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An Overview of Metal Fiber Applications

METAL FIBER APPLICATIONS PER SECTOR

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WHITE PAPER

An Overview of Metal Fiber Applications

Jérémie De Baerdemaeker and Jos Vleurinck, Bekaert NV

INTRODUCTION

Metal fibers – fiber material with a diameter range of 1 to 100 microns – exist in many forms, alloys and sizes. They are the most preferred basic materials for many different applications, varying from filtration to heat-resistant textiles to conductive plastics. Metal fiber structures and products display excellent porosity, electrical, thermal, corrosion and mechanical properties. Each of these properties makes them suitable for specific applications:

- Highly porous metal fiber structures are beneficial in a multitude of filtration applications.
- The low electrical resistance of metal fibers makes them suitable for applications that require electrical conductivity, such as conductive plastics and electro-conductive textiles.
- Their excellent thermal resistance means they withstand extreme temperatures and are thus highly suitable for heat-resistant and heatable textiles.
- For applications in corrosive environments, the use of high-quality alloys leads to metal fibers with outstanding corrosion resistance.
- Other advantageous mechanical properties of metal fibers include shock resistance, fire resistance and sound insulation.

This white paper highlights a wide variety of metal fiber applications. Future publications will explain each of these applications in more detail. If you wish to know more about the different types of metal fibers and how they are produced, please consult our white paper on An Introduction to Metal Fiber Technology.

AUTOMOTIVE

Diesel and gasoline particulate filtration

Diesel and gasoline particulate filtration requires sintered metal fiber media consisting of very fine, lightweight metal fibers (typical diameter between 17 and 30 µm). This is the material of choice when it comes to fine-tuning porosity (up to 88%) and alloy to achieve optimal filter performance and durability. The high porosity of the media can significantly improve the pressure drop over the filter. Choosing the right alloy makes the media more resistant to corrosion and extreme temperatures (up to 1100°C). Metal fiber media can be shaped into unlimited designs and will permit high flexibility for further integration into the exhaust system. Metal fibers contribute to an efficient and durable filter with a high sound absorption to eliminate the need for a silencer or muffler. If the filter only uses a low regeneration temperature, no complex regeneration strategy is needed.

Crankcase ventilation filter media

Oil vapor contaminants from an internal combustion engine need to be removed from exhaust air to meet vehicle emission regulations. This poses an important challenge to manufacturers of engine filters. A crankcase ventilation filter separates oil droplets from

blow-by gases from the engine. A non-woven stainless steel medium with superior porosity is required. Blow-by gases flow through the tortuous structure; the medium captures and coalesces the oil vapor into large droplets which are then drained and recirculated to the engine. With the oil separated, only clean dry gas remains. The medium's low pressure drop and high level of separation and drainage avoid clogging, which makes the filtration process more energy efficient and reduces oil consumption. It also keeps the engine compartment and components clean and it protects the engine intake and air filters. All these factors contribute to a longer filter life and lower emissions. In addition, a compact structure and the ability to operate without hydraulic or electric drives reduce the complexity of the crankcase ventilation system. Choose a customizable system which allows changing the filter efficiency, dimensions and web weights.

FAST FIBER FACT

A metal fiber can be distinguished from a metal filament by its diameter. For example, within Bekaert, filaments below 100 µm in diameter are considered as fibers.

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Heat-resistant material for automotive glass bending

The optical quality of automotive glass, such as a windshield, depends largely on the bending process and the equipment. A determining factor is the choice of covering material for the forming mold. The material needs to be resilient, soft, and resistant to impact and high temperatures, to prevent the glass from scratching and distorting.

Contact and separation materials for automotive glass bending are based on high-quality stainless steel fibers that can be combined with other materials such as PBO, para-aramid and glass fibers. These materials can cover various parts of a hot glass bending system, including male molds, press rings and rollers.

Steel fiber heat-resistant textiles have excellent dampening qualities to enable the production of scratch-free automotive glass even under the toughest of bending conditions. Cover materials for hot glass bending include press cloths, woven fabrics, tapes, felt and quench products, sleeves and ropes. The materials must be able to handle gradually increasing temperatures up to 700°C or even higher. Their high temperature resistance enables the smooth production of laminated and tempered automotive glass for use in windshields, back lites, side lites and sunroofs.

Heating cables for Selective Catalytic Reduction tubes and tanks

New diesel engines must meet the strict Euro 6/VI standards. The aim is to reduce harmful emissions such as CO2, diesel particulates and NOx to near zero levels. To achieve these levels, producers of diesel engines rely on Selective Catalytic Reduction (SCR) systems, which require heating cables in or around the SCR tubes to heat up reductants such as AdBlue® / DEF.

Steel fibers are available which have been designed specifically for this use. Made from durable wires, they produce homogeneous heat distribution that guarantees reliable, fast heating and a high resilience to temperature variations. Their high mechanical strength and corrosion resistance make them reliable components for SCR systems. Tailor-made solutions are also available for specific corrosion resistance, diameter and electrical conductivity. High flexibility makes them easy to process around or inside the tube.

Choose heating cables that feature a stainless steel copper construction for adequate conductivity and corrosion resistance. This way the cables can be used in direct contact

with AdBlue® / DEF, while improving heating distribution. It is important to select heating cables for SCR systems that have been tested and approved in cars, trucks, busses and light- and heavy-duty vehicles, and are suitable for Euro 6/VI compliant vehicles.

AEROSPACE

Hydraulic fluid filter media

Hydraulic systems are the driving force for many aircraft components. Any malfunction can be catastrophic. It is therefore critical to keep these systems clean and in perfect working order. Moreover, replacing components is extremely expensive.

To remove contaminants from the hydraulic fluid, in-line filters are necessary. The media inside these filters consists of either glass fiber or metal fiber. Glass fiber media is held together by binders, making it structurally weaker than metal fiber media. The fluid flow fluctuations and vibrations in aircraft hydraulic systems cause the glass fiber media to shed fibers, binder material and release contaminants into the hydraulic fluid. Metal fiber media on the other hand is extremely strong. The fibers are fused together by sintering, preventing them from breaking down.

Choose fiber media with high porosity and permeability, to give absolute filter ratings as low as 2 µm, and keep the hydraulic system free of the smallest contaminants. It should have high dirt-holding capacity, a low pressure drop and good on-stream life. Highest quality stainless steel fibers will provide excellent thermal and chemical resistant properties. A monolayer or multilayer graded structure can be both pleated and welded, allowing flexibility in filter element design.

Aircraft cabin sound attenuation

Metal fiber porous media can be used as a sound attenuation element for aircraft. For example, the cabin air conditioning system sound can be securely kept under control with metal fiber silencer elements.

TEXTILE

Antistatic fibers for textiles

Electrostatic energy can build up in various ways. Examples include contact and separation of a person's shoe soles with the ground, contact between clothing and skin, or even induction when a person comes into the electrical field of a charged object. The higher the resistance of a person to the ground and the lower the relative atmospheric humidity, the higher the charge will be.

The solution is to wear antistatic shoes and clothing. This is produced from yarn consisting of a stainless steel, polyester or cotton fiber blend with electrostatic discharge properties. The yarns dissipate any static charges generated by body movement and fabric friction, guaranteeing the safety of the grounded wearer or user.
Fibers with excellent wash resistance should be selected, for example allowing up to 200 industrial washes, and those meeting the EN 1149 norm for antistatic textiles.

#2

FAST FIBER FACT

The technical definition is of a metal fiber is "a manufactured fiber composed of metal, plastic-coated metal, metal-coated plastic, or a core completely covered by metal." In other words, it's any fiber produced from metals, which may be alone or in conjunction with other substances.

It is also recommended to select yarns that are surface conductors rather than core conductors. A surface conductor means that the conductive parts of the fiber are both on the inside and outside. The advantage is that these fibers are in direct contact with the wearer of the antistatic garment preventing charging up (when grounded). Core conductors on the other hand are only conductive on the inside of the fiber. This increases the risk of static electricity building up on the surface of the fabric which can induce a charge in a nearby object and cause damage.

Conductive fibers and yarns for smart textiles

Tracking various items on a massive scale is an important challenge for many industries. RFID is the new standard in wireless monitoring and tracing. A wide range of stainless steel fibers and yarns can be tailored to meet various smart textile applications including wearable electronics, sensors, antennas for RFID tags and electrotherapy pads.

Highly conductive stainless steel wire provides a fast and accurate response time, as well as high chemical and corrosion resistance. RFID antenna performance and processability can be enhanced by a protective layer, for instance to resist 200 or

more washing cycles at load pressures up to 60 bar. Stainless steel fibers for this application need to be ultra-fine and soft so that they can be easily processed and are hardly noticeable for the end user.

EMI shielding fibers and yarns for textiles

Stainless steel fibers and yarns are an ideal component for electromagnetic interference (EMI) shielding textiles. With a shielding protection of up to 55 dB in a frequency range of 300 to 1000 MHz, they nearly match highly efficient alternatives like silver and copper.

Stainless steel fibers as thin as 6.5 µm show superior conductivity and shielding properties. When electric fields act on conductive materials, the yarns dissipate electromagnetic radiation at the textile surface, protecting the wearer or user from harmful levels of EMI or E-smog. Stainless steel fibers are easy to process with traditional textile technologies, and offer durable performance even after numerous washes.

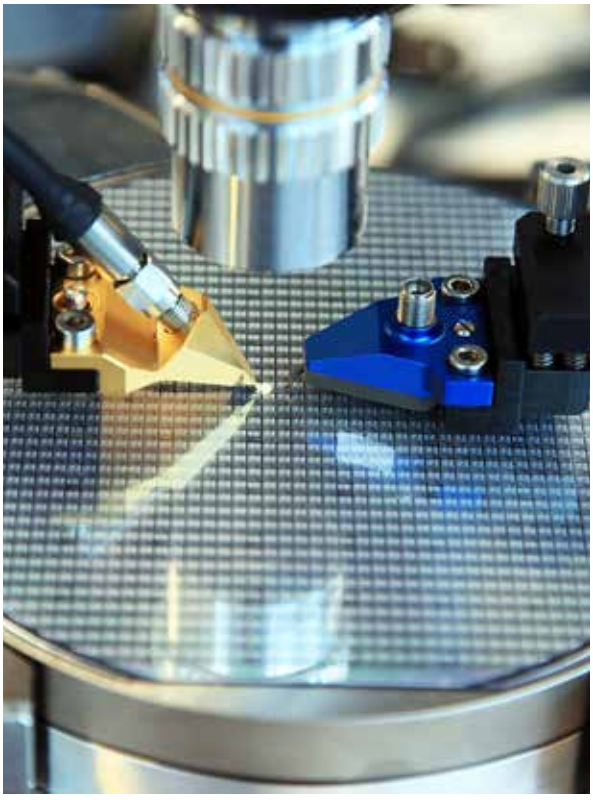
Specific applications include EMI blankets, braids and fabrics, pregnancy clothing, and high-voltage line garments.

Stainless steel fibers for heatable textiles

Continuous stainless steel yarns can be used for a wide range of heatable textiles, including garments, gloves, sleeping bags, and car seats. The yarns should be extremely flexible and supple, so they can be easily integrated into any type of textile while ensuring a high level of comfort to the wearer or user. Many material combinations and coating solutions are possible, depending on the required electrical or corrosion resistance. Cables can also be integrated in small circuits to enhance the warmth proximity with freedom of design. The high quality of the yarns ensures reliable and safe performance over the entire lifetime of the fabric.

The yarns can be insulated to increase the corrosion resistance, mechanical resistance and overall flex-life of the heating wire. This also enables consistent distribution of heat through the textile material, effectively preventing hotspots.

It's important to select stainless steel fibers with the appropriate electrical resistance for the heating function. This is generally determined by the fiber diameter and the number of fiber bundles.



Stainless steel fibers for cut-resistant textiles

A wide range of stainless steel filaments for the production of cut-resistant gloves, garments and sleeves can be blended with different materials to achieve properties such as high strength and flexibility. It is recommended to choose filaments that are very thin, but very strong. With diameters as thin as 35 µm, cut-resistant yarns using these filaments are extremely flexible and supple. This ensures the comfort of garments and glove design.

POWER & ELECTRONICS

Gas filtration

Any hot gas filter media should be able to resist temperatures up to 1000°C to ensure excellent filtration of hot gases in demanding applications such as oil refining, chemical gas filtration, natural gas filtration, coal gasification, calcination, and powder processing. Metal fiber, in the form of non-woven sintered media, offers extremely high porosity and a structure that enables efficient filtration at high operating pressure. This medium is easy to clean and shape, and offers high-temperature corrosion resistance.

HEPA filtration

To remove harmful particles, for example in the nuclear and semiconductor industries, non-woven media consisting of very fine fibers with consistent diameter is required. This ensures high

FAST FIBER FACT

Metal fiber media can reach porosities well over 90%. This is highly beneficial for applications where high porosity is required, such as diesel and gasoline particulate filters, crankcase ventilation filters, hot gas filters, and polymer melt filters.

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strength of the media while maintaining a very thin cross-section. Such a structure will enable efficient filtration at low pressure drop, even at the level of very fine sub-micron particles. Other recommended properties include thermal stability and chemical resistance. The ability of the media to be cleaned online will allow for continuous operation, while the possibility to pleat the media will enable a reduction in size of the entire system. Look for media capable of HEPA H14 filtration.

MARINE

Marine fuel and lube oil filtration media

In recent decades, marine engines have become significantly high-tech, especially with the introduction of innovative engine components like hydraulic controls and common rail injection systems. Engine parts need to be smaller, more performant, and more efficient than ever. This includes the fuel filter and the filters used in the engine hydraulic steering system.

Metal fiber sintered filtration media can be pleated and welded to fit a compact design for a smaller filter system footprint. It provides features such as high permeability, and filter ratings as low as 3 µm. This will effectively remove contaminants in fuel and lube oil, reducing wear on the engine components and reducing engine fuel consumption and pollutant emissions. Select a high-quality stainless steel with good thermal and mechanical resistance, and on-stream cleaning which further increases the filter lifetime.

#4

FAST FIBER FACT

One cubic meter of porous media can have well over 100,000 square meters of surface area.

INDUSTRIAL MANUFACTURING

Inkjet filtration

For ink filtration in inkjet cartridges and printheads, a very fine metal fiber filtration medium is used, encapsulated either in the ink cartridges or in the printer head. The size of the filter square or disk can be as small as 12 mm^2. Selecting this cleanroom grade material that offers fine filtration at high porosity, and high strength for a long lifetime, ensures that the media availability is on reel or cut to tailor-made dimensions.

Polymer melt filtration

For applications such as synthetic fibers, film, non-woven and chips, opt for a metal fiber medium that offers high porosity versus compressibility and the finest filtration ratio. It should be easy to clean and offer high corrosion and mechanical resistance for long on-stream lifetime.

Heat-resistant material for hollow glass manipulation

During the production of hollow glass, the smallest shock caused by tooling can scratch, crack or even break the glass. To prevent this from happening, all machine components that come into contact with the hot glass, such as stackers, fingers, conveyor parts and rollers, are covered with heat-resistant separation materials. A wide range of heat-resistant felts, tapes, knitted structures, braids and ropes are available to be easily glued, welded or screwed onto machine parts during the production of hollow glass.

#5

FAST FIBER FACT

Metal fibers can be tuned to have ductile elongation up to 25%. This characteristic is making metal fibers extremely interesting for new carbon composites structures.

High-quality stainless steel fibers have excellent dampening properties to absorb vibrations created during the manipulation process, and withstand temperatures up to 700°C. They can be combined with other materials such as PBO, para-aramid and glass fibers. These features increase the lifetime of glass products significantly, and also make them easier to process with a reduced risk of scratching and pitting. This results in the reduction of potential damage during the handling of delicate glass products, and thus the reduction of scrap.

ESD and EMI protection

Electrostatic discharge (ESD) and electromagnetic interference (EMI) can lead to accidents, fires or explosions. A highly conductive stainless steel fiber matrix structure in plastic products prevents ESD from building up and releasing a spark, or creates a Faraday cage offering excellent EMI shielding.

Metal fibers are durable, so their technical performance will not degrade, and are easy to process in compounding or injection molding. The fine fibers allow the production of plastic products in almost any shape and color without having to change the plastic molds. Moreover, metal pieces can be replaced by lightweight conductive plastics.

Stainless steel fiber reinforced composites

In many different sectors, more and more structural parts are being replaced with lightweight composite materials. For instance, carbon fiber based bicycles, airplanes or glass fiber based boat hulls. Stainless steel fibers can be used to create a composite material which is very impact resistant, and has supreme electrical conductivity properties. Possible applications include safer composite bicycles, impact-resistant leading edges in airplanes, or composites with supreme electrical charge dissipation properties.

The big disadvantage of carbon composites is the brittle and explosive breaking behavior. There is only a very limited amount of energy absorption before the composite shatters. It is found that a hybrid composite material – part carbon fiber, part metal fiber reinforced – is an answer to this problem. Due to the high elongation (up to 25%) of the steel fibers, large energy absorption occurs on impact, resulting in a composite which plastically deforms, but keeps its structural integrity after impact.

Heat-resistant materials for diverse applications

Stainless steel fibers can be used in heat-resistant materials for many different applications, notably in the automotive, machine building and equipment industries. They are the ideal alternative to fiberglass in terms of heat resistance and dampening properties, and as they are soft and flexible they are easy to shape, bend, weld or mold into diverse components.

Stainless steel heat-resistant materials exhibit interesting mechanical properties such as high tolerance to corrosion, even when exposed to high temperatures. They are non-flammable, chemically inert to other materials and feature excellent dampening properties. This results in long-lasting stability.

Heat-resistant contact material is used in various processes including the production of solar panels, container glass, glass bottles, flat glass,

FAST FIBER FACT

Metal fibers can be made out of many different kinds of alloys. The most common ones are stainless steel, titanium, copper and nickel, but new ones such as iron-aluminium and amorphous metal (“metallic glass”) are being discovered and used.

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aluminum and stainless cooking pans. For some applications, such as automotive glass bending, where temperatures can be somewhat lower, products that are blends of stainless steel and high-end heat-resistant polymer fibers are used.

Engineered fiber and textile solutions

It is possible to customize and engineer all kinds of fiber materials to meet specific application requirements. Possibilities include many kinds of steel alloys, as well as copper, nickel, high nickel alloys or titanium. Custom-built shapes and structures can be designed, such as 3D porous components, multilayer materials combining fiber media with wire mesh, or perforated plates.

Functionalities which can be achieved with custom engineered fiber solutions include high permeability, surface area, thermal and electrical conductivity, low thermal inertia, high ductility, wicking capabilities and corrosion resistance, all tailored to any specific application.

CONCLUSION

As clearly shown in this white paper, numerous application possibilities exist for metal fibers, in a range of sectors. They are all possible due to the excellent technical characteristics displayed by metal fiber structures and products. Moreover, new applications are being researched, developed and implemented every year.

Jos Vleurinck
is Head of R&D at the Textile division of Bekaert. There he leads new developments in heat resistant separation materials and in electro-conductive wires and textiles. Mr. Vleurinck has a Master in Electro-Mechanical Engineering and holds a PMP degree. Previous experience includes various global R&D management positions at multi-national corporations, leading multi-disciplinary development teams in automotive and consumer electronics.

Jérémie De Baerdemaeker
is Technology Manager at Bekaert Fiber Technologies. His Global R&D team focusses on metal fibers for Filtration, Conductive plastics and Business Development opportunities. Before starting his career with Bekaert, Mr. De Baerdemaeker worked as R&D Team leader at the Ghent University where he also graduated as Ph.D. Physics. He also worked as Post-Doctoral Fellow at the Center for Materials Research at Washington State University.

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BFTINFO@BEKAERT.COM
METALFIBERS.BEKAERT.COM

Bekaert is a world market and technology leader in steel wire transformation and coating technologies. To be the preferred supplier of steel wire products and solutions, we consistently deliver superior value to our customers worldwide.
Bekaert (Euronext Brussels: BEKB) was established in 1880 and is a global company with approximately 30 000 employees worldwide.

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