CHAM

Autumn 2010

PHOENICS News

PHOENICS – your Gateway to Successful CFD

Professor Spalding Receives Luikov Prize

Editorial

Recent Editorials seem to have been devoted to awards received by Professor Spalding and this is no exception. In September he received the Luikov Prize from the Academy of Sciences in Belarus in Minsk at a meeting on "Physical and Technical Problems of Power Engineering (Related to Heat and Mass Transfer): Perspectives of Development in the Century since the birth of A V Luikov". He shared the award with Professors Artem Khalatov and Yuri Matsavity.

On learning that he was to receive the Prize, Professor Spalding felt it appropriate to pay homage to Academician Luikov's work of some decades ago on porous capillary media.

In the course of preparing his lecture, entitled "Capillary-Porous CFD", Brian realized that this application could be included in PHOENICS. It should be of use in food processing, brick-making, and any other industry with an interest in drying products with maximum efficiency.

Byelorussion Academy of Sciences, Minsk

Artem Khalatov, Brian Spalding, Yuri Matsavity

Inside this Issue:

Points of interest:

- PHOENICS 2010
- PHOENICS & swimming in stratified water
- PHOENICS & flow of wind over terrain
- PHOENICS & mitigation of microorganism dispersion
- PHOENICS & Forest Fires
- PHOENICS & Air Flow in a Loading Station
- And More

2) PHOENICS Features

New Features in PHOENICS 2010 by John Ludwig of CHAM

2.1 Earth Improvements

2.1.1 Linked Objects

Often there is a need to link flow rate and temperature at one boundary condition to flow and temperature at another. Typical examples are:

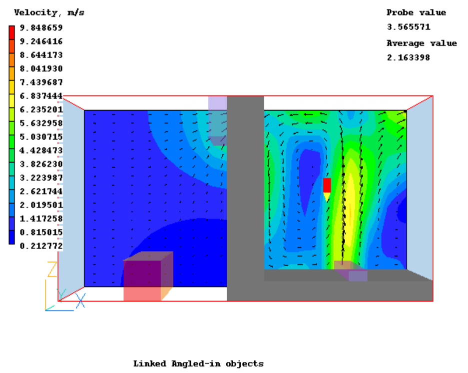
- Ducting that is not explicitly modelled that joins one part of a domain to another
- Intake and exhaust from an Induction Fan
- Active chilled beams

This can now be achieved by a pair of linked ANGLED-IN objects. One ANGLED-IN, set to extract flow, acts as a 'donor'. The immediately-preceding or immediately-following ANGLED-IN takes the flow rate from the 'donor' and uses it as the inflow:

- temperature, smoke and other scalars are taken as mass-averaged values at the donor' object;
- density is evaluated at the average temperature and ambient pressure;
- velocity is deduced from the mass flow rate (taken from the 'donor'), the flow area and the deduced density;
- turbulence values are computed from the turbulence intensity, velocity and hydraulic diameter.

Linking happens in pairs, so that a linked pair can be copied or arrayed. The correct objects will stay linked.

A pair of linked ANGLED-Ins is used to represent a duct joining the left and right-hand sides of the domain.



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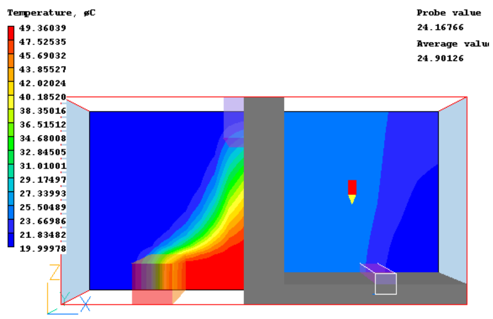
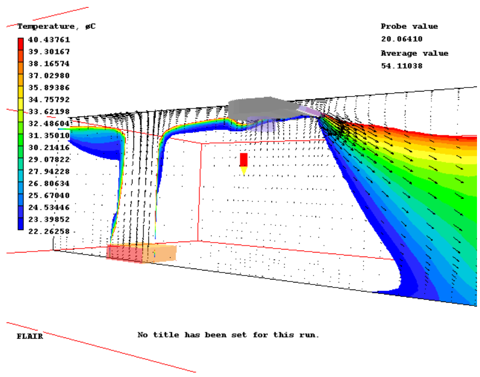


A pair of linked ANGLED-Ins is used to represent an induction fan



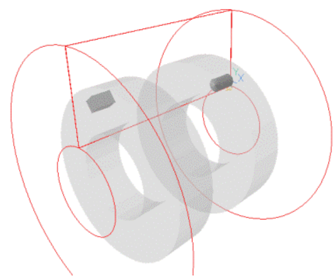
In parallel cases, ANGLED-IN objects can straddle processor boundaries and still produce the correct source.

Linked ANGLED-IN objects need not be on the same processor.

ANGLED-IN and OUT objects can act as GENTRA outlets.

2.1.2 Rotors

The previous restriction of only one ROTOR object has been removed. There can now be as many ROTORs as needed.



2.1.3 Parsol

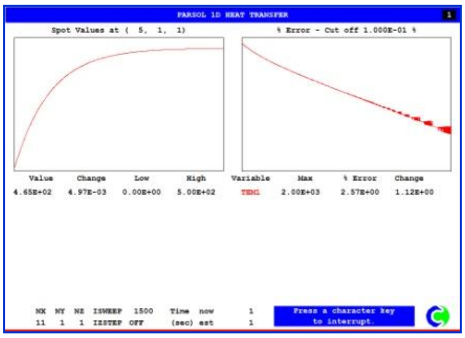
The PARSOL solids detection algorithm has been rewritten. One aim was to provide more robust detection. The other was to provide a better start-point for the long-awaited multi-cut cell. It has also resulted in a reduction of memory usage of around 8%.

For More Information On New Features Visit
www.cham.co.uk/whatsnew.php

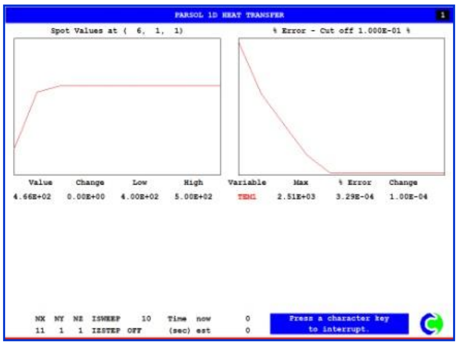
PHOENICS News: Features of PHOENICS 2010 are outlined here and various applications are featured throughout. If you would like to contribute an article to future editions please send it to me, Colleen King, at cik@cham.co.uk.
Tel: + 44 20 8 947 7651
Fax: + 44 20 8 879 3497
Web: www.cham.co.uk

2.1.4 Conjugate Heat Transfer

The performance of the conjugate heat transfer solver has also been improved. For a 1-D case, the 2009 solver with LITER(TEM1)=200 gave this convergence plot (for 1000 sweeps):



The 2010 solver gives this convergence with LITER(TEM1)=20 (for 10 sweeps):



2.1.5 Parallel Improvements

- The 'Nett source' echo for parallel cases now has the same format as sequential, showing the in- and out-flow splits and transient contributions.
- In parallel cases, ANGLED-IN objects can straddle processor boundaries and still produce the correct source.
- Linked ANGLED-IN objects need not be on the same processor.

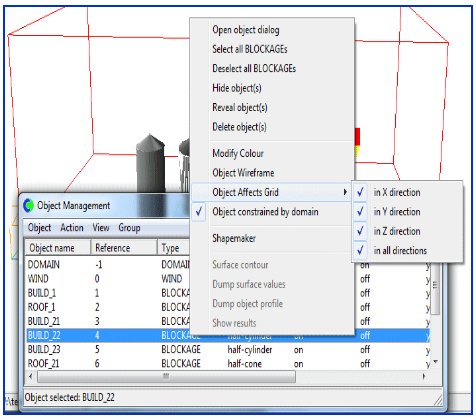
2.1.6 InForm Improvements

InForm can now:

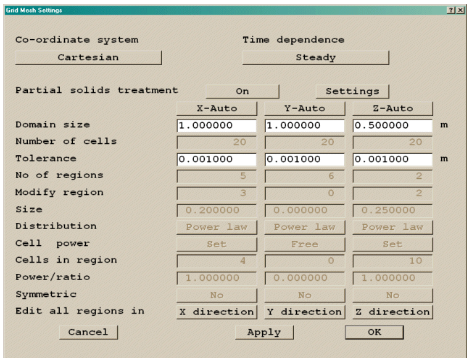
- use (much) longer and more complex formulae – up to 100 operands.
- be used to modify porosities.
- recognise BFC geometrical quantities.
- InForm OLD() function corrected.
- InForm SUM function corrected for parallel.

2.2 VR-Editor Improvements

The 'Object affects grid' attribute has been split into the three coordinate directions.



This allows greater control over how the grid is divided into regions in each direction. For example, we may want a floor object to create regions in the Z direction, but not need them in X and Y. The tolerance used in matching the grid has also been divided into the three coordinate directions.

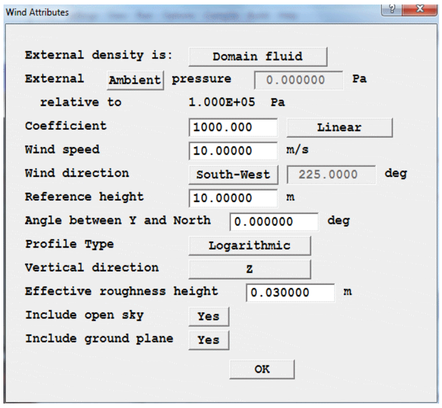


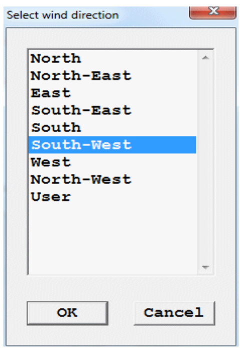
This can be helpful when the domain dimensions are very different in one direction, say in a tunnel.

Processing Q1 files with many Inform commands attached to objects has been made faster. The processing time of a data centre Q1 with 5000 objects, many of which had InForm commands attached, has reduced from well over half an hour to under 2 minutes.

More internal arrays have been made dynamic allowing bigger cases and more complex InForm commands to be handled.

The WIND Object has been extended to add pre-set compass directions for the wind direction.

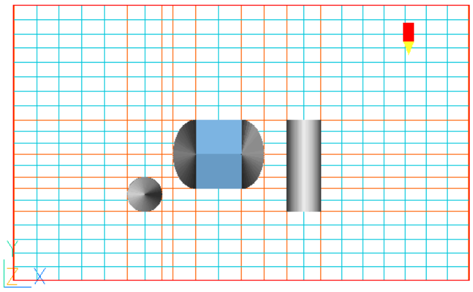


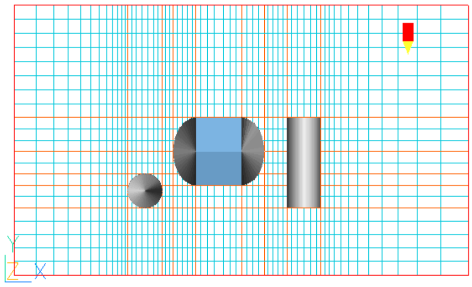


In transient cases multiple WIND objects are allowed which allows wind direction and/or speed to be changed with time.

An error in the Auto-mesher has been corrected. The grid refinement stops when the ratio between the size of the last cell in one region and the first in the next region falls below a set criterion. On the auto-mesh dialog, this was set as a fraction of the domain size, but was treated as an actual physical dimension when being compared to non-dimensional cell sizes. This means that for large domains, the refinement process terminated earlier than expected.

The image on the top shows the original auto-mesh, that underneath the new corrected version.





A new option allows minimum and initial cell sizes to be set as physical dimensions rather than fractions of domain size.

In PIL, the length of LABEL used together with GOTO has been increased to 68 characters.

The PIL SORT function can be used to sort a PIL array into ascending or descending order and remove duplicate entries which facility is used by our Data Centre models. An internal format has been changed to avoid a loss in accuracy during the sorting, and a tolerance has been added to help in identifying duplicates.

Better checking of the license file location in the Windows registry prevents the search path for the license from becoming so long that either the file cannot be found, or the search introduces an appreciable delay in the run.

There is a display of 32 or 64 bit in the window title bar and RESULT file, to make it plain which version is in use.

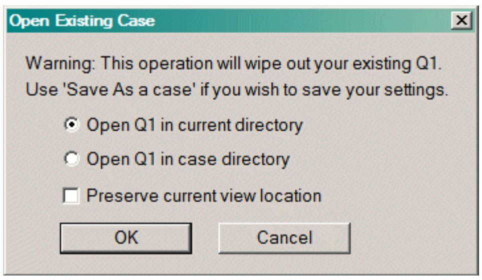
The current working directory is displayed in the status bar at the bottom of the Editor/Viewer window.

The Editor/Viewer screen proportions are fixed regardless of the screen aspect ratio.

The default image type (gif, pcx, bmp or jpg) for saved images can be set in cham.ini.

When opening an existing case, there is an option to:

- Copy case files to the current working directory, or;
- Switch the working directory to the folder containing the case files.



This will allow any geometry files specific to the case stored together with the case files to be picked up.

2.3 VR-Viewer Improvements

Viewer plots contours based on values interpolated from cell centres (for scalars) to the cell corners. Each time a new variable is chosen for plotting, the corner values are obtained by interpolation. For large grids, this causes an appreciable delay before the next contour is drawn.

Interpolated values are now stored in memory, and when the same variable is requested again, the corner values are restored from the internal store rather than being interpolated again. The delay in switching variables is now no longer noticeable even for very large grids.

The file name used to save profile and time-history plots can be set to any required string.

Profile and time-history plots can be saved to, and created from, macros.

Screen images of profile and time-history plots can be saved from macros.

Continuous and inverse colour contours can be set from a macro.

Macros still function after 'Cancel'.

Often streamline animations require several hundred if not thousands of steps or frames to produce acceptably smooth motion. If the whole animation were saved, at say 1/10th sec per frame, the resulting movie would last several minutes and be enormous. We can now specify the start and end frame numbers, allowing much shorter and hence smaller movies to be saved.

2.4 Flair Improvements

In Flair, the FIRE object has a new option to read the heat, mass and smoke sources from a table in a file, allowing any complex fire curve to be used. The tables consist of two columns of numbers in free format, with an optional first line of titles, for example:

Time	Mass		Time	Mass
0	0		360	0.0583
60	0.0073		420	0.0583
120	0.0219		480	0.0583
180	0.0365		540	0.0583
240	0.051		600,	0.072
300	0.0583			

The Earth solver will interpolate in the table to find the value at the current time-step. In the Q1 file, settings are:

```
> OBJ, TYPE, FIRE
> OBJ, TIME_LIMITS, ALWAYS_ACTIVE
> OBJ, PRE-TEMP, T_AMBIENT
> OBJ MASS-SOURCE, From table file
> OBJ, MASS-FILE, 1car_mass.csv
> OBJ, HEAT-SOURCE, From table file
> OBJ, HEAT-FILE, 1car_heat.csv
> OBJ, SCALAR-SOURCE, Mass Related
> OBJ, INLET_SMOK, 1.
```

The input files are ascii text files which can be created in any convenient manner.

The JETFAN object can set turbulence intensity. The k and ε values at fan location are then deduced from fan velocity and diameter. This can help improve spreading of the jet.

The 'Calculate link temperature' and 'Activation temperature' settings for a SPRAY_HEAD object activate the spray when the activation temperature is reached. In previous versions, a message was written to RESULT when the criterion was met, but the spray was not automatically activated. A table file containing the calculated link temperatures at the end of each step is also produced.

Tables of heat and smoke sources from FIRE objects are generated, allowing for easy checking.

A convergence table is produced showing the errors normalised by the inflow fluxes. This can often give a better impression of the convergence behaviour than the auto-normalised residuals on the monitor plot. The normalising quantities are printed to RESULT.

3) PHOENICS Applications

3.1 Is Swimming in Stratified Water Safe? by Bob Hornby

It has recently been hypothesised (New Scientist, December 2008) that stratification in lakes or the sea could be responsible for some of the 400,000 drowning incidents that occur each year (WHO 2002, Peden and McGee 2003, Inj Control Saf Promot 10:195-199). The article suggests that swimmers swimming in stratified waters (deep lakes in summer, fjords, river outflows into the sea) could find a significant percentage of their propulsive power used to generate internal waves rather than forward motion – resulting in fatigue and drowning.

This realisation has followed on from experimental investigations (using model boats) of the 'Dead water effect' which is known to considerably slow the motion of ships moving at low speeds in stratified waters (see PHOENICS Newsletter Spring 2009). It has been supported by further experiments (Sander et al 2008, Naturwissenschaften), in particular, *'where four subjects swam a short distance (5m) in homogeneous and in two different settings of stratified water. At the same stroke frequency swimming in stratified water was slower by 15% implying a loss in propulsive power of 40%.'*

PHOENICS modelling of the initial model boat experiments showed encouraging agreement and this has prompted the current more complex work to use PHOENICS to model the motion of a swimmer and to gain further understanding of the experimental findings. This requires the additional effect of the motion of arms and legs relative to the body to be determined.

For homogeneous flow, a simple mathematical model of the swimmer motion can be constructed (see figure 1). It is sufficient to consider a single arm motion as the second arm and two leg motions follow using the same analysis method.

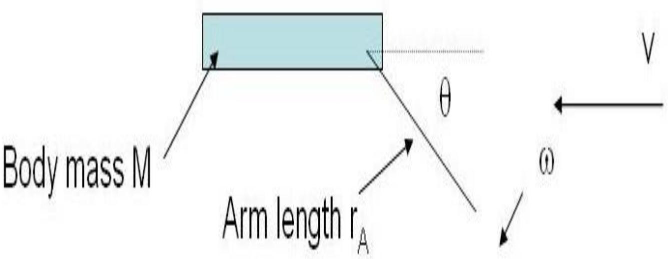


Figure 1. Schematic for a swimmer of mass M moving at velocity v from left to right (taken as positive y direction, with z measured vertically and x positive out of page) with arms rotating with angular velocity ω

The propulsive force on the swimmer minus the drag force is equal to the body mass multiplied by the body acceleration. The drag force due to just the body section can be written as

$$\frac{1}{2} c_B \rho v^2 A_B$$

Where c_B is the body drag coefficient, ρ is the fluid density, v the approach velocity (considering a reference frame with the swimmer body at rest) and A_B the body area normal to the flow direction..

The arms and legs contribute a propulsive force where the local arm/leg velocity is larger than v and a drag effect elsewhere.

For example, the axial arm force due to an element length dr of arm is:-

$$c_A \frac{1}{2} \rho(-\omega r + v \sin\theta)\left|-\omega r + v\sin\theta\right| b_A \sin\theta dr$$

Where ω is the arm angular velocity, c_A is the drag coefficient for the arm and b_A is the arm width. Note that this expression has been adjusted, for convenience, so that the values of ω, θ and v are positive.

Integrating this over an arm length and then incorporating the body drag force as above gives the equation of motion for a body propelled by two arms with a half cycle phase difference.

$$M\frac{dv}{dt} = \frac{1}{2} c_A \rho b_A \left(v^2 r_A \sin^3\theta - \omega v r_A^2 \sin^2\theta + \frac{1}{3}\omega^2 r_A^3 \sin\theta - \frac{2}{3}\frac{v^3 \sin^4\theta}{\omega}\right) - \frac{1}{2} c_B \rho v^2 A_B$$

A similar equation can be derived incorporating the leg motions.

A swimmer is modelled by PHOENICS in a reference frame at rest with respect to the body. This requires a uniform inflow velocity equal to the swimmer speed and an axial body force applied throughout the flow proportional to the swimmer acceleration. The ambient hydrostatic pressure distribution has been found to be a satisfactory outlet boundary condition. Other flow boundaries are assumed to be frictionless.

The body and head are represented simply by rectangular, solid, frictionless objects. Figure 2 gives the body dimensions used as well as other modelling dimensions which are representative of the experiments. The effect of arms and legs is represented by moving momentum sources as described below. A non-uniform Cartesian grid is used with 38 cells in the lateral direction 104 cells in the axial direction and 32 cells in the vertical direction with due regard to concentration of cells in regions of large gradient. Eighty time steps are used per swimmer stroke and four strokes are usually sufficient to achieve a near steady state.

A strong stratification (density 1000.0 kg/m^3 in the upper layer and 1025 kg/m^3 in the lower layer) is employed as in the experiments.

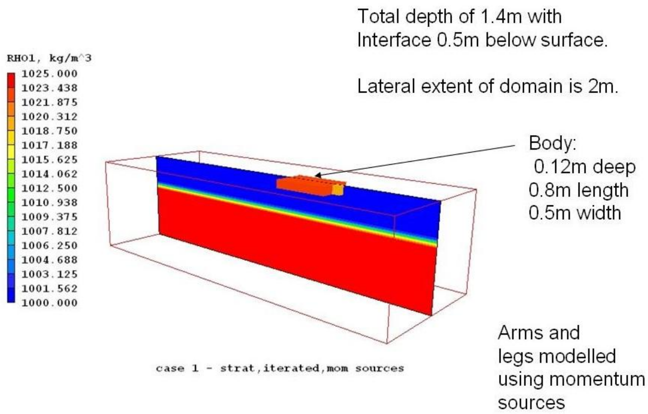


Figure 2. Dimensional modelling details for the PHOENICS simulation with x measured laterally out of the page, y in the swimmer direction and z vertically.

The equations to be solved by PHOENICS are as shown in figure 3 (using standard notation). The enthalpy equation is used to represent density transport. Sources are shown as subscripted S terms. F is the total propulsive force to the swimmer from arm and leg motions and D is the total drag from body, arms and legs. M is the total mass of the swimmer, taken as 70kg. A laminar viscosity is employed in this exploratory analysis but turbulence effects could be represented using one of the standard PHOENICS turbulence models. Note however, that turbulence effects are implicitly represented, in part, by use of appropriate drag coefficients for arms and legs. The drag due to the body section alone is computed from the pressure forces acting on the front and rear faces of the body and the friction force on the lower surface.

The arms and legs are assigned specific motions (for example arms rotating at a fixed angular velocity with a phase difference of π). Arms and legs are represented as thin plates, the arms with length 0.7m and width 0.1m and the legs with length 1m and width 0.1m.. Each arm and leg is then subdivided into n by m panels where n is the number of panels across the width and m the number of panels along the length. The values of n and m can be different for arm and leg.

At each time step, the coordinates of the centre of each panel are calculated and the panel velocity calculated there. Figure 4 shows a snapshot of the arm and leg positions so determined using a marker variable MARK. The centre of each panel is then associated with the PHOENICS flow cell in which it resides. For example, for each arm, the fluid force contribution of this panel to the axial and vertical momentum source terms is respectively

$$c_A \frac{1}{2}\rho(-\omega r + v\sin\theta)\left|-\omega r + v\sin\theta\right|\sin\theta dA$$

and

$$-c_A \frac{1}{2}\rho(-\omega r + v\sin\theta)\left|-\omega r + v\sin\theta\right|\cos\theta dA$$

where dA is the panel area, r the radial distance of the panel centre from the arm pivot point and θ the angle the arm makes with the horizontal (figure 1). The legs are treated similarly. Note that these expressions have been adjusted, for convenience, so that the values of ω, θ and v are positive.

These contributions are summed for all the arm and leg panels. The negative of the axial fluid force is used in the equation of motion for the body which is solved iteratively in conjunction with the fluid motion.

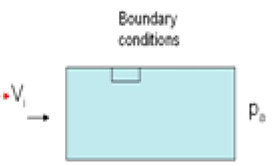
Figure 3. Equations solved by PHOENICS with boundary conditions

$$\frac{\partial \rho}{\partial t} + \frac{\partial \rho u_i}{\partial x_i} = S_m$$

$$\frac{\partial(\rho u_i)}{\partial t} + \frac{\partial(\rho u_i u_j)}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{\partial\left(\rho\nu \frac{\partial u_i}{\partial x_j}\right)}{\partial x_j} + (\rho - \rho_0)g_i + \rho\frac{dV_i}{dt} + S_{u_i}$$

$$\frac{\partial(\rho h)}{\partial t} + \frac{\partial(\rho u_j h)}{\partial x_j} = \frac{\partial\left(\frac{\rho\nu}{\sigma_h}\frac{\partial h}{\partial x_j}\right)}{\partial x_j} + S_h$$

$$M\frac{dV_i}{dt} = F - D$$



NB1: Coupled simulation, since V_i used as inlet condition advecting ambient values and dV_i/dt used in the body force in the axial momentum equation

NB2: Forces due to moving swimming components (arms, legs) modelled using a sub-discretisation of these components with time dependent allocation to PHOENICS flow cells.

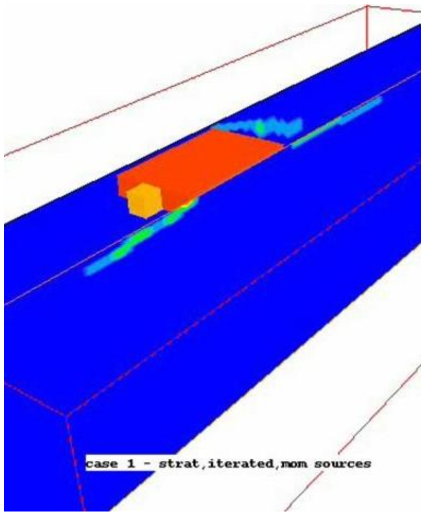


Figure 4. A snapshot of arm and leg movements shown using the MARK tracer. Note that the second arm is not visible because it is out of the water.

The PHOENICS coding to achieve the coupled simulation with moving momentum sources is fairly complicated so this was tested by comparing a PHOENICS run for a 2s stoke in homogeneous water with the mathematical model described above when the body drag component is set to zero (drag coefficients for arms and legs are set equal to 1.0). For this case the mathematical model and PHOENICS should agree exactly apart from errors associated with the subdivision of arms and legs (which should reduce as n and m, the subdivision parameters, increase). The results given in figure 5, for a swimmer starting from rest, show excellent agreement. But this figure also shows that there is no significant difference between the homogeneous PHOENICS run and a further run with the stratification profile shown in figure 1. This is a surprising result given the experimental findings.

Further PHOENICS runs for homogeneous and stratified water (parameters as above) which include the body drag term again show negligible difference. This is shown in figure 6, which also shows reasonable agreement with the mathematical model when a feasible body drag coefficient (0.4) is assumed.

Additional PHOENICS runs varying the stroke period and the upper layer depth for the stratified case also show insignificant difference between the stratified and homogeneous cases.

Hence the conclusion from the PHOENICS simulations is that swimming speed is NOT significantly affected by stratification. For the stratified cases, the simulations show no effect of the swimmer body on the density interface. For ships the hull interacts strongly with the density interface producing a deep broad wave which significantly affects the pressure distribution around the boat and therefore the drag. The swimming body has too little depth to produce an equivalent effect and the hands produce only a narrow wave that carries little energy.

This can be illustrated with the following simple calculation. A 70kg swimmer moving at $1ms^{-1}$ has kinetic energy of 35 J. The potential energy as each hand moves a differential mass of fluid, δm, through distance h is

$$\delta mgh$$

where g is acceleration due to gravity. Over n swimming strokes this energy sums to

$$2n\delta mgh$$

where 1 stroke involves a complete hand cycle.

In the preceding analysis about 4 strokes were required to reach a steady speed so take n=4. From the simulations, h is about 0.1m (the internal wave height) and the 'handful' of differential mass raised is estimated at 0.1kg.

This gives the potential energy associated with the internal waves created as 0.8J, small in comparison with the kinetic energy attained by the swimmer.

The conclusions from the simulations are therefore different to those from the experiments where a significant difference (reduction) in speed was attained when swimming in stratified water. Normally the experimental results would be given more credence, but then the difficulty in producing equivalent swimming actions in homogeneous and stratified water must be accepted. Or perhaps some subtle effect in the modelling has been overlooked?

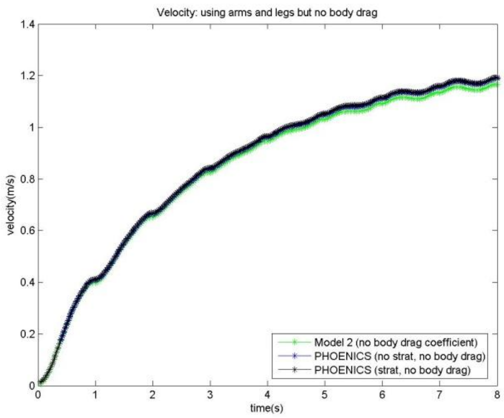


Figure 5. Comparison of PHOENICS results for homogeneous and stratified water for a swimmer starting from rest with a 2s swimming stroke. No body drag is included.

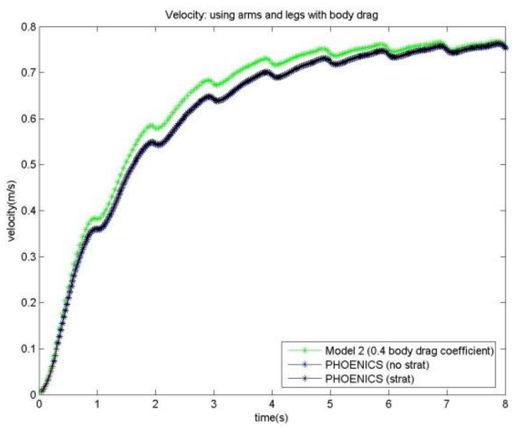


Figure 6. Comparison of PHOENICS results for homogeneous and stratified water for a swimmer starting from rest with a 2s swimming stroke. Body drag is included.

Comments are invited!
Dr Bob Hornby
Email: bob@hornby007.wanadoo.co.uk

CFD Online

A free online centre for Computational Fluid Dynamics where you can share news and experiences with other PHOENICS Users at www.cfd-online.com

4) Consultancy Applications

4.1 Meeting at Windsim regarding flow of Wind over Terrain

by Babis Tsimis of CHAM Limited

In June I had the opportunity to attend the WindSim annual user meeting and give a presentation on the collaborative Eurostars project between CHAM and WindSim. The meeting lasted two days and there were more than 50 attendees and many presentations.

At the end of the first day, we did the traditional sailing trip to the Oslofjord. A magnificent experience highly recommended to other "WindSim" users.

WindSim is a Norwegian company that built the software suite "WindSim" which is a wind engineering design tool offering CFD modelling via PHOENICS. It is integrated into a modular environment in which users can do anything on their project from environmental studies (sound & visual) to financial analysis and optimisation of the wind farm layout (micrositing).

Eurostars is EUREKA programme funded and supported by the EU with the aim of stimulating international collaboration and innovative research to help increase the competitiveness of European companies in the global arena. The Eurostars R&D project involving CHAM is a joint one with Windsim and Iberdrola on the integration of the unstructured grid technology of PHOENICS to the latest suite of "WindSim" software and the improvement of the convergence behaviour of the solutions for complex terrains. CHAM brings to the project its expertise in CFD, WindSim its expertise with CFD based wind resource assessment and Iberdrola its expertise in wind farm development. The aims are challenging with enough funding in place to guarantee the completion of the project.

CHAM is working with WindSim and Iberdrola to assist wind-farm developers increase the energy production of their farms and thus increase their profitability. The current project is well placed to take advantage of the fast growth that Wind Energy is experiencing worldwide. The price of producing energy from wind is now on a par with the price of producing energy from natural gas factories and this does not take into account the added environmental benefits of wind energy. The project is therefore well placed, as it develops cutting-edge CFD technology, to take advantage of the investment interest in the development of wind farms. In 2009, among the new energy capacity that was installed, Wind Energy was the first with 39%

of total capacity installed (10,183 MW of wind power capacity installed). Natural gas came second with 26% (2009 EU statistics for energy).

The meeting was a success, drawing almost double the amount of attendees of the previous year, a clear indication of the growth that this area is experiencing. There were attendees from several parts of the world, among which there were big Wind Turbine manufacturers, Siemens and REpower, and some large energy utility companies Iberdrola and Edison.

Innovative work is being done with regard to the software suite with companies developing plug-ins and useful modules for it. Some of the highlights from the presentations were the Techno-economic optimisation module that 'Agder Energi' created for WindSim, which assists developers in deciding what is the optimal size of a project and the optimal positioning of the turbines depending on the velocity and turbulence characteristics of the wind field that the software calculates. This is a very useful tool since wind speed varies significantly within sites in complex terrain. Thus there is a larger potential for layout optimisation than in flat terrain. During the meeting a wake model based on the Actuator Disc Concept, aimed towards capturing the wake losses in large wind farms was presented

Another highlight was a wind forecasting service called GMS (Global Microcasting Service), by AL-PRO, that uses "WindSim" to produce short term 48hr wind forecasts that can help the integration of Wind Parks in the existing electricity grid. This is a big issue for the Wind Energy industry since the unpredictability of Wind Power is leading to severe issues with the integration of the Wind power in the existing grids, and in many occasions on unusually windy days, energy surges coming from Wind Parks cannot be accommodated by the grid. GMS can also help with the Construction Scheduling, the Maintenance Scheduling, and the Energy Sales.

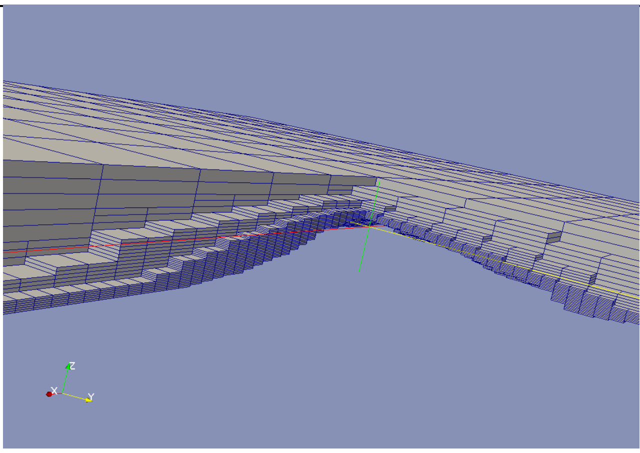
During the presentations, and over one-to-one conversations later, it was apparent that the main challenge that the users are facing has to do with convergence which is very hard to achieve for complex terrains with the Body Fitted Coordinates grid that the code currently uses. This grid tends to produce cells of very high aspect ratios which affects the convergence behaviour of the solution. Thus the unstructured grid technology that CHAM will introduce in the "WindSim" suite during this project is keenly awaited. Expectations are that convergence issues will be resolved with the new technology. With USP in place the growth outlook for the software looks extremely promising.

Another point of interest for the users was the fit of the USP grid to their terrain models. The USP grid on its own, being a rectangular grid leads to a fit which is step like. For high levels of refinement this effect is not very pronounced but it is still a worry for users. That is where PARSOL for USP comes in, the development team at CHAM has been hard at work to implement our PARSOL technology to the USP grid as well, with already very good results as can be seen from the Figures below.

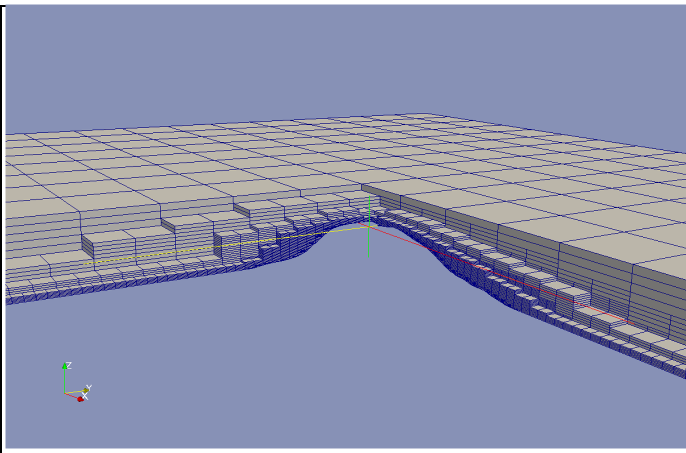
The developments will benefit many Users of Unstructured PHOENICS with a variety of applications so that benefits will not be restricted to that relating to terrain flows developed within the framework of the Eurostars project.

Finally the launch of the parallel version of the code based on parallel PHOENICS was announced. Users can now use 100% of their available computer resources in multi core machines and in the more powerful multi CPU machines too. This way they can reduce the execution time for a project or they can run even larger models.

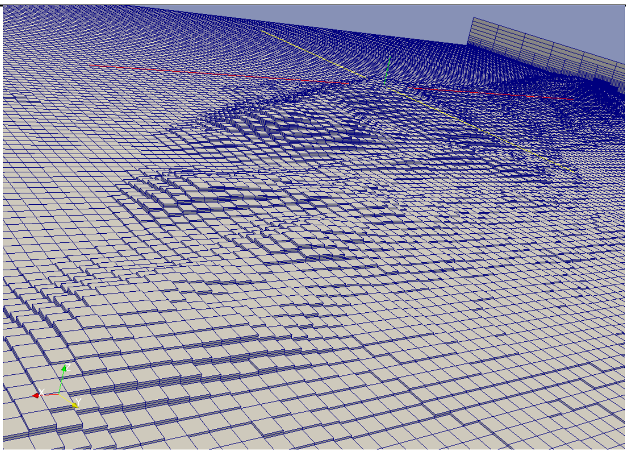
Overall this meeting was a very positive experience, it was encouraging and motivating to see and interact with such a large, friendly and vibrant community of users.



Whole Cells model



PARSOL model



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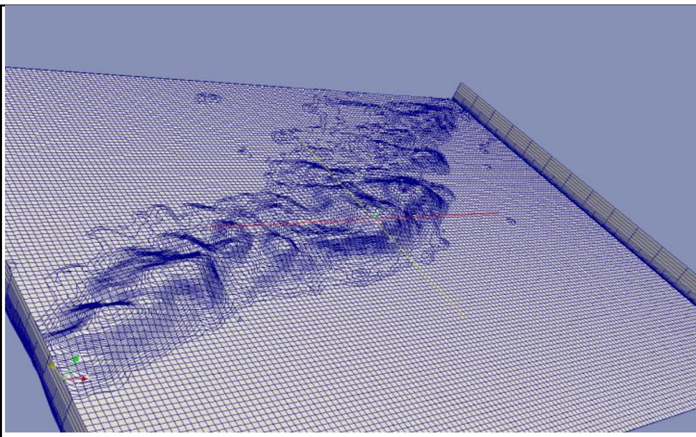


PARSOL model

5) User Applications

5.1 Mitigation of microorganism dispersion in patient rooms with UR-UVGI lamps

by M. Heidarinejad and J. Srebric,
The Pennsylvania State University

During recent decades, there is a renewed interest in transmission of airborne microorganisms, such as tuberculosis, and disinfection of patient rooms. A practical way to disinfect patient rooms uses upper-room ultraviolet germicidal irradiation (UR-UVGI) lamps. In this study, CFD has been used to study the performance of UR-UVGI lamps in patient rooms. This research project studies effects of CFD approximations on the UR-UVGI lamp performance evaluation. For example, in real patient rooms, due to existence of lighting lamps, UVGI lamps, supply and exhaust ventilation air, and microorganism source, non-isothermal CFD simulations should be used to accurately predict transport processes. This study uses PHOENICS commercial software to simulate the performance of UR-UVGI lamps in a patient room. Figure 1 shows an empty patient room with microorganism source in the middle of the room as modeled in the PHOENICS software.

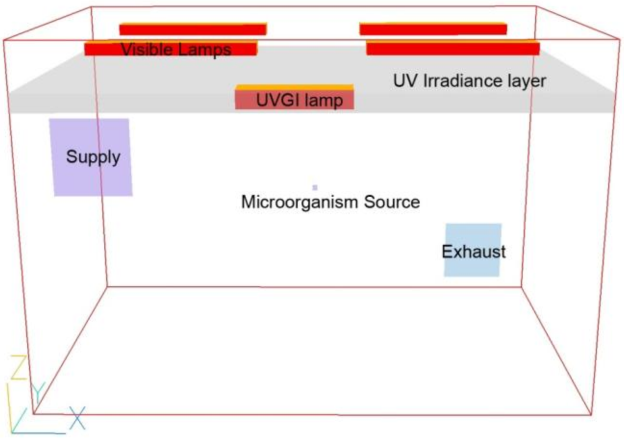


Figure 1. Simulated indoor environment in the PHOENICS software

This study uses the Eulerian approach to represent viable microorganisms as a concentration scalar. In addition, the disinfection effect of UR-UVGI lamps has been implemented into the CFD software as a uniform UV irradiance field in the UV irradiance layer, depicted in Figure 1. The UV irradiance layer has been represented as a sink term calculated based on a known microorganism susceptibility to UVGI lamp fluence rates. With all boundary conditions properly defined, Figure 2 shows CFD results of the microorganism distribution from the microorganisms' source when UR-UVGI lamps are turned "off," and when they are turned "on." To assess the UR-UVGI disinfection effectiveness, the fraction of remaining microorganism at the room air exhaust is usually measured. Therefore, in this study, the fraction of CFD calculated remaining microorganism at the exhaust has been compared with the experimental results. According to the simulations, 24% of the microorganisms survived with UR-UVGI lamps turned "on," while the experiments showed 18% survival rate. A new study is under way to compare CFD results based on the Lagrangian approach with the Eulerian results and a set of new experimental data. This comparison is important because most of CFD users will be inclined to use simplest possible simulation settings as long as the results are reliable.

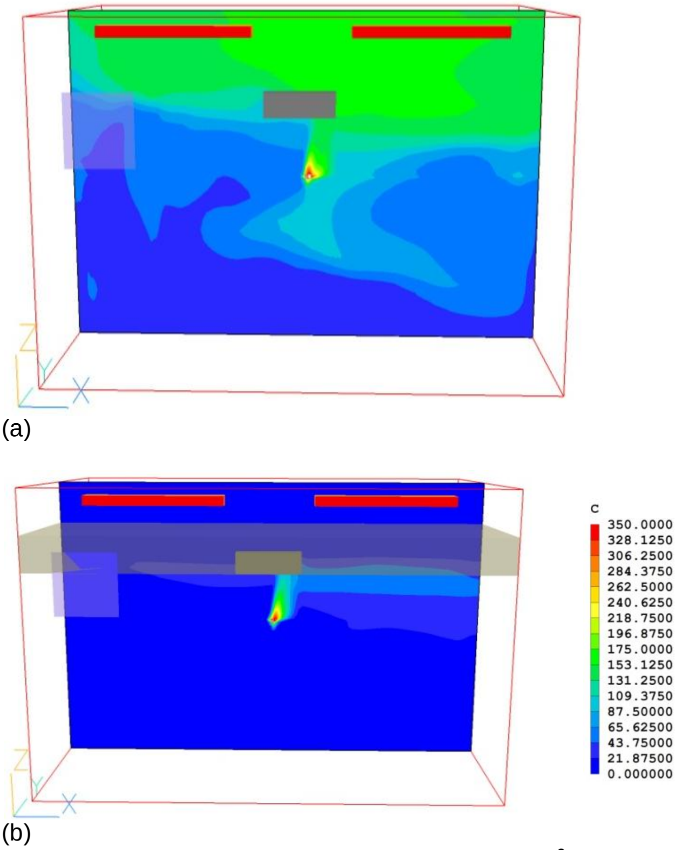


Figure 2. Concentrations of microorganisms (CFU/m^3) at the vertical cross section in the middle of the room with (a) UR-UVGI lamps off and (b) UR-UVGI lamps on

6) PHOENICS Use from Agents

6.1 CFD Modelling of Large Crown Forest Fire Behaviour *by ACFDA, V Agranat and V Permanov*

The computational fluid dynamics (CFD) modelling of large crown forest fire plumes has been carried out using PHOENICS, the general-purpose CFD software, customized for such modelling. General 3D conservation equations (mass, momentum and energy conservation) are solved numerically under input conditions specific for large crown forest fires. The standard high-Reynolds number k-ε model of turbulence has been applied and the atmospheric boundary layer has been introduced using the typical logarithmic profile. The input parameters of forest fire source (vertical gas velocity and fire temperature at the top crown surface) are defined based on empirical correlations dependent of the forest fire intensity. Radiation heat transfer was accounted for using IMMERSOL, the built-in PHOENICS radiation model. A typical area of individual forest fire considered in this study is 100mx100m. The effects of atmospheric boundary layer parameters (wind speed, temperature stratification and ground surface roughness) on the behaviour of multiple thermal plumes are analyzed. Hydrodynamic and thermal interactions between multiple plumes (potentially created by spotting) were studied in detail. As a result of mathematical modelling, steady-state 3D fields of gas velocity and temperature, smoke concentration and radiation fluxes have been obtained and analyzed while taking into account the mutual influence of the atmospheric boundary layer and the crown fire plume on each other. It was concluded that CFD modelling using PHOENICS could be applied systematically to investigate the dynamics of forest-fire-spread under the influence of various external conditions such as meteorological conditions (air temperature, wind velocity, etc), terrain specifics, forest type (various kinds of forest combustible materials) and its state (load, moisture, etc), in order better to understand the fundamental physical mechanisms, which control forest fire initiation and spread, and develop pragmatic (robust and user-friendly) physical-based forest fire behaviour modelling tools.

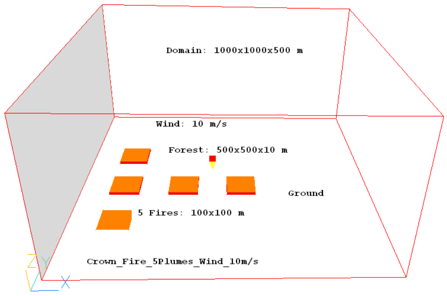


Figure 1: Wildfire Case Study: Fire Geometry and Energy

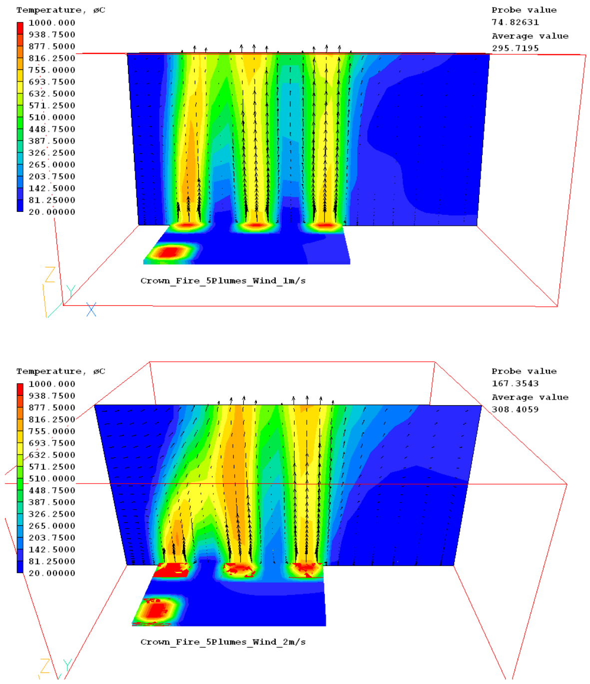


Figure 2: Wildfire Case Study: results (Plume Dominated Wildfires) Thermal Plumes for wind speeds of 1 (above) and 2 m/s (below)

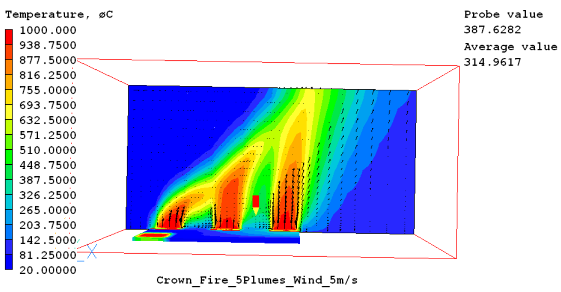


Figure 3: Wildfire Case Study: Results (Wind Driven Wildfires)

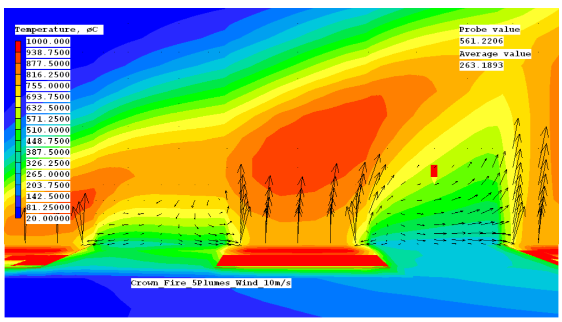


Figure 4: Wildfire Case Study: Results for 10 m/z Wind (Wind-Driven Wildfires)

Vladimir Agranat
Applied Computational Fluid Dynamics Analysis, Ontario, Canada
E-mail: acfda@sympatico.ca Web: www.acfda.org
Valeriy A. Perminov
Belovo Branch of Kemerovo State University, Russia

6.2 Use of PHOENICS to model a ventilation system in a tunnel

by Arcofluid: Mélanie LORENZ[(1)], Hervé BIOLLAY[(1)], Jalil OUAZZANI[(2)].

Introduction

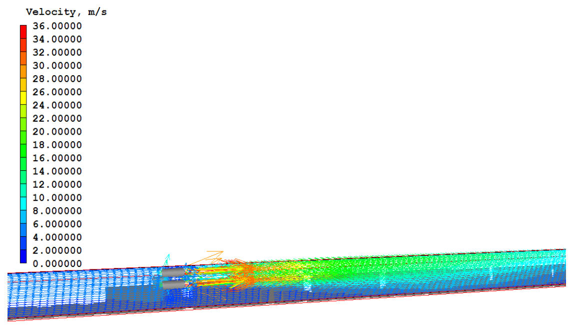
In case of fire in a tunnel, the aim of the ventilation system is to permit the evacuation of passengers. The two main ventilation systems are longitudinal and transversal. The longitudinal ventilation system pushes all the smoke downstream of the fire.

The aim of the transversal one is to conserve stratification. However, the spreading of smoke on long distance induces cooling of smoke layer and also loss of stratification. Therefore, smoke is extracted on the ceiling through outlet to maintain smoke stratification. PHOENICS allows the longitudinal and the transversal ventilation system to be modelled for this study.

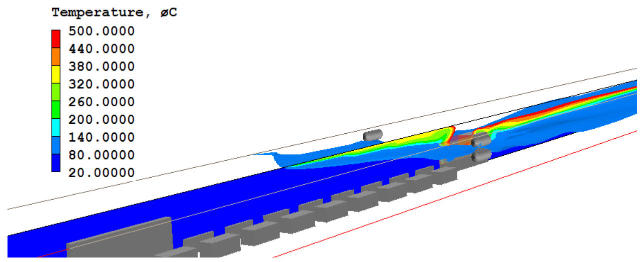
Longitudinal ventilation system

For this ventilation system, the longitudinal velocity is larger than critical velocity. The critical velocity is the minimum velocity to avoid the propagation of smoke upstream of the fire. This implies the use of jet fan. On PHOENICS, a jet fan is modelled using the function “Fan”.

Silencers are represented using 2 cylinders embedded (1 made of solid material and 1 of domain material, air in our study).

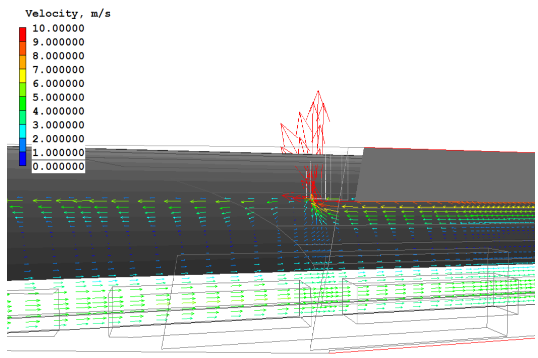


The fan is placed at the half of the cylinder length. The jet fan presence creates a gradient on the velocity vertical profile as it’s shown on the next figure. Therefore, the hot smoke is pushed downstream of the fire.



For this ventilation, the outlet is modelled using the function “OUTLET” on PHOENICS. The next picture represents the suction of smoke by the outlet

Transversal ventilation system



Conclusion

PHOENICS permits the user to represent the spreading of smoke in the tunnel and the influence of main phenomenon on this (buoyancy, fresh air flow…). The ventilation system can also be modelled (longitudinal and transversal).

(1) Egis tunnels Les pléiades n°35 – Park Nord Annecy F-74373 Pringy Cx
(2) ArcoFluid Parc Scientifique Unitec I 4 Allée du Doyen Georges Brus F-33600 Pessac

6.3 Air flow in a loading station of Octapharma AG by Frank Zimmerman, Zimmerman & Becker, Hielbronn, Germany (submitted and edited by Frank Kanters, Coolplug Germany)

Definition of task

For the loading station of a lyophilization facility for bio-pharmaceutical products the following needed investigation:

1. does planned air flow guarantee good uniform flushing of the loading station without dead zones during production?
2. are all the areas of the loading stations reached during disinfection mode with hydrogen peroxide (H_2O_2) ?
3. where must inlets for the water vapour-hydrogen peroxide mixture be placed to guarantee uniform distribution?

Procedure

1. modelling the loading station in 3D, including all relevant ventilation devices.
2. determining the simulation parameters based on the specifications of the principal.
3. stationary simulation of the air flow including existing heat loads in the loading station during production.
4. choosing a suitable position for the water vapour-hydrogen peroxide mixture inlets.
5. Transient simulation of the phases conditioning, disinfection and decontamination for a loading station at an air temperature of 30 °C.

Calculation data

Total air flow:	98000 m3/h
Inlet air flow:	17200 m3/h
Exhaust flow air:	17200 m3/h
Machine heat load:	11 kW
Other heat loads:	5 doors of surface temperature 55°C

Conditioning phase: 3 kg/h water vapour-hydrogen peroxide mixture (2 kg/h H_2O, 1 kg/h H_2O_2) and 120 kg/h dry air, duration: 30 minutes

Disinfection phase: 2.4 kg/h water vapour-hydrogen peroxide mixture (1.6 kg/h H_2O, 0.8 kg/h H_2O_2) and 120 kg/h dry air, duration: 120 minutes.

Conclusions:

Simulations with the PHOENICS/FLAIR-2009 software show the following:

Production operation.

1. loading station is flushed very well with an air velocity of around 0.45 m/s.
2. temperature distribution for a set point of 20°C is 19°C +/- 1K.
3. inlet flow and circulating air flow are not very well mixed. Since there are no people in the loading station this does not need to be a problem.
4. Using the "age of air" variable (available in FLAIR) it could be seen that the entrance and sterilisation area of the loading station are not so well flushed as the main area.

Disinfection operation.

1. distribution of the hydrogen peroxide revealed large differences across the loading station.
2. max/min ratio was 2. That means, when a concentration of at 800 ppm H_2O_2 is demanded at some places the concentration will be 1600 ppm H_2O_2.
3. causes of this were the placement of the exhaust openings and the mixture lances.
4. a better position of these devices could be advised.

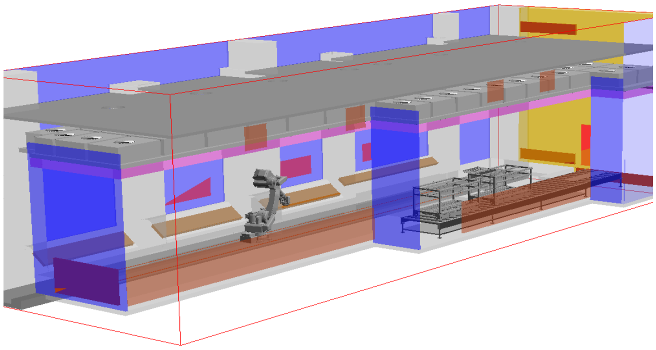


Figure 1. 3D loading station

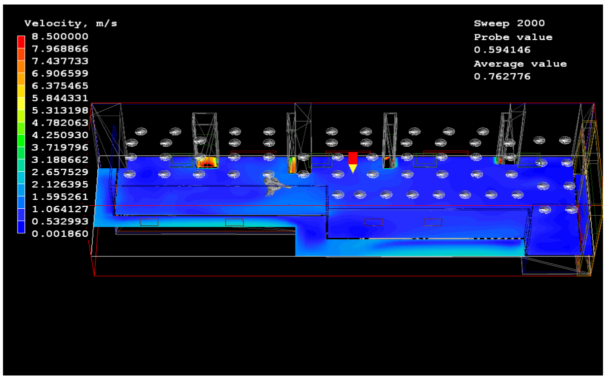


Figure 2. Air velocities at 1 m height (production operation)

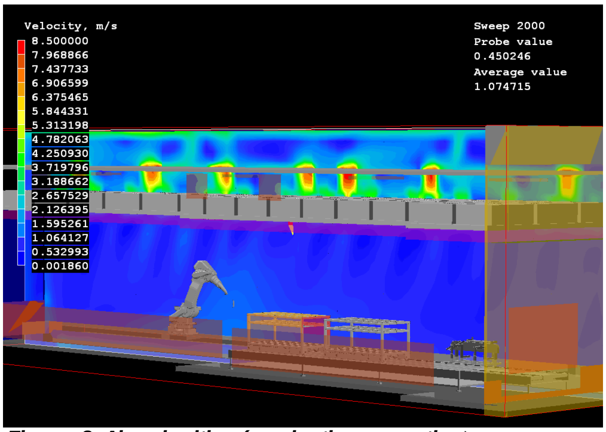


Figure 3. Air velocities (production operation)

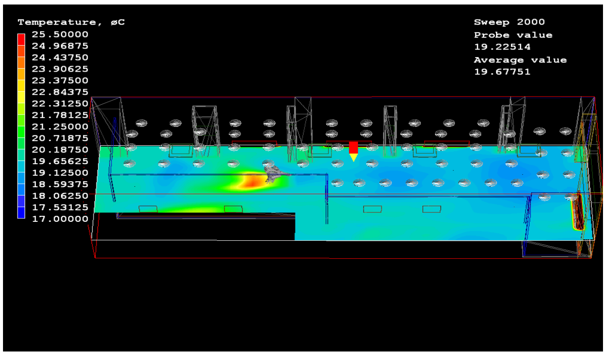


Figure 4. Temperature distribution at 1m height

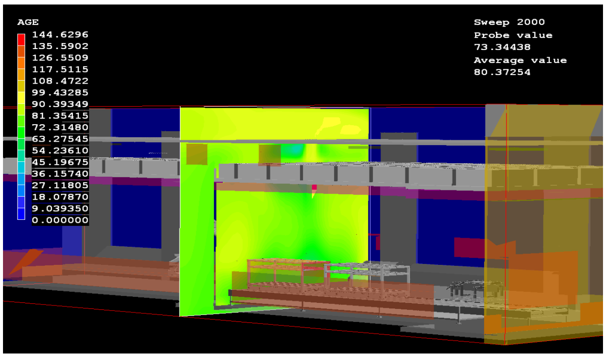


Figure 5. Age of air at a cross section (production operation)

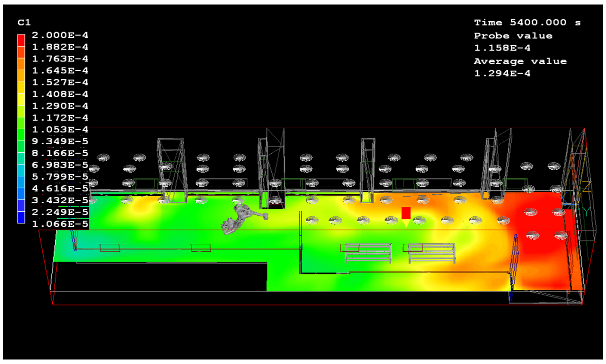


Figure 6. H2O2 concentration after 60 minutes at 1m height (disinfection operation)

7) News and Events

7.1 F1-VWT

"Not sure if you heard this yet or not, but the US Champions took the overall title in Singapore. This team comprised students from a school in Virginia and a school in Florida. They have spent several weekends in my classroom refining their designs over the past 9 months. Their use and discussion of their VWT results played a major part in their success. Thank you once again for providing me with the ability to teach such a highly motivated group of students. I will be asking them to write a summary article to send for use in your newsletter. I have attached a photo of the team touring the F1 paddock with Andrew Denford and Bernie Ecclestone."

Fred Stillwell, East Cobb Middle School STEM
Associate Director Georgia BEST Robotics

7.2 Eurostars

CHAM is collaborating on an EU-funded Eurostars Project in the field of wind energy, in conjunction with WindSim Norway and Iberdrola of Spain (see pages 7-8).

7.3 PHOENICS German User Day

The PHOENICS German User Day will be on Thursday January 20, 2011 in Aachen. It is organized by Coolplug and hosted by YIT, Uersfeld 24, D-52072 Aachen. Contact: Mr Frank Kanters for further information - frank.kanters@coolplug.com

7.4 Students

Sebastien Comberbach, a third year M.Eng student at the University of Warwick, returned to his university after a three-month placement at CHAM. He made a valuable contribution whilst he was with us and we wish him well with his studies.

Two students from King's College School, Wimbledon, of which Professor Spalding is an ex-student and an Honorary Fellow, spent a week at CHAM during the summer. We hope to extend this interaction between the School and ourselves.

7.5 Benelux PHOENICS User Meeting

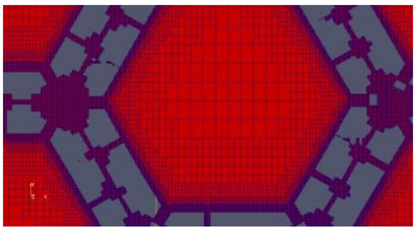
The annual Benelux PHOENICS User Meeting was held in Eindhoven at the Aristo Centre on September 28. The meeting was organized by Geert Jansen of A2TE, CHAM Agent for the Benelux area, and attended by Dr John Ludwig on behalf of CHAM. Thirteen PHOENICS Users from Benelux were present as well as Frank Kanters of Coolplug, the CHAM Agent in Germany. The day started with a short lecture on the capabilities of different hardware platforms to run PHOENICS. Participants had benchmarked their hardware running a specific library case; the results were compiled by Geert Janssen and compared to processor rating websites.

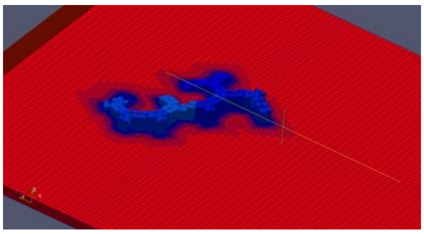
Presentations were made, by John Ludwig, outlining recent developments in PHOENICS, the use of InForm, available Radiation Models and advice on Convergence. These were well received by the participants, and generated several interesting questions from the floor.

To practice the newly gained knowledge there was a workshop, allowing all attendants to ask questions and discuss the pros and cons of setting various options in an intriguing "fire-simulation" test case.

Participants were interested in the progress of Unstructured PHOENICS, and were pleased with the mesh-generation capability demonstrated. It was generally felt that this was the way forward in the future.

It proved to be a very valuable and highly instructive day not in the least because of users sharing tips and tricks.





7.6 PHOENICS Delivery Information

PHOENICS 2010 is being supplied on DVD. Previous versions of PHOENICS were supplied on CDs, which have a capacity of 700MB. This capacity limit was steadily being approached over recent versions of PHOENICS, and the use of DVDs (with a capacity of 4.7GB) will allow more flexibility in what is supplied in future.

For example, a number of different PHOENICS versions could be supplied on the same DVD, such as 32bit Windows, 64bit Windows and Linux.