Improved minimum pipe control and pump switching for energy saving

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Many greenhouse operators in New Zealand use minimum pipe temperature as an 'insurance' against too high humidity. Indeed minimum pipe is an effective and reliable tool for humidity control if it is combined with some venting. But this is often done too drastically, and the energy consumption goes through the roof. This article explains how minimum pipe temperature can be set so that the pipes are warm when needed and cold when the conditions allow. It is also suggested that the pumps can be switched off when there is no heat demand.

Pipe control
The temperature of the heating pipes is dictated by the control programme in the computer. This calculates the pipe temperature needed for maintaining the required air temperature. The control programme uses settings chosen by the grower, including maximum and minimum pipe temperature. The minimum pipe temperature is important and can be used for a number of reasons: (1) preventing too high humidity, (2) preventing a dead climate with too low transpiration, (3) CO2 enrichment. In most cases minimum pipe temperature is used as a precaution against high humidity and hence fungal diseases. But many growers use it too casually, leading to excessive energy consumption. The energy waste can be substantial. How can minimum pipe be used better?

Minimum pipe temp
Minimum pipe temperature means that the pipes are kept above a certain temperature for instance at 45 °C, every moment in a certain period. If it gets too hot, the pipes will stay at their minimum temperature, and the vents will open.
The first question should be: why 45 °C, why not 42 or 37 °C? Every degree lower pipe temperature reduces the energy consumption by about 2 GJ per ha per day.
The second question is about the periods in the day. Energy can be used more efficiently by setting minimum pipe temperature differently for different periods of the day, and by choosing the start and end times of the period wisely, for instance coupled to sunrise and sunset. The third question is whether minimum pipe can be varied depending on the conditions. Warm pipes are desirable when it is dark and damp, but they are useless when the sun shines, unless for CO2 enrichment or to keep the (coal) burner going. The answers to these questions can be found in the control programme of advanced computers. They offer a wide range of options for the control of minimum pipe temperature.

Minimum pipe control
A lot of energy can be saved by making the minimum pipe temperature dependent on the conditions by using 'influences'. All more advanced computer systems can do that. The settings should be such that the pipes are warm when heat is needed, and cold (in fact 'minimum pipe temperature is off') when the conditions allow. For instance, it is very good to use a radiation influence: minimum pipe is set at 45 °C but it goes down automatically when radiation from the sun increases. This is based on the fact that the sun is much more powerful than pipes.
A good setting is to gradually reduce the minimum pipe by 20 degrees when radiation climbs from 100 to 250 W/m2. In this way the pipes will be 45 °C when radiation is under 100 W/m2, and will be only 25 °C when radiation is over 250 W/m2. If radiation is for instance 175 W/m2, the minimum pipe will be 35 °C. There are provisions to stabilise the minimum pipe, so that it does not change as quickly as the radiation.

There can also be a 'humidity influence' that makes that minimum pipe gradually goes down if the greenhouse humidity is gets better (lower), and minimum pipe is off when humidity is under 80 %.

Alternative approaches
An alternative approach is a reverse way of thinking, namely that minimum pipe is off, unless it needs to be on, for instance when the humidity is too high. From an energy-saving point of view this is the better way. Not all computers can do this, and it requires a good understanding of climate control and in the beginning close monitoring of what happens. The advantages of this approach are that one strategy can be used for the whole day. Moreover, this method is the best way of energy saving on humidity control.

Minimum pipe and venting
Remember, if minimum pipe is used for humidity control, it must be combined by a bit of venting to remove the excess moisture. This is because warm pipes lower the relative humidity, but not the absolute humidity. Moreover, warm pipes stimulate the transpiration, and so they increase the humidity (the absolute and relative humidity). Venting at the same time is the only way to counteract the humidity build up.
A good way of doing is choosing the venting temperature only just above the heating temperature, say about 0.5 degree. This makes that the vents open promptly in response to a small rise in temperature, which allows moist air to escape from the greenhouse. (Alternatively, humidity is controlled by minimum vent opening, and the heating pipes get warmer when needed).
Whatever the strategy, for energy saving it is very important that the vent temperature is never below the heating temperature! Another point is that the P-band for venting should be fairly high in winter, say about 10 degrees.
More was written about smart heating & venting in the previous article and will be again in a next issue.

Minimum pipe in late afternoon
Sometimes a minimum pipe is used to avoid a temperature drop in the late afternoon under winter conditions, especially in the South Island. After a sunny day, the radiation starts falling rapidly as the sun goes down. The heat demand rises quickly too, sometimes so fast that the heating system cannot deliver enough heat, so the air temperature drops sharply. To avoid this situation, the minimum pipe can be set at 35 or 40 °C in the late afternoon period before sunset. This will make the boiler start earlier so that the heating system is warm in time. It is important to choose the period correctly (coupled to sunset).
A good option is to use a radiation influence in this period. This can be different to the radiation influence in the morning (see above), namely with lower light levels. An example is to adjust the minimum pipe temperature by 20 °C in the range 50 to 150 W/m2 radiation. This means if the radiation drops below 150 W/m2 the pipe temperature will start rising. If it is below 50 W/m2, the pipes will be 20 °C warmer.

Pump switching off
Above we discussed the minimum pipe temperature, and making it dependent on conditions to save energy. Further energy saving can be achieved if the pump is automatically switched off when the pipes are cold. This saves power (= electrical energy), and also some heat (because the valve always leaks a bit, so that some heat is wasted). There are many hours in a year when the pipes are only luke-warm (e.g. 25-28 °C). Luke-warm pipes have little effect, certainly if it is a bit sunny. In this situation, it would be better if the pipes were cold instead of luke-warm, because then the pumps could be switched off. This requires that the minimum pipe falls back to a really low temperature (below 25 °C). Some computers have settings called 'absolute min pipe temp', which is standard set on 25 °C. But if this option is available, it is better to set this at 0 °C. Some computers have settings for switching off the pump. This can be set at say 26 °C. Note that the pump will never switch off, if 'absolute min pipe temp' and 'switch off' are both set at 25 °C.

Conclusions

Minimum pipe temperature is one of the many settings of pipe temperature control. Minimum pipe is often used as an 'insurance' against high humidity, but it costs a lot of energy. There are many additional settings (influences) for minimum pipe temperature control. Using them wisely can mitigate the energy consumption. A good method is making the minimum pipe temperature dependent on the humidity and radiation. Some examples were given. Concurrent venting is needed but should not be exaggerated. The venting temperature should never be below the heating temperature, and the P-band should be wide in winter. Avoid that pipes are luke-warm for a long time, as that has little use. In those hours the pipes can be set cold and the pump switched off automatically, to save electricity and some heat.

It pays to investigate the options of control and play with the settings. Many settings should be adjusted to either summer or winter conditions. It is advisable to run some tests in one compartment and compare with another compartment with alternative settings. Study the graphs of calculated and realised pipe temperatures. In hard cases, ask advice.

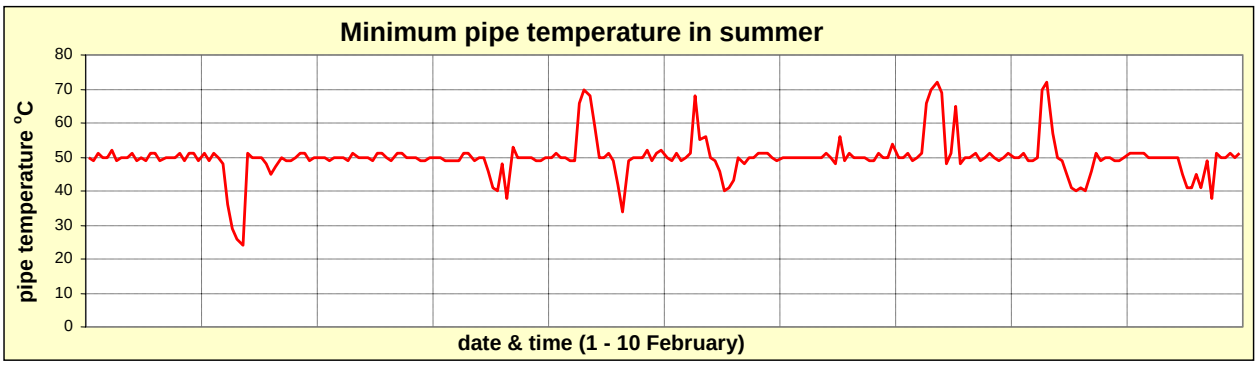

Figure: *Minimum pipe temperature is here set at 50 °C throughout the year. This shows the middle of summer (1-10 February). Peaks indicate pre-dawn heating. It is very likely that the minimum pipe was unnecessary on most summer days. Energy-efficiency can be increased by improved control of minimum pipe temperature.*