

PROCESSING OF SCRAP TIRES: TECHNOLOGY AND MARKET APPLICATIONS

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Discussion by:

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This paper is very educational and left me wanting to know more about scrap tire processing. The author does an excellent job covering scrap tire market opportunities, processing options, and some legislative background. Areas that I believe need additional coverage or clarification are:

(a) Why does a 1% increase in recycled rubber content decrease the durability of a new tire by 1%? Can additives be used to offset this adverse impact?

(b) Cost data should be included. As a trade association, you may be limited in stipulating prices. However, historical or regional price ranges would be very helpful.

(c) Some discussion on the analysis of tire derived fuel (TDF) would be helpful.

(d) The author states that processed tires should not be landfilled. This is misleading. Many operators of landfills shred tires prior to landfilling to prevent the tires from floating to the top. When a tire is compressed by the weight of the bulldozer compacting the refuse, the tire compresses and then springs up when the weight of the bulldozer is removed, often resulting in the tire "floating" to the top of the landfill.

(e) To promote future recovery of landfilled tires, is monofilling of tires a good idea?

AUTHOR'S REPLY

(a) The construction of new tires is a very complex process, which is constantly being improved through the reformulation of the "compounds" (the various materials that are mixed which gives the tire's components their properties). With the introduction of radial tires in the late 1960s, the property needs of the tire changed. Up to that point, the use of "reclaimed" rubber (recycled scrap tires) was common in new tire construction. In general, there was a greater demand for dynamic strength, flex, and aging resistance, all of which give the tire better performance than bias ply, non-

radial tires. These compound properties were obtained by increasing the levels of virgin and synthetic rubbers, and reducing the level of reclaim used in casing and tread compounds.

The performance disadvantages associated with the use of recycled scrap tires in new tire construction are higher hysteresis loss, heat build-up, and increased rolling resistance. Natural rubber has one of the lowest hysteresis losses of all rubber polymers. Addition of recycled rubber compounds with virgin rubber compounds generally increases hysteresis. Rubber compounds with high hysteresis loss return less energy during stretching, flexing, and compression than compounds with low hysteresis loss. This unreturned energy is converted primarily into heat. High hysteresis compounds increase rolling resistance and, as a result, use of such compounds is minimal in the flexing area (tread and sidewalls) of truck or passenger car tires used on highways. The additional recycled rubber to virgin compounds generally lowers tensile strength, fatigue cracking, and reduces air and moisture impermeability. All of these characteristics reduce the performance and decrease the service life of a tire.

Still, some recycled scrap tire rubber is used in new tire construction. While the quantity of recycled rubber (size reduced scrap tires) is relatively small when compared to the total weight of tires, it currently consumes 25% of all the ground rubber generated in the United States.

The applications for recycled scrap tire rubber in new tire construction is, in general, as follows:

- Passenger car and truck tires: (radial) maximum of 0.5% (bias ply) 1.0% maximum can be used.
- Agricultural tires: 3.0-5.0%.
- Off-the-road tires: 0%.

It is likely that recycled scrap tire rubber will continue to have a very limited application in new tire construction until there are scientific breakthroughs which improve the bonding of the recycled rubber to the virgin polymers used. Today, the tire industry continues to test and evaluate the utility of recycled rubber.

(b) As a trade association, the Council is restricted in its ability to discuss pricing issues. Furthermore, there is tremendous diversity in the processing equipment available,

and an equally tremendous range of prices.

(c) Tires are a petroleum based product. Eighty-eight percent of a tire (and tire-derived fuel — TDF) consists of hydrogen, oxygen, and carbon. The remaining 12% is comprised of sulfur, zinc, and trace metals. Attached is a representative listing of the components in a tire.

Composition of Radial Passenger Tire

Materials	Per Cent
Synthetic Rubber	27
Carbon Black	28
Natural Rubber	14
Steel Wire	10
Extender Oil	10
Organic Fiber	4
Other Petrochemicals	4
Other	3

Only 3% of tire has no fuel value

(d) The statement concerning the disapproval for land-filling of scrap tires was not given as a remediation for “floating” whole scrap tires. Nor was the statement given as a means to conserve landfill space. This statement was intended to suggest that landfilling scrap tires, where markets exist or where markets are being developed, disrupts or distorts these markets.

Scrap tires, like any solid waste, will be directed towards the least cost, legal disposal option available. One of the greatest concerns for any large-scale end user of tire-derived products is a consistent flow. Landfilling scrap tires will create a low-cost competitor that is likely to draw a significant percentage of the scrap tire flow away from viable markets. Hence, the statement concerning the restriction of scrap tires, whole or processed, to a landfill.

In areas which have no economically viable markets (i.e., where the closest processor or market is further than 150 miles away), landfilling scrap tires becomes the preferable disposal option.

(e) Scrap tire monofills have been a popular idea for the last 10 years. While it appears to offer an immediate answer to some short-term market problems, monofilling scrap tires does not appear to have any long-term benefits.

In most states which allow monofills for scrap tires, there is a requirement that the tires be covered with daily cover material, typically sand or dirt. Placing any of these materi-

als on a tire will reduce its attractiveness to scrap tire processors, since the cover material will cause additional wear on a scrap tire processing system. Many of these same states are also requiring that scrap tire monofills comply with the same construction and operational requirements as municipal solid waste landfills.

The construction and operational requirements have a direct impact on the economic viability of these operations. The initial tip fee for placing a scrap tire in the monofill will cover the “inbound” costs (on-site handling and possibly processing the scrap tire). If those monofilled tires are to be harvested at some point in the future, there will be costs associated with that as well. These secondary costs are probably not included in the initial disposal fee, since doing so would make the initial tip fee unattractive relative to other disposal options. Furthermore, if the costs of constructing a monofill are equal to municipal solid waste landfills, the cost to dispose of a scrap tire in a monofill would be prohibitively expensive. Case in point: the developer of a monofill in Ohio calculated that the tip fee which would cover the initial and secondary costs would be approximately \$3.00 per tire. The average tip fee for scrap tires in Ohio is currently in the \$0.65–\$0.75 range.

Discussion by:

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The paper provided an excellent overview of the scrap tire processing and markets. Mr. Blumenthal writes in an organized and concise manner. The following are comments and questions on the paper:

(a) The definitions were very helpful, since “crumb” rubber is used too often.

(b) It would have been helpful to have a composition breakdown of passenger and truck tires including percent rubber, metal, fabric, dirt, etc. The rubber portion could be further broken down into the types of rubber used and the historical tread of each type.

(c) Cross-section drawings of the processing equipment would be useful in understanding how they work.

(d) The paper included many good discussions of processing problems unique to tires such as nesting, wire removal efficiency, fiber removal, and particle shape. Other discussions could include: how to continuously feed tires which are bulky to shred; the bead wire effect on cutter life; how heat of the tires during shredding affects the processing; how to store and convey the processed rubber without bridging; and the effect of product quality on each market.

(e) Costs would always be helpful even if given as a range for processing each phase.

AUTHOR'S REPLY

(a) No reply necessary.

(b) A listing of the components of a typical tire is attached.

(c) A diagram of a typical tire cross section is attached.

(d) Bulky tires present their own problems for scrap tire processing equipment. Very large tires, such as rear farm tractors, earth movers, and mining tires need to be cut into sections before they can be dropped into the typical primary shredding system, usually with some form of mechanical arm. The shear size and durability of these tires can place tremendous pressure on a processing system, resulting in significantly decreased processing capacity (tires processed per hour) and strain on the knives and drive shafts.

The impact of bead wire (the wire which assists in sealing the tire to the rim) on shredding knives is significant. Typically, the tensile strength of bead wire is 1070 and/or 1080. If the tensile strength of the knives is equal to or less than that of the bead wire, the knives may not be able to penetrate the wire or will require constant sharpening. Sharpening or replacing a set of knives on a shredder is an expensive procedure. Costs for a set of new knives can be as much as \$20,000.

Heat generated from processing normally has little impact on the process. A tire will become soft and begin to lose shape at approximately 500–600°F. The temperature of a tire leaving an ambient system is far less than this range. In some ambient processing systems, water is used which not only keeps the system cool, but helps to reduce airborne particles. In the cryogenic processing system, the tire is exposed to extreme cold and then shattered by an impact device. In this case, heat is virtually non-existent.

To convey processed tires, a series of belts are typically used. The processed tire, once it is reduced to the desired size, is transferred to an industrial belt, which will transport the material to the next processing station. During the processing of the scrap tire, a significant amount of the wire is removed (beaten) from the tire. During the transfer of the shreds, they pass under a magnet which will remove the remaining metal.

Bridging of scrap tires occurs when they are "rough" shredded. This is when the processed scrap tire has wire (typically bead wire) exposed from the shreds. The simplest

way to avoid bridging is to have "clean" cut shreds. This is when there is no metal protruding from the shreds.

The impact of heat from processing and the way in which the tire-derived product is conveyed has no real impact on the material's quality or markets. The storage of tire-derived material can have an impact on its quality and markets.

When whole or processed scrap tires are stored outdoors for an extended period of time, they may become covered with a coating of dirt or other similar material. This form of "contamination" will reduce the markets available. In general, these exposed scrap tires are not desirable for processing into ground rubber, since they can be coated with dirt or grit. This foreign material will reduce the quality of the ground rubber, thus reducing the material's market value and acceptance. Furthermore, the foreign material will increase the wear on the processing system, in particular, the increased reduction of knife sharpness. Tires, whole or processed, pulled from long-standing piles, typically have two viable markets: tire-derived fuel and/or civil engineering applications.

(e) See reply (b) to Cosulich.

Discussion by:

Walter R. Niessen
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This overview of the technology and market aspects of scrap tire processing was timely and interesting. Increasingly, tire disposal is recognized as a serious problem and processing to a useful product is an important alternative to landfilling or "piles of tires."

The author correctly points out that processing cost is an important input to market assessment. Yet, he does not present cost data or suggest references to where such cost can be obtained. Perhaps he could remedy this in the Discussions volume?

AUTHOR'S REPLY

See reply (b) to Cosulich.

FIG. 1 ANATOMY OF A RADIAL PASSENGER TIRE
 (Part of Reply (c) to Joe Smisko)

