear. It is apparent that no one gasification process will be applicable for all ammonia from coal applications in the U.S. In addition to the selection of the gasification process, there are numerous other technical alternatives that the ammonia producer must consider, depending on his particular circumstances. The economic picture will depend on future availability and costs of feedstocks. We expect that natural gas costs will continue to increase in the future. We also expect the cost of coal to increase. It would appear that coal costs will not increase as much as natural gas in the next 10 to 15 years, but there is no certainty of this. One main objective of the TVA project is to firmly establish the economics of producing ammonia from coal. Accomplishment of this objective will provide a useful yardstick for U.S. industry as producers consider alternatives for meeting the nation's nitrogen fertilizer demand in the future.