PHOENICS

News

Winter 2009

Merry Christmas and a Happy New Year to all CHAM's Customers and Friends.

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1) Editorial

Professor Brian Spalding FRS, FREng, has been awarded the 2010 Benjamin Franklin Medal for Mechanical Engineering and will become a Franklin Laureate at a ceremony in Philadelphia, Pennsylvania in April 2010.

Professor Spalding joins Franklin Institute Laureates including Max Planck, Albert Einstein, Pierre and Marie Curie, Alexander Graham Bell, and Rudolf Diesel. He has expressed himself as "delighted but amazed" to be so honoured and to join such "awesome" company.

The Franklin Institute Awards date back to 1824. Recipients are selected by an all-volunteer Committee on Science and the Arts who award medals in Computer & Cognitive Sciences, Chemistry, Earth & Environmental Science, Electrical Engineering, Life Science, Mechanical Engineering & Physics. Potential recipients have their work evaluated for its "uncommon insight, skill or creativity, as well as its impact on future research or application to benefit the public". The awards are intended to provide public recognition and encouragement of excellence in science and technology (http://www.fi.edu/franklinawards.

The citations for Brian's award are:

Scientific citation: "For his seminal contributions to computational fluid dynamics (CFD), including the Finite-Volume methodology, SIMPLE algorithm, and standardization of the k-e (epsilon) model, and creating the practice of CFD in industry, thus paving the path for its widespread application "

Lay Citation: "For his seminal contributions to the computer modelling of fluid flow, creating the practice of computational fluid dynamics (CFD) in industry, and paving the path for the widespread application of CFD in the design of objects from airplanes to heart valves."

Brian Spalding is Managing Director of Concentration Heat and Momentum (CHAM) Limited, a company which markets the PHOENICS computer-software code he created. PHOENICS uses Computational Fluid Dynamics to model heat transfer, fluid flow, chemical reaction and stresses in solids.

The Award Ceremony will take place in the Rotunda of the Benjamin Franklin National Memorial at the Franklin Institute on April 29 2010. The presentation forms part of a week of activities during which Laureates will participate in educational programs including a symposium at a local institute held in Professor Spalding's honour.

2) Latest PHOENICS Features

2.1 STAGUS, the STAGgered UnStructured grid
by Brian Spalding

Early successful numerical computations of fluid flow employing the so-called 'primitive' variables *i.e. the* pressure and the three Cartesian components of velocity, made use of 'staggered' grids. By this is meant that the locations at which velocities were calculated lay between those at which pressures were calculated.

This seemed natural to those who approached the subjects with physics rather than mathematics in mind; for they could regard the discretisation essential to numerical analysis as that of replacing the real continuum by a series of 'tanks and tubes'. The pressures were to be calculated for the 'tanks' (from the equation of conservation of mass) and the velocities for the tubes (from the equations of conservation of momentum).

To use an electrical-resistance-network, voltages are always calculated at junctions between resistances and currents for the resistances themselves. Who would think of doing anything else?

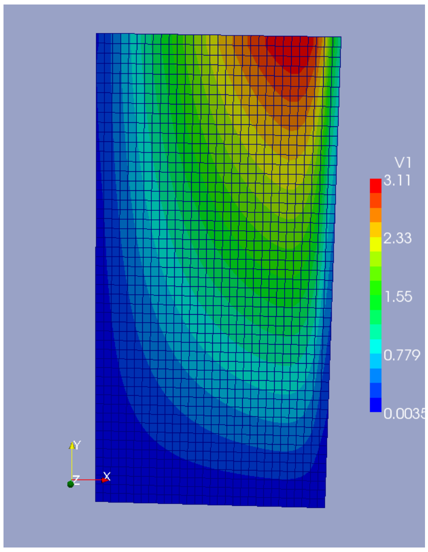
For some not-very-clear reason, the idea was later promoted that it would be 'better' to calculate the velocities and pressures at the same places; and from this idea arose schemes for what were variously called 'co-located', or 'colocated' or 'collocated' grids. The Rhie and Chow are most commonly given credit for inventing a set of equations allowing the said same-place variables to be computed.

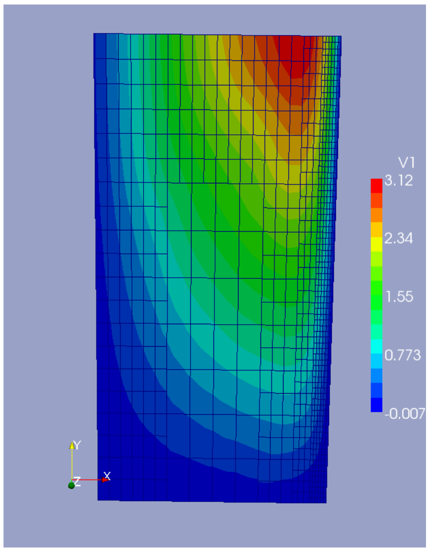
What 'better' has meant in practice appears to have been confined to code-writers' convenience, in that the 'control volumes' uses for momentum balances are the same as those for scalar variables such as temperature or mass-fraction; but such schemes often produce physically unreasonable results, particularly for those important flow phenomena (such as ground-water flow) in which the analogy with electricity is the closest.

PHOENICS has used, from the start, the staggered grid as its preferred option; but, when Unstructured PHOENICS (i.e. USP) was first created, the 'collocated-is-better' philosophy was given experimental credence. Some success was achieved, as is not surprising, for most unstructured-grid codes are based on it. However, there were failures too, not least in ground-water-like flows. Analysis of these led to the conclusion that, at least for the kind of unstructured grid used in USP, the 'collocated-is-better" advice needed to be put to practical test.

It was; specifically by Valeriy Artemov and Alexey Ginevsky who, with a little assistance from the present author, devised the STAGUS formulation which is now the default for USP. Although experience with it is limited, experience so far shows that:

- it exhibits the sturdy all-round convergence behaviour of Structured-grid PHOENICS (SP);
- in those circumstances in which it can be expected to do so (*i.e.* those of identical grids), its solutions agree with those of SP;
- when the grids are not identical, as illustrated below, the agreement is still as good as can be reasonably desired;
- STAGUS also requires less computer time for convergence than its collocated-vairables counterpart.





CHAM never claims (despite temptations!) to be the best; but it often been able, quite justly, to claim to be the first. Perhaps STAGUS is another example. Readers who refer us to earlier uses of staggered unstructured grids will be performing a good service. We shall happily acknowledge our as-yet-unknown predecessors.

2.2 CAD Import by John Ludwig

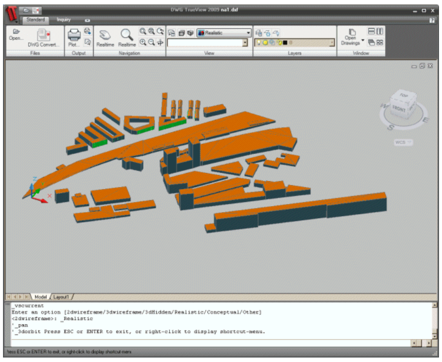
PHOENICS VR has always used built-in coding sequences to read STL and DXF files. Whilst the STL reader has been very reliable, the DXF reader has been restricted to a limited range of DXF elements. No other CAD formats could be used without going through a conversion program, such as AC3D from Invis or NuGraf from Okino Computer Graphics.

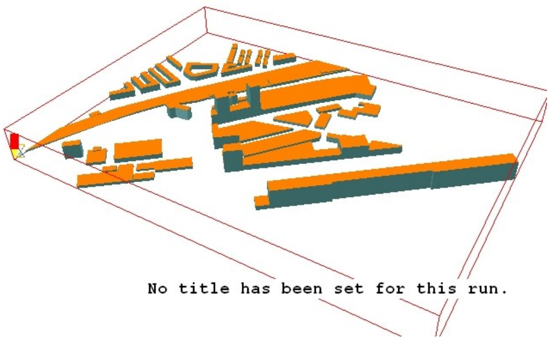
This limitation has been addressed by using readers in the OpenSceneGraph libraries to read files in the following formats and convert them to the PHOENICS-VR geometry format:

- STL - Stereo lithography file. This is available in many popular CAD programs as an export format.
- DXF - Drawing Exchange Format File (AutoCAD)
- 3DS - Autodesk 3ds Max
- WRL - Virtual Reality Modelling Language file
- DW - Files generated by DesignWorkshop from Artifice
- AC - Files generated by AC3D from Invis
- IV - Files generated by Open Inventor

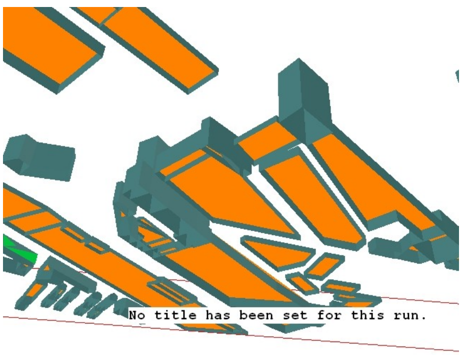
The range of CAD files directly readable by PHOENICS VR has thus been greatly extended, and the DXF import can now handle the current formats. In addition, a JPEG thumbnail of the converted geometry is created. This can be used later to identify another copy of the same geometry.

The following images show a DXF file viewed in DWG TruView 2009 and imported directly to PHOENICS VR.



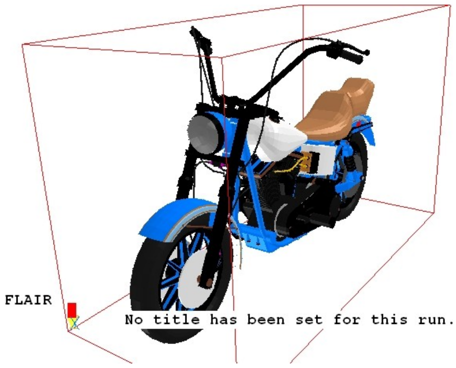


As a word of caution, the ability to import a file does not always mean that the geometry is suitable for PHOENICS! When this geometry is viewed from below, it is clear tat the buildings



do not form closed 3D volumes – they have no bases. No valid solution could be made with this file.

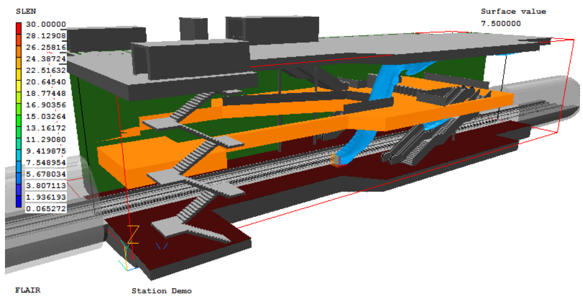
This 3D Studio file of a Harley Davidson also needs careful checking to make sure that all facets are pointing outwards.



Splitting CAD files into individual objects

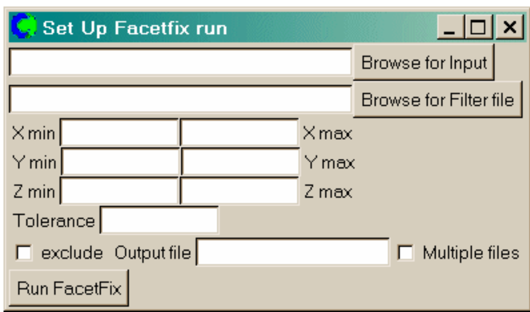
The FACETFIX utility program has been around for a long time now. It can read in an STL or DAT file and repair it by filling in holes (gaps between facets) and reversing back-to-front facets. It has always been able to identify closed volumes, and has used this to give each closed volume a different colour. It can now optionally output each closed volume as separate STL and DAT files.

This can be very helpful, as it allows for much better control over the grid, and also allows each object to have its own properties and sources.



The underground station shown above was imported as a single 3DS file. The resulting DAT file was then passed through FACETFIX to split it into the separate components. Eighty six of these were then re-imported in one step using the 'Import by Group' feature. This allows any combination of supported CAD files to be imported at the same time, preserving the relative positions of the objects.

The splitting is activated by ticking 'Multiple files' on the Facetfix setup dialog.



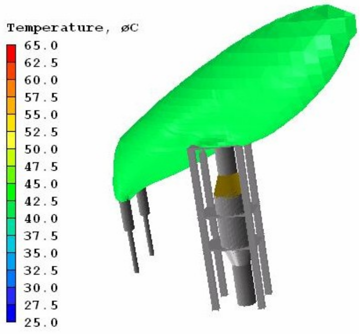
3) PHOENICS Applications

3.1 Process Safety Applications Using PHOENICS by (BakerRisk, Houston-TX)

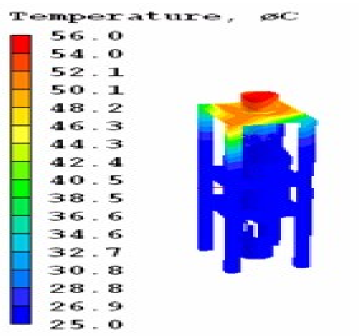
Baker Engineering and Risk Consultants, Inc. (BakerRisk, www.BakerRisk.com) has been using PHOENICS 2008 in process safety applications to investigate the thermal, flammable and toxic impact on equipment and personnel for onshore and offshore facilities. BakerRisk has numerous staff involved in CFD analysis using PHOENICS, and the following examples were provided by Arafat Aloqaily (AAloqaily@BakerRisk.com).

1) Dispersion of Gases from Turbine-Exhaust Silencers

PHOENICS 2008 has been used to simulate thermal impact of exhaust gases from two turbine exhaust silencers on personnel working at a platform downstream of the silencer stack. To evaluate a possible worst-case scenario, wind direction was chosen to direct exhaust plumes to the platform. The standard k–ε turbulence model was used in the simulations. Figure 1 shows the 3D envelope for temperatures ≥ 45 °C. The results showed that personnel standing on the target platform could be exposed to high temperatures. Platform design was modified, based on these results, to move personnel outside of high temperature zones.



3D **Temperature Profile**



Platform Surface Temperature

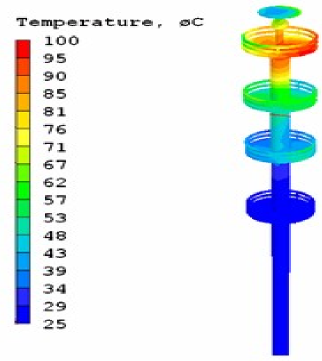
Figure 1: 3D Temperature Profiles for Two Turbine-Exhaust Silencers Affecting a Platform Downstream of the Turbines

2) Turbine Exhaust Impact on a Communication Tower

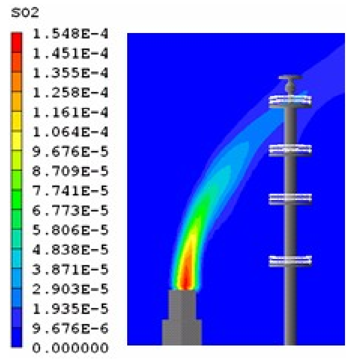
Thermal and toxic impact of high temperature turbine exhaust on communication equipment was simulated with PHOENICS 2008. To meet manufacturing specifications, the temperature of the communication equipment should not exceed set values.

The fuel burned in the turbine contains high sulphur content, and the concentration of SO_2 should not exceed allowable thresholds for maintenance personnel working at the tower, and those operating the nearby equipment on the platform (ie (i.e. PEL[1] and STEL[2]).

The simulation results show temperature and SO_2 at the communication tower (Figure 2). Alternative designs of the exhaust stack were proposed and simulated using PHOENICS, including redirecting flow away from the tower.



CommunicationTower Surface Temperature

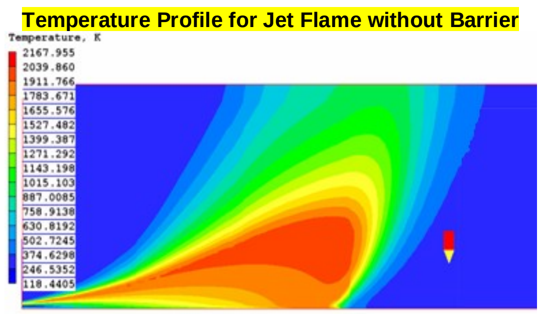


SO_2 Mass Fraction Profiles Impacting the Communication Tower

Figure 2: Thermal and Toxic Impact of Turbine Exhaust on Communication Tower

3) Jet Flame Temperature and Thermal Radiation Predictions

PHOENICS has also been used to simulate horizontal jet flames for a wide range of source parameters including pressure, temperature, and discharged rate. The temperature profiles and thermal radiation distribution were predicted for the jet flame using the standard k–ε turbulence model, the fast-reaction assumption for combustion, and the IMMERSOL radiation model. The use of thermal barriers to mitigate jet flames has been investigated and optimized using PHOENICS. Figure 3 shows an example of the temperature profile for a flame with and without a thermal barrier.



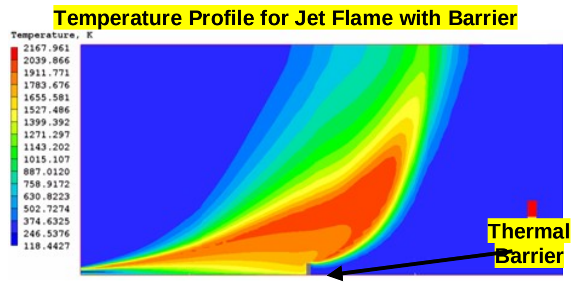


Figure 3: Temperature Profiles for Jet Flames with and without Thermal Barrier

[1] Permissible Exposure Limit
[2] Short Term Exposure Limit

4) Agent News and User Applications

4.1 ACFDA North America – by Vladimir Agranat

I) Uses of PHOENICS by Dr. Pascale Biron,

1) Assessing flow dynamics around instream structures in a fish-habitat restoration project in the Nicolet River (Quebec)

Using a detailed Digital Elevation Model (DEM) of the river bed, banks and instream structures (paired deflectors), we have constructed an "object bed" (similar to a CAD object in AC3D) and imported it into PHOENICS to run simulations at various flow stages using the k-e RNG turbulence model. Structures were emerged for the low-flow simulation and submerged at high flow.

We have related the bed shear stress patterns around structures and the dug pool (note that the objective of this restoration project is to create deep pool habitat for trout) to bedload transport using tracer particles. We have also modified the shape of the dug pool to see investigate the impact of morphology on flow dynamics. This is material that will be presented at the AGU conference in December.

2) Examining the impacts of various structures in a straightened agricultural channel

PHOENICS is used to model the 3D flow dynamics in a small straightened agricultural stream (in Quebec) in a section with two sharp bends where a lot of bank erosion is observed. Again, an object-bed based on a DEM and imported into PHOENICS to construct a Cartesian grid. Various structures will be tested (e.g. vanes of different types, energy dissipator) numerically to see how they can help reduce the bank erosion problems.

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E-mail: pascale.biron@concordia.ca

II) PHOENICS at CanmetENERGY-Varennes by David A. Scott, Scientific Researcher

Natural Resources Canada | Ressources naturelles Canada

CanmetENERGY-Varennes is one of Natural Resources Canada's three research facilities that focus on energy technologies. Located in Varennes, Québec (Canada), CanmetENERGY has a long history in modelling thermofluid scenarios using PHOENICS. In the past, the use of 2D transient and 3D steady-state PHOENICS models of an arena was part of a larger study that allowed the energy consumption of ice hockey and curling arenas to be significantly reduced.

More recently, CFD modelling at CanmetENERGY has focussed on two applications: modelling of the fluid flow and heat transfer inside ejectors for use in refrigeration applications; and modelling the fluid flow and heat transfer inside and surrounding geothermal wells for ground source heat pumps.

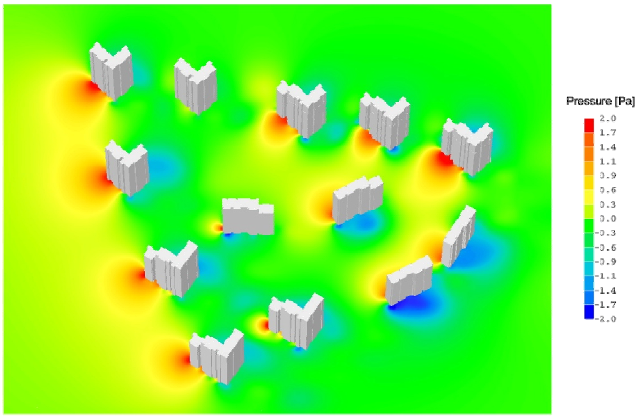
Ejectors are dynamic compressors that convert kinetic energy to pressure without the use of moving parts.

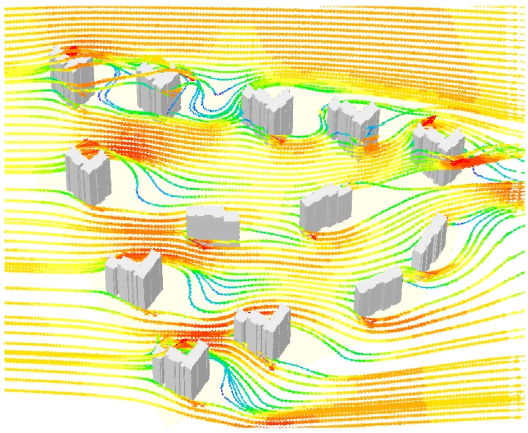
Ejectors are an old technology that has received a renewed interest in recent years, with applications in refrigeration and cooling, as well as in generating vacuums. Ejectors have long been operated with air or water however their performance has not been competitive with other technologies. CanmetENERGY is using PHOENICS to model ejectors that operate using synthetic refrigerants in an effort to improve their performance. Some of the challenges faced in modelling ejectors with CFD include: supersonic flows with shock waves; using the real properties of synthetic refrigerants; and the possibility of entering into two-phase flows composed of liquid droplets in a carrier gas.

Ground source heat pumps that use man-made geothermal wells are among the most energy efficient of the heat pump technologies; they are also one of the most expensive to install. PHOENICS is being used to create a detailed model of the tubing inside and the ground surrounding these wells. The CFD model is used to better understand the fluid flow and heat transfer in the tubing with the goal of reducing the costs of material and installation of ground source heat pumps.

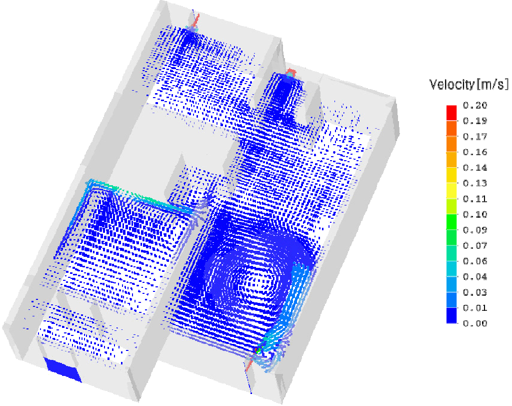
4.2 ACT Taiwan - by Dong-Seok Yeom

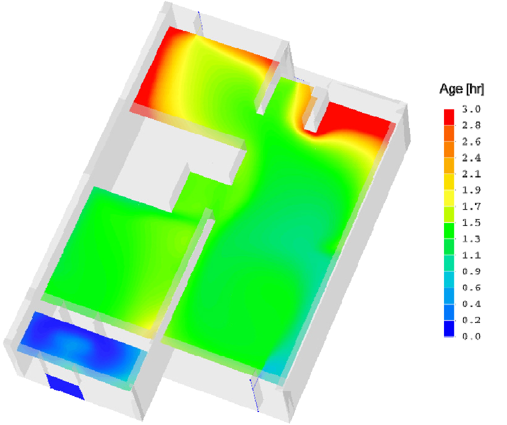
1) Visuals on Flows and pressure fields around and within building areas to determine which regions were best/worst for ventilation inside buildings.





2) Visuals on Air velocity and age distributions for the residential accommodation selected from the runs made in (1) above to study the effect of natural ventilation.





4.3 Coolplug Germany - by Frank Kanters

Coolplug is currently working on a new company profile including pictures and graphics which will be presented in the next Issue of the Newsletter. Plans for 2010 include improving sales into the building services engineering sector which is already the biggest market for PHOENICS in Germany but which can be expanded further because more traditional (small) engineering offices are going to use simulation software and PHOENICS is a cost-effective solution.

4.4 Shanghai Feiyi China by J L Fan

HVAC assessment of a computer room for the NanJing branch of China Mobile Limited by Shanghai Feiyi Limited

One of the computer rooms of the NanJing branch, China Mobile has the configuration as shown in figure 1. There are 5 air-conditioners with its each power as listed in Table 1.

		空调型号	台数	制冷量（单台）	投用时间
虎踞路51号	2层	佳力图9A U16	2	58.3KW	2004-6-1
	2层	佳力图9A U12	2	39.2KW	2004-7-1
	2层	佳力图6A U05	1	18.9KW	2004-7-1

Table 1. Air-conditioner type and capacity

PHOENICS/Flair was used to simulate the air velocity and temperature distributions in the computer room. PHOENICS was launched in 1981, the world's first commercial CFD software. PHOENICS/Flair is its special purpose-code, designed to help architects, design engineers and safety officers concerned with the performance of air-flow systems for the built environment.

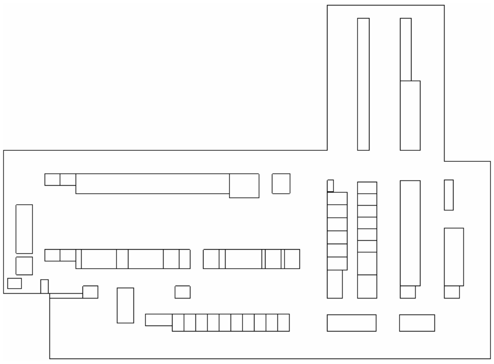


Figure 1. The configuration of the computer room

Figures 2 and 3 show the temperature distributions at 1m and 2m above the floor level respectively. As seen, there were 5 places, a distance away from air-conditioners, where temperature was rather high.

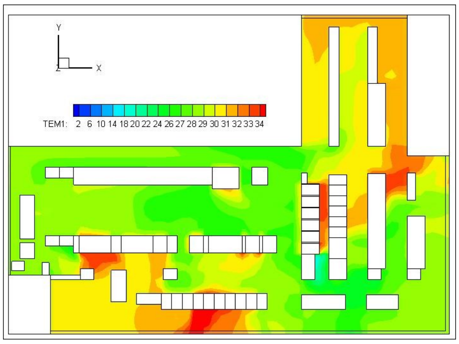


Figure 2. Predicted temperature distribution at 1m above floor level

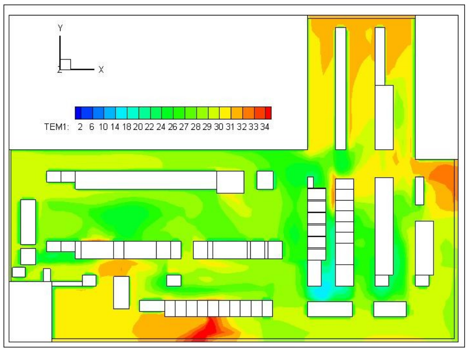


Figure 3. Predicted temperature distribution at 2m above floor level

Figures 4 and 5 show the air velocity distributions at 1m and 2m above the floor level respectively.

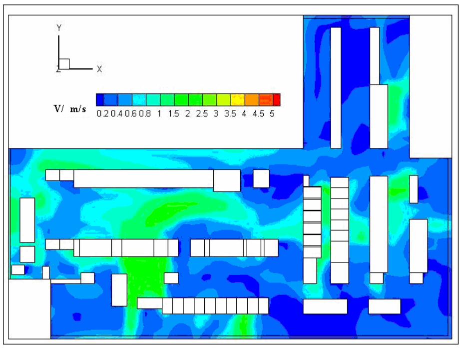


Figure 4. Predicted air velocity distribution at 1m above floor level

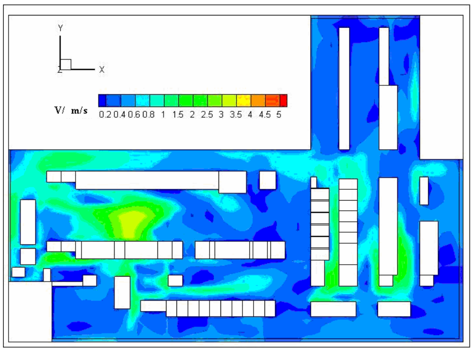


Figure 5. Predicted air velocity distribution at 2m above floor level

Based on the above prediction, the following suggestions were made in order to improve the situation as indicated by red circles in figure 6. To:

1. re-arrange the air inlet and air outlet locations for the air-conditioner so that the air was coming into the air-conditioner from its lower part and the air was discharged from the upper part of the air-conditioner.
2. increase air mass-flow rate through floor air vents around the cabinet row where the temperature was high.
3. move one row of cabinets 0.6m to the left in order to increase the space between the cabinet rows.

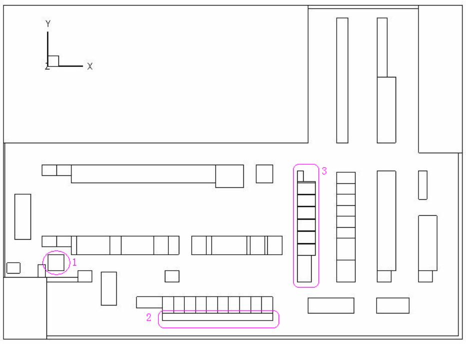


Figure 6. The proposed improvements

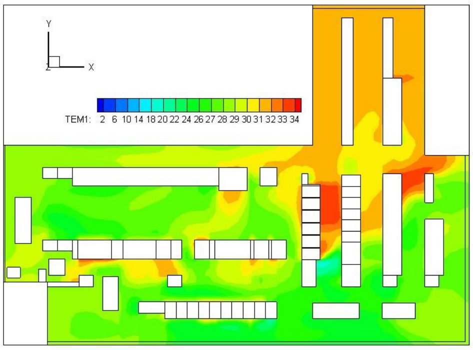


Figure 7. Predicted temperature distribution at 1m above floor level after the proposed improvements

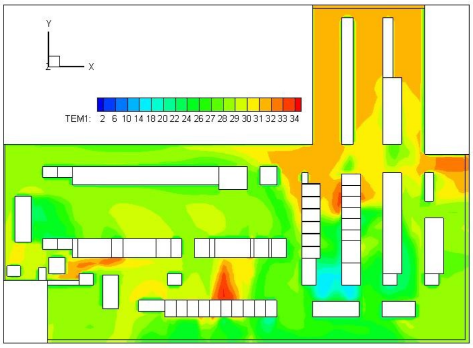


Figure 8. Predicted temperature distribution at 2m above floor level after the proposed improvements

Figures 7,8 show the improved temperature distributions at 1m and 2m above the floor level respectively whereas Figures 9 and 10 show the improved air velocity distributions at 1m and 2m above the floor level respectively.

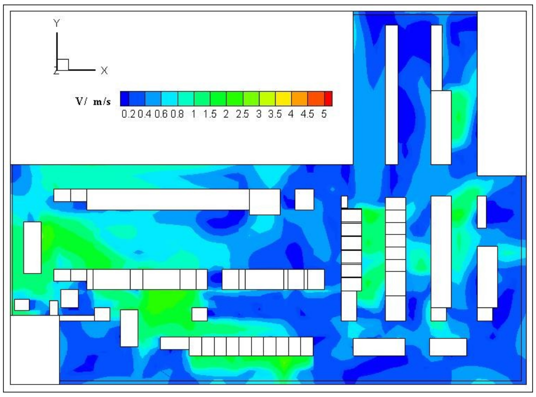


Figure 9. Predicted air velocity distribution after the proposed improvements

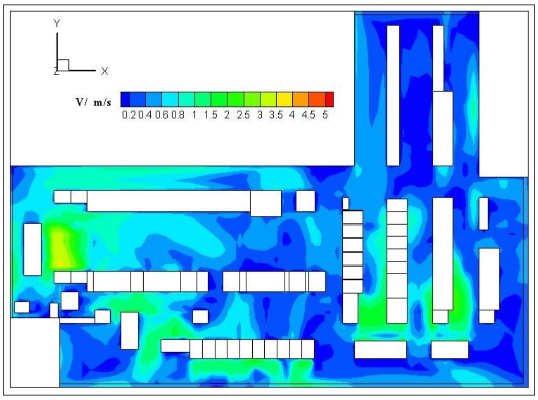


Figure 10. Predicted air velocity distribution at 2m above floor level after the proposed improvements

Newsletter Contributions

All Commercial PHOENICS Users are invited to email articles for inclusion on the CHAM website and in the next Newsletter to cik@cham.co.uk.

Academic PHOENICS Users are also invited to send contributions and are reminded that CHAM looks forward to receiving from them, on an Annual basis, their Reports outlining work carried out using PHOENICS (at the point where their Academic Licence is renewed each year).

Where Academic Users deal directly with CHAM the report should be sent by post, or by email to mjl@cham.co.uk. Where Academic Users deal through a CHAM Agent then the report should be sent to that Agent who will forward it to cik@cham.co.uk.

Thank you.

5) *News and Events 2009*

5.1 *Courses and Meetings*

Dr John Ludwig delivered a PHOENICS/FLAIR training course in November and a further one December 17-18. The courses are held at CHAM London on a regular basis and usually comprise a three-day programme with extra workshop time. Participants can share experiences and can present their problems to Dr Ludwig, and other CHAM staff, so that solutions can be reached and methods of working explored. The next CHAM course will be held in Wimbledon February 2 – 4 2010 and April 13 – 15 2010. For further information, or to book a place, please contact sales@cham.co.uk.

5.2 ***News re Deliveries by John Smith***

1) USB dongles

More customers are choosing to purchase a USB dongle (£100) which allows the flexibility of using PHOENICS on a number of PCs (both 32bit and 64bit Windows). A user with a single-user PHOENICS licence and one USB dongle can have PHOENICS on a laptop, home PC and Desktop PC (for example) and by moving the USB dongle amongst these PCs can utilise these resources efficiently.

2) Windows 7

PHOENICS 2009 will run under Windows 7, the latest offering from Microsoft. Windows 7 behaves in a similar manner to Vista when running PHOENICS 2009 and whereas previously the 'Desktop Composition' property setting sometimes needed to be changed (to resolve a VR Viewer graphics anomaly) in the next version of PHOENICS this will no longer be required.

5.3 Current and forthcoming Events

Dec 2 20 09	CHAM presented a paper at the CIBSE Seminar on the Role of 'CFD in Building and System Design'
Dec 17-18	CHAM PHOENICS/Flair Course at Bakery House.
Feb 2 – 4 2010	Next PHOENICS Training Course at CHAM: a regular CHAM Course comprising a Three-day Introduction. Attendees who so wish may come for only part of the time. e-mail sales@cham.co.uk to register for the next training course or to obtain further information. Courses can be run at customer sites by prior arrangement, see: http://www.cham.co.uk/training.php.
Feb 2 – 4 2010	The next PHOENICS-2009 training course is scheduled by ACFDA on February 2-4, 2010 in Toronto, Canada. Details are available on: http://www.acfda.org/our_offers/training.shtml and http://www.acfda.org/docs/Program2009_3days.pdf
Apr 13-15	CHAM PHOENICS/Flair Course at Bakery House.
Apr 26 – 30	Professor Spalding's Franklin Medal Award in Philadelphia, Pennsylvania
Jun 9 – 11	Professor Spalding is giving a paper at the 8^{th} International ERCOFTAC Symposium on Engineering Turbulence Modelling and Measurements in Marseille
June 2010	User Meeting in Shanghai and visit to Shanghai Expo. There will also be training courses held in Beijing, Shanghai, Xi'an and Shenzhen, dates will be announced in due course.

5.4 CHAM Staff News

We are pleased to announce that CHAM has three new members of staff. Dr Babis Tsimis joined in November and is working with Professor Spalding on Development and Improvements. Kate Taylor, who was with CHAM some years ago, has returned as an external Consultant helping with Consultancy and User Support. Adam Ludwig is with us on a temporary basis and has been working on Consultancy Support.

Professor Spalding gave a paper on *'Population Models of Turbulent Heat and Mass Transfer'* in Rome in September. He gave a paper on *'Computer Simulation of Flow, Heat Transfer and Combustion of Solid Fuel in Furnaces'* in Novosibirsk Siberia (above), in November He then gave a lecture entitled *'Lecture for Young Scientists'* at a Global Energy Meeting in St Petersburg in December.