A Business Plan for the Production of Crumb Rubber by Solid State Shear Extrusion

ENPRO 351-Fall 2003

Outline

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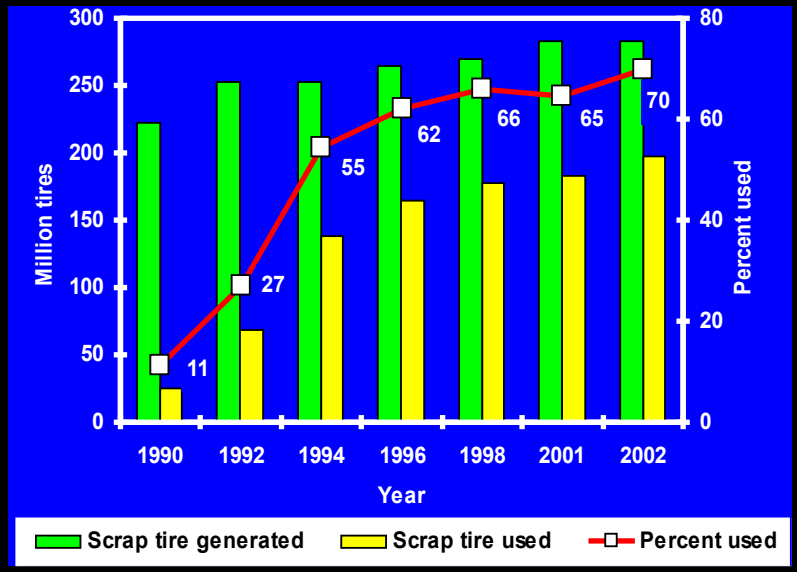
Problem Definition

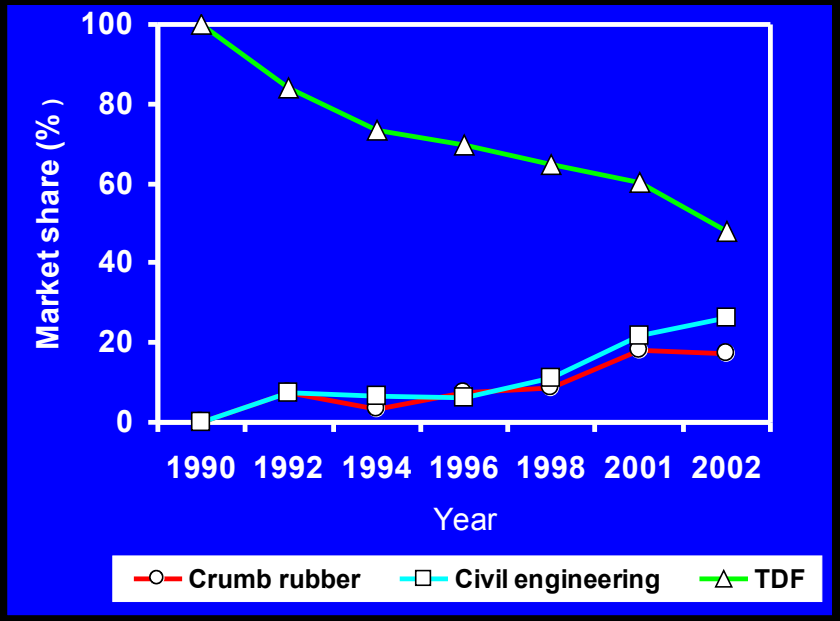
- In 2002, over 280 million scrap tires were generated in US
- 300 million scrap tires have accumulated over the past 10 years in the US
- These scrap tires are non-biodegradable and thermosets
- Scrap tire dumps serve as a breeding ground for rats, mosquitoes and ultimately diseases
- Serious fire hazards in stockpiles



Recycling

Major uses for scrap tires

- **Tire Derived Fuels (TDF)**
  - Air pollution, emits NOx, soot, etc
  - Only 1/4th of the energy invested is recovered
- **Civil Engineering Applications (CEA)**
  - Modified asphalt, longer life
  - Land filling to prevent leakage and leaching from other solid waste
- **Crumb Rubber**
  - High value added usage, with multiple applications



Use of TDF has decreased during the last decade – Not economically competitive

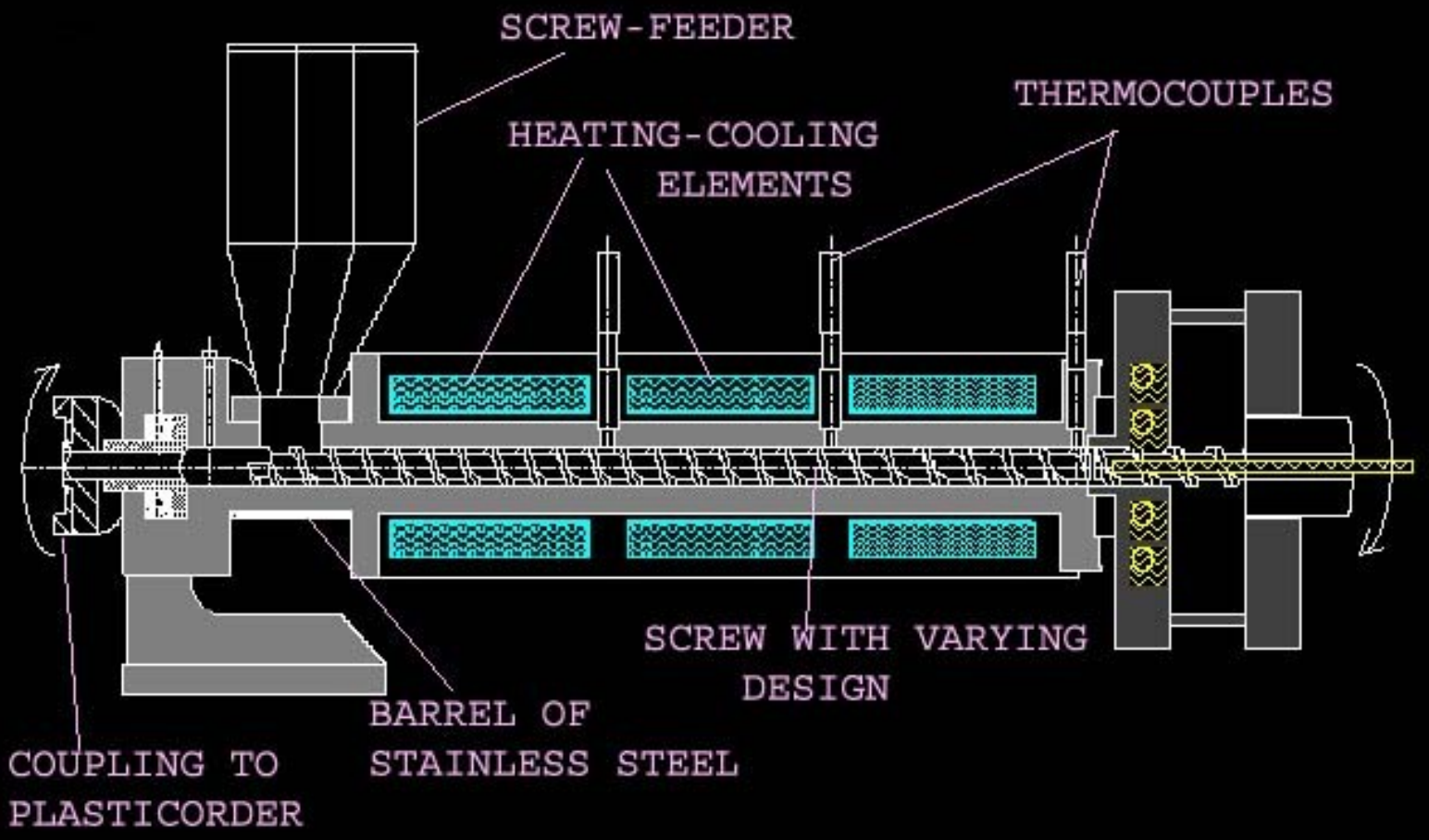
For all the applications size reduction is an important step

Pulverization Technologies

- Cryogenic Process
  - Size reduction is done by making the rubber brittle by using liquid nitrogen
  - Results in sharp edges and low surface area particles
  - No thermal degradation takes place
  - Expensive

- Ambient Process
  - Pulverization is done at normal or higher temperatures
  - Results in higher surface area, with irregular shape
  - Thermal degradation may occur due to high temperatures

Solid State Shear Extrusion



- A patented ambient pulverization process, developed at IIT
- The compression and shear forces are used simultaneously to crush the rubber
- Produces crumb rubber with superior characteristics/lower costs

SSSE Process

- Pulverize crumb rubber, with no chemical additives
- No moisture
- Approx. 33% reduction in cross-linking density and almost no thermal degradation
- High surface area, with irregular shapes
- Lower cost
- Can produce particles as small as 200 Mesh

Properties	Ambient Processes (Conventional)	Cryogenic Processes	SSSE
Particle Shape	Irregular	Regular	Irregular
Devulcanization	Not Applicable	Low	High
Surface Area	High	Low	High
Thermal Degradation	Yes	No	No
Price	Low	High	Low

Methodology

- Approximately 30 interviews were conducted with end-users and manufacturers of crumb rubber
- The strengths and weaknesses of SSSE and conventional methods were discussed
- Additional focus was on applications, size and price of competitive processes
- Obtained a sense of the market structure---size/growth/competition

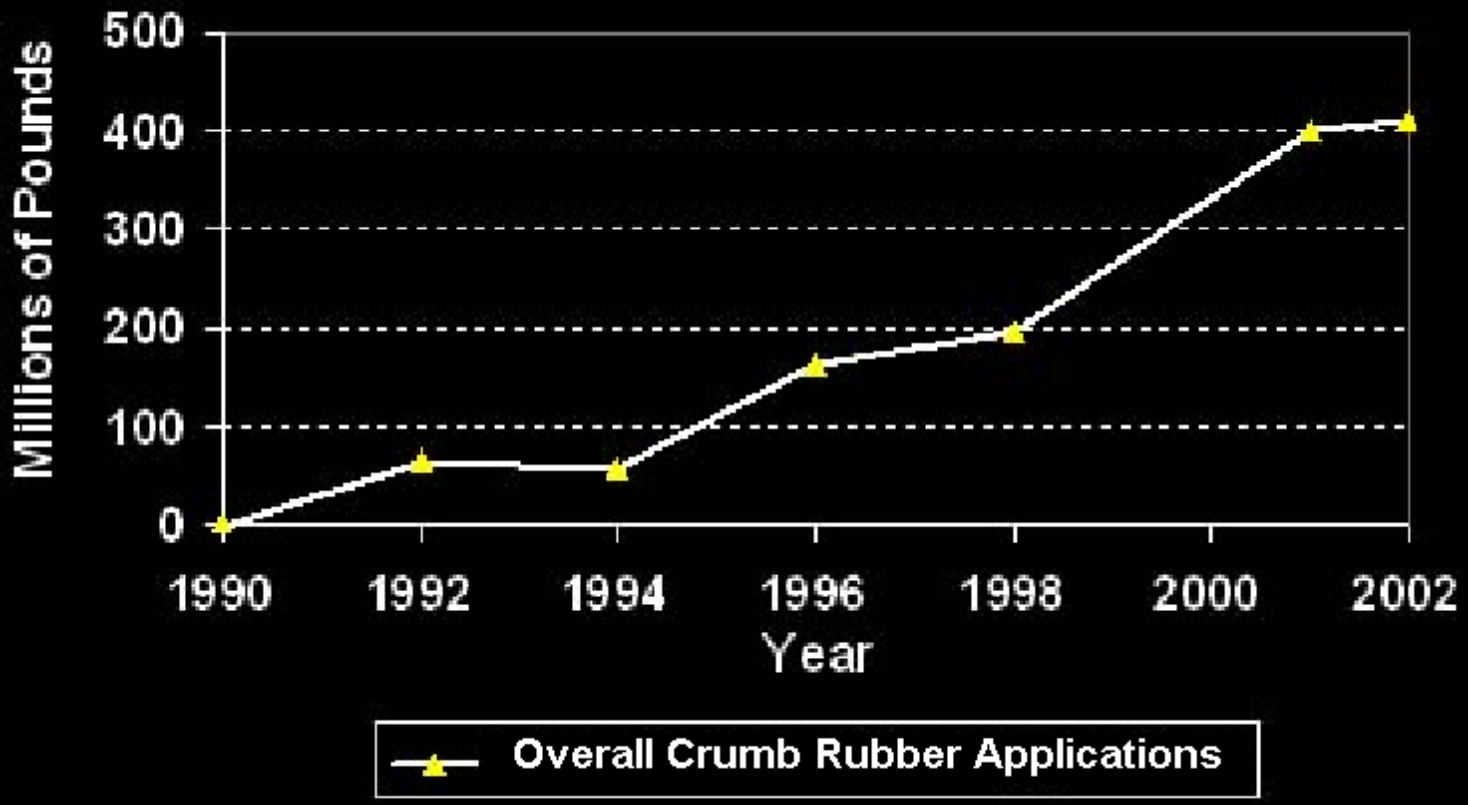
10-40 Mesh Applications

- Asphalt
  - Using crumb rubber in asphalt can increase its service life
  - Current use in CA, AZ, TX, FL; additional states considering use
  - Total use (all mesh sizes) in 2002= 200 million pounds
- Playground/Sport Surfacing/Athletic Fields
  - Second most promising in the crumb rubber market
  - Used in Astroturf/Astroplay; approximately 250,000 pounds per field
  - Total use (all mesh sizes) in 2002 = 70 million pounds
- Molded and Extruded Products
  - Tiles and mats for floor coverings
  - Livestock mats, railroad crossing, removable speed bumps
  - Total use (all mesh sizes) in 2002 = 50 million pounds

60-200 Mesh Applications

- Molded and Extruded Products
  - Crumb rubber molded with virgin rubber, usually to create rubber mats
  - Rubber coating and roofing
- Tires
  - New tires are created using 1-3% crumb rubber
  - Recent tests found acceptable use of up to 10% crumb rubber in new tires
- Emerging Applications:
  - Possible use of crumb rubber up to 25% of new tires
  - Sound proof walls and building materials
  - Additives in paint

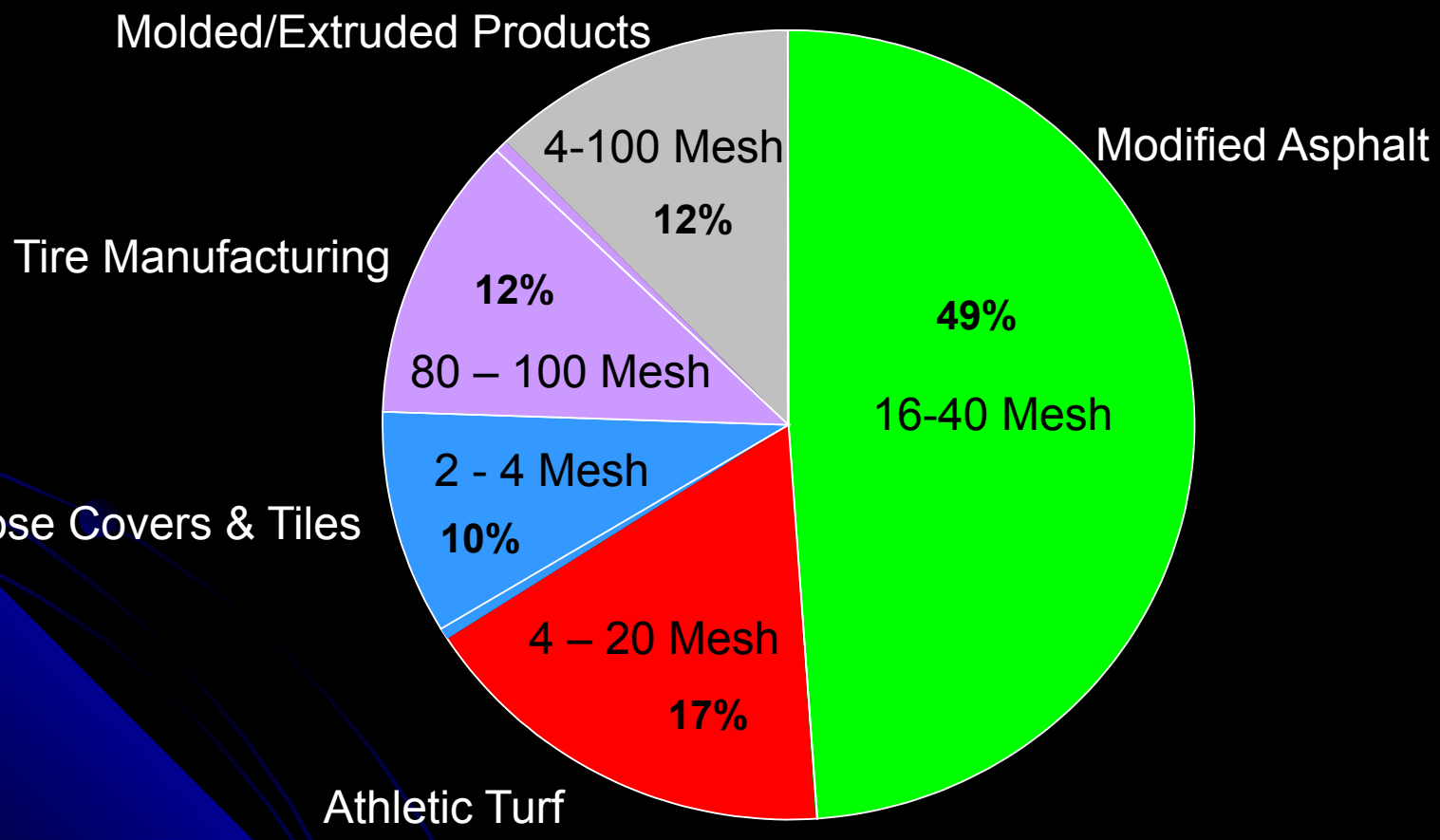
Market Growth from 1990-2002



Continuous increase in the usage of crumb rubber during the past decade, to 410 million pounds in 2002

Market Size of 2002

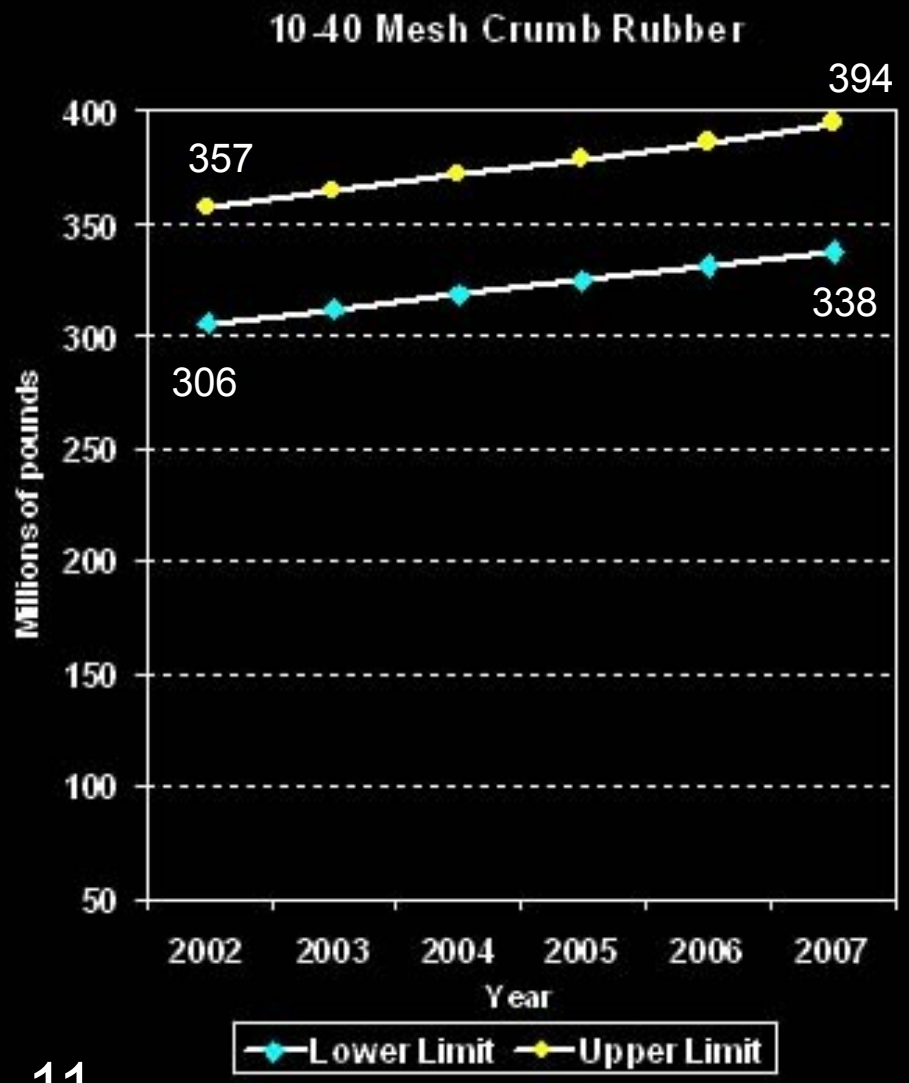
Total 410 million lbs of crumb rubber



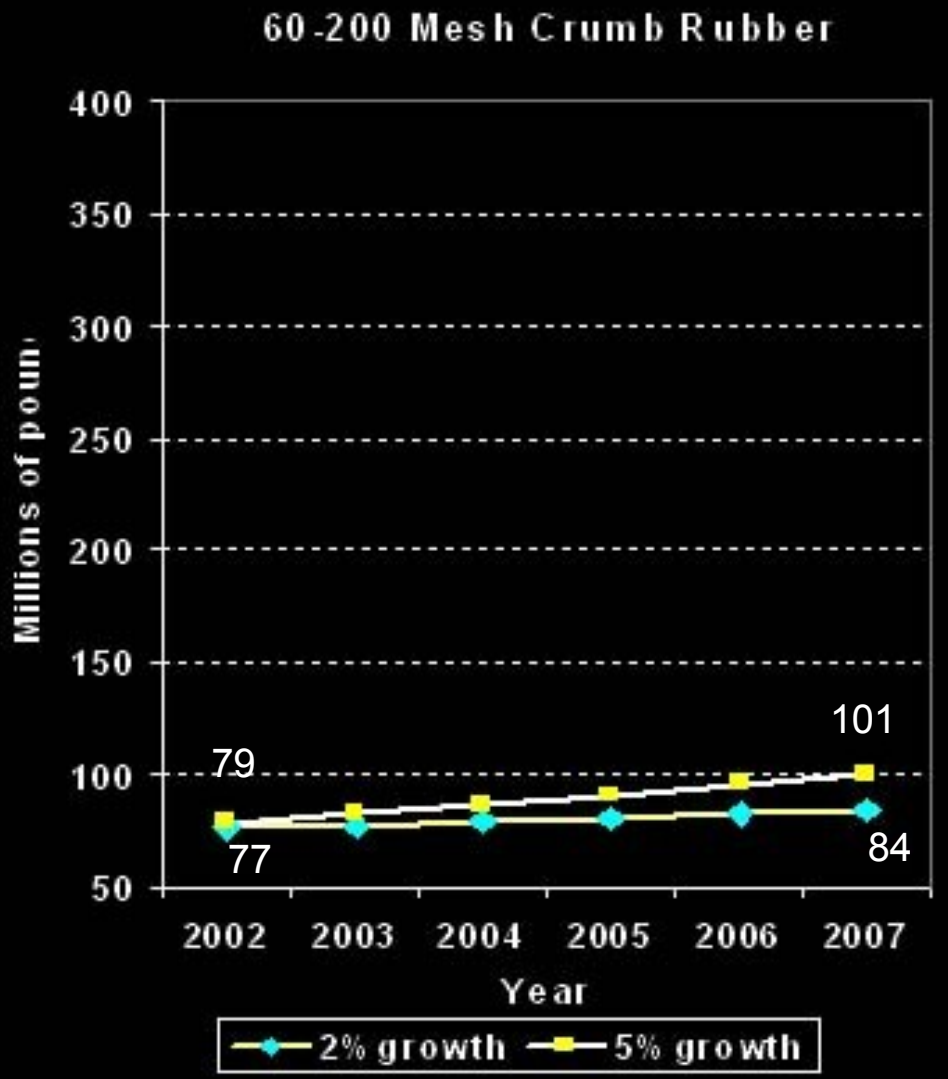
U.S. Ground Rubber Markets by Application and Particle Size (Adapted from the U.S. Scrap Tire Market Report 2002 from the RMA)

Estimated Growth 2002- 2007

Grew from 332 to 366 million pounds



Grew from 78 to 93 million pounds



Market Penetration

- Beginning with 1/8” processed rubber, the SSSE process produces (60%) 10-40 mesh and (40%) 60 - 200 mesh
- The penetration of the 10 – 40 mesh is limited, therefore the Team’s focus will be the 60 – 200 mesh, due to superior operating characteristics/cost
- Three reprocessing steps of the 10-40 mesh, will produce a more marketable ratio of (86%) 60-200 and (14%) 10-40 mesh.

Pro Forma - Key Assumptions

- Assume three reprocessing steps
- Revenue is generated from two market segments of crumb rubber
  - Focus is 60-200 mesh sales
  - 10-40 mesh sales are on an “as available” basis
- Two extruders are required to serve the production level required to support the sales forecasts
- To support this production level, labor works two shifts in year 2004, increasing to three shifts in year 2007

Revenue for 60-200 Mesh Size

- The SSSE process' market penetration was estimated 15 % in the first year, due to the superior characteristic/cost of this process
- Selling price is the average price of 80,100, and 200 mesh sizes, which totaled 32 cents/lb in 2002; increasing 3.5%/year.

60 to 200 Mesh Size				
Year	2004	2005	2006	2007
Market Size (million lbs)	84	86	90	93
Sale Price ($/lb)	0.33	0.34	0.35	0.37
Market Percentage (%)	15	18	21	24
Market Share (million lbs)	12.60	15.48	18.90	22.32
Revenue ($)	$4,158,000	$5,263,000	$6,615,000	$8,258,000

Revenue for 10-40 Mesh Size

- The share is based on 14 % of SSSE's total production
- The SSSE price will be constant at 10 cents per pound for 4 years due the SSSE's limited competitive position

Mesh Size 10 to 40				
Year	2004	2005	2006	2007
Market Size (million lbs)	345	352	360	363
Sale Price ($/lb)	0.10	0.10	0.10	0.10
Market Share (million lbs)	2.05	2.52	3.08	3.63
Revenue ($)	$ 205,000	$252,000	$308,000	$363,000

Pro Forma
Profit and Loss Statement

- Based on these forecasts, the SSSE process will be profitable each year
- The cumulative pre-tax income will be over $ 2,000,000 for 4 years

Year	2004	2005	2006	2007
Total Revenue ($)	$4,363,000	$5,515,000	$6,923,000	$8,621,000
Total Expenses ($)	$4,130,887	$5,141,580	$6,366,807	$7,650,158
Net Income ($) (Pre-tax)	$223,113	$373,420	$556,193	$970,842
Cumulative Income ($) (Pre-tax)	$223,113	$596,533	$1,152,726	$2,123,568

Investment

- Total investment of $1,400,000 is required
  - $600,000 for two extruders
  - $800,000 for working capital

Next Steps

Recognizing the significant potential of the SSSE Process, the Team recommends the following:

- Application research within the Paint market segment- resulting in lower cost and less brittleness

- Particle characteristic research to find the cross-link reduction and thermal conductivity for SSSE crumb produced from scrap tire sources

- Respond to the eight sample requests/campus visit, to gain a sense of the SSSE's competitive position

Thanks You!

Questions or Comments?