Australian Government

Australian Grape and Wine Authority

Process efficiency in winery operations

Summary report

Background

Wineries today are faced with the growing costs of doing business. Over the past three years the cost of electricity and gas for businesses has increased by 40% on average and this increasing trend is likely to continue. These increased utility prices, coupled with the strong Australian dollar places further pressure on export markets (and increased competition from low-cost imports). The result is an industry facing tighter profit margins, and an increased importance on the adoption of techniques and technologies that enable quality wine to be made at lower input cost.

Production efficiency is a business mindset focusing on implementing techniques and technologies to reduce costs, increase speed and optimise resource use. Many Australian industries such as the fast moving consumer goods (FMCG) industries, have successfully adopted production efficiency as a cornerstone for remaining competitive in local and global markets. Many production efficiency lessons can be learned from these industries and readily applied to the wine industry. Production efficiency isn't a module or a simple step, but a holistic change to all aspects of winery processes and management. This ensures profitability can be maintained through two aspects – making quality wine *and* improving cost management.

Process efficiency was identified as a key research priority by GWRDC's stakeholders during consultations on the *GWRDC Strategic Research, Development and Extension Plan 2012–17* (Strategic Plan). More specifically, it has identified an opportunity to increase knowledge within the wine industry about the potential opportunities from the fast moving consumer goods (FMCG) industries including milk, soft drink, fruit juice, beer, etc, and interpret it for the benefit of the wine industry.

Research Scope

During the investigation, five key measures were used to evaluate process efficiency. These five measures were:

- production speed
- labour efficiency
- materials efficiency
- energy efficiency
- water efficiency

The five process efficiency measures were evaluated against distinct wine process stages. These process stages included:

- receival
- destemming / crushing
- fermentation
- pressing
- clarification
- stabilisation
- maturation
- bottling
- warehousing
- transport

Findings from process efficiency opportunities used by FMCG industries were evaluated for their application to the wine industry. A range of potential process efficiency opportunities were identified and six opportunities were evaluated to have the greatest potential for improving process efficiency in the wine industry. These six opportunities were:

1. Measurement of metrics
2. Automation
3. Cross flow filtration
4. Fermentation efficiency
5. Cold stabilisation techniques
6. Continuous process systems

Out of these six opportunities, 'opportunity 1 - measurement of metrics' and 'opportunity 2 – automation' were determined to have the greatest impact for improving winery process efficiency across the full process chain. The full process efficiency report provides a listing of metrics to be considered for each winery process.

Process efficiency opportunities

The process efficiency opportunity section below provides further details around each opportunity including:

- a brief overview on each opportunity
- the impacts on the process efficiency measurement criteria for each opportunity
- an assessment on the practical application of each opportunity

Opportunity 1 - Measurement of Metrics

The measurement of process efficiency performance metrics provides tools for measuring performance and should be seen as a corner stone for increasing process efficiencies. Recording performance metrics can be done in a variety of ways; by seeking existing data, manually measuring process metrics, installing monitoring equipment or through full automation (and associated data recording). Once this data has been captured, analysis of process performance can be undertaken. This analysis provides a good information baseline so decisions can be made on the best way to improve process efficiencies.

How would measuring performance metrics improve process efficiency?

Process efficiency measure	Impact of opportunity on process efficiency measure
Production speed	Provides the data to identify bottlenecks, identify issues and increase production speeds.
Labour efficiency	Provides the data to identify poor utilisation of labour resources and identifies projects to increase labour efficiency.
Materials efficiency	Identifies material flows on site including loss and provides a tool to increase material efficiency.
Energy efficiency	Identifies energy use and loss on site and therefore provides tools to increase energy efficiency.
Water efficiency	Provides the data to identify water use and loss on site and increase water use efficiency.

How easy would it be to apply performance metric measurement in a winery?

Criterion	Rating	Comment
Commercial availability	High	Data measurement tools are readily available from commercial suppliers, or simple in house system can be used for capturing data.
Adoptability (ease of implementation)	Medium	This depends on level of complexity required for the plant – simple systems are readily implemented, more complex systems will be more challenging to implement.
Level of risk to quality or productivity	Low	This opportunity will increase quality and productivity.
Capital and recurring costs	Medium	Some capital and ongoing costs may be required.
Other technology or project risks	Medium	May require some additional skill sets to drive metric improvement.

Opportunity 2 - Automation

Automation can take various forms within a winery. It can be as basic as automating areas of a refrigeration system, or as complex as a fully automated winery. Automation is beneficial as it allows the improvement of all five process efficiency measures, i.e. production, labour, materials, energy and water. It does this by optimising process equipment, allowing round-the-clock operations, improving quality and reducing human error.

How would automation improve process efficiency?

Process efficiency measure	Impact of opportunity on process efficiency measure
Production speed	Significant increases to production speed and optimisation of process equipment.
Labour efficiency	Decreases manual labour allowing staff to be utilised more appropriately.
Materials efficiency	Provides greater process control and therefore reduces material waste.
Energy efficiency	Provides high levels of control and can significantly reduce energy – especially in refrigeration systems for wineries.
Water efficiency	Automation can provide additional water efficiency depending on the specific application of the automation system.

How easy would it be to automate processes in a winery?

Criterion	Rating	Comment
Commercial availability	High	Automation systems and service providers are readily available to the wine industry.
Adoptability (ease of implementation)	Medium	This depends on level of automation and the complexity of the proposed project. Some systems may be implemented by staff within the winery, other systems may require external assistance.
Level of risk to quality or productivity	Low	Automation is likely to increase quality and productivity.
Capital and recurring costs	High	Automation systems tend to have high capital costs, depending on the complexity and comprehensiveness of the system.

Opportunity 3 – Cross flow filtration

Cross flow filtration has emerged as an efficient filtration technique, with diverse application potentials for both the FMCG industries and the wine industry. Many wineries have implemented this technology, but many more have not implemented this technology yet. Cross flow filtration is flexible and can have multiple applications within a winery. It can be significantly more energy efficient than traditional winery filtration while allowing rapid filtration speeds. Cross flow filtration can improve material efficiency by eliminating the need for additives (e.g. diatomaceous earth) and reducing wine loss caused by movement through multiple filtration activities.

How would cross flow filtration improve process efficiency?

Process efficiency measure	Impact of opportunity on process efficiency measure
Production speed	Increased production speeds by allowing multiple filtration operations to be undertaken in one wine movement. Can completed filtration in one step instead of multiple steps.
Materials efficiency	Can reduce wine movement and decrease wine loss. Can recover wine from lees increasing production. Can reduce the use of bentonite.
Energy efficiency	Cross flow filtration is more energy efficient per litre of wine filtered compared with other filtration techniques.
Water efficiency	Cross flow filtration can be used to clean and reuse process water.

How easy would it be to implement cross flow filtration in a winery?

Criterion	Rating	Comment
Commercial availability	High	Cross flow filtration is readily available for commercial installations into wineries.
Adoptability (ease of implementation)	High	Cross flow filtration can readily replace existing winery filtration equipment.
Level of risk to quality or productivity	Low	There are no detrimental impacts on quality or production speeds. Cross flow filtration is likely to improve quality compared with rotary drum filtration systems.
Capital and recurring costs	Medium	Capital costs are moderate and some ongoing costs are required to replace filters periodically.

Opportunity 4 – Fermentation efficiency

A common issue in the wine industry during vintage is the lack of enough fermentation tanks. A faster primary fermentation rate allows more tanks to be reused during vintage. Slow or stuck fermentation not only decreases production speed, it can increase material use by requiring additives to 'restart' fermentation and require additional energy for temperature control. Increasing fermentation efficiency involves both understanding grape juice characteristics, correcting for any critical variations (i.e. pH, potassium availability, etc) and selecting strains of yeast that are best suited to the juice conditions. This ensures fermentation is undertaken in a controlled and efficient manner increasing production efficiency.

How would more efficient fermentations improve overall process efficiency?

Process efficiency measure	Impact of opportunity on process efficiency measure
Production speed	Can significantly increase production speeds and allow fermentation tanks to be reused more readily. This opportunity can reduce bottle necks during receival.
Materials efficiency	Can reduce both quality loss (due to poor fermentation) and decrease additional materials used to 'fix' problem fermentations.
Energy efficiency	Shortens fermentation times decreasing the time fermentation tanks need to be temperature controlled, therefore decreasing energy.

How easy would it be to improve fermentation efficiency in a winery?

Criterion	Rating	Comment
Commercial availability	Medium	Analytical equipment readily available for determining juice characteristics. Additional work required to characterise and publicise yeast strains and their suitability to juice parameters.
Adoptability (ease of implementation)	High	Assay protocols are required for juice, however most wineries should be able to undertake basic testing.
Level of risk to quality or productivity	Low	There are little or no impacts on quality depending on the yeast strains chosen. This opportunity will increase productivity.
Capital and recurring costs	Low	Little or no capital costs are required depending on level of automation. Recurring costs may include specific yeast strains.

Opportunity 5 – Cold stabilisation techniques

The largest energy cost for wineries is refrigeration. During cold stabilisation, high energy levels are required to chill the wine and maintain it at cold stabilisation levels. Traditional cold stabilisation techniques require wineries to maintain low temperatures for several weeks while tartaric acid crystallises out of solution. Contact stabilisation techniques greatly reduce crystallisation time and this increases production speeds, while reducing energy use. The tartaric acid crystals can be recovered using cross flow filtration, used in subsequent batches of wine, or sold to generate additional value streams. The use of heat exchangers to recover the lower temperatures of freshly stabilised wine can be used to chill the next batch of wine, further reducing energy use.

How would using contact tartrate stabilisation improve process efficiency?

Process efficiency measure	Impact of opportunity on process efficiency measure
Production speed	Significant increases to stabilisation speed compared with traditional cold stabilisation.
Materials efficiency	Recovery of tartaric acid crystals can increase materials efficiency and create an additional value stream.
Energy efficiency	The decreased time needed for contact stabilisation reduces the energy intensity of the cold stabilisation process. Using heat exchangers to recovery low temperatures for subsequent batches of wine significantly improves energy efficiency.
Labour efficiency	Some additional labour is required for adding seed crystals to wine tanks.

How easy would it be to implement contact stabilisation in a winery?

Criterion	Rating	Comment
Commercial availability	High	Materials are readily available to undertake contact stabilisation.
Adoptability (ease of implementation)	Very High	This opportunity can be substituted with existing traditional cold stabilisation methods.
Level of risk to quality or productivity	Low	There are little or no impacts on quality. Productivity is expected to increase.
Capital and recurring costs	Low	Little or no capital costs are required using this system. There are no recurring costs required if seed crystals are recycled.

Opportunity 6 – Continual processing techniques

Continual process systems have greater efficiencies compared with batched process systems. A batched process system requires the full process chain to stop until the batch bottleneck is ready for the next cycle. In the wine industry, batch pressing delays the receival, destemming, and crushing steps. This can lead to changes in temperature and increased oxidation. Continual process such as screw pressing allows the receival process flow to move from a batch process to a continuous process. This can alleviate bottlenecks throughout the receival chain. Screw presses have slowly been replaced by membrane press systems due to their ability to reduce expressed phenolic compounds. Changes in screw press technology such as using larger screw blades and slowing revolutions can reduce much of this phenolic expression while increasing production speeds.

How would using continual processing improve process efficiency?

Process efficiency measure	Impact of opportunity on process efficiency measure
Production speed	Significantly increases production speeds from receival to the fermentation step.
Labour efficiency	Increases to automation and process flows can reduce the labour needed to run the receival process chain.
Materials efficiency	Screw presses can recover more juice (however at a decrease in quality).
Water efficiency	Due to the compact nature of screw presses, they can require less cleaning and hence increase water efficiency.

Assessment on the application of the opportunity to the wine industry

Criterion	Rating	Comment
Commercial availability	High	Screw presses are still available, however not as common as previous years. Some additional engineering may be required to augment screw conditions to further decrease phenolic expression (i.e. larges blades, interrupted blades, etc)
Adoptability (ease of implementation)	High	Screw presses can directly replace existing pressing techniques
Level of risk to quality or productivity	Medium	Continuous processes will increase production speeds, however this may express more phenolic compounds and this may be detrimental to quality
Capital and recurring costs	Low	High capital costs are required, however units tend to cost less than membrane presses.

Conclusion

Much of the process efficiency technology found in FMCG industries is readily available for use in the wine industry. Some wineries have implemented this technology but others are yet to do so. In particular, cross flow filtration and process automation efficiencies are still being implemented. These delays in implementation are not due to the availability of technology, but are due in part to capital availability, lack of knowledge on efficient practices (such as contact cold stabilisation) or uncertainty about what the costs benefits are for increasing process efficiency.

The largest process efficiency difference between wine and FMCG industries is not technology based, but rather, a difference in management focus. Many of the leading FMCG companies have a core business focus around process efficiency and continuous improvement. This requires an understanding of current process efficiencies through measuring metrics, analysing these metrics and improving these processes. Every winery is different and every process efficiency opportunity will be different; it is only after analysing current winery process efficiencies that these opportunities can be fully understood and the benefits realised.

Once a winery has changed its core business focus to one of process efficiency, specific projects can be targeted for increasing efficiencies. As an example; the receival, destemming, crushing and pressing steps are a common process efficiency issue. In this example the bottleneck tends to be the pressing step. Projects such as continuous high volume pressing systems tend to alleviate this bottleneck, increase production speed and increase production efficiency.

Using another example; if a winery has undertaken a process efficiency analysis and determined that the fermentation step is an issue for their site, projects that increase this fermentation efficiency become important. This may include selecting yeast strains that are best suited to the characteristics of the juice feedstock.

Understanding current process efficiencies should be seen as key to improving business efficiencies. Undertaking these steps can lead to significant cost savings for the business particularly in regards to resources, materials and production speeds. This will require a change in paradigm for many wineries, but is necessary to ensure they remain profitable in the changing business environment.

Want to know more?

Measurement of metrics: Case studies 1, 2, 3 and 4

Automation: Case studies 1, 2 and 3

Cross flow filtration: Case study 5

Peri, C., Riva, M., & Decio, P. (1988). Crossflow Membrane Filtration of Wines: Comparison of Performance of Ultrafiltration, Microfiltration, and Intermediate Cut-Off Membranes. *American Journal of Enology and viticulture* , 162-168.

Fermentation efficiency: Case study 2

AWRI factsheet on stuck fermentation (http://www.awri.com.au/wp-content/uploads/stuck_fermentation_fact_sheet.pdf)

AWRI method for preventing and restarting stuck ferments (http://www.awri.com.au/wp-content/uploads/TN05.pdf)

Journal article (Schmidt, S.A. Dillon, S. Kolouchova, R. Henschke, P.A. Borneman, A.R. Forgan, A. Chambers, P.J. Pretorius, I.S. (2011) Grape juice and wine yeast: happy marriages and how to avoid getting stuck with the wrong partner. Wine Viti. J. 26 (4), 30–34 Order form AWRI library as S 1328 at http://www.awri.com.au/)

Cowey, G. (2014) Ask the AWRI: Top tips for a successful yeast culture. Australian & New Zealand Grapegrower & Winemaker (600), 42. Order from AWRI library as S 1586 at http://www.awri.com.au/)

AWRI Research, Development and Extension Plan 2006-2013: Final Report. Stream 2.1: Optimising fermentation performance to maximise wine production efficiency.pdf

	For current research into fermentation efficiency, refer to AGWA or AWRI: Herderich, H. Chambers, P. AWR 1302 *Defining the nutritional drivers of yeast performance and matching yeast to must*
Cold stabilisation	Journal article (Low, L.L.; O'Neill, B.; Ford, C.; Godden, J.; Gishen, M.; Colby, C. (2008) Economic evaluation of alternative technologies for tartrate stabilisation of wines. International Journal of Food Science & Technology, 43 (7), 1202-1216. Order from the AWRI Library as S 1067 at http://www.awri.com.au/)
Continual processing	Case study 2 Workshop summary http://www.awitc.com.au/workshops/Workshop%20W39.pdf