The Invisible World of Automotive Textiles

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You may think that comfortable seats and plush carpets make up the majority of textiles in your car, but actually many of the textiles used in modern vehicles are invisible—concealed away under the hood, or in the console panels, hidden in plain sight.
Why Add Textiles?

Why are automotive manufacturers adding more textile components to vehicles? They need to reduce weight to improve fuel economy, reduce emissions, and to comply with stricter standards concerning recycling and the manufacturing carbon footprint. It also makes economic sense to be more efficient and sustainable. Conversely, greater use of technology in a vehicle can add to the build weight. As demand for more connectivity and smart tech increases, can manufacturers find weight savings and increase sustainability by using even more textiles?

Car as Mobile Computer

“I view the automobile an information processing engine that also transports individuals from point A to point B,” says Sundaresan Jayaraman, Kolon professor and director of the Kolon Center for Lifestyle Innovation at Georgia Institute of Technology’s School of Materials Science & Engineering. “The moment you make this paradigm shift, and view the car as an information processing engine (aka computer) and not just as a transporter, the opportunities for innovation are limitless. Also, textiles are an integral and significant component of today’s automobile. So, it is important to leverage that unique position and presence to contribute to the concept of the connected car.”

A Brief History of Car Comfort

It’s 1976, it’s the hottest summer on record, and I’m sitting on the back seat of my dad’s big red Ford—a small child sticking to the vinyl leatherette fabric. No seat belts, no head restraints, and certainly no airbags. Noise reduction consists of nylon carpeting—minimal to say the least.

Thankfully, automotive textiles have come a long way. These days, smart seat belts that tighten when you brake and airbags that fold down into the smallest side panel come as standard equipment in new cars. Then there are noise reducing, fully recyclable plush carpets and head-linings. Seats today have head restraints, heater elements, lumbar support, and pocketed coil springs. Add new technologies such as stain-resistant seat covers, and smart fabrics that monitor the driver’s health and temperature, and you have an interior that is comfortable, safe, and designed for the modern commute—or for when that ice-cream gets dropped by the grandchild.

The driving experience of the last few years has seen some dramatic changes, from the introduction of foam seats to the use of radar-activated pre-crash systems.

Beginning the Journey

The first cars used coach seats passed down from the horse-drawn carriage, made from horsehair, webbing, and springs. By the 1930s, some cars had inflatable cushions (that were prone to punctures). Panels were metal or wood, and often handcrafted.

It isn’t until the 1960s that foam rubber is widely used as seating, with plastic replacing wood.
fashions appearing in the homes of baby boomers.) The industrial assembly lines of the 1970s saw expanded foam rubber as the most common filler for automobile seats, often with internal springs, and leather-look vinyls took the place of more expensive leather for sedans.

The 80s and early 90s saw cars and their interiors undergo a revolution. Sculpted seats, plush carpets, and velour headlinings suddenly became the norm. Lean manufacturing extolled efficiencies, with auto-factories assembling seats in line with the Japanese model of *kaizen*—a natural progression from the assembly line first instigated by Henry Ford. Seats, panels, and other components were delivered to the assembly lines “just in time” to be fitted into the vehicle. Laser cutting replaced dies for more efficient and precise fabric pattern cutting, robots were utilized in both durability testing and assembly (such as spot welding of seat frames), and modern safety features such as seat belts, airbags, and head restraints became standard.

By the 2000s, new regulations by federal governments (such as the EU) enforced recyclability and lower carbon emissions upon manufacturing. (For example, since 2015, EU quotas for the recycling of materials derived from scrapped vehicles are 95% recovery with at least 85% reused and/or recycled materials.)

**Are We There Yet?**

Now in the 2010s, increased awareness of sustainability and recycling targets drive the sales of hybrid fuel and electric cars, and vehicle interiors are changing again. This time, the revolution is with smart technology. Full integration is provided for personal devices, satellite navigation systems, cell phone chargers, and tablets. Radar can help the driver park the car, or trigger active safety devices in the event of a collision. Health monitoring seats synchronize with in-car systems, increasing ventilation automatically to keep the driver alert. And let’s not forget the continuing progress with completely autonomous, driverless vehicles. Manufacturers claim that you will no longer be the driver, just another passenger who can either relax into their smart seats for a massage, or continuing working in your portable office with full connectivity.

Automotive textiles are also changing. Natural composites of wood and flax make panels and consoles; coil springs and wool are inside executive seats; nanotechnology is used to keep seats clean and fresh; and seat belts not only think for themselves, but also are being re-engineered for better stretch and fit.

As I sit in my air-conditioned car, with contour-sculpted seats, synching my cell phone and checking my SatNav, I wonder what that little girl from the 1970s would have thought of the modern automotive experience. Even if we can’t know for sure if the future is bright—it’s certainly going to be connected.

**Fabric as an Information Infrastructure**

“The traditional view of textiles is that they protect and make individuals or surfaces look good,” Jayaraman notes. “My view is that a fabric is an information infrastructure that also protects and makes you look good. In other words, the yarns in the fabric can be used for transmitting information, say from sensors, or power, say from batteries. Moreover, the fabric itself can act as a sensor. This combination of a textile fabric being a sensor and/or a databus makes it a ‘meta-structure’ and can be deployed for multiple applications in the connected car. Advancements in conductive and optical fibers enhance the features of these fibers, thereby contributing to their increasing use in the automobile of the future.”

In terms of the driving experience, Jayaraman sees two main areas that will have the greatest impact—health and comfort, and driver safety. “In terms of the impact of smart textiles on the user, i.e., driver, smart textiles will enhance the experience for the driver in at least two ways,” Jayaraman says. “First, they will make the experience more comfortable; for instance, the ergonomics of seating can be enhanced depending on the user’s comfort level by measuring the pressure on the seat and back by the smart fabrics in the seats. The lighting of the interior panels can be enhanced through the optical fibers integrated into the structure. Smart textiles will also enhance the safety of the driver; for instance, sensors integrated into the car seat or the seat belt can monitor the driver’s weight, profile, and position, and accordingly control the deployment of the air-bag to minimize potential injuries to the driver from the deployment.”
Smart Seatbelts

When Jayaraman talks about how seat belts are becoming “smart” by using sensors and active safety features, he’s not discussing the future—some of these “smart-belts” are already in production. Current pre-tensioner systems work when a sudden change in mass (a collision) activates a pyrotechnic, retracting the belt, thus tightening and restraining the occupants so that they are in optimal position when the airbags deploy. Autoliv of Sweden, the world’s largest automotive safety supplier, has recently developed smart seat belts that work in combination with laser radar systems fitted to the vehicle. A motorized reversible pre-tensioner tightens the slack in the seatbelt when the vehicle detects an obstruction, and if no action is taken, the braking system activates. This is effectively a “pre-crash” system.

Nissan is working on a system they call “intelligent seat belts.” Their smart belts adapt restraining force on the occupant to the crash severity. Sensors under the seat weigh each occupant and calculate the load and restraint that are required for the relative size of occupant. However, seat belts must be comfortable too—or people won’t use them. Seatbelt webbings are made from polyester—which has better resistance to UV light than nylon—and are usually woven in plain, twill, or satin weave. However, in Japan, Nissan has been developing a herringbone weave, which they say will make seat belts more comfortable. In their “low-friction seatbelt,” the weave of the webbing changes from a regular weave to a variable herringbone. Nissan estimates improvement in flexibility by softening the sash portion to give a more comfortable feeling will result in a 20% reduction in tightness and a 10% reduction in the “pull force” required to slide the belt through the hoop. Nissan hopes this reduction in forces will reduce tightness during wear and encourage seat belt use.

Airbags

Radar systems and smart seat belts are examples of active safety systems—whereas standard seat belts and airbags are passive safety systems. All airbags must be both very strong and lightweight enough so as not to cause injury upon deployment. They are usually made from nylon 6,6 yarn in deniers of 420-840 (finer deniers of 235 are also used).

How does the nylon used in automotive textiles differ from other materials? “The nylon has similar properties to that used in some other applications,” Autoliv’s global textiles project team leader, Tom Hajkus, says. “However, the final specification is specific to airbag fabrics and is qualified individually for each product. The quality specifications and requirements are often stricter for airbag fabric use than for other uses.”
Recycling is a major factor in Autoliv’s manufacturing processes. “Recyclability is always considered and a significant amount of our waste and scrap is recycled. Our products are labeled to reflect the recyclability of our products after use,” Hajkus says. “For the nylon recycling, most of the scrap and waste occurs during the cutting process. Any recyclable material is sent to an external recycling company. We have several different technologies (combinations of construction, yarn, and coating types) and the recyclability depends on these.”

One innovation under development at Autoliv is in rear seat belt design. By manufacturing both airbags and seatbelts, they can provide integrated solutions and are currently developing the “bag-in-a-belt” rear seat belt. Here the webbing on the sash is part extra wide seatbelt, part air bag, which deploys in a collision. A gas generator forces several layers of webbing, held together by deliberately weak stitches, apart—giving a greater surface area to distribute load over the occupant’s ribcage.

Head Restraints

Pre-crash systems also feature in the latest head restraints. US car seat giant Adient (a spinoff of Johnson Controls) has developed a head restraint that uses “passive whiplash protection.” The “riACT” includes a pyrotechnic igniter to move the head restraint forward at 50 mm per second in the event of a crash. This coordinates with other pre-crash systems to minimize spinal injuries with adjustments to side wings and tilt made manually, or by built-in electric actuators connected to the seat control unit. “Pour-in-place” foams produce the head restraints with the mechanics and cover placed into a form and low-density foam poured in. Part of the substrate can use recycled PET.

“The systems which are in production are triggered by the vehicle sensors and deployed by a pyrotechnic igniter,” says Adient’s director of innovations for safety and comfort modules, Oliver Alber. “The function principle is that the igniter heats up a certain volume of air in a sealed volume which then expands and moves the head restraint towards the occupant’s head. The forward displacement of the head restraint is put into motion in 15-20 milliseconds, effectively minimizing injuries to the cervical spine.”

The riACT system has been in production since 2005. “While head restraints contribute to a safe and comfortable driving experience, weight and design are also major influencing factors,” says Alber. “We fulfill the highest expectations of automakers and drivers for these products and work continuously on optimizing these areas.” RiACT is currently in production in the BMW 5 and 7 series in the high-end seat versions (comfort seats). “This version is called riACT Gen 3,” says Alber. “We also have another version in pre-development which is called riACT Gen 4. The function principle is the same; however, it is slimmer than the Gen 3 model. This allows for better packaging conditions, especially for slim and sport seats with integrated headrest. Also, the deployment time is reduced to 10-15 milliseconds.” Alber says that the riAct Gen 4 would be coming on line in late 2018.

The Supporting Cast

Many of the components in a vehicle that are textiles, or have textiles as reinforcements, are all around you, taken for granted. If the seats and carpets are the glamorous leads of the automobile interior, then consoles and panels are the supporting cast. Armrests and consoles continue to evolve
into connectivity devices, with ports, cup holders, and cell-phone chargers. Decorative features such as stitching and high-end fabrics like leather are available as options, with manufacturers such as Adient creating modular designs with different customization, thus increasing the flexibility of the design.

**Panels**

Creating sustainability through increasing the use of natural fibers in the automotive manufacturing process has become very popular in recent years. Lineo of Belgium is producing a non-woven that uses pectin (the same substance that makes fruit jelly set) to bind together flax fibers, creating a composite designed to replace polyurethane and glass fiber compounds, used in side panels, trims, and rear seat panels. Flaxtape has a weight reduction of approximately 50% compared to traditional materials such as polyurethane, and is 100% recyclable.

Faurecia Automotive Seating equipped 2017’s Car of the Year, the Peugeot 3008, and also manufactures automotive panels and consoles. With their partners, Automotive Performance Materials, they are focusing on reducing CO₂ emissions during the manufacturing process by using bio-composites to replace traditional polyurethane foams. Their product, Naflean, uses 20% hemp fibers, in combination with polypropylene, to create a weight-saving and fully recyclable, injectable composite used in automotive interiors. Hemp is mostly organic in that it requires no fertilizer to grow and has a small carbon footprint. Its long fibers are durable and rot-proof, traditionally used for ship’s ropes. Head of Media Relations, Eric Fohlen-Weill, sees technology as the future.

“Comfort and connectivity will be essential tomorrow,” Fohlen-Weill says. “The automotive industry is undergoing a technological revolution in terms of connectivity and autonomous driving.”

**Back-Stage Textiles**

Finally, we have the back-stage textiles—those invisible vital components that keep the show going. Non-woven filters, knitted hoses, wheel liners, carpet backings, and flexible fuel tanks are always in the background, unseen. Not glamorous, but they are essential.

Arville, a family-owned company from the UK, specializes in supplying technical textiles worldwide to automotive manufacturers. Their fabrics reinforce mechanical rubber goods such as hoses and flexible fuel tanks. They also coat, waterproof, and seal fabrics ready for manufacturing uses.

Arville’s Head of Marketing, Andy Smith, says that cutting fabrics on the bias is important for reducing waste and costs for their customers. “We have special machinery [which] allows us to produce bias cut fabrics very efficiently,” he says. “Some textile reinforcements can offer great tensile strength, but because of their fiber type (e.g., aramids) and their woven construction, they have very low elongation in the warp/weft directions, which can limit how well they form into complicated shapes. Hose manufacturers can get around this by using the fabric on an angle (bias) but this can lead to extra waste. By offering fabric which is pre-cut on a bias at a specified angle, we can reduce their material waste and improve production efficiencies, with often significant cost-savings.”

Environmental concerns are especially important to Arville. “Arville is committed to running its business in a responsible, environmentally sound, and sustainable manner,” Smith says. “We recognize that our supply chain, processes, and products have both direct and indirect environmental impacts. We seek to identify these, and to find effective ways of eliminating or reducing them.”
Besides sustainability, innovation is also important to Arville. “We are continually innovating,” Smith says. “At the moment, we are working on developing a fabric with a unique weave construction that behaves as a hybrid between a woven and knitted fabric, with low elongation in the warp direction and high elongation across the weft. The benefits to the hose market would be a high strength fabric with excellent formability for complicated shapes.”

What the Future Brings

Jayaraman, who is involved in the creation of smart fabrics, summarizes his views on the driving experience. “The textiles in the car’s interior can serve as an effective platform for the integration of sensors and processors to significantly enhance the comfort and safety of the driver,” he says. “When the data from these sensors are integrated into the automobile’s data system, which, in turn, are connected to other automobiles, the connected ecosystem will give new meaning to the driving experience.”

Jayaraman sees smart tech and textiles combining to create multitasking car components. Fabrics can be integral parts of the web of connectivity within vehicles—sensing and activating systems autonomously. New bio-composites drawing from natural fibers, such as lignin, wool, and hemp, are enhancing the sustainability and recyclability of these components, and innovative technologies are cutting waste and reducing costs for manufacturers. Although hidden from view, these textiles benefit us all through enhanced safety features and added comfort. These benefits extend outside of our cars and into the wider environment. The increasing use of “invisible” textiles in our cars carry benefits that are clear for all to see.

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