CHAM Limited

Pioneering CFD Software for Education & Industry

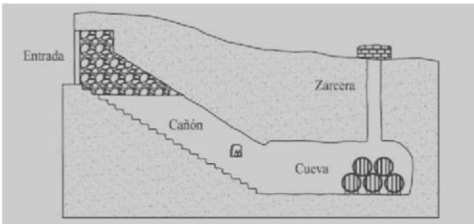
CHAM Case Study – Wine Cellar Ventilation

Bodegas – PHOENICS/FLAIR demonstration case

Introduction

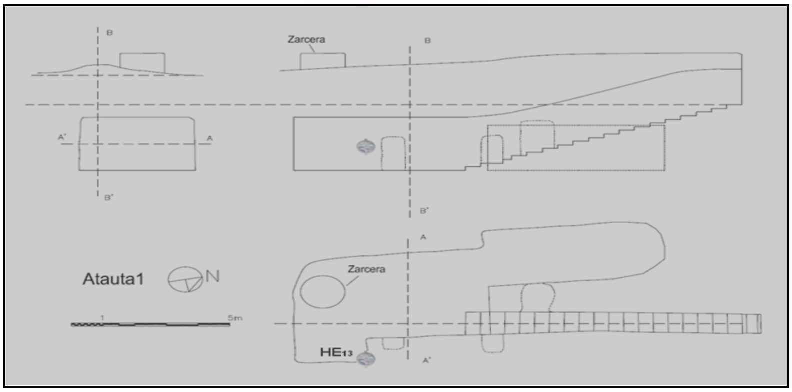
The thermal stability inside a traditional Spanish underground wine cellar depends primarily on the depth to which it is buried and the soil type and to a lesser extent, factors such as ventilation. However, it is extremely important to keep these cellars well ventilated, especially during the autumn, as the level of CO_2 released from the fermentation of the grapes can cause death within minutes.

The construction characteristics vary slightly depending on the area where they are, especially the terrain. In flat terrain wineries are always dug using a sloping access tunnel of variable length depending on the depth of the cellar.



Regardless of the type of excavation, these traditional underground cellars have common elements such as an entrance tunnel (horizontal or inclined), a cave for storing and ageing, and at least one ventilation shaft called a "Whitethroat."

The following demonstration was prepared on behalf of the Department of Construction and Rural Roads, School of Agricultural Engineers, Madrid, using extracts from their document **BODEGAS SUBTERRANEAS (Underground Wineries)**.



Cross-section of a typical underground wine cellar

The access stairwell leads down to the cave where the wine is stored for fermentation and ageing. The average depth is usually between 2 and 6 meters depending upon the terrain and may consist of a single room, but more usually with two or more rooms. Usually, there are one or more "Whitethroat" ventilation shafts.

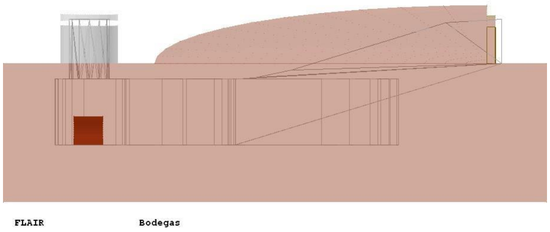
The environment in these underground structures varies with the seasons. In spring and summer, when the temperature inside the cellar is below the temperature outside, the heavier cold air makes it difficult for outside air to penetrate, which significantly reduces ventilation. The moisture level is significantly increased for the same reason, and the temperature of the cellar is influenced predominantly by the surrounding soil temperature. In the autumn and winter however, the temperature inside the cave is higher than outside, and the cold air outside penetrates through the ventilation points. The increased ventilation results in a temperature drop and a reduction in humidity, though the predominant influence remains that of the surrounding soil temperature.

A study has been undertaken by the School of Agricultural Engineers resulting in measured data for temperature and relative humidity taken at various heights within the cellar, over a period of 1 year. The new task is to create a CFD model of the Bodega, to compare with the measured data, for cases run under corresponding environmental conditions. The purpose is to create a template that can be used to predict the effectiveness of a variety of Bodega designs and locations.

The following images have been created from a steady-state simulation using non representative environmental conditions, but they nevertheless provide an indication of the flow regime, temperature variance, and CO2 release possibilities. Relative humidity has not been taken into consideration at this time. In the following scenario, the soil temperature is set at 10˚C, the air temperature is 24˚C, with the wind from the southwest. The CO_2 release rate is set as 0.002 Kg/s.

CFD model – side view

CFD model – top view



Wind ↗

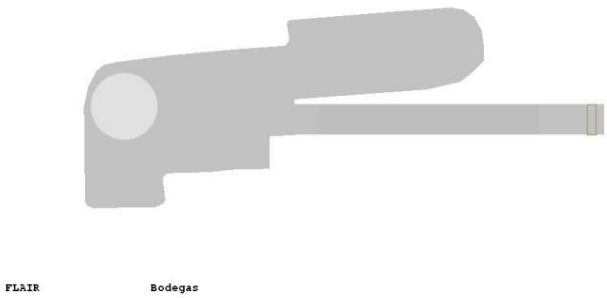
Whitethroat →

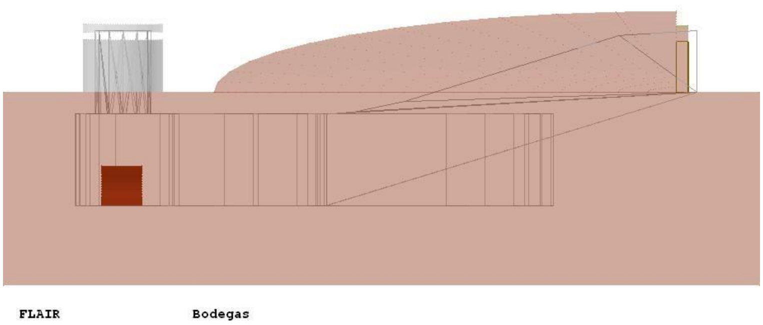
← Entrance

Barrels ↑

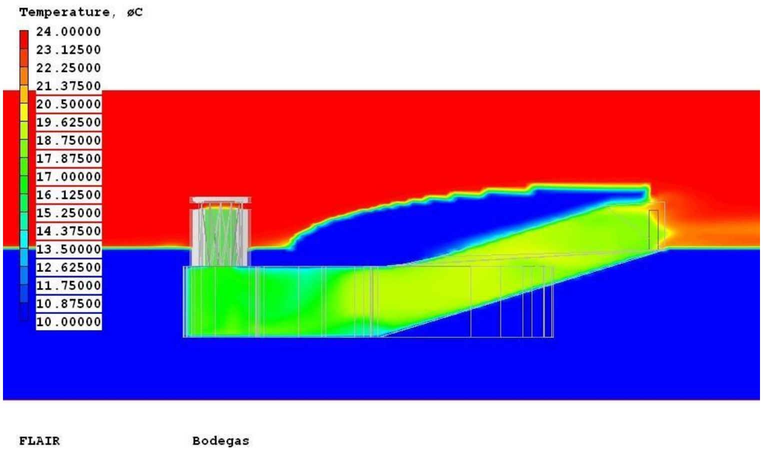
Cellar ↑

← Terrain

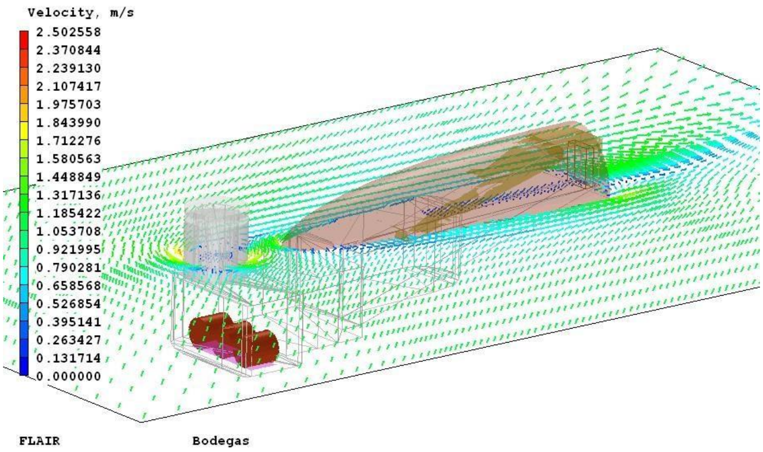




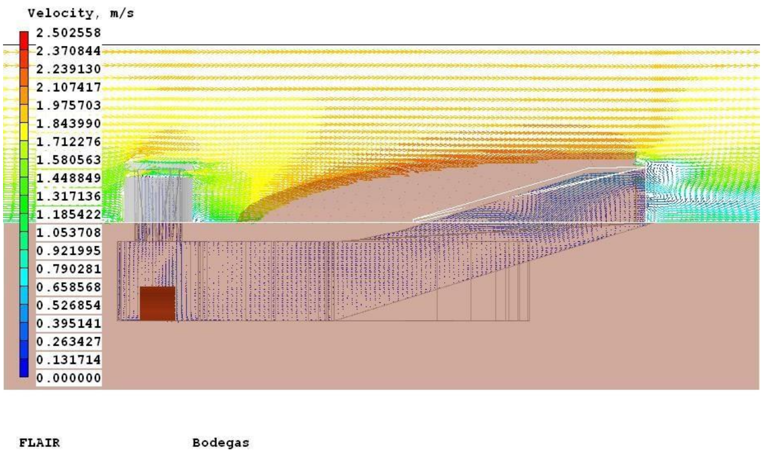
Geometry



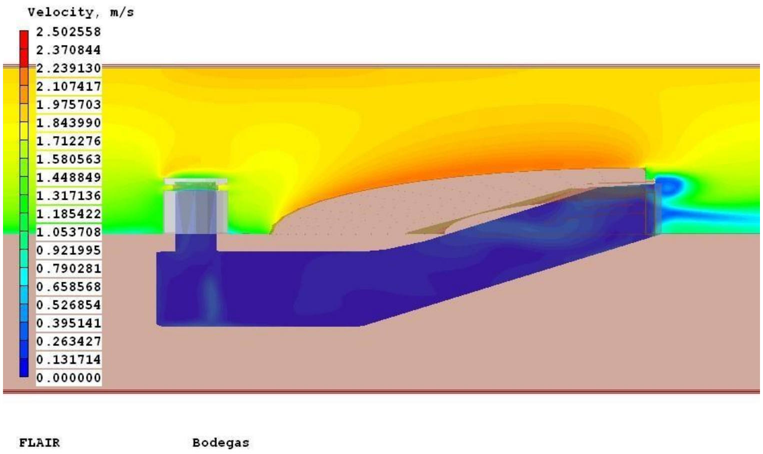
Temperature



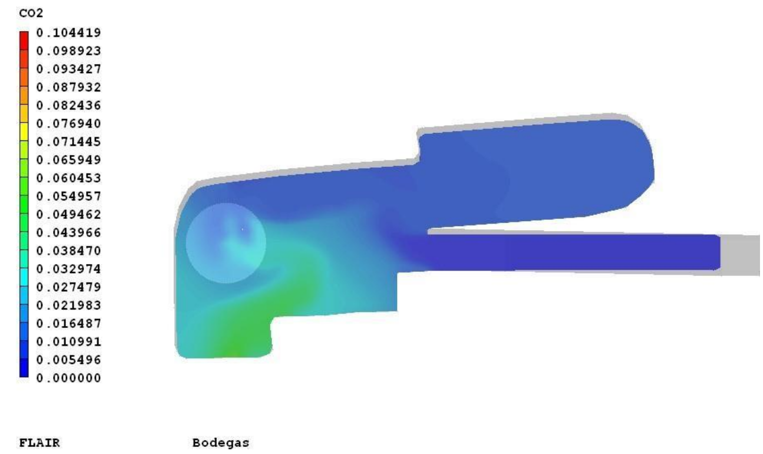
Velocity horizontal (above ground)



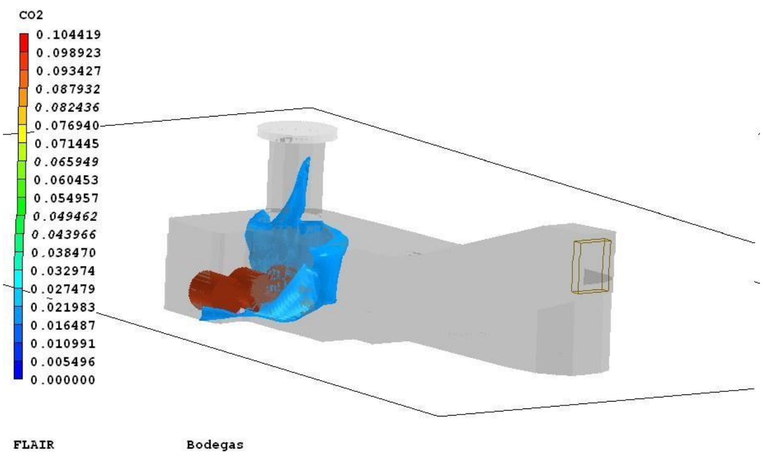
Velocity Vectors



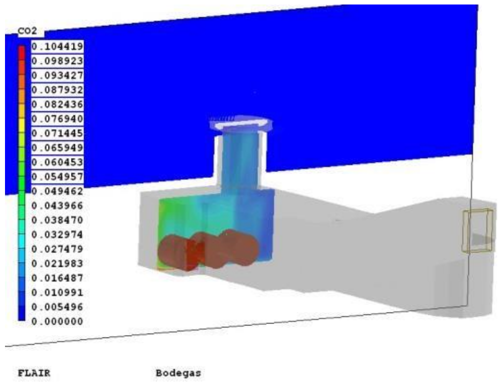
Velocity Contours



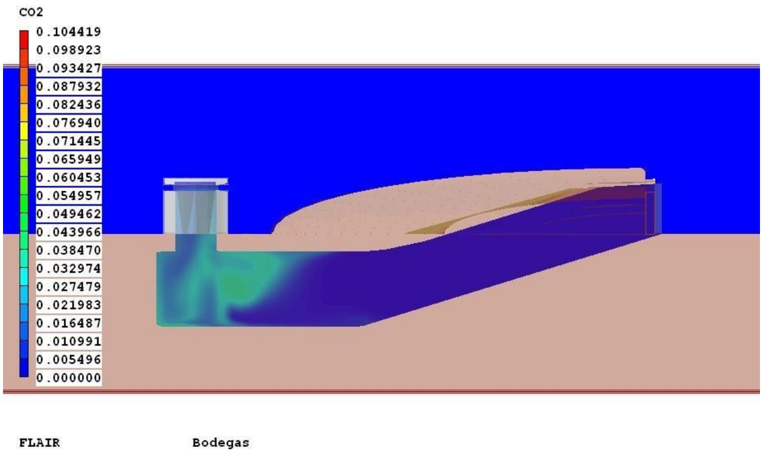
CO2 Horizontal plane



CO2 Iso-surface



CO2 (cross-section)



CO2

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