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Can this marriage succeed?

Special Edition Three

real QUESTIONS real ANSWERS

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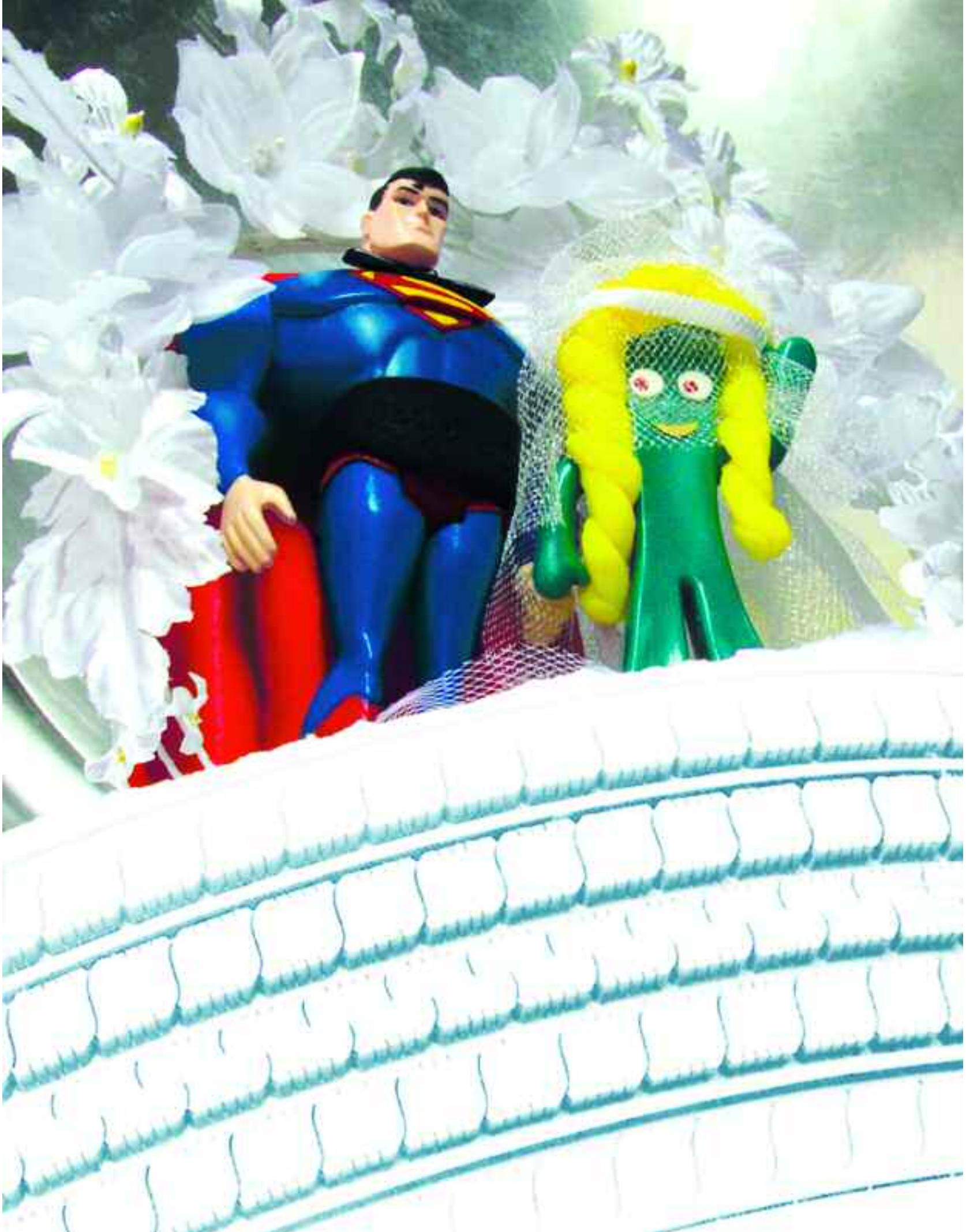
Can this marriage succeed

It's hard to imagine two substances so different. One is hard, heavy and quickly destroyed by water and air. The other is, well, "rubbery," light and – when cured – waterproof and resistant to air.

These differences, as in some marriages, are the very things that make these two work so well together as a team. But first, we've got to get rubber and steel to stick together. And tire makers have found some ingenious ways to do that, as we'll see.



Steel tire cord is torn away from rubber to test the adhesion holding the two together.

Treating steel wire with the metal cobalt – and coating it with brass formulations – helps rubber and steel to adhere to each other.

Coating bead wires with rubber helps keep the coils together and prevents them from rubbing against each other.

What's the advantage of sticking rubber to steel?

As we saw in the last article in this series, the steel superstructure of the modern radial truck tire represented a huge breakthrough in durability and fuel economy. Like the modern skyscraper, today's tires blend the lightweight strength of steel with the resiliency of rubber.

But marrying these two materials was not easy.

Why not?

Steel and rubber don't naturally stick to each other. And when they don't, the steel and rubber parts can tend to move independently. That can result in spaces, or voids, opening inside the tire, where the steel and rubber have separated.

Air and moisture can get into these pockets, rusting – and destroying – the steel. The steel can rub against the rubber, damaging it.

And, of course, when separated, steel and rubber simply aren't working together, which was the whole idea of marrying them in the first place.

Was this a problem with previous technology?

Before steel, tires used cotton, and later, synthetic fibers for reinforcement. Both are composed of tiny, thin fiber filaments. It was fairly easy to get rubber to permeate these cords.

To get the idea, imagine the difference between trying to get bubble gum out of a child's hair, and trying to get it off steel wire. With cotton, everything was so well "bonded" that separation of the cord from the rubber was very rare.

What's the solution?

As it turns out, there are several. For one thing, chemists have found that you can make rubber "stick" to steel more easily if you first treat the steel with the metal cobalt, or plate it with a variety of brass formulations.

And, if you completely encase the steel in rubber, that helps too. Both of these methods are used in the factory.

How?

Let's consider beads. The beads of a truck tire are large, sturdy rings that press firmly against the inside of the wheel to seal in the air.

To make a bead, you take fairly large, stout steel wire and wind it into a big hoop. In a Bridgestone tire, it may take between 40 and 50 turns of wire to make this hoop.

What role does rubber play?

Rubber is extruded around the wire as it travels toward the bead-winding machine. In this way, each turn of wire is "insulated" from the next by a thin layer of rubber.

This prevents the steel from "chafing" against itself as the tire undergoes stress, preventing damage to the bead.

The rubber also helps the wires in bead bundles stick together. Try winding some stiff wire into a coil without something to hold the strands in place, and you'll see what we mean.

And, of course, because the entire bead bundle is coated in rubber, the rubber on the outside helps bond the bead to the rest of the tire.

Steel cords are arranged parallel to each other and squeezed between heated rollers in a "calender" to coat the cords with rubber.

As the steel and rubber "fabric" comes out of the calender, it is wound up on rolls.

What about the steel in other parts of the tire?

The steel cord in the body ply and belts is a kind of "cable," made of multiple, fine strands of steel wire. Like string or rope, it's twisted together.

To make belts and body plies, steel and rubber are fashioned into a kind of "fabric." Individual strands of wire are carefully aligned with each other, then squeezed together with rubber between giant heated rollers called a "calender."

The result is something that looks a lot like black cloth. But unlike cloth, it's not woven. That is, all the strands of steel run parallel to each other, and there are no strands crossing at right angles.

Everything is held together by the rubber, which is on the top and bottom and between the strands, and which permeates the twisted steel fibers.

Is there just one kind of rubber and steel "fabric"?

Not at all. Body plies, which form the main structure of the tire, use different sizes of cord and different spacing between them than the reinforcing belts that go under the tread. Belts can vary in the same way.

And, different tires can use different types of belts and body plies. In some, the steel cords are wound less tightly, to create stiffer shapes that resist deformation. This is typical for tires used on the highway.

In others, the steel cords are wound to absorb stresses, so that they can "give" when they encounter obstacles. This kind of design is used for on/off-highway tires, which have to roll over uneven, rocky surfaces.

Like the fable of the willow and the oak in the storm, these cords "go with the flow," preventing them from being damaged – or even broken – by rocks and other hazards.

And the rubber also helps this fabric bond to the rest of the tire?

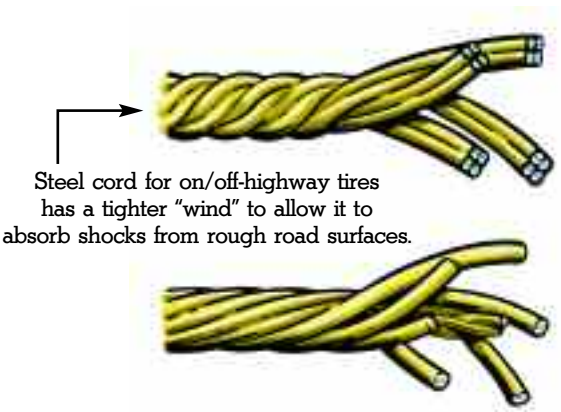
Exactly. As we discussed in a previous article in this series, part of the beauty of rubber is that it can chemically link itself together when it's cured.

As assembled, the tire may consist of different parts: tread, undertread, belts, body plies, sidewalls, bead fillers, innerliner, etc. But once the curing process is done, these "parts" are chemically bonded to each other.

Sort of like "glued" together?

Much better than glue. Chemical bonds link every bit of rubber to the bit of rubber next to it. In a way, it's like a chain: individual links, but one entity.

It's another reason the marriage of steel and rubber is so successful in today's truck tires. RA



Steel cord for on/off-highway tires has a tighter "wind" to allow it to absorb shocks from rough road surfaces.