Energy-efficient humidity control

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Typical autumn weather involves fairly high temperatures and high air humidity, which are perfect conditions for grey mould and other fungal diseases. Most greenhouse growers spend a lot of energy on trying to lower the humidity in the greenhouse, not always with success. Previous articles in this series have dealt with humidity. Without repeating previous articles, this article discusses the 'ideal' humidity level, control band, cross-over of venting & heating and the use of minimum pipe temperature.

Ideal humidity level

Most growers work with an idea of the 'ideal' humidity. For many growers this is around 80% RH, and they set their computer to control the RH in a band of 78-82%. This means that 78% is the lower limit and 82% the upper limit for control. More precise: when the RH reaches 78%, the computer starts taking action such as opening vents or increasing the pipe temperature. When the RH is 82% or higher, the action is maximum, i.e. the vents are open at the chosen level, or the pipes are at the chosen temperature. The humidity level in the greenhouse will be roughly in the middle of these limits, so 80%.

However, it must be questioned if 80% RH is really the ideal humidity. Why 80% and not 85 or 75? If the setpoint for humidity is set lower, it will cost more energy to maintain that. Higher RH levels are better for energy efficiency.

But what is better for the crop? Our starting point is that energy saving should not compromise the growing conditions or plant health. High humidity is undesirable because it stimulates fungal diseases (such as grey mould, Botrytis) and hampers the transpiration. The first is most prominent. A fungus attacks plants that are wet (because fungal spores need free water for germination). Plants do get wet by condensation (this happens when plants are colder than the dewpoint). The first objective of humidity control is to avoid condensation on the plants. Condensation occurs in principle when the RH is 98-100%. So why control the RH at 80%, when 100% RH is the real dangerous level?

Control band for RH

The RH measured by the measuring box is not a perfect indication of what happens. On places far from a heat source, there are cold spots where RH can be 10-12% higher than near the measuring box. So if the computer tells 88% RH, it can be 100% on cold spots. Therefore growers have to build in an ample safety zone: the control must aim at avoiding 88% RH. It has become a standard practice to build in an extra large safety and to aim for 80% RH.

Such a large safety zone is only necessary in greenhouses with a very poor temperature distribution. Therefore it is helpful to first measure the evenness of the temperature (more about this in a next article). When the temperature distribution is good, it is perfectly safe to accept a higher RH, for instance 85 or 86% at maximum. This will save energy. If you used to have a control band of 78-82% RH, you may want to change this to 80-84% RH. This is an improvement with minimal risk. Another possible improvement is to make the band wider, namely 6% wide instead of 4%. So the new humidity control band becomes 80-86%. This ensures a smoother control action (such as opening vents or increasing the pipe temp). It means that the control action starts when RH is 80%, and is complete when RH is 86%. This means that at 86% the vents are open at the required level (or the pipes are warm). This new and wider control band for humidity will be effective as well as energy efficient.

Heating, venting or both

Humidity control is based on increased heating and/or increased venting. Different computer brands have different approaches. Advanced computers offer a choice of approaches and combinations are possible. The four principles of avoiding high humidity are:

1) increasing the heating temperature
2) increasing the minimum pipe temperature
3) reducing the temperature where venting starts
4) setting a minimum vent position

Heating and minimum pipe temperature (option 1 & 2) are not very effective on their own. They work well only for a little while. Heating increases the temperature and hence reduces the relative humidity, but not the absolute humidity. Moreover, it stimulates transpiration, and this in turn increases the humidity. So heating alone is counter-productive. To make it work, heating must be combined with increased venting to remove the moisture. Many NZ growers don't do this, and they get disappointing results. On the other hand, if heating is combined with venting, there is a risk of overshoot. Too much venting causes the temperature to drop, and hence the heating pipes must become hotter again, etc. This causes unrest in the control and wastes energy.

Reducing the venting temperature (#3) or having a minimum vent opening (#4) removes the moisture out of the greenhouse, which is good. If it the greenhouse temperature drops, the heating will kick in. However, the disadvantage of adjusting the venting temperature for humidity control is that the vents may open too far and too wildly. Then the temperature drops, and the heating has to kick in, also leading to energy waste rather than energy saving. The best principle is with minimum vent opening, but this must be made dependent on inside humidity and if possible on outside conditions.

Cross-over of heating and venting

In some simple computers the only way of controlling high humidity is by a 'cross-over', this is concurrent heating and venting, or 'heating with the windows open'. Advanced computer can do better, but still some growers with an advanced computer do use cross-over because that is the only way they know. It can also happen inadvertently, because it is very easy to choose the settings so that an (accidental) cross-over. In addition, advanced computers have many hidden settings and adjustments and 'influences' so that things can happen that the grower did not expect.

Here is a real-life example of how incorrect settings cause a cross-over. The heating setpoint is 19 °C; venting starts at 20 °C. Humidity is controlled by a humidity-dependent increase of 2 °C on the heating temperature over a control band of 78-82% RH. This means that if the humidity gets 78% the heating temperature increases, and at 82 % the heating temperature is 21 °C (19+2). Because of this humidity control, the temperature in the greenhouse will reach 21 °C at some stage. Since this is clearly above the venting temperature (20 °C), the vents will open. The grower probably did this as he thought it was proper humidity control. This 'cross-over' or 'heating with the windows open' costs an enormous amount of energy, and it happens a lot! Another real-life example is that windows were found open at 30% and pipes were 65 °C on a cold winter day on the South Island, over a long period of time.

Check for energy wasting

When graphs are available in the computer, the grower can check whether the heating setpoint and venting setpoint overlap. However, it is harder to foresee what will happen if a certain influence kicks in under particular conditions (e.g. heating temperature adjustment due to high humidity, as described above). It pays to check all 'influences' in all periods of the day, to make sure that the venting setpoint is not under the heating setpoint (or only if it is done deliberately). The best method is to check graphs of historic data and see if there were times when the pipes were very hot and the vents were too far open. Even better is to look for periods when the pipes were hot, while the temperature was high enough and humidity was low enough. In these periods the pipes could have been colder. Notorious for energy loss are the early morning hours and also late afternoon around the pre-night temperature drop.

Summary
This article described why humidity control is often ineffective or energy-inefficient. It also described some approaches that do work well. There is much more to say about humidity control, such as: how to work with minimum pipe temperature, how to switch of the pumps when no pipe temperature is needed, and more. Some things will be discussed in future articles. Also, it was impossible to give here the exact details of optimal humidity control, because they are different for every computer brand, type and version. The subtle settings are irrelevant for growers with a simple computer. Advanced computers have very many settings (often hidden in the software), and it is impossible to describe those. The best thing is to get all the computer settings examined as part of an energy audit. This can be done by a specialist in greenhouse climate control, for instance Peter Mos from the Netherlands or Bert Houter from Pukekohe.

***Figure**. Humidity control by heating alone doesn't work; it should be combined with a bit of venting to remove the moisture.*