High-performance Hemp Fibres and Industrial Applications: brake linings, gaskets, and others

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Ladies and Gentlemen,

[Foil 0]

I'm going to talk about Setralit, a high-performance industrial fiber based on renewable materials. It was invented – or better to say discovered – by my company ECCO Gleittechnik GmbH, and has been (permanently) further developed since then. Actually it's not a single fiber type but a whole class of fibers which may look very different because they are tailored to varying industrial applications.

[Foil 1]

I would like to introduce our company.

Then I will tell you a little bit about the history of Setralit.

After that I will explain two of the most important development projects: the *ultrasonic process* and the *fibrillation* of plant fibers.

This will be followed by some technical aspects and application examples.

In my conclusion I will summarize and talk about future prospects.

Please, don't expect a sophisticated scientific presentation. We are a small private enterprise; our first goal is to sell. So, for us it's more important to know that things work and can be marketed rather then to exactly know why.

[Foil 2]

ECCO Gleittechnik is the mother company. It's a holding and includes several daughters. The main daughter companies are the Setral Chemie GmbH (SCG), a trading firm which operates in Germany and worldwide, and the Sétral S.à.r.l. (SSA) domiciled in France.

Setral Germany and Sétral France mainly work on special lubricants for industrial use. Production and trade of those lubricants in French speaking countries are managed by the French Sétral, which is where Setralit fibers owe their name. Setral and ECCO earn their money mainly with production and trade of those special and high-performance lubricants.

The third branch company, ECCO Fibre, is located in Southern Germany, and deals exclusively with the fiber business.

[Foil 3]

This slide shows the European sales network. Production facilities for lubricants are in Alsace, France. ECCO sales companies are in Austria, Germany, France, and Portugal, and representatives are found in fifteen more European countries.

[Foil 4]

This shows a few impressions of our company. The upper left photo depicts our company building in Seeshaupt, Southern Bavaria. Next to it you see the production buildings in France. The other photos show production and testing facilities.

[Foil 5]

As a producer of special lubricants we also supplied solid lubricants such as molybdenum disulfide and lubricating powder mixtures – so-called Mipos – to friction lining industries.

The situation there presented itself as follows:

Asbestos was banned, 1989 in Germany, and 1992 in the EU. Substitutes were already available: a) glass fiber, and b) aramid, a high-performance synthetic organic fiber: both in form of fiber pulp, analogical to asbestos. However, the producers of friction linings were not really happy with these substitutes: The first one created occupational health problems, the second one was really expensive.

In agriculture, on the other hand, there was an overproduction of foodstuff which led to set-aside of cultivable land. They were looking for alternative crops which were innocuous to closure premium.

Consequently the Federal Republic of Germany initiated a project to introduce vegetable fibers in friction materials. ECCO Gleittechnik, being a supplier to friction lining industries and known as problem solver, was invited to participate in this project.

This was the birth of *Setralit* – a refined plant fiber.

[Foil 6]

So, in 1989 Setralit was invented – or detected for industry. Between 1991 and 1993 the *Friction Project* was conducted. Various projects followed, mostly in co-operation with industrial partners. Most important were the two blue typed projects: *Ultrasound* and *Fibrillated Fiber*, which I will discuss in more detail later.

In 2002 we started to commercialize, together with external partners, and we finally succeeded by 2007 in market break-through with reference to the friction industry.

[Foil 7]

Demands on technical fibers are quite high in this industry because friction linings, especially brake pads, are regarded as security goods.

These are the demands on technical performance:

Excellent processing properties (e.g. high specific surface);

Satisfactory mechanical properties (e.g. tensile strength);

An adequate thermal stability; and

Very low quality variations.

There are also ecological demands:

Production must be safe for workers; the materials need to be non-toxic.

Production and use should be environmentally friendly.

And, of course, demands on market:

Fibers must be steadily available,

And exhibit a moderate and stable price.

[Foil 8]

Now, how about plant fibers?

Conventional plant fibers have already some quite interesting technical properties:

Low density,

High tensile strength (if we talk about the elementary fiber),

Alkali-resistance,

Low electrostatic loading,

And they are non-toxic (only to mention some).

There are other properties which might be advantageous or which might be adverse, like

Water absorption ability, or

Bio-degradability.

On the other hand, with conventional plant fibers we have a problem with:

Low temperature stability, compared to glass and aramid, and

Variations in quality.

Those two are definitely killing characteristics for the use in brake pads.

[Foil 9]

These problems had – among others – led to the development of our ultrasound technology. We call it the *Setralit® process of ultrasonic fiber break-down*.

The plant fiber raw material (flax, hemp, jute, ramie and others) is freed from non-fibrous plant components in what is the so-called *decortication*. Decorticated raw fibers are treated in an aqueous ultrasonic bath; the contact with ultrasound lasts only about 30 seconds. The material is freed from unwanted contaminants and plant constituents like glues, scents, natural dyestuffs, dust, spores and so on.

The treated fibers are washed and dried. And, finally, the dried "*ultrasonic*" Setralit fiber can be further refined in different ways (solely or combined), like carding, fibrillating, grinding, milling, cutting (exactly or randomly), or even ultra-fine grinding.

[Foil 10]

The main improvements we get with the SETRALIT® ultrasonic process are as follows:

Impurities (dust, microorganisms) and plant associated substances are removed completely or to a large extent.

The temperature stability increases compared to conventional plant fibers, due to higher purity, that means lack of thermally unstable fiber constituents.

Wettability and colorability, that are the abilities of the fiber to be wetted and dyed effectively and equally, are improved, due to the removing of water-repellent substances, such as waxes.

Last but not least – the variation of physical properties is strongly diminished; and consequentially, the variations in technical performance will also be diminished in the same way.

[Foil 11]

Let's come back to the demands on technical fibers – again with respect to their use in friction linings:

One of the most important technical demands on the fiber is to have good processing properties, like prevention of demixing and dust-binding. A prerequisite for that is a high specific surface.

Both (asbestos and aramid fiber pulp) have very high surface areas as shown here by scanning electron microscopy (SEM). Asbestos, as everybody knows, does not fulfill at all the ecologic demands.

Aramid fiber pulp which is largely used nowadays, may become questionable in the future, in terms of steady availability and moderate and stable price, since most of the aramid production is used for even higher priced bullet protection.

Conventional hemp, on the other hand, also shown here by a SEM photo, lacks a high specific surface. Thermal stability and quality constancy are also insufficient, but we had fixed that with ultrasonic treatment.

So we needed a means for increasing the specific surface.

[Foil 12]

A self-evident approach appeared to be fibrillation of hemp fibers in a similar way as it is done with aramid.

First the plant fiber raw material (flax, hemp, jute, ramie, and others) is freed from non-fibrous plant components and ultrasonically treated, shown on a previous slide. I've talked that over, already.

Clean ultrasonic fibers are cut to a preset length, depending on fiber type and on intended further processing. Such fiber chips (we call them "*Pommes*") are milled with a fibrillating device resulting in high-surface natural fiber pulp (see SEM picture).

Finally Setralit fiber pulp is packed (pressed in bales or loose in *BigBags*). The fibers might be used for further processing (for example air-laid nonwoven production).

[Foil 13]

These are SEM pictures of different plant fibers, Hemp, Flax, Ramie, which were fibrillated by the same method. As you can see, there are differences regarding the appearance of the fiber surfaces. Some plant fibers exhibit a stronger capability to form fibrils than others.

This observation helps us to selectively use certain fibers for a given application.

[Foil 14]

This table compares the characteristics of Setralit with those of aramid fiber pulp.

Many physical properties are very similar, like density, size, tensile strength, and E-modulus.

Decomposition temperature is significantly lower, 270 degrees Celsius versus 450 degrees Celsius, but that doesn't matter for brake application, because cellulose fibers have a high thermo-shock resistance.

Basic differences occur also with the ability to absorb water, sensitivity to electrostatic charging, and – of course – suspicion of toxicity. Altogether Setralit hemp fiber pulp turned out to be a very positive alternative to aramid in friction lining mixtures.

[Foil 15]

Another very interesting feature is the complete miscibility of Setralit with aramid fiber pulp, as is depicted on this foil.

Within only a few seconds of mixing the fibers entangle themselves very closely and the mixture becomes quite homogeneous. This is due to the very similar aspect images of these two fibers.

So in friction linings as well as in other applications like for example gaskets, aramid does not have to be substituted completely but by any favorable percentage.

[Foil 16]

The two main Setralit processes, ultrasonic treatment of plant fibers and fibrillation, as well as the materials being created by these processes, are patented. Moreover, for the ultra-sonic processing, the machinery is also protected.

[Foil 17]

Now we want to give some examples where Setralit fibers have been positively tested in concrete industrial applications.

The first project concerned friction linings, and the aim was to use natural fiber pulp in place of aramid fiber pulp in brake pads for passenger cars; it was a 100 % replacement. I mentioned this project before, and now I want to present the basic results:

Regarding friction coefficient and reproducibility, there is no significant difference. The wear of brake pad is about 20 % up, the wear of disk about 10 %. This slightly higher wear is compensated for by an improved driving comfort concerning a better “pedal feeling” during braking.

That proves that Aramid can be completely replaced by Setralit without significant quality loss.

[Foil 18]

If we take into account the current marketing prices, 15 to 25 euros for aramid and only about half of it for Setralit, there are strong arguments to use Setralit instead of aramid. And we actually already have some customers in the brake lining industry who do that.

As to the use of Setralit in gaskets, I only want to point out the analogies to friction materials. But the history of development of materials for gaskets shows strong similarities to that of brake linings:

A few decades ago they used quite a lot of asbestos in both applications. Now, both, gaskets and friction linings mostly contain aramid fiber pulp. First experiments with Setralit show, that natural fiber pulp will do as well, at least for some gasket types.

[Foil 19]

Another interesting application field of Setralit is construction materials. The cultural history of mankind shows that construction materials and plant fiber reinforcement go hand in hand.

One of our successful projects was to reinforce aerated cement, the so-called *Ytong stone* with SETRALIT.

At the beginning of this project, however, the Ytong stones proved to exhibit unacceptable quality variations if conventional plant fibers were used for reinforcement. It was an analog problem to that I talked about before. But after that only fibers treated by ultrasound were taken, and the result stabilized.

All results were normalized to 0.5 weight% fiber portions of the total dry solids, because it turned out that the improvement of mechanical strength properties increases proportionally with fiber content, and 0.5 weight% is a realistic amount of admixture. It was demanded that compressive strength must not decrease, and this was fulfilled. Bending tensile strength, the most important parameter, increased by 30 %, and the technical working capacity by more than 100 %, compared to reference with the specimen which didn't contain fibers at all.

[Foil 20]

The next example of industrial application of Setralit is reinforcement of plastics materials.

Here we compare the mechanical properties of glass fiber reinforced polypropylene (with 10 weight-% glass) and bast fiber reinforced polypropylene (with 30 weight-% fibrillated hemp fiber).

I want to confine myself to just showing that the physical values of certain parameters like tensile strength or bending E-modulus are not only reached, but even exceeded. Of course, in this application, the glass fiber was not substituted 1 to 1, but much more natural fibers (3 times more, by weight) were introduced.

[Foil 21]

Now I want to start summarizing:

ECCO-Fiber is the R&D business of ECCO Gleittechnik GmbH (which is the parent company) owned by Mr. Karl-Heinz Hensel. ECCO-Fiber has successfully developed a high-tech fiber based on natural resources for various applications.

Setralit fibrillated fiber is gradually substituting aramid fiber pulp within friction lining industries. Manufacturing of Setralit fibers is managed by an external partner. All relevant fiber developments have international patent protection.

[Foil 22]

This chart shows a summary of advantages of the ultrasound technology:

Fiber break-down with ultrasound is a safe and economic method. Fiber treatment is continuous (no batch mode). Physical conditions are modest and easy to control (moderate temperature, no high pressure, only a few chemicals). Upscaling is easy (with an *add-on system*). Changing over and backfitting is fast and cost-efficient.

Almost all plant fibers can be processed, adjustments are easy. Selective treatment of different plant fibers for further tailoring is well achieved by control of process parameters.

The energy required is low and can partially be covered by energy recycling and thermal utilization of process by-products.

[Foil 23]

Now we come to the Summary of Advantages of Ultrasound Technology. There are various unique reasons to invest in high-tech fibers based on renewable resources:

Fiber markets have a strong growth (25% in the past 5 years). Substitution of synthetic fibers offers an enormous growth potential. In every mass market there is also a need for high-performance products (like Setralit) for more sophisticated requirements.

ECCO's Setralit fibers have steady and homogenous qualities. Production of Setralit is environmentally friendly (for example CO_2 neutral); Setralit is fully biodegradable, thus matching ecological restrictions.

Growing global political pressure favors development of environmentally friendly products and production methods.

[Foil 24]

The potential next steps for Setralit will include a strategic partner. With such a partner the prospects present themselves as follows:

In terms of quality and pricing the Setralit fiber is an attractive alternative to aramid.

Market potential for Setralit fiber as a 100% substitute (for friction linings, gaskets and others) or as mixture with aramid amounts to 10% of the global market of aramid. Further development of product applications (plastic compounds, construction, and paper) creates an additional market potential for Setralit.

With a strategic partner this potential could be converted within the next 5 to 15 years. However, to exploit this potential, capital expenditures for plant and equipment would have to be considered.

Up to now, there has been only a very small business volume with the Setralit fiber, compared to our lubricant business; but we kept it going because we believed in it.

For many years there was only a limited acceptance in industry to use natural fibers in high-tech applications, mainly due to the belief that it wouldn't work.

But now, hopefully, we stand on the threshold of a new thinking and high-performance natural fibers become more and more accepted in Industry as a strong alternative to synthetic materials.

I thank you for your attention