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From Lab to Pilot: Process Design and Scale-Up of Wheat Straw Nanocellulose Production for Fertilizer Delivery Systems

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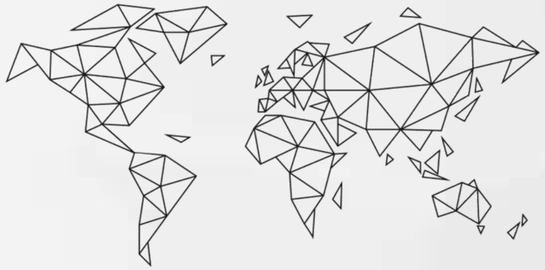
About us



SYSPRO

AUTOMATION BEYOND LIMITS

Founded in 2004

More than 180 employees

Offices in Spain, Portugal, Switzerland and the USA.

3 lines of activity:
GMP
Engineering
Solutions
IT/OT

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GMP

We automate and validate biotech and pharmaceutical plants. We operate under strict GMP guidelines, complying with CFR21 part 11 and EU Annex 11 following GaMP 5, ISA88, ISA101 guidelines.

ENGINEERING SOLUTIONS

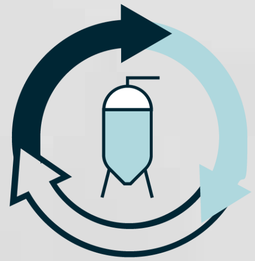
We carry out the automation and complete integration of the control and supervision of installations and equipment in industrial plants. We also design and build special machines, robotic systems and equipment for biotechnological, pharmaceutical and food processes.

IT/OT

We develop advanced IT solutions for industrial environments, offering perfect integration between Information Technology (IT) systems and Operational Technology (OT) systems.

Research and Development

We participate in a large number of R&D projects that allow us to use new technologies or substantially improve existing ones, seeking marketable developments in the different sectors in which we work.



Currently, the main focus of the lines of research in which we participate is that of **sustainability and circular economy**. We look for promising lines of research, but which are at a low TRL and we apply our knowledge as an industrial integrator to try to bring them to market.

We are currently working on two lines of development:

- **Digital platforms** for collecting process data from a wide variety of sources and processing it to optimize those processes.

- **Pilot plants** for the recovery and valorization of various types of industrial waste or side streams.

PYME INNOVADORA

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

R&D projects in which we have collaborated

AUTOWIND

Integral manufacturing system using laser technology for wind tower shafts of high structural quality.

B2BP

New bioprocess for the valorisation of agro-industrial biogas into bioproducts using a high-transfer bioreactor.

BeamShape

Intelligent and dynamic laser beam shaping for welding applications.

BIOGREEN

Green biorefinery from biomass to obtain bioplastics and cellulose acetate membranes.

Cadrado

CAD tools for the automatic evaluation of radiographic images.

CHEERS

Production of new non-plant biomass feedstocks and bio-based products by recycling and cascading the secondary streams from beer brewing.

COMSENSO

New additive manufacturing technology for metal components based on laser-assisted WAAM (L-WAAM) technology.

CONFORSHIP

New automatic thermal forming system for naval structures.

DESPEGA

New integral backrest for car seats using new technologies and over-injection.

DESTACAR

High-performance technologies for the manufacture of multi-material components.

diamante

Implementation of advanced sensor and control systems, under the Industry 4.0 paradigm, for multiwire cutting machines for granite blocks.

EcoeFISHent

Creation of a territorial cluster in northwest Italy for the development of a circular economy project in the fisheries sector.

EDAR 360

Digital solutions that enable the control and optimisation of wastewater treatment processes.

FADO

Innovative robotised laser additive manufacturing system.

INSIGNIA

On-line monitoring system using acoustic sensors to detect cracks in advanced manufacturing processes (Laser Cladding and Additive Manufacturing).

PEATON

Manufacture of Expanded Polypropylene (PPE) components that can be incorporated into structural and non-structural elements of the vehicle.

REPACELL

Research and development of systematised and automated processes for obtaining cellulose nanofibres from the revalorisation of paper/cardboard waste.

SALTO

Reconfigurable robotic manufacturing system using laser technology for textile cutting.

SENSO3

Innovative system for urban wastewater treatment based on ozone and controlled by nanobiosensors.

SM@RTM

Intelligent, adaptive and sustainable technologies for the agile and zero-defect manufacture of composite materials by SM@RTM resin transfer processes.

TRIHSENS

Efficient sensor for monitoring and alarm systems for trihalomethane precursors in drinking water.

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Funded by the European Union

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PROCESS DESIGN CONDITIONS

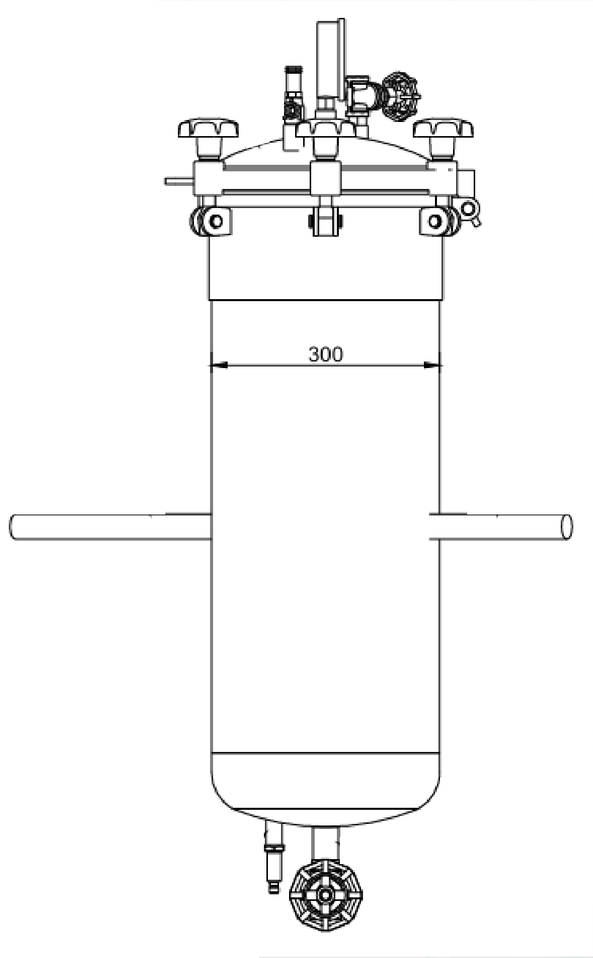
The production of cellulose is composed of four main steps:

Raw material: Wheat straw

Biomass Conditioning	Biomass preparation before the reactor (for example, particle size reduction)
Alkaline pulping	Process that uses alkaline chemicals to break down lignin and separate cellulose fibers from lignocellulosic biomass.
Bleaching process	Elimination of residual lignin and increases the brightness and purity of the pulp
Refining	Refining is used to mechanically treat cellulose fibers to adjust their morphology, enhance fibrillation, and optimize their performance for various applications

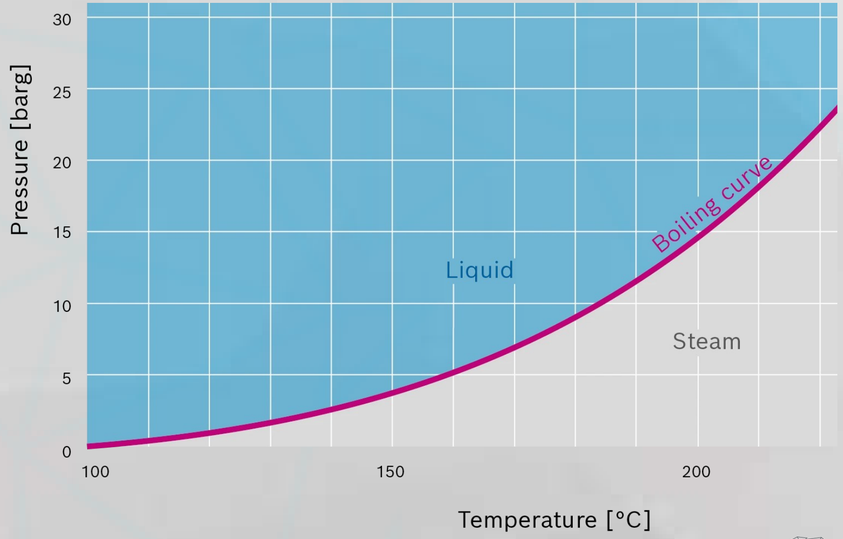
PULP DIGESTER

Uses: Alkaline pulping, bleaching treatment, washing steps.



- ❖ 50 L pulp digester was selected, ensuring gentle fiber treatment and minimize fiber damage.
- ❖ Automatic temperature control: temperature sensor and heated jacket.
- ❖ Pressure: No active pressure control is required.

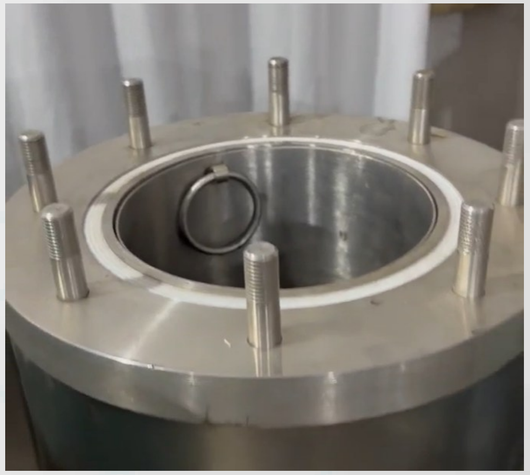
- ❑ Safety features:
  - Pressure gauge
  - Safety pressure relief system
- ❑ Compliance with:
  PED 2014/68/EU



1. Graph source: Bosch Industrial Heat. Pressure and temperature - boiling curve of pure water in a pressure-temperature graph (saturated steam). Available at: https://www.boiler-planning.com/en/technology/steam/pressure-and-temperature.html

PULP DIGESTER

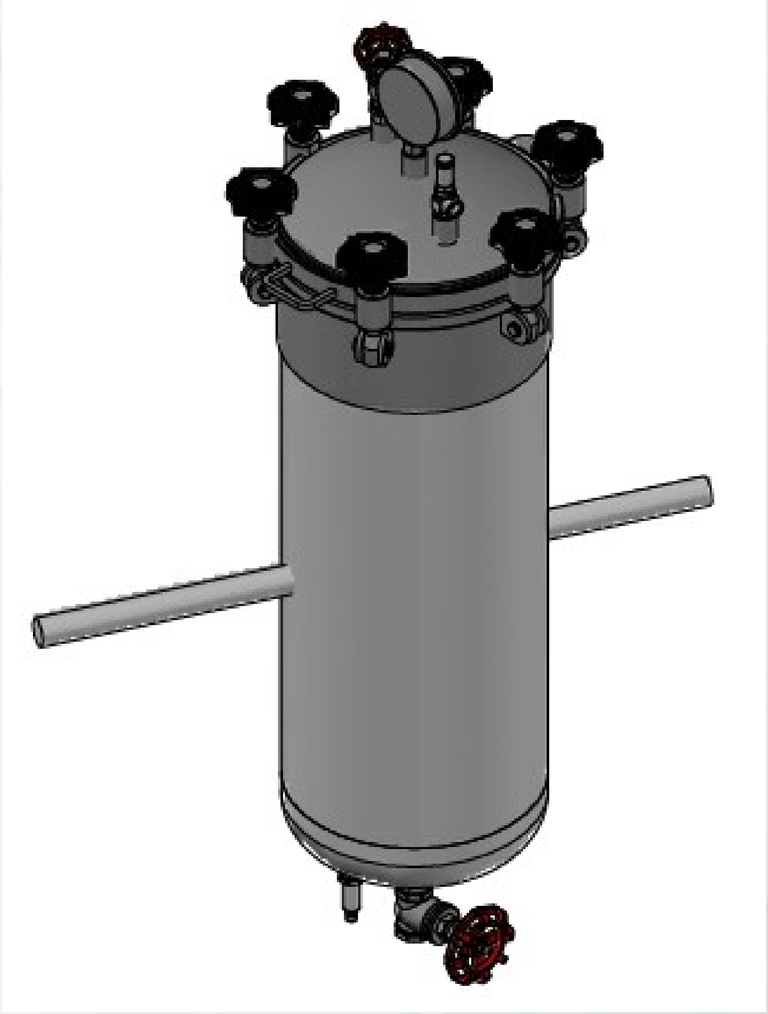
	304 Stainless Steel	316 Stainless Steel	ABS Plastic	Acetal, POM	Acrylic (PMMA)	Aluminum	Brass	Bronze	Buna N (Nitrile)	Cast Iron	Copper	CPVC	EPDM
Hydrofluoric Acid, 20%	D	D	C	D	C	D	D	B	D	D	B	C	D
Hydrofluoric Acid, 50%	D	D	C	D	C	D	D	B	D	D	B	C	D
Hydrofluoric Acid, 75%	D	D	C	D	D	D	D	B	D	D	B	C	C
Hydrofluoric Acid, 100%	B	B	D	D	D	D	D	B	D	D	B	C	D
Hydrogen Gas	A	A	A[1]	NA	NA	A	A	A	A	A	A	A	A
Hydrogen Peroxide, 10%	B	B	A	D	C	A	D	B	D	C	D	A	A
Hydrogen Peroxide, 30%	B	B	NA	D	C	A	D	B	D	B	D	A	B
Hydrogen Peroxide, 50%	B	A[1]	NA	D	D	A	D	B	D	NA	D	A	B
Hydrogen Peroxide, 100%	B	A[1]	A	D	D	A	D	B	D	B	D	A	D
Hydrogen Sulfide, aqueous	C	A	B	C	A	B	D	A	D	D	D	A	B
Hydrogen Sulfide, dry	C	A	NA	A	A	B	D	B	D	D	D	A	B
Ketones	A	A	A	D	D	B	NA	A	D	A	A	NA	D
Lacquer Thinners	A	A	A	D	D	A	A	A	D	C	A	NA	D
Lacquers	A	A	A	D	NA	A	D	A	D	C	A	A	D
Lactic Acid	B	B	D	B	A	B	D	B	A	D	B	A	A
Latex	A	A[1]	B	B	NA	A	A	A	A	A	NA	NA	A
Ligroin	A[1]	A[1]	NA	B	NA	D	NA	NA	A	A	NA	NA	D
Lime (CaO)	A	A	A[1]	B	A	A	NA	NA	A	A	NA	NA	D
Linoleic Acid	B	A	A	B	NA	A	D	C	B	D	D	A	D



- Material selection: chemical compatibility charts.
- Solid–liquid separation: Use of perforated basket preferred over decantation.
- Washing steps: monitoring removal of residual reagents via conductivity, pH, or visual inspection.
- Handling of solid material:
  - Risk of foaming and clogging
  - Reactor should be easily openable for loading/unloading.
  - Automatic operation when possible.

2. Table source: Industrial Specialties Manufacturing (ISM). (2020). Chemical Compatibility Chart. https://cdn-aorpci1.actonsoftware.com/acton/cdna/30397/f-0004/1/24/chemical-compatibility-chart-from-ism.pdf

PULP DIGESTER



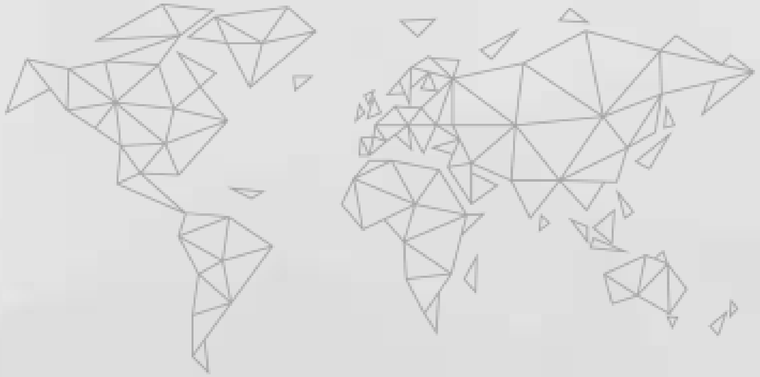
- ❖ Focus on automating unloading operation for safety
- ❖ Pressure release valve: automatic → opens at end of reaction
- ❖ Gaseous effluents condensed via heat exchanger
- ❖ Liquid discharge automatic valve→ intermediate tank
- ❖ Process control screen (HMI) for easy operation

DISC REFINER

Objective: Fibrillate and refine wheat straw pulp to achieve the desired fiber size and properties.

- ❖ Washed pulp is diluted with water to a solids content of 2–8%.
- ❖ Feed cone equipped with a screw feeder to ensure continuous pulp supply to the refiner.
- ❖ Centrifugal pump to recirculate the to the feed cone.
- ❖ Selection of disc geometry.
- ❖ The degree of refining is evaluated based on operating parameters:
  - ❑ Refining time
  - ❑ Disc gap (critical to control fiber properties)
  - ❑ Rotation speed of the discs

Thank you very much for your attention.



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