NETZSCH
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CASE STUDY

Mechanical processing of cellulose derivatives

Business Unit
GRINDING & DISPERSING

Mechanical processing of cellulose derivatives by comminuting, fine grinding and fine classification

State of the art

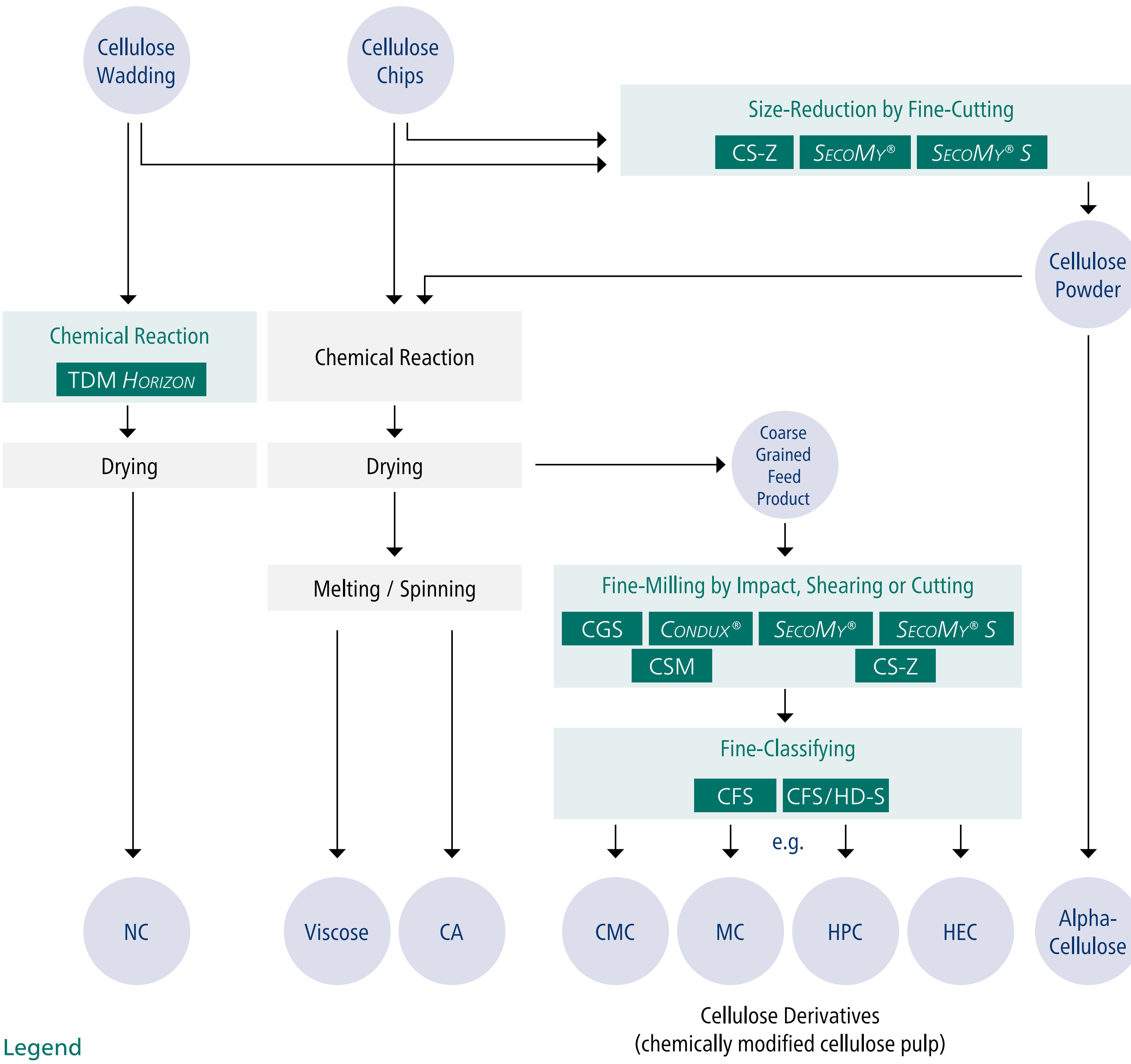
Paper is certainly the first thought that most people associate with the term "pulp" or "cellulose". Cellulose is an important raw material in paper production, but this is not the only area of application, as cellulose is of great technical and economic importance: the natural product is used in a variety of ways in the chemical, food and pharmaceutical industries. Both in its pure form and as a cellulose derivative, it is used as a thickening agent, carrier, filler, release agent, coating agent and foaming agent. As a food additive, cellulose and its derivatives bear the designations E 460 to E 466.

Cellulose is the main component of plant cell walls and therefore the most common organic compound. In 1838, the French chemist Anselme Payen succeeded for the first time in extracting cellulose from plants and determining its chemical formula. It was not until 1920 that the structure of the most common biomolecule found in nature could be determined. Hermann Staudinger was able to show that the unbranched polysaccharide is made up of several hundred to ten thousand glucose molecules. In 1992, the chemical synthesis of cellulose was achieved for the first time.

Cellulose is a white substance that is insoluble in water and is found in cotton in almost pure form (95%). However, it is mainly obtained from wood because this is the easiest of all cellulose sources to cultivate and process. The types of wood used contain significantly less cellulose than cotton (e.g. pine wood 44%; spruce wood 57.8%; beech 53.5%; poplar wood 50%). Overall, cellulose extraction is a complex process. A whole series of mechanical and chemical steps are necessary to separate cellulose from the natural by-products and then process it. At the end of the process, cellulose fibers are obtained that are approx. 1-3 mm long and are pressed and dried to form sheets (rolls or panels). The linters cellulose obtained from cotton is also often processed into bales.

For the various end applications, the cellulose or cellulose derivatives obtained in this way must be further processed by comminution, fine grinding and classification.

Processing of Cellulose Derivatives



Legend

TDM *Horizon* = Tooth Disc Mill
Condux® = Fine Impact Mill
CSM = Classifier Mill
CGS = Fluidized Bed Jet Mill
CS-Z = Fine Cutting Mill
SecoMy® = Fine Cutting Mill
SecoMy® S = Fine Cutting Mill with integrated Classifier
CFS = Fine Classifier
CFS/HD-S = High-efficiency Fine Classifier

Cellulose derivatives – Wide range of applications

A pulp powder with a small particle size and high bulk density is required in the production of cellulose derivatives such as CMC, MC or HPMC. The powders produced on the fine granulators are therefore also an intermediate product for further cellulose processing.

The product group of cellulose derivatives is divided into cellulose acetates, cellulose ethers and cellulose esters according to the type of chemical treatment. Their technical applications range from fibers, films, photographic films, glass substitutes and paint binders to paper glue, adhesives, soaps and synthetic resins.

A major customer is the construction industry, which uses cellulose-based thickeners to keep plaster, cement, wallpaper paste or special adhesives flowable for processing. Preferred substances are cellulose ethers, which in the construction sector include methylcellulose MC, hydroxyethylcellulose HEC, carboxymethylcellulose CMC, methylhydroxyethylcellulose MHEC and methylhydroxypropylcellulose MHPC.

Thanks to cellulose derivatives, varnishes and paints also manage the balancing act between flowability for processing and adhesion to the substrate.

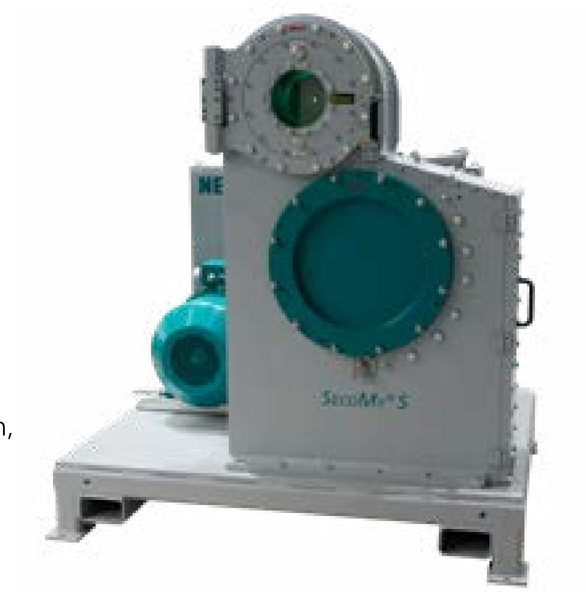
The food industry also relies on the thickening effect of cellulose derivatives to prevent ice cream, for example, from melting too quickly. In this area, there are high requirements for the raw materials used. Carboxymethylcellulose (CMC) and hydroxyalkylcellulose, e.g., hydroxypropylmethylcellulose (HPMC), dominate in food applications. And cellulose derivatives are not only found in obvious applications such as ice cream or ketchup. From baked goods, sauces, desserts, milk, meat, and fish products to beverages, they improve the texture, shape, consistency, and structure of food while remaining completely neutral in taste.

In liquid medications (e.g. nose drops), carboxymethylcelluloses CMC regulate the viscosity; they also do this in creamy medications such as thickeners (e.g. syrups, ointments, lotions).

In coated tablets and tablets, cellulose derivatives serve as a base material or binder. As soon as the tablets come into contact with water or liquid, the CMC acts as a so-called tablet disintegrant. The CMC swells enormously and breaks up the tablet.

Comminution and fine grinding of cellulose derivatives

Cellulose derivatives for technical applications and for the food industry undergo further fine grinding after the chemical reaction. Depending on the task and product properties, cutting mills, impact mills, or jet mills can be used for grinding cellulose derivatives.



NETZSCH Fine Cutting Mills

Cutting mills are used to grind and homogenize medium-hard to soft and elastic materials. In this process the material is ground by shearing forces using rotary- and stator knives. As a rule, the material is fed into the machine from above, it falls onto the rotor and is ground between rotor- and fixed cutting knives. As soon as the material has reached the desired fineness, it can leave the grinding chamber via the screen in the lower part of the machine where it then falls into the collection vessel.

Cutting mills made by NETZSCH are characterized by their robust design, their precision and reliability. In addition to the CS-Z and *SecoMy®* mills, the newly developed Fine Cutting Mill *SecoMy® S* with integrated air classifier can achieve finenesses of below 45 µm, thus widening the spectrum of possible uses for this type of mill.

NETZSCH Classifier Mills

The Classifier Mill CSM combines a mechanical impact mill with an integrated dynamic air classifier. Grinding takes place between a peripheral grinding track and the rotating beater gear. Due to the integrated classifier wheel, grain sizes free of coarse particles are achieved, whereby the self-adjusting internal circulation of the coarse material in the classifier mill leads to stable operation with the best possible energy utilization.

NETZSCH Jet Mills

In jet mills such as the Fluidized Bed Jet Mill CGS, size-reduction of particles is carried out in a gas jet. The grinding gas is guied into the grinding chamber via special nozzles and accelerated to such an extent that product particles are carried along in the gas flow and impact against each other. Comminution is autogenous and therefore low in contamination.

NETZSCH Fine Impact Mills

Derivatives, some of which are in granule form, are ground to the desired final grain size using mechanical fine impact mills or centrifugal mills. The products are mainly crushed within the machine by impact and shearing action. Depending on the product, the *Condux*® fine impact mill is operated with or without a screen. Screenless versions, e.g., as a corrugated disc mill, process the cellulose derivative in a single pass. The final fineness is determined by the circumferential speed and disc gap.

As a so-called blower or wing beater mill, a rotating tool works in principle against a stator body that determines the final size, which can be designed as a sieve path, corrugated grinding path or sieve/grinding path. This enables the product to be subjected to multiple mechanical stresses within the mill.

With a Fine Impact Mill *Condux*® 680 (rotor diameter 680 mm), for example, an output of approx. 1000 kg/h is possible with a final size < 0.8 mm with blower motor equipment and an installed drive power of 75 kW.

NETZSCH Fine Impact Mill *Condux*® 680

Practical examples for the comminution of cellulose derivatives

Product	Machine	Throughput [kg/h]	Fineness [µm]
Cellulose derivatives	*SecoMy*® 200	540 - 900	< 500
CMC	*SecoMy*® 50 *S*	55	125 (d_{95})
CMC	*Condux*® 1250	1800 - 2100	250 (d_{99})
HPMC	*Condux*® 300	66	150 (d_{50})
HEC	*Condux*® 680	2300	420 (d_{99})
HPC	CGS 50	100	53 (d_{50})

Fine classifying of cellulose derivatives

Various derivatives are not yet suitable for further use after a grinding process due to their particle size distribution. For special applications, for example, superfine end product qualities are required. Subsequent treatment to produce an exact particle size fraction is necessary to maximize the desired properties of the product or to obtain them in the first place.

NETZSCH Fine Classifier CFS

Classification in the finest particle size ranges is possible using NETZSCH Fine Classifiers to achieve sharpest cuts.

Both the separation of unwanted coarse particles and the significant reduction of fines (dedusting) are typical tasks. In these machines, a carrier gas and a rotating classifier wheel are used to generate a fine material and a coarse material mass flow from a feed mass flow. Dispersion takes place at the lower end of the apparatus using air, which flows into the classifier at high speed through a spiral housing and a blade ring. The classifier wheel speed is infinitely variable depending on the desired fineness quality and ensures adjustable, clean product classification.

A Fine Classifier CFS 510 is used, for example, to classify a previously ground cellulose derivative with the aim of separating coarse material. The end product is a derivative powder with a particle size of 200 µm (d_{97}) at a feed rate of 1250 kg/h.

NETZSCH Fine Classifier CFS 85

NETZSCH High-efficiency Fine Classifier CFS/HD-S

With the High-efficiency Fine Classifier CFS/HD-S, the achievable fineness, selectivity and possible yields have been significantly increased thanks to a peripheral blade ring around the classifier wheel and an improved classifier wheel geometry.

The product is fed into the machine from above. The necessary process air is fed in through a parallel inlet, which disperses the feed material extremely finely through a large number of adjustable guide vane gaps in a static guide vane basket and then guides it to the classifier wheel via the shortest route. Here, the separation of coarse and fine material takes place according to the set operating parameters.

The NETZSCH High-efficiency Fine Classifier can be used for separation limits in the range of d_{97} 2.6 to 60 µm, with the greatest possible separation precision. The existing machine series includes sizes for air flow rates from 100 Nm^3/h to 16,000 Nm^3/h.

When separating coarse material from methyl cellulose, the High-efficiency Fine Classifier CFS 170/HD-S achieves finenesses between 800 µm and 125 µm and a throughput of up to 2300 kg/h.

NETZSCH High-efficiency Fine Classifier CFS 340/HD-S

Mechanical processing of nitrocellulose

Nitrocellulose (NC, cellulose nitrate) is a well-established yet highly relevant material to this day. Through controlled nitration of cellulose, a versatile raw material is produced that – depending on its nitrogen content – plays an essential role in a wide range of industries:

- Coatings and varnishes: Nitrocellulose-based lacquers ensure fast drying, brilliant surfaces and excellent resistance, e.g. for furniture or automotive components.
- Printing inks: Nitrocellulose serves as a binder for high-quality flexographic and gravure inks on packaging and films.
- Cosmetics: Used in nail polish to create an elastic, glossy film.
- Medical & laboratory: Nitrocellulose membranes are essential in filters and test strips.
- Pyrotechnics & propellants: Guncotton (high nitrogen content) is a key ingredient for smokeless powders.

NETZSCH Hammer Mills

For the acid nitration required here, a special form of mechanical preparation is necessary to bring the pulp into a form that is as defibered as possible. This is made possible by using a special NETZSCH hammer mill. The heart of this machine is a rotor equipped with pendulum-suspended flat steel beaters. Depending on the application, different beater thicknesses from 3 to 20 mm can be used.

The pulp web material, which is continuously fed above the rotating beater unit by means of a special roller feeder, is caught by the rotating beaters and thrown against grinding tracks and screens or slotted grids. This results in defibration of the pulp material with minimal specks or knots.

With an installed drive power of 90 kW, a mass throughput of 1000 kg/h is achieved with a CHM 1000/1200-L1-EV hammer mill with a rotor diameter of 1000 mm and a working width of 1200 mm.

NETZSCH Hammer Mill CHM 1000/1200 L1-EV

NETZSCH Tooth Disc Mill

A horizontal tooth disc mill is used for the subsequent continuous nitration of this pulp. The previously defibrated pulp is continuously wetted and homogenized within the NETZSCH Tooth Disc Mill *Horizon* with the simultaneous addition of water and acid. This is achieved by friction and shearing action between a fixed and a rotating tooth grinding disc. Any remaining specks and knots are further broken down in the process.

The size reduction stage can be determined by preselecting the type of grinding disc (profile and number of teeth). Additional fineness adjustment is also possible during operation by adjusting the gap between the two grinding discs.

With an installed drive power of 90 kW, the Tooth Disc Mill *Horizon* 900 can process approx. 1100 kg of dry pulp in one hour.

NETZSCH Tooth Disc Mill *Horizon*

Summary

Of course, mechanical process engineering machine manufacturers not only have to meet the requirements of the processing industry in terms of presenting new product-related tasks. The technical design of machines is also becoming increasingly important within this branch of industry. Machine designs or system concepts in gas-tight or pressure-shock resistant design are of course a common "necessity" to consider the product-specific properties and existing regulations. New product qualities and/or production methods constantly present new challenges for mechanical process engineering, which must be met by continuous further development. This is also the guarantee for innovation. An important factor for the chemical industry too!

New tasks and requirements in the chemical industry will certainly continue to lead to further innovation in mechanical engineering in the future. industry will certainly lead to further innovation in mechanical engineering.

The owner-managed NETZSCH Group is a leading global technology company specializing in mechanical, plant and instrument engineering.

Under the management of Erich NETZSCH B.V. & Co. Holding KG, the company consists of the three business units Analyzing & Testing, Grinding & Dispersing and Pumps & Systems, which are geared towards specific industries and products. A worldwide sales and service network has guaranteed customer proximity and competent service since 1873.

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customer portal

NETZSCH Trockenmahltechnik GmbH
Rodenbacher Chaussee 1
63457 Hanau
Deutschland
Tel.: +49 6181 506 01
Fax: +49 6181 571 270
info.ntt@netzsch.com

NETZSCH®

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