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Black Magic; The Present and the Future Application of Oxidized and Carbon Fibers
(Fekete mágia; az oxidált- és a szénszálak jelenlegi és jövőbeni alkalmazási területei)

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Summary

A large percentage of the oxidized & carbon fibers raw material (nearly 95%) is PAN (Precursor) fiber, from which in a first step, namely oxidation at 200-250 ºC, the so called oxidized fiber (OPAN, OPF) is produced.

The **oxidized fiber PYRON** (having high LOI value and good insulating properties) can be processed into technical products or for e.g. protective clothing's using the well known textile technology processes. A significant part of the textile products made from OPAN is carbonized, from C&C composites airplane brake discs or brake linings are made, while another large part of the products, after carbonization, constitute a functional element in fuel cells.

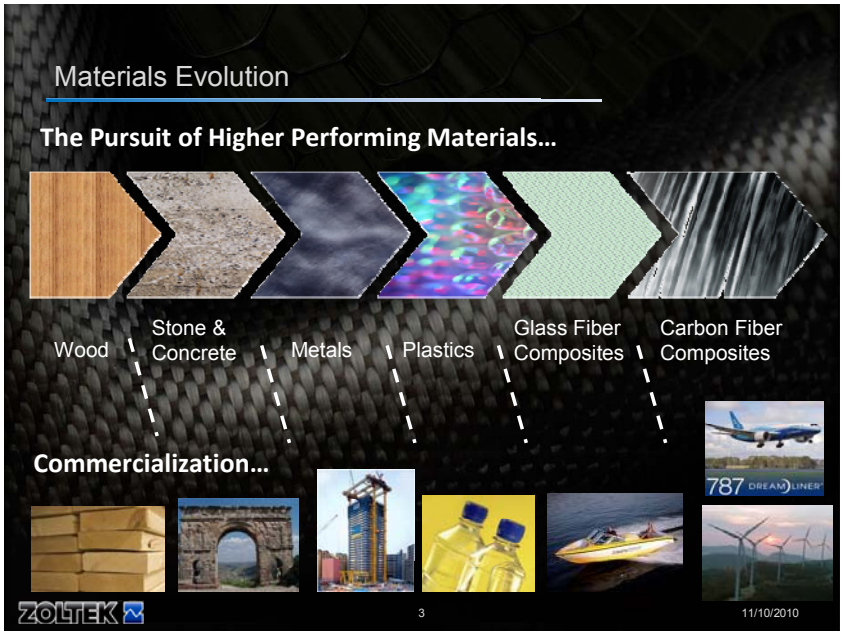
In the production of **carbon fiber (PANEX)** fibers from the oxidation ovens are further passed, under tension and into hot nitrogen gases 1000-1500ºC thusly forming carbon fiber, which's properties significantly differ from the initial material or the oxidized fiber. Primarily, its flexibility modulus and tensile strength that is outstanding. Due to this, the fiber is stiff and brittle, conducts electricity; therefore its processing requires special attention. Carbon fiber, in the case of especially high mechanical requirements, represents an indispensable composite strengthener.

In the various ages, materials used by man changed significantly, in our time polymers, as competitors to metals are becoming more & more significant.

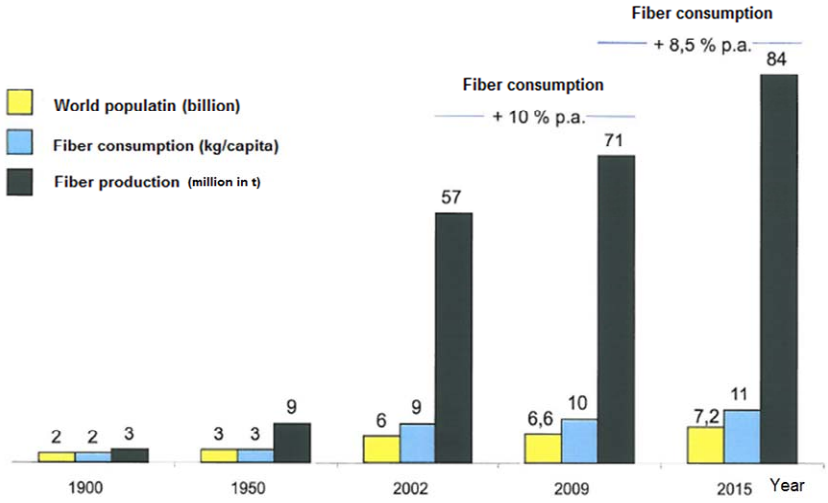
Another great challenge of today is to ensure the ever increasing demands for energy, while reduction of carbon dioxide emissions harmful to the environment is a must.

In the near past, the quantity of goods used by humanity has increased significantly. This tendency is true for the consumption of fibrous & composite materials and expectedly, this tendency will continue in the future.

Development of fibers having special properties and meeting the ever broadening spectrum of demands is undiminished, even today numerous new fibers are created, or rather the existing ones are modified per the increasing need. Besides the usage of textile fibrous materials and structures in the clothing & home textiles fields, this has been expanded with the introduction of technical textiles and a new dynamic field of application for these certain groups of fibers is their use as reinforcing material in composites.



Change of world populations, fiber consumption and fiber production

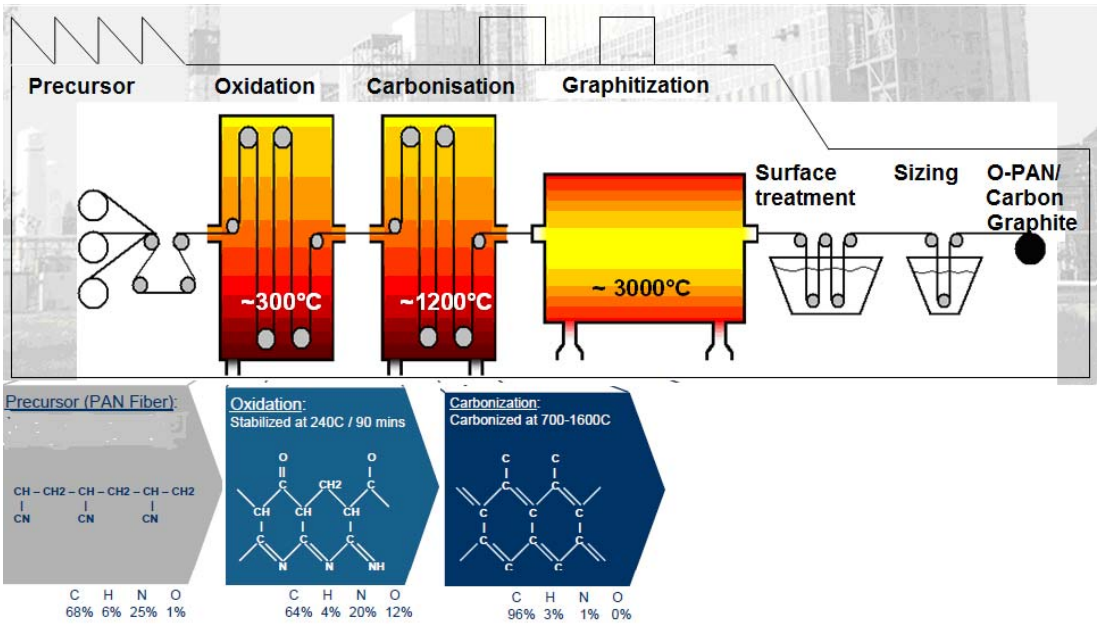


Whereas in the first three fields of applications, one of the most important mechanical properties of the used textile fibers, structures is tensile strength, in the case of composites besides the tenacity values, rigidity is also a determining factor which is attained by the use of reinforcing fibers or such structure forms which best meet the requirements. The mechanical properties of reinforcing fibers used in composites and textile structures can be best characterized by their high tenacity, low elongation & high flexibility of modulus.

Even amongst the composites, the carbon fiber is considered as having special properties „black magic", which is being used in ever broadening fields of applications and because of home production, its use also, means great possibilities for us.

Zoltek, using identical raw material (Precursor) and in the first phase of production, also using identical (Oxidation) processes, produces two types of fibrous material, namely; oxidized and carbonized fibers, which's properties (not considering their common black coloring), processing and field of application is significantly different.

The oxidation, carbonization and graphitization process



A part of the O-PAN fibers, although after some type of textile technology processing is carbonized, and similarly to the carbon fiber attain high carbon content (95-99%), the mechanical & other properties of these carbon materials differ from the properties of carbon fiber.

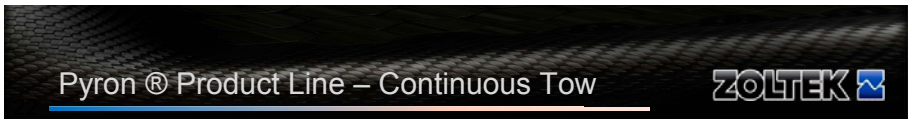
Pyron (oxidized poly-acrylonitrile fiber (OPF)) based on its strength – elongation properties, is a technical textile fiber (in 1,7 2,2 or 5 dtex fineness), with high LOI value and having excellent heat resisting, insulating properties. The OPF can be processed using the known textile technologies (spinning, weaving, knitting, non-woven), and can be used in the flame – heat resistant, heat – sound insulation fields.

In the course of using Pyron in other applications, the suitably formed non woven structure is carbonized at a high temperature and the thusly resulting paper like 99% carbon content material is used for fuel cell in hydrogen driven electric motors or electric energy containers.

Another significant field of application for Pyron, is when numerous layers, (non woven or woven) is carbonized (C), then diffusing carbon into it, a solid structure is formed (C – C composite), from which high heat resistant & wear proof brake discs, brake linings can be made.

Properties of Pyron and Panex

Properties	PYRON	PANEX
C contain (%)	62	>95
Thermo resistant	Good thermo-Insulator	Good thermo-Conductor
Electric	Electric Protective	Electric Conductivity
Tensile strength (MPa)	260	4200
Modulus (GPa)	8,5	242
Elongation (%)	20-25	1,5



Fiber count:	300 k
Density:	1.37 & 1.4 g/cc
LOI	40% & 50%
Fineness:	1.7, 2.2 & 5.0 dtex
Filament diameter:	12.5, 13, 20 µm
Elongation	23%
Moisture content:	6.5%
Tow mass	51 g/m
Tensile strength	240 MPa

Common applications
- Cutting into staple fiber
- Stretch breaking and processing into yarn
- Carbon-carbon brake applications

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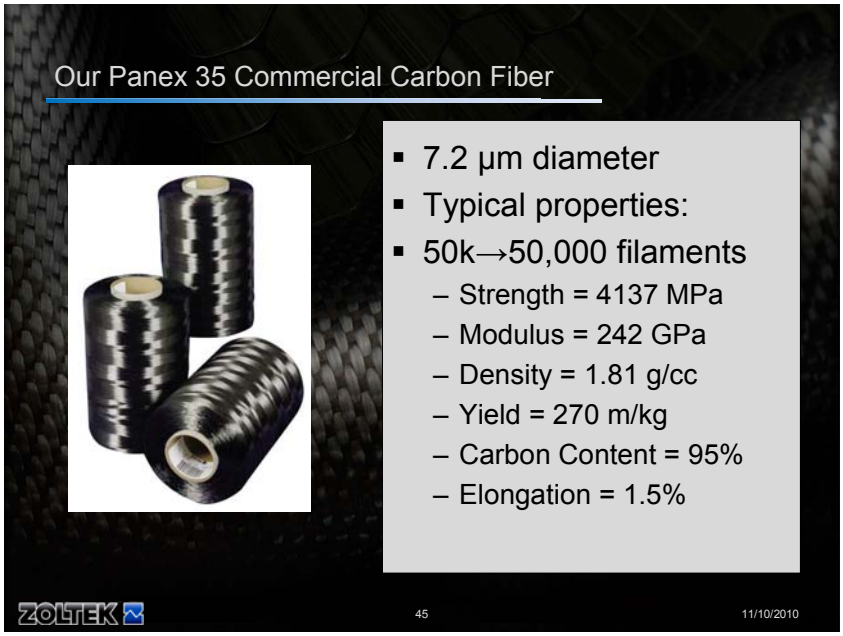
Following oxidation, the **Panex** carbon fiber is produced by passing it through (under tension) high temperature nitrogen gas, thusly carbonizing it. Carbon fiber is material having high tenacity, flexibility modulus, is brittle and a good conductor of electricity, therefore in its processing special care is required. Embedded into composites it is used as a directional structured reinforcing, bracing material.

Carbon fiber produced by Zoltek has a Ø of 7 µm (approx; 0,7dtex fineness), its tow contain a high number of fibers (50 k→50000 filament) which's main fields of applications are.

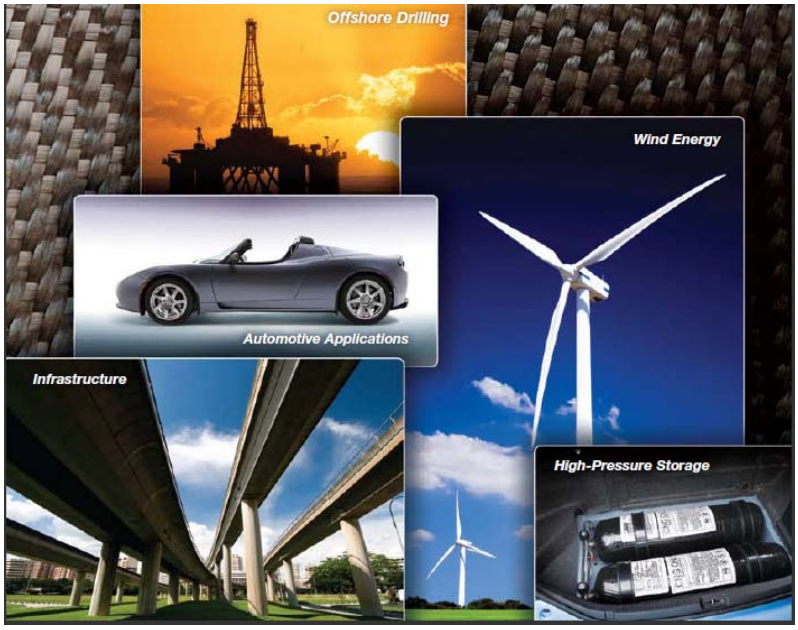


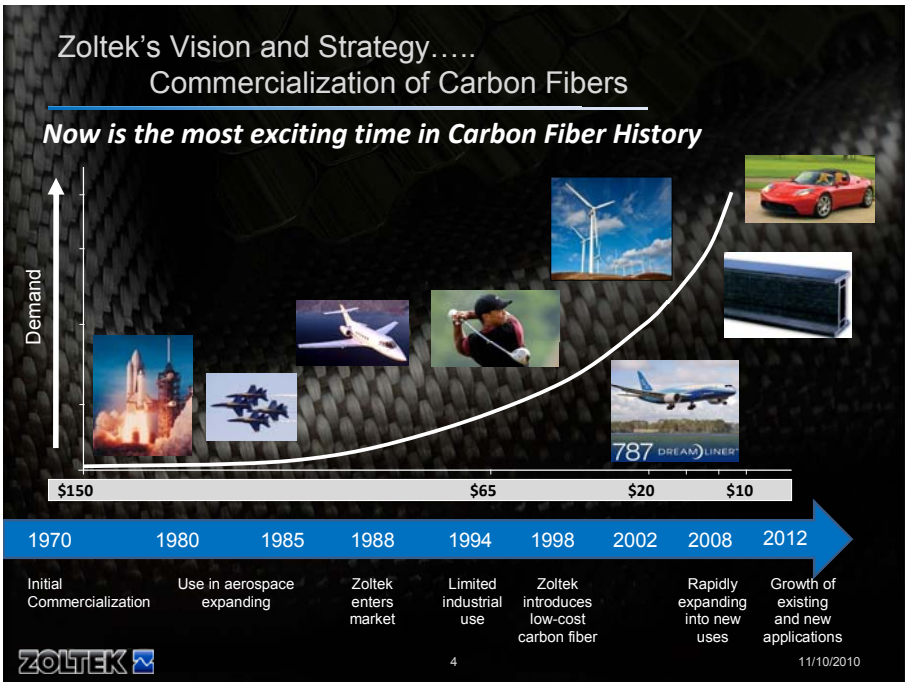
- As a bracing for over 40m long wind blades,
- Car bodies & chassis elements
- High pressure tanks
- Fastening cables for sea drilling towers
- Boat hulls
- Reinforcing building structures
- Manufacturing of carbon - ceramic composite brake discs

The carbon fiber in

- Powder or chopped form (3-10 mm) is extrudable
- Tow form may be laid, wound or
- Using various textile technology processes (UD, BD, MD or 3D) structures can be formed, which embedded in a matrix material can be used to reinforce composites

Carbon fiber is an indispensable fiber – textile structured reinforcing material for directional structured composites requiring high stress, rigidity, its mechanical properties, especially pertaining to mass, severalfold surpasses (its price also) the traditional steel or aluminum structures. Field of application is mainly those areas where especially high rigidity and tenacity is required, unavoidable.


Offshore Drilling
Wind Energy
Automotive Applications
Infrastructure
High-Pressure Storage


Zoltek's Vision and Strategy…..
Commercialization of Carbon Fibers
Now is the most exciting time in Carbon Fiber History
Demand
787 DREAMLINER
$150
$65
$20
$10
1970
1980
1985
1988
1994
1998
2002
2008
2012
Initial Commercialization
Use in aerospace expanding
Zoltek enters market
Limited industrial use
Zoltek introduces low-cost carbon fiber
Rapidly expanding into new uses
Growth of existing and new applications
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ZOLTEK
ZOLTEK's Mission
"To lead the commercialization of carbon fibers as high-performance yet low-cost reinforcements for structural composites in everyday commercial products."
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