



CHAM Limited

Pioneering CFD Software for Education & Industry

CHAM Case Study – Aviary Ventilation

Simulation of Ammonia Extraction from Poultry Farm

The case to be considered consists of an aviary house for breeding chickens. A great amount of ammonia builds up inside the structure which can affect the productivity of the facility and also the health of its workers.

The purpose of the simulation is two-fold. Firstly, to model the dispersion of ammonia in order to evaluate the effectiveness of the mechanical ventilation system (via the 8 central fans) as the concentration of ammonia inside the structure should be kept below 20ppm. A second aim is the thermal comfort of the occupants, by monitoring the temperature and humidity conditions within the aviary; again, with a view to improving productivity.

The conditions are defined as follows:-

Inlet – 50% Porous wall.

Outlet – 8 fans, centralised
on the rear wall

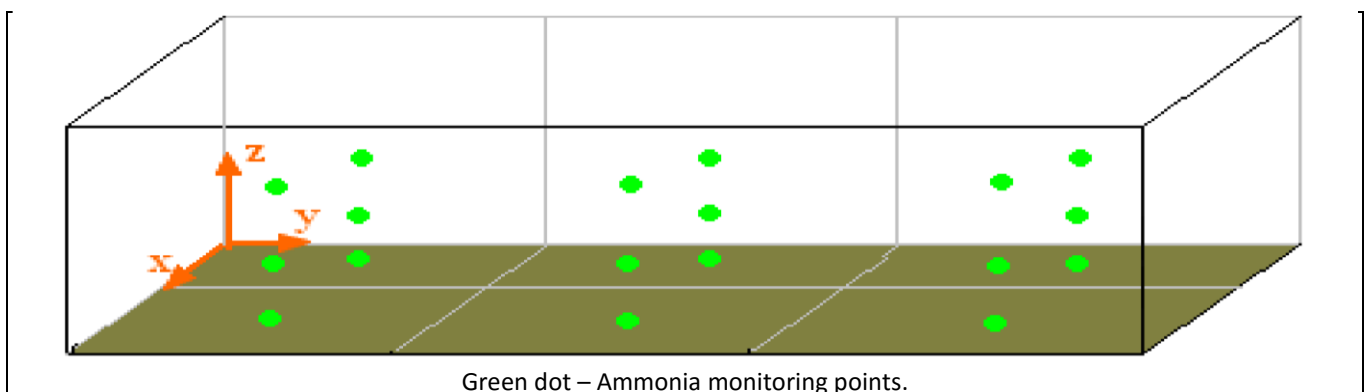


Figure 1 Geometry 90 x 22 x 3m



Figure 2 Porous wall (inlet)
Boundary Conditions

- XZ low – Inlet, 50% porous wall
- XZ high – Outlet, centralized Fans
- XY low – Ammonia release bed – 50 g/h
- XY high – ceiling, 0% porous
- YZ low – wall 0% porous
- YZ high – wall 0% porous

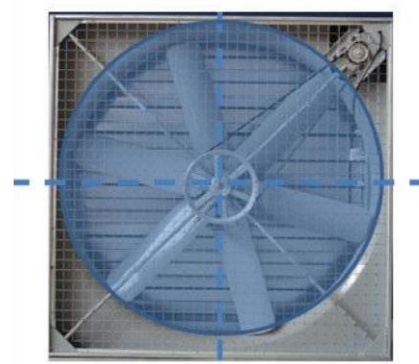
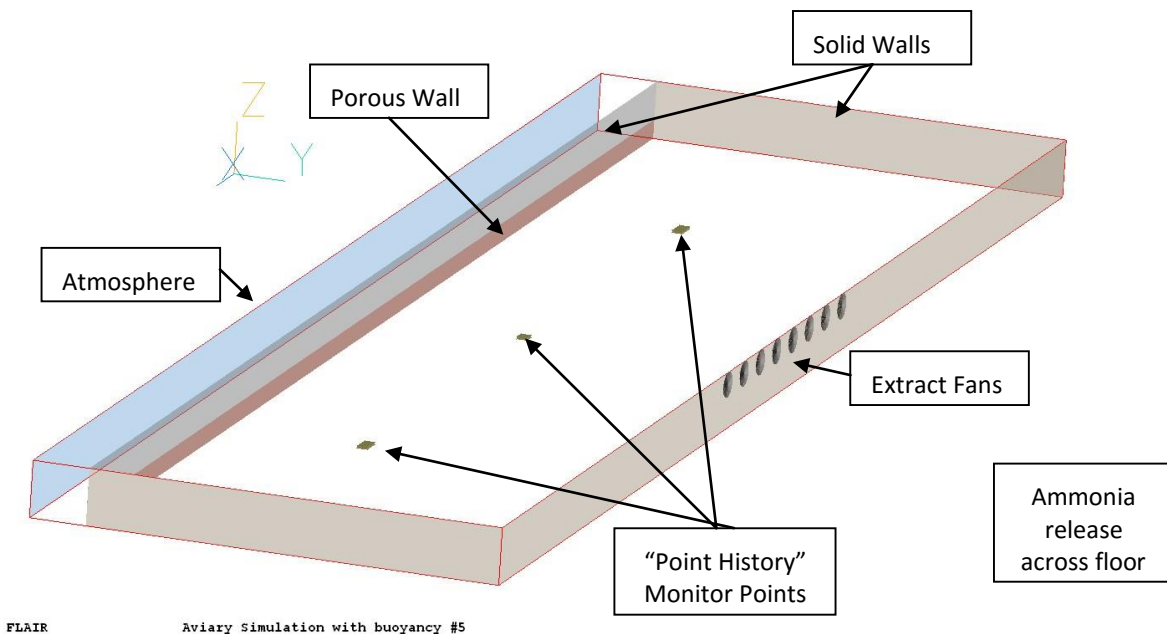
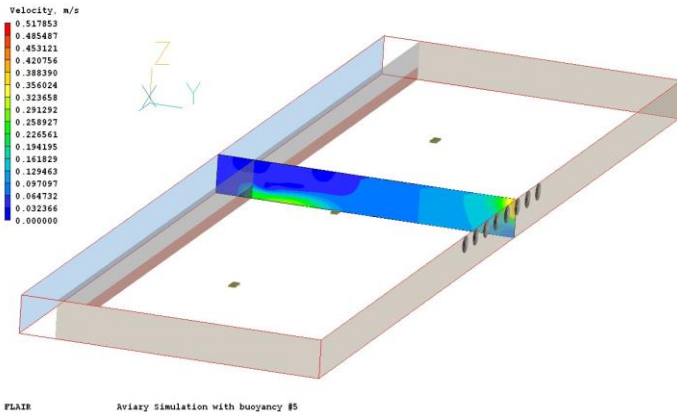


Figure 3 Fan – 1.3 x 1.3m



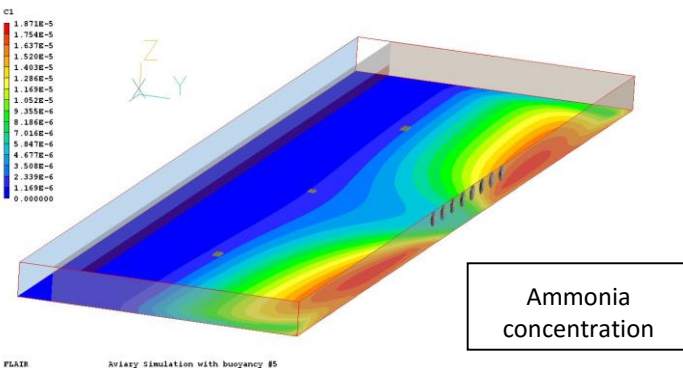
The ammonia release is the solution of a scalar, C1. The density is set to 'Ideal Gas, mixture gas constant' from Main Menu, Properties, Properties of current material (IDEAL_GAS, MIX_GCON). C1 represents the mass fraction of ammonia. The gas constants for air and ammonia are set to 287 and 488 respectively (Universal Gas Constant/Molecular Weight). Buoyancy is set using the 'Reference density' formulation. The reference density is set to that of air at ambient temperature and pressure.

The floor is an INLET, where the mass fraction of C1



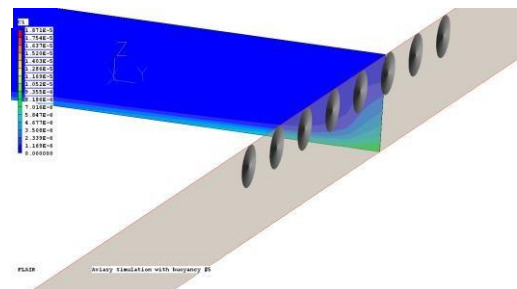
(ammonia) is 1.0. The mass flow rate is 50g/h, which is 0.0000138 Kg/sec. The porous wall is a PLATE with a porosity of 0.5, set a little way in from the edge of the domain. The pressure drop correlation is set Cross-sectional to 'CIBSE perforated plate', velocity which gives a quadratic loss coefficient of 4.

The atmosphere is represented as an OPENING on the edge of the domain next to the porous wall. The fans on the other side are all INLETS, with a negative velocity of 1m/s; ie extracting air from the domain. The other external walls are all PLATES.



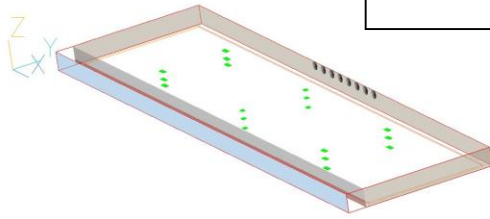
The concentration of ammonia in parts-per-million is specified via the INFORM (INput of FORMulae feature) as $PPM = 1E6 * density * C1$. As many "Point History" monitor points as are needed are located in areas of specific interest – in this case to assimilate data concerned with Ammonia concentration.

The temperature is also an important consideration. In this case, ambient conditions are defined as 20°C and the heat generated by the chickens set at 25°C.



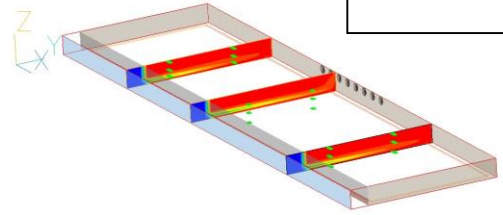
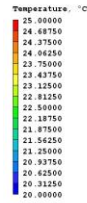


Geometry



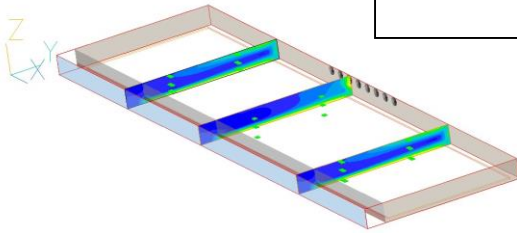
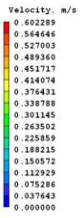
FLAIR Aviary Simulation with buoyancy #6

Temperature



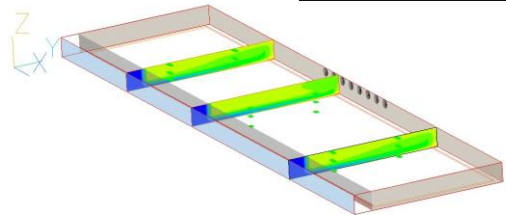
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Velocity

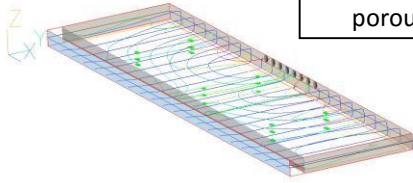
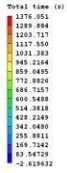


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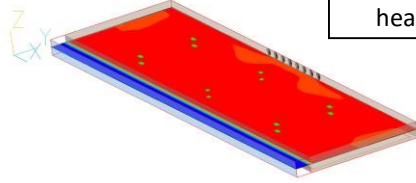
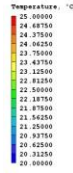
Ammonia concentration



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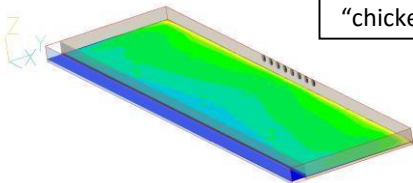
Streamlines from porous wall



Temperature - head height

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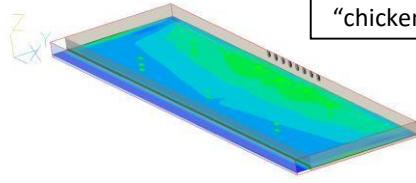
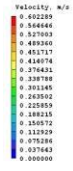
Aviary simulation with buoyancy #6



Concentration - "chicken" height

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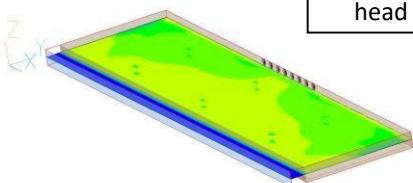
Aviary simulation with buoyancy #6



Velocity - "chicken" height

FLAIR

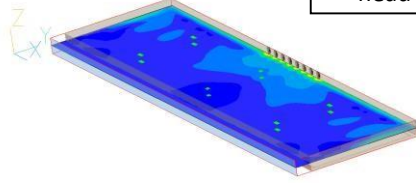
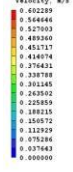
Aviary simulation with buoyancy #6



Concentration - head height

FLAIR

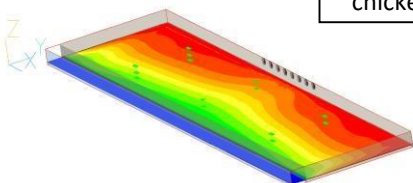
Aviary simulation with buoyancy #6



Velocity - head height

FLAIR

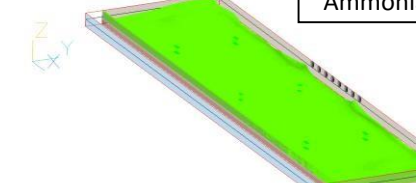
Aviary simulation with buoyancy #6



Temperature - "chicken" height

FLAIR

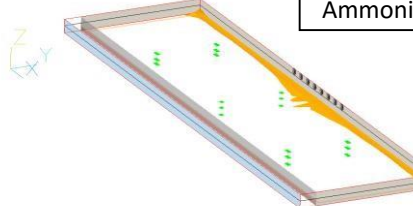
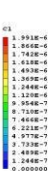
Aviary simulation with buoyancy #6



Iso-surface Ammonia @ 1ppm

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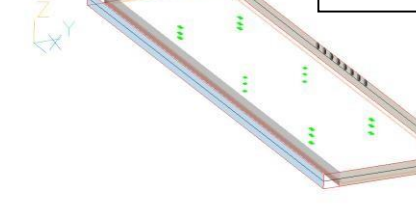
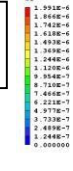
Aviary simulation with buoyancy #6



Iso-surface Ammonia @ 1.5ppm

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Aviary simulation with buoyancy #6



Iso-surface Ammonia @ 2ppm