Wheat Starch Processing
Engineering Excellence for Custom-Fit Solutions

engineering for a better world

GEA Mechanical Equipment

GEA, Committed to Perfect Solutions

engineering for a better world

Content

GEA companies worldwide

The GEA Group is one of the largest system providers of machines and process technology worldwide, especially in the food and energy industries, where it rates among market and technology leaders. The GEA Group focuses on demanding and sophisticated production processes and offers its customers efficient solutions.

Highest yields
Top quality products
Optimum energy usage
Innovation leadership
Minimum fresh water consumption *Minimum effluent streams*

Complete process lines
Excellent process know-how
Tailor-made solutions
Technology leadership
High quality equipment
Intelligent process design
High level of automation

Short reaction time
Global network for excellent support
Local process specialists
Customer focus
Fast and qualified local service support
Excellent spare-parts availability

Challenges of Today's Wheat Starch Processing

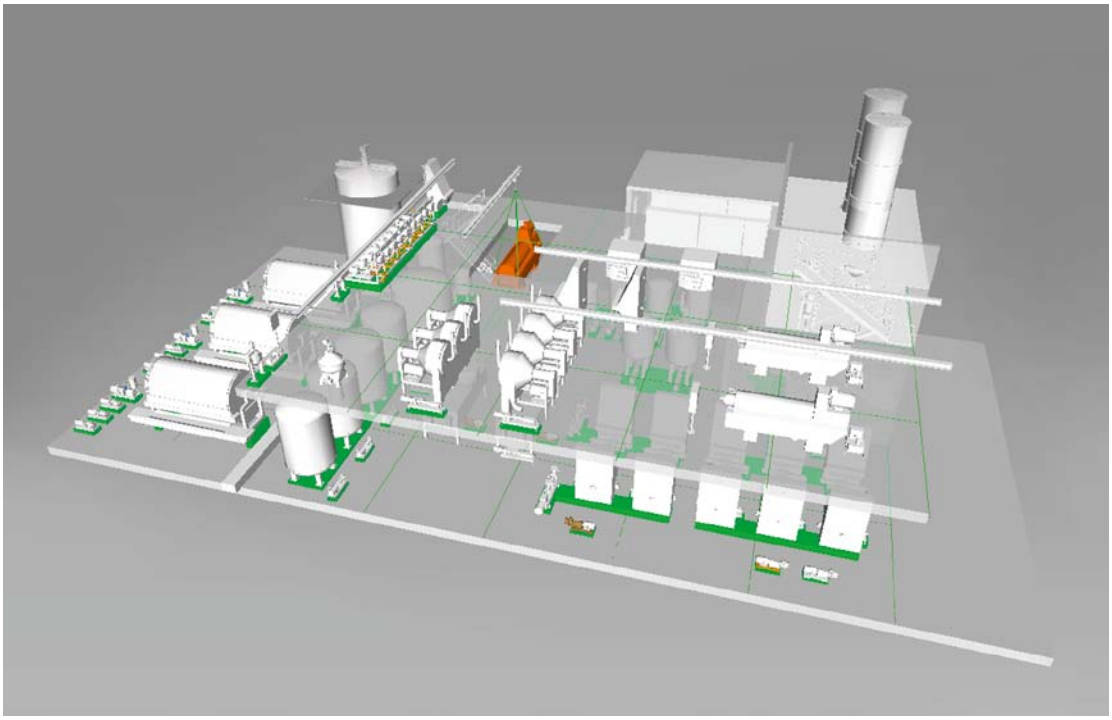
GEA Westfalia Separator Group, in close partnership with other associated GEA companies, is a pioneer in wheat starch processing. Over many decades we have continuously supplied the wheat starch industry with innovative solutions, from single machines up to complete processes. By working intensively together with our customers we learned to understand the major challenges the modern wheat starch industry is facing. Thus, we have developed extensive know-how to design, build and optimize complete multi-purpose plants for the recovery of wheat starch and gluten, co-products as well as subsequent ethanol production. The trick is to design the process in a way that enables our customer to react flexibly to the respective price level of each recovered product.

That is the key to maximize the profit of the overall investment. Key aspects for maximum profit are:

- High gluten quality and high gluten yield
- High starch quality and high starch yield
- Low energy consumption
- Low fresh water consumption
- Economic and efficient waste water treatment
- High uptime with little maintenance

The GEA Westfalia Separator Group process is designed to have

- Highest starch quality
  > protein content < 0.3 percent ds
- Minimum fresh water consumption
  > 2.5 – 2.7 m^3/t wheat flour
- High gluten yield and high gluten quality
  > 90 percent recovery of gluten protein



The use of the latest planning and visualization software gives you a virtually hands-on experience of how the plant will look like.

Whatever objectives are relevant: our solutions mean that success can be planned.
Agreed performances are attained reliably and permanently.

Service and Support: Putting Ideas into Practice

Besides the production process GEA Westfalia Separator Group can support you in constructing buildings and infrastructure. Along with local contractors we provide turnkey solutions from raw material storage up to the finished end product.

The use of the latest planning and visualization software gives you a virtually hands-on experience of how the plant will look like.

Original Manufacturer Service
GEA Westfalia Separator Group aims at creating the maximum revenues for its customers throughout the lifetime of their processes. Our service and support network is working all over the globe to make sure local service engineers are available wherever your company is located.

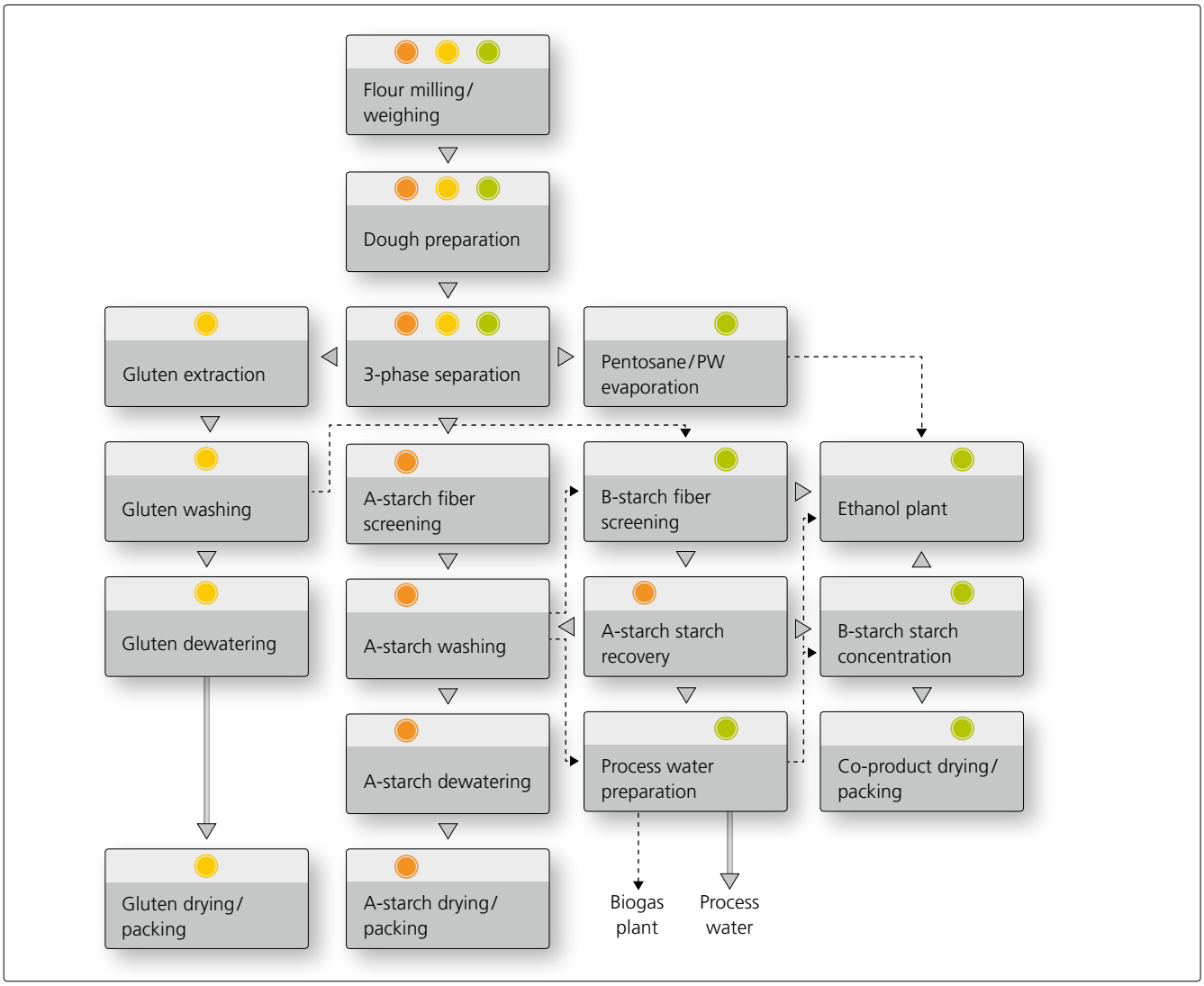
Original spare parts are the key for optimal performance and minimum downtime. Spare parts are supplied all over the world.

With online monitoring and preventive maintenance solutions for the decanters and separators GEA Westfalia Separator Group can even prevent standstills before they occur.

The Wheat Starch Process

Production process for gluten, starch and ethanol from wheat flour

Optimizing the overall yield and profitability can only take place when the complete process is taken into consideration. GEA Westfalia Separator Group is unique in being able to provide expert know-how and best in class technology for all the different process stages. Together with our local service and support staff we offer tailor made process solutions for the challenges the wheat starch industry is facing.



Process overview for production of gluten, starch and ethanol from wheat flour

Looking at the overall process there are 4 different main lines leading to various end and co-products:

- Processigng of A-starch
- Processing of gluten
- Processing of co-products (pentosane, B-starch and ethanol)

The best process setup is of course the one that makes for maximum yield and highest quality of the product our customer has in focus which is often determined by the different end product prices. Thus, the overall process has to be flexible enough to enable our customers to respond to the dynamics of the end and co-product markets.

Preparation is Everything

Dough preparation

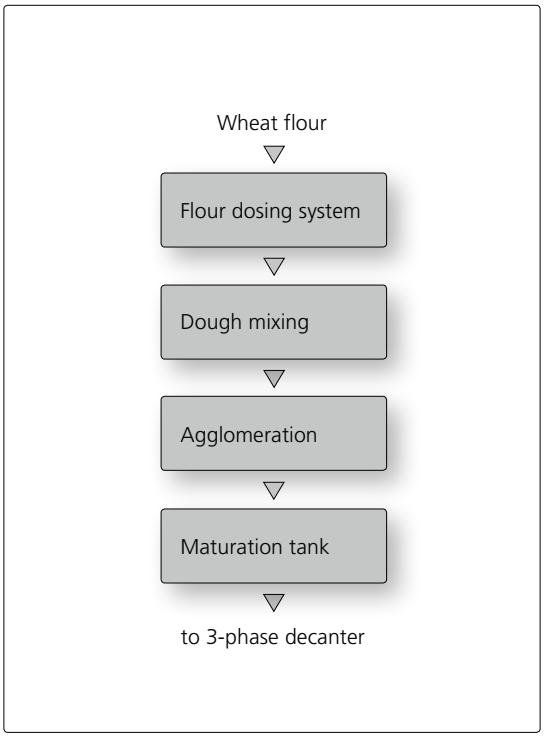
The integral part of the overall process, regardless of the desired end product in focus, is dough preparation. Here, the aim is to create a wheat flour/water suspension of agglomerated gluten and starch that can easily be separated by the subsequent 3-phase decanter.

The dough preparation is crucial for the end product quality and the overall process profitability. If for instance the gluten is not agglomerated properly in this stage the yield in the subsequent separation stages is not only lower, the gluten will also impurify the equipment later in the process, creating increased downtime.

These aspects are important for the perfect agglomeration:

- Intense mixing: mixing flour and water to create a lump free dough
- pH value: the proteins agglomerate at the isoelectric point
- Shear forces/energy: for proper agglomeration the protein molecules have to form lumps. Thus, they have to be influenced on micro level to force the molecules to come together. Therefore, high energy input is essential if you want to obtain a high gluten yield
- Final gluten hydration: to get complete hydration (swelling) of the gluten they need to rest for some time in the maturation tank

With the importance of a proper dough preparation in mind GEA Westfalia Separator Group has spent considerable efforts to develop the best technological solution to enable our customers to maximize their gluten yield.



Dough preparation

GEA Westfalia Separator Group expertise and scope of services:

Flour dosing system:

- We can advise and supply if needed

Dough mixer:

The dough mixer is designed as multi-purpose equipment. Similar machines are used as agglomerator and gluten finisher. The advantages of having one machine as basis for these three applications are reduced spare parts and reduced mechanical handling.

Agglomerator

An agglomerator is advised if:

- A lower separation efficiency of gluten and starch is required
- Flour quality is very high
- The investment costs have to be as low as possible

High pressure homogenizers

The best possible agglomeration is achieved by the high pressure homogenizer. With this machine enough energy is added to agglomerate the gluten regardless of the flour quality. The high efficiency agglomerator provides maximum security for a trouble-free and highly profitable operation of the overall process. If the dough is not prepared properly in this stage, gluten will be lost in the subsequent stages of the process. Poor gluten agglomeration not only means losing profit but also increased downtime due to fouling in consecutive parts of the process.

GEA Niro Soavi offers a specially designed high pressure homogenizer to put energy into dough and process the wheat starch. The dough (at 45 percent of viscosity) is processed at 50 – 100 bar pressure in order to improve separation efficiency and achieve higher quantity of gluten.

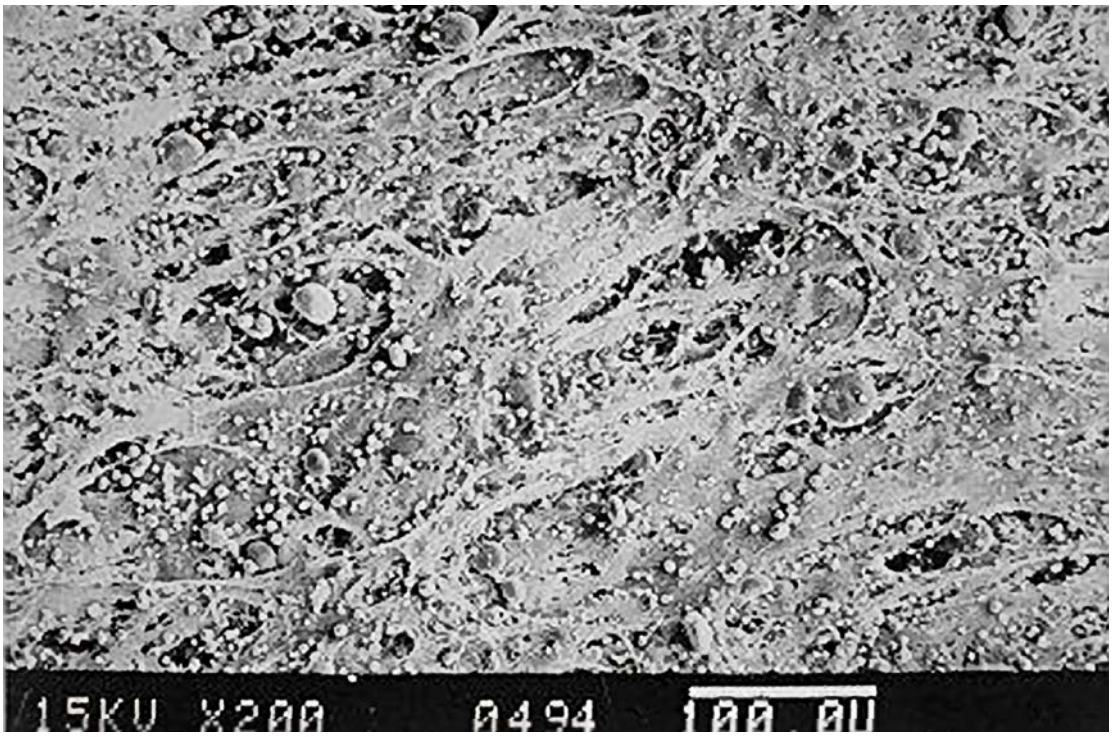
The dynamic high pressure homogenizer is a system made of a single acting reciprocating multi-plunger pump with a specific adjustable valve. The dough transits through the homogenizing valve under high pressure conditions to agglomerate particles.

Agglomerator

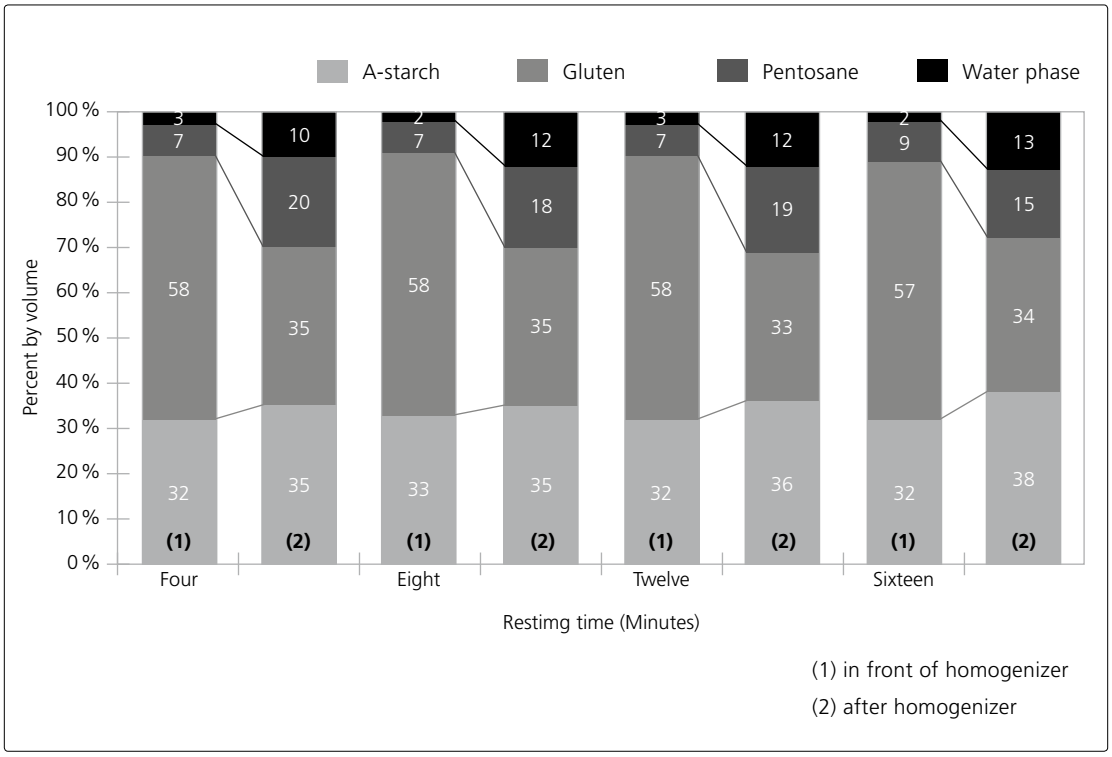
Dough mixer

Homogenizing valve

ArieteNS3090 homogenizer
(7000 l/h @100 bar)



Here you can see the effect of high efficiency agglomeration:
the high energy input releases the starch particles properly from the gluten.



Spin tests of the dough before and after high pressure homogenizing depending on resting time.
The diagram shows that the homogenizer makes for a much more defined segregation of the different phases. The results are: more A-starch, better gluten agglomeration, an increased water phase and a reduction in viscosity. In this example here a resting time of around 8 – 10 minutes seems to be optimal.

From One to Three

3-phase decanter sets the course: gluten, starch and co-products

Process description

It was GEA Westfalia Separator Group who developed and introduced the 3-phase technology for wheat starch processing. This reduces the consumption of fresh water for the overall process by up to 80 percent compared to the at that time state-of-the-art so-called Martin process.

In the 3-phase separation process, three fractions are separated based on their density difference:

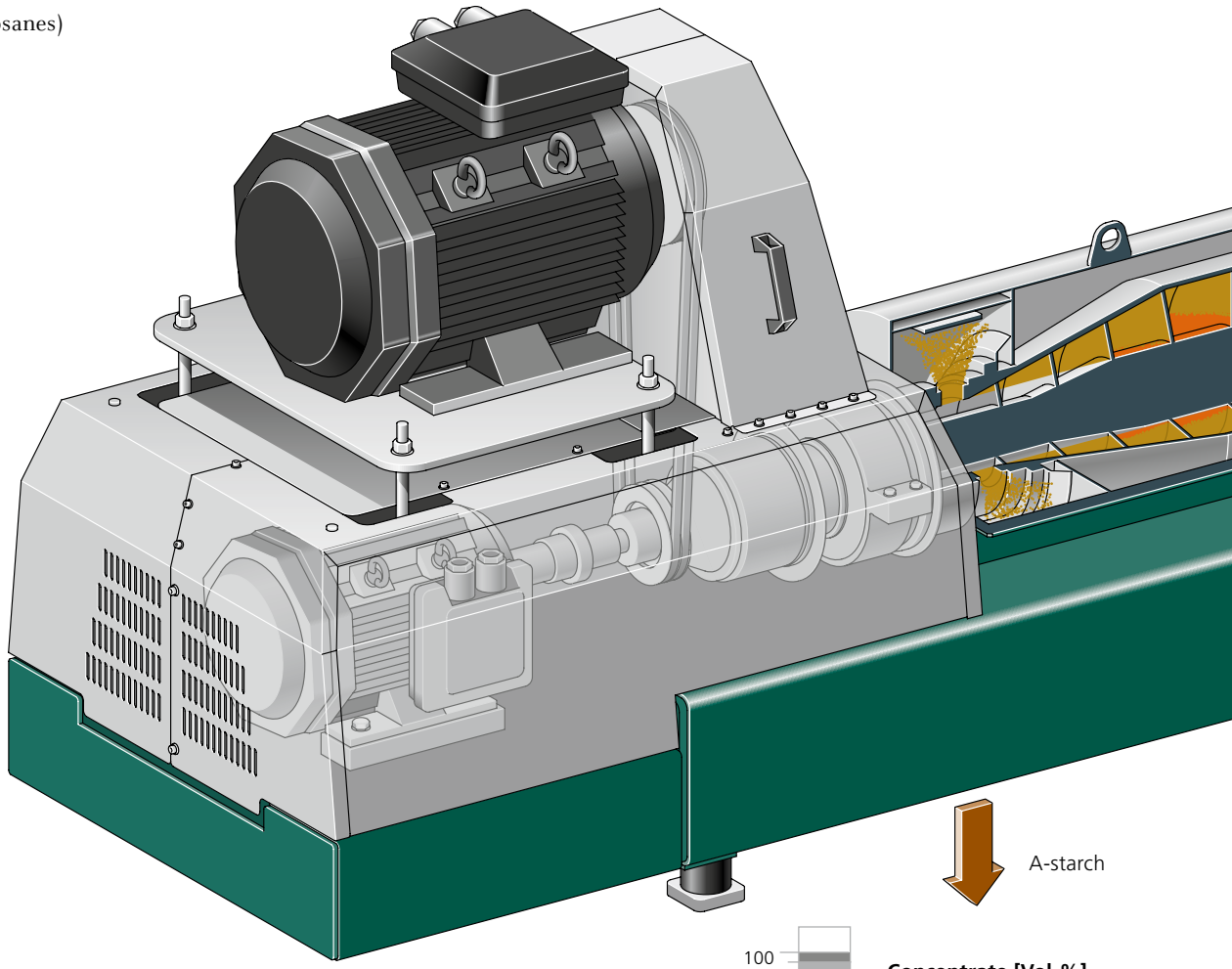
- Gluten and fine particle starch (B-starch) fraction
- Coarse starch (A-starch) fraction
- Liquid phase containing dissolved materials (Pentosanes)

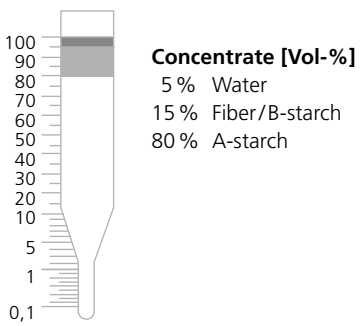
Equipment

GEA Westfalia Separator offers 3-phase decanters which are specifically designed for this process step.

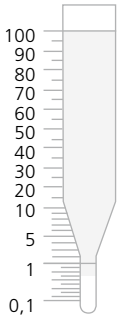
Benefits of decanters from GEA Westfalia Separator Group

- Outstanding throughput capacity and separation efficiency due to high g-Volumes, high speeds and always full torque, thus always high performance
- High differential speed range

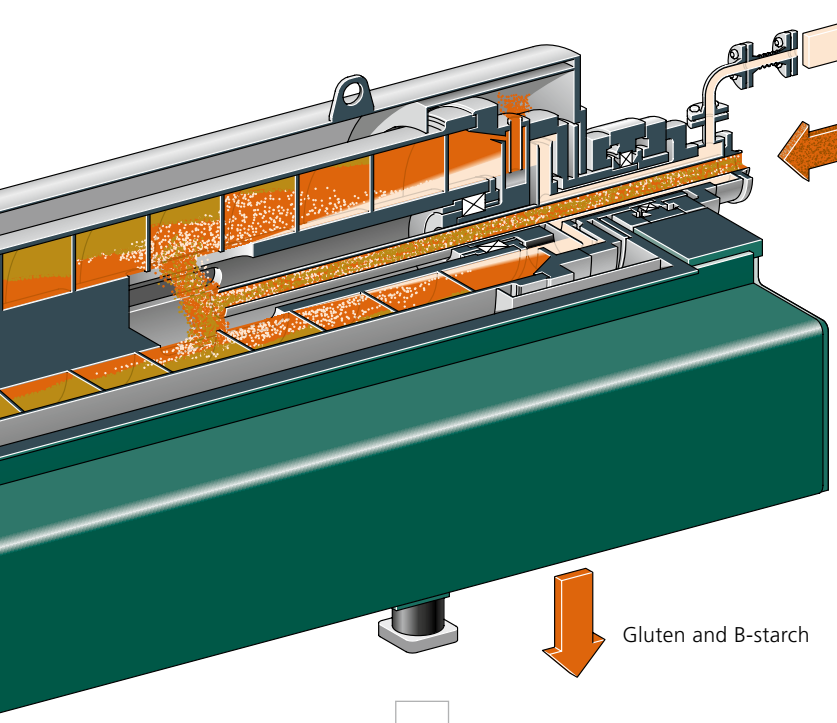




- Automatic optimization of torque and differential speed for always maximum dry matter independent of feed conditions
- Reliable and robust technology with high protection lubrication systems, external gears, high quality wear protection
- Energy efficient operation: no conversion losses of the drive system

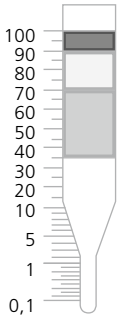


Overflow [Vol-%]
99 % Pentosanes Solubles
1 % Starch



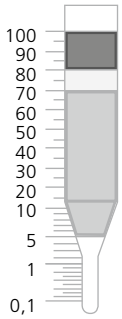
Pentosanes and water

Wheat flour slurry



Feed [Vol-%]
10 % Water
20 % Pentosanes
35 % B-starch/Gluten/Fiber
35 % A-starch

Gluten and B-starch



Nozzle Phase [Vol-%]
20 % Water
10 % Pentosanes
65 % B-starch/
Gluten/Fiber
5 % A-starch

Optimizing Gluten Yield

Extraction, finishing, dewatering and drying

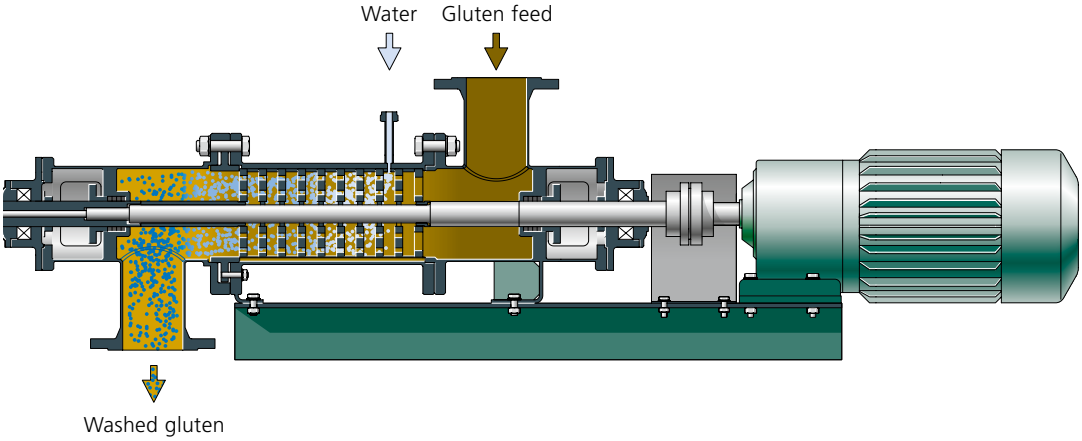
GEA solutions:

Extraction
GEA Westfalia Separator Group offers two different types of screens for gluten extraction, rotating drum screen and bend screen. Both separate B-starch from the gluten. In general though, bent screens require less energy, have a smaller foot-print and are easy to clean.

Washing
The gluten finisher ruptures the gluten once again and washes the extracted gluten removing the last starch granules. As a result, a higher protein content is obtained.

Our gluten finisher comes with plates and knifes for efficient cell rupture and therefore good extraction.

Dewatering
After finishing, the gluten is fed directly to bent screens and a screw press for dewatering. The GEA Barr-Rosin screw press, with recirculation system, dewaters wet gluten from the upstream separation process down to 65 percent moisture content. Prior to entering the ring dryer, wheat gluten is efficiently dewatered by a conical screw press which squeezes and extrudes the gluten allowing final traces of water to be separated over a screen. The protein is then extruded in a continuous film through a narrow passage or 'fish tail' feeder and across the dryer's disintegrator. The specially designed rotor shreds the wet gluten and mixes it with a recycled stream of dry material, resulting in improved heat and mass transfer and a high quality powdered product, with excellent vitality, water absorption and protein retention.



Gluten Finisher from GEA Westfalia Separator Group

Drying
The product from the press is pumped to a Full Ring Dryer and dried in a single step to a fine 7 percent moisture powder. The low temperatures used preserves the vitality of the gluten and consistently delivers a product of the highest commercial value.

The collected dry product is then sifted and the oversized particles are milled to deliver a final product of uniform size and moisture.

The ring dryer used to dry the vital wheat gluten operates on similar principles to the flash dryer, but the addition of a fishtail feeder, disintegrator and classification manifold allows selective internal recirculation of semi-dried solids. This increases the retention-time for large particles in the ring, whilst finer and drier material is discharged as product.

Continually developed over the years, Barr-Rosin ring dryers can be designed to utilise a variety of heat sources, including steam, gas or turbine exhaust gases. The ability to precisely control material recycle and residence times ensures the final products are of the very highest quality.

Pneumatic cooling and conveying
Wheat flour, starches or gluten can be pneumatically conveyed and cooled in a single unit operation. Using chilled or ambient air, the product can be conveyed from any dryer system and delivered cooled to the receiving vessel.

Packing systems
A complete system can be supplied to include transport, storage, and packing. Packing systems can range from semi-automatic to fully automatic bagging units.

Starch Recovery

A-starch fiber screening

In this stage the fibers and other coarse material are separated from the starch. This type of process is used both for the A- and the B-starch.

The fibers are removed by centrifugal screening. The pulp is put on a screen that is rotating at high speed. The screen is designed in such a way that only starch can pass but fibers cannot. During the screening process water is added to create an optimal separation of fibers and starch.

GEA solutions:
HEA Hovex centrifugal extraction sieves are designed to generate optimal separation between fibers and starch, with the lowest starch losses.

Features of the GEA Hovex centrifugal extraction sieves:

- Easy and stable operation (automatic feed pressure regulation)
- Low maintenance (vibration free, robust design)

Centrifugal extraction sieves with direct drives from GEA Hovex

A-starch Washing

Upgrading crude A-starch to high quality-starch

Process description

The quality and value of the starch end product is determined to a great extent by the washing of the crude A-starch. A high quality A-starch can only be obtained if remaining small fiber fragments, lipids, proteins and dissolved substances are washed out efficiently.

Hybrid washing process

When the crude starch is concentrated and diluted again with fresh water, contaminants are removed. When this is done in a multi-stage process, almost all contaminants are washed out. That's why the crude starch milk is pre-washed and classified in a 3-phase nozzle separator first. Subsequently, the concentrated A-starch is washed in a hydrocyclone system.

The use of separator plus hydrocyclone combines the best of both worlds. Our customers benefit from the maximum yield of a separator but also from the respectively lower maintenance and investments costs of a hydrocyclone unit.

Key features of GEA Westfalia Separators hybrid process

- Excellent process water due to 3-phase separator technology thus, only 2.5 – 2.7 m³ fresh water needed per ton wheat flour
- High starch quality:
  Protein content < 0.3 percent ds
- 3-phase decanter: fiber removal (via middle fraction) and starch classification.

Process	Yield	Maintenance	Energy	Water consumption	Investment
Separator	++	+	++	++	+
Hydrocyclone	+	++	++	++	++
Hybrid	**++**	**++**	**++**	**++**	**++**

Performance difference between washing systems
+ good performance ++ excellent performance

3-phase nozzle separators

The 3-phase nozzle separators separate the crude starch milk into a washed starch suspension fine fibers fraction and clear water fraction.

Benefits of a 3-phase nozzle separator

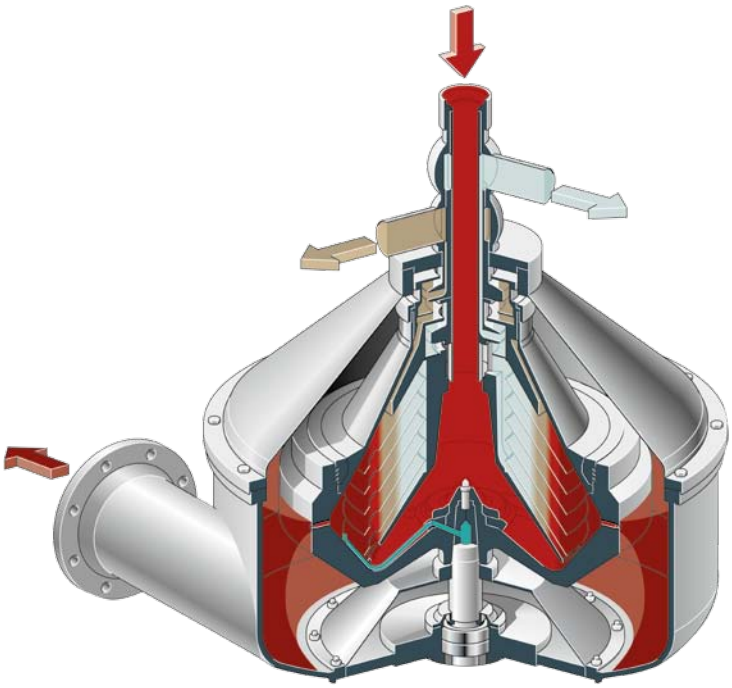
The special configuration with discharge of the concentrated starch fraction under pressure via nozzles and discharge of the other phases via centripetal pump creates the following benefits

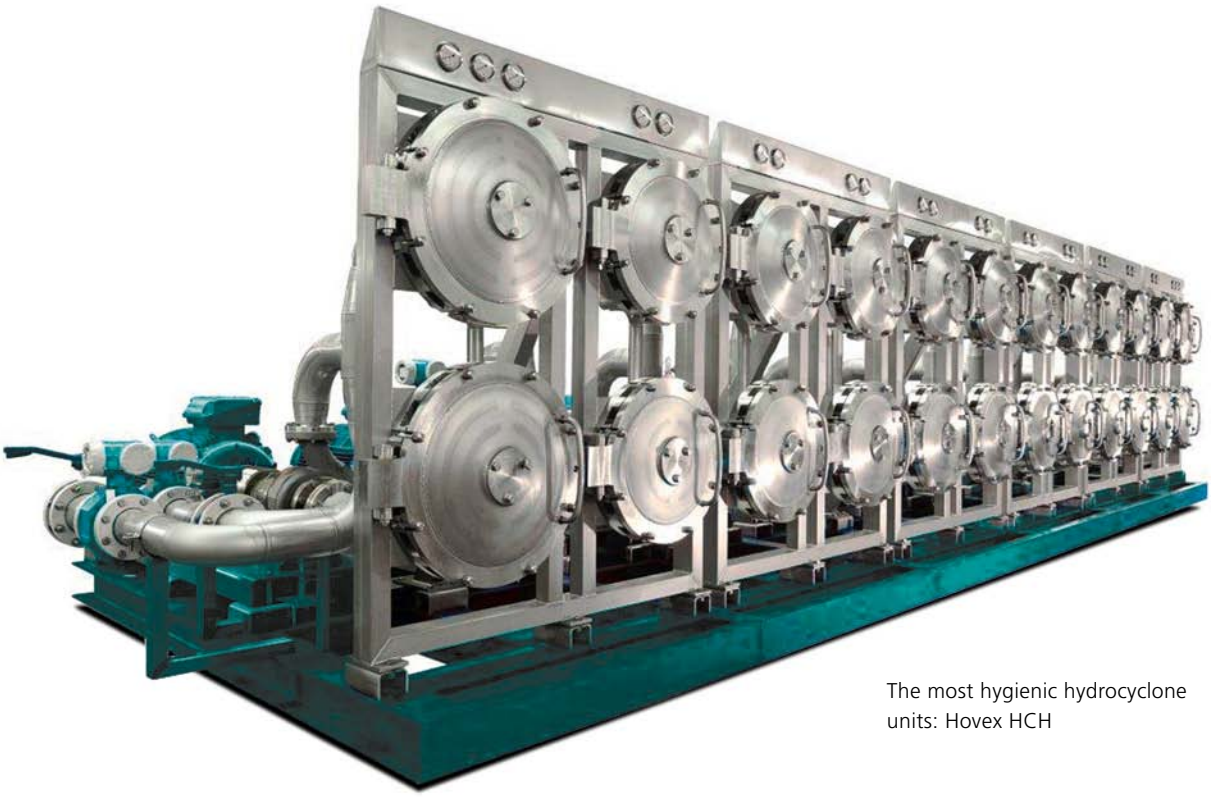
- Very efficient countercurrent washing
- A small number of washing stages and
- Minimum consumption of fresh water
- High purity wheat starch
- Excellent process water minimizing fresh water consumption
- Continuous and stable feed to the HC-Unit for uncomplicated washing

Other specific benefits of GEA Westfalia Separator Group nozzle separators

- Maximum performance with minimum maintenance because of state of the art drive concept
- No starch quality loss because of closed feed and discharge (no oxidation of starch possible)
- Low energy consumption because of modern drive concepts and special nozzle configuration
- CIP cleaning at operating speed
- No additional pumps for the liquid phase because of internal centripetal pump

Nozzle separators from GEA Westfalia Separator Group accomplish high starch yields in best quality at little water consumption.





The most hygienic hydrocyclone units: Hovex HCH

Hydrocyclone washing units

GEA Hovex offers normal and hygienic hydrocyclone washing units:

Hygienic Hydrocyclone system (HCH) is the most hygienic hydrocyclone on the market. This system is advised when

- Microbiological contamination of end product has to be low (food grade starch)
- Water contains little or no growth inhibiting agents

Normal Hydrocyclone units (HCC) are advised in any other cases.

Benefits of GEA Hovex hydrocyclones

- High efficient washing (no internal leakage)
- Easy to operate (Simple operation)
- Easy maintenance (Machine can be opened fast and easy)
- Low energy consumption (Energy efficient-pumps)
- Low water consumption (Less water needed because of high outlet concentration)

A-starch Recovery

More starch, less fresh water

In order to maximize the overall A-starch yield, GEA Westfalia Separator Group offers a recovery stage with a 3-phase nozzle separator. The centrifuge processes the B-starch fractions coming from gluten extraction and A-starch washing. The recovered A-starch is being conveyed back to the washing stage. The B-starch obtained here can be used for ethanol or animal feed production, improving the profitability of the overall process. The process water which leaves the separator as overflow is recycled back into the process. Thus, fresh water consumption is minimized as well as disposal costs. For more information about the nozzle separators, please see page 16.

GEA solutions:
3-phase nozzle separators

A-starch Dewatering

Improving the energy balance

Process description:
Dewatering machine
Both vacuum filters and peelers are used. Each solution has its specific advantages and disadvantages which are presented in the table.

	Vacuum drum filter	Peeler centrifuge
Dry solids	+	++
Operation	Continuous	Batch
Investment	++	+
Energy	++	+
Maintenance	++	+
Ease of operation	++	+

Advantages and disadvantages of vacuum drum filter and peeler centrifuge
+ good performance ++ excellent performance

Vacuum drum filter from GEA Hovex

A-starch Drying and Packing

A-starch can be dried using a specially designed single-pass flash dryer. Those flash dryers can be fed slurry at 30–35 percent solids content range and deliver a 10 to 12 percent final product.

GEA solutions:

Flash Dryers

The single pass Flash dryer is ideal for products that dry rapidly, due to the easy removal of free moisture. This makes the process suitable for most types of starches. Wet material is introduced into a stream of heated air where moisture is removed quickly without heat damage. High rates of heat and mass transfer are achieved as the material passes through the system. The design also has the advantage of being simple and easy to maintain. Continuous development of this technology ensures that GEA Barr-Rosin can offer the most effective pneumatic drying and conveying system.

Processing of Co-Products

Flexibility that pays off

Apart from gluten and A-starch there are still valuable substances left in the process which can be used for example for biogas plants or processed to either animal feed or bioethanol. The co-products are mainly pentosanes, fiber, process water and small granule B-starch. GEA has the know-how to design the complete process whether our customers go for subsequent ethanol production or decide to produce animal feed. If profitability is the key there are two crucial aspects: First, as already mentioned, dough preparation. The better the preparation, the better the yield. And second, flexibility. The overall process from flour milling to end product has to be designed in such a way that you can decide at any time which end product stream you would like to optimize.

During the production of starch, different process waters are produced when decomposing the raw substances. These mixing, dilution and washing waters contain valuable nutrients such as proteins. GEA Wiegand is offering evaporation plants to recover these nutrients by concentrating the process water and pentosanes. Thanks to extensive know-how, numerous investigations in the GEA Wiegand research and development center and thanks to the experience gained by thousands of evaporation plants, GEA Wiegand is able to offer tailor-made plant conceptions meeting the individual requirements of the customers. The scope of supply and services includes consulting, engineering, calculation, design, manufacture, delivery, quality control, commissioning and after-sales service, plant expansion as well as energy optimization.

Evaporation plant for wheat starch effluent

B-starch Fiber Screening

Recover the last fine particles

The underflow from gluten screening which consists mainly of B-starch still contains some fine gluten particles. In order to recover these fine particles the slurry is check-screened and conveyed back to A-starch recovery in order to improve the overall starch yield.

Therefore the B-starch coming from gluten extraction along with the middle phase from the A-starch washing stage are subjected to fine fiber removal by means of centrifugal screening. For more information about centrifugal sieves, please see page 14.

B-starch Concentration and Process Water Preparation

More starch, less fresh water

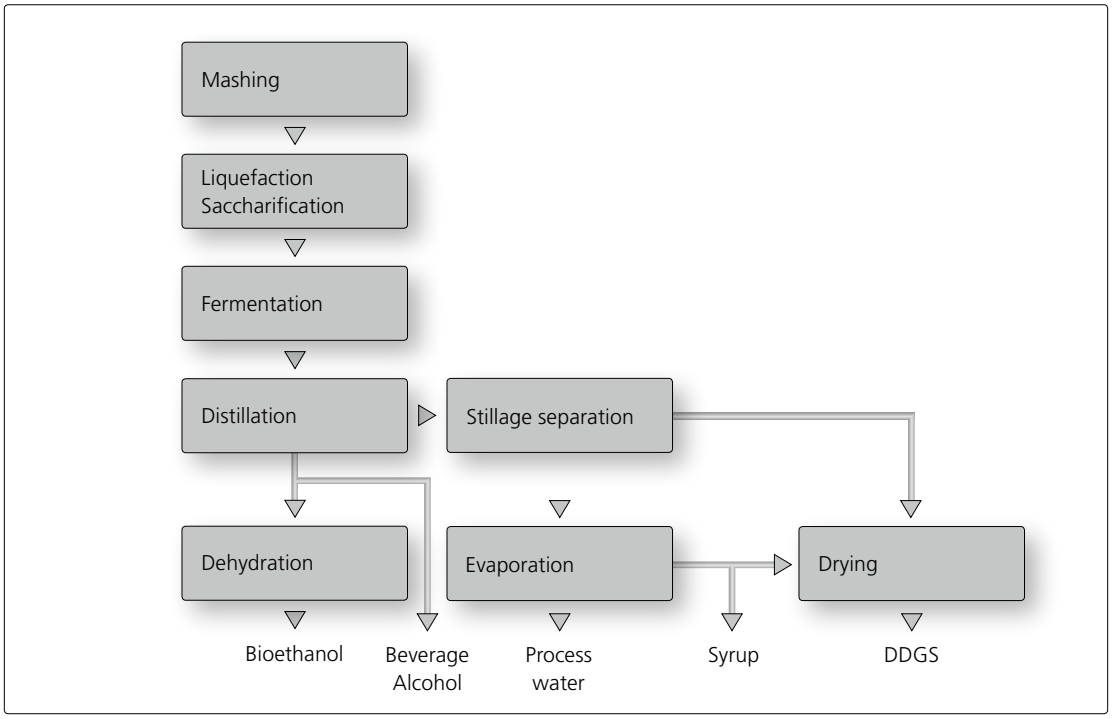
GEA Westfalia Separator Group offers 2-phase decanters and 2-phase self-cleaning or nozzle separators. The decanter concentrates the B-starch coming from the middle phase of the A-starch recovery stage and the fibers from screening stage. The process water from starch recovery is conveyed to the separator. The overflow can be recycled into the process to significantly reduce the fresh water consumption. At the same time B-starch yield is improved. For further information about decanters and separators, please see pages 9 and 16.

The concentrated B-starch from the decanter can either be used as animal feed or as feedstock for a subsequent ethanol plant.

Fermentation to Alcohol

Starch recovery with subsequent ethanol production – a worthwhile match

The higher the yield and quality of co-products extracted from wheat the more efficient the subsequent fermentation process and recovery of alcohol. Pentosanes and B-starch are used for ethanol production, some plants convert all starches into ethanol. The wheat starch process from GEA Westfalia Separator Group is designed in such a way that the customer has maximum flexibility to either recover starch or produce ethanol.



Fermentation to Alcohol

Process line for the treatment of stillage from the production of wheat based alcohol. Energy-optimized combination of evaporator from GEA Wiegand and dryer from GEA Barr-Rosin.

GEA Wiegand designs and delivers complete processing plants and components for the production of beverage alcohol (raw alcohol, neutral spirit) and dehydrated bioethanol as fuel additive from wheat.

GEA solutions:

- Raw material treatment
- Liquefactions and saccharification
- Fermentation
- Rectification and dehydration
- Thin stillage concentration
- Drying

Features of the GEA Wiegand ethanol process:

- Reliable, proven processes
- Highest product quality of alcohol processes and DDGS
- Minimum energy consumption by fully integrating the ethanol process in the starch process line
- Highly sophisticated process control systems

We live our values.

Excellence • Passion • Integrity • Responsibility • GEA-versity

GEA Group is a global engineering company with multi-billion euro sales and operations in more than 50 countries. Founded in 1881, the company is one of the largest providers of innovative equipment and process technology. GEA Group is listed in the STOXX® Europe 600 Index.

GEA Mechanical Equipment

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