Business Plan

- Introduction
- Methodology
- Market Characterization
- Market Size and Growth
- Financial Analysis
- Next Steps
A Business Plan for the Production of Crumb Rubber by Solid State Shear Extrusion
Problem

✓ Recycling of vulcanized rubber is a challenging technical problem due to its cross-linked structure.
✓ Conventional methods of devulcanization of scrap rubber result in degradation of polymer.
  – Thermal Devulcanization
  – Chemical Devulcanization
✓ Solid-State Shear Extrusion (SSSE) is an ambient size reduction technique that breaks cross-link bonds.
Develop Business Plan

✔ SSSE Technology
  - Study SSSE process
  - Evaluated pricing estimates of scaled-up version of SSSE (presently in laboratory stage)

✔ Crumb Rubber Market
  - 2002 Scrap Tire and Rubber User’s Directory
  - Interview crumb rubber end-users
  - Interview crumb rubber producers

✔ Recommended Applications
  - Rubber Modified Asphalt
  - Molded Products
  - Athletic Surfaces
  - Miscellaneous
Extruder Schematic

Feeder

Feeding (Zone 1)  Heating (Zone 2)  Cooling and Pulverization (Zone 3)
SSSE Particle Characteristics

✓ Pulverized Crumb Rubber With No Chemical Additives
✓ No Moisture
✓ Approx 33% Reduction in Crosslink Density
✓ High Surface Area
### SSSE Particle Characteristics

#### 5:1 Screw 1SSSE

<table>
<thead>
<tr>
<th>Mesh Size</th>
<th>Surface area</th>
<th>Crosslink Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-40</td>
<td>1600m²/g</td>
<td>21%</td>
</tr>
<tr>
<td>170-60</td>
<td>2800m²/g</td>
<td>34%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Mesh Size</th>
<th>Distribution (%)</th>
<th>Proposed Price (cents/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>6.7</td>
<td>49</td>
</tr>
<tr>
<td>70</td>
<td>12.7</td>
<td>22.5</td>
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<tr>
<td>40</td>
<td>13.4</td>
<td>14.4</td>
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<tr>
<td>30</td>
<td>23.9</td>
<td>13.5</td>
</tr>
<tr>
<td>25</td>
<td>25.4</td>
<td>12.5</td>
</tr>
<tr>
<td>20</td>
<td>13.4</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>4.5</td>
<td>9.5</td>
</tr>
</tbody>
</table>
54 companies in the rubber industry were interviewed.
- 33 End-users of Crumb Rubber
- 17 Crumb Rubber Producers
- 7 Others: Associations, Trade Publications, etc.

Interviews provided most accurate market assessment.
Applications of SSSE Rubber

✓ Flooring, Athletic Surfaces, and Molded Products
  - Anti-Fatigue Mats
  - Running Tracks
  - Playgrounds
  - Roofing

✓ Rubber Modified Asphalt

✓ Developing Applications
  - Automotive Tires
  - Adhesives
  - Paints
Flooring, Athletic Surfaces, and Molded Products

- These applications typically use sizes of crumb rubber that range from 20 mesh to 1".
- Within this market, the characteristics of SSSE-generated crumb rubber are comparable to that produced by other processes.
- The projected SSSE price (7 - 13¢ / lb) price range is lower than the current market price (9 - 20¢ / lb).
- More market research is recommended to confidently determine the SSSE process’s ability to compete on a price basis.
Rubber Modified Asphalt

- Uses a distribution of sizes compatible with SSSE
- Current market price (11¢ per lb) is well within estimated range for SSSE-generated crumb rubber
- Further tests on SSSE crumb rubber are recommended:
  - Reduction in cross-link density of tire rubber
  - Thermal conductivity
  - Ease of processing into RMA
  - Performance indicators of RMA made with SSSE-generated crumb rubber
Developing Applications

❖ As a high-quality filler
  – Automotive tires
❖ Ultra-Fine Particles
  – Adhesives
  – Paint
Current Market Size

✔ RMA 296 Million lbs.
  - Most accessible market for SSSE

✔ Molded Products 307 Million lbs.

✔ Athletic Surfaces 141 Million lbs.
  - Running Tracks
  - Playgrounds

✔ Other Applications 43 Million lbs.
RMA Market

- Current use CA, AZ, TX, FL
- GA, NC, MD, OK, NJ, PA, NY, SC and Montreal, Canada by 2004
- 30 lbs. crumb rubber per ton asphalt
- Use limited to non structural layers of hot mix
- Approx. 10% growth per year
- Up to 570 million lbs in 2007
Molded Products

- Enormous range of products
- Average 4% growth per year
- Rubber Mats
- Molded Roof Shingles
  - Very accessible to SSSE rubber
  - About 5% of total roofing market
- Up to 375 million lbs by 2007
Athletic Surface Market

- Running Tracks and Playgrounds use close to 100% recycled rubber
- 800-1000 tracks built per year
- Several thousand playgrounds/year
- Strong lobbying for rubber surfaces in playgrounds
- Average growth 7% per year
- Up to 200 million lbs. in 2007
## Summary of Market Growth

### Summary of Crumb Rubber Market

<table>
<thead>
<tr>
<th>Application</th>
<th>2002 Market Size</th>
<th>Est. Annual % Growth</th>
<th>Est. 2007 Market Size (in millions of pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMA</td>
<td>296</td>
<td>3yrs at 10%</td>
<td>570</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 yrs at 20%</td>
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</tr>
<tr>
<td>Molded Products</td>
<td>307</td>
<td>4%</td>
<td>375</td>
</tr>
<tr>
<td>Sport Surfacing</td>
<td>141</td>
<td>7%</td>
<td>200</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>43</td>
<td>4%</td>
<td>55</td>
</tr>
<tr>
<td>Areas that are not applicable to</td>
<td>209</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>SSSE</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total applicable market to SSSE</td>
<td>787</td>
<td>9%</td>
<td>1230</td>
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</table>
Financial Analysis

✔ Market Penetration in RMA, Molded Products, Athletic Surfacing, and Miscellaneous

✔ Profit and Loss Statement
Market Penetration

✔ RMA – 2% per year

✔ Molded Products – 1% per year

✔ Athletic Surfacing – 2% per year

✔ Miscellaneous – 1% per year
Penetration Summary

- Average price of 11.9 cents per pound
- Starting at $1.5 Million in year one
- Growing to $11.6 Million in year five

Following table shows calculations
### Projected Market Penetration

All numbers in millions

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rubber Modified Asphalt Market</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Market Size (Pounds)</td>
<td>296.00</td>
<td>325.60</td>
<td>358.16</td>
<td>393.98</td>
<td>472.77</td>
<td>567.33</td>
</tr>
<tr>
<td>Market Share</td>
<td>2%</td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Share of Market (Pounds)</td>
<td>6.51</td>
<td>14.33</td>
<td>23.64</td>
<td>37.82</td>
<td>56.73</td>
<td></td>
</tr>
<tr>
<td>Revenue (Average 11.9c/lb)</td>
<td>$0.77</td>
<td>$1.70</td>
<td>$2.81</td>
<td>$4.50</td>
<td>$6.75</td>
<td></td>
</tr>
</tbody>
</table>

| **Molded Products** |      |        |        |        |        |        |
| Market Size (Pounds) | 307.00 | 319.28 | 332.05 | 345.33 | 359.15 | 373.51 |
| Market Share         | 1%   | 2%     | 3%     | 4%     | 5%     |        |
| Share of Market (Pounds) | 3.19 | 6.64   | 10.36  | 14.37  | 18.68  |        |
| Revenue (Average 11.9c/lb) | $0.38 | $0.79  | $1.23  | $1.71  | $2.22  |        |
# Projected Market Penetration

<table>
<thead>
<tr>
<th>Sports Surfaces</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Market Size (Pounds)</td>
<td>141.00</td>
<td>150.87</td>
<td>161.43</td>
<td>172.73</td>
<td>184.82</td>
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<tr>
<td>Market Share</td>
<td>2%</td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
<td>10%</td>
</tr>
<tr>
<td>Share of Market (Pounds)</td>
<td>3.02</td>
<td>6.46</td>
<td>10.36</td>
<td>14.79</td>
<td>19.78</td>
</tr>
<tr>
<td>Revenue (Average 11.9c/lb)</td>
<td>$0.36</td>
<td>$0.77</td>
<td>$1.23</td>
<td>$1.76</td>
<td>$2.35</td>
</tr>
<tr>
<td>Misc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Size (Pounds)</td>
<td>43.00</td>
<td>44.72</td>
<td>46.51</td>
<td>48.37</td>
<td>50.30</td>
</tr>
<tr>
<td>Market Share</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>Share of Market (Pounds)</td>
<td>0.45</td>
<td>0.93</td>
<td>1.45</td>
<td>2.01</td>
<td>2.62</td>
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<tr>
<td>Revenue (Average 11.9c/lb)</td>
<td>$0.05</td>
<td>$0.11</td>
<td>$0.17</td>
<td>$0.24</td>
<td>$0.31</td>
</tr>
<tr>
<td>Total Pounds</td>
<td>13.17</td>
<td>28.35</td>
<td>45.81</td>
<td>68.99</td>
<td>97.80</td>
</tr>
<tr>
<td>Total Dollars</td>
<td>$1.57</td>
<td>$3.37</td>
<td>$5.45</td>
<td>$8.21</td>
<td>$11.64</td>
</tr>
</tbody>
</table>
Supplemental Revenue

- Compensation for taking scrap tires
- 19 Million pounds of raw material
- Approximately 1/3 waste
- At 25 pounds per tire this would be 760,000 tires
- At 50 cents per tire this would produce $380,000
Management Cost

✓ $180,000 per year
✓ President – sales and admin
✓ Salary of $100,000 per year
✓ 2 support staff
✓ Collectively paid $80,000 per year
✓ Increases 4% annually to account for raises
Rent

- 10,000 square feet
- $15 per square foot
- Total rental costs will be $150,000
Marketing Expenses

- Commission based sales force
- 5% commission on all sales
- Expenses - $5,000 per sales representative
- Five sales reps in year one, increase by one per year

- Promotional costs - $100,000
  - Trade shows
  - Advertising
  - $50,000 per year increase
Estimated Production Costs

- Electrical costs - $50,000
- Labor - $520,000
- Overhead - $420,000
- Maintenance - $150,000
- Taxes and Insurance - $150,000
Equipment Purchase/Depreciation

- Extruder - $280,000
  - Produces 13 million pounds per year
- Support system - $270,000
  - Grinder
  - Shredder
  - Conveyor system
- Depreciation will be based on a twenty-year amortization schedule
Based on the assumptions presented above, the net pre-tax income for the SSSE process is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>$101,870</td>
<td>$657,027</td>
<td>$1,340,832</td>
<td>$2,250,060</td>
<td>$3,409,059</td>
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</table>
# Profit and Loss Statement

<table>
<thead>
<tr>
<th>All numbers in millions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Market Share (Pounds)</strong></td>
<td>13.17</td>
<td>28.35</td>
<td>45.81</td>
<td>68.99</td>
<td>97.80</td>
</tr>
<tr>
<td><strong>Revenue</strong></td>
<td>$1.57</td>
<td>$3.37</td>
<td>$5.45</td>
<td>$8.21</td>
<td>$11.64</td>
</tr>
<tr>
<td><strong>Tire Income</strong></td>
<td>$0.38</td>
<td>$0.81</td>
<td>$1.31</td>
<td>$1.97</td>
<td>$2.79</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td>$1.94</td>
<td>$4.18</td>
<td>$6.76</td>
<td>$10.18</td>
<td>$14.43</td>
</tr>
<tr>
<td><strong>Fixed Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Management Cost</td>
<td>$0.18</td>
<td>$0.19</td>
<td>$0.19</td>
<td>$0.20</td>
<td>$0.21</td>
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<tr>
<td>Rent</td>
<td>$0.15</td>
<td>$0.15</td>
<td>$0.15</td>
<td>$0.15</td>
<td>$0.15</td>
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<tr>
<td><strong>Variable Costs</strong></td>
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<tr>
<td>Electrical</td>
<td>$0.05</td>
<td>$0.10</td>
<td>$0.16</td>
<td>$0.25</td>
<td>$0.35</td>
</tr>
<tr>
<td>Labor</td>
<td>$0.52</td>
<td>$1.12</td>
<td>$1.81</td>
<td>$2.72</td>
<td>$3.86</td>
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<tr>
<td>Overhead (80% labor)</td>
<td>$0.42</td>
<td>$0.90</td>
<td>$1.45</td>
<td>$2.18</td>
<td>$3.09</td>
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<tr>
<td>Taxes &amp; Insurance</td>
<td>$0.15</td>
<td>$0.32</td>
<td>$0.52</td>
<td>$0.78</td>
<td>$1.11</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$0.15</td>
<td>$0.32</td>
<td>$0.52</td>
<td>$0.78</td>
<td>$1.11</td>
</tr>
<tr>
<td>Sales Expenses</td>
<td>$0.025</td>
<td>$0.030</td>
<td>$0.035</td>
<td>$0.040</td>
<td>$0.045</td>
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<td>Commission</td>
<td>$0.08</td>
<td>$0.17</td>
<td>$0.27</td>
<td>$0.41</td>
<td>$0.58</td>
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<td>Promotional Expenses</td>
<td>$0.10</td>
<td>$0.15</td>
<td>$0.20</td>
<td>$0.25</td>
<td>$0.30</td>
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<tr>
<td>Depreciation</td>
<td>$0.03</td>
<td>$0.09</td>
<td>$0.11</td>
<td>$0.17</td>
<td>$0.22</td>
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<tr>
<td><strong>Total Expenses</strong></td>
<td>$1.84</td>
<td>$3.53</td>
<td>$5.42</td>
<td>$7.93</td>
<td>$11.02</td>
</tr>
<tr>
<td><strong>Net Pre-tax Income</strong></td>
<td>$0.10</td>
<td>$0.65</td>
<td>$1.34</td>
<td>$2.25</td>
<td>$3.41</td>
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<tr>
<td><strong>Cumm Pre-tax Income</strong></td>
<td>$0.10</td>
<td>$0.76</td>
<td>$2.10</td>
<td>$4.35</td>
<td>$7.76</td>
</tr>
</tbody>
</table>
Investment Required

- Third party funding needed for three years
- Development investment - $0.5 Million
- Investment in year one - $1 Million
- Investment in year two - $1 Million
- Investment in year three - $0.5 Million

- Total committed investment $3 Million
Next Steps

✔ Perform in-depth research into market pricing for flooring, athletic surfaces, and molded products

✔ Conduct materials testing on SSSE-generated crumb rubber as requested by RMA users

✔ Work with companies interested in developing a business using SSSE technology
  - Phoenix Recycled Products, Inc. of South Carolina
  - GreenMan Technologies of California
  - Emert Grinding of Pennsylvania
Thank You From EnPro 351

Shannon Phillips, Aidar Omarov, Michael Mroszczak, Pete Krzyzanowski, Matt Cerney, Ginny Brock
Aaron Lebedow, Dr. Hamid Aarastoopour, Nima Shahidi