Energy-efficient heating in poultry sheds

The main heating technologies used in poultry sheds are radiant and air heaters. Various factors need to be considered in determining the most effective and efficient technology for poultry sheds. Assuming similar combustion efficiencies within heaters, radiant and infra-red technologies will have inherently lower energy costs and may be 15 to 30 percent more efficient than brooder heaters. Alternative heating technologies, while less commonly used in poultry sheds than radiant and air heaters, may also be worth considering.

Introduction

Heating within poultry houses or sheds is a critical part of the process to ensure bird health, maximum chicken growth and minimum energy consumption. As such, the cost of heating a poultry shed represents a significant proportion of your total poultry-shed energy cost.

A wide range of technologies is available for heating in poultry sheds. There are a number of advantages and disadvantages to each type of equipment, and poultry producers need to consider many factors prior to investment, including capital costs and operating costs, access requirements, heat output, heat distribution and unit distribution/placement (Czarick, 2008).

While heater selection is critical to maximising poultry-shed energy efficiency, heater demand (heat load) and the unit's operation (control and maintenance) will also have significant impacts and should be considered accordingly (Czarick, 2005).

Technical factors

Modes of heat transfer

There are three fundamental types of heat transfer.

- **Conduction:** the transfer of heat via physical contact, without appreciable displacement of particles.
- **Convection:** the transfer of heat from one point to another via mixing of one portion of a fluid (liquid or gas) with another. Convection can be natural (i.e. motion caused by differences in density resulting from temperature differences) or forced (i.e. motion produced by mechanical means).
- **Radiation:** the transfer of heat from one body to another not in contact with it by means of wave motion through space. An example of this is the radiation given off by the sun.

All three modes of heat transfer may occur at the same time.

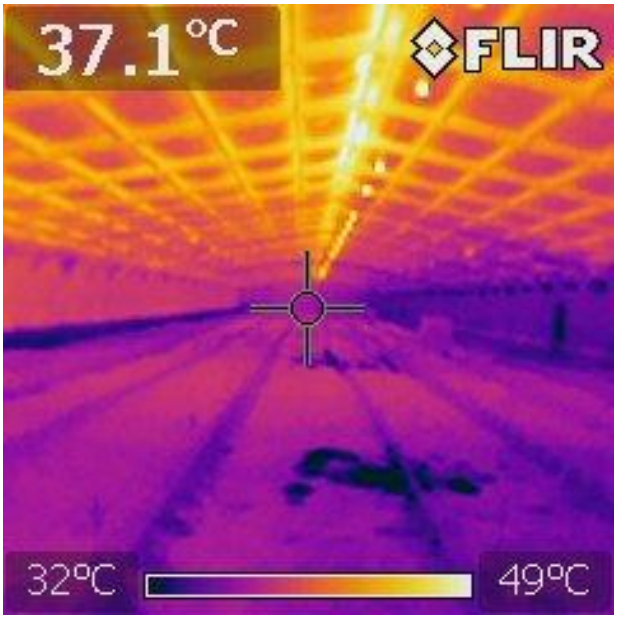

Figure 1: This infrared photo of a poultry shed demonstrates temperatures within the building. The lights are the hottest items in the shed, at 49 degrees Celsius, while areas of the floor are 32 °C. The air temperature within the shed is approximately 37.1 °C. The shed is in the process of being heated for a new batch of broiler chicks (Image: NSW Farmers 2013, using a FLIR i-7 thermal imaging camera).

Heat load

The 'heat load' within a poultry shed is the rate of energy input (heating) and removal (cooling) required to maintain desired internal conditions. Heat load will be a function of a number of factors. These include:

- **Desired internal conditions.** The temperature at which intensively-housed mature chickens perform best is between 17 °C and 27 °C (Former, 2003). This temperature will vary depending on the age of the chickens.
- **Ambient conditions.** The temperature difference between ambient conditions and desired internal conditions will drive conduction through the poultry shed walls and roof, and will introduce a heating or cooling load through ventilation and infiltration. Although desired internal conditions cover a wide range of temperatures, a poultry farm located near Newcastle would have experienced (dry bulb)

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temperature outside of these bounds 40 percent of the time in 2012 (Bureau of Meteorology, n.d.).

- **Internal heat load.** Internal heat load results will predominantly from the birds themselves, as well as from internal lighting.
- **Infiltration.** Air leakage and moisture migration will also have an impact on heat load.

If the aggregation of all the factors contributing to heat load within a shed is less than the heat loss from that shed, and the internal temperature is below the desired bound, heating will be required. Similarly, cooling will be needed if the aggregation of all factors contributing to heat load within a shed is greater than the heat loss from that shed and its internal temperature is above the desired bound.

Technology options

Forced-air furnaces or convective heaters

Forced-air furnaces or convective heaters heat air to be distributed (i.e. blown via mechanical means) throughout the poultry shed. Air heating can be done directly (gas combustion within the furnace) or indirectly (external water heater and internal hot water coil). The air circulated from the convective heater delivers heat to the chickens typically via forced convective means.

Figure 2: Indoor forced-air gas heater (left) and an infra-red image of a perforated heat distribution duct from an external gas heater with additional back-up radiative heaters (right) (University of Georgia, 2009).

Radiant brooders – some varieties are also called circular or 'pancake' brooders due to their shape – typically combust gas to create radiant surfaces (hot objects such as disks, tubes, angled reflectors) suspended above the poultry shed floor. These hot objects radiate heat toward the chickens and floor to provide the required heating. Radiant energy, in the form of infra-red radiation, turns into heat in an absorbent body. Air coming into contact with hot surfaces will be heated and create convective plumes above the unit. Reflectors are aimed so as to direct the majority of their heat down onto the shed floor, however. Brooders are usually self-contained, and are used in applications where flammable gases or vapours are not typically present, as combustion occurs within the same space.

Figure 3: Radiant gas heaters, or 'brooders'. From (Owens & Ray, 2013) and (GSI Inc.).

Unlike radiant brooders, radiant tube heater burners are enclosed, and not exposed directly to shed air. Air is drawn into the combustion chamber (firebox) and pushed through the tube, which radiates heat. Heat is directed toward the floor (and the birds) through the application of reflectors.

Radiant tube heaters produce a relatively large amount of radiant heat compared to that emitted by other radiant heaters due to the size of the radiant surface, which is heated by a gas flame.

Figure 4: Figure Examples of radiant tube heating; note that the combustion chamber (burner or firebox) is the box at the end. From (GSI Inc.) and (Owens & Ray, 2013).

Some radiant heaters incorporate burners and reflectors to produce heating patterns favourable to the rectangular orientation of most chicken sheds. Ultimately this will reduce the number of heaters required and hence the total costs.

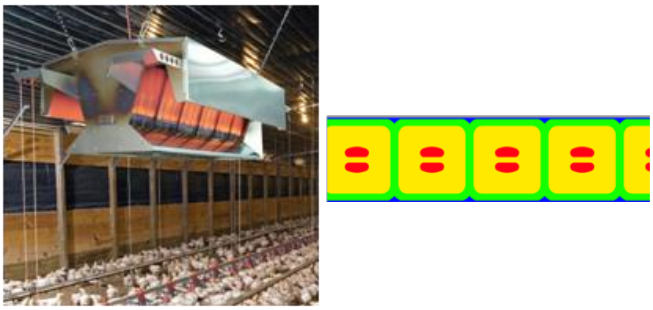

Figure 5: Shenandoah Generation 2 Quad-Glow radiant gas heater and its heating pattern (at floor level) (Shenandoah Corp., n.d.).

Some sources suggest that radiant brooders are between 15 and 30 percent more efficient than other types of heating. (Czarick, 1997).

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Alternative heating options

Usually, alternative heating sources are classified into hot water-based or hot air-based alternatives. Examples of alternative heating systems include:

- **Solar hot water systems.** These systems can be used in conjunction with gas- or electric-boost to generate hot water that can then be provided to convective heaters. Having a solar hot water system will reduce your gas consumption; however, hot air distribution is still via convective means. Refer to supplementary paper, *Solar hot water.*
- **Biomass.** Biomass-fuelled heaters typically burn wood pellets or woodchips, delivered from a nearby hopper, in order to produce the required heat. These units pull air from the poultry shed, heat it, and return it to the shed via ductwork to eliminate short cycling. Drawbacks associated with this type of system include reliability of supply and ongoing maintenance.
- **Ground or air-source heat pumps.** Heat pumps are devices that transfer heat from a source to a sink in the opposite direction to that of spontaneous heat flow. An external energy source is used to achieve the transfer of thermal energy from source to sink. The most common type of air-source heat pump is similar to compressor-driven air-conditioning units, which transfer (pump) heat from air to air. There are also air-to-water air-source heat pumps, which deliver heat to water. Ground-source heat pumps transfer heat from the ground to the air or from ground to water.
- **Underfloor heating.** Underfloor heating systems rely on conduction, radiation and convection as their means of heat transfer. Underfloor heating systems are either electric systems (utilising underground electric heating elements) or hydronic systems (utilising underground pipes for heat transfer). Hydronic systems can provide both heating and cooling, but require an external boiler and cooling unit, respectively, to do so. The overall efficiency of hydronic systems can benefit from waste heat from other on-site services. These systems are often inadequate for providing all the chickens' heating requirements.

Figure 6: Biomass alternative heating system (University of Georgia, 2009).

Figure 7: Biomass heating, including fuel (Czarick, 2008).

Other opportunities to consider when seeking to reduce the cost of poultry-house heating (Czarick, 2004) include:

- **minimising air leakage through sealing cracks** in side and end walls and roofs – so for houses with open-truss ceilings, ensure that the roof ridge cap is well sealed; if your poultry shed has side-wall curtains, investigate the option of using (insulated) tunnel doors,
- **reviewing the location of thermostats** to ensure that these are located appropriately,
- **installing well-sealing brooding curtains** to minimise heating requirements if the shed contains chickens of different ages that require varying thermal conditions,
- **minimising over-ventilation**, understanding that there is likely to be a balance between indoor air quality (CO_2, odour, moisture) and heating and ventilation costs,
- **monitoring variables affecting energy use**, such as ventilation fan static pressure, relative humidity, tunnel air velocity and temperature stratification,
- **monitoring the energy use itself** in order to highlight abnormal rates of consumption,
- **maximising insulation** to reduce heat transfer (i.e. heat gain in summer and heat loss in winter), and
- **inspecting heating equipment** regularly for signs of inefficient operation.

Evaluating quotes

Key considerations to be made when evaluating quotes for heating systems for poultry sheds include:

- the cost of gas,
- gas consumption,
- capital cost per heater unit,
- installation cost per unit,
- the number of units required (total cost),
- heat distribution (development of 'hot spots'),
- access and maintenance requirements and their associated costs, and
- overall heating system efficiency.

Assuming similar combustion efficiencies within heaters, radiant and infra-red technologies will have inherently lower energy costs. Analysis suggests that sheds with radiant tube heaters installed are more cost effective and efficient than sheds with brooder heaters (Czarick, 2005).

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Further information

NSW Department of Primary Industries > Agriculture > Livestock > Poultry
General information on poultry practices and regulations in NSW.
www.dpi.nsw.gov.au/agriculture/livestock/poultry

NSW Department of Primary Industries
DPI newsletter, *The Drumstick.*
www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/467932/The-drumstick-newsletter-autumn-2013.pdf

Valco
Information on gas-fired infra-red heating for poultry houses.
www.val-co.com/pdfs/products/Poultry/Climate_Control/VAL-CO_Guide_to_Infrared_Heating.pdf

Field report regarding radiant tube heaters for poultry houses
An in-depth report comparing infra-red radiant heaters to forced air heaters.
www.aces.edu/dept/poultryventilation/documents/RadiantTubeHeatPaper.pdf

Poultry Science Journal
ps.fass.org

University of Georgia Poultry Housing Tips
www.poultryventilation.com

Louisiana State University Agricultural Centre – Hill Farm Research Station
www.lsuagcenter.com

United States Department of Agriculture Research, Education & Economics Information System
www.reeis.usda.gov

United States Department of Agriculture National Institute of Food and Agriculture
www.usda.gov

References

Bureau of Meteorology, n.d. [Online]
Available at:
www.bom.gov.au
[Accessed 2013].

Czarick, M. &. F. B., 2004. Keeping poultry house heating costs to a minimum. *Poultry, environment & energy conservation poultry housing tips Vol. 16(10)*.

Czarick, M. &. F. B., 2005. The best way to cut heat costs is not to change your heating system. *Poultry environment & energy conservation poultry housing tips, Vol. 17(13)*.

Czarick, M. &. L. M., 1997. Reducing broiler house heating costs. *Poultry environment & energy conservation poultry housing tips Vol. 9(2)*.

Czarick, M. D. D. &. F. B., 2008. Alternative heating systems: an overview. *Poultry environment & energy conservation poultry housing tips, Vol. 20(14)*.

Former, I., 2003. *Infra-red brooding of intensive livestock,* s.l.: NSW Department of Primary Industries.

GSI Inc., n.d. [Online]
Available at:
www.gsiag.com
[Accessed January 2014].

Owens, W. E. & Ray, C., 2013. *Tube heater evaluations at the Hill Farm poultry demonstation houses.* [Online]
Available at:
www.lsuagcenter.com/en/communications/publications/agmag/Archive/2013/Winter/Tube-heater-evaluations-at-the-Hill-Farm-poultry-demonstration-houses.htm
[Accessed November 2013].

Shenandoah Corp., n.d. *Shenandoah Quad-Glow Heater.* s.l.:s.n.

University of Georgia, 2009. *Poultry Housing Tips: Hot Air Alternative Heating System Study – Hot Air Distribution.* [Online]
Available at:
https://www.poultryventilation.com/tips/vol21/n2
[Accessed November 2013].

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