Automation of gas usage

Don Allen and Roman Kluba
Air Liquide Australia Ltd, Elizabeth, SA

Introduction
It has been estimated that winemaking operations account for 16% to 20% of the total cost of producing a bottle of wine. In labour terms, this amounts to about 1.7 minutes per bottle, or 15 minutes per case of wine. Of that total, finishing operations are probably equivalent to around 6 minutes, or 40%, and bottling operations, 4 minutes or 28%. Many of these labour costs can be reduced with automation, in particular those related to gas applications. Gas-related labour costs in the Australian wine industry (on average) fall between 1 and 5 cents per bottle ($0.09 to $0.45 per case) and gas-related labour costs at least the same level, if not higher.

The decision in relation to automation needs to be broken into two parts, namely:

• why automate (the gas cost picture),
• how to automate (the equipment & procedure picture).

Why automate?
Australasia produces around 130 million cases (equivalent) of wine per year, and the figure is increasing quite rapidly. In producing this quantity of wine, the industry uses about 0.1 cubic metre (m³) of inert gas per case. Put another way, this is 100 litres of gas per case. This is an industry average, and if we look at a typical premium winery, the figure is five times this average, in excess of 600 litres per case. The cost of this gas usage is between $0.09 and $0.45 per case of wine.

The important consideration, however, is the gas-related labour costs. On average, this amounts to between $0.08 and $0.30 per case of wine, at least equal, and usually greater than the cost of the gas. Therefore, a 2,000 tonne premium winery could well have gas-related labour costs near $50,000 a year. Many of the current gas procedures do not work effectively, as we will demonstrate, plus OHS issues are now critical factors as well.

A look at four case studies will highlight the problem. These wineries all use dry ice ‘snow’ made from an on site bulk carbon dioxide storage vessel, which remains probably the main oxygen protection methodology. The measure used typically is a ‘winery bucket’. From audits carried out, this winery bucket is seen to hold around 8kg of dry ice. The following results show gaseous oxygen in the wine tank, read just above the wine surface.

• Victoria; procedure is “1 bucket, three times per week”. Tank was dosed at 8:00a.m., audited at 11:00a.m. Gaseous oxygen reading was 5% in tank 1, and 17% in tank 2.

• South Australia; procedure is “a bucket, three times per week”. Tank was dosed at 8:30a.m., audited at 10:00a.m. Oxygen reading 12%, and noted the specified “a bucket (4kg)” was actually closer to 2kg.

• NSW; procedure is 1 bucket, twice per week. Dosed Friday p.m., audited Monday a.m. Oxygen reading 15%.

• South Australia; procedure “a bucket, three times per week”. Dosed at 9:00a.m, audited at 12:00 noon. Oxygen reading 7%.

These audits results raise several observations about the use of dry ice snow:
• It is not effective for any longer than 3–5 hours, and is then dependant on the quantity used in relation to the ullage size. This point is overlooked in many cases.
• It is usually more expensive per equivalent m³ of gas, than a straight gas use.
• It is a time consuming operation, taking on average 3 to 5 minutes for the ‘bucket’ to fill.
• It is boring, and susceptible to over and under supply.
• The labour cost can be quite high, but potentially can be reduced by more than 50% with a gas system and with automation.
• Just simply using more gas is not an economic option. Numerous audits at wineries over a 10-year period have shown conclusively that in many cases, the volume of gas used is irrelevant. In several examples, more than 10 volumes of gas have been used, and the result (gaseous oxygen) is no better than 12%.

Automation of gas systems provides many of the following benefits:
• Precise control over the gas usage.
• Precise control over the gas procedures.
• Repeatability.
• The ability to operate 24 hours a day, seven days a week, regardless of public holidays, weekends, or weather.
• It eliminates OHS issues.
• It eliminates safety issues.
• It is usually far cheaper in labour terms.
• It can enhance wine quality.
• Automation can be linked into winery quality and management reporting systems.
• In may cases, automation is considered to be the practical application of ‘world’s best practice’.

If the cost of current procedures is calculated accurately, particularly where dry ice snow is being used, the total annual cost can be a quite significant figure. For example, if we consider the real cost associated with the use of the ‘winery bucket of dry ice’, we can establish the real costs.
The conversion of bulk liquid carbon dioxide incurs a loss of around 70%. In other words, for every 100kg of bulk liquid carbon dioxide used, only 30kg of dry ice snow will be manufactured (based on a system pressure of 2,000 kPa).

This means, the 8kg winery bucket needs 25kg of bulk carbon dioxide. The 8kg of dry ice is equivalent to just 4,000 litres of gas.

If the cost of the bulk carbon dioxide was $0.50/kg, then the cost of filling the winery bucket is $12.50 ($3.125 per 1,000 litres or m³).

It takes up to 5 minutes labour for the bucket to fill, and about 10 minutes to get it to the usage point (longer in many cases). Therefore, at the AWOTE labour cost of around $40 per hour, the labour component cost is $10.00.

The total cost therefore is about $22.50, or an equivalent cost per 1,000 litres (m³) of $5.62. If the winery doses 5 ullage tanks per day, by 35 weeks per year, the annual labour cost would be $8,750, and the total operation cost $19,687. In this time, the actual usage would be 3,500 m³, at a cost probably 70% higher than an automated gas system could achieve.

**Automation: the considerations**

With automation, several options are available with the degree of automation, the gas selection, and the gas dosing method being the main points of consideration. The system can be fully automatic, that is operating to a set point of an oxygen analyser, or it can be automated based on the gas usage or time, or even simply used as monitoring system.

- Fully automatic systems represent the ultimate in automation, and will usually be installed when it is critical that gaseous (or dissolved) oxygen level is controlled to close tolerances. Typically, such a system will be set up with the control being centrally located on a PC in the production or winemaker's office. An oxygen analyser (or analysers) will be required, the number depending on the total number of wine tanks being automated. For a 50-tank system, with oxygen monitored on each tank once each 20–30 minutes (in real time), then two analysers and four oxygen sensors are required. Good results have been achieved with these systems with N ovatec analysers built in Melbourne. The fully automatic system will provide options to select the gas (up to three selections per tank) and the required oxygen level. From this, the system would gas the ullage until the set point is reached, then shut down, and go into the regular monitoring mode.

- Gas volume, or timed systems on the other hand use a PLC (programmable logic control) to enable a set gas volume (depending on ullage size) to be dosed, or alternatively, a set volume over a set time. These systems work well and are quite suitable for small and large wineries alike. Modern PLC's are available with quite large capacities. With these systems, the gas injection is a function of time, and the user selects how long the gas is to be injected for, and the frequency of the injection. The performance will be audited at regular intervals to check that results are following expectations.

- Oxygen monitoring systems are the latest variation, and operate on the basis of a central oxygen analyser, and a sample line to each tank. Once every 24 hours, usually between midnight and 3:00a.m., the system dials each activated tank, reads the ullage oxygen, and transmits the data to either a nominated PC, or to a printer. The winemaker can make a decision in the morning, based on the actual results, and either gas or ignore the tank. The gassing system can be manual, automatic or the timed systems. These systems provide the hard data, which enables the winemaker to make a final decision as to the course of action.

Where an oxygen analyser is used, the sample point ideally will be at the wine interface, but a reading at the tank neck is suitable if the ullage has been adequately purged initially. This point was highlighted by the INRA (Montpellier) research, in which an analyser was also set up at the purge valve outlet of each wine tank.

Whichever system of analysis is installed, it is important to recognize that there is a time period required in order to gain a meaningful oxygen reading. Depending on the distance from the wine tank to the analyser, and the number of wine tanks serviced by each analyser, at least 3–5 minutes per sample is usually required. This point dictates the number of analysers and sensors required.

The data from any of the PLC's, with any of the systems, can be exported to a central location, and to either a serial printer and/or a SCADA (supervisory control and data acquisition) system. All automation systems should allow for full user control over system performance.

Oxygen control can be used to make an empty tank oxygen-free, can be used on a full wine tank, or used on any ullage size in between.

In installation terms, automating a gas system requires several decisions (as set out below) apart from the type of system or degree of automation.

- The pipeline distribution method (method, material, gases to be reticulated).
- The supply of gas (bulk, cylinders, packs, on-site nitrogen generator, type of gas).
- The gas injection point (at the neck, at the wine interface etc.).
- In the case of a mixed gas, the type and capacity of mixer, plus installation of a suitable buffer vessel, which may have some form of pressure control.
- A solenoid valve for each gas is required on each tank, plus one for the oxygen sampling line.
- The PLC or SCADA requirement.
- Location of the automation panels (in the winery or in a central location).
- Is the winery to permit adjustment in the winery by cellar hands, or is it to be centrally controlled.

The PLCs are available from a variety of manufacturers, in various sizes and capabilities. The choice of unit depends on the task required (the number of data points) and personal preference.

The use of SCADA systems mean that data logging and trending are possible, as well as remote points of control and multiple supervisory posts. They can exist on a winery LAN (local area network) or as a stand-alone.

Lastly, decisions can be made in relation to the type of networking required. With the sophistication of automation today, it is reasonable to expect that the system at the very least will enable analysis of particular winery areas, or even multiple sites. It should be set up with a variety of alarm points built in, as well as a series of wine ratios, to facilitate analysis of efficiency and quality.
Is automation expensive? The answer is yes and no. In our example of a 2,000 tonne (quality-driven) winery, case studies have shown that the (approximate) 160,000 cases of wine produced will cost about $48,000 in gas related labour, and probably $14,500 in actual gas cost. The winery may well have about 40 to 50 wine tanks, and probably 10 to 15 ullage tanks at a peak. The labour cost alone in this case is equivalent to about $400 per tank per month.

If the usage is dry ice snow, then the 39,000kg or so of bulk carbon dioxide used, could be reduced to about 12,600kg of carbon dioxide gas with a reticulated gas pipeline. This saving in carbon dioxide alone, at our average of $0.50 per kg means a saving of some $13,000. If we add the $48,000 in labour, but assume that 25% is still required, then we have a total saving of some $49,000 in a year. This represents many times the annual cost with an automated system, and would amortize even a quite complex system over not more than two years or so.

Modern process control is clearly here, and is used in many industries. The Australian wine industry has already embraced process control in some parts of the winery, and it is logical to expect its use in gas-related operations will continue to grow. The mechanics of installing automation are not onerous, but they need to be designed to suit the individual winery or winery requirements. Clearly they should be designed to permit easy expansion as needs increase, or as additional operations are added to the automation.

Automation of gas systems has been in use in the Australian wine industry for probably three years or slightly more. It has created a few objections from winemakers who feel their direct input is being minimized. The real benefit today however, is the quality and control that can be achieved, the efficiencies realised, and the peace of mind of knowing that the wine is being protected with technology that is state of the art.