Plastofuel™: Automating & Commercializing this EfW process

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“Discarded plastic is not trash - It’s a previously used resource!”
To be covered today:

- The product: Plastics
- The waste: Plastics
- The energy source: Plastics
- Making plastic-derived fuel efficiently: Plastofuel™
- Burning plastic-derived fuel cleanly: Eco-Clean Burners
The product: Plastics
Our first target has been plasticulture
Plasticulture is the use of plastics in agriculture.
Plastic culture is a multi-billion dollar industry!
Plasticulture is worldwide!
How extensive is the problem?

Total plastic (all kinds) produced in USA:
100 billion lbs.*

Total agricultural plastic used in USA:
1 billion lbs. **

* Krebs, ACC 2007
** Amidon Recycling, 2006
Also, we’ve targeted many wasted household products:

#2 HDPE (buckets, tubs, toys)
#4 LDPE (plastic sheeting, tubing)
#5 PP (bottle lids & labels, tubs, cases)
#6 PS (dinnerware, plates, clamshells, cups)
The waste: Plastics
Mismanaged resources
Open burning
Burying
Littering
Management options
Sending to landfill
Reduce
Reuse
Recycle
Thermal recovery

- No air pyrolysis
- Partial air gasification
- Excess air combustion
The energy source: Plastics
At Penn State, our belief is to recycle whenever possible.

If recycling is not an option...
Heating value, MJ/kg (Btu/lb)

<table>
<thead>
<tr>
<th>Material</th>
<th>Heating value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil</td>
<td>48.6 (20,900)</td>
</tr>
<tr>
<td>Polyethylene (pots, tubs, sheeting)</td>
<td>46.3 (19,900)</td>
</tr>
<tr>
<td>Polypropylene (rope, lids, tubs)</td>
<td>46.2 (19,850)</td>
</tr>
<tr>
<td>Cross-linked PE (PEX tubing)</td>
<td>46.0 (19,780)</td>
</tr>
<tr>
<td>Gasoline</td>
<td>44.6 (19,200)</td>
</tr>
<tr>
<td>Polystyrene (inserts, Styrofoam)</td>
<td>41.4 (17,800)</td>
</tr>
<tr>
<td>PA Kittanning coal</td>
<td>32.3 (13,900)</td>
</tr>
<tr>
<td>Wyoming coal</td>
<td>22.3 (9,600)</td>
</tr>
<tr>
<td>Wood</td>
<td>19.3 (8,300)</td>
</tr>
<tr>
<td>Newspaper</td>
<td>18.6 (8,000)</td>
</tr>
<tr>
<td>Textiles</td>
<td>16.0 (6,900)</td>
</tr>
<tr>
<td>Municipal waste (dry)</td>
<td>16.2 (7,000)</td>
</tr>
<tr>
<td>Yard waste</td>
<td>7.0 (3,000)</td>
</tr>
<tr>
<td>Food waste</td>
<td>6.0 (2,600)</td>
</tr>
</tbody>
</table>

...why not capture the high heat content of plastic?
There are 2 technologies we are striving to marry
First Technology –
Making plastic-derived fuel efficiently: Plastofuel™
Plastofuel™ extrusion concept is simple...

- Forces rigid & film plastic through a heated die
- Electric band heaters melt only a thin jacket
- Locks dirt & plastic pieces inside
Benefits of the process

- Works with common thermoplastics
- Low energy input (1/10th that of pellets)
- Can stockpile seasonal ag supplies
- #3, #4 - #7 have little value
- Market for MRF rejects
Benefits of combustion

- Densified for easy storage, transport and metering
- Clean burning when co-fired with coal
- 2000°F temperatures eliminate black smoke
- Dirt and debris managed with ash
Combustion testing

- Conducted at PSU’s Energy Institute
- A stoker simulator was used
- Emissions results were favorable
Prototype machinery development ...
Mid-1990’s -- Ram extrusion, 1½ inch diameter
Mid-2000’s --
Linear grid extrusion,
$1\frac{1}{2} \times 1\frac{1}{2}$ inch square
Calculations for linear grid system...

- 1:100 energy balance
- 500 lbs/hr throughput
Linear grid design spec’s…
Costs: Not yet determined

Power: 40 hp. diesel engine / generator

Hydraulics: 20 gpm, variable displ., load-sensing piston pump
Die temperatures ranged 310-350° F
Throughput averaged 46 lb/hr.
1:33 energy balance, high of 1:47
Loose feedstock bulk density: 5.2 lbs./cu.ft.
Avg. melt thickness: 0.06 inches
Nugget bulk density: 23.6 lbs./cu.ft. (4.5:1 reduction)
Nugget density: 44 lbs./cu.ft. (83% of solid plastic)
Energy balance (includes shredding): 1:36
Today, back to ram extrusion, 3 inch diameter
Latest prototype is still under development...
...whimsically called “80 mm Plastocannon”
Commercialization?
Partnering with pulp and paper industry
(One plant: 50-80 tons waste / day, year round)
Plan is to have manufacturer design for commercialization
So there you have it – a process to **efficiently make** a high-energy fuel ... Plastofuel™

Now, let’s peek at the 2nd technology* to **cleanly burn** plastic pellets

*Note this technology cannot feed large Plastofuel™ but someday will
Second Technology –
Eco-Clean Burners, LLC
Eco-Clean Burners concept

- Sustains combustion at 1100 °C (2000 °F)
- Hot water boiler system
- Fueled on pellets or granules
Horticulture Research Farm emissions testing...

2005: Clean pellets tested with great results

2007: Dirty mulch film tested with great results up to 17% dirt!
In 2005 & 2007, tested for 3 primary emissions:

- Particulates
- Acid gases
- Furans / dioxin
Demonstration site at Iannetti’s Garden Center near Pittsburgh…

- Test in production greenhouses
- Assure system is failsafe
- Verify fuel supply system
Iannetti’s Garden Center
What’s next?

Our design and research ideas include…

– Commercializing the Plastofuel™ machine

– Modifying feed device for Korean burner to accept large pieces / Plastofuel™

– Pilot testing Plastofuel™ combustion in large greenhouse or power producer setting
In summary, we know...

...we can make plastic fuel energy efficiently
...we can burn plastic very cleanly
...trash is a resource.

So, what are we waiting for?
Thank you. Any questions?