Newsfront

TIRES, OLD AND NEW

As the demand for new, fuel-efficient tires grows, engineers are developing new recycling methods to deal with the growing piles of used tires

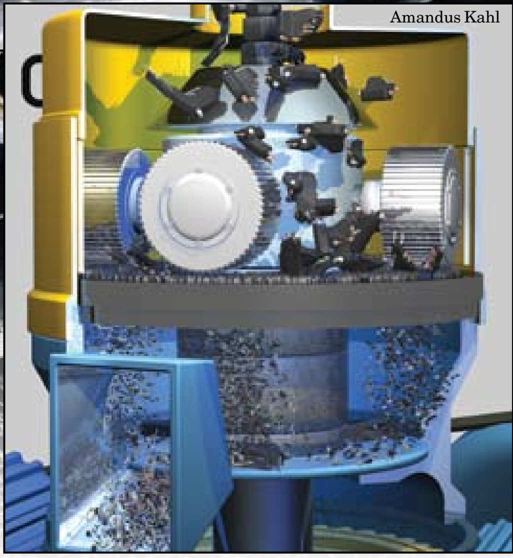


FIGURE 1. Mechanical methods have been the main way to recycle tires. This new grinding technology produces better quality steel and rubber crumb, while consuming less energy than traditional methods

Mobility as a "megatrend" has recently become the latest buzz-word, and synthetic rubber producers are boosting production capacities to meet the anticipated demand for more tires. At the same time, high fuel prices and increasing concern for the environment are driving innovations in rubber to make tires more fuel-efficient (see box on p. 19).

Meanwhile, efforts to find more efficient ways to recycle used tires are progressing, with some companies looking to capitalize on the resources — both energy and materials — that are tightly bound inside discarded tires.

Megatrend mobility

An estimated 5% of the nearly 3-billion Asian population own cars, compared to more than half the 406-million population of Western Europe and 80% of the 306 million in the U.S. So it's not surprising that all of the major tire manufacturers are investing in production plants in China, Thailand, India and elsewhere, to capitalize on the emerging markets there. In May, for example, Continental AG (Hanover, Germany; www.conti-online.com) officially opened its first tire plant in China. The €185-million investment in Hefei, in the Anhui province, has an annual production capacity of 4-million tires, and further expansion at the site to 16 million tires is planned.

Rubber producers, too, are looking east in order to meet the growing demand from tire manufacturers. In May, for example, Lanxess AG (Leverkusen, Germany; www.lanxess.com) broke ground for a new production facility in Singapore. The new plant, which is being built on the man-made Island of Jurong, will have a production capacity of 100,000 ton/yr of butyl rubber. The €400-million investment is the largest investment project in the history of Lanxess. The butyl rubber produced in Singapore will be used primarily in tires. The butyl rubber market is expected to grow steadily over the next 15 years, says Lanxess.

Since tires eventually wear out and have to be discarded, one has to wonder what is going to happen to all the new tires. Already, all over the world, there are mountains of used tires piled up (if readers haven't seen such tire heaps themselves, just type "used tires" into Google Images). Such landfilling is becoming a thing of the past, and today, there are a number of ways to recycle tires.

Recycling today

Worldwide, nearly 1-billion tires are manufactured each year, and nearly an equal amount of tires are removed from vehicles and defined as waste, according to the European Tyre Recycling Assn. (ETRA; Brussels, Belgium; www.etra-eu.org). In the E.U. alone, some 3.5-million metric tons (m.t.) of tires become waste each year. Although tires are not the biggest waste stream — over ten times more plastic waste is generated in the E.U. each year — tires contain a number of components that can be recovered for reuse, so recycling can make economical sense. Production of 1 kg of recycled tire granulate consumes 2,200 Btu, while the production of virgin rubber materials consumes more than 120,000 Btu for the same quality, says ETRA.

A typical tire is about 45–48 wt.% rubber (both natural and synthetic), 22 wt.% carbon black and silica, 15–25 wt.% metal, as well as textiles, zinc oxide, sulfur and additives. The challenge for recyclers is that the same properties that make tires durable and safe also make it difficult to recover the components in usable form.

What happens to these used tires varies widely by country. In Japan, for example, about 62 wt.% of the used tires in 2010 were used as an alternative fuel in various industries, such as paper manufacturing (39%), cement calcining (10%), steel manufacturing (3%) and others, according to the The Japan Automobile Tyre Manufacturers Association, Inc. (Tokyo; www.jatma.or.jp). Only 10% of the tires were recycled for reclaimed and powdered rubber.

In the U.S., about 76% of the 300-million tires generated annually are recycled, with tire derived fuel (TDF) accounting for about half in 2010, according to Dick Guss, environmental advisory council of the Tire Industry Assn. (Bowie, Md.; www.tireindustry.org).

In the EU, where landfilling of post-consumer tires was banned in 2003 (for shred and recycle residue in 2006), material recycling using a variety of treatments and technologies has grown to more than 36% of post-consumer tires, says ETRA.

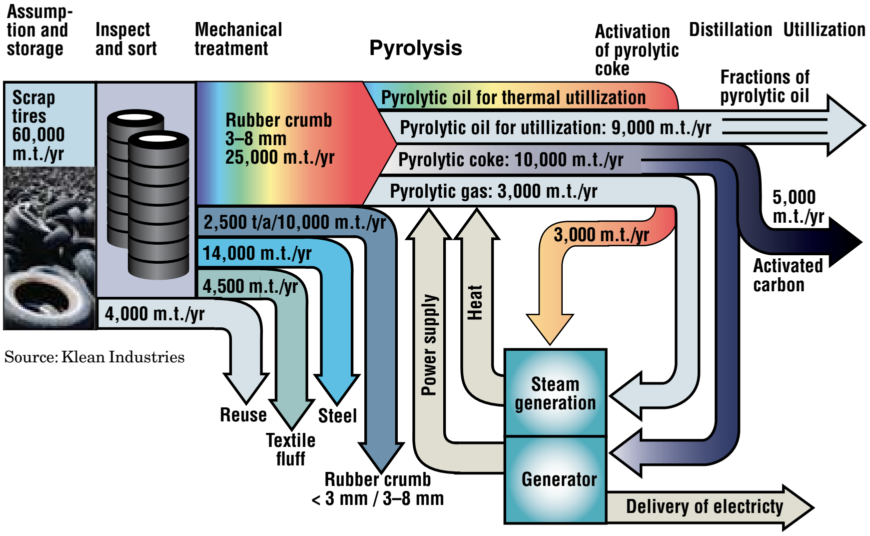


FIGURE 2. Pryolysis is emerging as a more efficient way to utilize the resources in tires compared to simple combustion as an alternative fuel source

Mechanical recycling

The standard way to recycle tires has been by mechanical methods, such as grinding, cutting and shredding, which physically separate out the main components as steel and rubber crumb. Although well established in the scrap industry, mechanical methods are continuously being improved to reduce costs and improve the quality of the recovered products.

For example, Amandus Kahl GmbH, (Reinbek, Germany; www.amandus-kahl-group.de) recently introduced its ambient-grinding process that is said to be more economical than traditional ambient or cold grinding processes. The process features the company's granulation press (Figure 1), in which tire chips (50–100-mm size) are ground between cylindrical pan-grinder rollers and a circular die designed as a perforated plate. The shearing force produced by the pan grinder, as well as the pressing force (up to 120 bar) applied by a regulated hydraulic system, decompose the tire parts and separate the components.

A Type 60-1250 granulation press processes up to 4.5 ton/h of tire chip to a granular size of 0.4–20 mm, which can then be classified into different product grades. A typical separation result is 15–20% steel, 15–20% textile-rubber mixture, and rubber crumb (4–6 mm, 15%; 2–4 mm, 15%; 0–2 mm, 30%). The quality of the steel, with low residual rubber and textile, can be sold for €100/ton, and the rubber crumb has a much larger specific surface than cold-ground crumb, says the company.

The modular system has a throughput of up to 15,000 ton/yr; higher capacities can be increased by adding modules. At €40/ton, production costs are about 25% that of traditional methods, says the company.

Thermal treatment

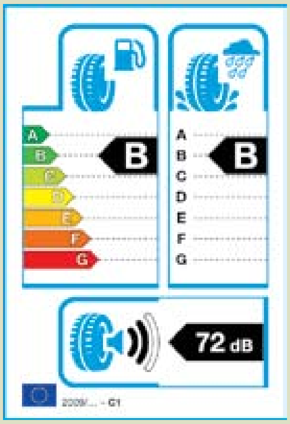
The sheer volume of automotive waste streams, in particular rubber and plastics is staggering, says Jesse Klinkhamer, CEO, Klean Industries Inc. (Vancouver, B.C., Canada). The current market for applications for recovered rubber, including that from tires, is saturated with old outdated technology and infrastructure that simple cannot handle all of the volume being produced. Although the current market for recovered rubber is growing, the demand for resources and energy far outstrips the need of recovered rubber, he says.

Established in 2005, Klean Industries acquired pyrolysis IP developed in Japan in the 1970s and further developed the technology into a patented, thermal depolymerization process that combines pyrolysis and gasification to convert tires into carbon black, steel and hydrocarbons (Figure 2). The company offers both batch and continuous systems with capacities of 3–500 m.t./d (continuous) and 4–60 m.t./d (batch).

FUEL-EFFICIENT TIRES

Friction between a vehicle's tires and the road is responsible for about 30% of fuel consumption. At the same time, the tires must grip the road, especially when wet, for obvious safety reasons. Finding the right balance between low rolling resistance and strong wet grip is the key to high-performance tires, says Frans Hordies, commercial director Synthetic Rubber, Styron (Berwyn, Pa.; www.styron.com).

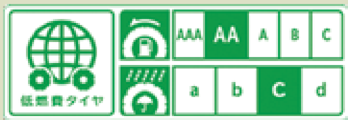
A tire is made up of many different components with different rubbers, both synthetic and natural. The tread accounts for the largest portion of synthetic rubber, and SBR (styrene butadiene rubber) is important for the treads. Styron has been developing a solution-based polymerization process to make SBR (S-SBR), and in the last five years we have seen an acceleration in the demand for this rubber, says Hordies. The latest generation of the company's S-SBR — Sprintan S-SBR 4602 — won this years "IQ Innovation Award" for breakthrough rubber technology. "S-SBR is now seen as a key enabling technology for delivering the two contradictory characteristics of low rolling resistance but with the same grip," he says.



Styrol built its first commercial production plant for S-SBR in Schkopau, Germany in 2000, added an additional stream in 2009, and is now constructing a third train scheduled to start up in 4th quarter of 2012. The new production line will introduce an additional capacity of 50,000 m.t. at the production facility in Schkopau.

Lanxess AG (Leverkusen, Germany) also sees high-performing "green tires" as the fastest growing sector in the tire industry, with an annual global growth rate of about 9%, and even higher (14%) in Asia.

Labeling tires for performance



Before November 1, 2012, tire manufacturer's in the E.U. will be required, by law, to declare the fuel efficiency, wet grip and external rolling noise performance of tires for passenger cars, light- and heavy-duty vehicles. The regulation was adopted by the European Parliament and Council in 2009 as a means to trigger fuel savings from the increased use of fuel-efficient tires. The European Commission estimates that between 2.4 and 6.6 MTOE (million metric tons of oil equivalent) can be saved, depending on the speed of market transformation.

Few consumers are aware of the impact of tires on gas mileage, and the Commission estimates that drivers can reduce their fuel bills by up to 10% between the best and worst set of tires available on the market. To increase awareness, tire performances will be displayed at the point of sale and on promotional literature. A standardized tire label (upper label) will inform consumers on three key performance attributes: fuel efficiency and wet grip performance — with a ranking scale of A (highest performance) to G (least performing) — and exterior rolling noise, in both decibels and one to three sound waves (one wave for the quietest, three for the loudest).

In January 2010, The Japan Automobile Tire Manufacturers Assn., Inc. (Tokyo; www.jatma.org.jp) introduced a voluntary standardized Tire Labeling System, which displays performance levels of fuel-efficient tires (lower label). The system grades tires for rolling resistance performance — on a five-scale range from AAA (best) to C (worst) — and on wet grip performance on a four-grade scale from a to d.

South Korea also introduced a similar labeling scheme a few months ago. ❒

"We receive thousands of inquiries on an annual basis for process technology regarding scrap rubber and tires, and have over a trillion dollars of deal flow in our current project-development pipeline," says Klinkhamer. "We simply can't build plants fast enough, even in today's current market conditions."

The company has 15 projects in development pipeline that are either in the permitting phase or entering the permitting phase, and Klinkhamer anticipates that at least seven of these projects will enter into the EPC (engineering procurement construction) phase in the next 18 months, depending on the E.U.'s economic recovery.

Two of these projects are currently operating, and final "hot trials" will be completed at the beginning of 2012. One of these, located in the U.K., is an integrated tire-resource-recovery facility that is supported by several collection centers. Current overall capacity is approximately 70,000 m.t./yr with 35,000 m.t. being processed thermally and the rest being chipped for TDF, ground for rubber applications and commercial retreading. Ultimately, this facility will recycle 4-million tires per year and produce 3-MW of electricity for export; 5,000 m.t./yr of carbon black; 10,000 m.t./yr of diesel-grade fuel oil; and 3,600 m.t./yr of steel.

The second project, in Ohio, is an integrated commercial truck-tire retreading facility with a capacity of approximately 45,000 m.t./yr with 35,000 m.t./yr being processed thermally and the rest being retreated.

Meanwhile, other pyrolysis processes are progressing toward commercialization. Metso Mining & Construction Technology (Danville, Pa.; www.metso.com), for example, has developed its Tire Pyrolysis System — a continuous process that processes tire shreds, in an indirectly fired rotary kiln, into carbon black, oil, gas and scrap metal.

The company has been operating a 50-kg/h pilot plant at its Pyro Systems Test Center in Danville, Pa. for several years, and the unit has over 1,000 h of operation, says Michael Schiefer, global sales engineer, Pyro. The company is now working on a large application at a brown-field site in the U.K., and includes a complete plant and utilities, he says.

Metso has concentrated on producing carbon black as the economical driver, and maximizing its production, says Schiefer. The company offers a design for continuous operation that is capable of handling 90–100 m.t./d of shredded tires.

Another pyrolysis process for recycling scrap tires, called Formex, has also undergone extensive trials in a 100-kg/h pilot plant in Eisenhüttenstadt, Germany, and a second plant is under construction near Marl, Germany. The process was developed by BOS Berlin GmbH (www.bosgmbh.com), and is being commercialized by abf GmbH (Eisenhüttenstadt; www.abf-engineering.de) (for process flowsheet, see *CE*, March 2002, pp. 27–31).

Microwaves

An alternative thermal recycling process that has taken 18 years to develop is now close to commercialization by its developer, Environmental Waste International Inc. (EWS; Ajax, Ont., Canada; www.ewcm.com). The process, called reverse polymerization, uses microwaves to break the chemical bonds of the rubber. Unlike pyrolysis, in which heat is applied from outside, the microwaves heat from within, explains EWS president Steven Simms. The heating principle is analogous to that used in microwave ovens, but operates at a frequency resonant with hydrocarbon bonds instead of those of water molecules, he says. As a result, the process operates at under 300°C (typically 280°C) compared to 700–800°C typical for pyrolysis. This means less char (burned carbon black) is produced and a higher-quality product is formed, says Simms.

In July, EWS started up its first pilot unit at its Ellsin Environmental facility in Saute Ste. Marie, Ont. The so-called TR900 pilot plant has a capacity to process 900 tires per day. Whole tires are continuously fed into the nitrogen-purged reactor in which about 100 microwave generators cause the rubber to break down and sublimate. Because each generator has its own power supply, it's possible to reduce the power as the depolymerization proceeds. This high degree of control minimizes the formation of char, says Simms.

"Since the unit started in July, we've had visitors from all over the world," says Simms, who anticipates first orders by the end of this year. With delivery times of 10–12 months, the first commercial units could be operating by 2013, he says.

The company is offering a commercial unit, the TR1500, which will process 1,500 tires per day. A modular design means scale up is simply combining two or four units. Investment costs for the TR1500 are around $12.5 million, and Simms estimates a payback period of about three years, "based on very conservative estimates on the value of the products recovered." The economics improves as the cost of oil increases because carbon-black production is directly tied to oil prices, he says. ■

Gerald Ondrey