EFFECTS OF MIST COOLING A BOAR STUD UNIT

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Abstract
A high pressure mist cooling system was installed in a Prairies boar stud unit to reduce the effects of heat stress on the boars. Misters were mounted in front of the air inlet system to provide cooling of fresh air into the facility. Monitoring was done during the summer of 2005 to determine the impacts on temperature, humidity and black body effects from the misting system. The data showed temperature reductions in the room when the misters were operating. Room temperatures were generally held below 26C when the misters were operating except during extreme hot temperatures with humid conditions. The misters lowered room temperatures versus outdoor temperatures by as much as 4.5C.
Effects of Mist Cooling A Boar Stud Unit

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ABSTRACT
A high pressure mist cooling system was installed in a Prairies boar stud unit to reduce the effects of heat stress on the boars. Misters were mounted in front of the air inlet system to provide cooling of fresh air into the facility. Monitoring was done during the summer of 2005 to determine the impacts on temperature, humidity and black body effects from the misting system. The data showed temperature reductions in the room when the misters were operating. Room temperatures were generally held below 26C when the misters were operating except during extreme hot temperatures with humid conditions. The misters lowered room temperatures versus outdoor temperatures by as much as 4.5C.

INTRODUCTION
Research has shown that heat stress in large pigs can severely affect feed and water intake, respiratory rate, feed conversion, and rate of growth. Lopez et al. (1991) found a 16.3% lower rate of weight gain and a 10.9% reduced feed intake of pigs raised in temperatures of 22.5 to 35C versus pigs raised at a constant temperature of 20C. Research on eating behaviour by Nienaber et al. (1997) found the average daily feed intake was less for heat stressed animals and was dependant on meal size as the number of daily meals was not different from controls. Brown-Brandl et al. (1997) monitored high-lean growth barrows (83.5 kg) at treatment temperatures of 18, 24, 28, or 32C for a period of 22 hours. Feed intake decreased at both 28 and 32C while water intake increased only at 32C. Respiration rate increased exponentially with increasing temperature above 18C. Nienaber et al. (1997) determined effects of heat stress are much greater on high-lean-growth finishing pigs versus moderate-growth pigs. The threshold temperatures at which growth rate of stressed animals would equal unstressed animals was calculated. For example; high-lean-growth pigs weighing 90 kg had a threshold temperature of 23C while moderate-growth pigs was 29C. Sibblies et al. (2005) found that heat stressed boars exposed to 34C and 31C for 10 days had a significantly lower number of spermatozoa and sperm viability versus control boars held at 24C and 21C. Her results indicated that semen from heat stressed boars have reduced fertilizing capabilities and an inability to be stored for use in AI.

Water based cooling systems have been proven to greatly reduce the detrimental effects of heat stress on large pigs. Bridges et al. (1997) evaluated the economic returns of investing in a misting-cooling system for growing-finishing swine. The returns varied from $0.49/pig to $3.40/pig depending on the severity of the weather year and the starting date in the facility. The use of a misting-cooling system reduced the time of growth to market and produced a pig with less backfat. Baccari et al. (1997) conclude that water
cooling was a good means of alleviating stress and improving the performance of gilts in severely stressing environments. Water cooled gilts exposed to temperatures of 35.8°C had a lower respiratory rate (84 vs. 109 bpm), rectal temperature (39.7 vs. 39.9°C), higher feed intake (1.95 vs. 1.73 kg/day) better feed conversion (67% less feed/gain), and gained 0.35 kg more per day versus non water cooled gilts.

It is expected that animals in a swine boar stud operation are similarly adversely affected by heat stress effects. The objectives of this study were to determine the reduction in dry bulb temperature of a high pressure mist cooling system in a boar stud unit.

**BOAR STUD UNIT**

A sectional schematic of the boar stud unit is shown in Figure 2. The boar stud room is a single room with a scissor truss type design. Air inlets are located along both sides of the room and ventilation chimney fans are located along the centre of the room. The roof sheathing is uninsulated galvanized steel.

**COOLING SYSTEM**

A high pressure mist cooling system by MEC Systems Inc. was installed. The system provided a maximum of 1,000 psi water with four step filtration for maximum particle removal as shown in Figure 1. Stainless steel mister nozzles and water line were installed in front of each air inlet as shown in Figures 2, 3 and 4 to cool the air coming into the building.

Each nozzle has a water flow rate of 0.0235 gpm US @ 1,000 psi. The total system provided about 0.4 gpm US per 100 boars when operating. The purchase cost of the system including filtration and water softener was approximately $30/boar. On-site installation was by management.

**MONITORING**

Monitoring was done during the summer of 2005 using data loggers at various locations as shown in Figure 2 to measure temperature and relative humidity. All data loggers were Hobo H8, recording at 10 minute intervals (except for local airport weather data, which is one hour intervals).

**Dry bulb temperature:**

- Logger #1 & 3 located in the attic prior to air inlet (note: inlets are located around the perimeter of the facility on the two sides).
- Logger #2 located in the centre of the attic, about 4’ off the insulation.
- Logger #5 located in the room at the control sensor (near center of the room).
- Outdoor temperatures from a local airport

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1 Mention of any product by trade name is not an endorsement
Black body temperature:
- Logger #4 incorporated a black body sensor placed in the room near pig level to determine black body effects from warmer than ambient surfaces, particularly the ceiling.

Relative humidity:
- Logger #5 located in the room at the control sensor. This logger monitored both temperature and relative humidity.
- Outdoor relative humidity from a local airport.

Mister operation:
The mister was operated according to rising indoor temperatures. Two stages were used depending on the indoor temperature.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Set Point Temperature</th>
<th>On-Time (seconds)</th>
<th>Off-Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>23°C</td>
<td>120</td>
<td>240</td>
</tr>
<tr>
<td>HIGH</td>
<td>25°C</td>
<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

RESULTS

Figure 5: Air temperatures – attic/room/black globe
Figure 5 shows all of the monitored temperatures. The mister operation is also shown as OFF/LOW/HIGH by the steps at the bottom of the graph. There are several items of interest here:

- Attic Temperatures: Locations #1 & #3, in the attic above the air inlets, show the highest measured temperatures. The thermal effects of the sun shining on the roof are apparent during sunny days as indicated by location #1 (south side) showing higher temperatures when the sun is shining. This indicates that the roof/sidewall is acting like a solar collector and preheating air prior to entry into the barn.
- Black Globe Temperatures: The black globe temperature is an indicator of the temperatures caused by radiant effects of the surroundings and provides a good value of what radiant heat influences could impact the pigs. This temperature was usually cooler than the ambient room temperature for the majority of the time, indicating the radiant affects from cooler surfaces such as the floor were larger than those from warmer surfaces such as the warm ceiling. As a result, the structure had little negative impact in terms of radiant heat impact on the pig comfort level.
Figure 6: Air temperature & RH – attic/sensor
Figure 6 shows the air temperatures for location #3 (side attic) and the ventilation control sensor, along with relative humidity. Items to note include:

- Room Relative Humidity: The room RH is generally within the 60-90% range except for a period of several days on 09-Jul and 10-Jul in which the RH was close to 100%. This period is shown as “A” & “B” on the graph. This was a very hot and humid time when the nighttime temperature stayed exceptionally warm (around 25°C). There were thunderstorms throughout the early morning and all day of the 11th. The mister operated on HIGH for almost a day and a half solid. This was the only time for the entire monitoring period that this high night temperature occurred.

- A number of periods with the higher humidity above 90% occurred during the night when the mister was either not operating or was running on LOW.

Figure 7: Air temperatures – attic/outside/room
This figure shows a close-up of the attic, outside and room temperatures from Figure 5. Items to note include:

- SideAttic#3: Maintains closer temperatures to outdoor with the exception of a temperature spike between 7:30 and 9am. The sun hits this portion of the roof during this time period and warms up the roof and inlet air.

Figure 8: Air temperature differences
Figure 8 shows the temperature difference in the room versus the attic and outside. The attic temperature shown is the average of both sides and the outdoor temperature. During typical day-time hot weather periods, the cooling system decreases incoming air by as much as 4.5°C from outside temperatures.

Figure 9: Relative humidity – outside & room
Figure 9 shows both the indoor and outdoor relative humidity. Outdoor ambient humidity for the period from July 9 – 11th were unseasonably high. This period shows daytime outdoor temperatures up to 32°C with outdoor humidity between 60 – 75%. Bennett (2003) shows 10-yr average humidity at slightly below 50% for this temperature. Relative humidity inside the room were generally 20% higher than outside ambient, a reflection of the moisture load from the pigs (respiration, dunging, water spillage, etc.), washing etc. plus the misting system.
CONCLUSIONS

The data shows a clear temperature reduction in the room when the misters were operating. Room temperatures were generally held below 26°C with the misters except during extreme hot temperatures with humid conditions. The misters lowered room temperatures versus outdoor temperatures by as much as 4.5°C and attic air temperatures by as much as 8°C.

The air intakes appear to be increasing the temperature due to system design. Corrections to achieve ambient outside air temperature and eliminate the solar effect of the galvanized roof would also decrease the average room temperature.

REFERENCES


Figure 1: Cooling System Filtration

Figure 2: Barn Section Schematic
Figure 3: Nozzle & Water Line In Front of Inlet

Figure 4: Row of Nozzles In Front of Inlets
Figure 5: Air Temperatures – Attic/Room/Black Globe

Air Temperatures
Attic/Room/Black Globe

Date/Time

Temperature (°C)

#1(Side Attic)
#2(Centre Attic)
#3(Side Attic)
#4(Blk Globe)
#5(Control Sensor)
Mist
Outdoor(°C)

Boar Stud
Mist Cooling

Thunderstorms

Sunny

Mostly Cloudy

Mostly Cloudy Then Clear

Thunderstorms

Mostly Cloudy

Period of sun vs period of cloud (same outdoor temperature)

Period of sun vs period of cloud

Then Clear

Period of sun vs period of cloud (same outdoor temperature)
Figure 6: Air Temperatures & RH

![Air Temperature & RH Graph](image-url)
Figure 7: Air Temperatures – Attic/Outside/Room

![Air Temperatures Graph]

- **Air Temperatures**
- **Attic/Outside/Room**

- **Boar Stud Mist Cooling**

- **Date/Time**
  - 7/7/05 0:00
  - 7/8/05 0:00
  - 7/9/05 0:00
  - 7/10/05 0:00
  - 7/11/05 0:00
  - 7/12/05 0:00
  - 7/13/05 0:00
  - 7/14/05 0:00

- **Air Temperatures (°C)**
  - 0
  - 5
  - 10
  - 15
  - 20
  - 25
  - 30
  - 35
  - 40
  - 45

- **Legend**
  - Outside
  - SideAttic#1
  - Mist
  - SideAttic#3
  - Room
Figure 8: Air Temperature Difference

Air Temperature Difference
From Area Indicated to Inside Room

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<th>Date/Time</th>
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</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

MIST (OFF/LOW/HIGH)

Boar Stud Mist Cooling

- OFF
- LO
- HIGH
Figure 9: Relative Humidity – Outside & Room

Relative Humidity (%)
Outside & Room

<table>
<thead>
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<th>3</th>
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<th>7</th>
<th>8</th>
<th>9</th>
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</thead>
<tbody>
<tr>
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<td>7/8/05 0:00</td>
<td>7/9/05 0:00</td>
<td>7/10/05 0:00</td>
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<td>7/14/05 0:00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mist (OFF/LOW/HIGH)