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Evaporative Cooling Systems for Poultry Housing

Introduction

Evaporative cooling is a simple low cost technique to reduce the temperature of livestock buildings in hot weather conditions. Popular in Africa and the Middle East it has not been used extensively in the UK. This technical note sets out the possible benefits for its use by UK poultry producers and details a performance trial on a broiler building.

Conventional Cooling Systems

Conventional poultry buildings use ambient air ventilation for cooling. Their success depends on ambient air temperature, humidity, air throughput, and the level of house insulation.

As ambient temperatures rise above 19°C ,internal temperatures will start to rise above 21°C (the optimum production temperature for most poultry.) In very hot weather house temperature rises much higher than this, especially where fan ventilation has been undersized or where insulation of the building is substandard allowing substantial solar heat gain.

Commercial Consequences

The consequences of house temperatures higher than 21°C are :

1. Bird performance (F.C.R.'s and/or growth rates) deteriorate.
2. Heat stress is increased leading to higher mortalities.

The welfare of the birds suffers and meat/egg production becomes less viable. In these conditions, some form of additional cooling would be desirable. Refrigeration (air conditioning) is too expensive.

However, evaporative cooling is a technique which can be applied. It is used extensively in hotter climates but has not been commercially adopted in the UK.

Fig 1. shows the number of degree hours per month measured at Birmingham averaged over five years when the temperature was above 19°C. This would equate to the amount of time an evaporative cooling system could be put to useful work. Total degree hours above 19°C using these figures are 1080 per annum.

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Evaporative Cooling

The Technique

As water evaporates heat energy is drawn from the surrounding air. This causes a reduction in air temperature and an increase in its relative humidity.

The degree of cooling is greatest at high air temperatures and low humidities. The warmer and drier the air, the more capacity it has to absorb moisture. The more moisture the air absorbs the greater the cooling effect.

Methods of Evaporative Cooling

There are two common methods for evaporative cooling :

1. Spray or fogging jets to atomise water into the building or the inlet air path.
2. Water soaked cellular pads through which the incoming air passes.

With the spray jet method the regulation of water droplets entering the building can be a problem. If the droplets are not fully evaporated the water 'carry-over' can cause wet litter. Complete treatment of the air is often impossible as it is difficult to ensure that the water spray will envelop all the inlet area.

Since there is no atomisation with the cellular pad system, there can be no litter wetting from 'carry-over'. Also, compared with the spray system a far larger percentage of the inlet air is humidified because the whole air stream comes into contact with the wet pad.

Cellular Pad Cooling System

The cellular pads are manufactured from a corrugated cellulose material which has been treated to provide efficient water absorption. The corrugations make the material rigid enough to be self-supporting and are designed to shed any dust which may collect. A chemical treatment also protects against decomposition caused by water. The corrugated nature of the material results in a large air/pad contact area. For instance, $1m^3$ of the corrugated cellulose material has a total evaporation surface area similar to a fifty metre swimming pool.

The cellular material is mounted in extruded PVC frames. This give structural support, delivers water to the top of the pad through a spray bar, and drains water from the bottom. (Figure 2)

Water supply is from a reservoir tank topped up from the mains water.

Cooling Trial

House Details

A pad cooling system was fitted to a small broiler building of wooden construction with a pitched corrugated sheet roof and a stocking area of $236m^2$.

The building was ventilated by five Air Controlled Recirculation Ventilation Units (A.C.R.U.) mounted on the walls. Each unit contained a 500mm propeller fan (Woods) delivering $2.12m^3/s$ at a fan pressure of 50 Pa. The ventilation incorporates a proprietary air recirculation and delivery system. The thermal insulation was poor. Two $1m^2$ celluar pads were fitted to the air inlet sides of these units using tapered wooden ducts.

Water was supplied to the system from a 250l tank via a pump delivering 60 litres/min. A water bleed off equivalent to 10% of the capacity of the pump was recommended to prevent the build-up of mineral deposits in the pipes and pads.

Control

Control of the system was by a single stage thermostat that sensed the temperature in the centre of the building at a height of 1m. The thermostat was set to switch on the water pump feeding the coolers at 22°C.

Results

The amount of cooling available from the system at various temperatures is represented in fig 3. Cooled inlet air temperature is plotted against the ambient air temperature. The 'no cooling line', indicates the relationship with no evaporative cooling system (a straight line with equal 'x' axis and 'y' axis values). The curved line indicated the effect of cooling. As the ambient temperature rises, the effect of the evaporative cooling becomes greater. It can be seen that for an ambient temperature of 24°C the air temperature entering the building was approximately 20°C.

Figure 4 shows the effect of evaporative cooling on building humidity in the evaporative cooled house compared to an adjacent building without evaporative cooling at different ambient conditions. During the night when the cooling is not required the humidities of the two houses are very similar and ar well below the ambient relative humidity. During the day however when the cooling is on, the humidity rises in the cooled house compared with the non-cooled house, but never more than 15% higher. It is interesting to note that the %RH of the cooled house during the periods of evaporative cooling (day time) remain substantially lower than the humidities in the house during the night time when the evaporative cooling is not working.

The graph in Figure 5 covers two days near then end of the broiler growing period. The temperature monitoring shows the effect of cooling on the incoming air temperature. Note the temperature depression during the day time when the cooling is in operation.

Conclusions

The results of this study can be concluded as follows:

1. Evaporative cooling using a cellular pad system can reduce air inlet temperatures by an average of 4°C for an ambient temperature of 24°C . This reduction increased to as much as 7°C at higher ambient temperatures.
2. House humidities during periods of evaporative cooling increased but still stayed considerably below night time levels when no evaporative cooling was taking place. Such a system should not therefore contribute to wet litter problems.
3. There is a considerable period of time when ambient air temperature is above 19°C and cooling could be used. During these times cooling can give financial benefits in terms of reduced mortalities and better bird performance.
4. Bird welfare can be improved by the adoption of an evaporative cooling system.
5. If an evaporative system was chosen for a new building the number of fan units installed could be reduced compared with a conventional ventilation set-up. On the basis of the test report, a reduction in fan numbers of at least 30% could be considered, without any detriment to cooling performance. The saving in fan installation cost could be set against the installation cost of the evaporative cooling system. The evaporative cooling based ventilation system would have lower electricity running costs because of the reduced number of fans.