

# Modelling the stored grains ecosystem

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# FLUENT

## Overview

Each year some 2 billion tonnes of food grains are harvested. Their total value to the farmer is about \$A 400 billion, which is about one fifth the value of the world's oil production.

Food grains must be stored typically for six months during which time they may be destroyed by insect pests, mites or moulds. This is the fate of about 20% of grains harvested in developing countries. Stored rains must be maintained in good condition so that they retain their functional properties such as germination for making beer, dough extensibility for making bread and whiteness in the case of rice.

The stored grains ecosystem has been modeled using *FLUENT*. By adding source terms to account for the hygroscopic nature of grains it has been shown that cooling grains can control populations of insect pests that would otherwise devastate the grain, and seed viability can be maintained at very high levels.

## Testimonial

"*FLUENT* allows the effects of a range of grain store geometries to be explored in a rapid and straightforward manner. Incorporating the effects of latent heat into the differential equations is a great step forward."

**James Darby**  
Team Leader  
Engineering and Biological Strategies  
CSIRO Entomology  
Canberra



Temperature distribution in bulk stored grains illustrating a large region of grain cooled to a temperature of 14°C, which is higher than the air inlet temperature of 10°C.

Contours of Static Temperature (c) (Time=2.6808e+05)

Nov 16, 2006  
FLUENT 6.2 (2d, dp, segregated, km, unsteady)



Relative population densities of the pest insect *Rhyzopertha dominica*, after 3 days of cooling grains with air with a temperature of 10°C and a relative humidity of 90%.

Contours of User Memory 5 (Time=2.6808e+05)

Nov 16, 2006  
FLUENT 6.2 (2d, dp, segregated, km, unsteady)

## Challenge

The technological challenge is to devise systems for preserving stored grains. One method of achieving this is to ventilate grains with cool air, but since grains are hygroscopic they adsorb and desorb moisture. This makes predicting their temperature non-intuitive. Grain ventilated using warm dry air may cool to lower temperatures than when they are ventilated with much cooler humid air. This means that *FLUENT* must be able to account for these hygroscopic properties

## Solution

The equations that govern heat transfer in porous media are modified to account for source terms that give rise to heat being liberated, say, when grains adsorb moisture from the air being used to ventilate them. In this way it is possible to calculate the microenvironment within grain stores. Since biological and biochemical phenomena respond to the microenvironment it is possible to predict how insect populations, moulds and seed germination respond to cooling

## Benefits

As a result of the work it is now possible to predict in unprecedented detail how design and operating conditions affect the quality of stored grains. For example, it has been shown that ventilation of grains with ambient air can prevent populations of a stored product insect *Rhyzopertha dominica* reproducing. If the grain were not ventilated their populations would increase 1 million-fold. The germination of wheat would be maintained above 99% whereas it would otherwise fall to 85%