Dry hopping and infusion technologies from Alfa Laval

– Optimizing large- and small-scale infusion

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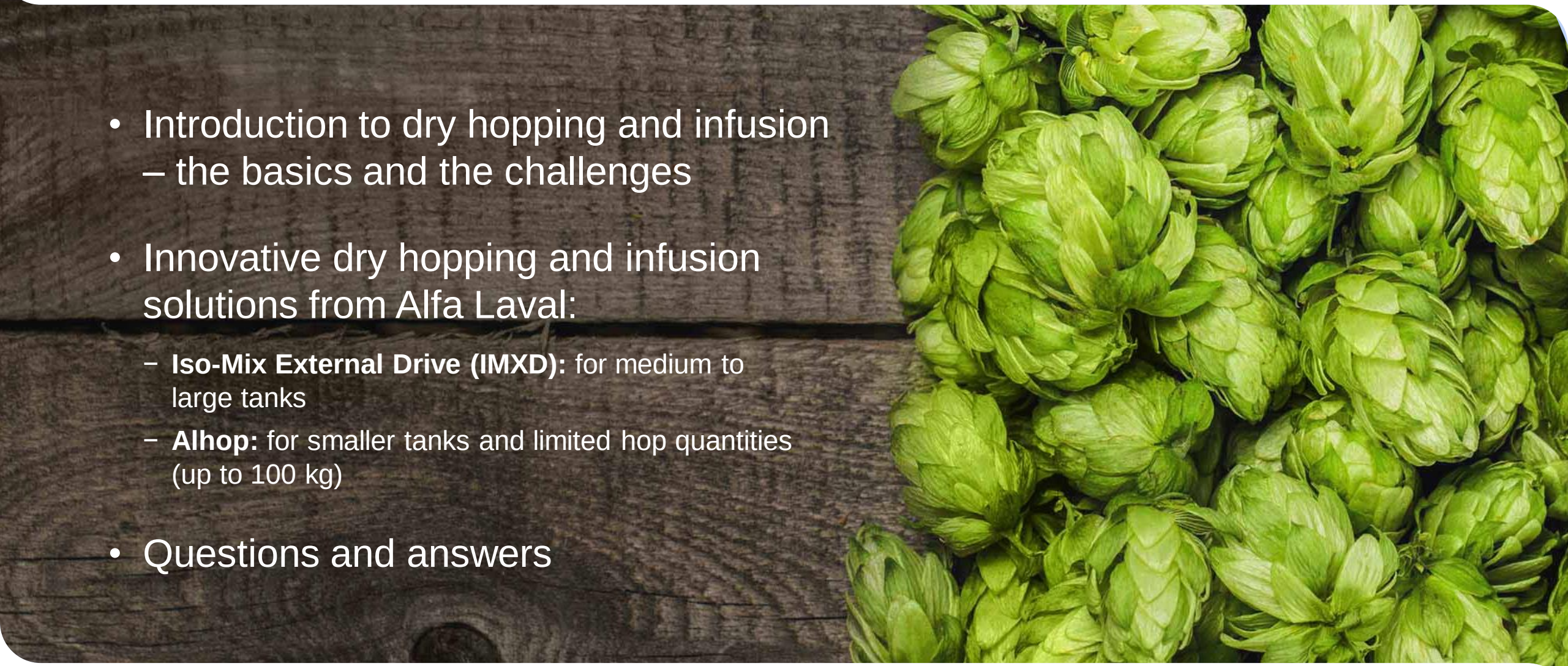
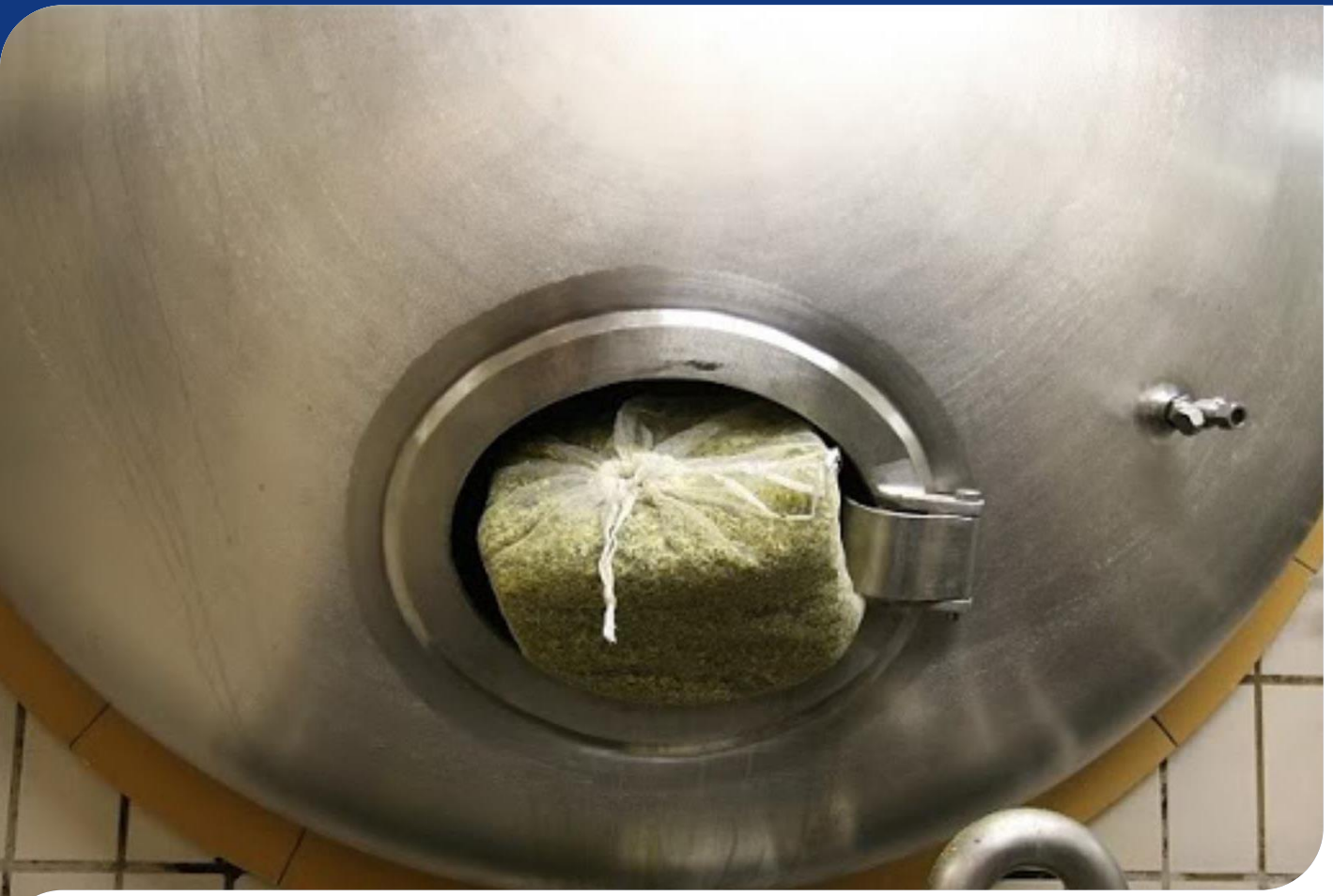
Agenda

– What will we talk about today



- Introduction to dry hopping and infusion – the basics and the challenges
- Innovative dry hopping and infusion solutions from Alfa Laval:
  - **Iso-Mix External Drive (IMXD):** for medium to large tanks
  - **Alhop:** for smaller tanks and limited hop quantities (up to 100 kg)
- Questions and answers

What is dry hopping and why is it done?



- Dry hopping is the addition of hops to the fermentation or maturation vessel during or after main fermentation in order to extract the hop flavours into the beer
- It differs from brewhouse hopping in that isomerization of humulones, which mainly adds bitterness, is not desired

Hop pellets for dry hopping

– Economic and process advantages compared to whole flower hops

- Hop pellets: dried, powdered and recompressed hops
- Most frequently used: T-90 pelletized whole hops
- Alternative: T-45 hops (concentrated lupulin fraction, less bract or vegetal matter)

Hop pellets for dry hopping

– Economic and process advantages compared to whole flower hops

- Pellets are most frequently used in dry hopping
  - Easier to handle
  - Less costly to store and ship
  - Better storage properties
  - Higher hop utilization
  - Easier to remove from wort/beer
- BUT...

Behaviour of hop pellets during disaggregation

– Static dry-hopping test: suspending porous bags of hops in 200 litres cold (10°C) water

Start of test
– weight of dry hops:

- Small bag: 3 kg
- Large bag: 5 kg

End of test (3.5 hours)
– weight of wet hops:

- Small bag: 9.8 kg (+227%)
- Large bag: 19.7 kg (+294%)

Behaviour of hop pellets during disaggregation

– Examination of hop solids after static dry hopping test

- Solids were tightly packed in bags upon removal from water
- High proportion of intact pellets at the centre of the small bag
- **Conclusion:** Incomplete hop pellet disaggregation due to insufficient expansion volume

Behaviour of hop pellets during disaggregation

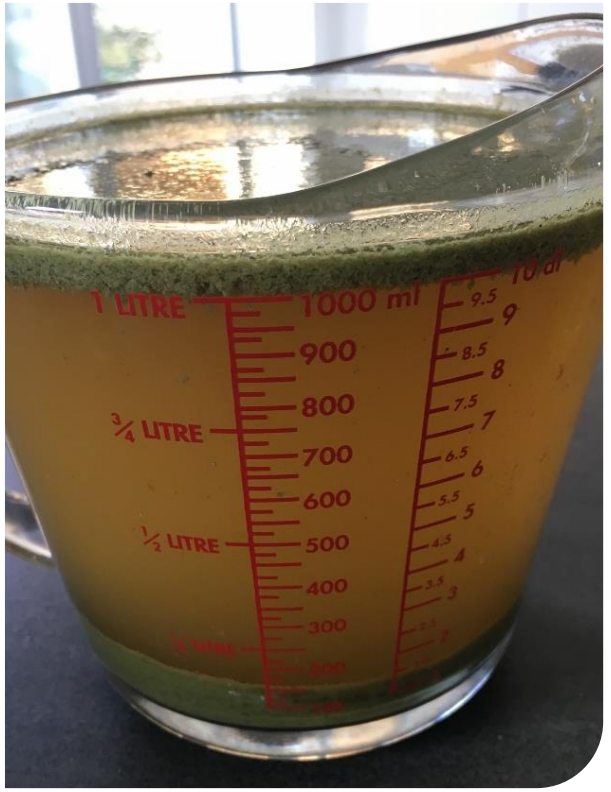
– Process risks of hop pellet dosing in confined spaces

- Pellets swell to 6–8 times the original volume
- Solids cake tightly due to insufficient space
- Impermeable to fluid flow
- Requires disassembly and mechanical excavation of solids

Behaviour of hop solids during dry hopping

– Settling patterns of hop solids in unmixed tanks

- *Left side:* slurry of 10 g Simcoe pellets dissolved in 100 ml warm water (40°C)
- *Right side*: slurry mixed into 1,000 ml cold water (10°C) and allowed to settle for two hours



Behaviour of hop solids during dry hopping

– Process issues related to settling patterns of hop solids before and during tank transfer

Maturation beer during filtration after 3–5 days settling time and cropping

Near end of filtration ~2–3%

Ending filtration → blockage

Significant hop material

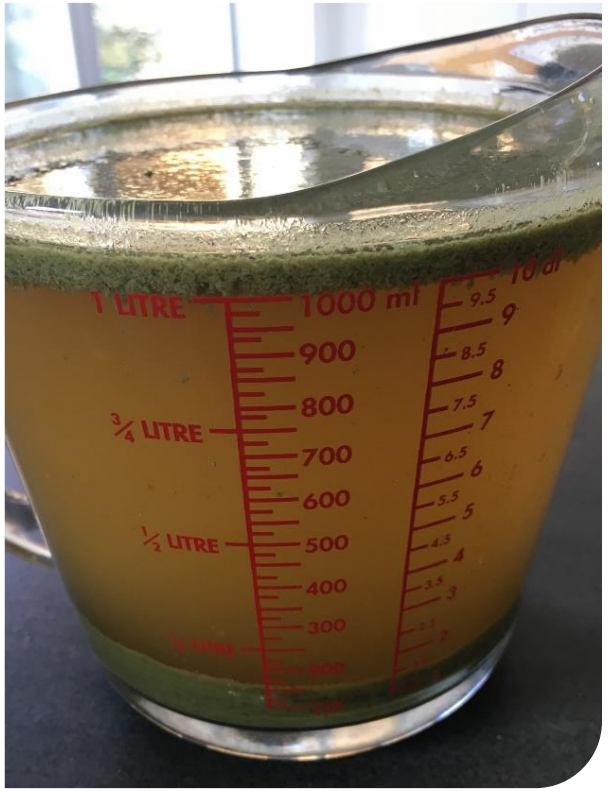
Blockage of outlet line caused by floating solids leaving the tank last

Carryover of solids from centrifuge to filtration system

Blockage of heat exchanger down-stream of the tank

Extraction rate of hop aromas

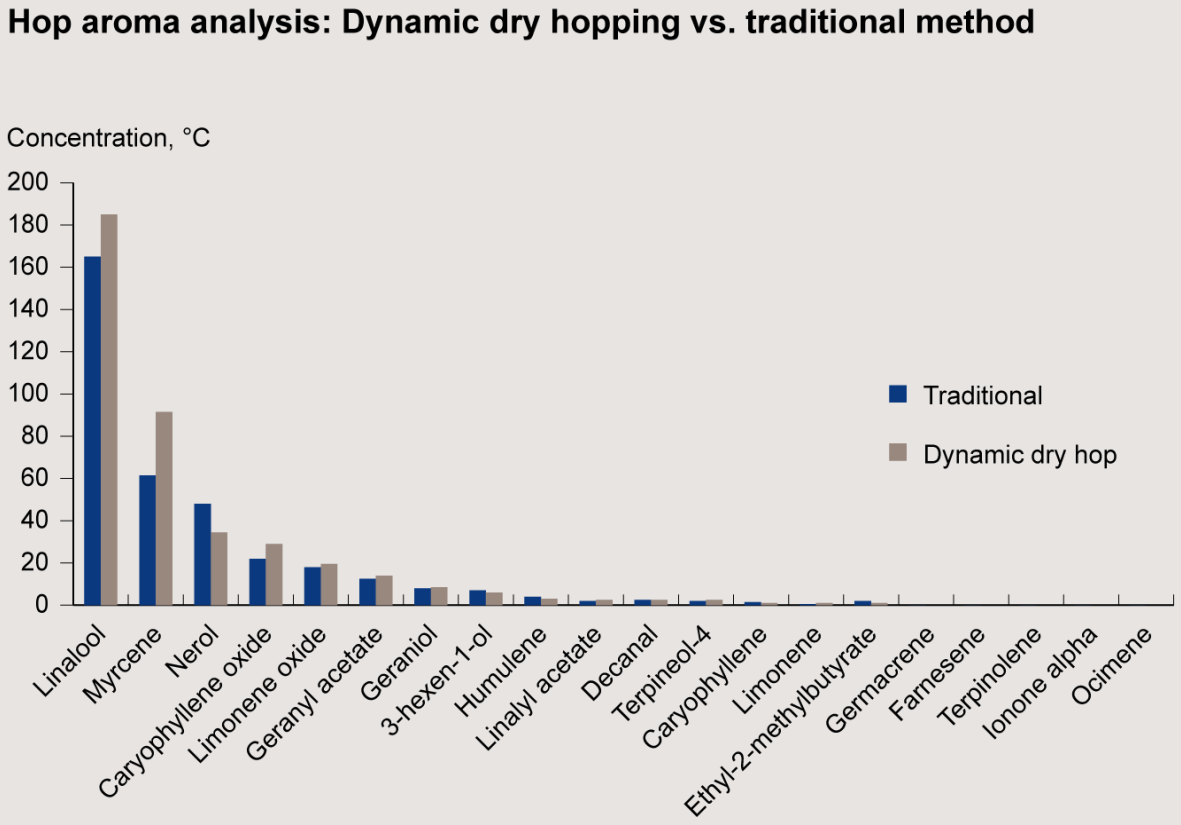
– Limitations of aroma extraction in static dry hopping



- Extraction is driven by the concentration gradient between the hops and the beer
- Extraction rate is temperature-dependent – cold extraction is slower
- In unmixed liquids, the beer directly beside the hop solids becomes saturated, and extraction slows or stops
- Beer in the middle of an unmixed tank does not extract much hop aroma or flavour due to hop solids settling on tank bottom and/or top

Dynamic dry hopping – solution to the challenges

– Advantages of mixing during dry hop dosing, extraction and beer transfer/hop removal



- More effective hops dispersion
- Faster and more efficient aroma/flavour extraction
- Shorter hop residence times
- Homogenization of hop particles during transfer
- Efficient separation of hops from beer by centrifugation
- Reduced beer losses
- Reduced process times

Not only dry hopping!

– Dynamic technologies can also be used for other flavour infusions

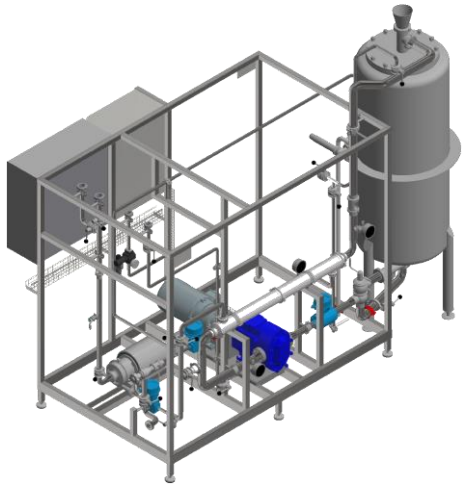
- Coffee
- Spices
- Fruit pulp
- Liquids
- Powders

Dry hopping and infusion solutions

– Alfa Laval IMXD and Alfa Laval Alhop

Alfa Laval IMXD integrated system

- Integrated in the fermentation/maturation vessels
- Hops are mixed within the main vessel
- For larger volumes (200–5,000 hl tanks)



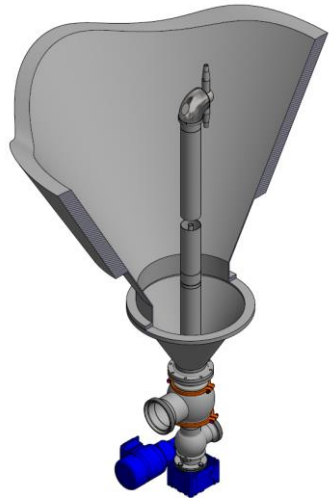
Alfa Laval Alhop module

- Skid-mounted system
- Hops remain outside the main vessel
- For smaller volumes (5–50 kg or 10–100 kg of pellets per batch)

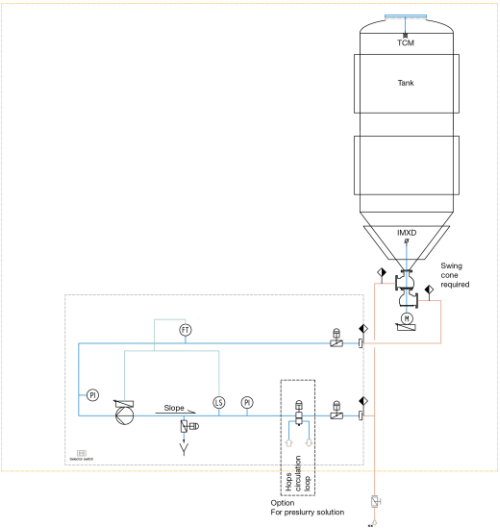
Alfa Laval IMXD integrated system

– Provides efficient mixing and homogenization during hop dosing, extraction and hop removal

- Alfa Laval Iso-Mix External Drive (IMXD) Rotary Jet Mixer



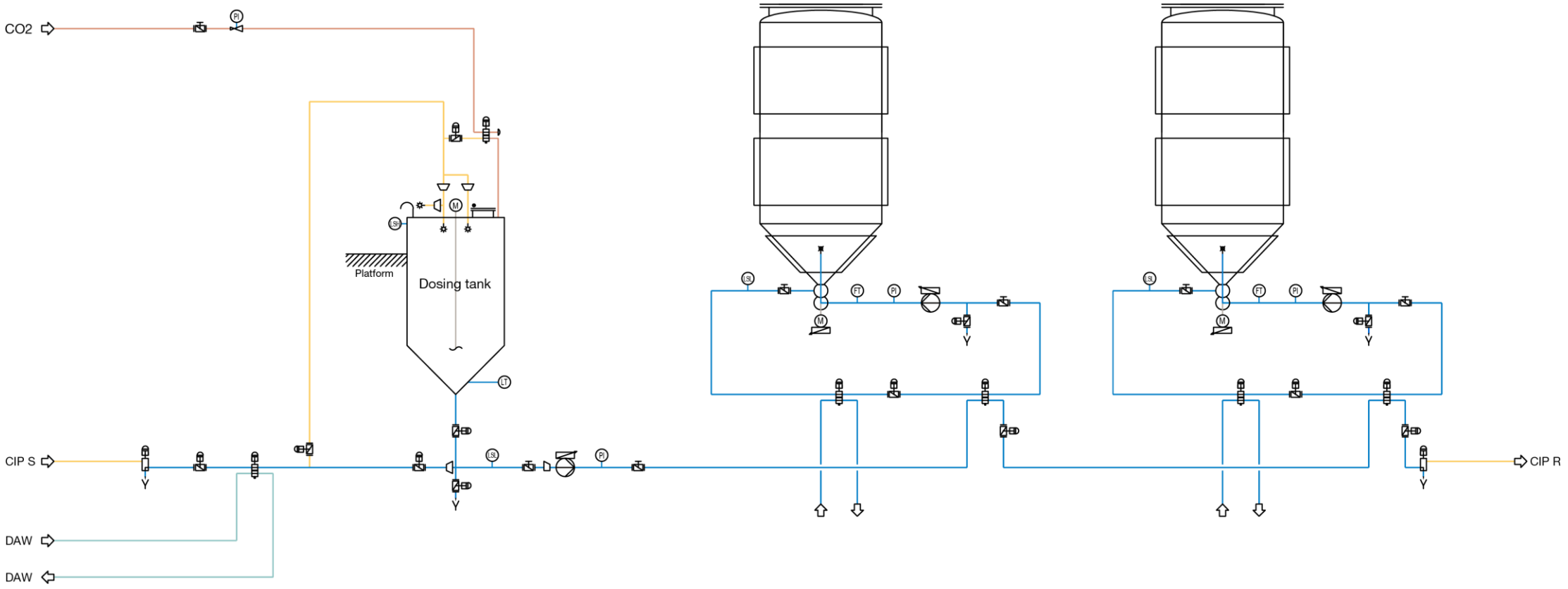
Cutaway of IMXD installation on tank dosing point



P&ID showing IMXD, circulation loop and hop

Dry hop slurry tank with IMXD systems

– Optimal solution for automated dry-hopping system for larger tanks

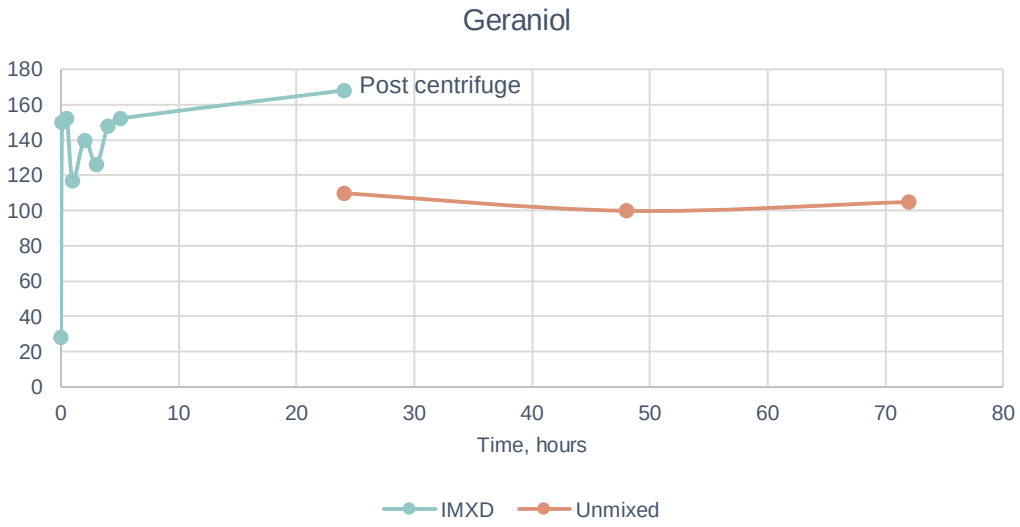


Effect of IMXD system on hop aroma/flavour extraction

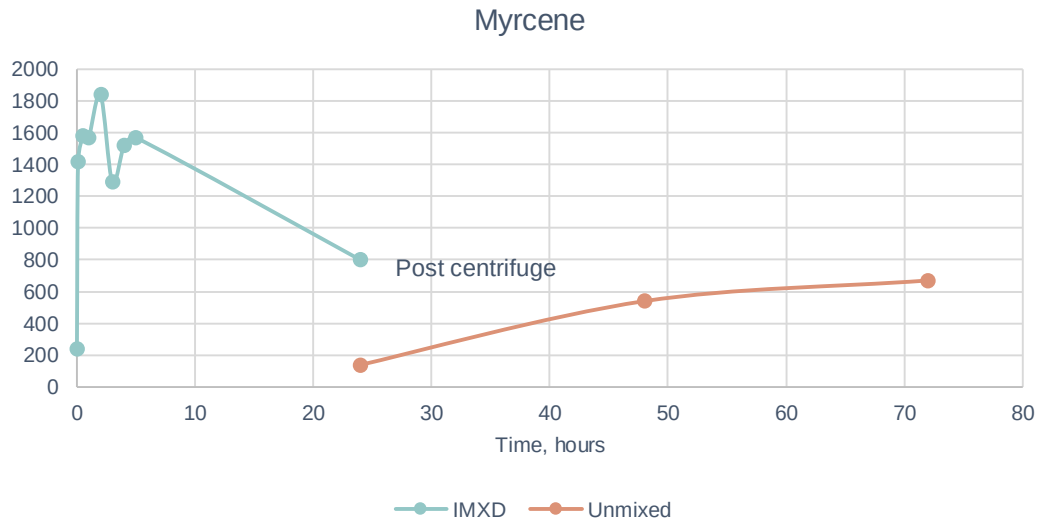
– IMXD versus static process: GC analysis of two hop aroma components for mixed dry hopping

IMXD vs. static process

Full aroma extraction in 6–8 hours with IMXD vs. 70+ hours in an unmixed tank



Non-volatile: full retention after centrifugation



Volatile: significant decrease after centrifugation

Aroma retention of volatiles: effect of centrifuge type

– Comparison of retention rates of monoterpenes in top-feed versus hermetic bottom-feed centrifuges

- Higher retention of volatile monoterpene compounds at outlet of hermetic bottom-feed centrifuge
- Data supported by customer experience in certain industries, such as champagne production
- Non-volatile geraniol included for comparison (no loss in centrifugation)

Compound	Customer 1 (top-feed HSS)			Customer 2 (bottom-feed HSS)		
	Concentration (GC analysis)			Concentration (GC analysis)		
	Inlet	Outlet	Decrease	Inlet	Outlet	Decrease
Myrcene	1550	800	48%	1114.7	978	12%
Geraniol	150	170	–13%	498	506.1	–2%
Caryophyllene	32	8	75%	23.3	15.6	33%
Humulene	475	150	68%	87.8	63	28%

HSS – high-speed separator or centrifuge

IMXD system improves hop removal efficiency

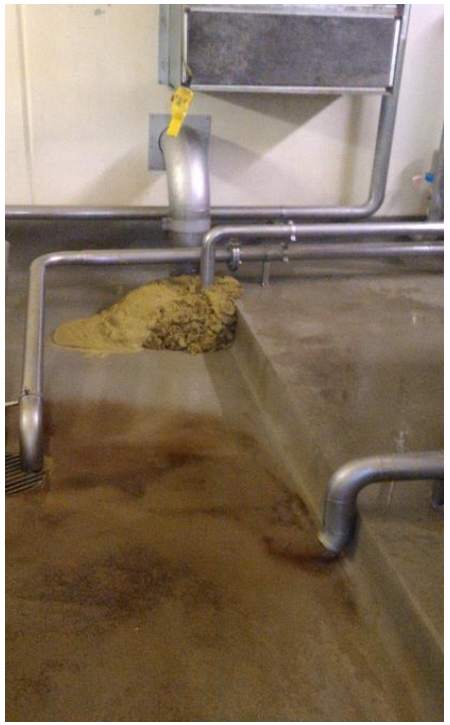
– Homogenization of centrifuge feed stream enables complete hop removal and reduces beer losses

- Samples at inlet to centrifuge taken at various times during the transfer of >800 hl dry-hopped beer
- All samples have similar concentrations of yeast and hop solids
- Homogeneous feed to separator allows consistent inlet flow to machine, efficient separation performance and complete solids removal
- Significant reduction in beer losses compared to settling of hop solids and draining from tank

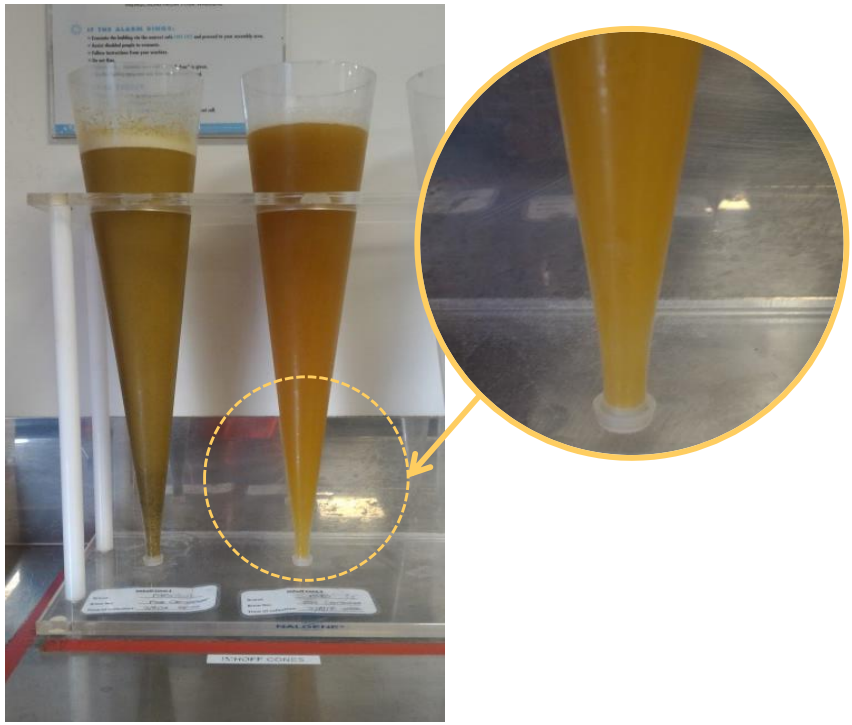
IMXD system improves hop removal efficiency

– Full solids removal by centrifugation with reduced beer losses

- Hop solids removal may require extra flushing water or more frequent discharges to move the solids to a waste tank
- Drier solids may be discharged straight to a container
- Automated discharges: baseline turbidity of dry-hopped beer higher than for lagers



Sample of solids discharge



Pre → post-centrifuge

Dry-hopping process improvements with IMXD system

– Comparison of unmixed process versus IMXD for two different dry hopped brands at one customer site

	Brand 1		Brand 2	
Criterion	**Old method**	**IMXD**	**Old method**	**IMXD**
Tank residence time (from end of ferment to filtration)	5–7 days	24–36 hours	7–10 days	24–36 hours
Number of tanks used	4	2	4–5	2
Cropping loss	Up to 10% cold break + hops	Solids removed through centrifuge <2% loss in maturation from cold break	Up to 15% cold break + hops	Solids removed through centrifuge <2–3% loss in maturation from cold break

Physical and process requirements for IMXD system

– Suitability criteria for implementation of IMXD for dry hopping/flavour infusion

- Tank size: minimum 150 hl, maximum 5,000+ hl
- Hop dosing rates: up to 15 g/L
- Tank must have removable/swing cone
- Minimum clearance from tank outlet to ground > 1.0 meters
- Any method of hop dosing/addition is suitable
- Hop dosing rate must be controlled
- Hop removal by centrifugation optimal
- Settling and draining of hop solids also okay

Summary: IMXD system optimizes your process

– Benefits of IMXD system for dry-hopping, flavour infusion and fermentation optimization

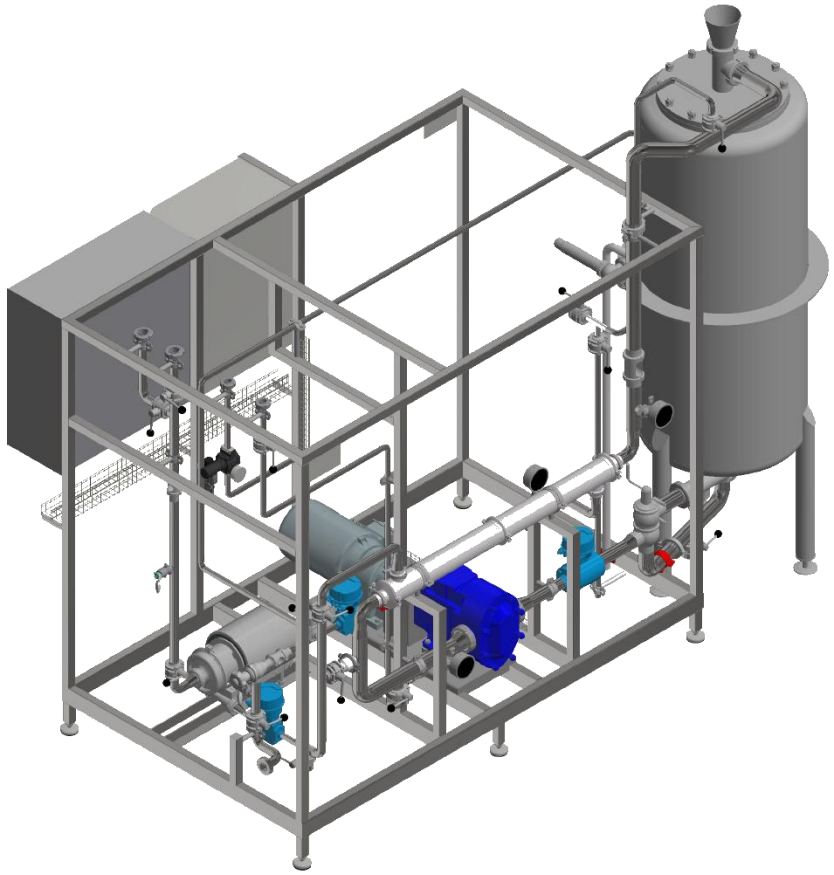
- Reduced process time
- Lower product losses
- Smaller waste streams
- Complete hop removal
- Fast, efficient aroma/flavour extraction
- Product flavour matching
- Larger product batches possible
- Higher hop dosing rates possible
- Additional benefits for fermentation optimization, mixing, gas addition and chill back acceleration
- Fast return on investment

Alfa Laval Alhop dry-hopping system

– Skid-mounted system

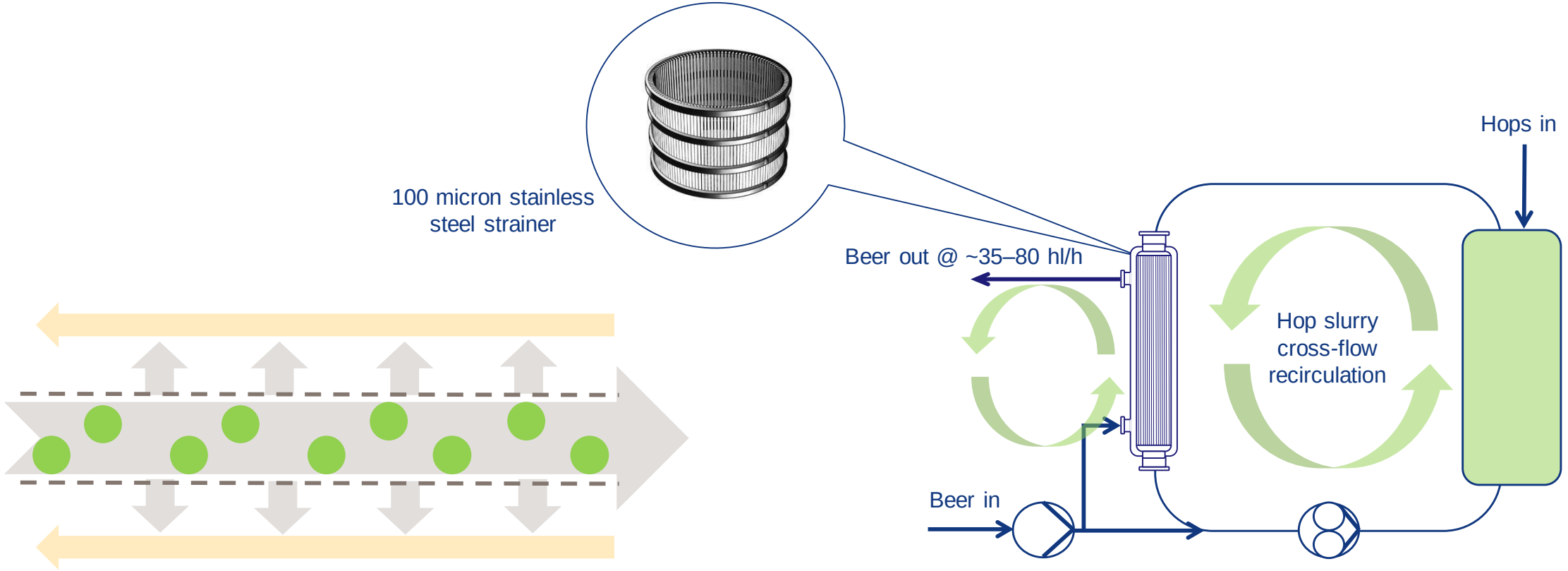
Hop addition → Dis-aggregation → Extraction → Hop removal

- Skid-mounted system
- Capacity: 5–50 kg or 10–100 kg of pellets



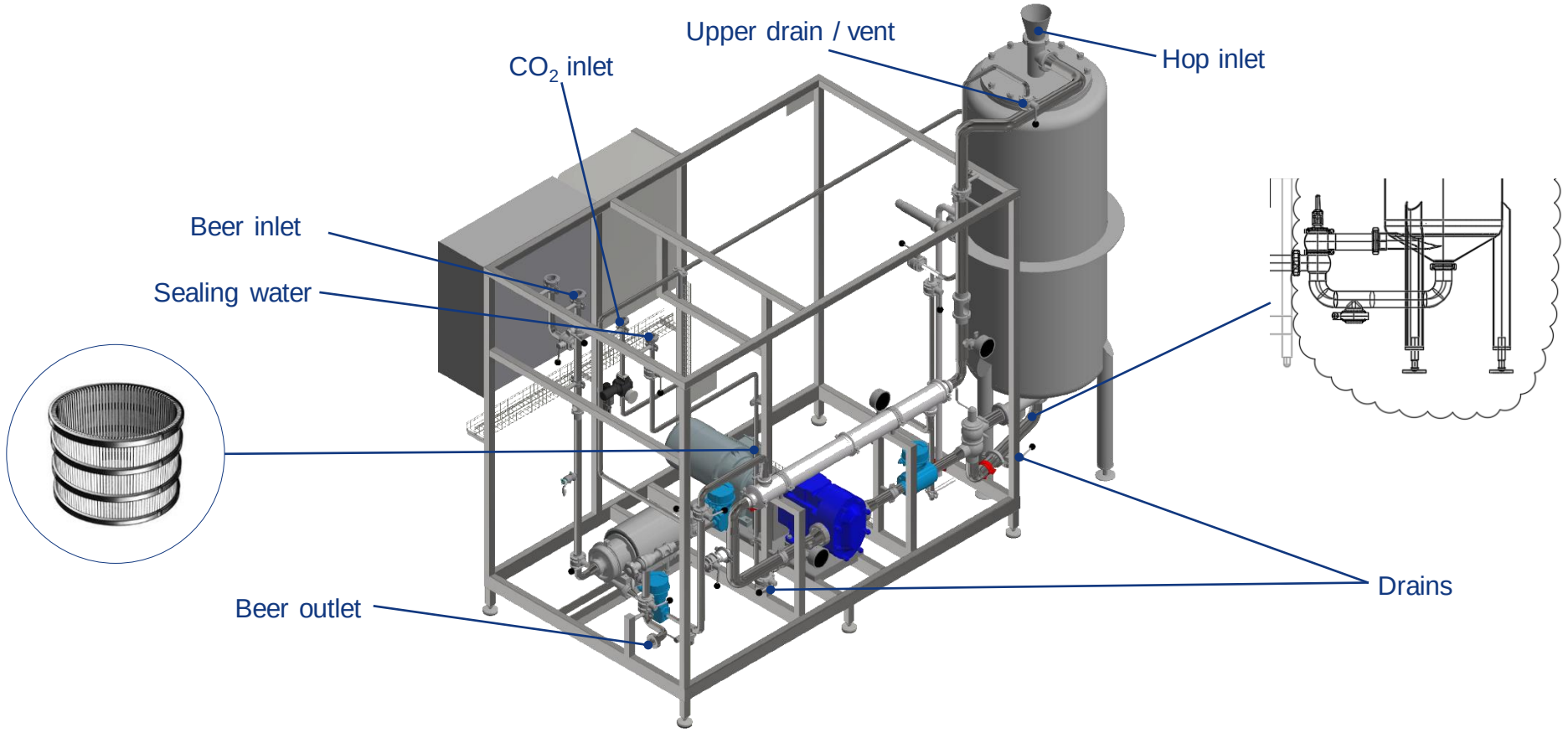
Alfa Laval Alhop dry-hopping system

– How it works



Alfa Laval Alhop dry-hopping system

– EU pilot overview: 50 kg max. load

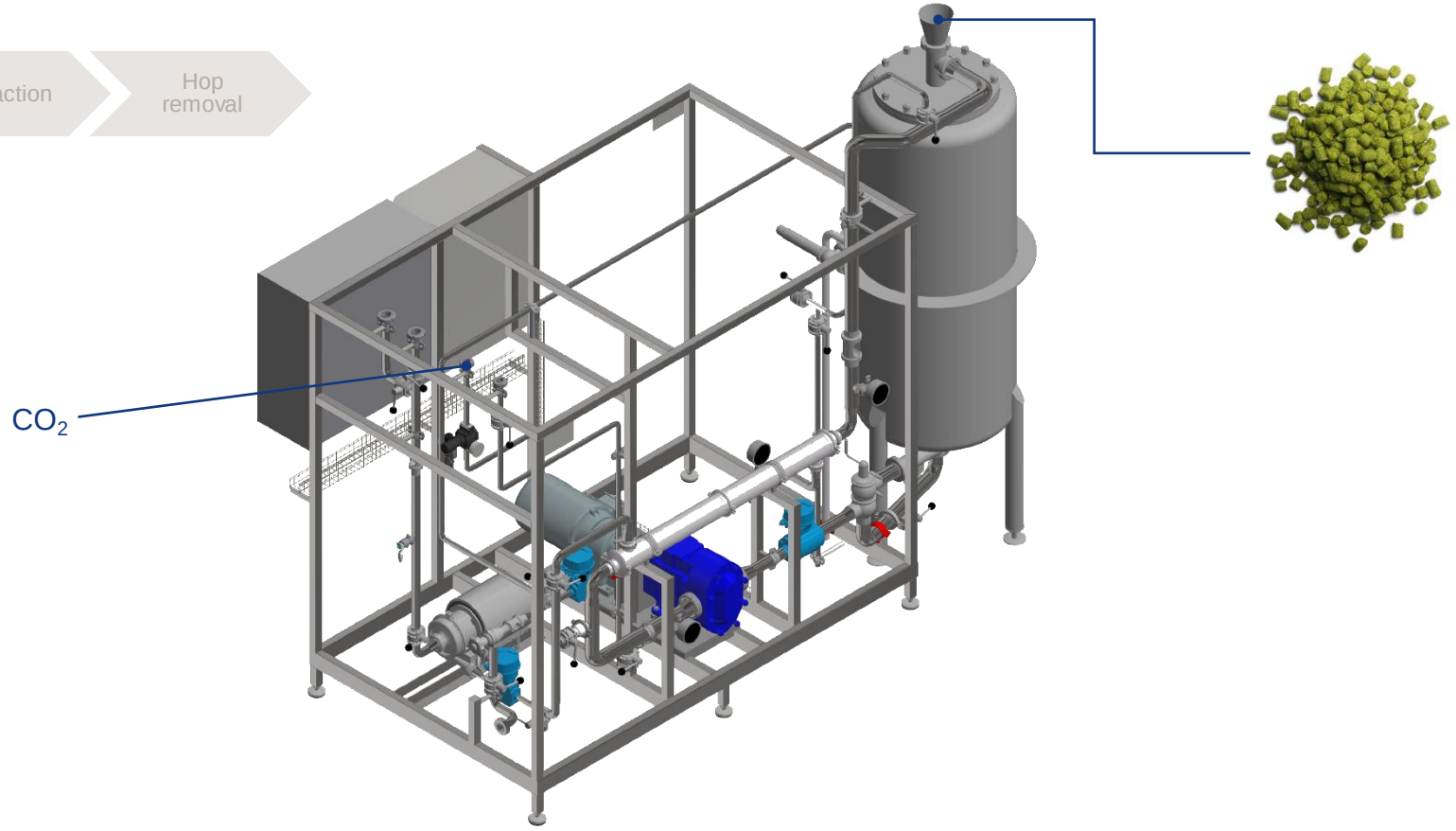


Alfa Laval Alhop dry-hopping system

– Production steps

Hop addition | Dis-aggregation | Extraction | Hop removal

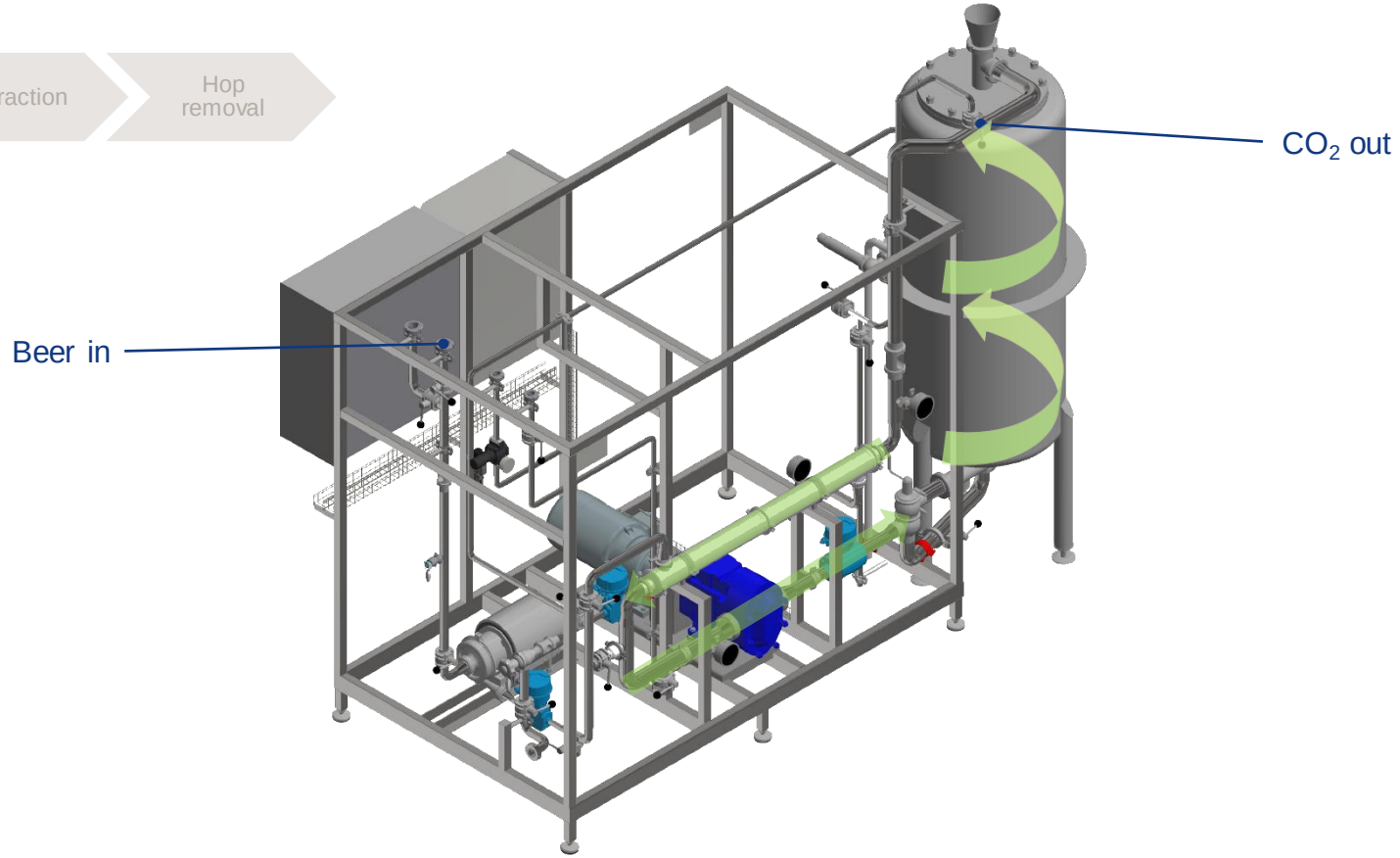
Status: clean and empty system



Alfa Laval Alhop dry-hopping system

– Production steps

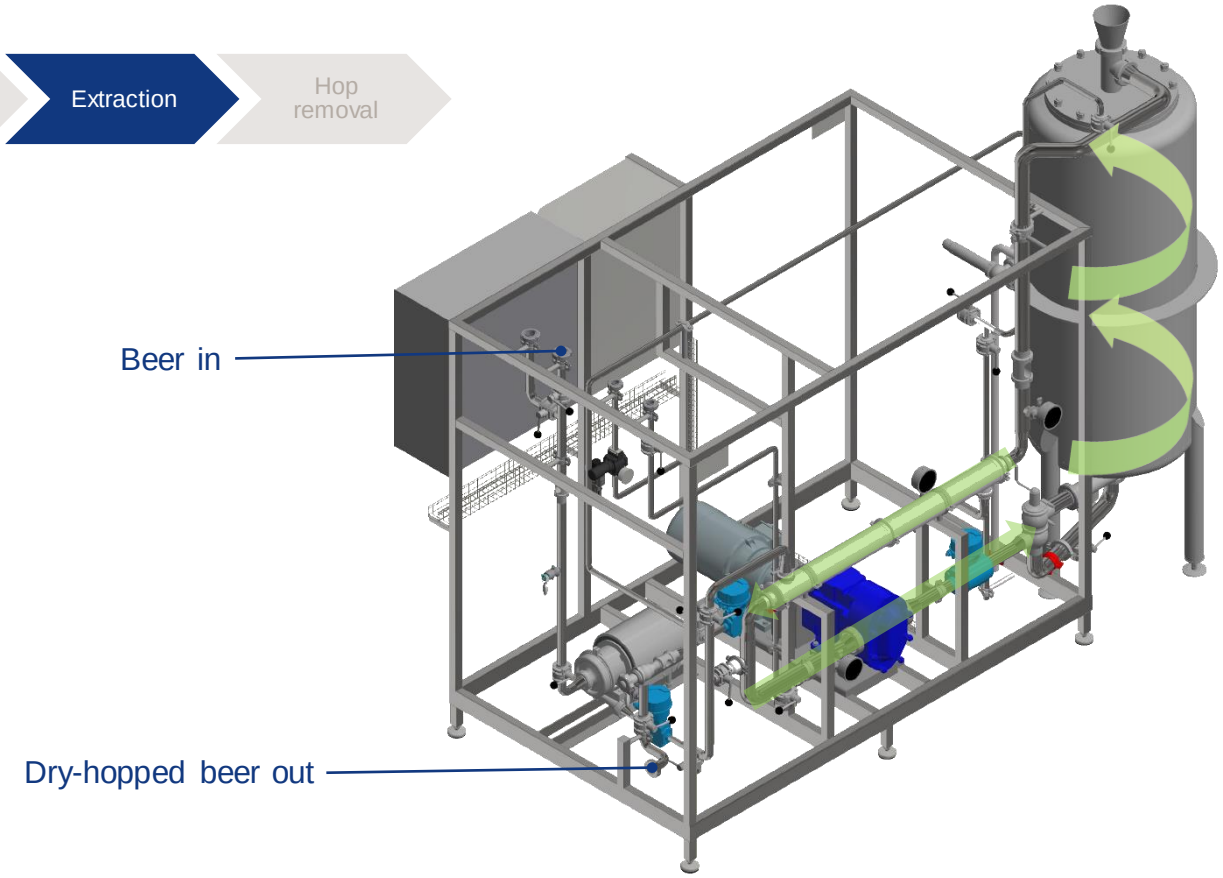
Hop addition | **Dis-aggregation** | Extraction | Hop removal



Alfa Laval Alhop dry-hopping system

– Production steps

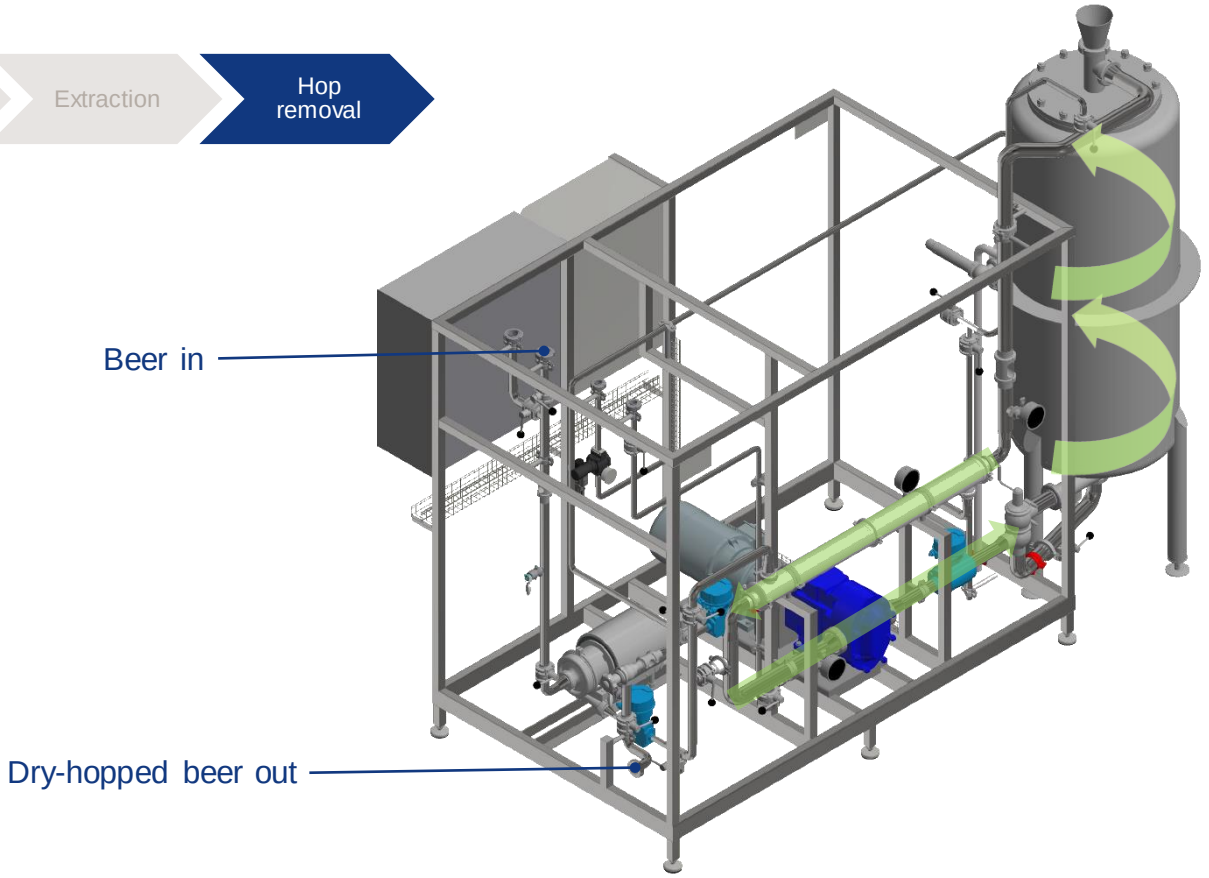
Hop addition | Dis-aggregation | **Extraction** | Hop removal



Alfa Laval Alhop dry-hopping system

– Production steps

Hop addition | Dis-aggregation | Extraction | **Hop removal**



Alfa Laval Alhop dry-hopping system

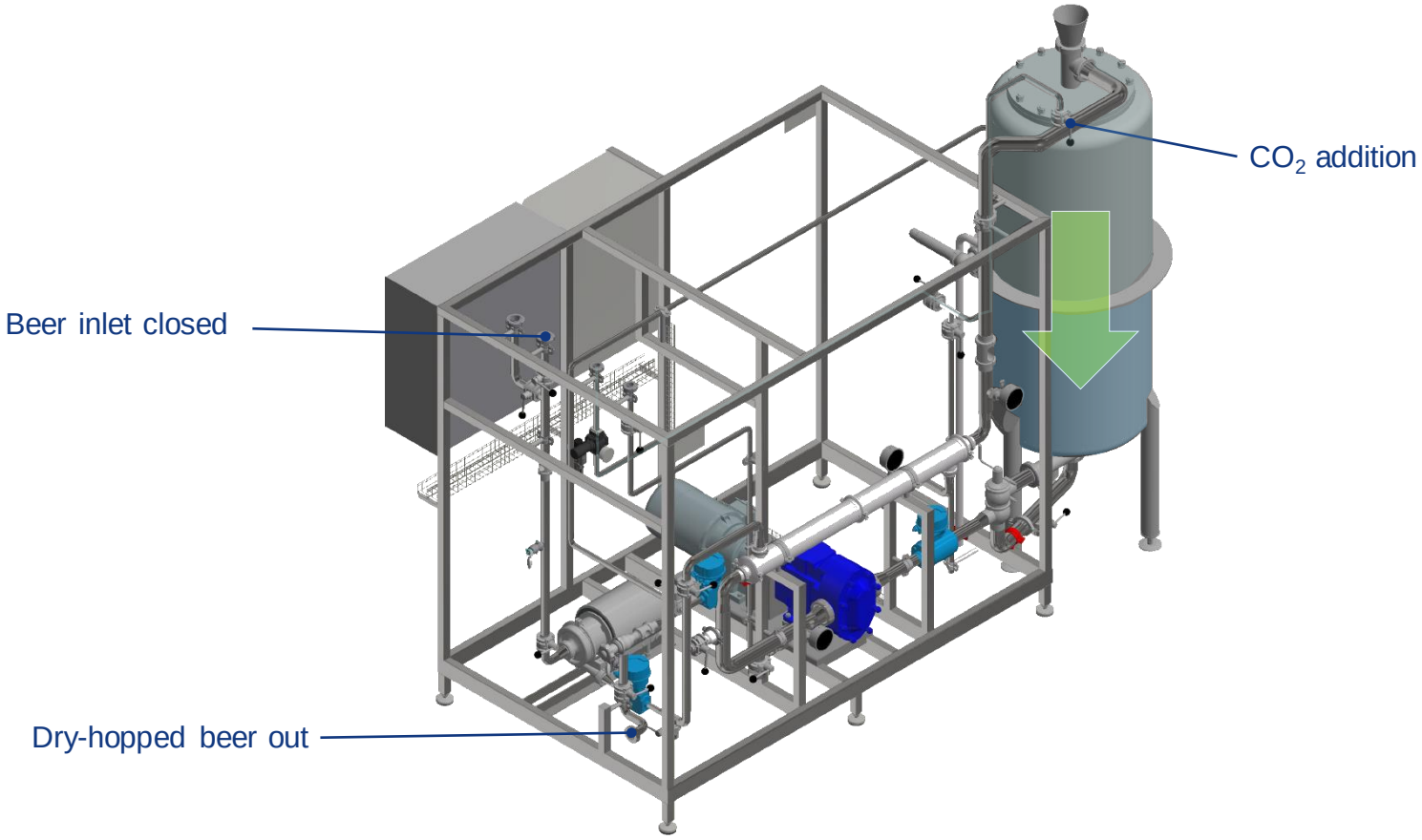
– Beer recovery

Beer recovery

- Concentration
- Diafiltration

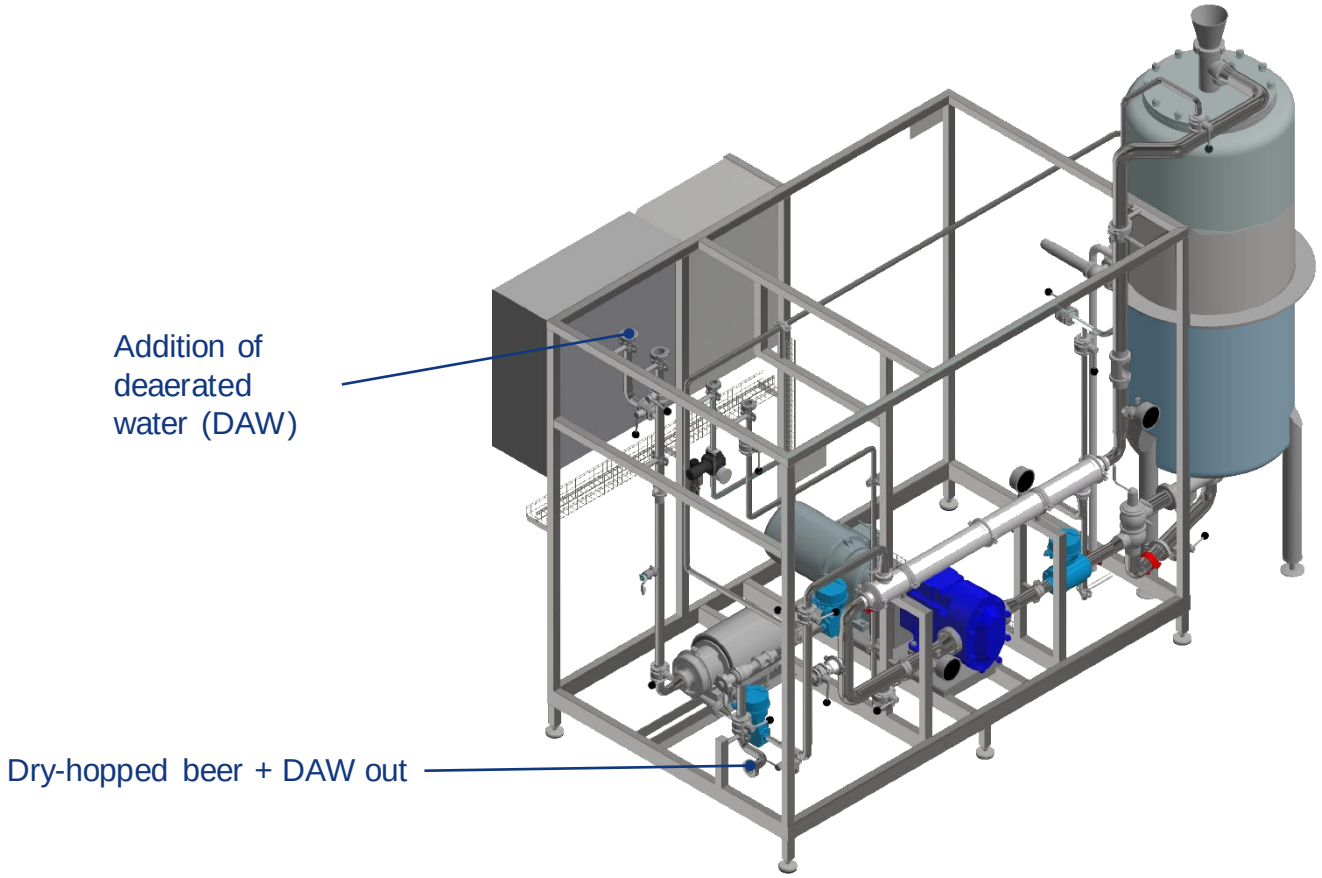
Alfa Laval Alhop dry-hopping system

Beer recovery – concentration



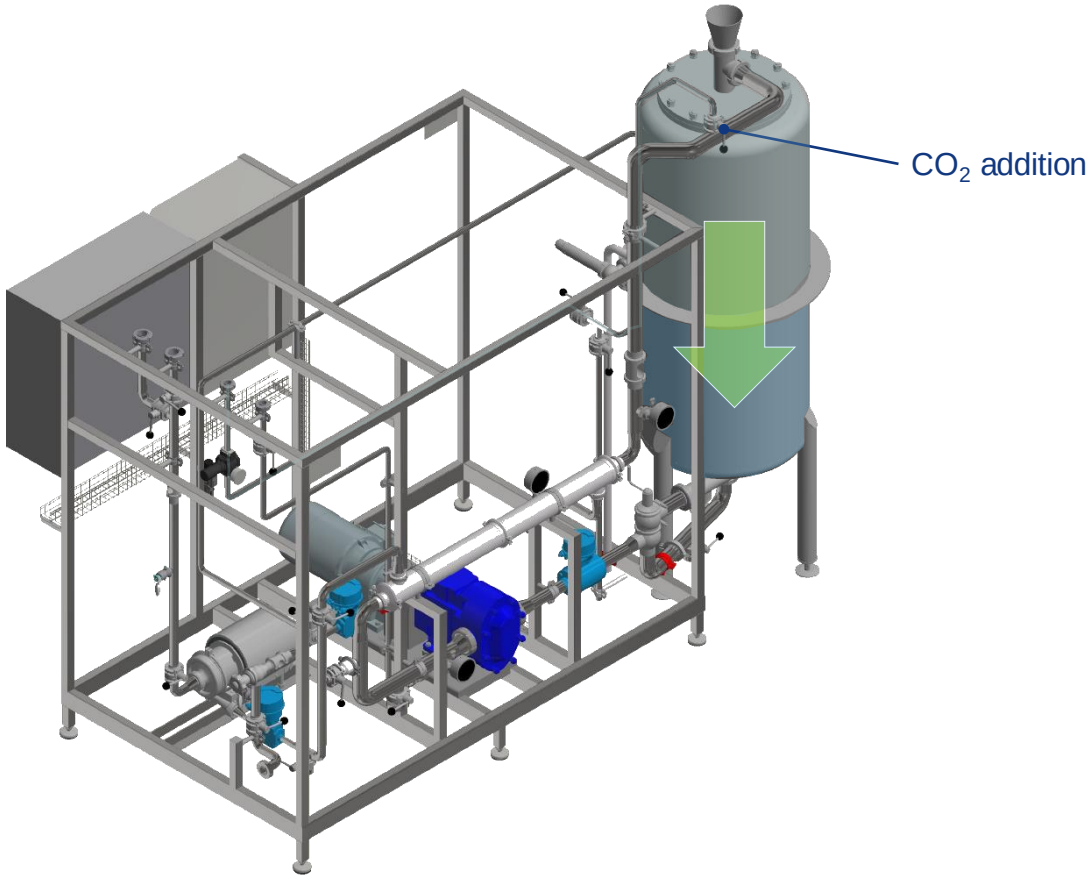
Alfa Laval Alhop dry-hopping system

Beer recovery – diafiltration



Alfa Laval Alhop dry-hopping system

Beer recovery – concentration after



Alfa Laval Alhop dry-hopping system

VLB results – BRŁO brewery, Germany

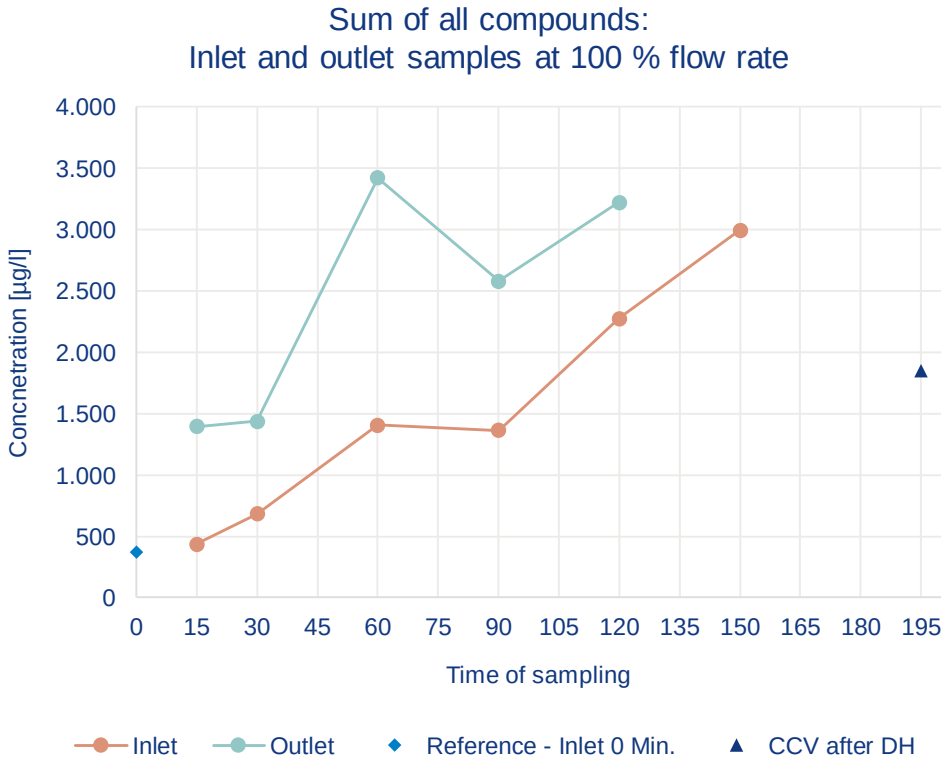
Parameter	Result
Density (g/cm^3)	1.00845
Alcohol (% mass)	4.95
Alcohol (% volume)	6.32
Extract, apparent (% mas)	2.63
Extract, real (% mas)	4.88
Original extract (% mas)	14.35
Apparent degree of fermentation, calculated (%)	82.5
Real degree of fermentation, calculated (%)	67.7
Colour (EBC)	18
pH	4.52
Bitterness Units (BU)	52

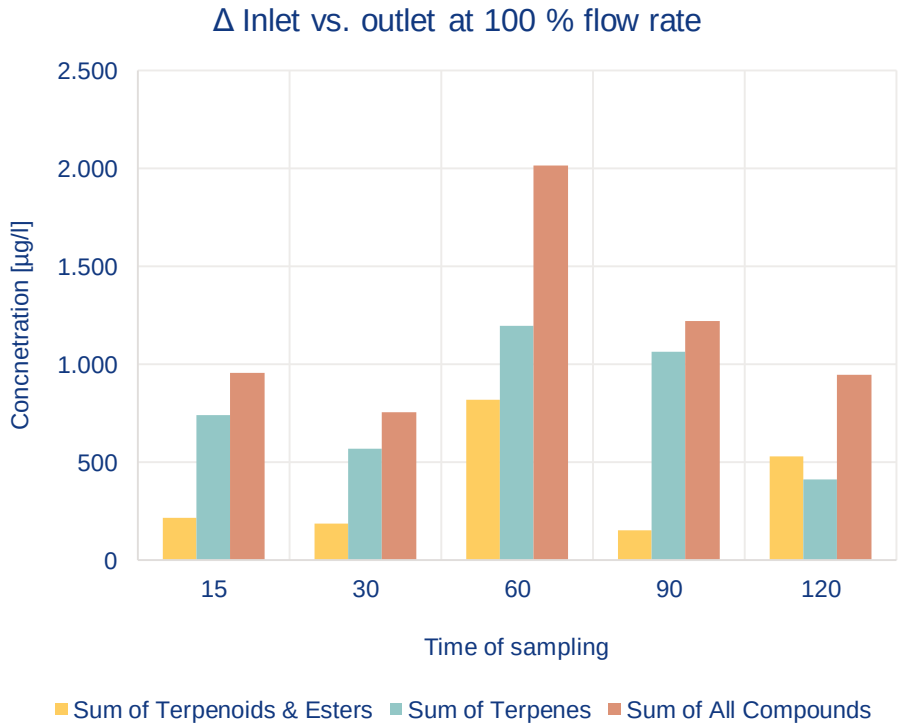
Dry hopping dosage:

- 120 hl + 30 kg hop pellets
- 250 g/hl

Alfa Laval Alhop dry-hopping system

VLB results – BRŁO brewery, Germany

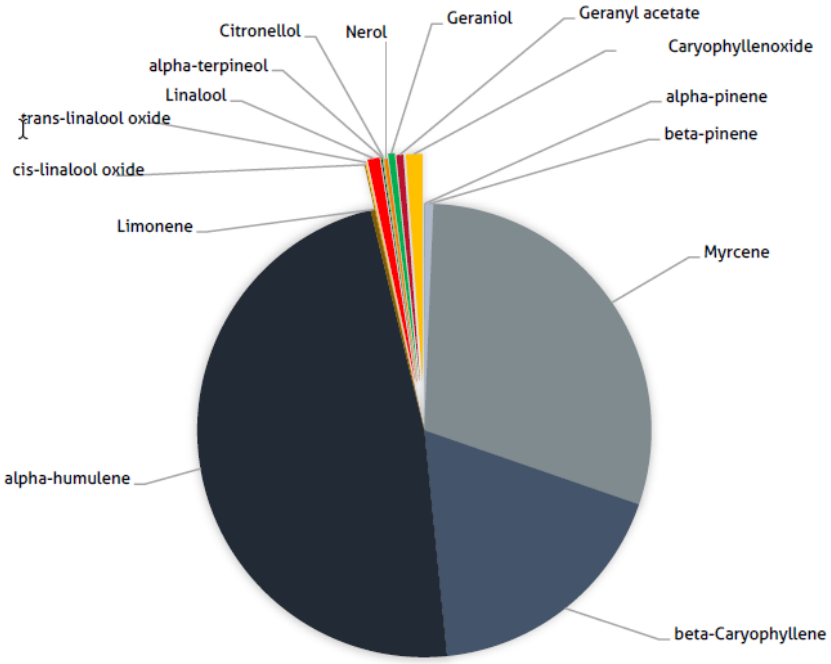




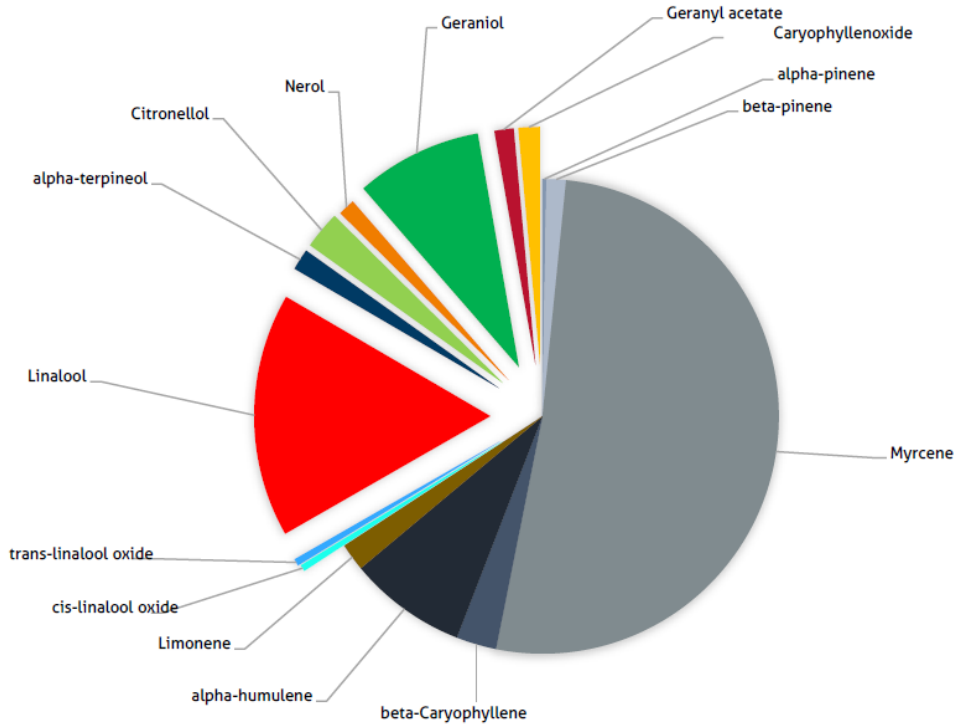
Alfa Laval Alhop dry-hopping system

VLB results – BRŁO brewery, Germany

Distribution of hop oil compounds in hop pellet mixture

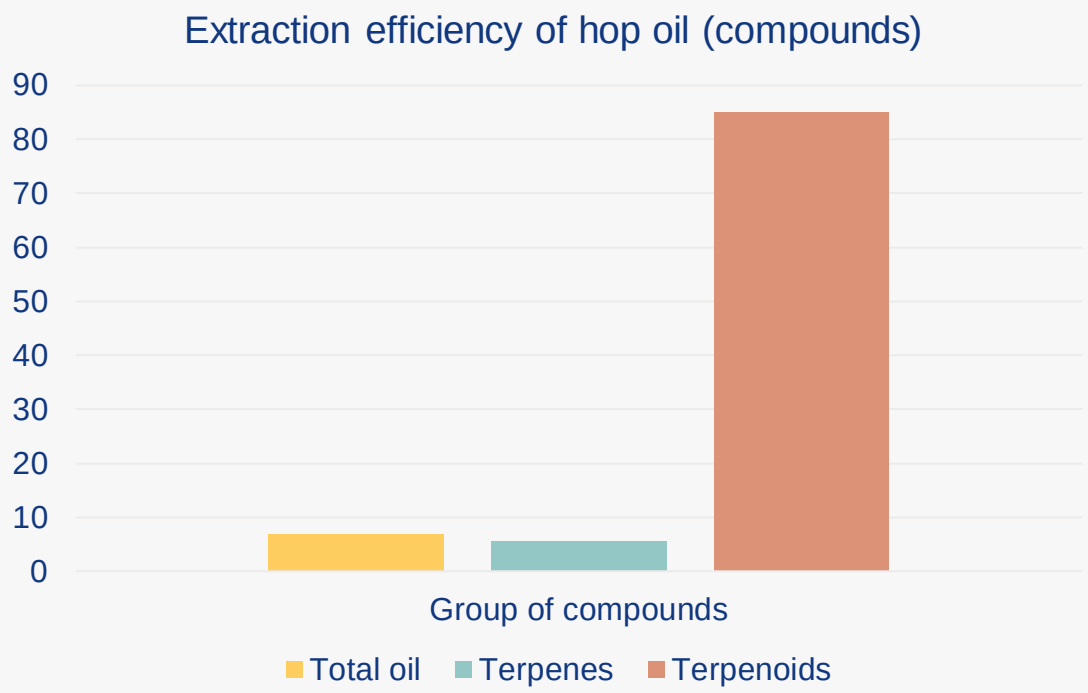


Distribution of hop oil compounds in beer CCV after dry hopping



Alfa Laval Alhop dry-hopping system

VLB results – BRŁO brewery, Germany



"The high extraction rate of about 85% for the more polar terpenoids can be regarded as success for the dry-hopping procedure and beneficial for hoppy aroma. With static dry-hopping techniques, it usually takes several days to extract these valuable compounds into the beer. The procedure in this trial however took about three hours."

VLB BERLIN

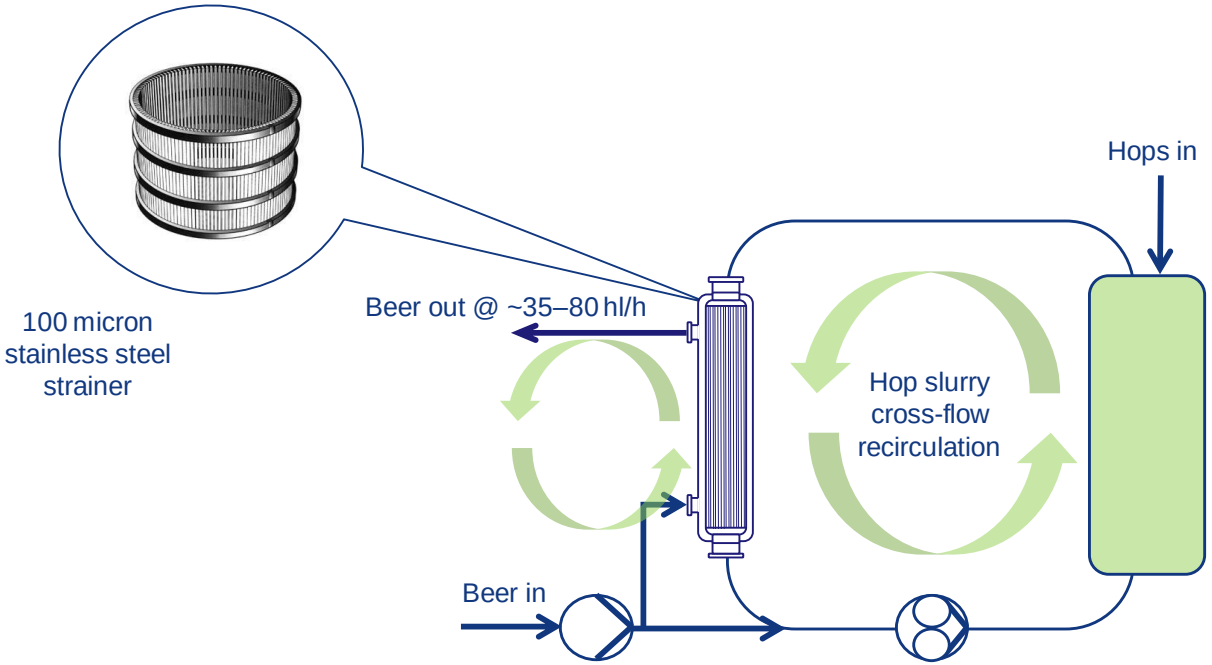
Alfa Laval Alhop dry-hopping system

VLB results – BRŁO brewery, Germany

Solids retention (drying method)

- Total solids % before dry hopping: 4.76%
- Total solids % after dry hopping: 4.89%

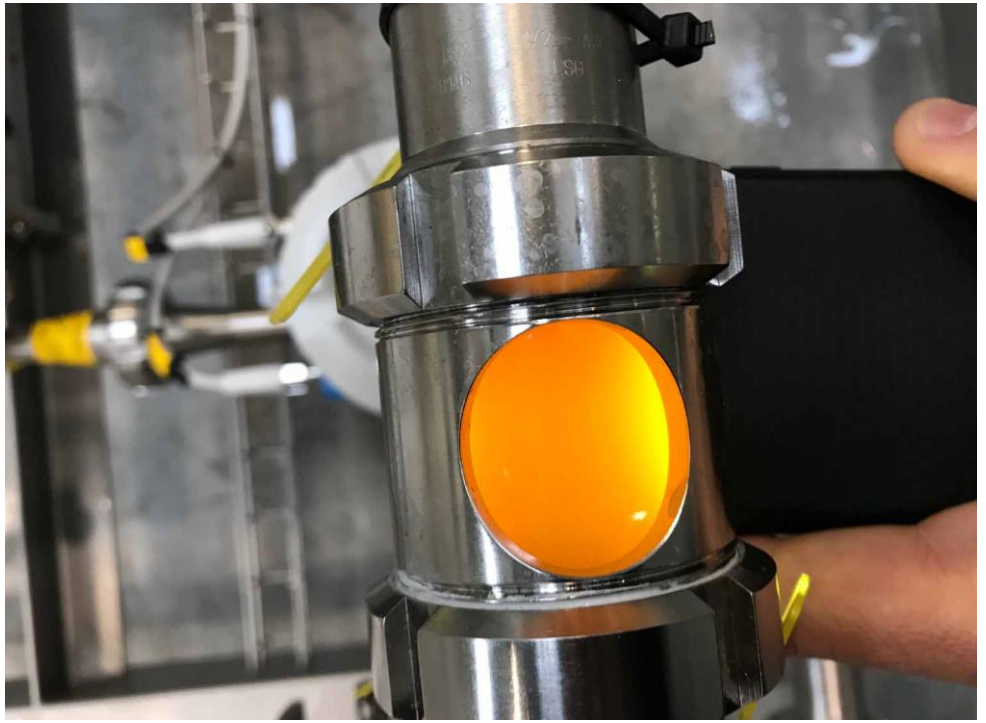
Overall 3% increase in solids content, including beer-soluble compounds from the hop pellets



Alfa Laval Alhop dry-hopping system

EU pilot: first EU run, inlet versus outlet

Beer inlet



Beer outlet

Alfa Laval Alhop dry-hopping system

EU pilot: second EU runs, inlet versus outlet

Beer inlet

Beer outlet

Alfa Laval Alhop dry-hopping system

VLB results – BRŁO brewery, Germany

Beer inlet

Beer outlet

Alfa Laval Alhop dry-hopping system

VLB results – BRŁO brewery, Germany

1.2% beer losses
(without DAW recovery step)

- 1.45 hl out of 120 hl
- 5 l/kg of hop pellets

Hop slurry sample during trials not conducted with VLB

Alfa Laval Alhop dry-hopping system

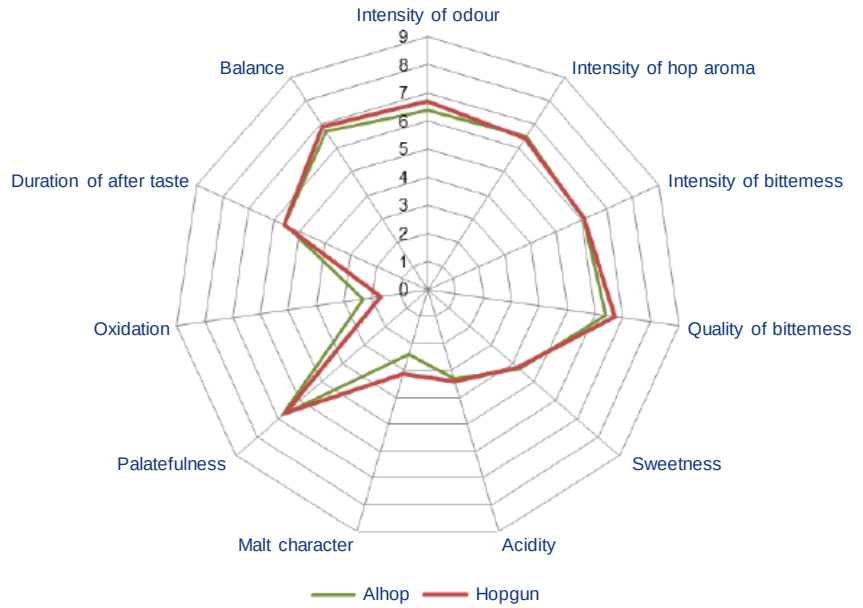
VLB results – BRŁO brewery, Germany

Sensory analysis

“It can be summarized that no significant difference was found between the general quality ratings of BRŁO Pale Ale samples.

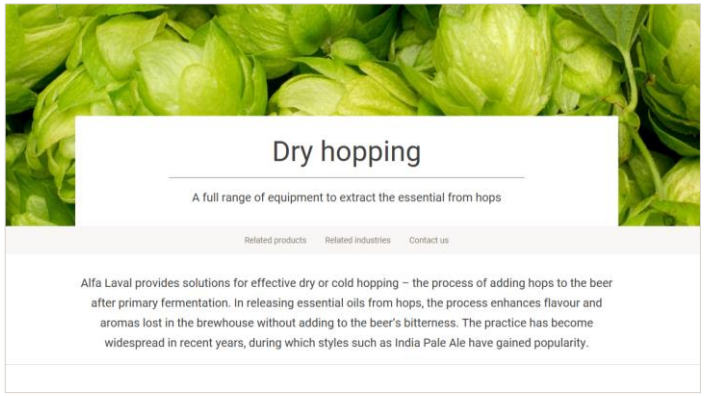
Furthermore, the samples for BRŁO Pale Ale (Alhop vs. HopGun) did not differ in their perception for any attribute. Therefore, the differences were also not strong enough to influence the general quality scores.”

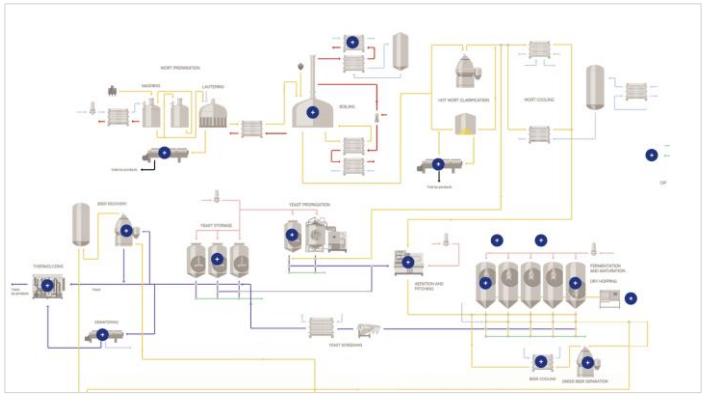
Spider web diagram for the comparison of for BRŁO Pale Ale (Alhop vs. HopGun)



More information

- Dry hopping
- Alfa Laval IMXD
- Alfa Laval Alhop
- Beer production
- Commercial brewing
- Craft brewing





Q&As


ALFA
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