



Tire Recycling

The development of innovative uses for recycled rubber provide solutions for the disposal of scrap tires.

HISTORY

Rubber recycling is not new. In fact its history goes back more than a hundred years to a time when rubber was a scarce commodity. In 1910, an ounce of rubber cost the same as an ounce of silver. Over time rubber recycling declined. One reason for this was the increased use of synthetic rubber made from cheap imported oil. This reduced the value of recycled rubber and made it less cost-effective. Another reason relates to the development and spread of steel belted radials. These tires eventually became scrap tires that were extremely resilient and therefore extremely difficult and expensive to recycle. With the decline in rubber recycling came the growth of stockpiles of scrap tires.



ANNUAL GENERATION

Nearly 300 million scrap tires are generated in the U.S. and Canada each year. This is approximately equivalent to one passenger tire per person per year. This number of tires laid side by side would circle the earth's equator more than twelve times. For many years scrap tires have been accumulating in landfills, illegal stockpiles, vacant lots, fields, abandoned buildings and roadsides. These stockpiles can pose a serious threat to public health and safety, as well as to the environment.



HAZARDS OF TIRE PILES

Large stockpiles have the potential for large fires that are tremendously detrimental to the environment and extremely hard to extinguish once started. Large fires may burn for months all the while creating acrid black smoke and toxic liquid run-off. The smoke contains toxic chemicals and air pollutants while toxic chemicals from

the run-off are released into surrounding water and soil. Attempts to extinguish fires by conventional means can actually increase the damage.

Stockpiled tires can provide nesting areas for rodents and other vermin. The puddles of water found inside tires provide convenient breeding grounds for mosquitoes. The spread of West Nile Virus has given new urgency to the need to eradicate scrap tire stockpiles.

Elevated incidence of other mosquito-borne diseases has been reported near large tire piles.

Even tires that are disposed of in sanitary landfills create environmental problems. Buried tires sometimes "swim" their way back to the surface which can result in expensive damage to landfill cover and containment systems. For this reason, many jurisdictions have

banned the landfilling of whole tires.

The scrap tire story needn't have a sad ending. Twenty years ago only 10% of scrap tires generated in the United States were reclaimed through recycling or other uses. Today, more than 80% of scrap tires are pulled from the waste stream and reused in some way.

MANAGEMENT STRATEGIES

Solutions for scrap tires are ranked in terms of the 3-R hierarchy. The Rs in order of preference are Reuse, Recycle, and Recover (energy). Obviously the best use of a scrap tire is its reuse. Some tires find their way "as is" into domestic second-hand markets. Others, particularly medium truck tires, are retreaded first. About 10% of scrap tires from industrialized countries such as the U.S. are sold as second-hand tires in less developed regions such as Central America.

The best management strategy of scrap tires that are not suitable for reuse or retreading is recycling. Most recycling efforts involve the manufacture of crumb rubber which is used as a feedstock in the production of finished goods. The markets and applications for crumb rubber have grown tremendously in the past two decades as uses outside the traditional rubber manufacturing industry are becoming increasingly important. A wide variety of recycled rubber products is the result.

Tire Derived Fuel (TDF) burned in cement kilns, pulp mills and other industrial plants is a reasonable use for scrap tires if recycling is not a viable option. The energy required to create rubber compounds is 3 to 4 times the energy released when tires are burned. Use of recycled rubber therefore makes more sense than burning tires both environmentally and economically.

METHODS OF PRODUCING CRUMB RUBBER

Technical developments in the past two decades have produced more cost effective methods of reducing scrap tires. Size reduction accomplishes two things. It makes it possible to separate the steel and fiber from the rubber. It also processes the rubber into a sellable particle size.



TIRE RECYCLING PROCESSES

Nearly all processors begin by shredding the tire. This primary reduction step reduces the volume of tires and creates a material that is more easily handled. Tire shredders typically are shear shredders with two counter rotating shafts producing 2-inch shreds.

The shred is further reduced using either an ambient

or cryogenic system. In an ambient system the shred, at ambient temperature, is fed into one or more granulators fitted with screens that determine the size of the output. Steel is removed from the resulting material by magnets and fiber is removed by aspiration and sifting so that only rubber particles remain. If larger sized rubber particles (typically 1/4 inch or larger) are desired

the process may end here. More often, smaller sizes are required in which case the rubber is processed through one or more cracker mills. These mills have two counter rotating corrugated rolls placed very close together that "crack" the rubber into smaller particles as it passes through. The ambient system is effective where the targeted output size is 30 mesh or greater.



10 Mesh
Crumb
Rubber

In a cryogenic system the tire shreds, or in some cases the whole tire, is super-cooled using liquid nitrogen. The cold rubber, now extremely brittle, is processed through a hammer mill which shatters the rubber into smaller particles. The output is dried and classified into specific gradations. Smaller particles can be produced with the cryogenic process than with an ambient system. It requires fewer pieces of equipment than the ambient

system and energy and maintenance costs may be less. A drawback of the cryogenic process is the cost of liquid nitrogen. Cryogenic crumb rubber particles have very smooth surfaces compared to crumb produced ambiently. Most crumb rubber customers require particles that are rougher with greater surface area therefore cryogenic material has limited applications.



A-R performs in all climates

beneficial characteristics. A-R pavements typically last significantly longer than conventional asphalt. Reduced pavement thicknesses can often be built with the same or better service life as thicker conventional asphalt pavement.

When a road ages and cracks appear it is commonly overlaid with new asphalt concrete. The original cracks often transmit or

END USES/PRODUCTS FOR CRUMB RUBBER

Shredded tire chips are used in civil engineering applications as a substitute for conventional construction materials such as crushed rock or gravel. Smaller rubber chips may be colored and are used as playground cover and landscaping mulch.

On average less than 5% of a new tire consists of recycled rubber. The largest market for crumb rubber is the molded products sector which uses crumb rubber in combination with urethane binders. Products include agricultural mats, sports flooring, speed bumps, railway crossings, weightlifting plates and acoustic flooring.

Crumb rubber is often used in the construction of running tracks and poured-in-place playgrounds. Increasingly, artificial turf fields are made with a carpet of long synthetic grass fibers that are unfilled and held upright with crumb rubber. These are becoming the playing field of choice for many professional sports teams. Crumb rubber is even combined directly into natural turf so as to reduce compaction and improve drainage. Golf courses use it around tees and greens.

ASPHALT-RUBBER (A-R)

One of the largest and fastest growing uses of crumb rubber is in asphalt pavements. Mixing rubber into the asphalt binder produces a pavement with a number of

reflect through the new layer of pavement within a short period of time. The use of A-R as an overlay greatly decreases this reflective cracking thereby providing an extremely cost effective road maintenance technique.

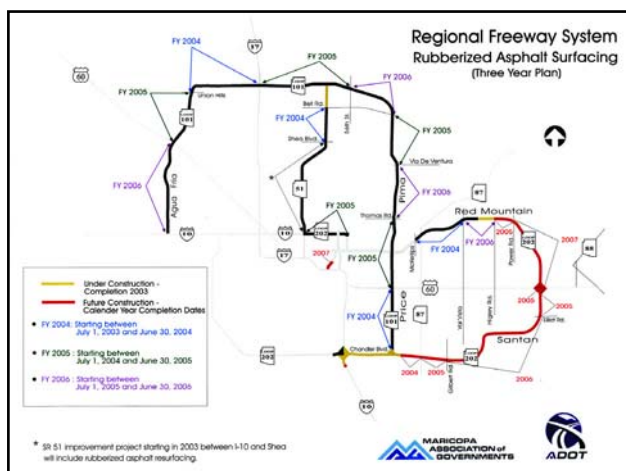
The cracking and rutting that result from extreme temperatures are reduced using A-R. The engineering properties of A-R, along with reduced maintenance costs, can dramatically reduce the costs of building a pavement and maintaining it over its lifetime.

A-R roads have also been shown to be safer with a lower incidence of serious motor vehicle accidents. Noise pollution is also greatly reduced in pavements made with rubber. Largely because of this the entire freeway system in and around Phoenix, AZ is being surfaced with asphalt-rubber.

The environmental bonus of this durable, cost effective, quiet pavement is that each lane mile consumes 2,500 scrap tires. Every ton of A-R paving material contains the rubber from 2.5 scrap tires. Therefore, if you divide the population of an area by 2.5 that's the quantity of A-R paving (in tons) that would consume all scrap tires generated within that area.

Thousand Oaks, CA is one city that does just that. Does your city or town use asphalt-rubber?

It's no wonder that, from its humble commercial beginnings in Arizona in the 1960s, the use of A-R has spread across North America to applications on every continent. This growing technology has a very exciting future in its contribution to recycling scrap tires the world over.



The Arizona Quiet Pavement Pilot Program

Glossary of Terms

Ambient Ground Rubber – processing where scrap tire rubber is ground or processed at or above ordinary room temperature.

Asphalt-Rubber – asphalt cement modified with a minimum of 15% crumb rubber modifier (CRM).

Asphalt-Rubber Blend – a blend of crumb rubber modifier (CRM) (finely processed to a No. 16 to No. 30 mesh gradation) and asphalt cement, which is utilized as the binder in various types of pavement rehabilitation and construction procedures. The CRM percentage can range from 15 to 26 percent CRM by weight of the asphalt cement depending on the specified application. The CRM and asphalt cement are blended at elevated temperatures to promote the chemical and physical bonding of the two constituents. Various petroleum distillates or extender oils may be added to the blend to reduce viscosity, increase spray-ability and promote workability. The blend can be used as the binder in chip seals, cape seal applications, pond linings, or gap and open graded hot mix. When used as a binder in hot mix applications, the aggregate gradations and the quality of the aggregate need to conform to industry approved specifications.

Asphalt-Rubber Concrete – implies the use of an asphalt-rubber binder with gap or open graded aggregate gradations in a hot mix application.

Automobile Tires – tires with an outside diameter less than 66 cm (26 inches) used on automobiles, pickups, and light trucks.

Buffing Waste – high quality scrap tire rubber which is a byproduct from the conditioning of tire carcasses (casings) in preparation for re-treading.

Crackermill – machinery that tears apart scrap tire shreds by passing the material between rotating corrugated steel drums, reducing the size of the rubber to a crumb particle generally 4.75 mm to 425 microns (No. 4 to No. 40) mesh sieve.

Crumb Rubber Modifier (CRM) – a general term for scrap tire rubber that is reduced in size and used as a modifier in asphalt paving materials.

Cryogenically Ground Rubber – a process that freezes the scrap tire rubber and crushes the rubber to the particle size desired.

Devulcanized Rubber – rubber that is a complex macro structure material and through vulcanization the sulfur molecules form complex cross linkages between and within the rubber macromolecular structure. Devulcanization is the process by which the sulfur molecules are de-

linked from the rubber molecules and stabilized, thereby facilitating the formation of new cross-linking structures with reapplication of heat and pressure.

Dry Process – any method that mixes the crumb rubber modifier (CRM) with the aggregate material before this mixture is charged with the asphalt cement. This method only applies to hot-mix asphalt production.

Extender Oil – an aromatic oil used to supplement the reaction of the asphalt cement and the crumb rubber modifier (CRM).

Granulated Crumb Rubber Modifier (CRM) – cubical, uniformly shaped, cut crumb rubber particles with a low surface area, which is generally produced by a granulator.

Granulator – a process that shears apart the scrap tire rubber, cutting the rubber with revolving steel plates that pass at a close tolerance, reducing the rubber to particles generally 9.5 to 2.0 mm (3/8 inch to No. 10) sieve size.

Ground Crumb Rubber Modifier (CRM) – irregularly shaped, torn crumb rubber particles with a large surface area, generally produced by a crackermill.

Reaction – the interaction between asphalt cement and crumb rubber modifier (CRM) when blended together at a certain temperature for a certain period of time. The reaction, more appropriately defined as polymer swell, is not a chemical reaction. It is the absorption of aromatic oils from the asphalt cement into the polymer chains of the crumb rubber.

Recycled Tire Rubber – rubber obtained by processing used automobile, truck or bus tires.

Rubber Aggregate – crumb rubber modifier (CRM) added to the hot mix asphalt mixture using the dry process.

Rubber-Modified Asphalt Concrete – a hot mix asphalt concrete mixture with dense graded aggregates using a rubberized asphalt type of binder. (Note: The CRM percentage is generally low (5 to 10%) and is generally the finer mesh (30 mesh or lower).

Rubber-Modified Hot Mix Asphalt – a hot-mix asphalt mixture that incorporates the crumb rubber modifier (CRM) primarily as rubber aggregate. Also known as the “dry process”.

Rubberized Asphalt – asphalt cement modified with crumb rubber modifier (CRM) at less than 15 percent by total weight of the asphalt cement.

SAM – the abbreviation for a Stress Absorbing Membrane. A SAM is used primarily to mitigate reflective cracking of an existing distressed asphalt or rigid pavement. It is usually associated with an asphalt-rubber binder sprayed on an existing pavement surface at .60 gallons per square yard (± .05 gallons per square yard) and immediately followed by an application of a uniform pre-coated aggregate, which is then rolled and the aggregate is embedded into the binder layer. The nominal thickness normally ranges between 6 and 9 mm (1/4 and 3/8 inch).

SAMI – the abbreviation for a Stress Absorbing Membrane Interlayer. A SAMI is the same as a SAM but is applied prior to an asphalt concrete overlay. This overlay may or may not contain crumb rubber modifier (CRM).

Shredding – process that reduces scrap tires to small pieces 0.15 meter squared (6 inches squared) and smaller.

Stress Absorbing Membrane – a surface treatment (membrane) using an asphalt-rubber spray application and cover aggregate. Same as a SAM.

Stress Absorbing Membrane Interlayer – a surface treatment (membrane) generally associated with an asphalt-rubber spray application and cover aggregate, designed to resist the stress and strain of reflective cracking and delay the propagation of the cracks through a new overlay. Same as a SAMI.

Tread Rubber – rubber that consists primarily of tread rubber with less than 5 percent sidewall material (approximately).

Truck Tires – tires with an outside diameter greater than 66 cm (26 inches) and less than 152 cm (60 inches); used on commercial trucks and buses.

Vulcanized Rubber – rubber that has gone through the vulcanization process. This is a process by which an agent, such as sulfur, is added to rubber in the manufacturing process to give the product certain required characteristics, such as strength, hardness and elasticity. Rubber is a complex macro molecular structured material and through vulcanization the sulfur molecules form complex cross linkages between and within the rubber macromolecular structure.

Wet Process – a method that blends crumb rubber modifier (CRM) with the asphalt cement before incorporating the resulting binder for use in an asphalt paving or surfacing project. This terminology is generally associated with asphalt-rubber binder materials.

Whole Tire Rubber – rubber that includes tread and sidewalls in portions that approximate the respective weights in an average tire.