Pyrolysis Process Development at Advanced Fuel Research, Inc. (AFR)

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AFR has been involved for several years in R&D on the pyrolysis-based conversion of biomass into fuels, chemicals and materials [1]. More recently, this work has also involved process development, such as a prototype waste pyrolyzer for spacecraft use [2- 7] and the pyrolysis processing of animal manure for remote power generation [8,9].

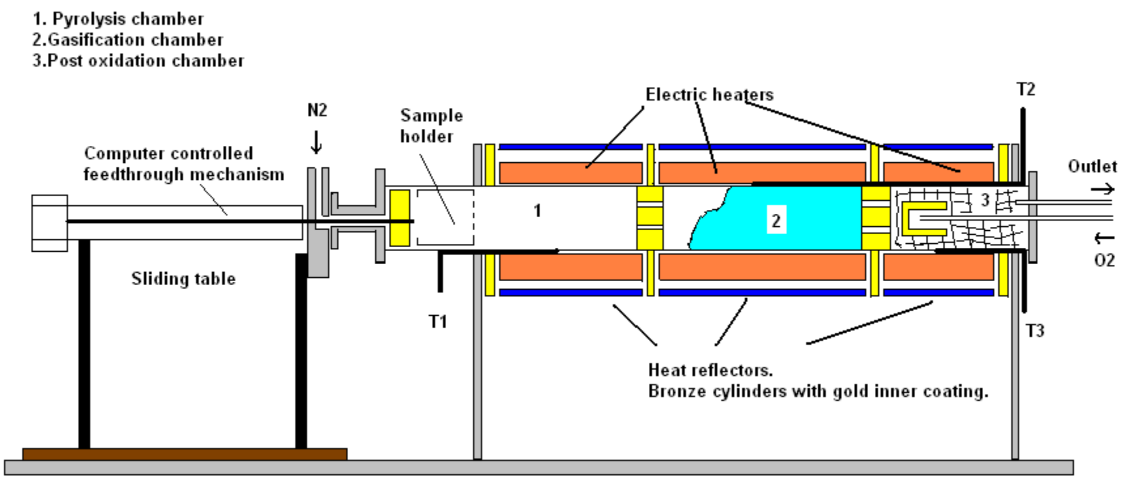

Figure 1. Schematic of AFR Three-Stage Pyrolysis/Oxidation Reactor System.

A schematic of the current NASA prototype reactor system is shown in Figure 1. That prototype was designed for studying the pyrolysis of mixed solid waste streams, including paper, soap, plastic, and inedible plant biomass, which are relevant to spacecraft activites. During the initial processing step, the first stage is the primary pyrolysis zone, for thermal decomposition of the sample into gases, liquids and a char residue, while the second stage contains a catalyst bed for decomposition of the liquids, and the (optional) third stage contains a catalyst bed for oxidation of the volatiles. Each of these stages are heated independently (~673-973 K for the first stage, 1323 K for the second stage, 973 K for the third stage). During the second-processing step, the purge gas is switched to CO_2 (or H_2O) and gasification of the char can occur in the first stage (if desirable) while gasification of the carbon deposits

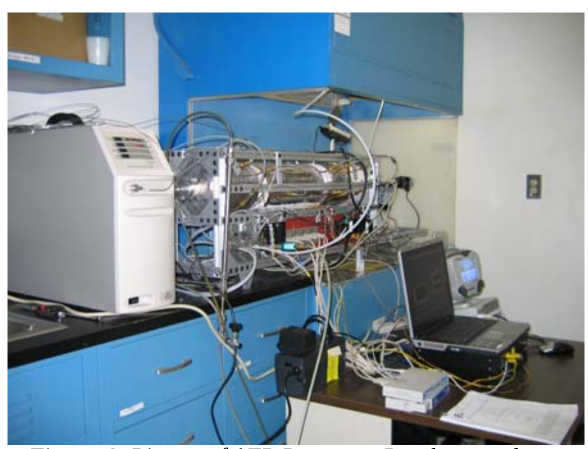

Figure 2. Picture of AFR Prototype Pyrolyzer and Control Computer.

from the cracked oils will occur in the second stage. Alternatively, the conditions in the first stage can be adjusted to provide activation of the char or no reaction at all, in which case the char can be removed and used for some other purpose. A picture of the current AFR prototype reactor installed at the NASA Ames Research Center is shown in Figure 2. It is anticipated that a suitably modified system could be used in terrestrial applications to produce fuel gases from wastes for distributed power generation

A set of experiments was done under similar conditions in an earlier version of the NASA prototype reactor [2] with wheat straw and poultry litter (see Table 1) samples and these results are shown in Table 2. The yields for char were about 10 wt % higher for poultry litter than for wheat straw, which is consistent with the higher amount of ash in the starting material (see Table 1). The yields of H_2 are somewhat lower from poultry litter than from the wheat straw sample, which is probably due to the fact that much of the hydrogen in the starting sample ends up as NH_3 in the product gas. The yields of CH_4, CO, and CO_2 were generally similar in either case.

Table 1 – Composition of various waste samples used in prototype pyrolyzer (wt. %, dry, ash-free basis)

Sample	Ash[a]	C	H	O	N	S
Local Wheat Straw	6.0	49.0	6.1	42.9	1.8	0.20
Poultry Litter[a]	22.1	47.4	6.5	39.5	5.6	1.0
Notes:	a=dry basis					

Table 2 – Typical Results from Pyrolysis of Wheat Straw or Poultry Litter (wt. %, as-received basis)

Product	Sample Type	
	Wheat Straw	Poultry Litter
Char	30.8	40.8
H_2O	7.8	14.3
Carbon	3.3	4.9
Trap & Filter	7.6	3.4
Total Gases	50.2	38.2
H_2	2.0	0.8
C_2H_4	0.2	0.3
CH_4	2.9	3.3
CO_2	24.9	20.3
CO	16.4	13.5

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