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# An introduction to Metal Fiber Technology



# CONTENT

Introduction

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A brief history of metal fibers

---

Types of metals commonly used

---

Production processes

---

Definition metal fiber

---

Types of fiber products

---

Properties

---

Application segments

---

Conclusion

---

# WHITEPAPER

## An introduction to Metal Fiber Technology

Jérémie De Baerdemaeker and Jos Vleurinck, Bekaert NV

### INTRODUCTION

70 years after their first industrialized use, metal fibers are now widely produced and available in a wide range of different alloys and product forms. Their increasing use in industrial applications is driven by a combination of high electrical conductivity and excellent high thermal corrosion resistance. They offer a proven technology with a huge variety of possible applications that contribute to a cleaner, safer, quieter and more comfortable world.

This white paper provides an overview of the production processes involved in metal fiber production, the various types of metal fiber products, their key properties and a short summary of the main application segments.

## A BRIEF HISTORY OF METAL FIBERS

Metallic filaments and yarns have been used for more than 3000 years. Gold and silver were hammered into extremely thin sheets, cut into ribbons and worked into fabrics. Examples include magnificent Persian carpets and Indian ornamental sarees. Down through the centuries, kings and queens have worn garments that have glittered with gold and silver fibers twisted or wrapped around cotton or some other thread.

In the mid-20th century, the more industrialized use of metal fibers in various applications began, when the Dobeckmum Company produced the first modern metal fiber in 1946.

During the early 1960s, Brunswick Corp. conducted a research program to develop an economical process for forming metallic filaments. They started producing metallic filaments in a laboratory-scale pilot plant. By 1964 Brunswick was producing fine metal fibers as small as 1  $\mu\text{m}$  from 304 type stainless steel. Their 750,000 lb.-per-year metal filament plant in Michigan, USA was brought on stream in 1966. Metal fibers are now widely produced and used in all kinds of technology. It's a mature sector with a wide range of applications.

## TYPES OF METALS COMMONLY USED

Thanks to good electric and heat conductivity, high corrosion and thermal resistance, and excellent EMI and ESD shielding capabilities, stainless steel fibers are used throughout numerous consumer and industrial applications in diverse fields. Fecralloy (iron-chromium-

## DEFINITION METAL FIBER

Technically, a metal fiber can be defined as "a manufactured fiber composed of metal, plastic-coated metal, metal-coated plastic, or a core completely covered by metal."

In other words, a metal fiber is any fiber produced from metals, which may be alone or in conjunction with other substances.

A metal fiber can be distinguished from a metal filament by its diameter. For example, within Bekaert, filaments below 100  $\mu\text{m}$  in diameter are considered as fibers.

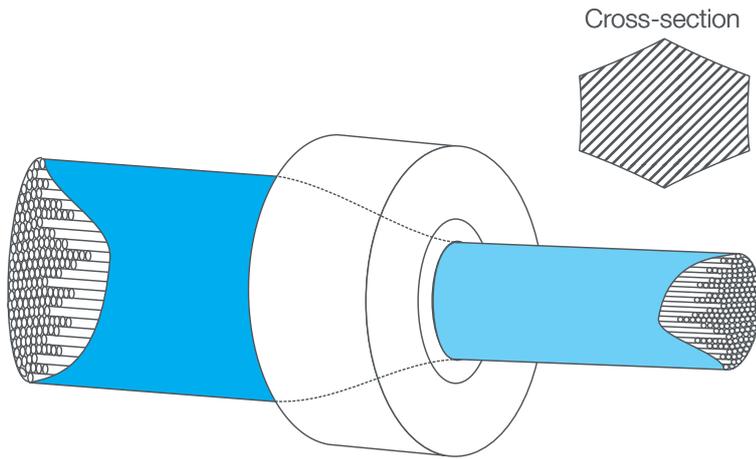
aluminum alloy) fibers are even more resistant to high temperatures and are often used in vehicle exhaust pipes and high temperature filtration felt and burners. Nickel displays resistance to chemicals, acids and alkalis, and good electric and thermal conductivity, making it suitable for diverse applications.

## PRODUCTION PROCESSES

There are several ways to produce metal fibers, which can then be transformed into knitted, braided, woven or non-woven products that resist high temperatures or provide electrostatic protection or electromagnetic shielding.

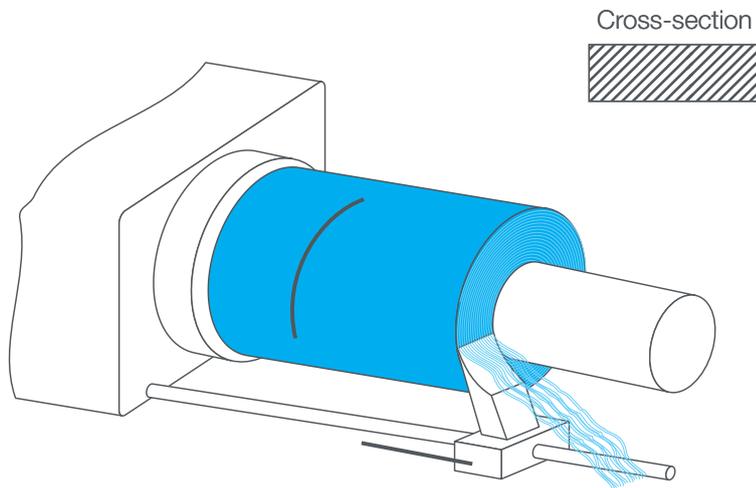
### Bundle drawing

The most common technology is known as bundle drawing. Several thousands of filaments are bundled together in a so-called composite wire, a tube which is drawn through a die to further reduce its diameter. The covering tube is later dissolved in acid, resulting in individual continuous metal fibers. This composite wire is drawn further



#### BUNDLE DRAWING

allows for the production of a continuous metal fiber bundles in a very wide range of diameters and with lengths of up to several kilometers.



#### FOIL SHAVING

produces semi-continuous fibre bundles from a metal foil with diameters as small as 14  $\mu\text{m}$ .

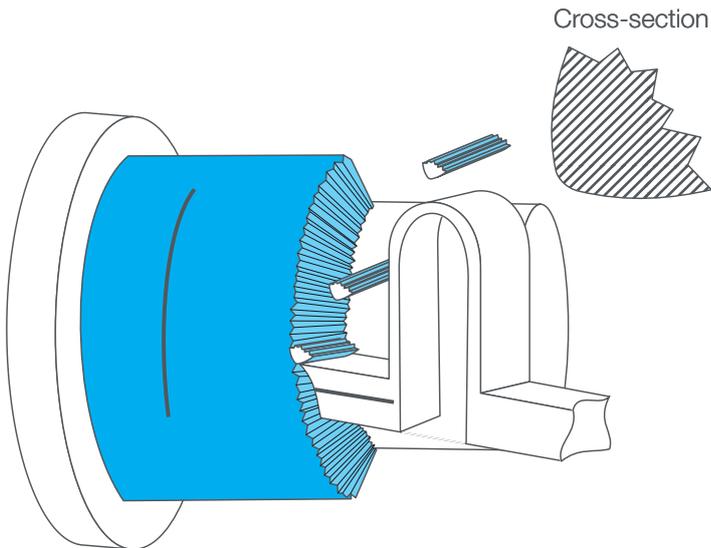
until the desired diameter of the individual filaments within the bundle is obtained. Bundle drawing technology allows for the production of continuous metal fiber bundles with lengths of up to several kilometers.

Due to the nature of the process, the cross-section of the fibers is octagonal. In order to achieve high-quality fibers, this technology can be fine-tuned, resulting

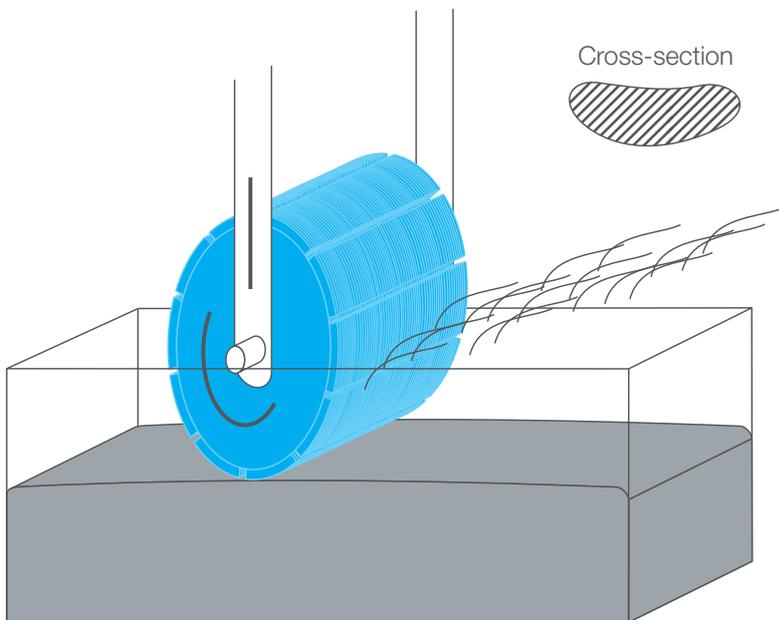
in uniform, very thin fibers with a very narrow equivalent diameter spread. Special developments within the last couple of years have allowed this technology to be used for the production of fibers with diameters as small as 200 nm and below.

#### Foil shaving

With foil-shaving technology, fibers with diameters down to 14  $\mu\text{m}$  and a more rectangular cross-section are feasible. This produces semi-continuous bundles of fibers or staple fibers.



**MACHINING**  
produces individual staple fibres  
as small as 10  $\mu\text{m}$ .



**MELT SPINNING**  
produces semi-continuous fibers via rapid  
solidification of liquid metal onto a rotating  
cooled wheel. The resulting fibers are  
coarse, with diameters typically larger than  
40 $\mu\text{m}$ , and up to 250 $\mu\text{m}$ .

### Machining

Machining of staple fibers can produce semi-continuous bundles of fibers down to 10  $\mu\text{m}$ . Improving staple fiber manufacturing allows a narrow diameter spread on these kinds of fibers as well as tuning of the geometry of the fiber. This technology is unique compared to foil shaving or fibers from melt spinning, due to the small diameters that can be reached and the relatively small diameter spread.

### Melt spinning

Melt spinning produces semi-continuous fibers via rapid solidification of liquid metal onto a rotating cooled wheel. The resulting fibers are coarse, typically above 40 $\mu\text{m}$  fiber diameter up to 250 $\mu\text{m}$  and have a kidney shaped cross-section.

## TYPES OF FIBER PRODUCTS

### Sintered media

Metal fibers are converted into fiber media either as non-woven fleece or sintered structures composed of fibers ranging from 1.5 to 80  $\mu\text{m}$  in diameter. These porous metal fiber media have been used for their uniqueness in highly demanding applications. The benefit of having the combination of an outstanding permeable material (porosities up to 90% for sintered and up to 99% for non-woven structures) combined with high corrosion and temperature resistance is highly valued. The sintered porous structure has no binder as the individual fibers are strongly bonded together by inter-metallic diffusion bonding. 3D sintered structures have also become a standard product. Some of the latest developments are relate to filtration media using a combination of metallic and non-metallic fibers, allowing the best of both worlds.

### Short fibers

A specially designed process allows the production of individual powder-like metal fibers known as short fibers with a length over diameter (L/D) range of 100. These short fibers can be used as such or in combination with metal powders to produce sintered filtration structures with ultra-high levels of filtration while allowing unique levels of permeability.

### Polymer pellets

Other metal fiber products are polymer pellets or grains composed out of metal fibers. Several bundles of fibers are glued together with a variety of sizings and an adequate compatible extrusion coating is applied. After chopping these coated bundles into pellets they can be used as additives in the production of engineered conductive/shielding plastic pieces by injection molding and

extrusion. The unique benefit of metal fibers is the conductive network formation with a relatively limited volume of conductive additives.

### Non-wovens

Non-wovens or felts can be produced with metal fibers, just like with traditional textile fibers. In a very limited number of cases, needle punching can be applied to entangle the fibers and obtain needle-punched felt.

### Yarns

A bundle of endless stainless steel fibers can be converted to yarns by textile spinning processes. There are two forms of yarn: one with a low amount of fibers and one with a high amount of fibers. The former, with a number of filaments of around 275, can be converted into a filament yarn by adding twist to the bundle. Bundles with several thousands of fibers are typically used to convert

## PROPERTIES

Metal fiber structures and products display excellent properties, such as high porosity, which benefits the function and structure of specific applications. Their low electrical resistance makes them suitable for any application that requires electrical conductivity. Excellent thermal resistance makes them withstand extreme temperatures, while corrosion resistance is achieved through the use of high-quality alloys. Other advantageous mechanical properties of metal fibers include shock resistance, fire resistance and sound insulation.

fibers into spun yarn. That can be done by stretch breaking and subsequent traditional yarn spinning technologies. This results in 100% metal yarns. During the spinning process, tows can be blended and blended yarns can also be produced. Blends with cotton, polyester and wool are possible.

Subsequently, metal yarns can be further converted into various textile products using textile processes. Knitting (circular, flat, warp) and weaving are possible, as well as braiding. Blended textile products can be obtained by combining metal yarns with other yarns, or by using yarns that have two kinds of fibers inside and hence are already blends by themselves.

#### Electrical cables

To make cables, two or more filaments are twisted together a number of times. During the process, a cable's torsion and straightness are monitored. The cable can be fine-tuned for a certain application by combining different filament strengths, diameters or the number of twists, or by preforming.

#### Composites

Metal fiber can be used as reinforcement fiber for composite materials, improving breaking behavior upon impact and electrical conductivity. Traditional carbon or glass fiber reinforcement fibers have very limited elongation possibilities, which results in a brittle and explosive breaking behavior. Metal fibers act perfectly complementary to this, and can absorb much more energy before breaking. Processing is no different from any other reinforcement fiber for composite material. It is even possible to combine metal fibers with other fibers into a 'hybrid' composite structure, which combines all the benefits of carbon, glass and steel.

## APPLICATION SEGMENTS

#### Esd/emi protection

Metal fibers are used to protect a variety of products against ESD and EMI such as big bags, brushes, carpets & upholstery fabrics, plastic compounds, and personal protective clothing.

#### Filtration

Filtration applications range from diesel and gasoline particulate filtration, gas filtration, HEPA filtration, hydraulic fluid filter media, inkjet filtration, marine fuel & lube oil filtration media, polymer melt filtration, and crankcase ventilation filter media.

#### Heating

Specific applications in this segment include car seat heating, heatable clothing, and SCR heating.

#### Hot glass manipulation

Stainless steel textiles offer unique advantages during the production of automotive glass, automotive mirrors, ballistic glass, container/hollow glass, and solar glass.

#### Specialties

This segment includes applications such as brake pads and clutches; composite reinforcement; cut-resistant gloves; heat pipes; regenerator materials; seals, packing & gaskets; smart textiles; sound attenuation; and cooking ware forming.

## CONCLUSION

70 years after their first industrialized use, metal fibers are now widely produced and available in a large range of different alloys and product forms. The increasing use of metal fibers in industrial applications is driven by a combination of high electrical conductivity and excellent high thermal corrosion resistance. Traditionally, metal fibers are processed into two main product groups: sintered media and textile products. Sintered media are used in several demanding microfiltration

processes due to their high porosity, cleanability and durability, whereas textile products allow the creation of metallic structures which are soft, flexible and feature exceptional dampening properties. Metal fibers are a microscopic material that can contribute to enormous efficiency gains. They offer a proven technology with a huge variety of possible applications that contribute to a cleaner, safer, quieter and more comfortable world.



### **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](mailto:BFTINFO@BEKAERT.COM)

[METALFIBERS.BEKAERT.COM](http://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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