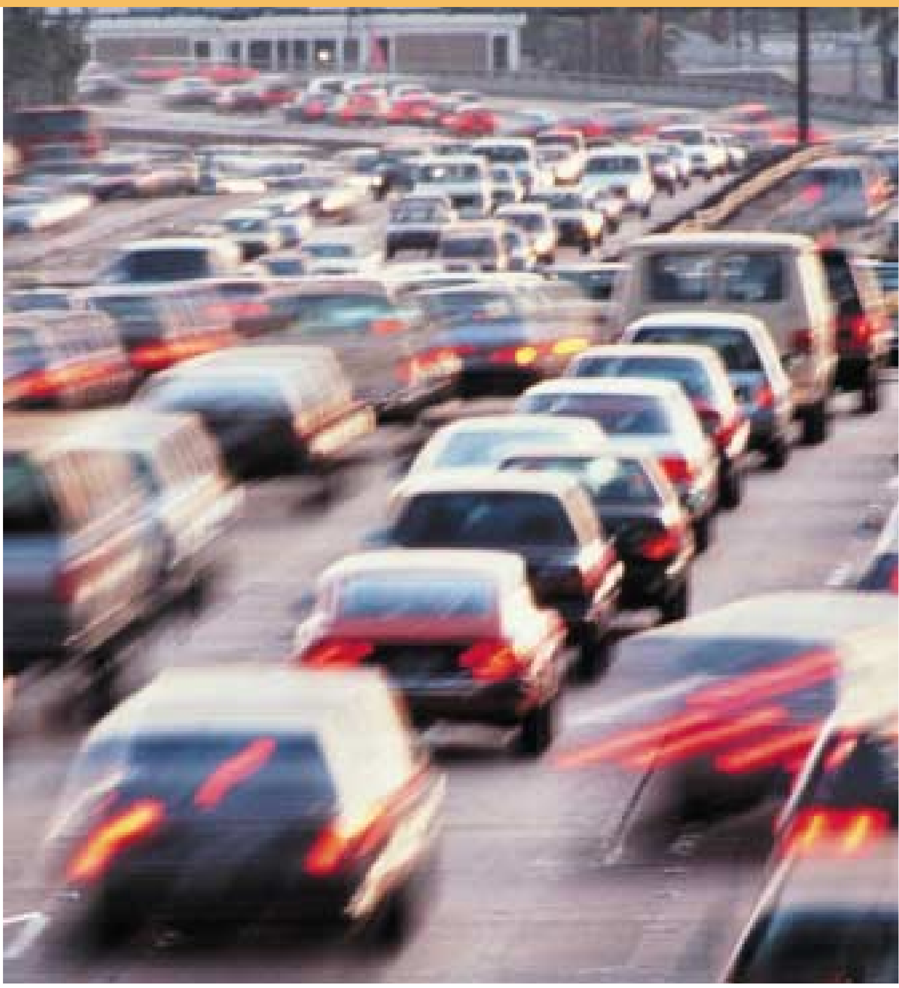
For every action there is an equal and opposite re-action. If that sounds familiar, it should: that old theorem - one of the building blocks of Newtonian physics - explains a lot about the world we live in and the way things work. Why a rubber ball bounces, for example. How a skater can move on ice. And one of the things it explains best of all is: how car tires work… and why they fail.

If rayon didn't exist, we'd have to invent it now…."

When it comes to keeping cars rolling, rayon 'beats the heat'



That's important, because, though we are not always fully aware of it, we entrust our lives to tires. Every time we move out onto the road, the only thing separating us from the brute forces of the asphalt are four rapidly re-acting patches of reinforced rubber.

A good car with bad tires will not provide anything like "pleasant motoring", and will eventually behave like a skater on blunt skates, like a rubber ball that is egg-shaped instead of round. In fact, the decades of remarkable safety- and comfort-enhancing technology that go into today's cars in the form of 'smart' suspension, special subframes, ABS and power steering, have little or no value when the tires fail to perform.

It is fascinating to see how technological developments in cars and tires are closely linked. A car may be a miracle of technical engineering; without the right tires, the driving characteristics will be poor.

The automotive industry has long served a spearhead function. Here technology has advanced at a pace equaled in few other sectors. “Today’s family car,” says Brún Jelsma, market consultant for Cordenka - the world’s leading manufacturer of rayon carcass reinforcing cord - “outperforms the sports car of the 1970s. And that’s not just a matter of pure speed. It also has to do with the ability to control that speed, with the agility of a car that has been vastly improved by advances in suspension, steering, traction-control and braking.”

In recent years, car manufacturers have gone back to the drawing board again and again to meet what Jelsma calls “new requirements constantly being superimposed on a set of already existing ones.” New mechanics and electronics have been applied to responsibly push the envelope of safety and performance. Today’s consumer, after all, expects his or her car to be safe, to be fun to drive, to produce no useless vibrations, to have quick response and to perform consistently over time… at any time that performance is needed.

Dimensional stability

And that, Jelsma says, is exactly where tire technology comes in. Ideally, the reinforcement element in tire carcass construction addresses precisely those issues: by ensuring a controlled and lasting tire geometry, reinforcing materials should serve the aims of preventing vibrations, ensuring agility and guaranteeing those merits throughout the entire working life of the tire.

Tire-reinforcement technology, in other words, should be all about the development and proper application of dimensionally stable materials. Cords for carcass reinforcement should stay unaffected over tire life till the very last kilometer, whatever happens to the tire during its lifetime. Only then can the agility promised by the car manufacturer to the demanding driver be truly delivered. One illustration of why tires should be considered an integral part of the car’s suspension system.

The greatest enemy of dimensional stability is heat. It starts in tire production with the high temperature of the rubber curing. The carcass cords should keep their length, and not shrink. When driving, heat is generated by the “hysteresis” of the rolling tire. That heat raises the temperature on top of that resulting from the ambient air and the contact with a hot road. The carcass cords should react to force variation as if they were still operating at room temperature (“modulus” not affected by temperature) and should keep their initial length over the whole tire life (no “creep”).

Rayon, polyester, polyamide (“nylon”), aramid and steel cord, the materials used in tires, have all their own physical properties and react differently to load and heat.

The strengths of rayon, polyester and polyamide cords are all fit for use in the car tire carcass.

Aramid, in fact, has far too much strength, but could - theoretically - be used in existing, modern tire technology. It would, however, lead to over-engineering and therefore raise costs unnecessarily.

Steel cord is also much too strong for the car tire carcass; in addition, it does not easily fit with today’s car tire carcass technology.

In unique simulation tests, Acordis has subjected rayon, polyester, nylon and aramid to a comparison.

- **Heat shrinkage** (due to the curing process) is negligible for rayon and aramid. This is not the case for the thermoplastics polyester and nylon. Freedom from shrinkage is necessary for tire uniformity, i.e. for a perfectly round and straight tire (“no vibrations”).

- **The dynamic stiffness** in the longitudinal direction of rayon and aramid cords is much higher than that for equally strong polyester and nylon cords. That applies even more to circumstances in which tires get hot. In that case tensile stiffness of the *thermoplastic* materials decreases substantially - a sharp contrast with the *thermostable* rayon and aramid. What this means is that the contribution to the agility ("direct response") of the car Is best with rayon and aramid, and is guaranteed even in tough conditions.

- Rayon and aramid barely exhibit any **creep** in the simulation of the time effect of load and heat. Polyester and nylon, on the contrary, do.

The integrity of the initial length of the carcass cords guarantees uniformity and agility over the whole tire life.

Four materials were compared. For the industrialized countries only two play a role for the car tire carcass: rayon and polyester. Nylon has almost completely disappeared from the car tire carcass, logically in view of the foregoing. Aramid scores on all items, but the hi-tech fiber has such a strength level that adoption of it in the car tire carcass would lead to over-engineering and, consequently, waste of money.

Rayon scores well on all points. The very modern polyester tested clearly lags behind, even though - admittedly - a HMVLS (high modulus very low shrinkage) fiber of this type is a clear improvement over the original, high-strength polyester.

The Acordis simulation tests illustrate the thermostability of rayon and aramid. They also illustrate the fact that thermoplastic materials like polyester and nylon suffer from heat - whatever tricks spinners, dippers and tire makers may apply in order to alleviate those effects. Unfortunately, such procedures often bring with them other, undesired effects (e.g. sidewall indentation as a result of post-cure inflation).

The conclusion is clearly that, when it comes to car tire carcasses, rayon is the perfect link with the road in the sophisticated suspension and steering system.
Rayon complies with the criteria for "Quality": it **is** good and it **stays** good. (It performs as if it were the high-tech fiber aramid, but at considerably lower costs.)

Flat spotting

Rayon's excellent dimensional stability, Jelsma notes, also makes the material practically insensitive to what is referred to as "flat spotting". Flat spotting can take place when a heated car tire is left to stand still for a longer period of time. Reinforcing materials with a lower dimensional stability will then form a flat "footprint" at the spot where the weight of the car has pressed the tire against the ground. As a result, when the car is driven again, the driver may experience the sensation of tires that are not perfectly round. When not familiar with this phenomenon, the driver may even think that his expensive car (brand) has shortcomings in ride and handling.

Acordis developed the simulation testing in the second half of the nineties, when they compared the four materials in terms of hysteresis ("heat generation"/"energy loss") under dynamic load.
The similarity between rayon and aramid was immediately apparent: both materials generated little heat at elevated temperatures. Polyester and nylon turned out to generate significantly more heat at an elevated, but still realistic, service temperature. In other words, as Jelsma puts it: "The structure of wet-spun rayon and aramid is more stable even at high temperature than that of the melt spun polyester and nylon. Rayon and aramid are thermostable ".

Based on the above-mentioned test results, and the obvious advantages they imply in terms of both safety and performance, Jelsma says he advises everyone to look at the side-wall when buying new tires and to make sure there is "rayon inside".
"Rayon's in-tire dimensional stability makes for finer motoring, by ensuring the permanence of properties and uniformity over the tire's life.
This results in impeccable ride, fine cornering behavior and best vehicle handling… crucial characteristics of today's technologically refined cars.
So an economically viable tire cord that 'beats the heat' when it comes to dimensional stability and dynamic stiffness is really the perfect complement to today's automotive high technology. In fact, if rayon didn't already exist, we'd have to invent it now…"

(Details of direct comparison of rayon with polyester are presented under www.cordenka.com, Service page, section Presentations 15.01.01 Paper Expo 2001 Cannes)