MEMPHIS INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROJECT

COLD FLOW MODEL DESIGN AND PLAN
(Deliverable #43)

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COLD-FLOW MODEL TEST PLAN

TASK IX TECHNICAL SUPPORT

**INDUSTRIAL LOW-Btu FUEL GAS
DEMONSTRATION-PLANT PROGRAM**

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Objective

A cold-flow model is being built to gather information for appropriately designing the venturi and the bottom section of the gasifier to attain the required ash discharge rate in the demonstration plant. Ancillary tasks will investigate the effect of different feed locations and different means of injecting fines.

Background

A model is necessary because the operating conditions of the pilot plant gasifier do not permit the type of testing required to meet the above objectives. The pilot plant gasifier has been operated with 2 and 3 in.-diameter venturis. Discharge rates through the venturi appropriate to the feed rates used have been on the order of 100 lb/hr. The demonstration plant design calls for a total ash agglomerate discharge from each gasifier of approximately 10,000 lb/hr. Scaling up venturi sizes and discharge rates from the pilot plant to the demonstration plant level is a primary motivation for building a cold-flow model.

Larger sized venturis will be necessary to handle the larger discharge rates, and the model will be capable of incorporating up to an 8-in.-diameter venturi or other multiple-discharge nozzles. All equipment in the cold model will be capable of operation at 200 psig, which will enable testing to be conducted at the operating pressure of the demonstration plant, i.e., 90 psia.

The location of the solids feed nozzle is also of interest to the U-Gas[®] Process scheme. The spatial distribution of the feed within the bed and the residence time of feed solids are important because they provide adequate residence time of fine sizes in the bed and adequate contact of coal volatiles to promote tar cracking within the bed. Similarly, the location of fines re-injection may be optimized by providing maximum residence time within the bed for a given feed rate, while providing minimal disturbance to the grid or venturi regions. This can be done by varying both the location of fines injection nozzles relative to the grid and the feed rate per nozzle, both of which would probably have an effect on the aforementioned objective.

Cold-Flow Model Equipment

The cold-flow model will be built in a facility now under construction for conducting work on equipment-modeling features of the HYGAS[®] Process.

This building, called the Fluidization Test Building (FTB), is being fabricated by Cannon Steel Erection Company. By incorporating the Industrial Fuel Gas (IFG) cold model into the building, only minor changes to the steel structure have been required prior to erection. These changes have been certified by Frank Gisende, a registered structural engineer in the state of Illinois. A layout of the equipment in the FTB is shown in the two right-hand sections (A-A and B-B) of Figure 1. The equipment being incorporated specifically for the purposes of Project 9600 work is shown in bolder outline. This equipment includes the test vessel (built in two sections — upper and lower), a receiver vessel for solids discharged from the system, agglomerate feed hoppers, venturi piping specialty, and piping and instrumentation. The cyclone, cyclone receiver vessel, filters, and compressor will be shared between both projects. Vessel drawings have been prepared for all necessary vessels and are shown in Figures 2-6. Specifications have been drawn up for most of the required valves and similar instrumentation, and they have been ordered. A common solids feed handling and conveying system for both projects is currently being designed.

A flow and control diagram is shown in Figure 1, and a layout of control instruments on the panel board is suggested. Isolation valves between the separate systems are provided. Compressor controls and the panel board will be shared and are not shown. Pressures on the system will be controlled by using a back-pressure-control valve PCV (9-1). A variable pressure drop across the control valves FV (10-1) and FV (10-2) will result, but flow through these valves will be controlled by the use of control loops involving pneumatic controllers and orifice plates. The compressor discharge pressure will be kept under control by the use of a bypass control valve PCV (1-3). Compressor discharge temperature is controlled by the use of an after-cooler using cold water cooling. Adequate overpressure and overtemperature safeguards on the compressor have been incorporated as part of the compressor package. Nitrogen gas will be used in the system and will be filtered and recycled. The use of nitrogen gas will enable coal or carbon-containing materials to be used in the tests safely, with no hazard of dust explosion. The nitrogen gas will return to the inlet of the system at a pressure determined by the drop in the pressure caused by the back-pressure-control valve, cyclone, filters, and piping. Pressure gauges across the filters are used to determine the point at which

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TANK ORIENTATION:

NORTH

PLAN ELEVATION SIGHT AND TEST PORT DETAIL

NO SCALE

NOZZLE AND SUPPORT LIST

NK	SIZE	Nº	DESCRIPTION	USE
A	10"	1	150° FLG.	GAS OUTLET
B	1"	1	3000° 1/2 COUPLING	PRESS. TAKE-OFF
C	1/2"	1	"	PRESS TAKE-OFF (ALT.)
D	24"	1	150° FLG. / DAVIT	MANHOLE
E	-	3	SEE DETAIL	SIGHT & TEST PORT
F	1/2"	2	6" LG. NIPPLE / CAP	GRID ROD-OUT OPNG.
G	-	4	DESIGNED BY VENDOR	TANK SUPPORTS
H	48"	1	CLASS 175, S.O. FLG. 9/16" FOR PRESS. VES.	CONNECTING FLANGE
J	2"	1	150° FLG.	AGGLOMERATE FEED CONN.
K	2"	1	150° FLG. / BLIND	FILL CONN.
L	3"	1	150° FLG.	CONTROL LEAD CONN.
M	6"	1	150° FLG.	RUPTURE DISC / B&K CO.

DESIGN CONDITIONS

ASME CODE SEC. VIII DIV. 1: UNFIRE PRESS. VESSEL CODE

CODE STAMPED WITH FULL RADIOGRAPH

DESIGN PRESSURE = 200 PSIG

TEST PRESSURE = 300 PSIG

MAX. ALLOW. TEMP. = 200°F

2:1 RATIO ELLIPTICAL HEAD.

ALL WELDED CONSTRUCTION PER CODE.

MATERIALS OF CONSTRUCTION

ALL MATERIAL SHALL BE LOW TEMP. C.S.

SHELL & SA-283 - GRC

40'-0" HEAD : SA-283 - GRC

LEVEL FLANGES: SA-181 - GRJ

NOZZLES: SA-53 - GRB

Figure 2. UPPER SECTION OF IFG TEST VESSEL

NOZZLE LIST

NO.	SIZE	NO.	DESCRIPTION	USE
H	48"Ø	1	CLASS 175, S.O. FLG. W/RF FOR PRESS. VESSEL	CONNECTING FLG.
R	12"Ø	1	150# FLG. W/BLIND	HAND HOLE
N	8"Ø	1	150# FLG.	GRID GAS IN
P	10"Ø	1	150# FLG.	VENTURI GAS IN

 NORTH
 TANK ORIENTATION

DESIGN CONDITIONS

ASME CODE SECTION VIII DIV. 1 OF THE
 UNFIRED PRESSURE VESSEL CODE
 CODE STAMPED W/FULL RADIOGRAPH
 DESIGN PRESSURE = 200 PSIG
 TEST PRESSURE = 300 PSIG
 MAX. ALLOW. TEMP. = 200°F
 2:1 RATIO ELLIPTICAL HEAD.
 ALL WELDED CONSTRUCTION PER CODE.

MATERIALS OF CONSTRUCTION

ALL MATERIALS SHALL BE LOW TEMP. CS.

SHELL : SA-283 - GRC
 HEAD : SA-283 - GRC
 FLANGES : SA-181 - GRJ
 NOZZLES : SA-53 - GRB

Figure 3. LOWER SECTION OF IFG TEST VESSEL

NOZZLE SCHEDULE

NO	SIZE	NO	DESCRIPTION	USE
A	18"	1	OPEN	HOPPER
B	2"	1	150# SO. FLG.	DISCHARGE

MATERIAL SCHEDULE

- ① 3/8" PLATE
- ② 1/4" PLATE
- ③ 3"x3"x3/8" ANGLE (3 REQ'D)
- ④ 8"x8"x1/2" PLATE (3 REQ'D)

LOCK HOPPER

DESIGN CONDITIONS

UPPER HOPPER

DESIGN PRESS. ATMOS. PRESS
 MAX. TEMP. 200°F
 ALL WELDED CONSTRUCTION.
 CONT. WELD ALL SEAMS

LOCK HOPPER

ASME CODE SEC. VIII DIV. 1 UNFIRED
 PRESSURE VESSEL CODE.
 CODE STAMPED WITH FULL RADIOGRAPH
 DESIGN PRESSURE = 200 PSIG
 TEST PRESSURE = 300 PSIG
 MAX. ALLOW. TEMPERATURE = 200°F
 ALL WELDED CONSTRUCTION PER CODE

MATERIALS OF CONSTRUCTION

ALL MATERIAL SHALL BE LOW TEMP. C.S.
 SHELL : SA-283 - GR C
 FLANGES: SA-181 - GR J
 NOZZLES: SA-53 - GR B

Figure 4. AGGLOMERATE FEED HOPPERS

ELEVATION

NO SCALE

BILL OF MATERIAL

MK A	10" 150° RF WN FLANGE
MK B	8" " " " "
MK C	6" 150° RF SO "
MK D	10"X6" "ST" CONC. RED.
MK E	10"X8" "ST" RED. TEE

Figure 5. VENTURI SECTION OF IFG TEST VESSEL

MATERIALS OF CONSTRUCTION

ALL MATERIALS SHALL BE
CARBON STEEL

NOTES

- 1) ALL WELDED CONSTRUCTION
- 2) ALL WELDS TO BE CONTINUOUS
- 3) FABRICATED OUT OF 3/16" PLATE
- 4) UPPER CONE TO BE DRILLED
AS DIRECTED BY ENGINEER

Figure 6. GRID DETAIL OF IFG TEST VESSEL

new filter elements are to be installed; an adequate supply of these will be available on the plant site.

The test vessel, which is 4 feet in diameter, will be accommodated with a variety of nozzles and instrument taps, the exact functions of which can be modified with little difficulty. Initially, instrumentation for determining the bed level, bed density, and pressure will suffice and is shown in Figure 1. Those parts of the grid and venturi that are to be provided initially are under design, although an arrangement possibly suitable to the lower test vessel has already been completed (Figure 7). A removable insert, which will enable venturi sizes as large as 8 inches to be employed, will be used. Sketches of these items are shown in Figure 8.

Test Plan

Tests on the system will be performed as follows: Gas rates adequate to prevent material from discharging from the venturi, and at the grid to provide adequate fluidization, will be set. The latter will be conducted at a low pressure setting. Solids will then be conveyed pneumatically into the system to the desired level. Solids are pre-weighed prior to being introduced into the conveying system. If agglomerate-like materials are to be used, they are also pre-weighed but are introduced separately through a lockhopper arrangement; this can be done at pressure. In the series of tests to determine discharge capabilities of the venturi, various combinations of bed agglomerate concentrations, bed heights, venturi velocity, superficial gas velocity, etc., will be set and discharge rates of materials measured. A discharge hopper that can store a sufficient quantity of material for the experiments is provided. The material collected in the hopper in a set period of time is discharged to a tared container or drum and weighed. This is repeated for other conditions. Typical ranges of the variables will be as follows:

Bed Height	2-6 ft
Superficial Velocity	1-4 ft/s
Venturi Velocity	5-75 ft/s
Venturi Diameter	2-8 in.
Agglomerate Particle Size	1/8 and 1/4 in.

For tests on distribution of fines or feed material, a step change or impulse change in the type of feed or fines can be made, and measurements of the concentration of this material at various locations in the bed or exit can

Figure 7. GRID DESIGN STUDY

Figure 8. DESIGN DETAIL OF TEST INSERT

made. This is the classical approach to determining the residence-time distribution. The exact nature of the material to be used for this type of test is yet to be determined, and its properties must be such that it can easily be distinguished from other materials and measured. Sodium tripolyphosphate has been used in such tests by IGT and other investigators.

The results of several such tests for different means of introducing feed or fines can be compared. We will make estimates of the conversion of fines as a function of residence time and the evolution of volatiles as a function of time-temperature history and will, therefore, be in a position to evaluate the results of this study and make appropriate recommendations. A schedule for the above work is shown in Figure 9.

jb/ac

LEGEND:

COMPLETE

TO BE COMPLETED

Figure 9. SCHEDULE FOR COLD FLOW MODEL

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