Using predispersed fibers to improve OTR tires

By Steven Monthey
Rhein Chemie Corp.

Santoweb-treated cellulose fiber product provides reinforcement for both cured and uncured rubber compounds.

Unlike spherical reinforcements such as carbon black or silica that rely on chemical or van der Waals forces to strengthen the rubber compound, fiber reinforcements have an aspect ratio that give them a directional value to their strengthening of the compound.

The aspect ratio is the length of the fiber divided by the diameter of the fiber and reinforces the rubber compound much like that of rods or wire meshes in concrete. This type of reinforcement is quite efficient so even a small amount of fiber reinforcement can give a significant increase to low elongation modulus and tear strength.

Aramid fiber can also be used to achieve similar reinforcement. The two differences with aramid fiber are its heat resistance and its ability to be split into almost infinitely smaller fibers. Since aramid has an extremely high tensile strength, these very small fibers are still capable of giving significant reinforcement resulting in a noticeable higher surface area and aspect ratio than conventional fibers can achieve.

Executive summary

One of the major causes of premature failure for off-the-road tires is the penetration of a cut so deep in either the tread or sidewall that it reaches the air chamber and flattens the tire.

Predispersed fibers have long been used to improve the performance properties of industrial products such as power transmission belts. Now testing shows that predispersed fibers significantly can improve the cut and chip resistance of off-the-road and other tires that operate in harsh environments.

This paper will present data on both cellulose and aramid predispersed fibers showing their advantages when added to OTR tread or sidewall compounds.

Types of Santoweb products

There are five types of Santoweb products:

- Santoweb D is treated with a black styrene-butadiene rubber binder, modified for bonding and designed for use in natural rubber, SBR, butadiene rubber, polyisoprene and polychloroprene compounds.

  - It contains a resorcinol formaldehyde treatment which requires a methylene donor such as HMMM or HMT to achieve maximum reinforcement. Santoweb D is usually recommended for loadings above 10 percent.

- Santoweb DX also is treated with a black styrene-butadiene rubber binder, modified for bonding and designed for use in natural rubber, SBR, butadiene rubber, polyisoprene and polychloroprene compounds.

  - Unlike Santoweb D, Santoweb DX does not require a methylene donor for maximum reinforcement. Santoweb DX is usually recommended for loadings below 10 percent.

- Santoweb H is treated with a black EPDM binder, modified for bonding and designed for use in EPDM and butyl compounds.

  - It contains a resorcinol formaldehyde treatment which requires a methylene donor such as HMMM or HMT to achieve maximum reinforcement. Santoweb H can be used at any loading.

- Santoweb W is treated with a non-black polyvinyl chloride binder modified for bonding and designed for use in nitrile and silicone compounds. It requires both a resorcinol and a methylene donor to achieve maximum reinforcement. Santoweb W usually is recommended for loadings higher than 10 percent.

For the purpose of this paper we will only deal with Santoweb DX.

Types of aramid fiber master batches

Aramid fibers are categorized by their fiber type and the polymer type in their binder. Their nomenclature consists of Rhenogran trademark followed by the fiber type (either P91 high surface area or P95 normal surface area) then the percentage activity and finally the binder polymer type.

Since the majority of this type of fiber master batch goes into power transmission belts, the most common types are Rhenogran P95-40/EPDM and Rhenogran P91-40/EPDM. Other binders include polychloroprene, natural rubber, nitrile, See Fibers, page 18

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and hydrogenated nitrile.

Unlike some of the Santoweb products, aramid fiber masterbatches do not have any adhesion enhancement. Usually no more than 10 phr loading is recommended for aramid fiber masterbatches.

Proper mixing of fibers

To get the maximum benefit from either Santoweb products or an aramid fiber masterbatches, certain steps must be taken to ensure proper dispersion.

First, for off-the-road tire tread compounds, only 2 to 10 phr loading is recommended. This loading gives the best resistance to cut and chip growth while keeping the tread wear and processing properties as consistent as possible with a normal compound.

Next, the fiber should be added as early as possible into the compound with the other reinforcements. This is important with both the Santoweb products and the aramids to get as much dispersion as possible.

In the case of aramid fibers, they may need to be added into a masterbatch so that additional mixing time can be spent if necessary. All mixing should be done in an internal mixer as mills do not disperse these products in a reasonable period of time.

Why use a polymer bound fiber?

Chopped cellulose fiber and aramid pulp are difficult to disperse unless they are predispersed in a polymer matrix. This is particularly true with aramid fiber.

Aramid fiber has a linear molecule that is very polar in nature, making it extremely difficult to disperse without some kind of binder. The inherent aromatic linear chain gives the fiber a spring-like nature when processed into a pulp. These microscopic aramid springs aggregate with each other and take extreme energy to separate each individual to be dispersed into the resulting compound.

Being polar, aramid pulp is easier to incorporate into polymers like NBR or HNBR but significantly more difficult to incorporate into polymers like EPDM, NR and polybutadiene. As with many other ingredients which have dispersion problems, aramid prepreg is a solution.

Table I. NR compound with 10 phr polymer-bound aramid pulp versus a control with no fiber added.

<table>
<thead>
<tr>
<th>Testing</th>
<th>Control No fiber reinforcement</th>
<th>Experimental 10 phr of polymer bound aramid pulp (5 phr fiber)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML 1+4 @100°C</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>Physical Properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Cured 15 min.@170° C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness (Shore A)</td>
<td>57</td>
<td>74</td>
</tr>
<tr>
<td>10% Modulus (Mpa)</td>
<td>0.53</td>
<td>2.28</td>
</tr>
<tr>
<td>25% Modulus (Mpa)</td>
<td>0.86</td>
<td>3.95</td>
</tr>
<tr>
<td>50% Modulus (Mpa)</td>
<td>1.33</td>
<td>4.49</td>
</tr>
<tr>
<td>100% Modulus (Mpa)</td>
<td>2.38</td>
<td>4.99</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>360</td>
<td>220</td>
</tr>
<tr>
<td>Tear (N/mm)</td>
<td>23.2</td>
<td>29.7</td>
</tr>
</tbody>
</table>

Fig. 3. Low elongation modulus effect for NR.

The author

Steven Monthey is a technical service chemist at Rhein Chemie Corp.

He has 41 years of experience in the rubber industry, with Goodyear, Bandag, Dayco, Cabot and Hercules before joining Rhein Chemie.

Monthey’s background includes work in product design for hose and belt applications, tires and retreads, vibration isolation, medical components and many other rubber segments. At Rhein Chemie in Chardon, Ohio, he is currently involved in the development and marketing of company products used in automotive, tire and medical applications.

He graduated with a bachelor’s degree from Washburn University in Topeka, Kan. Monthey can be reached at steven.monthey@rheinchemie.com.

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Many rubber, plastic and silicone based products can be dramatically improved with fibers. Adding treated or untreated cotton, polyester, pan carbon, aramids and/or nylon boosts performance in a multitude of ways. Characteristics such as coefficient of friction, abrasion resistance, compression set, tensile modulus, temperature control, green strength, cut and tear resistance, noise reduction and many others can be positively altered.

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Zhongding

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“We wanted our people to have as much warning as possible,” Seketa said. Zhongding Sealing, formed by its parent company in 2008, is expanding its noise, vibration and harshness product distribution center in Monroe, Mich., by about 70,000 square feet, increasing its size to about 150,000 square feet, he said. The center is “the North American market. The project is expected to be complete in July. Including the addition, it is a 100,000-sq.-ft. NVH technical center and about 15,000 square feet for the firm’s administrative operation. The majority of the site will be used as a distribution center for the company’s products from China and other plants.

The firm’s U.S. headquarters will eventually move to the Monroe facility from its current location. Zhongding Sealing is closing the Strasburg facility partially because it mirrors the parent company’s production complex in China, Seketa said. “It’s the only plant we operate that actually competes with our operation in China.”

Steve Seketa

Mitas

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Looking to add more tire builders and other staff, the executive said. By year end, he said, the Charles City plant is expected to have 237 employees and production capacity of about 12,500 metric tons of tires a year. Approximately 24 U.S. employees are undergoing training at plants operated by Mitas A.S. in Europe. The company selected Charles City, located in the U.S. agricultural heartland, as the site of its U.S. factory for several important reasons, Chavrut said, including “its Midwestern location, very low costs, high work ethics, and the forthcoming approach of local and state authorities.” It’s also a good place to manufacture its products, he said, because the market in North America is one of the largest for agricultural radial tires both for the OEM and aftermarket segments, he said.

Gross margins are anticipated this year. The U.S. operation will continue to improve “as long as the American farmer’s business grows. Besides, the radial farm tire offers better characteristics when compared with the diagonal tire and when mounted on powerful tractors. So the share of radial tires on the farm tire market is expected to continue growing.”

Mitas tires North America focuses on manufacturing large radial tires, weighing up to half a ton, in Charles City. Parent Mitas A.S., a business unit of Czech Republic-headquartered CGS A.S. Holding Group, makes a wide range of industrial and motorcycle tires, operates three factories in the Czech Republic and another in Serbia.

Fiber

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Santoweb fiber is much easier to disperse but still needs a polymer binder to help fiber couple and create easily into the compound matrix. Advantages of short fiber reinforcement in OTR tire treads

Since short fibers act like wire reinforcement in concrete, they provide several advantages in rubber compounds. First, they provide a stopping point for cutting or cracking when mounted on powerful tractors.

Zhongding Sealing’s parent stepped into the U.S. market in 2008 when it bought Allied-Baltic Rubber Inc. and the Strasburg plant for $4.5 million. It renamed the operation Zhongding Sealing Parts USA and set up its American headquarters at the facility. A year later it acquired Buckhorn Rubber Products Inc. and Michigan Rubber Products Inc. for $8.5 million from Akron-based Myers Industries Inc. to boost its presence in the U.S. The company has continued to grow since then, with its last acquisition coming in October when it purchased Precix Inc., a producer of about 1 billion parts a year based in New Bedford, Mass.

Legally know as Acushnet Rubber Co. but operating as Precix since 2001, the firm produces high-performance sealing products—primarily for the automotive, aerospace, energy and industrial industries—at the company’s 365,000-sq.-ft. plant in New Bedford.

Obituary

To his colleagues he was the ever-gracious gentleman, always ready with kind words delivered with the elegant Teahan touch. To a favorite editor temporarily away from the office, he wrote: "I await the day that you are again the brow-beating dominatrix we all love.” For her help in his epic battles with “the abomination”—the newspaper’s computer system—he annually awarded her a box of premium chocolates. Teahan was inducted into the Michigan Journalists Hall of Fame, received a Distinguished Service Citation from the Automotive Hall of Fame and a Lifetime Achievement Award from the Detroit Chapter of the Society of Professional Journalists.

Jack Teahan

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