Solar Upskill #14

Hydraulic design issues in designing SWH systems for commercial situations

Ian Sumner

Ian Sumner's solar upskilling series continues. In the previous article, he looked at the variable nature of the hot water demand in commercial solar water heating systems. In this, the second part of his article on designing commercial solar water heating systems, he looks at the hydraulic design issues to be addressed and why an installer should not just install a conventional domestic system without first considering the implications.

As we stated in the previous article, the key differences between domestic and commercial applications are that the commercial application;

- requires hot water on demand
- often has per+
- iods of relatively low or no hot water demand
- often has periods of relatively high hot water demand
- is often large and has complex hydraulics
- often has significant structural requirements

Commercial systems require much greater input in to the design of the system than domestic systems, to optimise its performance, maximise savings and to ensure long term reliability. Commercial systems will be exposed to extremes in temperaures and pressures and highly intermittant hot water demands. Strategies must be put in place to manage these extremes and the components in the system must be capable of withstanding these extreme temperatures and pressures.

Detailed engineering design and thermal simulation software allows us to determine the most appropriate size of solar system to be installed, determine system parameters including flow rates and to size system components including pipework and pumps and also to determine the most suitable control methodology.

Flow rates through a solar water heating system significantly impact upon the performance and likely savings achieved from the system. Too low flow rates result in a greater temperature difference across the solar collector and thus a reduced performance. Too high flow rates result in mixing within the cylinder in open loop systems, one of the most important factors in system performance, noise and excessive pump power.

Historically, many designs were based upon rule of thumb flow rates through collectors, usually around 0.015litres per second per square meter of collector area, which was based upon a maximum temperature rise across the collector of around 20°C in Summer. However, modern designs often utilise variable flow rates depending upon the system demands and criteria.

We use thermal simulation software to predict the potential utilisation of the system, the likely temperatures in the system throughout the year based upon the solar gain, water flow rates and the predicted hot water demand.

Figures 1 and 2 below are sample graphs of commercial solar preheat systems from simulation software. Figure 1 is the graph of the expected collector temperature in a system with a high and continuous hot water demand. The solar system cannot satisfy the peak demand, the hot water cylinder does not reach its maximum temperature and so the collector does not stagnate. Figure 2 shows a commercial system that has an intermittant hot water demand, the graph shows the collectors reaching high temperatures in the Summer months. These high temperatures must be adequately managed to ensure long term reliability of the system.

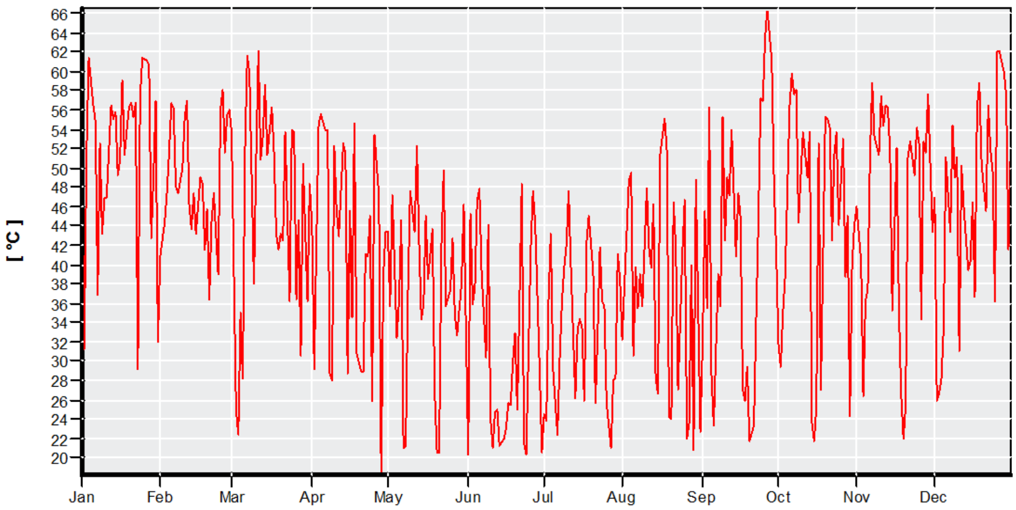

Figure 1 Collector temperature in a system that is unable to satisfy the hot water demand and the collectors are not allowed to stagnate.

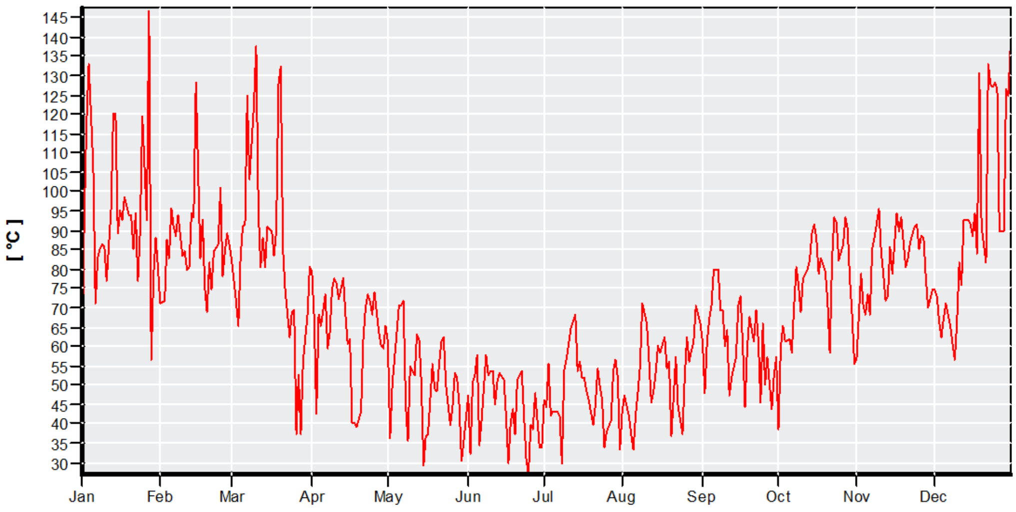

Figure 2 Collector temperature in a system that has an intermittant hot water demand with the collectors exposed to excessive temperatures during the Summer months.

Pipework sizing and pump selection is dependent upon the collector area, size of the system and the flow rates through the system. For instance as a rule of thumb;

- 9.5mm copper tube can generally be used for collector areas to $3m^2$
- 15mm copper tube can generally be used for collector areas to $9m^2$ and,
- 20mm copper tube can generally be used for collector areas to $28m^2$

The above pipe sizing is based upon a flow rate of 0.015litres per second per square meter of collector area and pipe lengths of up to around 10m or so between the cylinder and collector. Greater lengths may require the pipework to be increased in size or a larger pump selected.

Many of the pumps used in domestic-sized systems will be able to satisfy the demands of smaller commercial systems. For instance, a commonly used, 90 Watt 3 speed pump will usually have a no flow point on its pump curve of around 5m head. An engineer or experienced plumber will be able to calculate the resistance to flow and select a suitable pump. Advice can also be sought from pump suppliers.

We generally design a commercial solar system around the concept of a drainback solar system. In many cases we utilise variable speed drives, many modern solar controllers such as that shown in Figure 3 below offer variable speed outputs. The variable speed drive will usually control the speed of the pump based upon the temperature differential across the solar collector, as the temperature differential increases, i.e. there is more heat to be collected, the controller will increase the speed of the pump and conversely the speed will reduce as the temperature differential decreases. A solar system with a variable speed drive will be more effective and more efficient than a solar system without one. Particular benefits are seen in open loop solar systems, where the pumps are allowed to start on a fast speed with high torque, thereby minimising the potential for a pump to seize from being unable to start on a low speed and will then slow down which will reduce mixing of the hot water cylinder. Guidance should be sought from pump suppliers to ensure that the pump being used is suitable for being speed controlled and its lowest recommended speed.

Figure 3 Modern solar controller with a variable speed drive giving it the design duty, maximum torque on start up to reduce the potential of seized pumps and reduced flow rates during pumping to reduce mixing within the cylinder.

Many remote solar installations are opting for 12 volt controllers and pumps, it is critical that the 12 volt pump is selected for the particular system, i.e. a 5 watt or a 10 watt pump may not be sufficient and a greater wattage pump may need to be selected.

Ian Sumner is the technical director of Energy Conscious Design Limited and EcoSolar. Ian used to work as a plumber who subsequently completed a degree in building services design and has completed thesis on trying to get solar hot water to be cost effective in the UK. Ian also has significant local experience in solar system design and installation and is currently the only solar water heating system designer accredited by the Solar Industries Association in New Zealand.

Ian says, "This series of articles is intended to be an introduction to solar water heating only and I do not intend to provide specific design advice."

For more detailed information please request a free copy of the latest EcoSolar Solar hot water installation guide or send any questions or requests for topics to be covered to Ian Sumner. Email on ian@ecosolar.co.nz or 0800 ECOSOLAR that's 0800 32676527.

Energy Conscious Design and EcoSolar, in conjunction with several trade and professional industry associations, are in the final stages of preparing training sessions that will tour New Zealand, these training sessions are suitable for both specifiers, designers and installers, please contact Energy Conscious Design for dates and seminar locations.