Performance Testing of a Moving-Bed Gasifier Using Coal, Biomass, and Waste Plastic Blends to Generate White Hydrogen

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Project Objectives

- Qualify coal, biomass, and plastic waste blends based on performance testing of selected pellet recipes in a laboratory-scale updraft moving-bed gasifier
- Testing will provide relevant data to advance the commercial-scale design of the moving-bed gasifier to use these feedstocks to produce hydrogen
- Effects of the waste plastics on feedstock preparation (i.e., blending and pelletizing) and the resulting products (i.e., syngas compositions, organic condensate production, and ash characteristics) will be a focus

Funding: $625k ($500k gov't, $125k cost share)

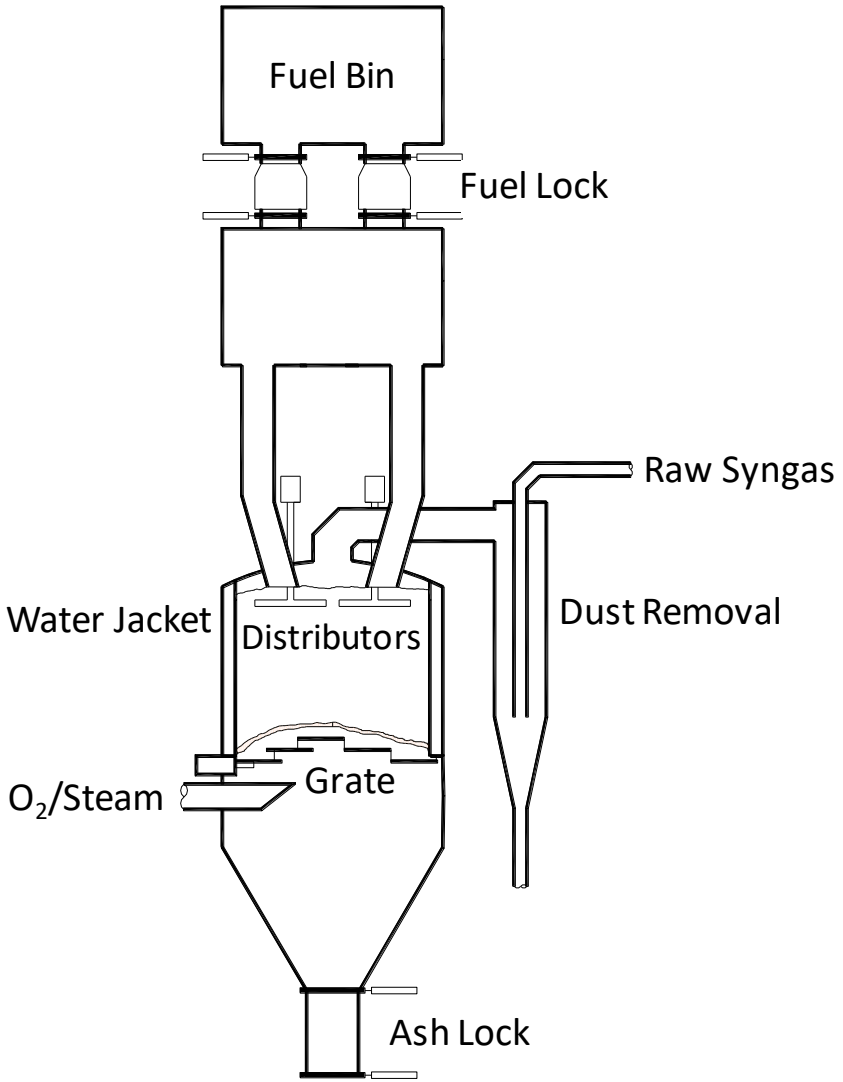
Project Team Organizations

EPRI	• Prime, lead organization, overall project management, and administration (Task 1) • Leading Test Plan Development (Task 3) • Key personnel – George Booras, Jose Marasigan, and Horst Hack
Hamilton Maurer International, Inc. (HMI)	• Gasification technology developer (sub-recipient) • Leading Feedstock Procurement and Preparation (Task 2) and Data Analysis and Reporting (Task 5) • Key personnel – Rolf Mauer and David Thimsen
Sotacarbo S.p.A	• R&D organization in Carbonia, Italy (sub-recipient) • Leading Gasifier Testing (Task 4) • Key personnel – Dr. Alberto Pettinau and Simone Meloni

The DOE Project Manager is Debalina Dasgupta

HMI Moving Bed Gasifier

- The moving-bed gasifier has been demonstrated with many coal ranks as well as biomass. Testing suggests that it should be well suited for blends of coal, biomass, and plastic waste.
- As the fuel descends, it is dried, devolatilized, and the resulting char is gasified. Ash is removed through a grate and collected in a lock hopper.
- CO_2 produced by combustion and the steam from the blast react with the char in the gasification zone to produce CO and H_2
- Streams leaving are ash out the bottom and dry gas/tar/water vapor/dust out the top



California Pellet Mill (CPM)

- In 1931, the company created its first pellet mill, the 30-hp flat bed with stationary flat die
- Will do the blended feedstock preparation in the form of pellets
- Has considerable experience creating fuel pellets including ones using biomass and waste and has worked with HMI and Sotacarbo on prior projects
  - Presented results of pilot gasifier test runs with coal/car fluff pellets at the 2007 Clean Coal Technology Conference in Sardinia

Sotacarbo R&D Facility

SOTACARBO SUSTAINABLE ENERGY RESEARCH CENTRE

- Sotacarbo and HMI have collaborated for 17 years on the installation, commissioning, operation, and automation for enhanced operation and control of updraft moving-bed gasifiers for industrial multi-fuel gasification processes
- HMI designed the lab-scale 12” inner diameter updraft moving-bed gasifier at the Sotacarbo facility that will be used for this testing program
- The current project team members from HMI and Sotacarbo have performed significant testing at this facility

Sotacarbo Pilot Moving-Bed Gasifier

Major Project Tasks

- **Task 2 – Feedstock Procurement and Preparation:** Finalize feedstock selection and pellet formulations. Prepare and ship pellets.
- **Task 3 – Test Plan Development:** Specify test data to be reported, review facility instrumentation, and specify sampling procedures
- **Task 4 – Gasifier Testing:** Perform baseline coal gasification test, and tests for 9 different pellet formulations
- **Task 5 – Data Analysis and Reporting:** Correlate gasifier performance with pellet composition, assess overall prospects for gasification of mixed blends, and prepare the final report

Overall project schedule is two years (7/1/21 to 6/30/23)

Task 2 – Feedstock Procurement and Preparation

- Biomass is corn stover
- Coal is PRB subbituminous
- Plastic waste is auto-shredder residue (ASR), a.k.a. “Car Fluff”

HHV, Btu/lb*	Biomass	PRB	Plastics
Dry	8,681	11,516	13,240
As-Rec	4,922	8,564	N/A

* Assumed Heating Values (to be confirmed)

Feed fractions based on dry mass input

No.	Biomass	Coal	Plastic
1	0	100	0
2	31	69	0
3	31	53	15
4	32	36	32
5	47	53	0
6	48	41	12
7	49	27	24
8	67	33	0
9	67	25	7
10	68	17	15

Feed fractions based on heat input

No.	Biomass	Coal	Plastic
1	0	100	0
2	25	75	0
3	25	56	19
4	25	38	38
5	40	60	0
6	40	45	15
7	40	30	30
8	60	40	0
9	60	30	10
10	60	20	20

Approximately 150 kg of tri-fuel pellets are required for each test run

Feedstock Supply

- Corn stover supplier was identified in Nebraska
  - Stover was chopped to minus 1” before delivery to CPM
- Peabody provided Powder River Basin (PRB) coal from their North Antelope Rochelle mine near Gillette, WY
  - Three supersacks of PRB coal were delivered to CPM
- OmniSource provided 2 tons of ASR (car fluff) from Indianapolis and 2 tons from Toledo
  - As-received ASR had much larger pieces than anticipated, and was shredded to -1/2” before delivery to CPM
  - After shredding the ASR it still contained small fragments of metals and wire
  - Additional pre-treatment of the ASR was required

Additional Pre-Treatment of the ASR

- Ball milling of ASR at a facility in Rhode Island was used to reduce size of the ASR and metal particles to prevent damage to CPM's pelletizing die
  - The ball mill had 40-gauge mesh screens (0.4 mm opening)
- Metals were either reduced in size to below 0.4 mm, or they stayed in the ball mill chamber and were separated from the ASR "powder"

Ball-milled ASR -40 mesh (left), +40 mesh (right)

Tri-Fuel Pelletizing Tests Were Successful

- Pelletizing tests at CPM were conducted between July 18-25, 2022
- Pelletizing 100% PRB was not successful (will use lump coal for baseline)

Recipe 3 (left) and Recipe 7 (right)

Close-up of pellets

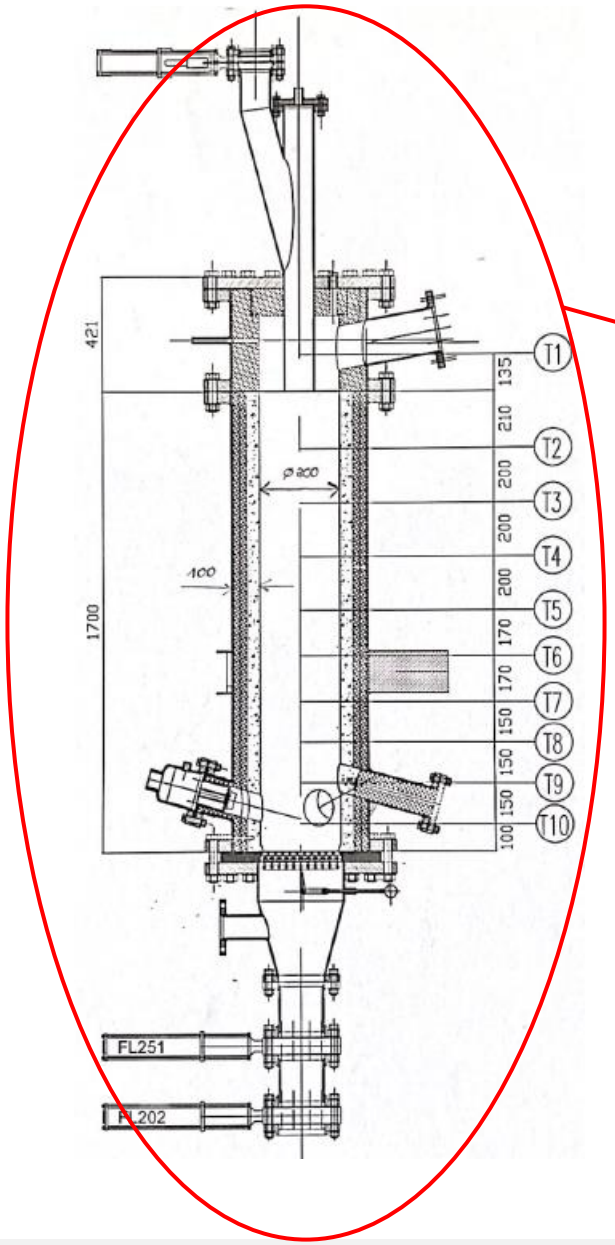
Pelletizing head open. See the pencils sticking out of the die.

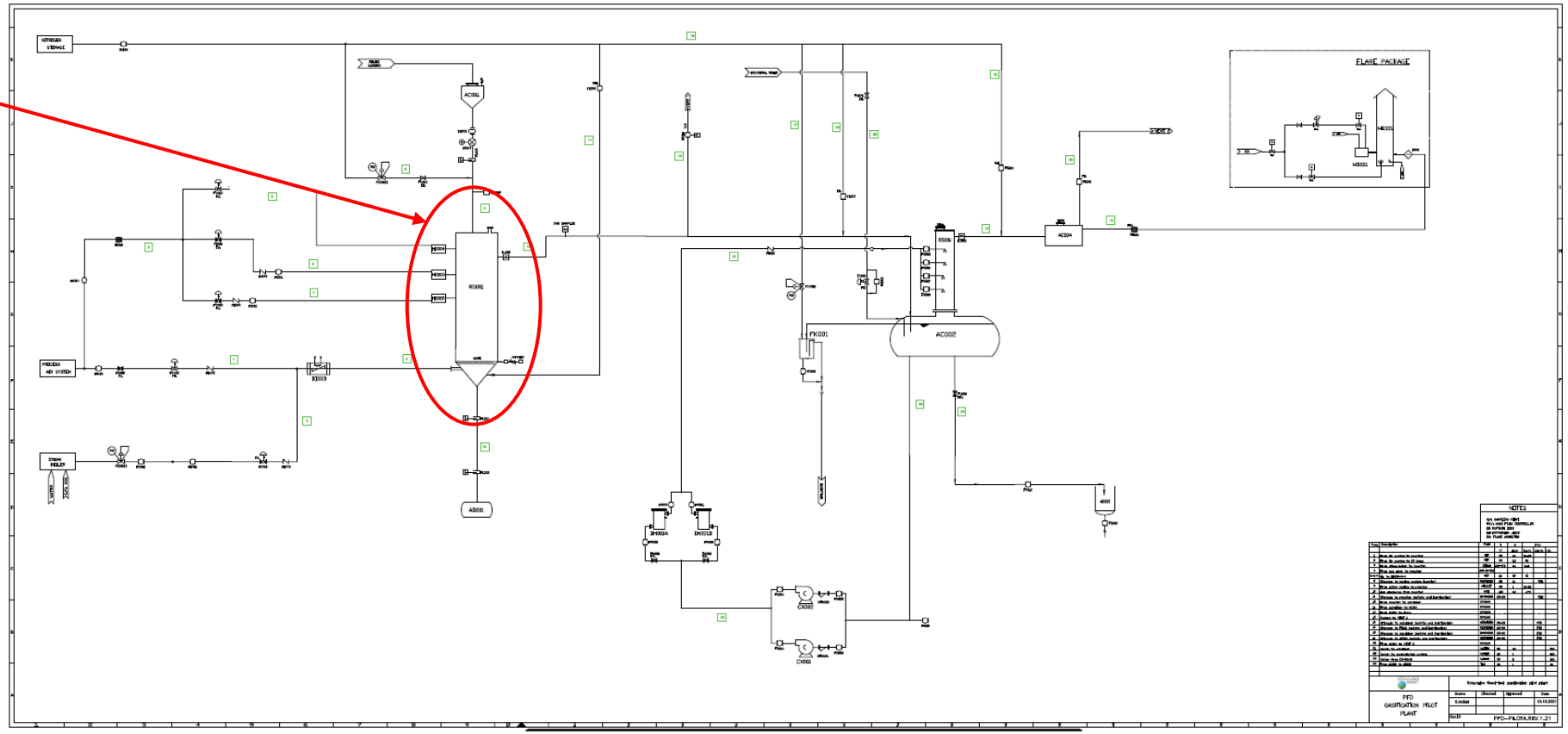
Weighing pellet sample for PDI (Pellet Durability Index) test.

Task 3 – Test Plan Development

- Sotacarbo's lab-scale gasifier process flow diagram (PFDs) and piping and instrumentation diagrams have been reviewed
- HMI has reviewed what instrumentation is, or will be, in place, and what other instrumentation may need to be procured
- Sampling and testing procedures are being finalized
- Gasifier startup procedure has been reviewed
- Each gasification test run will last one day, and the gasifier and other equipment will be cleaned up between runs

PFD for Sotacarbo 12” Inner Diameter (ID) Gasifier





Task 4 – Gasifier Testing

- Sotacarbo is completing modifications to their 12” ID lab-scale moving bed gasifier
  - The gasifier is being refurbished, including new refractory wall
  - Piping will be reinstalled after the refractory is replaced
  - Other maintenance activities are being performed
- The gasification system should be available for initial shake-down tests in early fall 2022
  - Lump PRB coal (~1 inch) will be used for the shake-down tests

Reactor removal and refractory layer before the reconstruction

New Gasifier Refractory Has Been Installed

Task 5 – Data Analysis and Reporting

- Individual test run reports will include:
  1. Introduction, project background
  2. Test Objectives
  3. Description of the Fuel Tested – From CPM production report.
  4. Description of the Test Facility
  5. Test procedures
  6. Conduct of the Test – Prose description of the conduct of the test and how conduct might have differed from procedures. Qualitative discussion of the gasification behavior of the test pellets.
  7. Test Results – Test data with descriptions that aid in interpretation.
- Sections 1-5 will be short (~1 page) and similar from test to test, with edits to indicate changes specific to the test being reported.
- The unique test results are in Sections 6 and 7.
- These individual test reports will be appendices in the overall project final report.

Next Steps

- Prepare report on the tri-fuel pelletizing tests
  - Ultimate/proximate analyses and heating values for all tri-fuel pellet samples
  - Ship the tri-fuel pellets to Sotacarbo in sealed barrels
- Finalize the gasification test plan and reporting format
  - Including an outline of the individual gasification test reports
- Complete installation of the lab-scale gasifier
  - Begin shake-down testing of the gasifier and instrumentation systems

Gasification test runs are scheduled for 4Q 2022/1Q 2023

Acknowledgment and Disclaimer

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