Absorption chilling in horticulture - Part 1

In this first of two articles Dr Andrew Marchant reviews a technology that can cut the cost of operating cold stores, but is little known within the industry. The second article next month will look at some specific sites which are operating absorption chillers. Andrew is Director of the horticultural engineering consultancy Hennock Industries Ltd.

What's different?

Most refrigeration systems rely on a motor driving a piston up and down compressing a gas (known as the vapour compression cycle) - absorption chillers put in heat to achieve cooling! The technical aspects are complicated and beyond the scope of an article like this, but it's a system that's been around in the commercial world for many years, and popular for certain applications because of the reasons detailed below. It may seem strange to be using heat when we want to achieve cooling, but as with all forms of refrigeration, it is a question of using one source of energy to move a second source, that is removing heat from the cold room to the outside. In fact there are several other methods of refrigeration, including one using sound developed by NASA for use in outer space! Several refrigeration companies manufacture absorption chillers in the range often used in horticulture, and they are likely to become more common.

Why aren't there many in horticulture?

In the past absorption chillers were limited in their application due to an inability to achieve low temperatures (below around 5^{o}C) on smaller units. New developments have changed this, and systems are now being installed (see photo) capable of reaching -10^{o}C. There are already a few on horticultural sites, and some details of these will follow in next month's issue.

A second reason is that refrigeration companies are not as used to this system as conventional compressors, and it is not likely to be suggested unless asked for. Although there can be a problem finding local service agents there are now an estimated 2500 units in the UK and some units are 35 years old and still working.

A further reason is that generally the initial capital cost of installing an absorption chiller is greater than the comparable compression cycle chiller. Hence, having put a job out to tender it is unlikely that an absorption chiller will be quoted for due to this high initial cost. However in some circumstances the installation of an absorption chiller can actually be lower than a compression cycle one.

What's good about it?

- One of the first things is lack of moving parts, and as we all know that means reduced maintenance. From an engineer's angle one of the worst types of motion is reciprocating motion, exactly the one that is used on the piston compressors that are fitted to most smaller installations. The main parts on the absorption chiller are the burner for the heat source, the fans and the pumps. Life-span of the units is also considered good for the same reason, although some of the smaller units have had problems with the electronic controls and have not proved as maintenance free as they should be.

- A second benefit is the reduced fuel costs. Absorption chillers can operate on almost any fuel, but for nursery operations it is likely that gas will be used, this being the most common fuel usually. For larger nurseries paying around 16p/therm (0.55p/kW.h) and daytime electricity prices of 5p/kW.h then the fuel costs of an absorption chiller are likely to be around 62% those of a comparable electrical unit.

- The efficiency of refrigeration systems is measured by a term called Coefficient of Performance (COP) - this reflects how much cooling energy you get from each unit of energy you put in. Here absorption chillers are not as good as vapour compression ones, but the silver lining is that because they use a primary energy source, *i.e. the fuel is burnt at point of use*, it is a cheap fuel compared to electricity, a secondary source generated miles away with significant costs and losses. For this reason the energy running costs of absorption chillers are lower in many situations (not in cases where off peak electricity tariffs can be used for the majority of the time). In overall emissions they also compare well, and have good ‘green’ credentials. To assess overall environmental impact is complicated and the refrigeration industry has a weighting system - TEWI - taking into account CO2 emissions, CFC’s and other factors. The TEWI for a normal absorption chiller is about the same as that of an electric system running on a new ‘environmentally friendly’ refrigerant (R134a), which at present few do, and the absorption chiller running on the double effect cycle has a TEWI of almost half.

- Ease of installation due to ‘skid mounted’ packaged approach - no refrigerant to pump into the system on site.

- The units can also be used for heating as they have an integral burner, thus making them ideal for temperature control applications where there may be a requirement for cooling or heating.

- Noise - absorption chillers can be quieter, but although there is no piston noise there are still fans, and these can often generate the sound which causes complaint as, being directional, it travels furthest.

- A further consideration on some sites may be that electrical supply reinforcement costs may be avoided as the heat source can be gas or LPG.

- Having a gas burner it is in theory possible to utilise the flue gas CO2 within a CO2 enrichment system (although this is probably not deemed acceptable by manufacturers it has been done - see next issue’s article for a case study).

What are the down sides?

The main disadvantage of the absorption chiller is it’s greater capital cost - this will typically be an additional anything between 20 and 100% over a conventional vapour compression system.

Where does it fit in?
It is likely that for absorption chilling to be attractive some or all of the following will need to apply.

- The gas price per unit (kW.h) should be 20% of the electricity price or less.
- There is a need for either heating or cooling.
- The cost of electricity supply reinforcement / installation will be expensive.
- There is a benefit from a 'greener' image.

The types of ideal situation where such may apply would be:-

- soil cooling / warming - for example for alstroemeria or freesia. Benefits here include not only the potentially lower running costs but also the ability to use the heating capability of the unit.
- cold store where short term cooling is only required during the day periods (when electricity is relatively expensive) - for example produce cooling after picking for either edibles or cut flowers.
- packhouse cooling (again where cooling is only required in the day and therefore electricity is relatively expensive).
- certain customers may have a preference for suppliers which have a strong environmental policy, and such a unit is generally considered more compliant than a vapour compression unit.

Further possibilities include the installation of combined CHP and absorption chiller units - these are already available in packaged form and could again fit in with the high rate CO2 user who wishes to 'lose' more of the surplus heat generated during the day.

What does the future hold for this system?
Developments to watch out for are smaller units that utilise the so called *'double effect'* system, allowing a higher COP and reducing running costs to as little as 55% of the *'single effect'* units.

Finally of special interest to horticulture is possible CO2 extraction from the flue gases, and seeing an official 'seal of approval' from manufacturers for this would be welcome.

Absorption chilling in horticulture - Part 2: Case studies

Last month In the first of two articles Andrew Marchant reviewed a technology that can cut the cost of operating cold stores, but is little known within the industry. In this the second article he looks at some specific sites which are operating absorption chillers.

Last month's article outlined the principles and type of applications for absorption chillers, the type that do not use electricity as a primary fuel but rather use heat to produce cooling. This type of refrigeration has been around for many years, but has only recently become more popular, particularly within commercial air conditioning systems. To date there have been few units installed in horticultural applications, although from an engineering and economic viewpoint they have much to recommend them in certain applications. This month we give two case studies where units have been installed and operated for a number of years.

1. Packhouse cooling - Premier Rose Company Ltd

On many sites traditional packhouses there can be a problem with high summer temperatures. Staff get too hot, and (more importantly to some!) the product gets too hot. With the advent of cool chain systems it has become not just desirable but also mandatory to maintain lower packhouse temperatures. At Premier Roses the decision was a part of an overall quality policy - the company is one operating the Quality Assurance scheme, where flowers have to be cut and loaded into cold store within 2 hours, and then maintained at this temperature. Before the cooler was installed packhouse temperatures used to range up to 25^{o}C, now they can be kept below 20^{o}C. The cool chain element is one reason why independent vase life testing showed that roses from Premier lasted up to 24 days.

The installation comprises an absorption chiller located outside the packhouse (see photo 1) with chilled water connections to a cooling coil and air distribution duct (see photo 2). The cooling coil runs on chilled water supplied by the unit via a heat exchanger, and provides a temperature of around 10^{o}C from the coil.

Installation details

Date installed:	1995
Rated capacity:	17kW
Packhouse floor area	600m2
Glasshouse area served	5.6 hectares
Cropping	all year round cut roses
Production method	rockwool slabs on trough benches

Costs

The cost of the overall installation, including the ductwork in the packhouse was around £5,000, but this has been part of a special arrangement with Premier's gas supplier whereby the installation cost was tied up with a 5 year gas purchase agreement.

Reliability

The unit has been very reliable over the period of operation, with the main problem being due to high air speeds from the duct discharge causing labels to be blown out of their trays. It is planned to remedy this by installing a fabric ‘sock’ discharge which will increase the outlet area to reduce discharge air speeds to a minimum.

2. Soil cooling with CO2 enrichment - Paul Domaille

The benefits of maintaining soil temperature in a freesia crop from planting until soon after the leaves are up has been known for a long time, with the control over scheduling being the most important. For soil cooling a water temperature of around 10°C is generally chosen, and is circulated at relatively high speed to minimise the temperature difference between the flow and return. The choices are between use of groundwater (if you have it in sufficient volume and temperature) and mechanical refrigeration. For the latter the choice is between conventional vapour compression systems and absorption chillers. The absorption chiller unit installed by Paul Domaille at Cliffdale Vinery on Guernsey can be seen in photo 3. As the island has no mains gas supply it is fuelled by LPG, and has been operational since 1994.

Reliability.

Overall the unit has been reliable, with typically a couple of call-outs per year. Most of the problems that have occurred have related to the secondary cooling system rather than the chiller itself, for example water pump failure and cooler fan jamming due to some insulation breaking off and being sucked in. It has also been necessary to replace a couple of the electronic control circuit boards.

CO2 extraction

As an experiment a take-off for flue gases has been installed and a summer CO2 system run from the unit. The take off consists of a hood over the top of the unit, with supplementary fan in the duct exactly as per a similar system for ‘conventional’ flue gas utilisation (see photo 4). The main concern of the manufacturers has been that if the CO2 distribution system is not sized properly it could lead to abnormal flame characteristics in the burner unit. Because of this they have installed an oversized extraction fan on the chiller itself, and this has led to more fan noise. Hence Paul has added the plywood baffles to the tops of the units, which are visible in photograph 5.

Installation details

Date installed:	1994
Rated capacity:	34kW
Glasshouse area served	3000m2
Crop	Freesia
Production method	Soil grown

Costs

The overall cost of the installation, including the soil heating distribution and controls, was £11,500. Pay-back of any soil cooling installation depends to a certain extent on weather conditions, but should be within 3 years. In this case the very hot summer of 1995 enabled production from this soil cooled crop to be maintained on schedule, and therefore allow picking when other growers cannot and hence achieve better prices.

A survey conducted on Guernsey in 1995 by the Committee for Horticulture's Technical Services and the Freesia Growers Association found that the costs of the gas fired unit were sandwiched between that of electricity on the e20 tariff (an interruptable supply with no equivalent on the mainland) and the e12 (12 hours at a rate about equivalent to a mainland day rate. On the mainland with lower gas prices the unit should have operating costs generally well below that of electricity on day tariffs (see last month's article).