FECAL SLUDGE TREATMENT BY VISCOUS HEATING

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Initial Thoughts

- Feces is viscous

- Viscous substances produce heat under layer deformation

- An existing technology – e.g. polymer melting for extrusion molding
How Viscous is Human Feces???

Shear rate decrease with viscosity for various feces and simulants.

![Graph showing shear rate decrease with viscosity for various samples.](image)
System Geometry

- The cone will rotate inside a shell.
- Layer deformation of Feces will occur in between the gap of shell and cone.
- High temperature as a result of viscous heating will kill all microorganisms.
Feasibility simulation in COMSOL Multiphysics

**Assumptions**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1000 kg/m³</td>
</tr>
<tr>
<td>Viscosity</td>
<td>5 Pa.s</td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>0.03 W/(m.K)</td>
</tr>
<tr>
<td>Heat capacity</td>
<td>4186 J/(kg.k)</td>
</tr>
</tbody>
</table>

Temperature gradient @ inlet velocity 0.002 m/s @ 500 rpm
Effect of Clearance

Temperature with clearance @ 0.1 m, angle = 21.8°
Effect of path length

Temperature with reactor length @ 21.8 and clearance = 0.001m
Effect of angle

Temperature with angle @ length = 1 m, clearance = 0.001 m
Fully Instrumented Reactor
Reactor Core
Reactor Core Installed
Effect of Hold-up Time on Temperature

Temperature with time. 100 psig, 1150 rpm and 0.75mm gap spacing gives a near linear plot.
Summary of Simulant Experimental Results

- Temperature rises as rpm increases
- Temperature increases as hold-up time increases
- Temperature increases as gap space decreases
- The highest observed temperature is 200°C
Parasite Destruction

- A satisfactory destruction approaching 99% was achieved for *Thrchoris trichuira* eggs.

- Max temperature achieved for smallest spacing (0.75 mm) and highest rpm setting 1700.

- Kill rate at lower temperature indicates destruction using shear stress alone.

- Speed may be lower because of the presence of a considerable amount of baboon hair in the samples.
**Trichuris trichiura** egg destruction in Baboon feces

<table>
<thead>
<tr>
<th>rpm</th>
<th>Spacing</th>
<th>Temperature</th>
<th>Egg Kill</th>
</tr>
</thead>
<tbody>
<tr>
<td>875</td>
<td>1.20</td>
<td>42°C</td>
<td>93%</td>
</tr>
<tr>
<td>1700</td>
<td>0.75</td>
<td>51°C</td>
<td>99%</td>
</tr>
<tr>
<td>1700</td>
<td>0.75</td>
<td>86°C</td>
<td>95%</td>
</tr>
</tbody>
</table>
Photomicrographs of *Trichuris trichiura* eggs from helium being processed through the extruder 400 x magnifications
Second Prototype

- Spacing = 0.7 mm
- rpm can be varied as necessity
- Portable
Concluding thoughts

- Shear stress and temperature controlled by rpm and spacing

- Recycle of “dryer” feces would increase viscous; as could solid wastes (paper, grass, saw dust)

- Possible to combine with other technologies as a sanitation step.

- A small motor connected to a battery using solar power is sufficient for small-scale use