ADDING VALUES

Upholstery Concepts for Automotives using Smart Textiles

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Abstract

New textile materials are constantly being brought into the automotive field, and automobile design is a leader in innovative and spectacular developments where smart textile materials are used. The main elements of the current project are textile material research, automotive research, design and development of two upholstery concepts for automotives using smart textiles. The added values are RFI/EMI (Radio Frequency Interference / Electro Magnetic Interference) shielding qualities, light emitting, light reflective and antistatic qualities. Values in the smart-textile area are obtained through choice of material and textile techniques.

Transportation textiles are considered high performance technical fabrics, but they must also meet the aesthetic demands of the market. In the current project the design is inspired by Japanese architectural thinking and strives to relate to outdoor environment to reduce the border between indoor and outdoor environment. The inspiration source is water surfaces. The colour setting is also inspired by water surfaces. Material selection is based on the chosen added values, material qualities, appearance and availability.

The result of the work is two different upholstery concepts visualizing qualities of smart materials and requests the automotive field.

Sprinkle is an upholstery with light emitting, light reflective and antistatic values. The materials used are monofilament, polyester and electroluminescent wires.

Wave is an upholstery design with antistatic, light reflective and RFI/Emi shielding qualities. The materials used are stainless steel yarn, rubco and monofilament.

Keywords

antistatic, automotives, conductive, electroluminescent wire, metal, smart textiles, RFI/EMI shielding, upholstery, weaving
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**Introduction**

Parts of the textile field are rapidly changing as a result of the introduction of a new range of textile materials, so-called smart textiles. Smart materials, with their reversible characteristics, respond to stimuli, e.g. light, temperature and electrical fields by changing their form, their colour or their viscosity.

This field is now introducing new types of textile materials; such as conductive textile materials, colour-changing materials that react to environmental stimuli or various shape-memory materials. The use of smart materials is a dynamic and innovative area merging research, development and use.

The textile design field with new types of materials and techniques will open up new ways of creating and controlling through development of products with increasing levels of functionality. These may include structural and non-structural functions, individually and in combination, both active and passive. It will apply both to large structures, fixed and mobile, and to consumer products, such as textiles and clothing. Smart materials will play a critical role in this development (Braddock & O’Mahoney, 2005).

**Innovative automobile design**

New textile materials are constantly being brought into the automotive field, and automobile design is a leader in innovative and spectacular developments where smart textile materials are used. Although the vehicles themselves become smarter, the level of integration of smart textiles is low and so far smart textiles for automotive use have just scratched the surface (Fung, 2001).

A smart textile suit can e.g. provide a lot of information on the driver. It can indicate the level of thermal comfort of each individual passenger, the level of concentration on the driver, reduced awareness and much more. All these parameters have a direct impact of the quality of driving. Ultimately, the suit could inform the vehicle that it is not allowable to continue driving.

A recent example of innovative automobile design is the Senso model that was showed by the Swiss design and concept powerhouse Rinspeed at the 2005 motor show in Geneva. The Senso model detects and influences the mood of the driver and responds positive stimuli if the driver is in a bad mood. A biometric watch measures the drivers’ pulse and a mobile eye camera records his driving behaviour. The collected data are evaluated in a computer and the vehicle then responds with different stimuli such as light or acoustic...
stimuli (Ritter, 2007).

Another example of innovative automobile design is the Maybach 62 that has an integral electro transparent panoramic roof that, depending on the exterior light, changes between transparent to dark to protect the interior (Ritter, 2007).

This paper gives an overview of the functions that can be achieved by smart textiles in general. In vehicles as well, smart textiles can introduce new features. The project deals with the issue of automotives and smart textiles and presents two upholstery designs with added values directed for automotive applications.

**Aim**

The aim of this project is to design upholstery concepts for automotives using smart textiles. Values in the smart-textile area will be obtained through the choice of material and textile techniques.

**Definition**

The design work will include research on how automotive experts view colour and trim including current issues and future prospects.

The design is inspired by the Japanese architectural thinking where the border between indoor and outdoor environment is bridged through the choice of material and organically shaped design to achieve an appealing surrounding (K-Special). The design is inspired by water surfaces both concerning surface structure and colour setting.

**Scope of work**

This Degree Project has been carried out through research on both smart textiles and automotive colour and trim, using literature studies, study visits, interviews and information search on automotives and smart textiles.

Results from previous research on automotive uses of smart textiles are extended through further research and through interviews. The upholstery design is based on research and on a market analysis. Artistic development and woven samples have been produced to visualize design ideas in order to achieve a final design for upholstery concepts for automotives using smart textiles.

**Previous design projects**

In my previous design projects I have worked with upholstery for vehicles.

One project was “Upholstery for car seats. Designs with a feminine expression for Volvo XC90” where a design on upholstery for a certain car was carried out. It was an experimental and an investigational project and its focus revolved around expression.

Secondly I designed and produced seat upholstery for a public long distance bus in co-operation with Väveriet in Uddebo.

In the third project, added values for upholstery regarding the smart tex-
tiles area were investigated. Research on smart textiles was focused on automotive uses, and resulted in a material tool box with experimental samples, new material and research data on “added values”.

Values added to upholstery using smart-textiles is an issue that I find particularly interesting, and this project integrates the knowledge achieved in the previous projects. Research data, textile knowledge and aesthetical capability are brought together to design upholstery concepts for automotives using smart textiles.

Upholstery concepts are a visualization of functional and artistic values for automotive upholstery.

AB Ludvig Svensson

AB Ludvig Svensson, a leading textile manufacturer situated in Kinna in Sweden, produced and sponsored the upholstery designs created in this Degree Project.

The support and help from AB Ludvig Svensson has been extraordinary and instructive throughout the project. The opportunity to get inputs and support from a company where innovative function meets modern design has been very valuable.
The following chapters provide a textile historical survey, an introduction to and a discussion about smart materials and finally an overview of current smart materials suitable for textile applications.

Entering the textile field is entering a field constantly changing. The development from handicrafts to industry was the start-off for what is happening within the field today.

The Industrial Revolution began with textile manufacture, with spinning machines and mechanical looms. The work has moved on from the home to the factories. Cotton took over from wool and linen as the most important material and increased production was accompanied by a bleach and dye industry which formed the basis of the modern chemical industry. In this way, the new type of production and textile products engendered significant changes in all realms of society (Gervers, 1977).

Similar changes are now occurring based on developments in data-, gene-
tic- and nano-technology. Research and knowledge about intelligent materials and smart textiles is spread over a broad spectre. Progress is being made in the aviation and space industries, the weapons industry, advanced textile industry and more (Smarttextiles).

This paves the way for new potential in the field of textile design with new possibilities in the way of experimentation and co-operation in relation to other professional environments (Ritter, 2007).

Until now, fashion designers and designers of sports clothing have been quickest off the mark in adopting current innovations. Architecture is another professional field in which textile materials and techniques are used both on exteriors and in interiors in highly unorthodox ways. The same applies to other more space-oriented forms of expression, such as dramatic arts. In addition different textile techniques and materials are being tested in acoustic research.

Textile materials are good bearers of new technology, because textiles are used in a great extent in our everyday lives. Integrating technology in textile materials makes the technology more accessible and less intimidating because human beings are comfortable with textile materials: “...textiles seemed like an interesting material to work with, as it is a material that we often think of as soft, warm and something we like to have close to our bodies” (Ernevi et al, 2005, p.47).

In some cases technology is incorporated into textiles, in other cases technology is transformed into a textile material; for example substrates can in the form of fibres or yarns, making them manipulable.

The following chapter summarises some classes of material that I through my research work found are commonly being referred to as being “smart”, with a focus on materials used in the current design work.

Smart Materials

Following technical textiles and functional textiles, smart textiles have also come into force. The term smart-textiles covers a broad range, and the application possibilities are limited only by imagination and creativity. As mentioned previously the following chapters summarize some classes of material that I through my research work have found are commonly being referred to as being “smart” and materials used in the current design work.

Definition

One way to start an overview of smart materials is to provide a definition of smart materials. To define a smart material one needs to understand what is meant by smart behaviour and then develop a definition (Smartmat).

Smart or functional materials usually form part of a smart system that has the capability to sense its environment and the effects thereof and to respond to that external stimulus in a useful, reliable, reproducible and usually reversible manner via an active control mechanism. Often, the sensing function alone is taken as sufficient to constitute smartness.

Smart behaviour is the reaction of a material to some change in its envi-
Smart materials respond to environmental stimuli with particular changes in some variables. For that reason they are often also called responsive materials. Depending on changes in some external conditions smart materials change their properties (mechanical or electrical appearance), their structure, their composition or their functions. Mostly, smart materials are embedded in systems whose inherent properties can be favourably changed to meet performance needs (Addington, 2005).

**Colour changing**

**Photochromic material**

Photochromic materials change colour reversibly with changes in light intensity. Usually, they are colourless in a dark place, and when sunlight or ultraviolet radiation is applied molecular structure of the material changes and it exhibits colour. When the relevant light source is removed the colour disappears.

Changes from one colour to another colour are possible mixing photochromic colours with base colours. Photochromic materials are used in paints, inks and they can be mixed into mould or casting materials for different applications (Soton) (Ritter, 2007) (Addington, 2005).

**Thermochromic material**

Thermo chromic materials change colour reversibly with changes in temperature. They can be made as semi-conductor compounds, from liquid crystals or using metal compounds. The change in colour happens at a determined temperature, which can be varied by doping the material. Thermo chromic materials are used to make paints, inks or are mixed...
into moulding or casting materials for different applications (Berglin, 2006) (Ritter, 2007) (Addington, 2005).

**Light emitting**

**Electroluminescent materials**

Electroluminescent materials produce a light of different colours when stimulated electronically (e.g. by AC current). While emitting light no heat is produced.

Like a capacitor the materials is made from an insulating substance with electrodes on each side. One of the electrodes is transparent and allows the light to pass. The insulating substance that emits the light can be made of zinc sulphide or a compound.

Electroluminescent materials can be used for making light stripes for decorating buildings, or for industrial and public vehicles safety precautions (Berglin, 2006) (Ritter, 2007) (Addington, 2005).

**Fluorescent material**

Fluorescent materials produce visible or invisible light as a result of incident light of a shorter wavelength (i.e. X-rays, UV-rays). The effect ceases as soon as the source of excitement is removed.

Fluorescent pigments in daylight have a white or light colour, whereas during excitation by UV radiation they irradiate an intensive fluorescent colour.

Fluorescent materials can be used for paints, inks or mixed into moulding or casting materials for different applications (Ritter, 2007) (Addington, 2005).

**Phosphorescent material**

Phosphorescent or afterglow materials produce visible or invisible light as a result of incident light of a shorter wavelength (i.e. X-rays, UV-rays) detectable only after the source of the excitement has been removed. Afterglow effect pigments are polycrystalline inorganic zinc sulphide (green afterglow) or alkaline earth sulphides (red or blue afterglow), and can be used in paints, inks or mixed into moulding or casting materials for different applications (Ritter, 2007) (Addington, 2005).

**Light emitting diodes LED**

LEDs are a semiconductor device that emits incoherent narrow-spectrum light. This effect is a form of electroluminescence. LEDs are usually constantly illuminated when a current passes through them, but flashing LEDs are also available.

LEDs can emit light of an intended colour without the use of colour filters that traditional lighting methods require. This is more efficient and gives lower initial costs together with the fact that LEDs have an extremely long life span. LEDs used in textiles are called photonic textiles.

Photonic textiles can be made interactive, and they achieve interactivity by incorporating sensors e.g. orientation and pressure sensors and communication devices e.g. Bluetooth and GSM into the fabric.

Lumalive is a photonic textile, which uses cloth as a lighted graphic display medium. Lumalive was developed by Philips Research Technologies and integrates a flexible array of miniature coloured light-emitting diodes into a piece of cloth, which allows the cloth to display e.g. graphics, text and animation (Lumalive) (Addington, 2005).
Moving materials

Conducting polymers
Conducting polymers are conjugated polymers, through which electrons can move from one end of the polymer to the other. The most common are polyaniline (PAni) and polypyrrole (PPY). Polypyrrole has been used for the development of micro muscles. Polyaniline films sandwiched around an ion-conducting film are considered as material for artificial muscles for robots.

A current flow reduces one side and oxidises the other and ions are transferred. When one side expands and the other contracts it results in a bending of the sandwich and in that way electrical and chemical energies are transformed into mechanical energy (Ritter, 2007) (Addington, 2005).

Piezoelectric material
Piezoelectric materials produce an electric field when exposed to a change in dimension caused by an imposed mechanical force (piezoelectric or generator effect). Conversely, an applied electric field will produce a mechanical stress (electrostrictive or motor effect). Piezoelectric materials transform energy from mechanical to electrical and vice versa. The stress is very small, 0.1-0.3%. They are used for sensing purposes (e.g. microphone, transducer), and for actuating applications.

Similar to piezoelectric materials are electrostrictive and magnetostrictive materials used in high precision actuation. They are ferromagnetic materials which experience an elastic strain when subjected to an electric or magnetic field respectively (Ritter, 2007) (Addington, 2005).

Polymer gel
Polymer gels consist of a cross-linked polymer network inflated with a solvent such as water. They have the ability to reversibly swell or shrink (up to 1000 times in volume) due to small changes in their environment (pH, temperature or electric field).

Micro sized gel fibres contract in milliseconds, while thick polymers layers require longer time. Polymer gels have high strength and can deliver sizeable stress. The most common polymer gels are polyvinyl alcohol (PVA), polyacrylic acid (PAA) and polyacrylonitrile (PAN). There are many potential applications such as artificial muscles, robot actuators, absorbers of toxic chemicals), but presently very few of them have a commercial diffusion (Chem) (Iupac) (Addington, 2005).

Shape memory alloys (SMA)
Shape-Memory Alloys are metals that, after being strained, at a certain temperature revert back to their original shape. A change in their crystal structure above their transformation temperature causes
them to return to their original shape.

SMAs release large forces that are generated when encountering any resistance during their transformation, as they can recover large strains (Ritter, 2007) (Addington, 2005).

**Temperature changing materials**

**Thermoelectric material**

Thermoelectric materials are special types of semiconductors that, when coupled, function as a “heat pump”. By applying a low voltage DC power source, heat is moved in the direction of the current (+ to -).

Usually thermoelectric materials are used for modules where a single couple or many couples (to obtain larger cooling capacity) are combined. One face of the module cools down while the other heats up, and the effect is reversible. Thermoelectric cooling allows for devices, that are small and light, high reliability and precise temperature control, and quiet operation. Disadvantages include high prices and high operating costs due to low energy efficiency.

New materials with better thermoelectric performances are being investigated and will improve the efficiency of thermoelectric devices, decrease their operation costs, and widen the range of their applications (Thermoelectric) (Ritter, 2007) (Addington, 2005).

**Metals**

Metals are inorganic materials characterized by a metallic bonding of the atoms, a crystalline structure and a metallic sheen.

Metals are generally very malleable, ductile and strong. They have high densities and relatively low melting temperatures. Metals are good conductors of electricity and heat, and are easily attacked by corrosion and oxidation. Furthermore metals are reflective and feel cool. Metal alloys contain more than one metallic element (Addington, 2005).

**Steel**

Steel is an alloy of iron and maximum 2.1% carbon. The strength increases with the carbon content. Low-carbon steel (less than 0.3 % carbon) is generally used for common industrial products such as sheets and tubes. Medium carbon steel (0.3 to 0.6 % carbon) is stronger than low carbon steel and used for automotive and machinery applications. High carbon steel (more than 0.6 % carbon), is strong, hard, and wear resistant and is used for cutting tools, springs and cutlery (Addington, 2005).

**Stainless steel**

Stainless steel is corrosion resistant, strong and ductile. In the presence of oxygen a thin, hard adherent film of chromium oxide develops on the surface. The film protects the metal from corrosion (passivation). The film builds up again if the surface is scratched. With increased carbon content, the strength of stainless steel increases and corrosion resistance is reduced.

Stainless steel can be recycled. Since nickel is a limited resource, recycling of stainless steel should be kept separate from other steels (Addington, 2005).

**Fibres**

Fibres are pliable hair-like substances, built up by long chains of basic molecules. Fibres are very small in diameter in relation to their length. Long continuous strands of fibres are called filaments.

Most fibres are organic materials, but a number of inorganic fibres exist. A fibre’s properties depend strongly on both the external and internal fibre structure as well as the chemical composition. Properties therefore vary significantly. Crystalline areas give tensile strength, stiffness and stability, while amorphous areas are weaker but more moveable (Hatch, 1993).
Glass fibres are made of silicon oxide with addition of small amounts of other oxides. Glass fibres are characteristic for their high strength, good temperature and corrosion resistance and low price. There are two main types of glass fibres: E-glass and S-glass. The first type is the most used, and takes its name from its good electrical properties. The second type is very strong (S-glass), stiff, and temperature resistant. Glass fibres are used as reinforcing materials in many sectors, e.g. automotive and naval industries, sport equipment etc (Addington, 2005).

Carbon fibre
Carbon fibres are the stiffest and strongest reinforcing fibres for polymer composites, the most used after glass fibres. Carbon fibres, made of pure carbon in form of graphite, have low density and a negative coefficient of longitudinal thermal expansion. Carbon fibres are very expensive and can give galvanic corrosion in contact with metals. Carbon fibres are generally used together with epoxy, where high strength and stiffness are required i.e. in race cars, automotive and space applications and sport equipment (Addington, 2005) (Fung, 2001).

By combining smart materials and textiles there are many properties one can achieve. Applications for smart textiles are developing rapidly. The functionality of the materials which historically was limited to protective uses, today has virtually unlimited potential. Smart textiles can now re-charge personal electronic devices, detect ailments, conserve energy, self clean, mimic nature, monitor temperature changes and even react to external stimuli.

The first generation of intelligent textiles uses conventional materials and components and tries to adapt the textile design to fit in the external elements. They can be considered as e.g. e-apparel, where electronics are added to the textile.

An example is the MP3 player from Infineon that easily can be incorporated into a garment. The different components for the MP3 player are interconnected through woven conductive textiles. However, non-textile components are likely to cause a certain discomfort and connections between textile and non-textile components remain troublesome and challenging.

In the second generation, the components themselves are increasingly being transformed into full textile materials e.g. through nanotechnology.

Smart materials and textiles

Market analysis: Automotives

Research on smart textiles for automo-
tive use for this project has partly been done in the fall of 2006 and spring 2007.
Study visits at companies in the automotive field, interviews with active designers together with literature studies were the base for personal reflections and a summary of the information found.

Parts of the research particularly on smart materials have been presented in the background chapter, and the following sections summarise smart textile trends, feedback on interviews and feedback on presentations.

Existing research is limited to two different areas, one concerning future aesthetics for automotives and one concerning future functionality needs.

Initially I contacted textile designers who all work professionally with automotives to get their viewpoints on previous research and on future prospects concerning aesthetics and the use of smart textile materials.

The interviews were not traditional interviews but were informal discussions of the issues mentioned previously.

Contacts
The interviewed persons were Nina Grelsson, textile designer at Volvo Trucks; Boel Hermansson, Studio Chief Designer at Volvo Car Corporation, Dorte Bo Bojesen, previous chief designer at both Gabriel and Borgstena Textiles and Maria Greger, Senior Designer, Colour and Trim at Mazda Motor Europe Gmbh.

Furthermore I exhibited at the 2nd International Conference within the Nordic Network NEST that took place in Gothenburg, Feb. 22-23, 2007: FOCUS: The Car Interior of the Future, where speakers from e.g. Volvo Car Corporation, ENSAIT, France, W. Zimmermann GmbH, LYTRON Technology, Eybl International, TITV and IFP Research participated: This gave me an opportunity to get feedback on my work and an update on current issues (NEST).

I also participated and exhibited at Trendsitter Tag: Mode für Autositze in Hannover March 29, 2007, where I presented my work and had the opportunity to get feedback once more. At Trendsitter Tag representatives from VW, Dip. Eng. Daniela Finocciaro from AundE GmbH and Dip. Des. Karl-Heinz Wagner, Product design ISRI GmbH participated amongst others (Trendsitter Tag).

Previous and current research work has also been presented and discussed at a public design seminar at The Swedish School of Textiles, Feb. 21, 2007 and presented and discussed at workshops led by designer Elisabeth de Senneville from France and Elodie Ternaux, director at MateriO in Paris.

Finally research took place through literature studies partly provided by the following contacts mentioned e.g. research reports, talks and e-mail contacts with e.g. Jørgen Nielsen, Account Manager at Trevira Neckelmann A/S; Christian Dalsgård from Chr. Dalsgaard Project Development; Lars Fast, researcher at SP Technical Research Institute.
Maria Greger from Mazda summarized an opinion often spoken: “It’s always difficult to discuss colour ways. New colour ideas are always requested. Looking to the fashion or the furniture design the car industry is proposing a lot new ideas, and bright colours are definitely interesting. Unfortunately, the customer who is buying the car and selecting an interior makes a practical choice, one that improves chances to resell the car later on”.

The issue of future aesthetics for automotives differs due to type of vehicle. A general preference however is for the modernistic space-oriented look where added values as e.g. light setting are clearly displayed.

Even the colour setting depends on the level of the vehicle. Small cars can be more fashionable while premium cars are more sophisticated, etc. Basically the car colours inside and outside are influenced by general trends.

The use of textile smart materials in upholstery increases usability and provides possibilities for a changed design even when it comes to a bright colour setting and surface structure. Antistatic, conductive and bio-active materials increase dirt repellence and optimize the interior environment.

**Trends and visions**

Through the interviews and the extended research several trends and visions appeared. The ones summarized in the following sections are those which came up most frequently.

The distinction between wearable electronics or electronic textiles and coated or processed textiles is disappearing when it comes to intelligent textiles. The trend toward interdisciplinary
work for innovative progress benefits both fields, and it forces development. Flexible electronics, textile electronics, semi-conductive fibres, flexible displays and photo tonic textiles such as the ones presented by Philips in 2006 named Lunalive, where tiny LED’s were integrated into different textile materials so the textiles worked as screens (Lunalive), are some of the new interdisciplinary developments.

Light setting in automotives is an issue that is of great interest. Through integrating light sources in textiles an equal light setting becomes a possibility as well as adding light to parts of the vehicle interior where light has not previously been present e.g. doormats and side linings.

Highly relevant issues include integrating conductive material in upholstery for automotive use, not only for anti-static properties, but also for EMI / RFI shielding, heating and cooling properties and to replace heavy cabling. Through integrating conductive material functionality can be added where needed e.g. seat adjustment and seat control.

Another field of current interest is nano-technology. The application areas seem countless and research is an important issue. Nano-technology as an interdisciplinary field where different technologies, functions and capabilities intersect is of great interest and applications can be made within e.g. medical textiles, automotive textiles and nonwovens (Intelligente tekstiler).

Especially nonwoven textiles offer new possibilities. Developing new nano fibres in nonwovens the opportunity of producing materials with extended physical qualities like e.g. viscosity, strength and density. One area of improvement by adding nano fibres in nonwovens is an increase of the hydrophobic textile surface (Intelligente tekstiler).

Environmental issues

One important design challenge today is to design things that will last, and at the same time come apart easily to be recycled and reused (Braddock & O’Mahoney, 2005). Our way of thinking about environmental issues has changed. Environmental concern no longer only means sorting garbage for recycling but refers to awareness of how we live.

The emphasis today is not on cost but on the added value that technology may bring to a product. Designing new products with added values through using new technology and new materials is a way to justify designing new products.

The awareness of how a product is constructed and from which materials it has been made is closely linked to the environmental viewpoint that how a product ends its life is a natural extension of how and from what it is manufactured.

In a sustainable perspective it is not recommendable to use materials that come from unrenewable resources. So far, however, ecological or sustainable materials are not fully adequate alternatives for automotive interior design due to insufficient abrasion resistance, colour fastness and flame retardancy. Ecological or sustainable materials do not yield a product with the possibility of a long life span although innovative development takes place even in this field.
In 2005, Daimler Chrysler began using biological composite materials made from coconut, sisal, jute and other plants. This biological material is used mostly on the interior of the car and finds its way into seat cushions, seat backs, under floor body panels and interior door panels. One of the benefits of using these biological compounds is that they can be recycled and reused and the manufacturing process involved is far more environmentally friendly than that of conventional synthetic compounds (Daimler Chrysler).

Environmental concerns have so far not been a dominating issue when it comes to automotives but this is, however, a significant issue today within the automotive field. An environmental concern means not only a reduced use of fuel, but a genuine concern about materials and construction. Further comments on environmental issues are given in the discussion chapter.

Design
The following chapters describe the development of the design work from idea to prototype. I have tried to describe relevant decision points in the design process and the process is described in an almost chronological order. Personal reflections, decisions and descriptions of the practical work are mixed to give a whole picture of the design process.

Design vision
As explained earlier the aim of the project is to design upholstery concepts for automotives using smart textiles. Values in the smart-textile area are obtained through choice of material and textile techniques such as weave bindings. The added values sought in this project are RFI/EMI shielding qualities, light setting and antistatic in accordance to the research, trend- and market analysis.

The design strives to relate to outdoor environment in order to connect to the idea of designing to reduce the border between indoor and outdoor environment. The inspiration source is water surfaces. Colour setting is also inspired by water surfaces, and it is linked to the market analysis. Material selection is based on the chosen added values, material qualities, appearance and availability.

Time planning
The time schedule for the design project has been followed throughout the project and has served as a good reference when making design decisions.
Inspiration

Water surfaces

Added values and smart textiles correspond movement and change, and even for automotives movement and change are significant key words.

The positive interview response on the woven samples used in the market analysis contributed to the decision of continuing with water surfaces as design inspiration.

The different distinguishing features of water surfaces correspond well with the qualities sought for this design project. Features as e.g. light reflective, transparency, 3-dimensionality, movement and change are qualities that suited the design concept well.

As a starting point for the sketch work I photographed water surfaces, and I reused previous photos of water surfaces so that not all photos should be season related. From the different photos I made a selection chosen to show the variety of water surfaces and photos that communicated the features mentioned in the previous chapter. The photo collection later was used as a base for different design ideas when making mood boards and sketching. Taking photos and investigating water surfaces was a good complement to the ongoing research work. It provided time for reflection on the design and on the research.

Art and dance

For further inspiration I visited 4 modern dance performances and a textile art exhibition. In dance, movement and change are significant key words too. The body language of the dancers communicates like running water in a wordless language. Light setting and sound scenery underline the movement and constant progress and involve the spectator in individually interpretations.

Two dance performances were from the Cullberg Ballet. The first was End by Sidi Larbi Cherkaoui. End revolves around finding a direction in life and in one’s relationships with other people. A creation about breaking down walls – real and imaginary.

The second performance was Blan-
co by Johan Inger. Blanco is a work all about hunting for an illusion, a hope for a world not yet scarred by experience. Repeated attempts are made to enter something that is unattainable.

Furthermore I watched Body+Soul that are two performances in a production with the Gothenburg Ballet and the Gothenburg Opera Orchestra.

The first performance was Wind around my Heart by Regina van Berkel, where physical capacity is taken to its limits, as the choreographer looks at the forces that make human bodies move instinctively.

The second performance was Breeding Spaces by Daniela Kurz, where sound, light, images and the dancing took the spectator forward into what could be interpreted as a new evolutionary stage.

The textile art exhibition was the Norwegian Textile Triennale 2006 that was exhibited at the Röhsska Museum in Gothenburg. Several art pieces were 3 dimensional, and combined unconventional textile materials with innovative textile techniques within the framework of textile art.

**Textile qualities**

**Material**

As a part of the investigational work woven samples were produced to test weave designs, weave density and material combinations.

Previously I have gathered a number of different textile materials that all have in common that they add extended values to usual textile values. When choosing the materials, I focused on conductive materials, light emitting materials, haptic and visual values, bioactive and chromatic materials.

Textile samples were then woven to visualize the different materials. The samples did not fulfil technical requirements for upholstery, but they presented added values and all were designed according to the idea of reducing borders between indoor and outdoor environment inspired by water surfaces.

The added values for these samples were aesthetical, bio-active, conductive, light reflective, light emitting, phosphorescing, radiance shielding, antistatic,
haptic and term chromatic.

When working with different kinds of conductive threads I tested conductive qualities, aesthetical values and functional weaving qualities. Especially the conductive qualities and the functional weave qualities were decisive as to which materials to continue working with.

In the following chapters different materials and values are evaluated when they were considered or tested. In the current design project the focus is on RFI/EMI shielding qualities, light emitting and antistatic values and the materials discussed in the following chapters are limited to these areas.

Warp
To obtain the desired transparent and futuristic appearance I chose to use monofilament yarn as warp material. Monofilament yarn has the qualities required for upholstery e.g. abrasion resistance, colour fastness and flame retardancy, and it corresponds well to the design concept.

Black and transparent monofilament yarns were tested to try out the impact of the warp colour towards the weft material.

Warp sections with black monofilament yarn emphasized the 3-dimensional surface design by adding a sense of deepness. Especially in more irregular structures, the black warp added extra value to the design by creating a tactile rhythm in the pattern structure.

Different yarn densities were also tested. Monofilament yarn, depending on the yarn diameter, has a stiffness that has to be considered when deciding on warp density. I tried different densities from 15 threads per cm to 30 threads per cm. Depending on the weft material the stiffness and therefore also the drape ability and upholster qualities varied.

Finally I decided on warp densities around 25 threads per cm and monofilament yarn with a diameter of 0,16mm and 0,22mm. The yarn diameters are moreover even the most commonly used at Ludvig Svensson, which is the company that produced the final prototypes.

Weft
The research from the market analysis indicated requirements for conductive materials integrated in upholster to obtain added values as e.g. radiance shielding, antistatic and data transmitting.

A selection of conductive materials were therefore used as weft material when test weaving. Previously I had tested different conductive materials to find the most suitable for weaving.

Bekintex produces Bekitex® that is a stainless steel yarn suitable for textile production, and it is the conductive material that corresponded best with the design concept and the required added values, and I therefore chose to use it for the prototypes.

Another conclusion from the market analysis research was the demand and
ambition of integrating light into textile material. As regards light and displays the options are still rudimentary but electroluminescent wires, fibre optics, thermochromic materials and LED’s are being used.

Several alternatives were considered for weft material and are discussed in the following text.

Using photochromic or thermochromic material provides aesthetical values e.g. independence between an exterior light source and the photochromic material making the design changeable and thermochromic material providing a time limited mood-light. However these values must be considered to be primarily aesthetical and not suitable as functional light, since they cannot be fully controlled.

Electroluminescent material, fibre optics and LED’s provide light due to external input which one can adjust and control. For automotive use light integrated into textiles needs to be a functional light possible to adjust and control and tests were therefore concentrated to functional light emitting materials.

Using optical fibres in textile constructions causes difficulties both in production and later on even for applications since they are too fragile. Therefore, optical fibres were therefore not considered for the weft in this project.

Integrating LEDs could be an option to achieve an adjustable light source. Due to the complex technical construction for integrating LEDs in textiles, however, I chose not to work with LEDs in this design project.

An electroluminescent material was another option as a light emitter. Electroluminescent wire is a decorative, flexible wire that glows. It generates no heat and can be integrated or combined into many materials. Electroluminescent wire comes in limited colours but some colours will vary depending on the frequency used to power them (Light and Motion).

The electroluminescent wires can be a part of the warp and integrated in the design. The light can be adjusted and controlled and corresponds well with the light reflective qualities of a water surface.

The electroluminescent wires are connected to an inverter using AC current, and the light emitter is therefore fully controlled.

Weave design
Different bindings were tested to sketch woven structures simulating the water surfaces. The weave constructions should show the warp threads so that the transparency and light reflective qualities of the warp could contribute to the design impression and make the surface structure similar to a water surface through e.g. a 3D structure.

The weave constructions should also optimize the added values such as antistatic, radiance shielding, light emitting and light reflective. For radiance shielding certain net distances are required, and the weave bindings were therefore not only evaluated because of aesthetics but also because of functionality issues.

The woven designs were all produced in a computer controlled hand loom, and the weave-binding-sketching was done directly in the computer while weaving. To sketch and test weaves at the same time using the computer was for me a joyful creative way of working. It was also time-wise and economically a good way of testing materials and bindings, since expensive materials could be tested in small amounts, and both warp and weft density and material could be easily manipulated.

The weave designs were evaluated with reference to both the market analysis and the design concept. As mentio-
ned in the interview chapter people tended to choose the same samples partly due to aesthetics and partly due to the added values.

Even the test weaving showed that similar weave designs corresponded well with the design concept both regarding aesthetics and functionality and I therefore decided to continue with two different weave designs that could be used individually and that also complemented each other when used together.

The two designs have conductive qualities, radiance shielding qualities, antistatic qualities, light emitting and light reflective qualities. In the following text I refer to the designs as Sprinkle and Wave.

Colours
The colour setting was directed by the water theme and by the market and trend analysis. Colours were picked from the selected photos of water surfaces, and colour samples were painted and added in colour collections beside the photos on the mood boards.

In the market analysis designer Maria Greger asked for brighter colours. When discussing with Boel Hermansson and Nina Grelsson from Volvo, both of the designers emphasized a tended brighter colour setting for automotive interiors. Looking at new automotive interior design one can see this tendency easily. When using a bright colour setting in car interior comfort increases through an extended space experience.

Many smart materials are so far available in limited colour scales. The current design concept is however well suited for the yarn colours available on the market.

The different grey metal yarns correspond well with the light reflective water surface and the monofilament yarns add transparency and light reflective values that are also to be found in water.
Selected designs

Sprinkle

Sunlight reflected in moving water where water drops sprinkle and sparkle. Sprinkle is an upholstery design where the monofilament warp forms an irregular and light reflecting surface structure. Electroluminescent wires emit light that together with the light reflective metal and monofilament threads forms an irregular and unpredictable design. The colour setting is grey and white and it is an irregular, marbled colour setting.

Originally another design was chosen to be Sprinkle, but because of changes in the production it was not possible to weave with the needed threading and amount of shafts as is needed for the original Sprinkle – design, and another design was therefore chosen as Sprinkle.

On the first Sprinkle design the monofilament warp a weft net forms a regular pattern on top of a tabby weave, and electroluminescent wires appear in small sections in the warp direction. On the first Sprinkle design, which was only woven as samples, the design appears to be constructed of a net overlaying plain-weave cloth. Weft threads are shifted in the cloth to give distortions. The weft threads move in eccentric paths and are caught infrequently, so that they zigzag across the cloth.

It is of course a limitation with the long floats in the ends or picks, but the weave construction is optimal for displaying materials as e.g. the light wire, and if used for applications where abrasion is not a dominant issue the weave design has good aesthetical qualities and correspond well with the current design concept.

To be able to present a blue colour setting that linked to the design concept I considered printing a digital print on the final upholstery to get an overall colour setting. I even considered printing the blue colour in a large scaled non figurative pattern, so that the irregularity would be further emphasized. I therefore sketched different print suggestions inspired by the photos, and added these sketches on the mood boards for further work and discussion. One idea was to print parts of the pattern with a photochromic print to extend the aesthetical value. Later on I decided against printing because of difficulties printing on the fabric due to its 3-dimensional structure. Instead colour suggestions are shown as painted colour samples.

The materials used for Sprinkle are silver, polyester, transparent monofilament and electroluminescent wires. The current weave design that was produced as Sprinkle optimizes the light reflection through displaying the monofilament warp to a great extent. The electroluminescent wires are tied to the fabric with monofilament used in the weft direction and they emit light that reflects in the monofilament yarn and the weft yarn.

The weft yarns are polyester and silver. Silver provide the antistatic values and the weave binding places the weft as an almost overall layer on the backside of the fabric so that antistatic values is optimized. Silver was chosen because it was the only metal/polyester yarn available when time for production. Silver also provide antibacterial values, however, it is an expensive and environmental
unfriendly option so for further production other alternatives should be considered. The added values to Sprinkle are light emitting values, light reflective values and antistatic values.

Automotive application areas can be at the roof or as side linen to provide an overall light setting. Regular car upholstery often induces quite high voltages on the driver. One can significantly lower the charging of a person by electrostatically improved textiles, even though static shock is not necessarily suppressed. Efficiency of electrostatic discharge (ESD) suppression depends on the chosen technology: antistatic agent or conductive fibres, type of conductive yarn, pattern etc. (Lars Fast, SP).

The antistatic values for Sprinkle have been evaluated and they meet the requirements in a satisfactory way.

Wave

Like a ploughed field waves flow in changeable light. Moving and changing directions and colour scale. Metal, white, black and transparency form a bright colour scale that also is light reflective due to the materials used and to the 3-dimensional surface structure.

The black sections in the warp mix into the transparent warp and create a soft changeover in the design that emphasizes the 3-dimensionality in the surface structure. The warp threading forms the surface structure, and the threading is made especially for this design. The binding is a double weave with tagging points constructed from twill and tabby. The materials used for Wave is Bekitex®, (stainless steel), rubco yarn (polyurethane), transparent and black monofilament.

The added values are EMI/RFI shielding, antistatic and light reflective. Automotive application areas can be at different surfaces in the car to ensure that electronic systems run stably and without disruption from external sources. The upholstery can shield electronic devices in cars and work as a mosquito net for EMI shielding since shielding is a combination of absorption and reflection. Textile is a good solution for shielding since it is flexible, light, reusable, dye able and it can be flame retardant (Trevira CS).

Result

The exploration of upholstery concepts for automotives using smart textiles is here visualized in two upholstery designs; each one displaying different added values requested by the automotive field.

The length and width can be adjusted to suit different applications. The textiles for the current project are adjusted to the demands of the prototypes used to present the fabrics.

Production facts for weaving are presented in appendix 1.
Sprinkle

**Added values**
- Light emitting
- Light reflective
- Antistatic

**Materials**
- Silver
- Polyester
- Monofilament
- Electroluminescent wires
Wave

Added values
Antistatic
EMI/RFI shielding
Light reflective

Materials
Bekitex®, (stainless steel)
Rubco yarn (polyurethane),
Transparent and black monofilament

Image 48; Wave
This chapter starts with a discussion of smart textiles, automotive applications, development and environmental issues. The discussion provides an overview of these issues mixed with a personal evaluation of the design work and the result.

Smart + Textiles

Textiles are present everywhere and at all times. They are widely accepted and easy to use. Textiles offer a range of combinations of basic materials (fibres), structures and treatments. Textiles have the potential to be a powerful tool to supply general or very specific solutions. The potential is there, ready to be exploited.

The development of smart textiles reaches far beyond imagination; some stories may seem science fiction. But part of the new materials and structures have already reached the stage of commercialization, although much larger part however is still in full development or still have to be invented even.

Design is a critical component of the development of textile materials for automotive interiors. It contributes to the overall quality of the vehicle interior, and to its costs. The appearance of the vehicle passenger cabin affects the perception and satisfaction of the occupants.

For many years textile products have played an increasing role in providing both safety and comfort to drivers and passengers. Integrating extended values through using smart textile material now bring an additional dimension.

New smart materials provide and react to valuable information; for example sensors may alert the seat the occupant’s body size, temperature and driving alertness. Fabrics are being developed to monitor the cognitive status for commercial truck drivers, public transportation and individual drivers (VDC-Corp).

Product development

The long-term resources dedicated to bring new automotive products to market is tremendous considering that multiple projects are being developed several years ahead of production launch.

In addition to the new-market vehicles, new fabrics are needed to “freshen” existing models.

Even before current automotive products phase out of production, suppliers must have new innovative products under development to offer at the earliest possible opportunity.

More advanced products are developed for the concept cars introduced at auto shows around the world to test new directions in vehicle design. Textile products introduced in concept cars may be experimental in nature and may not necessarily be certified for automotive use. Concept cars are used not only to create enthusiasm and acceptance by the consumer, but also to encourage manufacturing’s buy-in for new processes that might be needed.

A consideration of automotive product design can normally not be disconnected from the context of the total vehicle development.

In the current design project however the upholstery designs are concepts for automotives in general and not for
a certain vehicle and they are therefore not connected to the context of a total vehicle.

The emphasis has been on added values that respond to requests from the automotive industry rather than designing for a certain context.

To explore automotive requests and smart textiles with a general approach has been a very satisfactory way of conducting this research and it has made it easier to establish contacts with different companies and people within the automotive field and the smart textiles field.

The general approach also facilitated the exploration of smart materials and this attempt to define them.

Environmental concern

Concern for the environment has so far not been predominant when it comes to automotives but it is a significant and current issue today within the automotive field.

There is a growing interest in the sustainability of automotive products and their impact on the environment, particularly through responsible decisions from development to use “end of life” disposal (Fung, 2001). By 2003, 80% of all new vehicles built in Europe were required to have 80% recycled content (Just-Auto).

From a consumer perspective ecological awareness is growing. Consumers could take a more committed stand on the transportation industry and its role in the environment from vehicle design and manufacture, through use and end of vehicle life.

The consumers and their advocates may take the industry to task in the future on corporate responsibilities in green issues, and in human rights as has occurred in other textile-related global industries, such as sport apparel (Nike).

The current design concepts Sprinkle and Wave are experimental in nature and are not certified for automotive use, but are developed to visualize new potential for textile automotive design and to encourage curiosity and enthusiasm. The design including both chosen materials and weave bindings are in the prototype stage, and for a final product the materials and the construction would have to be considered further regarding sustainability.

Balancing technology, profitability, and human quality of life are common
goals, and there are many approaches to address these often conflicting goals. Developing greener products through the design of new vehicles and the use of textile composites and components will be a major challenge in the future.

Design process

The design work has included many aspects. The research on materials, the automotive field and on possible application areas was extensive and very useful in the design work.

The many inputs from professionals and the opportunity to ask for more information were encouraging and spurred the project forward. Aesthetic, technical, environmental or theoretical issues were all evaluated and discussed on basis of the research findings.

The idea of designing to reduce the border between inside and outside to create an extended aesthetic value and to emphasize the feeling of safety and calmness has worked out well.

The designs correspond well with the inspirational source, water surfaces, both regarding surface structure and colour setting.

The design concepts Sprinkle and Wave are both suitable for upholstering due to their irregular pattern and their added values.

The added values, light reflective, light emitting, radiance shielding and antistatic, are visualized in the upholstery in a clear way, and hopefully the upholstery designs will entice interested people and force progress work in the field of automotives and smart textiles.

As mentioned previously it is important to be able to control the added values. Functionality, reliability and safety are very important issues for automotives, and these issues have served as guidelines when evaluating the designs. Even though the designs are concepts visualizing new additional possibilities they must give a trustworthy impression.

To add new smart textile material to textile design influences the design process. In the current project I have considered how to integrate smart textile materials and constructions in a traditional design process. Smart textile fabrics need to be constructed so that the added values function e.g. the net construction for radiance shielding qualities and material display for antistatic qualities. The construction issues when combining aesthetics and smart textile functionality have had me reflecting on my own design process. It is an exciting challenge not to compromise either the aesthetics or the functionality, and it is a consideration that I will keep on integrating and developing even in future.
design works.

Using unconventional materials in production challenge the production. Conductive yarns disrupt the loom computing control system, and special adjustments have to be made. The electroluminescent wires and the stainless steel threads used in the warp direction were on separate warp beams to facilitate the production.

Most of the materials used for Sprinkle and Wave are expensive compared to materials used for usual upholsteries. Designing concepts using smart textiles to visualize additional potential development do not mean that a future product will represent the same costs. Expensive materials can be replaced with similar looking cheaper materials if it does not impact the added function. A large-scale production will also reduce the costs.

Since most smart textile materials do not fulfill usual technical requirements as e.g. abrasion, they cannot be used on seats. The design concepts Sprinkle and Wave do, however, provide additional values more suited for other application areas than seats. Application areas where abrasion is not a significant issue, such as inside roof lining, side lining, trunk lining etc. are all possible application areas.

Depending on the functionality required, applications are impacted too. EMI/RFI shielding fabrics have to be upholstered with great awareness to the wavelengths that have to be interrupted.

Values added to upholstery using smart textiles is an issue that I find particularly interesting, and this project has been an exciting journey learning more about that topic. The knowledge gained from the project research and market analysis has been invaluable when making design decisions.

When designing for automobiles a number of aspects must be considered. The requirements for automotive textiles are many and the standards are high. It is, however, an exciting field especially due to the constant force of progress and new additional values. Integrating smart textiles in automotive design has an enormous growth potential and great future prospects.

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Appendix

Sprinkle

Warp 1
Monofilament Ø 0,16m
Transparent
30 threads/cm

Warp 2
Electroluminescent wire Ø 2,3 mm
White
1 wire/7,5cm

Weft 1
Monofilament Ø 0,16m
Transparent

Weft 2
Trevira C, pes
Weave binding
Wave

Warp 1
Monofilament Ø 0,16mm
Transparent

Monofilament Ø 0,22mm
black

22 threads/cm

Warp 2
Bekinox 12/2
1 thread/cm

Weft
Rubco prodnr 200000699

Bekinox 12/4

Warp order
(From left to right) 1 threading report
Red square = transparent monofilament
White square = black monofilament
Weave binding