Assessment of heat-stress conditions in naturally ventilated dairy cattle buildings

Applicant: Dr Thomas Bartzanas, Senior Researcher, Centre for Research and Technology-Hellas (CERTH)

Host: Prof. Thomas Amon**,** Leibniz-Institute for Agricultural Engineering Potsdam Bornim (ATB), Department of Engineering for Livestock Management

Rationale

Climate conditions within a livestock building affect animal health and welfare rate. Heat stress in dairy cattle is one of the leading causes of decreased production and fertility in cattle during summer months. Cows require additional energy to dissipate the heat and regulate body temperature. Heat stress has several serious and economically deleterious effects such as:

- Decrease in dry matter intake. Feed intake is reduced by 10 – 15% during periods of heat stress
- Decrease in milk production. As dry matter intake drops, so does milk production.
- Reduced fertility / reproduction. Relative studies in the literature have shown that the percent of inseminated cows that were confirmed pregnant dropped from 30% in winter to 10 to 15% in summer
- Reduce rumen efficiency. Recent research indicates that heat stressed cows have reduced rate of passage, lower rumen pH, higher rumen ammonia and change in volatile fatty acids
- Reduced butterfat production (%). Butterfat declines by up to 0.3% units during summer.

Heat stress is driven by four main climate variables: air temperature, relative humidity, solar radiation and air velocity. From the above-mentioned four variables temperature and humidity are more readily measured and thus more easily accessible that the other two. For this reason a common method of measuring heat stress has involved the development of a temperature-humidity (THI) index.

There are many ways to decrease the apparent effects of heat on dairy cattle. One of the most important points to consider is increasing air flow exchanges, a strategy which theoretically lead to a lower temperature and humidity, thus to a reduced THI. The majority of large dairy cattle livestock buildings using natural ventilation systems for air renewal. In that buildings the assessment of THI was realized by unique values of air temperature and air humidity usually measured in the centre of the building. However no climatological variable is homogeneous in large naturally ventilated buildings (NVB) but instead they are mainly governed by internal airflow, building structural specifications and cows activity. In NVB, the internal air flow patterns are primarily influenced by the prevailing flow conditions in the atmospheric boundary layer, as well as by local side specific factors like structural and management related conditions of the barn.

Materials and Methods

Experimentally it is very difficult to analyse airflow and associated microclimate patters in large ventilated buildings but it can be assessed using modelling techniques such computational fluid dynamics (CFD). Numerical techniques, like Computational Fluid Dynamic (CFD) can render efficiently and accurately the quantification of the variables compound the microclimate inside livestock buildings. Computational fluid dynamics is a simulation technique that can efficiently develop both spatial and temporal field solutions of fluid pressure, temperature and velocity, and has proven its effectiveness in system design and optimisation within the chemical,

aerospace, and hydrodynamic industries. Over the last decade CFD has found widespread use by agricultural engineers, because of the advent of cost effective computer hardware and high quality CFD software. Actual weather conditions and structural specifications could be simulated and changed in the CFD model while maintaining stable and intentical boundary conditions. Computational fluid dynamics simulations can be a valuable tool for analyzing the internal airflow and understanding the effects of the building structural characteristics with respect to ventilation.

Aim of the STSM

To assess, more efficient and accurate, the heat stress of dairy cows in large naturally ventilated dairy cattle buildings using computational fluid dynamic tools.

Host organisation

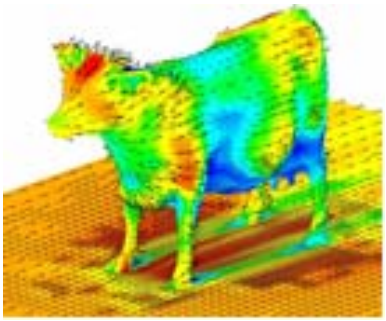
The host organisation has a series of experimental data of climate distribution in large dairy cattle buildings. So far the assessment of heat stress was done based on measurements of air temperature and air humidity in the centre of these buildings.

Applicant

The applicant is using computational fluid dynamics (CFD) tools for assessing the internal microclimate of agricultural structures in the last 15 years. In the framework of the proposed STSM the applicant will combine his knowledge and expertise on CFD with the experimental data of host organisation in order to assess more efficient and more accurate the heat stress of dairy cows. Additionally, parametric investigation can be conducted studying the impact of the external wind speed and direction on the distributions of air flow, temperature and humidity in specific points inside the building.

Objectives

- To estimate the thermal heat stress index of dairy cows in large naturally ventilated buildings using as input the spatial distribution values of air temperature and air humidity inside the building and not only certain values from the central of the building.
- To proposes, based on CFD simulations, alternative building and natural ventilation system in order to reduce the THI



Airflow and associated air temperature distributing around a cow in a naturally ventilated building (CFD result)