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DEVELOPMENT PROGRAM TO SUPPORT INDUSTRIAL
COAL GASIFICATION

Quarterly Report 1

January 15, 1982

Work Performed Under Contract No. AC01-81FE05147

Davy McKee Corporation
Cleveland, Ohio

TECHNICAL INFORMATION CENTER
UNITED STATES DEPARTMENT OF ENERGY

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DAVY McKEE CORPORATION

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I. OVERVIEW

The Development Program to Support Industrial Coal Gasification is on schedule in the First Quarter, and it is anticipated that it will continue on schedule for the remainder of the program.

The efforts in the First Quarter centered on collecting background information and data, planning, and getting the experimental program underway. The three principal objectives in Task I-A were accomplished. The technical literature was reviewed, the coals and binders to be employed in the program were selected, and tests and testing equipment to be used in evaluating agglomerates were developed. In Task II, the entire Erie Mining facility design was reviewed and a large portion of the fluidized-bed coal gasification plant design was completed.

In the Second Quarter, much of the work in Task I will be experimental. Wafer-briquette and roll-briquette screening tests will be performed. In Task II, work on the fluidized-bed gasification plant design will be completed and work on a plant design involving entrained-flow gasifiers will be initiated.

II. TASK SUMMARY

TASK I-A TECHNICAL LITERATURE REVIEW

The technical literature review was completed. A list of potential binders was developed and six to twelve single binders and a half dozen multiple binder combinations were selected for study. Six test coals with high potential for use were also selected. Preliminary concepts of binder and coal pretreatment and of agglomerate post-treatment were developed. A report summarizing all this work is presently being prepared.

TASK I-B PRELIMINARY STANDARDS

Information of how suitable coals react in a gasifier environment was reviewed. Testing procedures and test equipment were developed to measure properties of coal materials that are important to gasifier use. These tests will be used to evaluate agglomerates in the program. A preliminary look at the economics of agglomeration was made, with particular emphasis on setting an upper cost limit that would be reasonable for a process. The best size and shape for agglomerates for coal gasification and possible methods of upgrading coal at the mine that might improve overall performance were studied. The six selected coals plus anthracite will be used as standards in the program. Work was begun in preparing and testing samples of these materials.

TASK I-C SCREENING TESTS

All coals and binders for screening tests were ordered and a number were received during the period.

TASK II-A ERIE MINING STUDY REVIEW

A review of the Erie Mining reports was completed. This review provided the design basis for the three alternate design cases.

TASK II-A WINKLER GASIFIER DESIGN

A base case engineering design for the Winkler gasification technology is almost complete. The design includes gasifiers, waste heat recovery, hot cyclone and particulate removal. Three gasification systems are required for the base case.

An extensive literature search was made to obtain information regarding air-blown Koppers-Totzek gasification technology. This effort did not reveal any published sources of information relating to air-blown Kopper-Totzek gasifiers. Contact was also made with Koppers in the U.S. and German licensors of K-T technology.

Both sources stated that they feel that this technology is impractical, and neither appears to have any interest in developing it. An investigation was begun into the possible use of other air-blown entrained-flow gasifiers.

TASK II-A ENTRAINED FLOW GASIFIER DESIGN

Work is not due to start on this subtask until an evaluation and selection of an entrained-flow gasifier has been completed. This activity is scheduled for February of the Second Quarter.

III. PROJECT DETAIL SUMMARY

A. AGGLOMERATION PROCESSES

Agglomeration is defined as any method that will enlarge the size of particulate matter and produce an agglomerate in the form of a compacted shape, with or without the addition of a foreign substance called a Binder. Most agglomeration methods can be classed in one of two categories: processes involving agitation and processes involving compression. Processes in each category and typical equipment used to carry out the processes are as follows:

Agitation Methods

1. Pelletizing - Disc, Drum and Cone Pelletizers
2. Granulation; Micropelletizing; Instantizing - Special Devices, such as mixers, drums and granulators.

Compression Methods

1. Briquetting - Double Roll Presses with pocketed rolls.
2. Compacting - Double Roll Presses with smooth or corrugated rolls.
3. Auger Extrusion - Screw Extruders and Dies
4. Ram Extrusion - Ram Extruders
5. Brick or Blockmaking - Brick Presses
6. Tableting - Tablet Presses

Of the above processes, only briquetting, pelletizing and extrusion appear to be practical approaches to produce coal agglomerates for a gasifier. Granulation, micropelletizing and instantizing result in very small agglomerated shapes, 1/8 inch in diameter or less. Brickmaking, blockmaking and tableting are specialized processes that in the past have been generally confined to specific industries, such as bricks, clay, ceramic tile, refractories, and pharmaceuticals. The shapes and sizes produced by these processes are not particularly desirable for use in a gasifier. Briquetting and pelletizing are the processes that will be investigated in this project. Extrusion may be examined in the

project if sufficient funds remain at the end of the program and if the DOE Project Manager specifically requests it.

B. Coal Pretreatments

It may be desirable to treat the coal fines generated in handling in some manner to make them more suitable for agglomeration. This treatment may be performed at the coal mine location or at the gasifier site. Treatments can be employed to change the size distribution of the coal fines, to change the surface characteristics of the coal, or to change its chemistry.

The size distribution may be altered by screening, by grinding, or by a combination of these approaches. Screening separates the coal fines into two or more fractions. To achieve a different size distribution generally means discarding a portion of the fines.

Single or double screening is usually employed at the gasifier (for fixed-bed gasifiers) to separate less than 1/4 inch material from lump coal being charged to the gasifier. Coarse screening is often performed at or near the mine to produce a sized coal for use in the gasifier, screening in this case separates as-mined or washed coal into two coarse sizes, for example, plus 1-1/2 inch and minus 1-1/2 inch fractions.

The surface characteristics of the coal can be changed in several ways. Heating the coal in air or oxygen even at low temperatures will oxidize the coal fines and change their surface characteristics. Treating the coal with a solvent, such as benzene, acetone, toluene or a coal derived compound, particularly at elevated temperatures and pressures, is believed to improve the properties of coal surfaces for agglomeration.

The chemistry of a coal fines mixture can sometimes be modified by screening out a fraction that contains an unwanted species, such as clay or iron pyrite. Washing is a process often employed with as-mined coal to separate fines from coarser coal. Clay particles tend to be small in size and remain with the fines. Coal fines can be washed also, but in doing so, special agents are generally required and the process is known as beneficiation.

Like screening, beneficiation methods, such as froth flotation and jigging, can reduce significantly clay and pyrite levels.

Drying is a process that will reduce the water content of a coal fines' mixture and therefore change its overall chemical composition.

From a practical standpoint, beneficiation processes should best be performed at or near the mine site. The reason for this is that these processes result in a coal fraction that requires disposal. Few other pretreatments make sense at the mine site, except perhaps drying in special cases. The transportation of the treated fines from a mine to a gasifier site for agglomeration can be difficult, dirty, and dangerous.

Agglomeration of fines at the mine, however, can be economically attractive, although it must be remembered that additional fines will be generated from the agglomerates during transportation to the gasifier. Also, this approach will not solve the problem of fines' generation from lump coal, which is the principal feed to the gasifier. It appears, therefore, that in most cases agglomeration should be performed at the gasification plant and that most pretreatments, if employed, should also be performed there.

C. Agglomerate Post-Treatments

A variety of different post-treatments can be given to coal agglomerates to change their physical or chemical properties. Drying is a common post-treatment given to pellets. Briquettes can be exposed to treatments such as:

1. Low-Temperature Oxidation.

Oxidation at 150°C to 200°C can often increase the softening point of a hydrocarbon binder, such as tar or pitch. If carried to an extreme, oxidation can set the binder and prevent degradation during gasifier exposure. Even the partial oxidation of briquettes can result in case hardening of the briquettes' surfaces, which could improve performance.

2. Drying.

This process will be of most interest when an aqueous binder is employed.

3. Reaction with CO₂.

It may be possible to harden briquettes containing lime or magnesia by exposing the briquettes to CO₂. The

CO₂ reacts with the lime or magnesia forming calcium or magnesium carbonates, which are strong, hard phases.

4. Heat Curing at Moderate Temperatures.

This treatment could result in improved gasifier performance for briquettes containing sodium silicate and cement-type binders that are amenable to curing treatments.

5. Carbonizing.

The conversion of a liquid organic binder to graphite by heating in a controlled atmosphere will often improve the properties of a briquette.

6. Thermosetting Techniques.

Although thermosetting compounds, such as resins, are too expensive to be considered as possible binders for coal agglomerates, it may be possible to convert tars and oils to thermosetting compounds in situ by exposing briquettes with these binders to formaldehyde or paraldehyde.

All the approaches described above will be investigated in the program.

D. Gasifier Performance

From past experience, it is known that some coals perform well in fixed-bed gasifiers, while others do not. Much less is known about the performance of coal agglomerates because so few have been used in gasifiers. It is known, however, that some briquettes will withstand a gasifier environment (for example, binderless briquettes made from German brown coals), while others will fail calamitously.

To be useful, agglomerates must not only stand up inside the gasifier, they must withstand handling outside the gasifier as well. If excessive fines are generated in the handling of agglomerates, little is achieved in agglomerating in the first place. Readily accepted tests can be employed to measure expected performance in handling outside a gasifier. To measure expected performance inside a gasifier, less definitive tests are available.

One reason why definitive tests are not available is that the precise processes going on inside a gasifier are complex and not fully understood. Most treatments of the processing of coal in a fixed-bed gasifier assume that the coal charge moves in plug flow and that little rotational movement of individual coal particles occurs. In reality, this is not entirely true. Owing to gasifier side-wall effects, to uneven gasification across the bed area, and to the presence of a stirring or levelling arm in many cases, significant tumbling and abrasion occur. Temperature and pressure profiles in a gasifier also vary with the type of gasifier, the size of gasifier, the coal being employed, steam and air additions, and other variables. Because many different chemical reactions are believed to occur inside a gasifier and because these reactions are influenced by temperature, pressure, and the presence of different chemical species, it is not difficult to see why gasifier performance is not fully understood.

With briquettes that have failed in fixed-bed gasifiers in the past, failure has often been attributed to the distillation or evaporation of the binder in the top regions of the gasifier. With the loss of the binder, the coal particles making up the briquettes rapidly collapse and revert to their previous form. In doing so, they readily fill the gasifier chamber allowing few or no voids for the upward passage of air, steam, and product gases. The result is poor gas production and poor gasifier performance.

Briquette failure may also occur for other reasons. Like highly caking coals, briquettes can stick together at some stage during their descent through the gasifier. This sticking-together causes bridges across the diameter of the gasifier that hold back the charge above. Below these bridges hot spots occur that, in turn, cause clinkering and uneven gas flow up through the gasifier. Gas composition is generally affected detrimentally.

Degradation of agglomerates in the bed by abrasion or failure by loading can occur if the agglomerates are weak, but these failure modes may be less important in general than the other two discussed above. Pellets are expected to be more prone to failure by abrasion or crushing than briquettes because they are generally weaker than briquettes. Strength measurements made on heated samples should give some indication of the ability of samples to withstand crushing and abrasion at elevated temperatures.

E. Agglomerate Size and Shape

What is the best size for an agglomerate to be used in a gasifier? Unfortunately, there is no widely accepted answer to this question. The best size must be a balance between the size that will display the best properties, the size that can be most economically produced, and the size that will perform most satisfactorily in the gasifier. Generally speaking, large agglomerates are more economical to produce than small agglomerates. For example, a smaller percentage of flashing occurs in briquetting 2-inch shapes in comparison with 1-inch shapes, so less material must be recycled. However, for a 10-foot diameter two-stage gasifier, an agglomerate in the 1/2-inch to 1-inch diameter range might be most desirable from an operation standpoint. From a properties standpoint, a 1-1/2 inch briquette might show the best strength. After considering all factors, one can decide on the best size.

What is the best shape for the agglomerate? Again, there is no best answer. Many gasifier experts say that a spherical shape or a shape approaching a sphere is best. Spherical shapes permit uniform packing of the bed and good movement of gas upward through the bed. No detailed studies, however, have shown conclusively that a bed of spherical coal shapes is better than one of pillow shapes or of almond shapes or even of rod shapes. More research is needed in this area.

In the present program, the bulk of the briquetting experiments will be performed on pillow-shaped briquettes, approximately 7/8-inch by 3/4-inch by 1/2-inch. Other briquette sizes, however, will be examined. Most pellets will be spherical in shape with a nominal diameter of 1-inch, although, again, other sizes will be examined.

F. Literature Survey

The principal objective of the literature survey was to review the technical literature to identify potential binders for coal agglomerates and to identify methods employed in the past to agglomerate coal fines and the results of past briquetting and pelletizing experiments performed on coal fines. Approximately 75 potential binders were identified. Very little information or data were found on the use of coal agglomerates in coal gasifiers. Coal briquettes in the past were used primarily for direct burning applications.

The bulk of the material used in the literature survey was obtained from various technical libraries. A computer search of published reference material was initially conducted. Many articles were reviewed. Some of the best information sources were those published by the United States Bureau of Mines and those presented at various conferences of the Institute for Briquetting and Agglomeration (IBA). In total, more than 75 articles dating from the early 1900's to the present were obtained and were reviewed. Information was also obtained from discussions with chemical suppliers and with individuals experienced in the field of coal agglomeration.

Numerous binders were tried in the past with varying degrees of success. The binders used were either singular components or combinations of one or more binders. Included were coal-derived compounds and certain sulfur-capturing compounds. The most common binders for coal in the past were various tars, pitches, asphalts and petroleum still bottoms. While these materials were at one time available at a reasonable cost, today most are fairly expensive and their use in coal agglomeration may be limited for economic reasons.

The list of identified binders appears in Table 1. Each candidate is presently being evaluated on the basis of: (1) cost; (2) availability; and (3) results of tests reported in the literature.

TABLE I
BINDERS EMPLOYED IN BRIQUETTES IN THE PAST

ORGANIC BINDERS

1. Albuminates	27. Molasses
2. Alcohol	28. Paraffin
3. Asphalt Emulsion	29. Petroleum Pitch
4. By-Product Coke Oven Tar	30. Pine-Wood Tar
5. Carnauba Wax	31. Pitch Emulsion
6. Casein	32. Pittsburg Flux
7. Chemically-Treated Peat	33. Polyvinyl Alcohol
8. Coal-Tar Creosote	34. Potato Starch
9. Coal-Tar Pitch	35. Producer-Gas Tar
10. Corn Starch	36. Refined Bermudez Asphalt
11. Crude Oil	37. Refined Trinidad Asphalt
12. Dextrin and Sucrose-Starch	38. Rosin
13. Drying Oils	39. Slack Wax
14. Fir Tar	40. Slaughterhouse Refuse
15. Gelatin	41. Tannic Acid or Tanning Liquours
16. Gilsonite	42. Tapioca Starch
17. Glue (By-Product)	43. Thermoplastic Resins
18. Gum Arabic	44. Thermosetting Resins
19. Hard-Wood Tar	45. Vegetable Pulps
20. Humates	46. Water-Gas Tar Pitch
21. Impsonite	47. Wax Tailings
22. Leonardite	48. Wheat Starch
23. Lignin Liquor	49. Wood Pulp
24. Lignin Powder	50. Pulped Straw
25. Lignite Tar	51. Sawdust
26. Maltha	52. Seaweed

INORGANIC BINDERS

1. Alum	13. Metal Stearates
2. Bentonite	14. Natural Cement
3. Clay	15. Peat with Soda Ash
4. Colloidal Alumina	16. Plaster of Paris
5. Colloidal Silica	17. Portland Cement
6. Copper Sulphate	18. Potassium Silicate
7. Fuller's Earth	19. Silica
8. Lime	20. Slag Cement
9. Lime Hydrate	21. Sodium Borate
10. Magnesia	22. Sodium - Calcium Salt
11. Magnesia Cement	23. Sodium Silicate (Water Glass)
12. Magnesia Oxy-Chloride	

G. Binders to be Investigated - Task I

The literature gives numerous materials that have been tried as binders for coal fines with various degrees of success. Many materials can be readily eliminated from consideration on the basis of cost, past performance, or availability. Six binders were chosen for initial study in the project. These binders are: (1) high-temperature coal-tar pitch; (2) gasifier tar; (3) lignosulfonate; (4) bentonite; (5) hydrated lime; and (6) water glass. All have been reported in the literature as being successful in agglomerating coal. Other binders, such as starch and gilsonite, will also be considered in the program.

The following binder candidates are presently on hand at Davy McKee:

<u>Binder</u>	<u>Supplier</u>
a. Gilsonite	American Gilsonite Company
b. Wyoming Bentonite	Federal Ore & Mineral Corporation
c. Coal Tar Pitch	Reilly Tar & Chemical Corporation
d. Corn Starch	A. E. Staley & Company
e. Sodium Silicate	E. I. DuPont & Company
f. Hydrated Lime	Local Source

The following binder candidates were ordered:

<u>Binder</u>	<u>Supplier</u>
a. Wheat Starch	Henkel Corporation
b. Calcium Based Southern Bentonite	American Colloid Corporation
c. Petroleum Asphalt	SOHIO
d. Dolomite	Pfizer Corporation
e. Lignin Powder (Norlig A)	American Can Company
f. Gasifier Tar	Caterpillar Tractor Company

H. Coals to be Investigated - Task I

Six coals were selected for agglomeration studies. They were selected on the basis of known gasifier use, on the basis of obtaining a wide cross-section of coal type and geographic locations, and on the basis of use in previous DOE programs. The six coals were:

1. Pittsburgh #8 bituminous coal
2. Illinois #6 bituminous coal

3. Wyoming Bighorn sub-bituminous coal
4. Montana Rosebud #14 sub-bituminous coal
5. Texas lignite
6. North Dakota lignite

The class in which each of these coals fall and a typical proximate analysis of each coal are given below.

1. Ohio - Pittsburgh #8 Seam

Class II - Group 4 (High Volatile Bituminous B)

As-Received Analysis (WT %)

Moisture	3.6
Volatile Matter	37.8
Fixed Carbon	53.4
Ash	5.2
Sulfur	1.3
Heating Value (BTU/LB)	<u>13,600</u>

2. Illinois - Illinois #6 Seam

Class II - Group 5 (High Volatile Bituminous C)

As-Received Analysis (WT%)

Moisture	7.8
Volatile Matter	33.6
Fixed Carbon	50.2
Ash	8.4
Sulfur	1.0
Heating Value (BTU/LB)	<u>12,400</u>

3. Wyoming - Big Horn Coal Basin

Class III - Group 2 (Sub-bituminous B)

As-Received Analysis (WT%)

Moisture	17.0
Volatile Matter	35.5
Fixed Carbon	45.2
Ash	2.3
Sulfur	0.4
Heating Value (BTU/LB)	<u>11,000</u>

4. Montana - Rosebud #14 Coal Deposit

Class III - Group 3 (Sub-bituminous C)

As-Received Analysis (WT%)

Moisture	16.3
Volatile Matter	35.8
Fixed Carbon	32.6
Ash	15.2
Sulfur	0.9
Heating Value (BTU/LB)	8,860

5. Texas - Lower Calvert Bluff Formation

Class IV - Group 1 (Lignite A)

As-Received Analysis (WT%)

Moisture	33.7
Volatile Matter	29.2
Fixed Carbon	29.8
Ash	7.3
Sulfur	0.5
Heating Value (BTU/LB)	7,300

6. North Dakota - Indian Head

Class IV - Group 1 (Lignite A)

As-Received Analysis (WT%)

Moisture	38.9
Volatile Matter	25.5
Fixed Carbon	30.2
Ash	5.4
Sulfur	0.5
Heating Value (BTU/LB)	6,750

The above six coals and anthracite will be employed as standards in the program. The properties of lump samples will be compared with properties of agglomerates developed in the program. The anthracite to be employed will come from the Nanth coal seam located in New Philadelphia, Pennsylvania. A typical analysis of this coal is as follows:

PENNSYLVANIA - NANOTH ANTHRACITEAs Received Analysis (WT%)

Moisture	3.3
Volatile Matter	3.3
Fixed Carbon	84.3
Ash	9.1
Sulfur	0.6
Heating Value (BTU/LB)	<u>13,350</u>

I. Preliminary Standards and Tests to be Performed in Task I

Two particular qualities are required of agglomerates. They must withstand handling outside the gasifier and they must stand up inside the gasifier. Lump coal standards are being tested as follows:

1. Lump Coal Tests to Establish Preliminary Standards for Agglomerate Handling

a. Crushing Strength

Crushing strength is a property often determined on briquette samples, but rarely determined on lump coal samples. In the project, crushing strengths of lump coal samples are being determined for comparison with strengths of briquettes and pellets. For these determinations, special minus 1-inch plus 3/4-inch lump coal pieces are being utilized. The sedimentation layer of each piece is being employed as the sample base and is being ground flat on a sanding disc. The top of each sample is also being ground flat. The distance between the top and bottom flat surfaces is approximately 1/2-inch to 3/8-inch.

Tests run on Pittsburgh #8 coal gave an average crushing strength of 2055 lb (10-sample average) with a standard deviation of 535 lb. Earlier, 3/4-inch by 3/4-inch by 1/2-inch shapes were sculptured from lump coal by cutting with a low-speed band saw and final grinding with an abrasive disc. This method was very time consuming (10 samples required eight hours preparation time). The average crushing strength of the sculptured shapes was 2096 lb (10-sample average) with a standard deviation of 543 lb. Both sample types therefore gave similar values. For this reason, the first, less costly method will be used for all other coals.

It should be noted that by applying a crushing force perpendicular to the sedimentation layer will generally give the maximum strength of the coal. The making of samples with flats perpendicular to the sedimentation layer, however, is difficult and time-consuming. For this reason it is recommended that it be considered only in special cases.

b. Tumbler Tests

Because of the limited amount of each agglomerate that will be available, a tumbler only a third the width of a standard ASTM tumbler will be used. This tumbler will require a seven-pound charge of minus 1-inch x 3/8-inch lump coal or whole briquettes.

The standard tumbler test involves evaluation after 2400 revolutions at 40 rpm. For the present program, the number of revolutions that generate 25 percent minus 1/4-inch fines from the poorest coal in gasification tests will be selected as the standard number of revolutions to be used in all subsequent tests.

2. Lump Coal Tests to Establish Preliminary Standards for Agglomerate Behaviour in a Gasifier

It is assumed that the critical temperature range for both lump coal and agglomerates is between 200°F and 1500°F. If degradation occurs at higher temperatures, the coal or agglomerates will have entered the gasification zone in a gasifier where degradation may, in fact, be beneficial. From past experience, degradation problems are known to occur in the top regions of the gasifier, where temperatures are relatively low.

In the 200°F to 400°F temperature zone of the gasifier, drying takes place. Little devolatilization of organics occurs in this zone but some agglomerates, particularly if made with tar or pitch binders without special treatment, go through a softening stage during which time mechanical strength is greatly diminished. Not only may agglomerates disintegrate in this temperature range, but they may also fuse and form clusters. Lump coal in this temperature zone will usually not fuse but may develop fissures that weaken the lumps or result in breakage into small pieces.

Between the temperatures of about 400°F and 1500°F, both lump coal and agglomerates will devolatilize and may fuse or break down into small pieces. Gasification generally does not occur appreciably below 1500°F.

While eventually it may be of interest to determine how agglomerates behave at specific temperatures within the 200°F to 1500°F range, the planned tests are designed to observe the behavior of agglomerates that survive heating to 1500°F and holding at that temperature.

a. Effect of Heating to 1500°F

Lump coal and agglomerates will be placed inside a stainless steel box with a loose fitting lid and the box will be placed inside a muffle furnace preheated to 800°F. The coals will be brought up to 1500°F within 1/2 hour and after reaching 1500°F, they will be held at this temperature for 20 minutes before being removed and placed in a nitrogen purge container for cooling. The volatiles evolved during heating are expected to prevent oxygen from contacting the charge.

After cooling, the contents of the box will be observed and comments on the appearance, such as degree of swelling, fusion, size degradation and friability, will be recorded. Because these observations will be subjective, they will always be made by the same 1 or 2 operators.

If individual pieces of coal or briquettes can be readily removed and appear to have a reasonable strength, they will be subjected to a crush test and/or to a tumbler test, as described below.

b. Small Scale Tumbler Test

Because the material in a gasifier in most cases is exposed to a rubbing rather than dropping action, material in the program will be tested in a tumbler where it is exposed to sliding and rolling actions. A tumbler 6 inches long and 6 inches in diameter will be employed. The number of revolutions and the tumbler speed will be selected as before.

c. Crushing Strength

If the coal samples and briquettes survive heating and have sufficient strength to be handled afterward, the crushing strength of these materials will be determined using procedures followed on unheated samples.

d. Swelling Test

Relative swelling of the cut coal and briquettes will be determined by observing the profile of

heated specimens against a grid and noting changes of the major dimensions. Photographing the profile against the grid will be attempted to try to obtain a record of swelling.

It may be possible to obtain a more accurate measurement by volume displacement measurements after impregnation with paraffin. Both techniques will be explored.

All six coals and anthracite will be analyzed in accordance with ASTM coal classification for:

- A. Percentage Moisture: Surface & Inherent
- B. Percentage Volatile Matter (Dry Basis)
- C. Percentage Ash (Dry Basis)
- D. Percentage Sulfur (Dry Basis)
- E. Free Swelling Index
- F. Ash Fusion Temperature

J. Upper Costs for Briquettes

The study of the upper cost limits for economical agglomeration of coal for a fixed gasifier is in progress. The following factors which influence the economics of the agglomeration are being investigated:

- a. Cost of Coal "As Received"
- b. Fraction of Fines in Coal
- c. Potential Sales Value of Fines
- d. Fraction of Binder in Agglomerate
- e. Cost of Binder
- f. Cost of Pre- and Post-Treatment
- g. Operating Cost of Agglomeration Facility

The relationships between these factors are being investigated and graphs are being developed, which will serve as guidelines in the development of an economical process. The

above items a. to e. will be considered as variables. The cost of pre- and post-treatments (Item f) is not being treated graphically because of its complicity. But this cost will be estimated individually for promising binders during later phases of the program.

K. Erie Mining Review

The Erie Mining Study Reports were reviewed to establish the required capacity and operating conditions for the three alternate cases proposed in this new study. The amount of product gas to be made is 20 billion Btu/day, which is the total requirement for the pelletizing plant. The gas is required at a pressure of 29 psia. Coal sources are low sulfur Western coals and high-caking Eastern coals with sulfur contents of 2.5% and greater.

L. Winkler Gasifier Plant Design

Preliminary process flow diagrams have been completed of a base case design for the Winkler gasifier. Heat and material balances for the gasifier, waste heat recovery, dry cyclone and wet scrubber have been completed. Coal drying requirements have been determined and a preliminary design of the dryer has been initiated. Grinding requirements for the coal feed have also been determined and a preliminary crushing station design has been initiated.

An evaluation of steam utilization and char handling has also been started.

M. Entrained-Flow Gasifier Plant Design

As part of the literature search to obtain information regarding air-blown Koppers-Totzek gasifiers, use was made of the Davy McKee computer which performs a "Bibliographic Literature Search" by accessing "Dialog". This file which contains well over 150 data bases is used to reference subjects by cross checking numerous different headings or titles. The result of this effort indicated that there are no published sources of information relating to air-blown Kopper-Totzek type gasifiers. In addition, both the American and German licensors of this technology were also contacted. The discussions revealed that to date no design of an air-blown Koppers-Totzek gasifier had ever been performed and that both licensors believed the concept to be impractical and had no interest in developing such a design. Each also stated that they would participate in this study only on a fee basis as a subcontractor.

An investigation of other air-blown, entrained-flow gasifiers was also started. Three possible candidates are:

1. The C-E (Combustion Engineering) Gasifier
2. The Otto-Saarberg Gasifier
3. The TRW Gasifier

IV. PROJECT WORK FORECAST - FOR THE SECOND QUARTER

TASK I

The following activities are planned:

- o Prepare and issue a Topical Report on Task I-A work.
- o Prepare and issue a Topical Report on Task I-B work.
- o Prepare and evaluate standard samples of the six selected coals and anthracite.
- o Prepare and perform screening tests on a large number of wafer briquettes to determine the best binders and to observe how various pretreatment or post-treatments and briquetting conditions affect briquette performance.
- o Begin the preparation and testing of roll briquettes.
- o Initiate the preparation and testing of pellets.

TASK II

The following activities are planned:

Winkler Gasifier Work

- o Complete and issue final process flow diagrams for the gasifiers, waste heat recovery, dry cyclones and particulate removal.
- o Complete coal crushing and coal drying designs.
- o Complete steam system design.
- o Complete design of char handling system

Modify the Erie Mining Study process flow drawings as required to reflect changes above.
Complete and issue a utility summary.

Complete and issue four line equipment lists.

Start preparing capital costs.

Prepare operating costs.

Entrained Flow Gasifier Work

- o Complete an evaluation of the candidate entrained-flow gasifiers.
- o Select in conjunction with the DOE Project Manager one of the candidates above to be the second alternate gasifier design for Erie Mining.
- o Start the design of an entrained-flow gasifier plant.

V. PROJECT ORGANIZATION

VI. MILESTONE SCHEDULE AND STATUS REPORT

FORM DOE 538
(11/78)

U.S. DEPARTMENT OF ENERGY

MILESTONE SCHEDULE AND STATUS REPORT

PAGE: OF

FORM NO. 1-110
OCT 1981

1. Contract Identification		Development Program to Support Industrial Coal Gasification												2. Reporting Period 11/28/81 through 12/25/81		3. Contract Number DE-AC01-81FE05147										
4. Contractor Name, address		Davy McKee Corporation 6200 Oak Tree Boulevard Cleveland, Ohio 44131												5. Contract Start Date October 1, 1981		6. Contract Completion Date November 1, 1983										
7. Identification Number	8. Reporting Category (e.g., contract line item or work breakdown structure element)	9. Fiscal Years and Months																				10. Percent Complete				
		FY 1981												FY 1982												
SUBTASK		OCT.	NOV.	DEC.	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT.	NOV.	DEC.	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	a) Planned	b) Actual
1A	Review Technical Literature																								68	68
1B	Preliminary Standards																								55	55
1C	Screening Tests																								3	3
1D	Optimization Tests																								0	0
1E	Large Tonnages Preparation																								0	0
1F	Preliminary Engineering																								0	0
1G	Economic Evaluation																								0	0
2A	Develop Plant Designs																								22	22
2B	Plant Costs & Economics																								0	0
3A	Project Administration Clerical, etc.																								18	18

11. Remarks

Revised January 13, 1982

12. Signature of Contractor's Project Manager and Date

Harry J. Gaborish 1/13/82

13. Signature of Government Technical Representative and Date

Sidney G. Nelson