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Research Institute

Lees: Reverse Racking, Rheology and Recovery

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The Australian Wine Research Institute

Outline

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- Background – the problem with wine movements
- Reverse racking – a different approach to lees removal
- Rheology – the science of material (e.g. lees) flow
- Recovery – new(ish) technologies for lees processing

Wine movements

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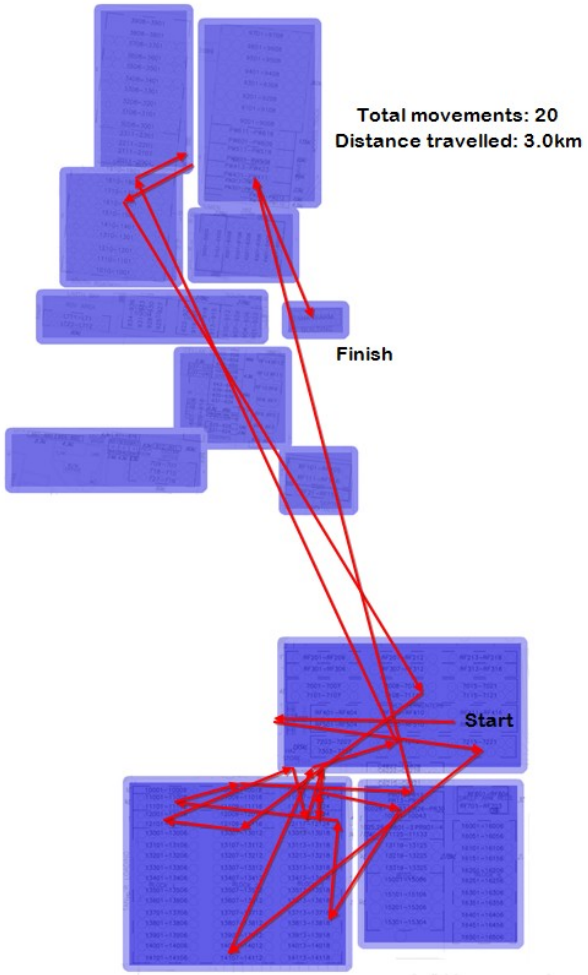

Problems with wine movements

- Labour (setup, pushes, tank cleaning)
- Water use / wastewater production
- Tank availability

- Interested in practices and technologies that allow wine to remain in the same tank, while still achieving the same processing outcome

Normal racking

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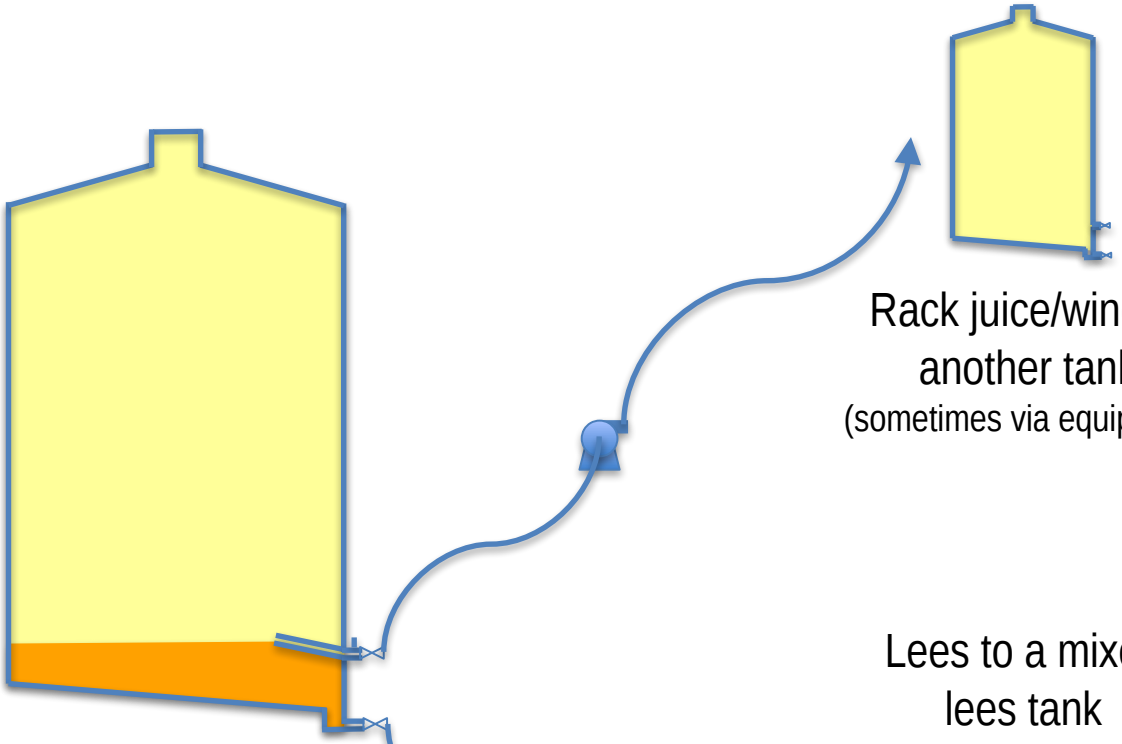
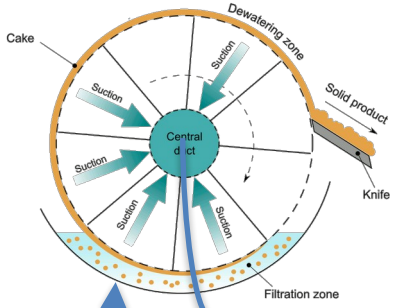
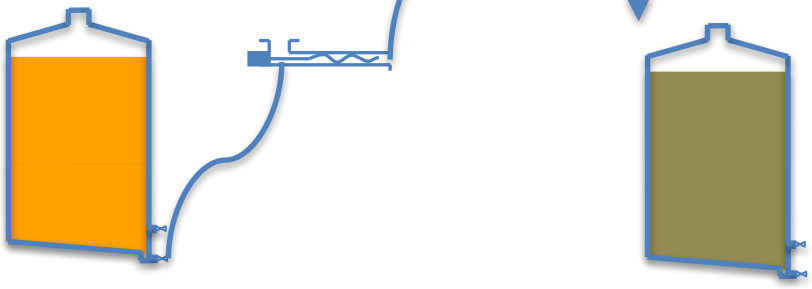


Rack juice/wine to another tank
(sometimes via equipment)

RDV



Lees to a mixed lees tank



Lees juice/wine

Reverse racking

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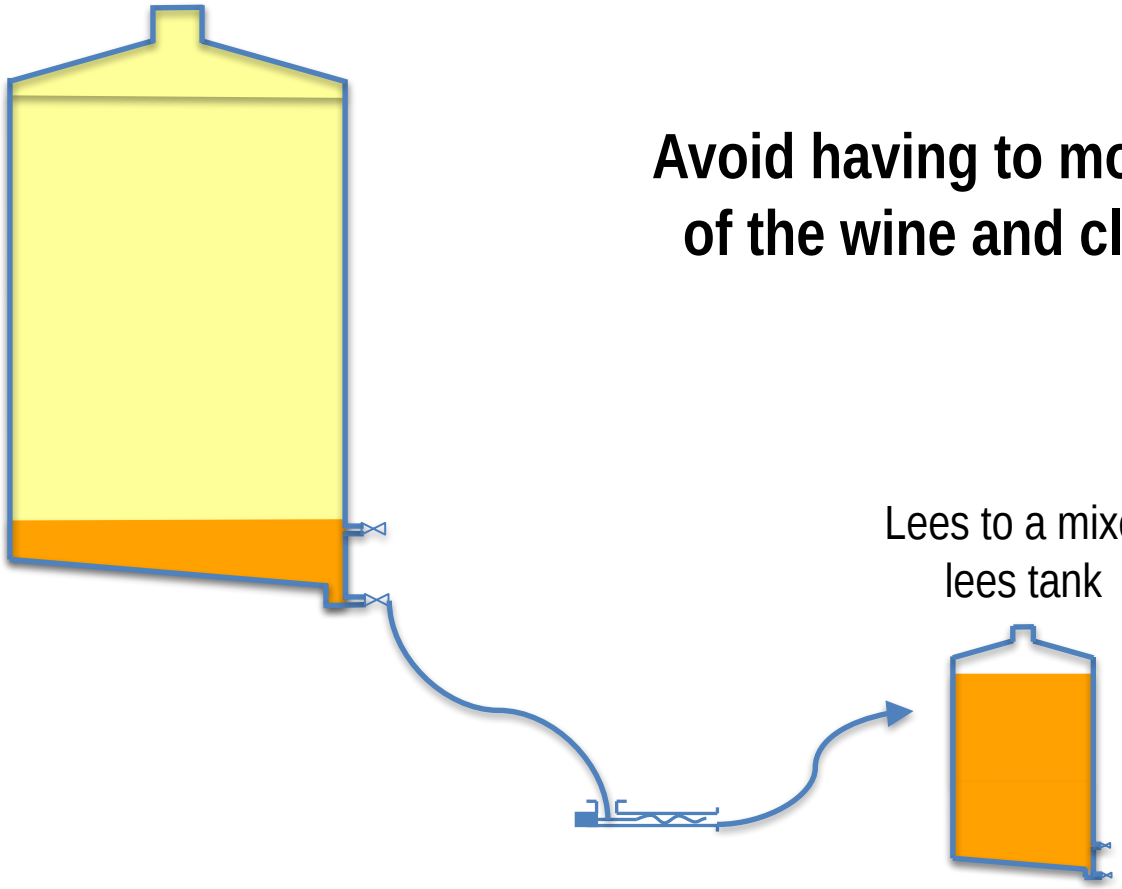

Avoid having to move the bulk of the wine and clean a tank

Reverse racking

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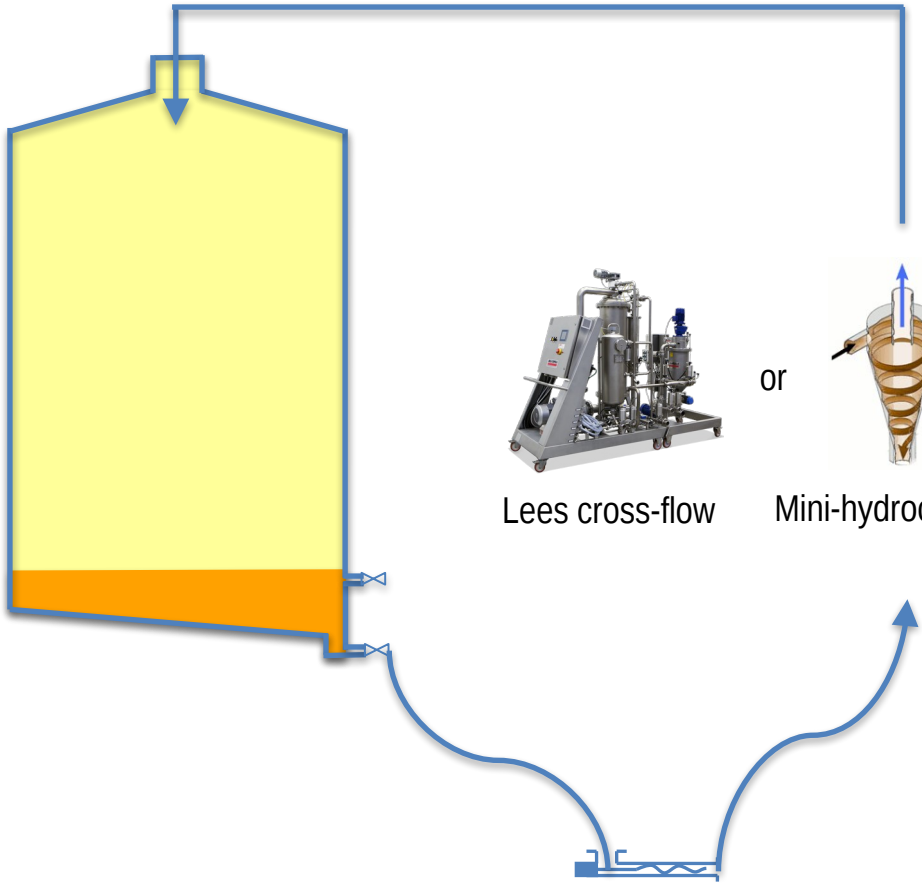
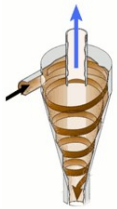


Recover high quality wine into the same tank

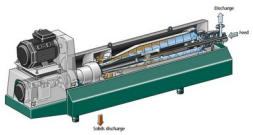
Lees cross-flow

or



Mini-hydrocyclones

or



Decanter centrifuge

Reverse racking - challenges

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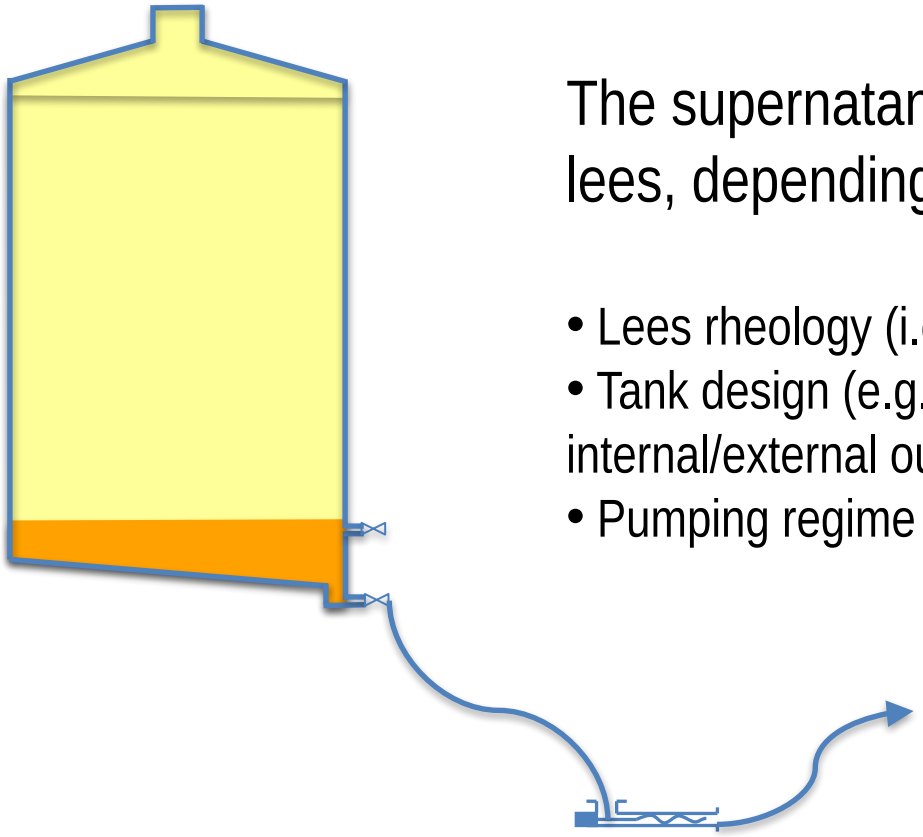

The supernatant can channel through the lees, depending on:

- Lees rheology (i.e. flow characteristics)
- Tank design (e.g. floor angle), surface finish, and internal/external outlet sump/pipe work
- Pumping regime

Rheology basics (*rheo*: to flow)

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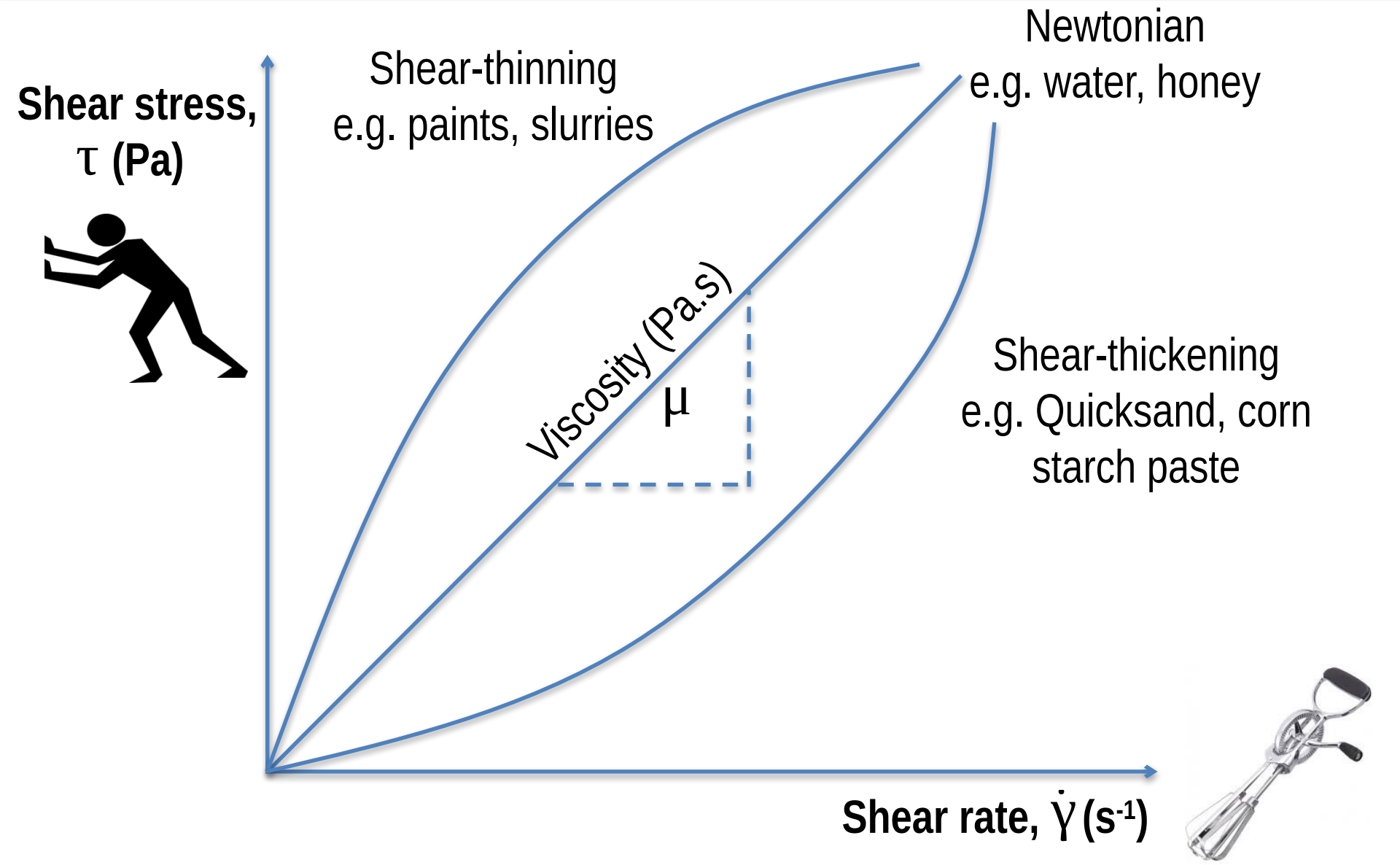

Rheology basics – yield stress

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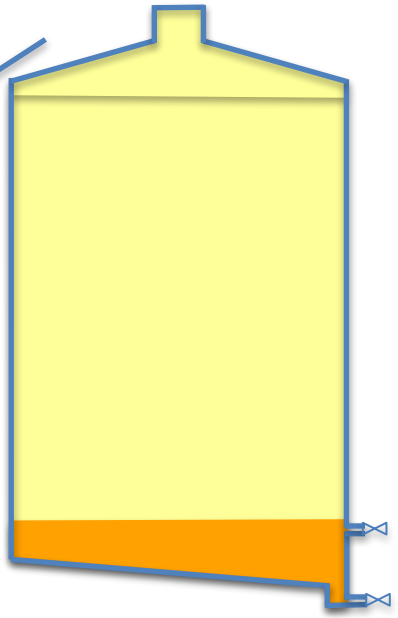
>15 Pa

Shear stress, τ (Pa)



Yield stress:

- Minimum stress required to make a structured fluid flow
- Transition between solid-like and fluid-like behaviour

Shear rate, $\dot{\gamma}$ (s^{-1})

Rheology – lees samples

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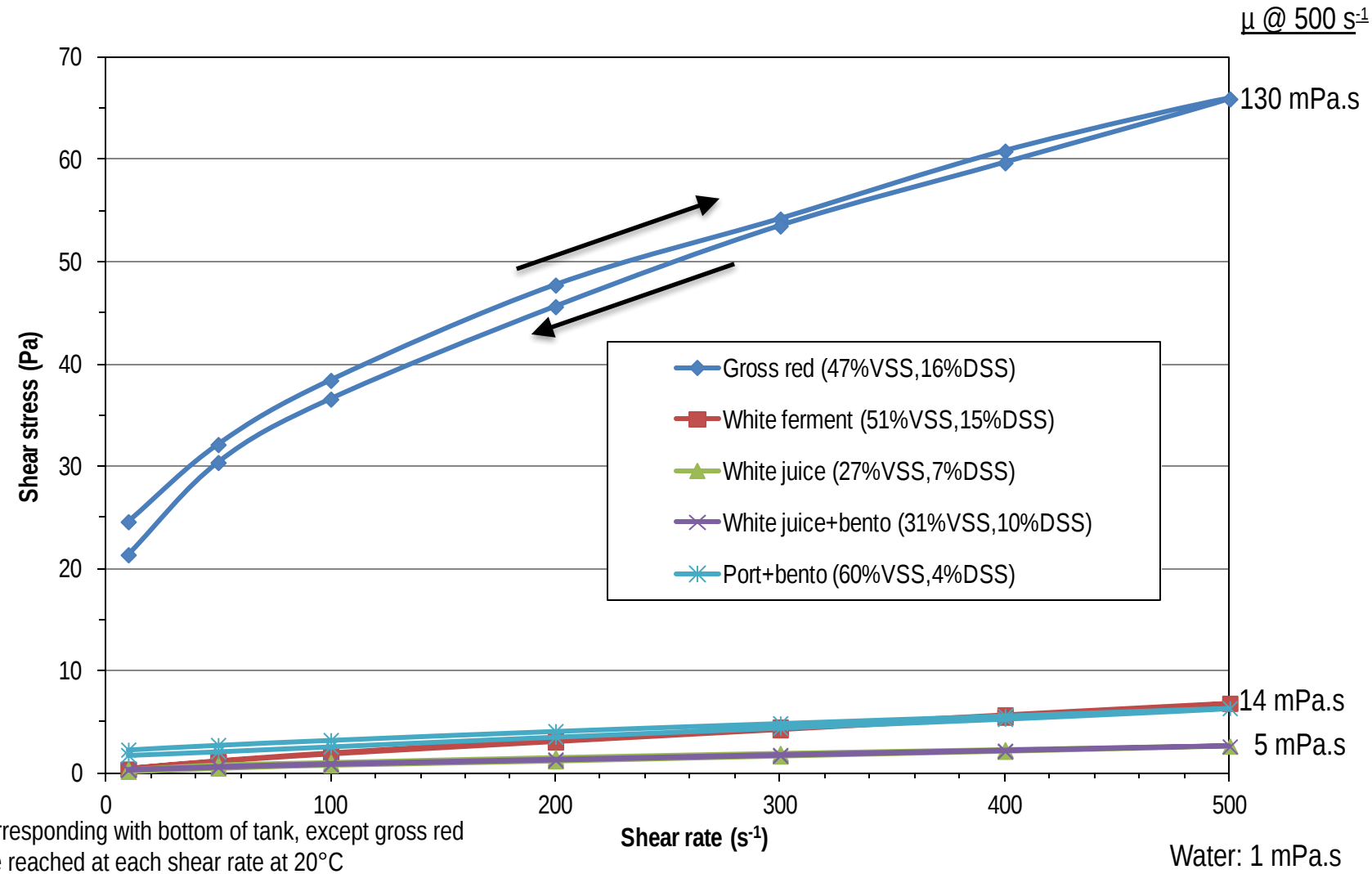

Notes:

Samples corresponding with bottom of tank, except gross red

Steady state reached at each shear rate at 20°C

Have only analysed one white ferment lees sample so far, getting more samples

Volume suspended solids (VSS): 3,000 x g, 5 minutes

Dry suspended solids (DSS): 70 °C, 24 hours (corrected for soluble solids using 0.2μm filtered control)

Rheology – lees samples

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Lees type	Yield stress (Pa)	App. viscosity @ 500s^{-1} (mPa.s)	VSS (v/v)	DSS (w/w)
Gross red	28	130	47%	16%
White ferment	<0.5	14	51%	15%
White juice	<0.5	6	27%	7%
White juice with bentonite	<0.5	5	31%	10%
Port with bentonite	3	13	60%	4%

Notes:
Samples corresponding at bottom of tank, except gross red
Have only analysed one white ferment lees sample so far, getting more samples
Rheological analysis at 20°C
Volume suspended solids (VSS): 3,000 x g, 5 minutes
Dry suspended solids (DSS): 70 °C, 24 hours (corrected for soluble solids using 0.2µm filtered control)

Temperature effects on rheology

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Lees type	Yield stress (Pa)		App. viscosity @ 500s^{-1} (mPa.s)	
	20°C	4°C	20°C	4°C
Gross red	28	38	130	190
White juice	<0.5	<0.5	6	9

Settled white juice – example of gradients

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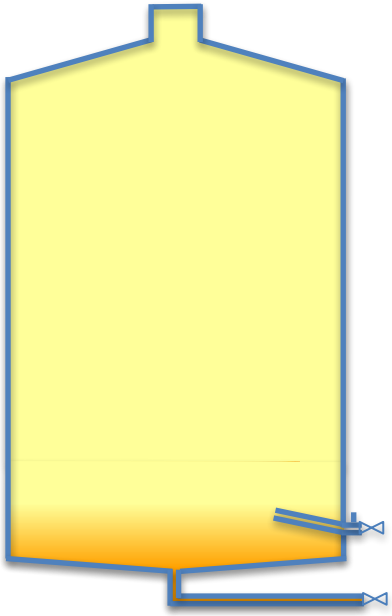

Height (m)	VSS (v/v)	DSS (w/w)	App. viscosity @ 500s^{-1} (mPa.s)	$d_{0.5}$ (µm)
10	n.m.	0%	1.9	n.m.
2.2	<2%	0%	2	11
1.7	<2%	0%	2.3	11
1.2	9%	0.3%	2.9	11
0.9	18%	3%	4.3	12
0.5	23%	5%	4.6	14
0	27%	7%	5.8	18

Notes:
Rheological analysis at 20°C
Volume suspended solids (VSS): 3,000 x g, 5 minutes
Dry suspended solids (DSS): 70 °C, 24 hours (corrected for soluble solids using 0.2µm filtered control)
Particles size by laser diffraction (Malvern Mastersizer 2000)

Oak chip effects on rheology

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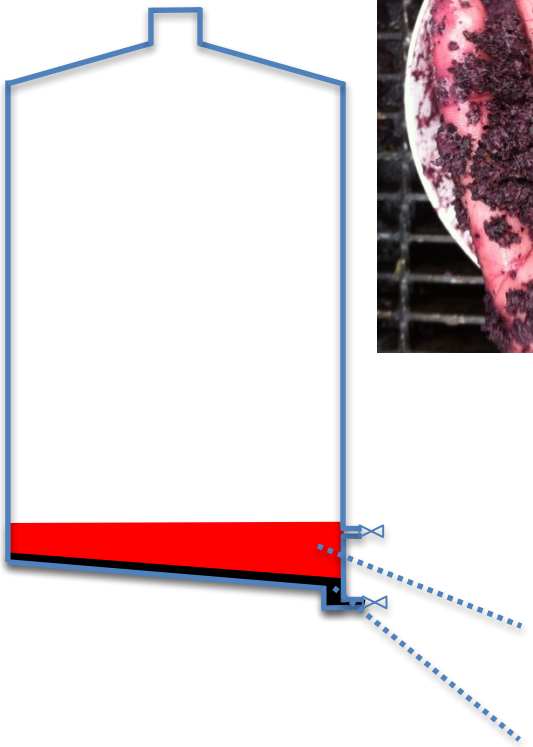

Lees layers	Yield stress (Pa)	VSS (v/v)	DSS (w/w)
Grape and yeast derived lees	60	60%	19%
Oak chips lees on tank bottom	280	n.m.	33%

- Oak chips provide structure to the lees and prevent it from flowing (high yield stress)
- Alternatives: ‘oak-bomb’ tanks, commercial liquid oak/tannins (regulatory issues?)

Recovery – RDVs (prevailing practice)

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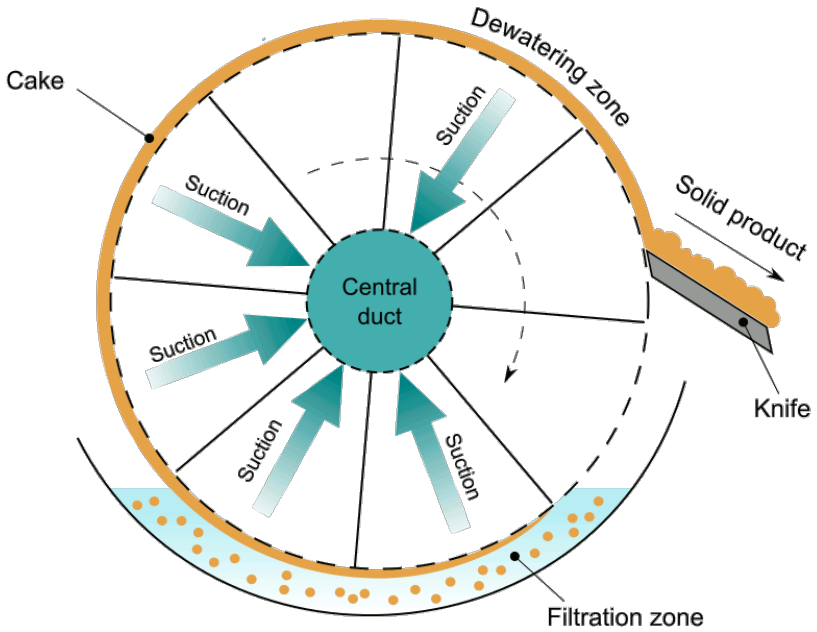
- RDVs have been the lees processing workhorse at wineries for many years
- Reasons that alternatives are being considered:
  - Quality downgrades for higher value products resulting from oxidation and dilution with water
  - Product can still be relatively turbid
  - High labour requirements
  - Filter aid (perlite or DE) needs to be purchased and spent material dealt with
  - Operator safety? Perlite seems to mainly be used instead of DE so appears to be much less inhalation risk than when working with DE (perlite contains <0.1% crystalline silica)



Pall Oenoflow HS

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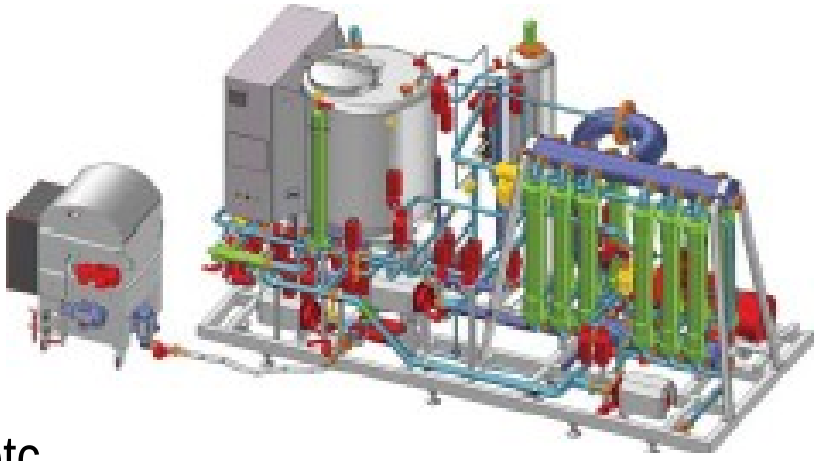
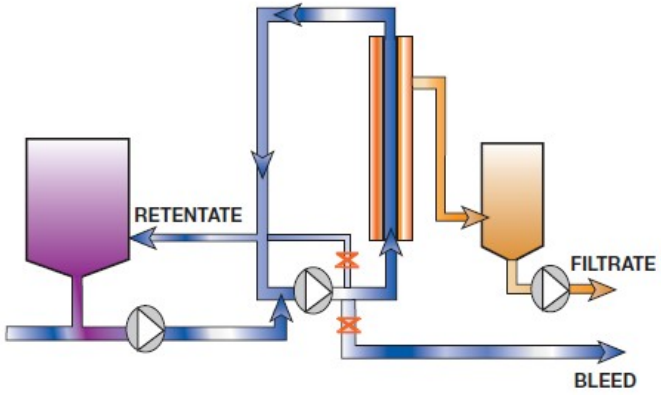
- Similar to standard cross-flow
- PVDF symmetric membrane
- Wide bore hollow fibres (~3mm?)
- Upwards rather than downwards flow (maybe helps prevent settling, clogging)
- Versatile – most types of lees & wine
- Rotary sieve to remove seeds, petioles, etc



Schematic (including rotary sieve)

Filter skid (cut-away of a filter module inset)



Flow path schematic

Bucher-Vaslin Flavy FX (adapted) & Leestar

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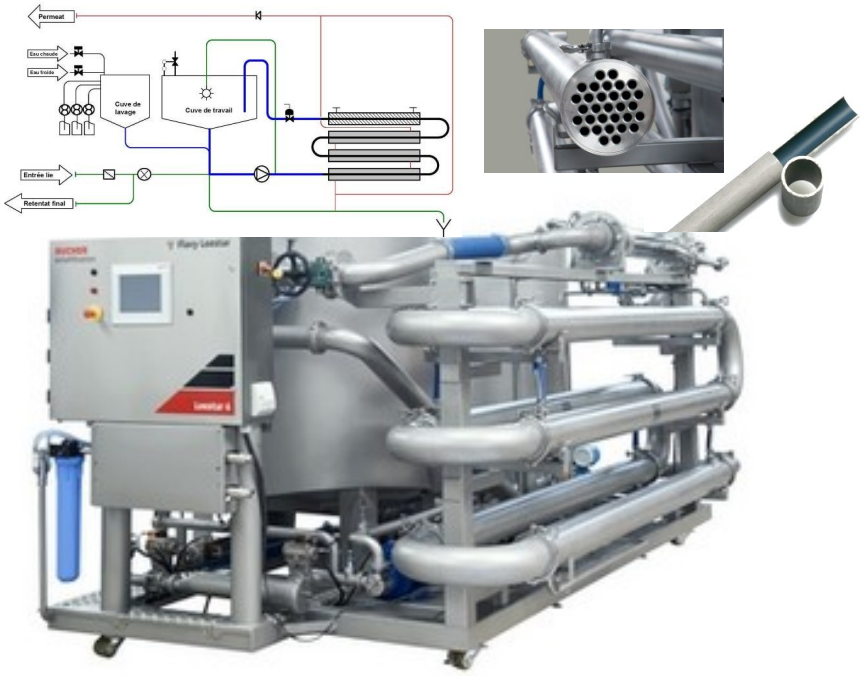
1. Adaptation of normal Flavy FX wine X-flow to use on settled must lees (largest volume of lees)

- Must lees or wine (no fining agents allowed in either)
- PES asymmetric membrane
- Wide bore hollow fibres (3mm instead of 1.5mm)
- Rotary sieve to remove seeds, petioles, etc
- Head cleaning system to prevent blockages

Rotary sieve + filter + head-cleaning + wide bore

2. Leestar

- TiO_2 membrane on sintered SS support
- Very wide bore (18mm)
- Versatile – most types of lees (too slow for wine?)
- Requires cooling – a lot of heating? (low filtrate per recirculation)



Unit with flow schematic and internal config.

Della Toffola Omnia CFKF

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- Ceramic membrane on titanium support
- Wide bores in filter monoliths (3.5 – 6mm)
- Versatile – most types of lees and wine
- Rotary brush strainer to remove seeds, petioles, etc
- Head cleaning system with brushes and aspirator

Filter monoliths in housing

Filter unit (including rotary brush strainer on the right)

Head cleaning system

TMCI Padovan Dynamos

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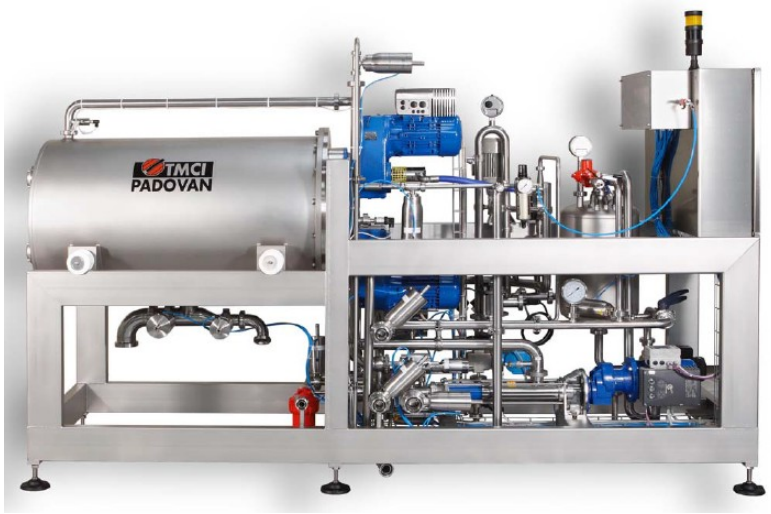
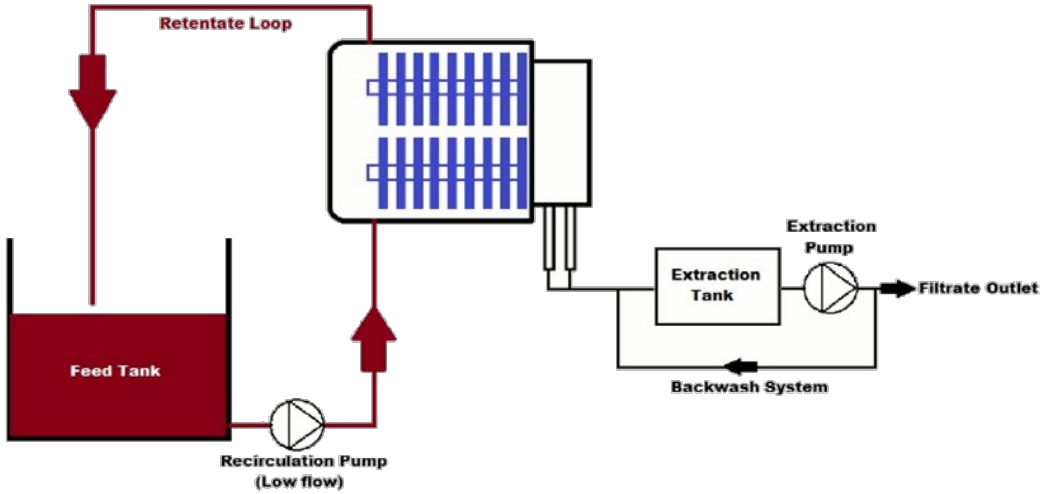
- Cross-flow cleaning action on membrane generated by rotating filter as opposed to recirculation flow
- Ceramic membrane
- Versatile – most lees types (too slow for wine?)

Ceramic rotary filter discs



Filter unit



Flow schematic

Decanter centrifuges (e.g. GEA Westfalia, Alfa-Laval)

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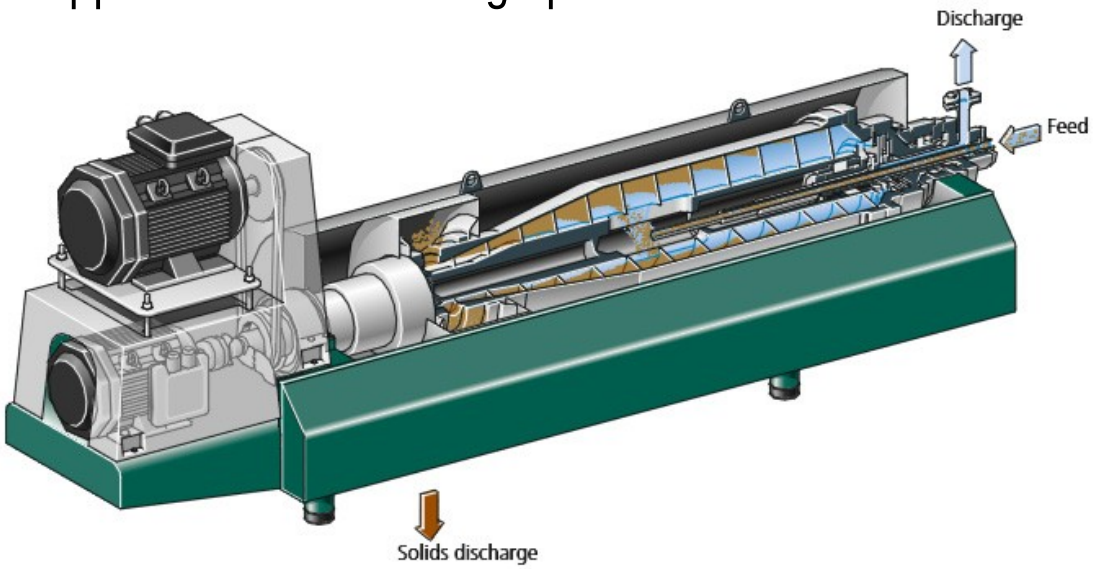
- Separation principally by centrifugal force as opposed to by screening
  - Depends on a solid-liquid density difference
  - More effective at removing larger rather than smaller particles

$$v = \frac{d^2(\rho_s - \rho_l)r\omega^2}{18\mu}$$

- Lower cake moisture content and potentially higher throughput than lees cross-flow filters
- Turbid product relative to lees cross-flow filtration – additional filtration required
  - Is a pretreatment rather than a final clarification step
- One-pass as opposed to recirculating operation



RDV alternatives - summary

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- Difficult to know which of the alternatives is best without controlled comparative trials on a range of different lees over a long period
- Lees filters described provide much clearer product than RDVs
- Equipment generally features increased level of automation over RDVs
- Lower wine recovery than RDV with some of the devices discussed, but lower turbidity and higher quality
- Very short payback periods (<2 years) are claimed by several suppliers – but payback period may be quite winery dependent, e.g.:
  - Labour use for RDVs at the winery? (is 1 person operating 1 or 5 RDVs)
  - Level of downgrade from RDV use at the winery? (e.g. $20/L → $1/L vs. $1/L → $1/L)
  - Perlite disposal arrangements

Thank you – any questions?

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Acknowledgements

- Australian grape growers and winemakers and the Australian government for funding through the GWRDC

GWRDC GRAPE AND WINE RESEARCH AND DEVELOPMENT CORPORATION

- Wineries who have given us access to data and allowed us to collect samples
- Equipment manufacturers who have supplied information on their equipment