CADAL CRAFT

Cooling and heating your boat from the Sun

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Cooling systems on boats normally depend on running generators overnight to provide the necessary electric power. On many large boats heating is done the same way, on others diesel or gas heaters run over night, or solid fuel stoves are installed.

Self evidently gas and solid fuel heaters are not risk free - carbon monoxide poisoning from blocked flues and even fires on board are alas all too common. Many owners therefore plumb for diesel heaters on board - the diesel heater being installed outside the habitable portion of the boat. All these systems suffer from the same issue however - we are producing green house gasses in order to keep warm.

We can arrange, for a combustion engine driven boat, to have at least our day time heating driven from the waste heat from the propulsion system. A future fuel cell system, designed to be a battery charger, could also provide heating as a by product. Fuel cells, despite multiple announcements going back to the 1970s, are still not available, though we can live in hope.

Overnight what can we do?

We could run electric bar heaters using batteries to provide power to an inverter to provide the required higher voltage power. If we assumed that we needed to run a single 2 bar electric heater rated at 2kW of heat over night, for say 14 hours, we are going to need a seriously large battery bank.

2kWh of energy in is sufficient to run this 2 bar electric heater for 1 hour where it produces 2kW of heat. This ratio of efficiency is 1:1, and this can be represented as a single number co-efficient of performance (COP) of 1. Such an electric heater can be considered a direct fuel heater - as the amount of energy put into the system equals the amount of energy output by the system. Gas heaters and solid fuel or diesel liquid fuel heaters are the same in terms of efficiency.

To run our 2 bar electric heater for 14 hours means 28kWh of energy, and that means, for a lithium battery bank where we can use a maximum of 70% of the available capacity, a battery bank of 40kWh just to run that simple bar heater.

Obviously this is not a practical option as the battery bank has to be huge even for the limited heating in this example.

A sound principal is to heat or cool your boat using a heat pump. These have been around for many years (Geneva town hall has been heated by such a systems since 1928) and for marine use are marketed as chiller air-conditioning systems. Recent systems have started to become seriously efficient.

Air sourced heat pumps, whereby heat is taken from (cold) outside air in winter to heat a hot water circulating heating system have become popular in the UK. These, while dramatically more efficient than direct heating, run at COP numbers of between 2.2 and 2.8: by which we mean 1kW of electricity can be used to provide upto 2.8kW of heat. Issues of course are as it gets colder outside, the air sourced heat pump becomes less and less efficient. COP numbers of 2.0 at -20C and 2.8 at 0C are typical figures.

Ground sourced heat pumps, where heat is taken from well below ground level where temperatures rarely change from 8-10C all year round, are also well established in the UK but with the additional cost of installing a deep drilled hole or a pipe buried at least 2m below ground level in a trench of 50m or so in length. These have COP numbers running from 4 to 5.

Obviously ground sourced heat pumps are impossible on rivers and canal boats. What we can do is implement a form of water sourced heat pumps. With these installation costs fall in between the air sourced and ground sourced options. Essentially we pump water into our heat exchanger. Available data indicates that river and canal water rarely falls below 5C and more typically is over 8C in most rivers and canals in the UK year round. As air temperatures fall, water gets covered by ice which is a reasonable insulator, therefore keeping water underneath the ice cover liquid in all but the most extreme winters (with solid frozen canals having happened only twice since the 1940s.). Ice cover on rivers is rarer still as the constantly flowing water in a river system continually gets warmed up from the ground the river runs over.

The down side of water sourced heat pumps is the potential for the heat exchanger inside the heat pump to be gummed up with fine mud and small sized aquatic life, and of course raw water can freeze inside the unit causing serious issues inside the boat. An alternative is to use an external heat exchanger. These have been successfully used on American waterways for many years. However these externally mounted heat exchangers are likely to have a very short life on UK canals and rivers due to the narrow waterway sections, and the low draught available, resulting in multiple impacts on the heat exchanger.

The alternative to conventional heat exchangers is to use a hull integrated heat exchanger and these are indeed commonly used on UK canal boats, referred to as skin tanks, for engine cooling. The temperature delta here is relatively high (75C engine water to 10C canal water) so can be quite small. In order to get usable surface area for heating we need tanks which are a scale of magnitude larger and which require structural integration into the boat hull to make them work effectively - a patent pending development.

So a hull structural heat exchanger feeding a heat pump optimised for heating (not cooling) using a glycol coolant to prevent freezing even in harsh winters means we can look to operate with efficiencies approaching household ground sourced heat pumps on a boat - COP numbers of 4 should be achievable in all but the harshest of winters.

This puts our 2kW bar heater example on a different footing - it means that with a decent heat distribution system on board (ie fan blown not radiators), good insulation and double glazing on all windows, that we should be able to heat the whole boat using 2kW of output power, needing just 500W of input electricity at a COP no of 4, resulting in us needing just 14x500W = 7kWh of usable battery bank. Even if we add a further 50% power requirement for circulating pumps and other inefficiencies, it still means that battery bank on board of just 14kWh can be enough to heat the whole boat on the coldest of days. For much of the year we should be able to do much better than that.

So how much solar can we fit on board a boat? Our Cadal 60 happily supports 1200W of solar (with a different deck layout this could be a little larger).

If this panel set could work at 80% conversion for 8 hours per day we can generate enough power to replace the energy in our batteries we have used for heating overnight. Of course this is unlikely so additional energy inputs will be needed in the colder months, but for a lot of the year it is theoretical possible to replace most if not all of the energy required for heating just from solar.