ENPRO 352
Tire Recycling for a Better Future

Leading Tire Recycling Methods

Ambient grinding systems use consecutive grinding steps to achieve smaller particle sizes. They are limited to the production of large particles in the size of 10 - 40 mesh.

Cryogenic systems cool the rubber to a glassy state and hammer the material to produce small particles. High costs are associated with the use of liquid nitrogen to cool down the rubber.

Current Recycling Technologies

Tires are collected and fed into shredders.

Steel, non-reclaimed rubber particles, fibers, etc. are removed before feeding rubber into granulators.

Where does SSSE fit into the current recycling process?

With this technology, ground rubber particles can be produced at much lower operating costs than the competing cryogenic process and can produce fine particle sizes not achievable with current non-cryogenic technology. SSSE is best licensed as an add on to ambient systems. In the absence of the ability to purchase upstream equipment, the customers for SSSE are companies who desire to produce mesh 70 or greater rubber particles.

Risk and Mitigation

Feedstock sensitivity - use “clean” 1/4” feed with no steel parts or fibers
Scale up - limited scale up of extruder due to max exerted forces, use multiple extruders
Demand - use in conjunction with PPIPN, optimal particle size for use with PPIPN technology will reinforce a need for SSSE technology.
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Which would you rather see?

Our Solution
Novel Technology:
Solid State Shear Extrusion
IIT Patented

How does it Work?
The Solid State Shear Extrusion (SSSE) process uses a modified screw extruder to grind rubber chunks into very fine particles.

- 1/4" crumb rubber is fed into the extruder
- screw provides compression through three temperature zones
- counter-rotating plates provide additional shear
- rubber catastrophically shears into fine particles

The Problem:
- Each year, more than 280 million scrap tires are generated in the US.
- It is estimated that 2-3 billion tires are stockpiled illegally.
- Scrap tires are very difficult to recycle. They cannot be recycled through melting and conventional processing.
- Large, uncontrolled fires, breeding of vermin, and hazardous human diseases such as malaria, West Nile virus, and Dengue fever occur in tire landfills

Preference Ranking for Sustainability

<table>
<thead>
<tr>
<th>Rank</th>
<th>Recirculation Method</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Recycled rubber from##secondary sources or scrap tires</td>
<td>Most sustainable and low energy for production, reduces landfill, improves soil health, and reduces water pollution</td>
</tr>
<tr>
<td>2</td>
<td>Natural rubber from##primary sources</td>
<td>Better for energy, reduces reliance on fossil fuels</td>
</tr>
<tr>
<td>3</td>
<td>Natural rubber from##secondarily processed tires</td>
<td>Better for energy, reduces reliance on fossil fuels</td>
</tr>
<tr>
<td>4</td>
<td>Natural rubber from##thirdarily processed tires</td>
<td>Better for energy, reduces reliance on fossil fuels</td>
</tr>
<tr>
<td>5</td>
<td>Natural rubber from##fourtharily processed tires</td>
<td>Better for energy, reduces reliance on fossil fuels</td>
</tr>
<tr>
<td>6</td>
<td>Natural rubber from##fiftharily processed tires</td>
<td>Better for energy, reduces reliance on fossil fuels</td>
</tr>
<tr>
<td>7</td>
<td>Natural rubber from##sixtharily processed tires</td>
<td>Better for energy, reduces reliance on fossil fuels</td>
</tr>
</tbody>
</table>

The Purpose:
The team will show the business potential of using SSSE technology to convert waste rubber into higher value added products. The team will also develop real market applications using PPIP technology which may offer improvements in existing rubber based products or dramatically reduce the cost of an already existing product without compromising quality.

Natural rubber, unlike latex or other acrylcs, does not mix well with water. Particulate phase interpenetrating polymer network (PPIP) technology chemically modifies rubber particles to disperse in water.
- rubber particles are swelled using acrylic acid and an additional solvent
- the acrylic acid strings together, allowing rubber particles to mix with water
- the smaller the particles, the better this works

How does it Work?