QUANTUM 340 LITRE TITAN HEAT PUMP WATER HEATERS AND THE APPLICATIONS

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Abstract

This paper presents the Quantum 340 litre heat pump water heaters (panel and coil models) and the performance of the panel model tested under real climate conditions and a case study for the coil model. In the 'heat-up' tests, the COP of the system varied from 2.85 to 4.38 in different air temperatures and radiation conditions with the panels laid horizontally. The COP of heating is then related to the sol-air temperature. A further increase in COP can be obtained if the panels are tilted at the optimal angle. The tests indicate that the Quantum solar heat pump water heater can work very efficiently not only at sunny, but also at low radiation, conditions. The coil model is especially suitable for the situations where the cooling air conditioning is needed. Quantum heat pump water heaters are really the energy efficient water heaters.

1. INTRODUCTION

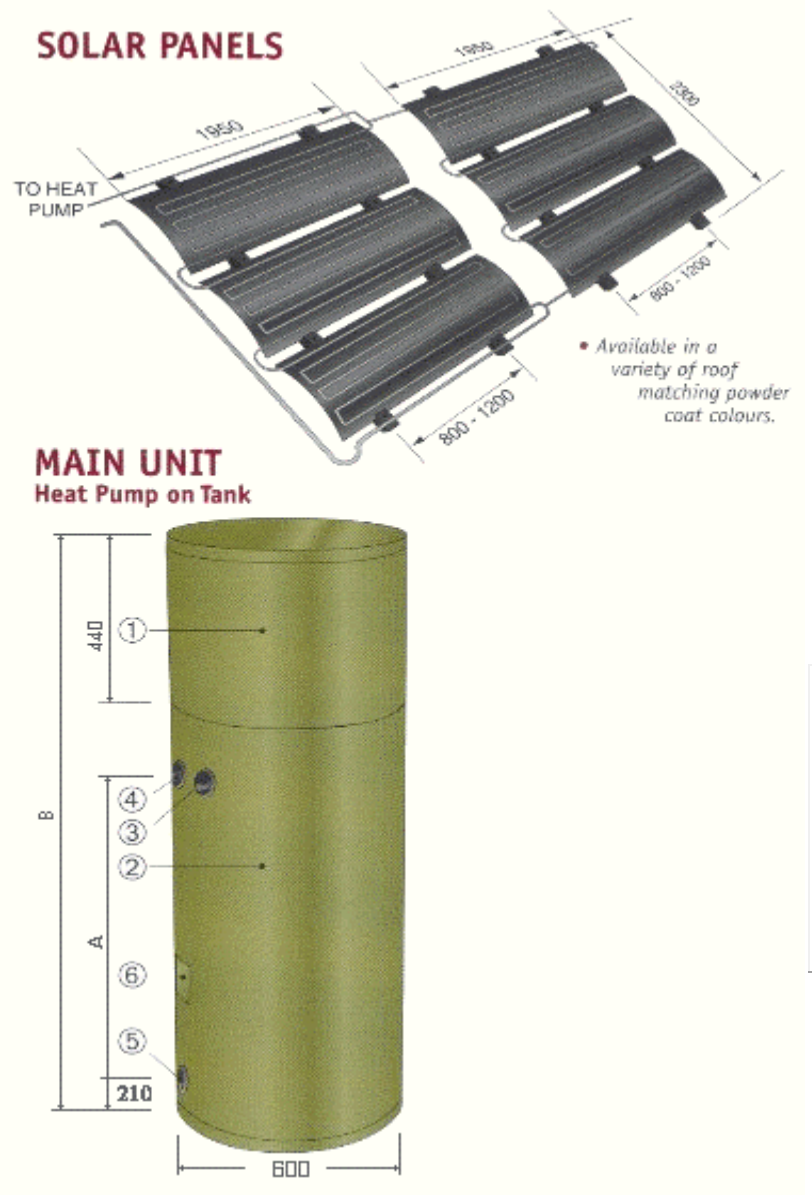
Hot water supply is a necessity in developed countries and it is becoming more and more popular in the developing countries. The water heaters commonly available in the market are electrical resistance type or fossil fuel (eg, gas or oil) type. This types of heaters consumed much high quality energy. A better way to use energy is by the technology of heat pump. However, owing to some reasons, only a few manufactories make heat pump water heaters. Quantum Energy Pty Ltd is one of them, and the water heaters produced by Quantum Energy Pty Ltd own excellent performances. This paper presents the Quantum 340 litre heat pump water heaters and the performance of the panel model tested under real climate conditions and a typical application for the coil model.

2. THE QUANTUM 340 LITRE SOLAR HEAT PUMP WATER HEATER

The outward appearance of Quantum 340 litre Titan heat pump water heater (panel model) is shown in Photo 1, the operational layout of Quantum 340 litre Titan heat pump water heater (coil model) is shown in Fig. 1, and some key numbers of them are listed in table 1. Either of the water heaters contains two units: the main unit and the evaporator (coil or panels). The main unit consists of a hot water tank and a heat pump on top. The solar panels are normally placed on the roof. The low temperature refrigerant runs through the evaporator and collects heat from the air, rain and the sun, and releases it with the heat converted from the energy driving the compressor to the water in the tank and heat the water efficiently.

Table 1. Some Key Numbers for Quantum 340 litre Titan Solar Heat Pump Water Heater

Compressor	1.7kW Rotary
Power Supply	240VAC/50Hz
Power Input Rating	2.21kW Nominal
Refrigerant	R22
Condenser	Tube Wrapped Around Tank
Water Tank	340 ltr, Steel/Vitreous Enamel
Evaporator	6 Solar Panels (60 kg) for Panel Model
	150 Watts for Coil Model



Key

1. Heat Pump
2. Water Tank
3. P&T Valve
4. Hot Water outlet
5. Cold Water inlet
6. Thermostat Cover

Dimensions	
A	1540
B	2165

Photo 1. Quantum 340 litre Titan Heat Pump Water Heater (Panel Model)

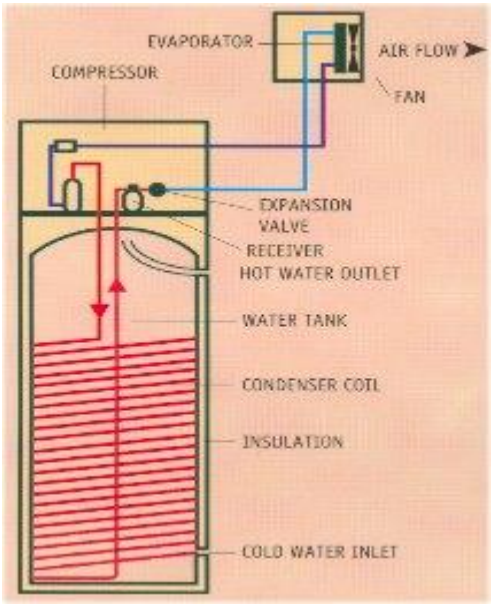


Figure 1. The Layout of Quantum 340 litre Titan Heat Pump Water Heater (Coil Model)

3. THE HEAT-UP TESTING

The testing data of Quantum 340 litre titan heat pump water heater (panel model) are listed in table 2.

Table 2. The Testing Data of Quantum 340 litre Titan Heat Pump Water Heater (Panel Model)

No	Average Air Temperature (^oC)	Average Radiation (W/m^2)	Temperature Rise of the Water	Heating Time (h:m)	Electricity Consumption (kWh)	COP of the System
1	40.2	862.5	27.7	1:03	2.492	4.38
2	22.8	124.2	30.5	1:48	4.223	2.85
3	36.7	582.2	26.2	1:13	2.805	3.69
4	24.8	476.2	32.7	1:41	3.968	3.25
5	25.2	611.6	32.6	1:33	3.631	3.54
6	25.3	794.7	31.6	1:26	3.427	3.64
7	32.9	921.9	31.4	1:20	3.448	4.25

From the data, it can be seen that the performance of the system is not only related to the air temperature but also to the radiation. The effect of solar radiation, thermal radiation and convection can all be incorporated in a single calculation by introducing the sol-air temperature. The sol-air temperature is expressed as (ASHRAE 1997)

$$t_e = t_0 + \alpha I_t / h_0 - \varepsilon \delta R / h_0 \quad (1)$$

where t_e is the sol-air temperature, t_0 is the air temperature, α is the absorptivity of the surface, I_t is the total solar radiation incident on the surface, h_0 is the combined outer heat transfer coefficient by radiation and convection, ε is the hemispherical emittance of surface, δR is the difference between the long-wave radiation incident on surface from sky and surroundings and radiation emitted by blackbody at outdoor air temperature.

The thermal radiation correction term, $\varepsilon\delta R/h_0$, is usually approximated as being 3.9 ^{o}C for horizontal surface. Taking α=0.92 (Incropera and Dewitt 1996) and h_0 =22.7W/(m^{2}K) (ASHRAE 1997), the relationship of the COP of the system and the sol-air temperature is shown in Fig. 2.

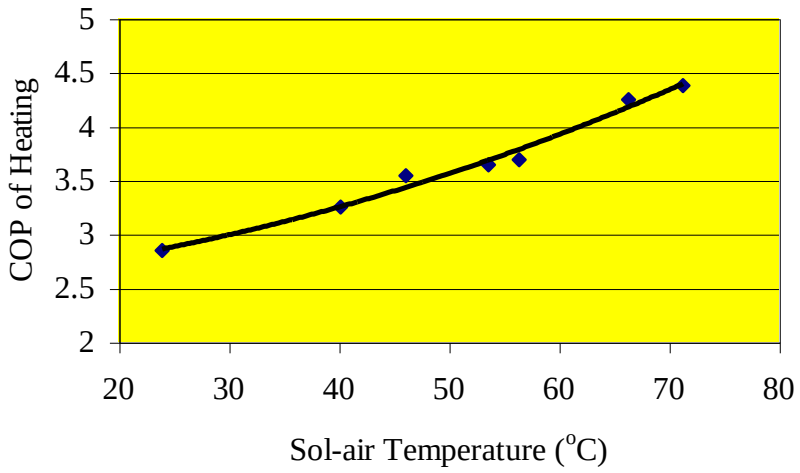


Figure 2. The COP of the System Vs. the Sol-air Temperature

4. THE ADVANTAGES AND APPLICATIONS

Quantum heat pump water heaters have the following advantages.

Compared to other solar water heaters, Quantum solar heat pump water heater can work in any weather conditions and any roof or wall face efficiently even in cold temperature areas because of its unique characteristics. There is no heavy tank mounted on the roof while the panels are rather light (only 60 kg) so there is no need to strengthen roofs. Since water is not used in the panel there is no risk of freeze. The panels are made from aluminium and could not be damaged by normal hail and can last as long as the roof. Since the panels can go on any roof face, it complies the home appearance, and the slim line design does not clash with roof aesthetics.

In generally, Quantum solar heat pump water heater can supply hot water reliably and efficiently. It is one of the most energy efficient water heaters.

Quantum heat pump water heaters can be used in any application. Some typical applications for Quantum Heat Pump water heaters are

- Domestic

Large energy efficient homes. Large domestic family homes

- Commercial

Retirement Villages. Caravan Parks. Hotels, Motels & Hostels. Schools. Restaurants. Hospitals. Laundries.

5. CASE STUDY: ROYAL CROWNE PLAZA HOTEL – SINGAPORE

This 5 star hotel has 495 rooms. It requires 55-56°C hot water 145,000 litres with a peak load of 21,300 litres over a 2 hour period. The previous hot water plant consisted of 2 Oil Boilers and 3 large storage tanks. The exhaust emission levels and the maintenance cost of S$12,000 combined with a substantial running cost of S$2.33/$m^3$ hot water delivered were too high and unacceptable.

Quantum proposal was to install 30 Quantum 340 litre Titan Heat Pump Water Heaters (Coil Model) in conjunction with 2 m^3 of additional storage. The cool air, as the by-product of generating the hot water, was channelled into the air-conditioning system to provide additional benefits by reducing the cooling load for the central air conditioning equipment. The total project cost was S$178,300 (including dismantling of the old system, equipment purchase, installation and commissioning of the new system).

Photo 2. Layout of Quantum Water Heaters for Royal Crowne Plaza Hotel – Singapore

The Quantum heaters providing an hourly recovery rate of 193 litres/heater @ΔT = 30°C including heat loss in the ring main. The heat pumps operated at the COP of 3.25 (just evaluating

the heating effect). Hot water production costs were S$1.13/$m^3$ delivered or S$1.03/$m^3$ produced (S$0.1/$m^3$ for heat loss). The air-cooling rate was 140 – 150 kW per day. The cool air supplied by the heat pumps and used by the air-conditioning system results in significant net electricity savings. Plant maintenance services were also reduced to negligible levels.

Compared to the reference year July 1997 – June 1998, savings over the year July 98 – June 99 were

- Fuel Oil reductions: 128,665 litres (S$41,173)
- Electricity savings: 861 MWh (S$78,333)
- Gross Purchased Energy savings: 5385 GJ (S$119,506)
- Maintenance Cost savings: S$11,500
- Gross Financial savings: S$131,006
- Gross CO_2 emission reductions: 791 MT (Elec.: 430 MT @0.5kg/kWh & Fuel 361 MT @2.8 kg/litre)
- Simple Payback on investment: 1.36 years
- Payback in reference to new fuel boiler: 1 year (new boiler cost S$70,000, old boiler efficiency 55%)

This case study again shows that using a heat pump system for combining water heating and air conditioning can play a very significant role in commercial buildings with benefits in energy saving, cost saving and CO_2 reduction. This flows on to provide a cleaner and safer environment for us all.

6. CONCLUSIONS

Quantum heat pump water heaters operate very efficiently. For the panel model , in the 'heat-up' tests, the COP of the system varied from 2.85 to 4.38 even though the panels are put horizontally. It can be deduced that Quantum solar heat pump water heaters can operate in all seasons of the year, day and night, and in most place of the world. For the coil model, it is especially energy efficient when the cool air is also made use of (Quantum makes it handy to happen). If you are thinking about solar or energy efficient water heater, invest in a Quantum heat pump water heater.

ACKAGEMENT

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