

Why is recycled rubber not used in tyres?



The drivers are all there for greater use of recycled rubber in tyres: Raw materials costs are high and recycle can save money; the environmental message can be used and the technology is very nearly there. But there is still a way to go.

By David Shaw, ERJ Staff, dshaw@crain.com

According to Gopinath Sekhar of SRI Elastomers, there are three barriers to the widespread use of treated or de-vulcanised recycle in rubber goods in general and tyres in particular.

Two of these are managerial while the other is technical. The main technical issue with treated or de-vulcanised materials is the shelf life, but the biggest problems are the managerial and branding issues of professionalism on the one hand, and logistics and volume on the other.

On the technical side, SRI, like a few other companies, supplies a compounding material which is based on a treatment applied to granulate. The treatment is claimed to selectively break the sulphur bonds within the rubber compound.

There are a range of treatments which claim to break the sulphur bonds, but all of them face certain problems. At first glance these treatments lead to fresh compound, but in reality, the compound contains accelerators, excess curing agents and other active ingredients. In many of these treated compounds, these chemicals start to react during storage, leading to substantial reductions in the shelf-life and reducing cure-

safety margins dramatically.

Some experiments have shown that compounds lose over 75 percent of scorch

safety when these up-cycled ingredients are added. Sekhar said, "It can work in the lab, but the manufacturers need that safety margin."

A second issue which is part technical and part managerial is that a lot of these de-vulcanisation processes are carried out on a two-roll mill, or a bank of such mills. A typical batch of 10 - 15 kg takes 8 to 10 minutes to process, so

SRI is now testing tyres made from 'upcycled' granulate

SRI Elastomers was founded by Tan Sri Dr. B C Sekhar and is now run by his eldest son, Gopinath Sekhar. SRI has worked on de-vulcanisation of rubber for over a decade, but the current effort was re-invigorated in 2006. SRI has established production and tests with big-name tyre makers.

Currently the company has re-processed a range of passenger car tyres and truck tyres. SRI Elastomers aims to keep the two streams separate, so that it has a stock of material derived from whole car tyres and a separate stock of material derived from whole truck tyres. Sekhar said the separation of tyres into car and truck categories will be a major hurdle for the tyre disposal industry to adopt, as it adds an extra step to their process and requires more handling and storage facilities. While the de-vulcanisation process is a change, it does not affect the waste handling industry as much as the segregation issue, said Sekhar.

The car tyre material, he said is more or less 60-40 between synthetic and natural elastomers, while the commercial vehicle tyres generate material which is approximately 80-20 NR-SR.

Sekhar said the NR-rich material tends to go back into tyres, whereas the SR-rich material has a range of applications, but is less desirable for the tyre industry. "It would be good to put it back into tyres, but we do not need to do that. There are more than enough applications to consume the material," he said.

Asked if these were low-grade applications like traffic bollards and suchlike, Sekhar said, "It has the same value as the NR based compound but would be more suitable in more synthetic based applications." He said it is being used in automotive components such as anti-vibration mounts and even into sidewall compounds in tyres.

With the NR-rich compounds, SRI has been working hard to get it into commercial truck tyres. The company is working with more than one of the big-name tyre makers, but the companies concerned are subject to non-disclosure agreements, so Sekhar was not at liberty to reveal their names. However, he said, "We are dealing with the top tyre makers. I stopped going after the smaller ones as we do not have enough capacity to deal with them. The larger ones are very demanding and we have done as much as we can."

He said the level of attention from those companies has been gratifying: they are working very hard on the project, but progress is slow, by the nature of the business. Sekhar said the tyre makers are working to timescales of two to five years. Currently, said Sekhar, at least one of the tyre makers has completed advanced laboratory testing and completed small scale tyre building. They have now completed production scale tyre building in both passenger car tyre and commercial vehicle tyres, with road testing underway.

Different types of recycling

There are three broad approaches to recycling post-consumer scrap. Each offers something to the rubber industry, but none is an ideal substitute for virgin polymer.

The first is simple granulate, the second is reclaim and the third is post-processed granulate. Unprocessed granulate is rarely useful for anything other than as a filler used in proportions up to around 5 percent rubber.

Reclaim is an aggressive chemical process designed to smash up long molecules. It ends up as a paste which can be used as a viscosity modifier. Given the cost of NR and the lack of availability in some places, it has gained use as an additive, but rarely in the premium segment of the market or in professional mixing rooms.

Processed granulate, which allows the crumbs to be brought together into a sheet for subsequent processing, is the most promising product, but has drawbacks.

The quality of recycled rubber is controlled by a wide range of factors.

Granulated rubber (which includes buffings)

This is generated from old tyres. The tyres are destroyed by various different technologies, which result in granulate or rubber powder. This powder varies in many ways, such as composition, size, surface area and level of impurities.

Composition of the powder would, in an ideal world, be based around the different components of a tyre so that granulate produced exclusively from truck tyre tread compounds is made from mixtures of natural rubber, carbon black and various chemicals and accelerators. On the other hand, granulate produced exclusively from inner liner material would end up being composed of halobutyl rubber, also mixed with carbon black and some active chemicals.

This level of discrimination is not possible at the current state of the art, so in practice, the industry has three broad types of granulate.

- * The basic and most common grade is granulate made from mixed whole tyres.
- * Next comes granulate made from exclusively car tyres.
- * Next in the scale is granulate made exclusively from truck tyres and
- * Finally there is granulate made from tread buffings.

The materials made from buffings are composed almost exclusively of natural rubber, carbon black and active ingredients. Material sourced from whole truck tyres has around 20 percent synthetic rubber content, including butyl from the innerliner, and SBR and BR from the carcass and sidewalls. Nevertheless, the polymer in this material is typically around 80 percent natural rubber.

Granulate derived from car tyres is usually around 60-40 synthetic and natural rubber. It also contains silica and other materials and is less repeatable in terms of content.

Crumb made from mixed tyres may have content ranging from 60 percent synthetic down to less than 10 percent and is even less likely to be repeatable from batch to batch.

The surface texture of each granule depends on the production process. Cryogenic grinding takes less energy to break the rubber apart, as the rubber fractures, leaving smooth, glass-like surfaces whereas ambient grinding rips the rubber apart, leaving rough textures with a high surface area-to volume ratio.

Size matters

As with most powders, the ratio of surface area to volume matters. On the whole, the smaller the particle size, the better the performance.

Barton said, "You can do more with a 75µm particle than you can with a 400 µm particle. You can get different surface appearance, different tensile properties and different processing capabilities, so yes, size matters."

Reclaimed rubber

Reclaim is an aggressive, energy-intensive system in which rubber powder is cooked with some aggressive chemicals under pressure. The waste products are highly polluting, which means it tends to be more common in countries where environmental regulation is either weak or poorly enforced.

In Europe there is only one supplier of reclaim – Rubber Resources in the Netherlands, part of the ELGI group.

This process breaks long molecules into shorter ones and the result is often a kind of paste. Each batch can weigh around 400kg, and takes around three hours to process. Depending on the pressure, temperature and chemicals, the resulting material can retain some of the properties of the original, but Sekhar said in the end the ability to perform is severely compromised. It does, he added, have a place as a viscosity modifier, but that has become confused as the price of rubber has increased.

Some producers, including RR, are using buffings to improve the quality of the reclaim, but this is limited in application. RR sells this product under its Ecorr RNR grade designation. Elgi/RR wants to expand their recycling activities in India, the EC, the US and in South America but said this can only be achieved with support from the tyre industry.

De-vulcanisation

According to Sekhar there are several technologies which claim to de-vulcanise rubber. The three names which are commonly used are SRI, Lev gum and Watson-Brown. Some systems use high shear without chemicals while others use a chemical process combined with shear to achieve similar results.

What the tyre makers say

Use of recyclate is not something many tyre makers want to speak about. There are a number of reasons for that. Partly it is that people perceive recycled materials as somehow worse than virgin. For this reason, companies in the business use words like Upcycled (SRI) or Regenerated (Watson-Brown).

Second, there are product liability issues. If a company is found to use recycled materials and a product containing those materials subsequently fails, the victims potentially can claim negligence by the manufacturer for compromising the performance of the product by using low-cost ingredients.

Third, there is a desire among premium tyre makers to build the best tyres possible. If their technical departments do not believe that the recycled goods available on the market are sufficiently well-qualified or sufficiently repeatable, then they will not approve them for use in the tyres.

Nevertheless, some tyre makers told ERJ that they are using recyclate in their products.

Michelin said it is working on the subject, but is still some way from using it in its tyres.

Continental said the company does use limited amounts of recyclate in some tyre compounds, but only in proportions of around 3 percent.

A Yokohama spokesman said that in 2010, 1.8 percent of its total elastomer volume was made up of recycled materials. This is being used in tread compounds in car and truck tyres and in race tyres.

The spokesman said Yokohama is working with Lehig, among others, to maintain the physical properties of compounds containing post-consumer scrap.

The spokesman said Yokohama believes in using recycled ingredients in its products and is working hard to achieve this in many different applications. It intends to increase this activity in the coming years.

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Scrap tyres (top left) are chipped or crumbed (top right), then processed into compound strip (bottom right), before being used in tyres (bottom left)



each mill can process up to 100kg per hour, or a couple of tonnes per day at best.

Sekhar said this simply does not produce enough material at viable cost for use in the tyre industry, where even a small retread plant mixes upwards of 20 tonnes per day

He said, "You can use that process (on a mill) for a few kg, but if you have orders for 5 tonnes, or 100 tonnes per day, then you are dead, and these are the issues that have to be overcome."

Recycling business has a poor reputation

The third key issue was identified by Alan Barton, CEO at Lehigh Technologies. He said the rubber recycling industry has a terrible

reputation for professionalism and for knowing what is going into their process and what the process does to the materials. "Coming from speciality chemical industry, I was taken aback getting a view of this industry and realising what a poor reputation it had – and for good reason," said Barton.

Speaking in separate interviews both executives underlined the same three points as being barriers to the increased use of post-consumer scrap in tyres and other products.

Both companies said they are in discussions with various other participants in the field, but declined to mention any names.

At Lehigh, Barton said the company currently provides a range of granulates, most

of which are untreated. These untreated granulates are ground down to fine sizes, which improves the ratio of volume to surface area. Even at that size, however, the company does not expect its customers to use the materials in loadings above 10 percent if the compound is optimised for crumb, but more normally in the range of 3 to 7 percent if it is not.

Only when the powder is treated and formed into a sheet can the loadings be increased, and even then, said Barton, it is unlikely to go above 20 percent in any application. He said, "There is no doubt that a functionalised system would be better than either the powder alone or the reclaim."

He said there are two routes to such functionalised systems. One is de-vulcanisation. This process, he said, can "unzip the cross-links which exist in a compound, in a soft, gentle, low-energy fashion and which allows them to be zipped back up."

Barton noted that "we are involved with people working on that," though he declined to mention any names.

Barton said there are other kinds of treatment in addition to de-vulcanisation. The company has already agreed to work with Dow Chemical's coatings division to find ways to modify the surface of the crumbs in order to make the crumb interact more energetically with the surrounding rubber matrix.

This approach, he said, "appends reactive chemical moieties to the outside of the powder. Instead of unzipping the polymer, you are adding functionality to the surface of the powder."

"Our view of that," said Barton, "is that we can put different types of reactive groups on the outside, suited to plastic application or rubber application or household application." ■

Lehigh treats recycled rubber as a speciality chemical.

When you mention recycled rubber, many people think immediately of low-grade, unqualified materials delivered by an unprofessional and often incompetent supply chain.

Lehigh aims to change that. The company is staffed by people with a background in speciality chemicals, and they are treating the business in exactly that way.

Alan Barton, CEO said, "We saw how the industry was viewed and we felt we had to change that. The way we changed it was to take the speciality chemicals mind-set and apply it to what we are doing. That means employing your own tech team. You need to know more about what you are doing than anyone else does and to back that up with data that is credible and useful."

Barton continued, "You have to have a manufacturing environment that is safe, process-controlled, supply-chain oriented and quality-focused and big enough to be a credible supplier."

"Then," he said, "you have to start working on showing customers how to use the material so that they can get the optimum combination of benefits of performance, cost and environmental benefit."

Lehigh is making headway. He said the employment history and technical background of the Lehigh team instantly wins an audience among many of the potential customers.

Currently, he said, Lehigh is part of the landscape of suppliers of crumb in various size ranges and compositions and different levels of purity and cleanliness. However, the company has a roadmap to deliver more advanced products.

At present the company said it has supplied recycled material used in 100 million road-going tyres – passenger car and truck. The vast majority of that business is in North America.

In passenger car, said Barton, "We have significant business in both replacement and OE tyres across the whole performance range." He said Lehigh exports some material to Asia for use in high performance OE tyres. The company has made public pronouncements about its relationship with Yokohama Rubber Co.

Watson-Brown gets new management, changes tack

A fresh management team is driving Watson-Brown HSM down a new path, but the company remains focused on regenerating post-consumer and post-industrial scrap rubber.

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Watson-Brown HSM has new management and a new strategic goal. The company was founded by Chris and David Brown, and they developed a system for devulcanising rubber using a specially-designed machine which applied high shear.

Their business model was to take high value compound scrap (based on polymers such as FKM, HNBR and suchlike), process it and sell it back to the customers for use as a compounding ingredient in fresh compounds.

Since the start of 2011, the company has appointed a new chief executive – Ken Dowling – and the founders have removed themselves from the business while Dowling has brought in a complete new management team.

Dowling comes from the polyester side of ICI and has brought in a team of industry heavyweights, who understand both the technology and the financial needs of a young business with a pioneering technology.

A technical consultancy contract between Watson-Brown and a company controlled by the Brown brothers lapsed in March of this year and has not been renewed.

A new approach to market

Dowling's approach is slightly different from that of the Brown brothers. He noticed that in many of the high-tech rubber companies that the Brown brothers were attempting to woo, quality, reputation and performance are more important than saving a few euros on rubber compound.

Thus, even though it might have been possible for those companies to save some money using the old business model, the technical and commercial risks were not worth the saving.

The new business model focuses not so much on the technical performance of the material, though that remains as good as ever. Instead, Dowling's focus is on high street brand names who set a significant value on their ability to present a positive image to their eco-minded customers.

The first successful project in this area was the use by the Timberland shoe company of Green Rubber produced by the outfit headed by Gopi's younger brother, Vinod Sekhar.

Although Dowling declined to discuss that project, he acknowledged that the thinking in

Watson-Brown HSM runs along similar lines. Dowling said, "We want to talk to people who use rubber products but who need to be seen to be re-generating their products rather than causing the problem. There are certain companies where that is far more important

than any money that can be saved by using the product in the mix."

He said Watson-Brown is in the final stages of due diligence with a well-known global brand name. He said that if this deal goes through, and he expected that to happen toward the end of 2011, then it would set a seal of approval on the Watson-Brown technology, and that would lead to further work. In the mean time, however, this single big project is absorbing a lot of time and energy.

"The last thing we want is to have hundreds of people phoning us up to do trials. There is a planned roll-out and planned funding and we are not all the way down the road yet." ■

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