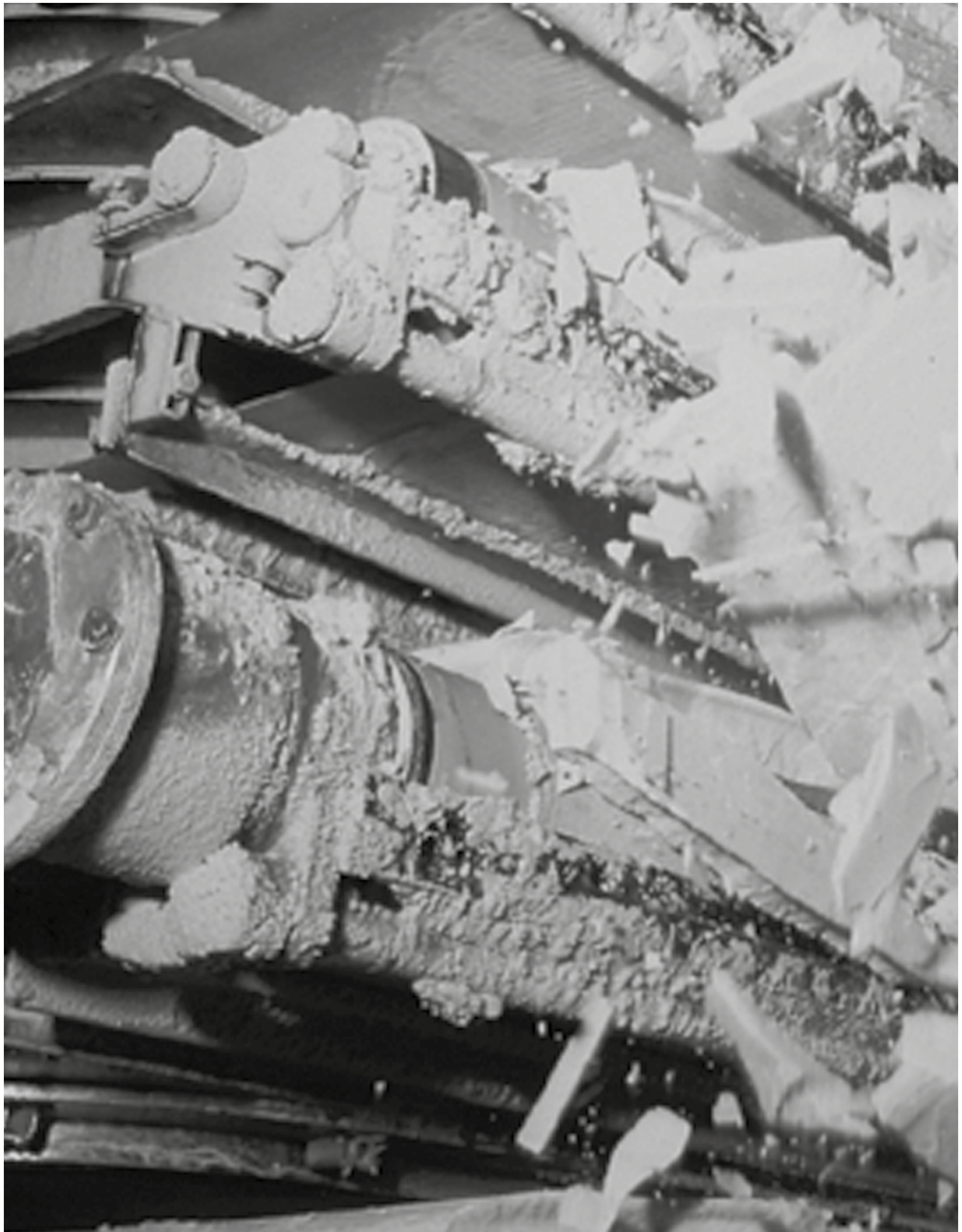
Metso:Outotec

Whitepaper



Transforming starch processes with automatic pressure filters

Abstract

Automatic pressure filters completely transform modified starch production processes. By replacing centrifugal separators with advanced pressure filtration technology, they deliver dramatically superior results — with drier cake and clearer filtrate — while consuming significantly less wash water. These results translate into significant business benefits and unlock process capacity in parts that may be located far away from the filter such as drying and waste handling. Furthermore, the quality of the starch produced is superior in terms of washing results and, crucially, consistency.

This paper compares centrifugal separators with Metso Outotec Larox® pressure filter technology and its potential impact on modified starch processes, demonstrating the increases in production as well as the savings in water, energy, and waste-treatment costs that they enable. The paper is based on real data from one of more than 60 installations where Larox PF Filters are currently operating.

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Preface

Prior to the introduction of the Metso Outotec Larox PF filter, the leading-edge process comprised a combination of centrifuge separators (hydro-cyclones) and horizontal peeler centrifuges. This arrangement was widespread and, while it produced adequate product quality, it was sub-optimal, particularly in terms of installed power capacity, and consumption of water, fuel, and power. Perhaps most importantly, the high level of product passing through the centrate not only meant there was a high demand on the waste-handling system, it also resulted in the loss of valuable product that could have been sold to customers.

Metso Outotec Larox PF filtration technology was selected for the redesign of the modified starch process of Hainan Yedao Co. Ltd, China. The data in this paper is based on the results achieved following the installation of the filter. The line has now been running for more than a decade and the filter has consistently delivered superior product quality and consistency for Hainan Yedao Co. Ltd.

2. Operating principle

2.1 Horizontal peeler centrifuge and disc centrifuge separator
Horizontal peeler centrifuges and disc centrifuge separators are still used in many native and modified starch processes. The operating principle, and hence the structure, is based on centrifugal force generated by machinery revolving at high speed.

Peeler centrifuges are traditionally used to produce batches of washed modified starch. Typically, a starch suspension is fed to the unit while it rotates, relatively slowly, in order to distribute the starch evenly over the filter cloth or mesh that covers the inside of the drum. Once filled, the drum is spun quickly to drive the liquid through the formed cake. Wash liquid can also be fed to the drum and forced through the cake. The cake is discharged by a blade that moves into the rotating drum towards the filter medium. The required clearance at the end of the cycle means that the residual cake, known as the heel, inevitably remains on the cloth. The heel may be used as a form of pre-coating for the next cycle or washed off by back flushing.

2.2 Automatic tower press filter
The Metso Outotec Larox PF filter has transformed many industrial processes, for example in fine chemicals, pigments, modified starch, and pharmaceutical fermentation broth. The primary dewatering mechanism is pressure filtration, in which a pressing force of up to 16 bar can be used. As a result, the energy consumption of the PF filter is significantly lower than that of centrifugal separators. The unique manner in which the cake is formed and subsequently sustained means that other operations, such as washing and drying, are as efficient and effective as possible.

The absence of a high-speed revolving mass or any continuously moving parts makes plant construction and machine maintenance simple. The Larox PF filter also consumes less fresh water and provides a much higher starch recovery than centrifugal separators. The technical parameters of the filter installed at Hainan Yedao are shown in Table 1 below.

TABLE 1. Larox PF filter technical parameters

Process	Modified starch
Larox filter type	PF19/25 B2 H60
Filtration area (m^2)	18.90
No. of filter plates (1500 × 4010 mm)	12
Expandable to filtration area (m^2)	25.20
Filter chamber depth (mm)	60
Max. working pressure	16
Total footprint (m^2)	39.50
Dimensions (meters, length × width × height)	4.25 × 3.80 × 4.10
Weight (tons, excluding accessory tank)	16

The following chapters describe the working principle of the Metso Outotec Larox PF filter.

2.2.1 Feeding

When the plate pack is closed, a set of chambers is formed and starch suspension enters these through feeding pipes. A filter cake builds up and filtrate passes through the filter cloth, support grid, and filtrate hoses.

Because the cake is static and horizontal, it is extremely uniform and there are no misaligned forces to either deform it or cause cracks to form within it.

2.2.2 First pressing

The pressing medium enters the space behind the diaphragm under high pressure. The diaphragm squeezes the cake, forcing more liquid out.

2.2.3 Solids washing

After the pressing pressure is relieved, wash water enters the chamber through the same feed pipe as the suspension, filling the filter chamber while forcing the pressing medium out from behind the diaphragm. The water then passes through the filter cake solids, washing out impurities before exiting the filter chamber through the filter cloth to the filtrate collection line.

2.2.4 Second pressing

A second squeeze with the pressing diaphragm forces the wash water to pass through the cake in a uniform front. Because the cake is uniform and unstressed, this minimizes the presence of thin or thicker areas that may cause short-circuiting or bypassing. This ensures the best possible cake washing and the lowest possible water consumption.

2.2.5 Solids drying

Compressed air enters the chamber through the feed port, pushes the diaphragm up, and passes through the cake in a uniform front in much the same way as the wash water. The airflow through the highly uniform cake reduces the residual moisture in the cake to the lowest possible level and also removes any remaining filtrate from the filtrate area.

FIGURE 1. Symbols representing the different materials in the dewatering process.

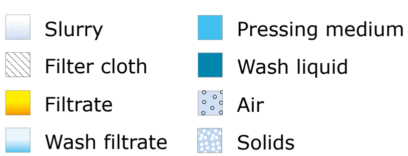


FIGURE 2. The starch suspension enters the filter chambers.

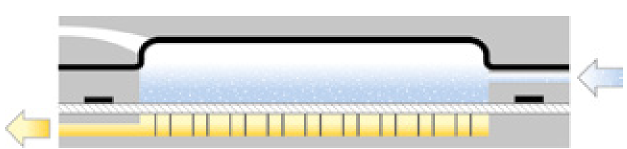


FIGURE 3. The pressing medium enters and squeezes the cake, forcing more liquid out.

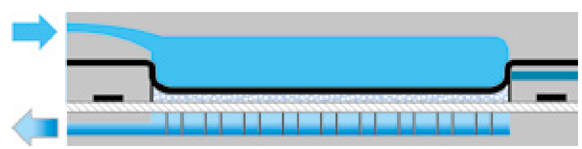


FIGURE 4. Wash water enters the chamber, washing out impurities as it passes through the filter cake before exiting through the filter cloth.

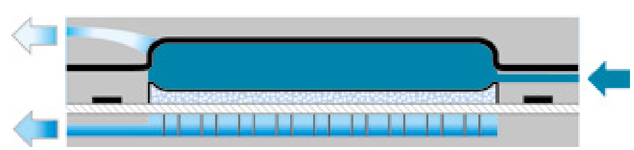
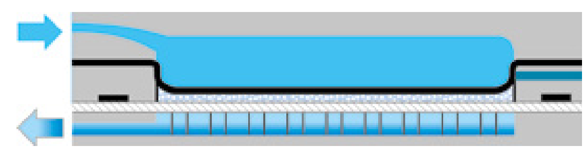


FIGURE 5. The second squeeze with the pressing diaphragm forces the wash water to pass through the cake in a uniform front.



2.2.6 Solids discharge and filter cloth washing

When the drying step is complete, all the filter chambers open up simultaneously. The filter cloth drive motor starts to move the endless filter cloth, discharging the solids from both sides of the filter. In this way, all of the starch is passing forward through the process at all times, with no material hold-up.

At the same time, the filter cloth cleaning device washes both sides of the cloth in order to maintain a consistently high level of filtration efficiency and to remove any residual starch.

Metso Outotec Larox PF12 filter

FIGURE 6. Compressed air enters the chamber to reduce the residual moisture in the cake and remove any remaining filtrate.

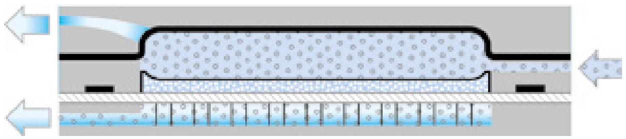
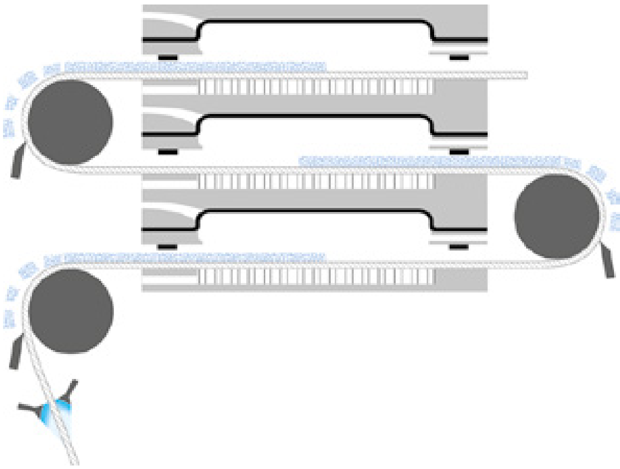


FIGURE 7. The filter cloth drive motor discharges the solids from both sides of the filter; the filter cloth cleaning device washes both sides of the cloth.



Metso Outotec Larox PF15 filter

3. Comparison and analysis

This chapter compares the results obtained using the PF filter with those of the centrifuge process.

The equipment for slurry agitation, wet process modification, and heat drying is almost identical in both centrifugal and pressure-filter processes. Heat is transferred by hot oil, which is heated by natural gas. In order to compare the economic benefits of the two different technologies, they were calculated using the same capacity.

A complete washing and dewatering cycle can be accomplished in a single Larox PF filter. In the alternative setup, the same starch throughput would require three disc centrifuge separators (2 × DPF550 and 1 × DPF445) and three horizontal peeler centrifuges (GK1250).

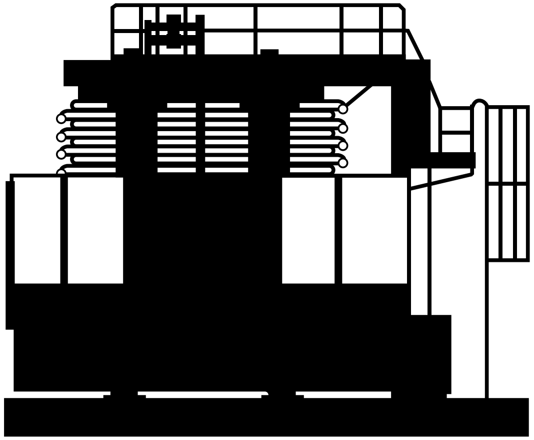
3.1 Starch capacity calculation

One Larox PF19 filter is used in Hainan Yedao. One process cycle takes about seven minutes including feeding, first pressing, washing, second pressing, cake drying, and cake discharge. The total cycle time is about 10 minutes if a second washing step is required. The average filter cake thickness is 35 mm and the filtration area is 18.9 m2. Assuming the working time is 20 hours per day, the starch processing capacity would be
18.9 m2 × 0.035 m × 20 h/day × 60 min/h / 10 min = 79.38 m3/day of starch cake. The residual moisture content of the cake solids is about 32% and the density is 1.24 t/m3. With a required final moisture content of 14%, the starch production is about 77.83 t/day. The highest recorded capacity achieved in Hainan Yedao is 120 t/day.

In the centrifuge process, the cycle time of the GK1250 peeler centrifuge is approximately 10 minutes, the chamber volume 225 liters, and the maximum feeding capacity 280 kg. Assuming the working time is 20 hours per day, the starch processing capacity would be
0.280 t × 20 h/day × 60 min/h /10 min = 33 t/day. The residual moisture content of the cake solids is approximately 37%, and with a final required moisture content of 14%, the starch capacity is about 24.6 t/day. This would mean that more than three centrifuges would be required to achieve the same starch capacity as in the Larox PF filter process. The following calculation assumes three centrifuges.

3.2 Installed power capacity calculation

The installed power capacity of the Larox PF19 filter is approximately 35 kW and the total installed power capacity is less than 50 kW including compressed air and high-pressure pumps. In the centrifuge process there are three disc centrifuge separators and three horizontal peeler centrifuges. The total installed power capacity is
55 × 2 + 30 × 1 + 46.50 × 3 = 279.50 kW.



A Larox PF filter can handle a complete washing and dewatering cycle. The same starch throughput would require several centrifuge separators and peeler centrifuges.

3. Comparison and analysis

3.3 Electricity consumption

The electrical power consumption of the wet process is approximately 140 kWh, with the centrifuge machine accounting for about one third of the total consumption, or approximately 46.6 kWh/t. In comparison, one Larox PF19 filter only consumes about 7.5 kWh/t.

3.4 Footprint

The footprint of the Larox PF19 filter (including the areas where the filter is operated) is approximately 39.5 m^2 and the total space required is 50 m^2. The footprint of three disc centrifuge separators and three peeler centrifuges is 16 × 3 + 9 × 3 = 75 m^2 and the total space required is about 120 m^2. Furthermore, a PF filter can reduce building costs because there is no rotating mass to include in the structural design and the process piping and cabling requirements are also less complex.

3.5 Starch yield

The yield of the Larox PF19 filter is 2% higher than that of a process that uses centrifuges. This is mainly due to the volume of wash liquid and the extremely clear filtrate.

3.6 Water consumption

The average water consumption of the wet process when using centrifuges is approximately 25 t/t D.S whereas one Larox PF19 filter has an average water consumption of 2.5 t/t D.S., comprising 2 t/t of cake washing water and 0.5 t/t of filter cloth washing water.

3.7 Cake solids moisture

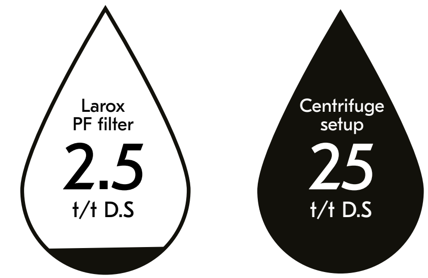
Depending on the case in question, the residual moisture content of the solids coming from the Larox PF19 filter is approximately 32—34%, while the residual moisture of the solids from a centrifuge is about 38%.

3.8 Steam consumption for starch drying

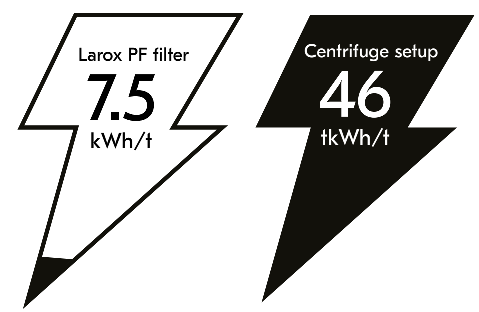
Vaporizing one ton of water requires 1.8 tons of steam and the moisture content of the finished product is approximately 13%. Drying the solids from a centrifuge consumes about 0.96 t/t of steam, while one Larox PF19 filter consumes approximately 0.74 t/t, which represents a saving of 0.22 tons of steam per ton of product. Alternatively, with a Larox PF filter, the drying capacity of an existing dryer increases by almost 30%.

3.9 Filtrate and waste water condition

The filtrate of the Larox PF19 filter is very clear. COD value is about 2000. After dealing with the anaerobic content, the water could be used as irrigation water. The filtrate of centrifuge looks like an emulsion with a COD value of 4000-5000.



One Larox PF 19 filter consumes 2.5 t/t D.S on average, compared to 25 t/t D.S with a centrifuge setup.



One Larox PF19 filter only consumes about 7.5 kWh/t, while an equivalent centrifuge process consumes about 46.6 kWh/t.

3.10 Manpower requirements

Unlike centrifuges, which require at least three people per shift to operate, the automatic Metso Outotec Larox PF19 filter doesn't require an operator to be present.

3.11 Expandability

If the process owner wants to increase capacity, they can simply add some plates to the existing PF filter frame and install a longer cloth. No further changes are necessary, and the floor plan of the plant remains exactly as before.

In contrast, with a centrifuge setup, increasing capacity would require at least one further centrifuge to be installed. If this has not been taken into account in the construction, piping, and cabling designs, then it could result in a time-consuming and costly redesign project.

3.12 Product quality

The PF filter installed at Hainan Yedao has ensured highly consistent starch product quality.

3.13 Investment and economic benefit comparison

Tables 2 and 3 below show the investment and economic benefit comparison for a product yield of approximately 30,000 tons per year in the Hainan Yedao modified starch process.

According to Table 3, for a plant with an annual starch capacity of 30,000 the Larox PF19 filter could save over 3,180,000 yuan per year, or approximately USD 410,000, compared to a conventional centrifuge setup.

TABLE 2. Investment comparison between centrifuge and Larox PF filter

	CENTRIFUGE INVESTMENT		PF FILTER INVESTMENT		REMARK IN 2005
MAIN EQUIPMENT	Local supply	209	Metso Outotec Larox	600	
POWER SUPPLY	280 kWh	77	50 kWh	15	Initial investment
WATER SUPPLY	150 m^3/h	230	15 m^3/h	30	
STEAM SUPPLY	5.74 t/t	220	4.44 t/h	170	Average €33/t/h (250 yuan/t/h)
DRYING	8 t/h	199	6 t/h	153	
FOOTPRINT	120 m^2	18	50 m^2	7.5	Average €150/m^2 (1000 yuan/m^2)
TOTAL		**953 (€k)**		**975.5 (€k)**	

TABLE 3. Economic benefit comparison between centrifuge and PF filter

ITEM	CENTRIFUGE		LAROX PF FILTER		LAROX PF ADVANTAGE		
	Consumption/ unit	Consumption/ year	Consumption/ unit	Consumption/ year	Unit price (€k)	Benefit (€/t)	€k/year
ELECTRICITY	46.60 kWh/t	1,398,000 kWh	7.50 kWh/t	225,000 kWh	0.06	2.44	73.07
WATER	25 m^3/ton	750,000 m^3	5.50 m^3/t	75,000 m^3	0.10	2.34	70.09
STEAM	0.96 t/t	28,800 t	0.74 t/t	22,200 t	9.31	1.83	54.82
STARCH ULLAGE	1.10 t/t	33,000 t	1.08 t/t	32,400 t	207.67	4.15	124.60
MAN POWER		12 persons		0	1,038.36	0.00	12.46
DEPRECIA-TION (10 YEARS)	-	65.30	-	69.60	-	-	-2.19
TOTAL							**332.872**

4. Conclusion

The proven and technically advanced Metso Outotec Larox PF automatic tower press filter offers significant process benefits as well as efficiency and energy savings, and can replace traditional centrifuges in many industrial applications.

When applied to a modified starch process it is clear that the Metso Outotec Larox PF filter has low power and water consumption, as well as high productivity, while reducing process waste.

Furthermore, the Metso Outotec Larox PF filter can also advance the technology level of the process with its advanced automation. The advantages of the Metso Outotec Larox PF filter becomes even more impressive with higher energy prices.

Increased production

- Dramatically reduces product loss (starch solids) to filtrate with effective pressure filtration
- High availability due to fully automatic operation
- Lower moisture in cake leads to significant increase in dryer capacity
- Process can run 24/7 without the need for regular cloth changes

Lowest possible solids load to waste water treatment

- Automatic pressure filtration with continuous cloth results in exceptionally clear filtrate

Significantly reduced water and energy consumption vs. centrifugal separators

- Horizontal chamber pressure filtration provides more efficient cake washing, reducing the cake washing ratio while improving ash content
- Reduced equipment power consumption
- Lower moisture in cake helps cut dryer energy consumption

Improved starch quality and consistency

- Efficient cake washing improves starch quality
- Dryer cake requires less thermal drying after filtration leading to improved product quality
- Fully automatic operation results in a more consistent product

Reference

Guangxi Naning Chemical Pharmaceutical Co. Ltd., Mr. Luo Ming, Zhou Haikun, Xu Binyuan, Liang Zhi et al,, Comparison of Filtration Equipment in the Application of Hexahydric Alcohol Production, published in academic exchange session of the China Starch Association Sugar Alcohol Specialized Society, May 2004.

Author

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