

A flue gas condensor for energy saving

Elly Nederhoff

CropHouse Ltd, New Zealand

Elly@CropHouse.co.nz

Published in the Grower 58(2), 2003, p. 42-43 (adjusted)

The price of energy is likely to rise in the near future due to economical and political developments such as declining fossil fuel sources and the need to reduce CO₂ emission. Greenhouse growers use quite a lot of energy for climate control, and the higher energy costs will reduce their income. The third article in this series deals with the flue gas condensor. This is a device attached to a gas-fired central heater (boiler) that retrieves energy from the hot smoke before it leaves the stack. A condensor can save 10% or more on energy costs. Apart from the initial investment and servicing twice a year, there are no costs or disadvantages of operating a flue gas condensor. Nearly all boilers in the Netherlands are equipped with a condensor.

How a condensor works

A boiler such as used with a central heating or pipe heating system loses quite a bit of energy via the stack. This wasting can be overcome by installing a condensor between the boiler and the stack. A condensor recovers the energy from the flue gases before they leave the stack. The recovered energy is used to heat up the return water from a hot water pipe heating system, or to supply heat to a separate heating net. The way it works is that the condensor contains metal surfaces that are in contact with a stream of cold water. The metal surfaces get the same low temperature as the water. When the hot gases come in contact with the cold metal, the heat (so called thermal energy) is transferred from the hot gases to the cold metal and then further to the cold water. So the water stream is warmed up and this will be used for greenhouse heating. In addition, if the metal is cold enough, condensation occurs in the flue gases. Condensation means that the water vapour in the flue gases condensates on the cold metal. It is important that condensation generates a lot of energy (so-called latent energy). Also this energy is transferred via the metal to the water stream of the heating system. Condensation occurs only if the temperature of the metal is below the so-called dewpoint temperature of the gas, e.g. below 60 °C. The water that is formed by condensation is discharged.

Pipe and lamella condensors

In greenhouse horticulture the condensor is built as an extension of the boiler. The energy transfer takes place at metal pipes. There are three types of condensors: pipe condensor, lamella condensor and combi condensor. In a pipe condensor the flue gases flow through pipes that are surrounded by cold water. The water flows along the pipes but in opposite direction of the gas. In this system the temperature of the flue gases can get as low as the temperature of the incoming water. If the water is cold enough, water vapour in the flue gases condensates on the walls of the pipes.

The second type is the lamella condensor. In this type of condensor, the pipes contain cold water and are surrounded by flue gases. The pipes have aluminium lamellas attached to them to enlarge the contact surface with the gases. The flue gases are blown over and across the cold pipes and lamellas. The lamellas are not as cold as the pipes and the gases cannot be cooled as low as the temperature of the incoming water. This makes a lamella condensor less effective than the pipe condensor. The lamella condensor is cheaper to install and smaller in size than the pipe condensor. It is the most commonly used type in the Netherlands.

Combi condensor

A combi condensor consists of two condensers in one system: one condensor cools the flue gases down for instance from 160 to 70 °C, and the second takes care of further cooling from 70 down to 40 °C. This second condensor also takes the condensation energy out of the flue gases. Usually both condensers are lamella types. The first of the two condensers operates at a high temperature level, and delivers the heat to the return water of the normal pipe heating system. The second condensor operates at a much lower temperature level. This condensor is usually connected to a separate heating net that runs at a lower temperature. This can be a bench heating, root-zone heating, overhead heating, water heating etc., which is additional to the main heating net. It is also possible that both are connected to the normal heating system. In that case, the second condensor pre-heats the cold water, and the first condensor then heats the water further to the required high temperature. A combi condensor retrieves nearly all energy that is present in the flue gases, and therefore achieves a very high energy efficiency. But the investment costs are of course higher than for a single condensor.

CO₂ enrichment

The flue gases have some characteristics such temperature, volume, water vapour content and CO₂ content. These characteristics are important if the flue gases are used for CO₂ enrichment. The characteristics are improved by using a flue gas condensor. For examples: the flue gases that come out of the boiler are often around 200 °C. This is too hot for CO₂ enrichment, and therefore a large volume of fresh air is mixed in. This brings the temperature down to 40 °C (which is good) but it also reduces the CO₂ content from over 10% to only a few percents (which is not good). If a flue gas condensor is used, the flue gases drop in temperature (which is good) while they remain rich in CO₂. Moreover, the flue gases are stripped of water vapour, which is also desirable.

Efficiency

A condensor can transfer heat only to water that is colder than the flue gases. So the colder the water, the more the flue gases can be cooled down, and the more energy is recovered. Therefore a condensor is most effective when it uses water of a special heating net that operates at a low temperature level. Moreover, cold water (below the so-called dewpoint temperature of the gas) can induce condensation of the water vapour in the flue gases. This yields a lot of energy. The efficiency of a condensor is as follows: cooling the flue gases from 160 to 60 °C saves 5% energy (about 0.5% per 10 °C). Cooling the flue gases down from 60 to 40 °C saves another 6% on energy. This is about 3% per 10 °C, due to recovering thermal energy and condensation energy. The total energy saving for cooling flue gases from 160 to 40 °C is about 11%. This total energy recovering can only be achieved by a combi condensor. The efficiency is even better if the boiler itself has a low efficiency, because an inefficient boiler leaves more energy in the flue gases, so therefore there is more that the condensor can retrieve.

Safety

The water that is formed by condensation has to be removed through a water outlet. This outlet needs a siphon to prevent that gases escape. Further, the condensor must be safeguarded against too high temperature and pressures. At excessive temperature a thermostat switches the burner off. At excessive pressure two safety valves are automatically opened. There are boilers that operate normally on gas and can operate on oil as a back-up fuel. Such a condensor must be bypassed whenever sulphur-containing oil is used as fuel.

Acknowledgements

Much of the information in this article comes from 'Manual for heating of greenhouses' (in Dutch), Westland Energie Services BV, 2001.