Maximizing bird cooling during hot weather

As long as we feed birds during hot weather we are going to have problems with heat stress...

Best way to remove excess heat from a bird is through air movement

Simmons & Lott 1981
Five pound bird 85°F

Broilers (85°F - 250 ft/min vs. 550 ft/min)

Body temperature vs. Air speed
(individual bird at 85°F – Drury Siegel, 1968)
More air movement, more heat removal, panting rate decreases…

Respiration rate vs. Air speed
(individual bird at 85°F – Drury Siegel, 1968)

Air speed (ft/min)

0 50 100 150 200 250 300 350 400 450 500 550

80
70
60
50
40
30
20
10
0

Air movement and bird performance during hot weather

- The greater the amount of air movement, the greater the amount of heat removed, the better the performance.

High air speeds lessens the effect of high humidity

Air movement and bird performance during hot weather

Broilers

Broiler weekly weights
(77°F night – 85°F day)
There are specific reasons why large birds benefit most from high air velocities. First, it is not because they produce more heat per pound of body weight... In fact, they produce less heat per pound. But, there does tend to be more heat production per square foot of floor space. More pounds per ft² = more heat per ft². There are a couple of other reasons why large broilers require more air speed....
This brings us to a very important point...

- All the air speed in the world does little cooling if the birds are packed together.
- Bird cooling is determined as much by how much a bird’s surface area is exposed to air movement as the amount of air movement.

We must keep the birds spread out to maximize air movement over bird surfaces.

Very low density
(85°F air temperature – 450 ft/min)

Moderate density – same house
(85°F air temperature – 450 ft/min)
High density – same house
(85°F air temperature – 450 ft/min)

Density differences = Temperature differences

High bird densities also lead to high floor temperatures

Floor temperatures and bird density

Floor temperatures and bird density

We must keep birds uniformly distributed by installing fences...
When they are young…

Ideally one for every 100’ of house length

Water meters should be used to determine if the birds are uniformly distributed

Water consumption

How much air speed should a house have if we are growing a large broiler?

- Depends to a large extent on density.

- But strictly from a bird cooling standpoint you really can’t have too much:
  - 600 ft/min (minimum)
  - 700 ft/min?
  - 800 ft/min?
  - Higher?

- But it is important to realize that…
High air speeds = High cost
(broilers, breeders, commercial layers)

- A higher cost than many people realize…

Total tunnel fan capacity

- 1990 the typical 40' X 500' house had a little over 7 cfm per square foot of floor space to obtain an air speed of 375 ft/min (true average)

- Today to obtain 550 ft/min the same house requires 10 cfm per square foot of floor space

Fan power usage

- Typical 48" fan in 1990 used about 1,000 watts of power.
  - 0.4 watts per square foot to obtain 375 ft/min

- Today a typical high capacity 54" fan uses over 1,500 watts of power
  - 0.6 watts per square foot to obtain 550 ft/min

Evaporative cooling system water usage

- A fogging system in 1990 tunnel house would use between 3 and 4 gals/min

- Today with an air speed of 550 ft/min a house's evaporative cooling pads could use over 9.5 gals/min.

Today there is growing interest in even higher air speeds...

- 600 ft/min
- 700 ft/min
- 800 ft/min?

Obtaining these higher air speeds is more difficult/expensive than many realize

For instance…What does it take to obtain an air speed of 700 ft/min?
50’ X 550’ broiler house

- 50’ X 550’ with 9.25’ average ceiling height
- Cfm = air velocity X house cross-sectional area
  - = 700 ft/min X (9.25’ X 49’)
  - = 317,000 cfm

How many fans?

- Choretime – 52” high capacity
- 0.05” = 29,100 cfm
- 0.10” = 27,300 cfm
- 0.15” = 25,000 cfm
- 0.20” = 22,700 cfm
- 0.25” = 20,200 cfm
- 0.30” = 17,000 cfm

How many fans?

- # of Fans = Total cfm/fan cfm
  - = 317,000 / 27,300
  - = 11.6 fans

  To be safe let’s put in 13… which should increase the air speed to approximately 810 ft/min!

How much pad area?

- Pad area = total cfm @ 0.05” / 350
  - = 317,000 / 350
  - = 1,080 square feet

- Pad length = Pad area / Pad height
  - = 1,080 / 4.7’
  - = 230 linear feet
- Or
  - = 115 feet per side
  - Let’s put in 120’ to be safe

Would we get the air speed/bird cooling we designed for?

Tunnel ventilation system performance study (broilers, breeders, layers)

- Funded by USPAE, Choretime
Measuring house air speed

- 15 anemometers on 5 poles (3 anemometers per pole)

Data loggers record average air speed every minute for 20 minutes with different number of fans operating.

Anemometer poles

- Allows the determination of the air velocity profile and...
- The total amount of air moved by the tunnel fans

\[ \text{Cfm} = \text{velocity} \times \text{area} \]

550’ X 50’ Broiler House
Average air velocity Vs. Number of fans

<table>
<thead>
<tr>
<th>Number of fans operating</th>
<th>Average Air Speed (ft/min)</th>
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<tr>
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<td>12</td>
<td>600</td>
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<td>13</td>
<td>650</td>
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Average air speed across width of house

- Only around 100 ft/min variation across width of house
Broiler house – little side wall friction

Breeder house – very high side wall friction

Broiler house vs. Breeder house

The difference in side wall friction is very important for two reasons...

Centerline velocities can be deceiving in houses with rough side walls

Side wall friction has an effect on the profile as number of fans operating increases
Air velocity uniformity

- Smooth walled houses
  - As fan numbers increase air velocity across the width of the house increase uniformly.
  - Increasing the number of fans operating from 7 to 13 increased air velocity at the side walls and the center of the house 375 ft/min.

- Houses with smooth walls
  - As fan numbers increase air velocity across the width of the house increase uniformly.
  - Increasing the number of fans operating from 7 to 13 increased air velocity at the side walls and the center of the house 375 ft/min.

- Houses with rough walls (breeder house)
  - As fan numbers increase air velocity in the center of the house increases much more rapidly than on the side wall.
  - Increasing the number of fans operating from 6 to 9 increased air velocity at the center of the house by 150 ft/min and only 50 ft/min at the side wall!

Broiler wind-chill chart (air temperature = 85°F)

Low slat velocity results in significantly hotter birds...

- Lower wind chill effect...
- Lower air exchange rates...

Scratch area
This will tend to occur in all houses with rough side walls...not just breeder houses.
What happens when the side wall is smoothest location in the house?

Inside aisle – cages on both sides of aisle
Outside aisle – cage on one side of aisle

Commercial layer house (highest air velocities in outside aisles)

There are also differences in the amount of friction – floor vs. ceiling

Average air speed vs. Height

Floor friction changes with light intensity
Without and with birds present

Air velocity in the broiler house was lower than expected...

Measured the static pressure to determine why...

- At controller = 0.135"
- At the fans = 0.17"

Then the static pressure was measured at:

- Pad
- Total tunnel inlet
- ¼ house
- 20’ past half house curtain
- ¾ house

Static pressure change down the length of the house

What are we really doing when we measure static pressure in a tunnel house?

- Basically what we are measuring how much work it takes the fans to move the air from outside to where you are standing inside the house.
½ house pressure measurement

- It is the total of the amount of work it takes to…
  - Pull the air through the pads
  - Then through the tunnel doors
  - Into the cross-section of the house
  - Then down ½ way the house.
- Each action requires work (measured in pressure) of the fans

Static pressure

40" tunnel door opening on 5' tall pad

Transition area...

- Pad area is much larger than the cross-sectional area of the house.
  - To obtain more air speed we add fans...
  - We add more pad as we add fans….
  - But the cross-sectional area (pipe size) remains the same
- You are taking air from over 1,000 square feet of pad and cramming it into a 450 square foot pipe
Static pressure

When every a fluid flows down a pipe there is a resistance/friction.

In water pipes we use the following equation to determine how much work/pressure is required to move water through a pipe:

\[
\text{Loss} = \text{PSI Loss Value} \times \text{Pipe length} / 100
\]

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 PSI loss value table

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<th>1 1/4&quot;</th>
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How much work/pressure does it take...

To move water down a 500 long pipe at a flow rate of 5 gals/min?

Friction:

\[
\text{Loss} = \text{PSI Loss Value} \times \text{Pipe length} / 100
\]

\[
\text{Loss} = 0.8 \times 500/100
\]

\[
\text{Loss} = 4 \text{ psi}
\]
Poultry house is basically a pipe… and the same laws of physics apply

Do this large of a change in pressure occur in all houses?

- No… the large pressure changes primarily occur in high air velocity houses.
- Due to a law of physics discovered by Daniel Bernoulli in the early 1700’s
  - Pressure increases with the square of velocity
  - More simply put, if you double the velocity of a fluid in a pipe, the pressure/work required to move the fluid through the pipe or fitting increases four fold.
Similar things happen when a fluid flows through fittings...

- **90 degree elbow - 1” PVC pipe**
  - For instance, the pressure required to move water through a single 1” PVC 90 degree elbow at 5 gals/min. is 1.5 psi.
  - Double the flow rate to 10 gals/min. and the pressure required increases four fold to approximately 6 psi.

Water filters...
- Double the flow rate (5 vs 10 gals/min)....quadruple the pressure.

Tunnel ventilation
- Is nothing more than a pipe system with...
  - Pumps (fans)
  - Pipe (house)
  - Fittings (pads)

For instance, it takes work to pull the air through a pad

Pad pressure curve
(typical air velocity = 350 ft/min)
If we double the air speed through a pad (by installing half as much)

In the past air speeds were fairly low...static pressures were low

- Air speed through pad = 350 ft/min
- Relatively minimum pressure/work

 Pad pressure curve

In the past air speeds were fairly low...static pressures were low

- Air speed down the house = 375 ft/min
- Minimal transition pressure
- Minimal pipe pressure

"Transition and pipe" pressure curve (smooth wall broiler house)

Total pressure (measured at the fans)

- Pad pressure = 0.05"
- Transition and pipe pressure = 0.035"
- Total = 0.09"
New houses...

- Air speed through pad = 350 ft/min
  - Pad pressure has remained relatively minimal

- But tunnel air speeds have increased = 600 - 800 ft/min
  - High transition pressure
  - High pipe pressure
  - For example...

Tunnel air speed vs. Total static pressure

- 400 ft/min = 0.05" + 0.035" = 0.09"
- 500 ft/min = 0.05" + 0.055" = 0.11"
- 600 ft/min = 0.05" + 0.08" = 0.12"
- 700 ft/min = 0.05" + 0.105" = 0.16"
- 800 ft/min = 0.05" + 0.135" = 0.18"
  - This is for smooth walled houses, without tunnel doors, and clean pads
  - Realistically you would probably need one to two points of pressure to determine the true operating pressure.

Air velocity was lower than expected, because the static pressure was higher than expected.

High air speeds = High static pressure

You really can’t do much to reduce the static pressure the fans are operating against.
Adding pad will do little good...

To decrease static pressure by one point, pad area needs to be increased 15%.

Pad pressure is a small percentage of the total.

600' broiler breeder houses – no pads (600 ft/min)

0.15" pressure at the fans

Longer the pad the worse the dead spot becomes...even with tunnel doors

You can't avoid high pressures

- Remove tunnel doors?
  - Worse case scenario they are only adding a couple points of pressure...but they do help to minimize the tunnel inlet area "dead spot".

High air velocity = High static pressures

- If you want the cooling associated with the higher air speeds you need to determine the number of tunnel fans required based on a true operating pressure.
But, there is a limit to air speed you can obtain in a tunnel house...and we are almost there.

Something we are already seeing in some commercial layer houses...

NO pads...very “clogged” pipe
(Static pressure rise per 100’ of house length)

Commercial layer house

Upgrading to higher air velocities can be difficult because older fans may not work well under high static pressures...

50' X 500'
11 old 48” slant wall fans
1 new 50” Aerotech
2 old 36” fans

Average velocity = 350 ft/min
In the end...

- The existing fan capacity @ 0.15" = 145,000
- Additional fan capacity @ 0.15" required to obtain 600 ft/min = 120,000 cfm