# PHOENICS News

Summer 2014

## Editorial

## PHOENICS-2014

PHOENICS-2014 is available to all users with current Maintenance Contracts and to all new users.

The main new feature of PHOENICS-2014 is the inclusion of SPARSOL as default which enables users to model solids of arbitrary thinness in a more efficient way than has previously been the case (see p 3).

PHOENICS is moving into the field of Apps and Information on the work currently being undertaken to implement these is outlined by Professor Spalding (see p 2).

The third aspect featured is the extension of PIL objects improving ease of use by enabling the shape of such objects to be set by users via their own menu (see p 2).

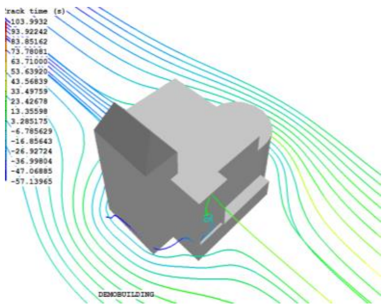
The Newsletter gives information on bug fixes within PHOENICS-2014 for those interested (see p 5).

## SimScenes / Apps

See page 2 for information on Apps from Professor Spalding, page 10 for a description of HeatEx (a heat exchanger App) and below for a brief description of a Virtual Wind Tunnel (VWT) to model Cityscapes:

### Cityscape Simulation, Wind Tunnel SimScene: Urban-VWT

### Why simulate Cityscapes?



*Building loaded Into URBAN-VWT*

Simulation is used to assess the effects of the wind over a newly designed building and the impact of the new building on pedestrians and the surrounding cityscape. Using **Urban-VWT** architects, building engineers, urban planners and local authorities can obtain:

- Forces on roofs and walls.
- Pedestrian comfort information.
- Rates of heat loss or gain between buildings, atmosphere and sky (in development).
- Concentration of pollutants (in development).

PHOENICS-Direct is a low-cost, simplified user interface for CHAM's PHOENICS CFD software package. PHOENICS-Direct, embodied within the application-specific SimScene **Urban-VWT**, leads the user directly to just the capabilities required. Contact sales@cham.co.uk for more information.

## General

Professor Spalding received a doctorate ***honoris causa*** from Imperial College in May at one of three post-doctoral graduation events that day with some 600 students, including Alexander Adam from CHAM, obtaining Masters or Doctorate awards.

## Contents

**1) CHAM Product Updates**
1.1 New Features of PHOENICS-2014
1.2 Embedding PHOENICS into Information Modelling Platforms
1.3 PHOENICS-2014 Bug Fixes
**2) PHOENICS Applications: External**
2.1 CFD Analysis of Wind Loading on a Rooftop Nightclub by Marek Magdziarz
2.2 PHOENICS Modelling of Non Equilibrium Shocks by Bob Hornby
**3) PHOENICS Applications: Internal**
3.1 Heat Exchanger Simulation: HeatEx
**4) Agent News**
**5) PHOENICS Diary**

PHOENICS News

## 1. PHOENICS Product Updates

### 1.1 New Features of PHOENICS
**by Brian Spalding, CHAM**

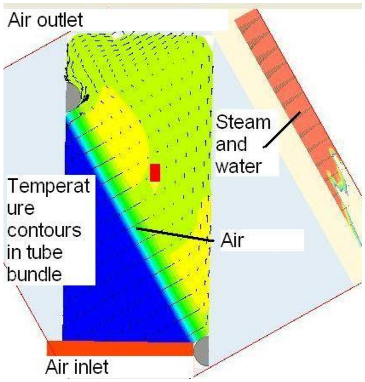
### The Appearance of Apps

General-purpose CFD codes such as PHOENICS are all very well for specialists; and narrower-purpose ones such as FLAIR suit practitioners in a particular but still broad sector, such as heating and ventilating. However, the majority of engineers, surgeons, and others who could benefit from CFD, are not doing so because codes which 'speak their language' do not exist. What they need are 'apps', which accept instructions expressed in their own words, interpret these to the 'CFD-engine', and ensure that it then produces the numbers, pictures and words which have been implicitly asked for.

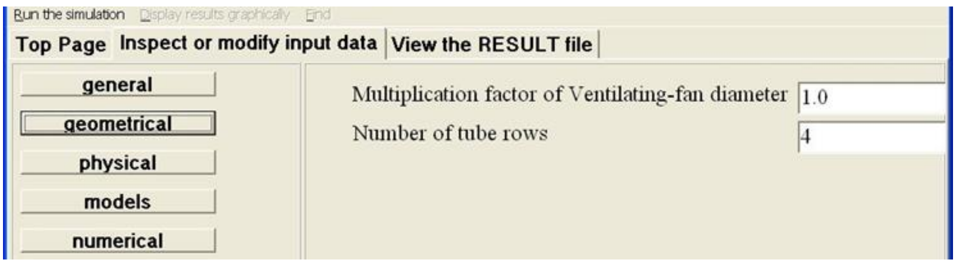
CHAM is now devoting much effort to the creation and marketing of a series of narrow-focus apps; and has developed special tools to enable both its own staff and its many skilled users, so to do. PHOENICS Input language, PIL, has long existed; and the first step in creation of an app is to write a parameterised PIL file as a transmission channel for the app-user's desires. Such is the power of PIL that this can nearly always be done without having to add any new source coding to that embodied in the PHOENICS executable.

App **users,** however, do not have to learn PIL; they are presented with an adapted-for-them on-screen menu. Heat-exchanger designers, for example, are there enabled to specify: the TEMA flow configuration, the shell diameter, the tube length, the number of baffles and the diameters of inlet and outlet nozzles; and of course also the fluids involved, their inflow rates, and their inlet temperatures. These are all items of information they **can** provide. Unknown information, such as heat-transfer coefficients, and internal distributions of pressure, flow-velocity and temperature, are calculated by the app.

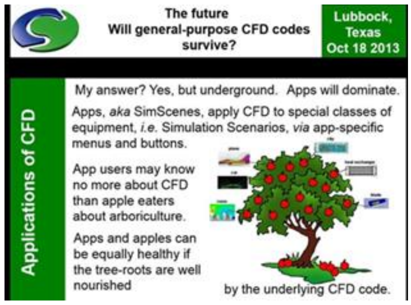
Even heat exchangers of unconventional type may be designed in this way as exemplified by the following image of an air-cooled condenser:




CFD experts may note with interest that the multiple-grid technique is being exploited. In this the finned-tube-bundle region is covered by one part of the grid for air outside the tubes; and by a second, extra, part of the grid for the steam within them. But such subtleties need not trouble the condenser designer or operator. Their app-**creator** has taken care of that. The app **use**r has only to supply data through simple menus such as:




Such menus are created, displayed and responded to by a new interface module called PHOENICS-Direct, in response to an app-specific scenario file. This has been created automatically by a second new module, the PQ1-editor, a tool devised to make the creation of apps as easy as can be. CHAM's intention is thus to enrich with palatable fruit the metaphorical app-tree in the lecture-extract below.




### PIL Objects

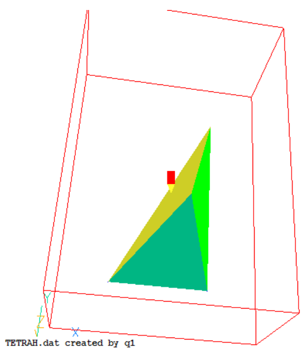
The more varied are the apps the greater is the variety of objects which have to be introduced into the simulation scenario; and also, incidentally the more numerous are the unprecedented uses to which The PHOENICS Input Language proves capable of being put.

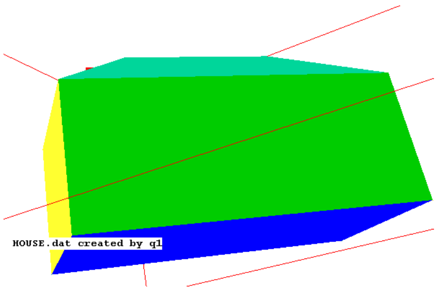
The PHOENICS library contains a very large number of objects, expressed by way of .dat files; and their positions, orientations, sizes and (to a limited extent) shapes can be altered by the settings of parameters in the input file.

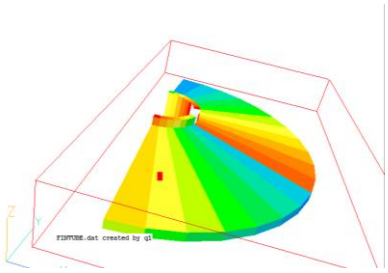
PHOENICS News

However, the shape limitations are severe: a wedge may be changed by stretching; but its two triangular surfaces are always parallel; its three other surfaces are always rectangles; and two of them are always at right angles. There can be few PHOENICS users who have not at some time found these restrictions irksome.

Of course, means of escape have been found. Thus, new shapes have been created by joining two or more old ones; a tube has been created by placing a cylinder of fluid inside a concentric cylinder of solid having a larger diameter; and the powerful ShapeMaker module has been capable, for many years, of creating objects of more elaborate shape. Recently however it has been shown that the arithmetic-execution and file-writing capabilities of PIL are well-suited to the creation of what may be called 'customised .dat files'; and, although the details are hardly likely to be learned by app-users, they are well within the capability of any app-creator. Some images of objects made in this way now follow:




What is especially convenient about such 'PIL objects' as they are called, is that their shapes are controlled by **parameters** which can be set by app users by way of their own PHOENICS-Direct menu, to see immediately on the screen what has been done, and to change it at once if it is not as wished. Moreover the fragments of PIL which create them are storable in a file library occupying far less space than the existing library of .dat files.

## *Thin Objects*

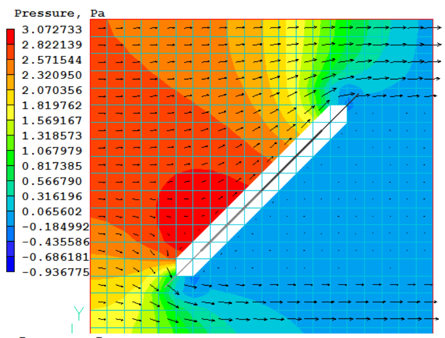
The fin shown in the last of the three examples is rather thin; and indeed it might be even thinner than the smallest cell of the computational grid; which will surely alarm those users of earlier versions of PHOENICS who have seen them fail in such circumstances. It is therefore timely to announce that PHOENICS 2014 can satisfactorily handle solids of arbitrary thinness.

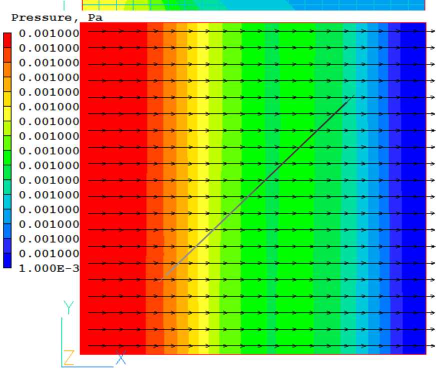
This has come about because the way in which the PHOENICS solver module responds to solid~fluid interfaces has been simplified and generalised.

It can be said, for those interested in nomenclature, that the earlier algorithm called PARSOL (*i.e.* PARtial SOLid) has been replaced by a new one called SPARSOL (*i.e.* Structured PARSOL). Moreover both of them belong to the family of techniques which has recently become fashionable under the acronym IBM, standing for Immersed Boundary Method. PARSOL was among the first of these. SPARSOL is perhaps the latest.

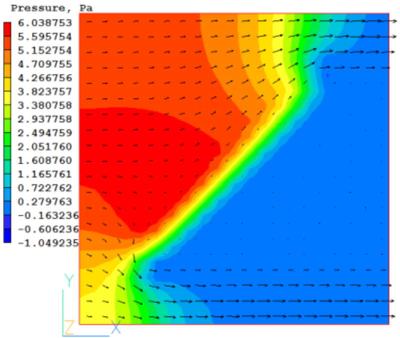
More important is the fact that the PHOENICS user has nothing to do in order to activate the new coding. For it is now the default choice.

Some examples of thin-object flows now follow. The first concerns an inclined facetted object in a left-to-right flow. The grid is fine enough for no cell faces to be cut by more than one facet. Therefore even PARSOL could represents it effect upon the flow, as shown by the first image. But only just; for, if the same object is shifted a small distance to the right in the same grid, its effects disappear, as the lower image shows.

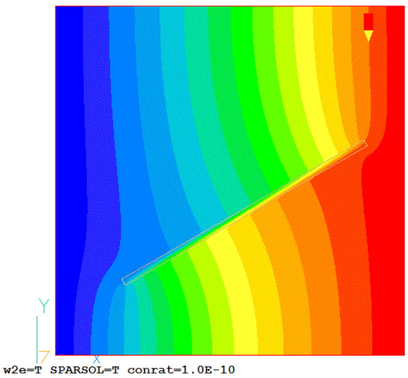


SPARSOL, by contrast, which generated the next image, always affects the flow whatever its position in the grid and indeed no matter how thin is the body.




Temperature effects can also be properly represented by SPARSOL. The following images shows the effect of a embedding an arbitrarily thin strip of non-conducting material within a domain of finite conductivity, the left- and right-hand boundaries of which are held at differing temperatures. When PARSOL is used, by contrast. The temperature field is entirely unaffected by the body.




That is not to say that all situations can yet be handled so satisfactorily. Had the conductivity of the embedded strip had been much greater than that of its surroundings rather than much smaller, then the isotherms should be distorted is a quite different way, becoming locally parallel to the strip rather than at right angles to it. In the current PHOENICS-2014 this does not yet happen infallibly; but how to procure it is known, and its introduction is on the short-term agenda.

In summary, the ability of the PHOENICS Satellite module to create PIL objects, and the ability of the PHOENICS Earth module to accept those that are arbitrarily thin opens the way to new practically important applications. One that immediately springs to mind is the thin-bladed rotary fan, examples of which are everywhere to be seen. This too is on the apps-in-preparation agenda. Readers who are interested in simulating such devices are invited to become beta-tester collaborators.

## 1.2 Embedding PHOENICS into Information Modeling Platforms by Dr Geoff Michel

Following past collaboration between the two companies for the Hevacomp Simulator, CHAM has been working with Bentley Systems ([www.bentley.com](http://www.bentley.com)) to create the first of a new series of CFD-solver "plugins" for their suite of Information modelling platforms.

The prototype is based upon Bentley Systems' AECOSIM Building Designer (ABD) package. The CFD solver for ABD simulates the flow around 3D solid objects to predict air pressure, velocity and indices for human comfort; the solution also provides information on how a new construction might affect pre-existing structures.

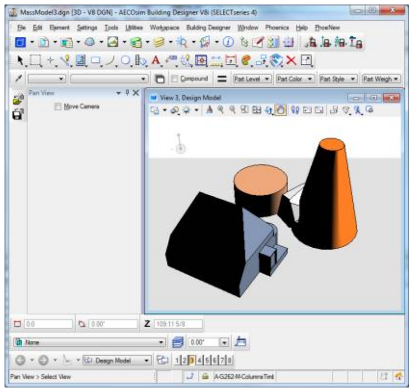


*Fig 1: View of a CAD-designed*

The geometry is converted automatically and passed through the PHOENICS-Direct interface which applies relevant parameters (such as grid size, wind speed and direction).

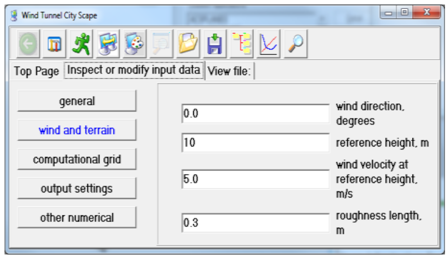



*Fig 2: Simplified interface to specification*

The CFD solver terminates once predefined criteria - known as Key Figures of Merit - are met and displayed.

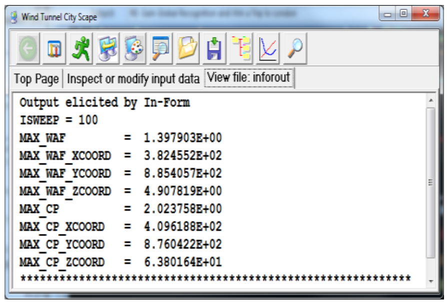



*Fig 3: Figures of Merit extracted from PHOENICS Results*

The results are generated using intelligent defaults, ready for inspection in both numerical and graphical form.

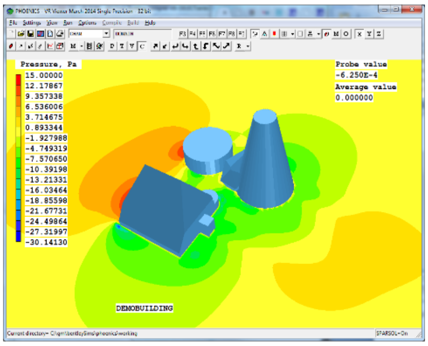



*Fig 4: Contours of pressure around design location*

It is envisaged that the PHOENICS-Direct prototype for ABD will form the template for CFD solver integration to other CAD products in the Bentley System range.

## *1.3 PHOENICS-2014 Bug Fixes*

The last edition of PHOENICS News listed some modifications and new features of PHOENICS-2014. This edition gives bug fixes included in the new release.

### *In the VR-Editor:*

- Correction to rotation of assembly object and related sources.
- Correction for plate object at NX boundary when XCYCLE=T.
    - Correction for PLATE at Xmax when cyclic boundary switched on - did not block flow previously.

### *For the Viewer:*

- Corrections to cyclic contour plotting.

### *In Earth:*
### *Bug Fixes and Improvements:*

- Better treatment of touching internal plates.
- PARSOL – total removal of NUD (Never UnDo) default.
- Better treatment of cells cut by >1 object.
- Intermittent Parallel ‘volcano’ effect cured.
- Correction to source allocation in cut cell – always to fluid part except for energy to solid.
- For *facetted* objects, when a total source is applied to an inlet or plate partially covered by a blockage, the entire source is applied to the open area. For *cuboid* objects, the source is reduced by the ratio of open area/total area. Consequently, the facetted code has now been modified to produce the same behaviour as the cuboid code.
- In parallel if a restart is attempted with no PHI/PHIDA present the error trapping kicks in too late and a failure occurs at the point the local PHI file is being read. Error trapping has been modified to skip to the error exit as soon as the master file cannot be found.
- Corrections to parallel implementation of S2SR.
- Further general minor corrections to parallel:
    - CHEMKIN link and mechanism files copied to slave processors in parallel.
    - Correction to use of {} in InForm in parallel.
    - Correction to InForm NETS() function.
    - 1-D block correction implemented in parallel.
- Improvement to calculation of C3EB constant in buoyancy term in turbulence model to account
- for staggered velocities and domain edges.
- Windows-style dialogs for Earth monitor interrupt.
- Net sources printed to result each time the solution file is dumped.
- Time-flux stores double precision to get more accurate energy balance in transient cases.
- Cure occasional NaN in apparently converging run. Caused by division-by-zero in wall function coding for certain values of laminar viscosity.

**PHOENICS-2014 is ready for delivery to new users and those with a current maintenance contract.**

***Contact** sales@cham.co.uk **to obtain a copy.***

***The Autumn Issue of the PHOENICS Newsletter is now in production.***

***Please send contributions, in Word format, to Colleen King (cik@cham.co.uk).***

***Please ensure that all technical contributions contain graphics.***

***Full attribution will be given.***

***Thank you.***

## 2. PHOENICS Use: External

### 2.1 CFD Analysis of Wind Loading on a Rooftop Nightclub 102m above Ground using PHOENICS

*by Marek Magdziarz*

Marek Magdziarz from Poland has been using PHOENICS to support his consulting service since 2007. A recent project involved CFD simulation of winds surrounding the roof of the Millennium Plaza skyscraper in Warsaw; ordered by the owner of a new night club situated on its roof platform (+102m above ground.) The owner wanted to check that the architects had designed a sufficient number and height of plexi-glass wind-shields (216cm) around the edge of the platform – and textile material roofs above the main bar, grill bar and DJ's desk – to cope with winds experienced at that height.

The domain size used for Marek's CFD model was X=250m, Y=250m, Z=150m; the total number of cells exceeded 6.2 million, with the smallest cell size being approximately 10x20x10cm. Building geometry and all the objects therein were created using A3CD and exported as DAT files.

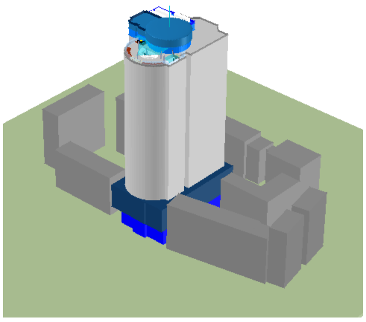


*Fig.1: View of skyscraper & surrounding buildings.*

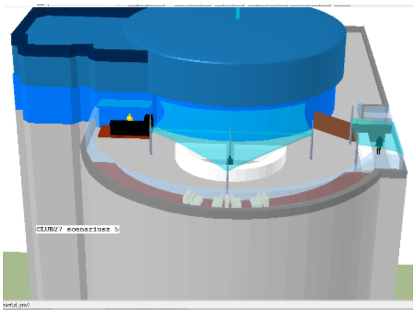


*Fig.2: Front view, 3D model of Nightclub.*

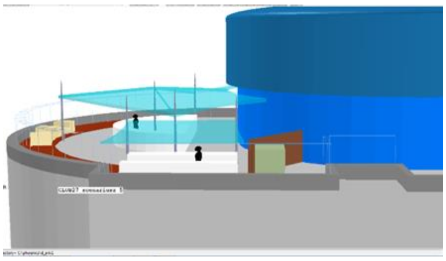


*Fig.3: Side view, 3D model of Nightclub.*

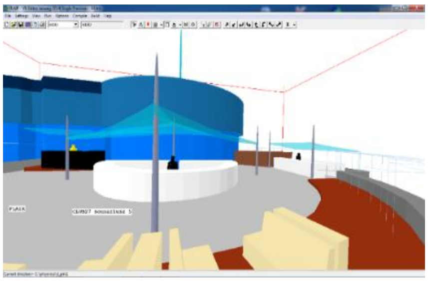


*Fig.4: Side view from customer's rest zone in 3D model of Nightclub*

The CFD model was run for various environmental conditions and design scenarios:

- winds from West and North;
- wind speeds of 1.5m/s and 3m/s;
- with and without textile roofs; and
- various wind-shield heights (216cm, 266cm, 316cm).

Figures 5, 6 &7 show the results of a scenario based on a 3m/s wind from West, 216cm high plexi-glass wind shields, plus 3 textile material roofs.

The pressure around roof platform and building varies between +13Pa and -25Pa, but the maximum local wind speed reached ~10m/s in this scenario for which images are shown below.

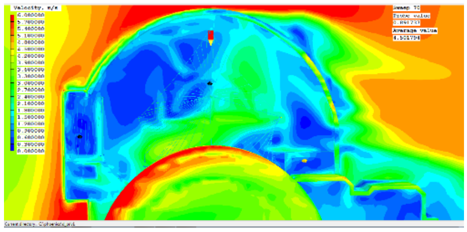


*Fig.5 Plan view at chest height*

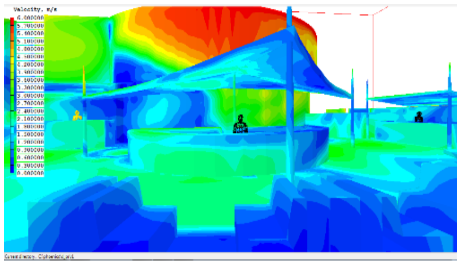


*Fig.6: Side view from customers' rest zone on all surfaces of blocks with wind speed plots.*

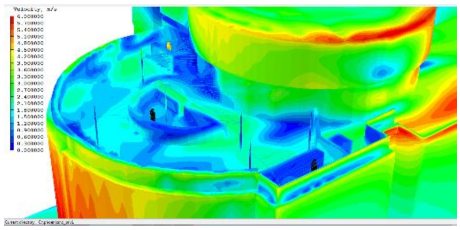


*Fig.7: Side view on all surfaces of blocks with wind speed plots.*

Both the architect and his customer were satisfied and impressed by the capabilities of PHOENICS and the realistic geometries created from scratch via AC3D.

Email: marek.magdziarz@wentylacja-strumieniowa.com.pl

## 2.2 PHOENICS Modelling of Non-equilibrium Shocks
by Bob Hornby

### Introduction

The assumption of Classical Gasdynamics, that the variations of fluid properties can be described by a set of equations derived considering the fluid to be everywhere in instantaneous equilibrium, is only justified when characteristic times ('relaxation times') for adjustment of the molecular energy states are very much smaller than the time taken by the fluid to encounter significant changes in its environment. When this assumption is not true the full non-equilibrium processes occurring must be accounted for.

For example, consider a gas consisting of molecules with energy contributions from translational, rotational and vibrational motions. The former two modes require relatively few collisions to attain equilibrium so that any non-equilibrium is exhibited only in flows with a correspondingly small characteristic time. This is equivalent to saying that non-equilibrium phenomena in the translational and rotational modes need only be considered in regions of high gradients, for instance in the viscous interior of shock waves. The characteristic time for adjustment of the vibrational energy modes is much larger than for the translational and rotational modes so that the region over which vibrational modes attain equilibrium is much larger.

Consider then the structure of a shock wave in such a gas. It consists of a very thin region (usually treated as a discontinuity) in which the translational and rotational modes adjust to an equilibrium state (and in which the vibrational modes can be considered to be 'frozen' in the upstream state) followed by a much larger region in which the vibrational modes attain equilibrium. Such a shock is shown in figure 1.

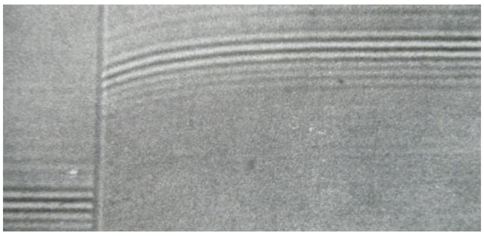


*Figure 1. Interferometer photograph of a shock wave in carbon dioxide with initial temperature and pressure 295K and 1 atmosphere. Vertical fringe displacement is proportional to density difference. Note the very narrow region with a large density jump corresponding to adjustment of translational and rotational degrees of freedom followed by a wider region in which vibrational modes adjust. The shock is travelling from right to left or equivalently the flow from left to right with $M_f$=1.407 and the shock stationary.*

This implies that if the upstream Mach number based only on the translational and rotational energy states (the 'frozen' Mach number, $M_f$) is less than one, then the initial 'discontinuity' illustrated in figure 1 is no longer present. The translational and rotational modes remain in an equilibrium state while the vibrational modes adjust. Such a shock is called fully dispersed (ref 1). The shock in figure 1 is called partly dispersed. In the same way, consideration of all the energy states defines an equilibrium Mach number ($M_e$) which will be larger than the frozen Mach number. Defining

$$M_f = \frac{U_n}{\sqrt{\gamma_f RT}} \quad , \quad M_e = \frac{U_n}{\sqrt{\gamma_e RT}}$$

where $U_n$ is the upstream flow velocity normal to the shock, $R$ the gas constant per unit mass of gas and $T$ the upstream absolute temperature and

$$\gamma_f = \frac{c_p}{c_v} , \gamma_e = \frac{(c_p + c_{vib})}{(c_v + c_{vib})}$$

where $c_p$, $c_v$ are specific heats at constant pressure and volume relating to translational and rotational modes (giving $\gamma_f$=1.4) and $c_{vib}$ is specific heat for vibrational mode.

The condition for a fully dispersed shock then becomes

$$1 \geq M_f > \sqrt{\frac{\gamma_e}{\gamma_f}}$$

These waves have been shown to be relevant to the structure of sonic bangs (ref 2) which (at ground level) may be fully dispersed with thicknesses orders of magnitude greater than would have been calculated ignoring the effects of the vibrational energy modes. A convenient way to study the development of waves in which vibrational relaxation is important is via shock-tube experiments in gases with a relatively high vibrational content (e.g. carbon dioxide or nitrous oxide). In these cases wave development may be made to take place over laboratory scale distances.


*Figure 2. Interferogram of the steady two dimensional flow of nitrous oxide at $M_f$=1.56 past a wedge whose upper surface is inclined at 2° to the freestream, showing broadening of the wave (due to vibrational relaxation) away from the upper wedge surface.*

Figure 2 shows an interferometer photograph of supersonic flow set up in a shock tube over a wedge section with its upper surface set at 2° incidence. The shock wave emanating from the wedge tip is seen clearly in the upper section of the photograph (other features shown are irrelevant to the subsequent discussion and modelling).

At the wedge tip only the translational and rotational degrees of freedom have characteristic times sufficiently small to respond to the wedge disturbance. The vibrational modes remain effectively frozen at their freestream energy values.

This leads to a very narrow frozen shock at the wedge tip which decays rapidly with distance from the wedge surface. Towards the top of the photograph, the shock is, fully dispersed and close to its fully developed state with a balance achieved between non-linear steepening and diffusive smoothing.

## *PHOENICS Modelling*

PHOENICS has been used to model the above flow in 2D, treating translational and rotational degrees of freedom as being in local equilibrium and vibrational modes in non-equilibrium. The flow can then be treated as an ideal gas flow with constant specific heats and heat transfer at a rate equal to that at which energy is transferred between translational and rotational modes and vibrational modes. Cartesian and Body Fitted Coordinates (BFC) have been employed to model the upper surface of the wedge.

For the Cartesian grid the wedge is modelled using a wedge object from the shape library (with PARSOL switched on). For the BFC grid the upper wedge surface naturally forms the lower boundary. In each case the *y* coordinate is vertical and the *x* coordinate horizontal.

The Cartesian grid used 715 cells in the *x* direction and 700 cells in the *y* direction. The BFC grid used several grid refinements (see later). Flow was assumed to be laminar.

Equations were solved in non-dimensional form with pressure, density, temperature and relaxation frequency normalised with respect to their upstream values, $p_0$, $\rho_0$, $T_0$ and $\phi_0$. Flow velocity is normalised with respect to $(RT_0)^{0.5}$, specific heats with $R$ and the coordinates with $(RT_0)^{0.5}/(\rho_0\,\phi_0)$.

Non-dimensionalised equations are then the same as dimensional ones except for the absence of $R$ in the equation of state and a laminar viscosity set to *1/Re* (so effectively very small).

*P1, U1, V1, H1* and *C1* are solved for with *C1* taken as the vibrational energy content represented with the rate equation

$$\frac{dC1}{dt} = \rho\phi_0(c_{vib}T - C1)$$

where $c_{vib}$ and $\phi_0$ are approximated with their freestream values as the shocks under consideration are weak.

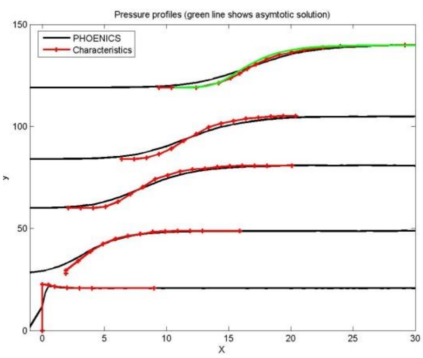
This necessitates a source term on the right hand side of the *C1* equation equal to $\rho$ times the right hand side of the above equation. The energy equation, solving for the enthalpy (*H1*, with the built in source term set) then has an additional source term equal to the negative of that set for *C1*. The complete set of equations is solved using KOREN.

## *Comparison of results with the MOC and experiment*

Two simulations have been carried out using Cartesian and BFC grids. The first with a frozen freestream Mach number of 1.49 and $c_{vib}$ equal to 2.12 is compared to a solution generated by the Method of Characteristics (MOC, ref 3). The MOC solves compatibility relations along forward and backward characteristics and streamlines in conjunction with the jump relations across the frozen shock. Because the method follows the wave paths it generates very accurate solutions. The second simulation with a frozen freestream Mach number of 1.56 and $c_{vib}$ equal to 2.28 is compared to the shock tube run illustrated in figure 2. Results from the first case are shown in figure 3 for pressure profiles along the wedge surface and at *y*=28, 60, 84 and 119. The *X* coordinate equals *x-y/tan(β)* where $\beta$ is angle of initial frozen shock to the horizontal (44.44°in this case). This allows a compact graphical representation.

It can be seen that PHOENICS results are in good agreement with those derived using the MOC for the vibrational relaxation regions (both in magnitude and position).

As expected the frozen shock wave is smeared in PHOENICS results as the region is too thin to be represented adequately on either grid; a good prediction of the pressure jump at the wedge tip is obtained nonetheless. The frozen shock decays quite rapidly away from the wedge tip (note the very small pressure jump predicted by the MOC at *y*=28) and so is not an important feature of the calculation above wedge surface.



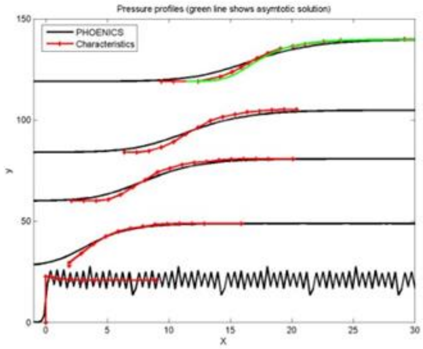



***Figure 3. First case: $M_f$=1.49, $c_{vib}$=2.12. Comparison of PHOENICS results (dark lines) with Method of Characteristics (red crosses) on the wedge surface and at non-dimensional distances y=28, 60, 84 and 119 from the wedge surface (the latter corresponding to a near fully developed state). The green line shows the exact fully developed solution. The top comparison is with the BFC grid (nx=685, ny=600) and the bottom comparison with the Cartesian grid (715 by 700).***

Cartesian grid results show an oscillatory behaviour along the wedge surface but with a mean value following MOC results. This reflects Cartesian grid inability to represent the wedge surface smoothly.

The oscillation amplitude is, however, relatively small and is rapidly damped with distance from the wedge surface. The green line in both sets of results is the exact fully developed pressure profile. This is accurately predicted with the MOC.

PHOENICS results show a slightly broader wave profile as a result of numerical diffusive effects.

Results from the second case using the BFC grid have been cast into dimensional form and the fringe pattern calculated using the computed density distribution.

The calculated interferometer fringe displacement near the top of the shock tube test section at *x*=0.03609m is shown for several grid refinements in figure 4. 610 by 600 and 810 by 800 grid cell refinements give virtually identical results but still dot quite match up with the exact fully developed fringe displacement, indicating some residual numerical diffusion in the PHOENICS results.

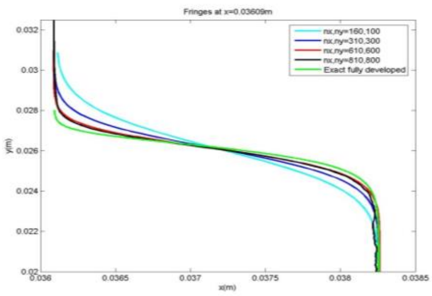



***Figure 4. The second case: $M_f$=1.56, $c_{vib}$=2.28. A computed interferometer fringe displacement through the shock at x=0.03609m (near the top of the shock tube test section, see figure 2) for several grid refinements. The green line represents the fully developed shock wave fringe shift.***

Figure 5 shows the computed fringe pattern using a 610 by 600 BFC grid. The green line is the calculated, exact fully developed fringe displacement which is seen (at this scale) to agree quite well, but does so earlier than expected indicating a broader computed shock which visual inspection of figure 2 also supports.

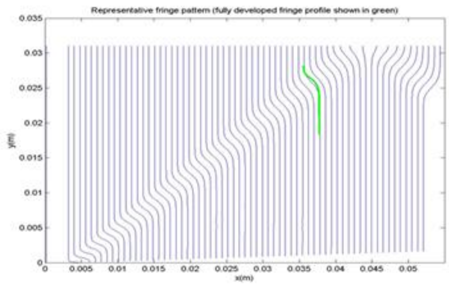



***Figure 5. The second case: $M_f$=1.56, $c_{vib}$=2.28. Computed interferometer fringe distribution (to be compared with figure 2). The green line represents the exact fully developed shock wave fringe shift***

## *Conclusions*

PHOENICS has been used to compute a weak, non-equilibrium shock wave generated by supersonic flow of a gas over a wedge with its upper surface inclined at $2^0$ to the horizontal. The vibrational modes attain equilibrium over a relatively narrow inclined region of the flow, making it computationally time consuming to achieve good accuracy with a structured grid. Cartesian and BFC grids were used to model the flow.

Neither grid is sufficiently refined to capture in detail the frozen shock which decays rapidly with distance above the wedge tip, but this is not a significant feature of the simulation. The Cartesian grid produces small oscillations on the wedge surface (presumably due to the stepped nature of representation); they die out quickly away from the surface.

Good agreement is obtained in comparison with the MOC (which is known to be efficient and accurate for these flow types) both for shock wave position and structure.

The BFC grid has the wedge surface as a smooth boundary and so produces good agreement with the MOC on and above the wedge surface.

Both grids produce slightly broader far field waves than predicted by the MOC or suggested by comparison with a shock tube interferometer fringe pattern.

## *References*


1. Lighthill M J. Surveys in Mechanics, ed Batchelor G K and Davies R M, Cambridge University Press, pp 250-351, 1956.
2. Johannesen N H and Hodgson J P. The Physics of Weak Waves in Gases. Rep Prog. Phys, pp 629-676, 1979.
3. Liepmann H W and Roshko A. Elements of Gasdynamics. John Wiley & Sons, 1967.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## 3. PHOENICS Use: Internal

### 3.1 HeatEx: Heat Exchanger Simulation

**HeatEx** is an App, exemplifying those described in Item 1.3 above and provided via PHOENICS-Direct which, embodied within its application-specific SimScene or App leads the user directly to the capabilities required and no more.

**HeatEx** simulates the thermal performance of three-dimensional shell and tube heat exchangers.

The use of CFD enables designers to overcome most of the limitations of the manual and numerical methods currently used to rate heat exchanger performance, by removing some of the simplifying assumptions which such methods are forced to make, such as:

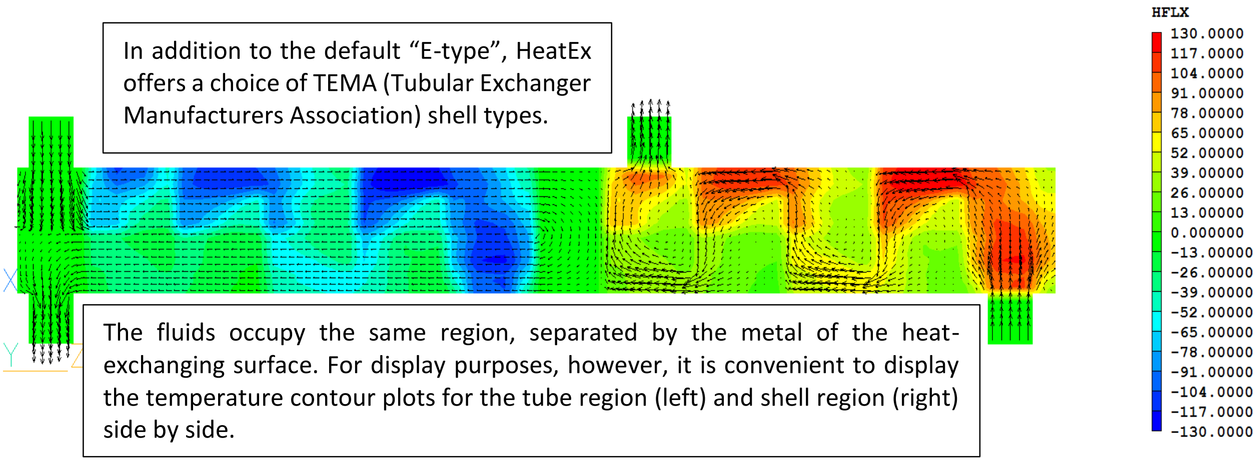
- uniformity of fluid properties;
- uniformity of heat-transfer coefficient; and
- independence of time.

Manual techniques such as 'stream-analysis' used for predicting steady-state thermal performance remain inappropriate for determining locations of:

- high velocity (likely to cause tube vibrations);
- low velocity (where deposition of solids may occur);
- deviations (from heat-transfer coefficients presumed uniform);
- time-dependent effects.

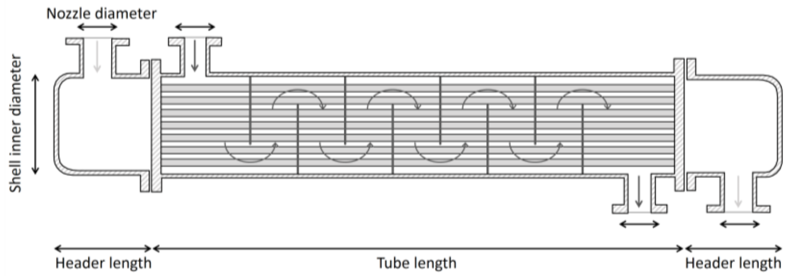
Given sufficient computational resources, other mainstream CFD codes – like PHOENICS – can be used to simulate 3D flows with variable fluid properties, using a detailed fine-grid CFD model of flows between and inside tubes. The HeatEx SimScene employs a "space-averaged" (SA) CFD technique sufficiently economical to be used in everyday design on portable computers. **HeatEx** enables the heat-transfer behaviour of the entire heat exchanger to be predicted swiftly and accurately, whilst avoiding the modelling presumptions of manual predictions.

In addition to the default "E-type", HeatEx offers a choice of TEMA (Tubular Exchanger Manufacturers Association) shell types.




The fluids occupy the same region, separated by the metal of the heat-exchanging surface. For display purposes, however, it is convenient to display the temperature contour plots for the tube region (left) and shell region (right) side by side.

**HeatEx** provides a pragmatic aid for designers and manufacturers to develop more efficient, and cost effective, heat exchangers.




#### User Inputs

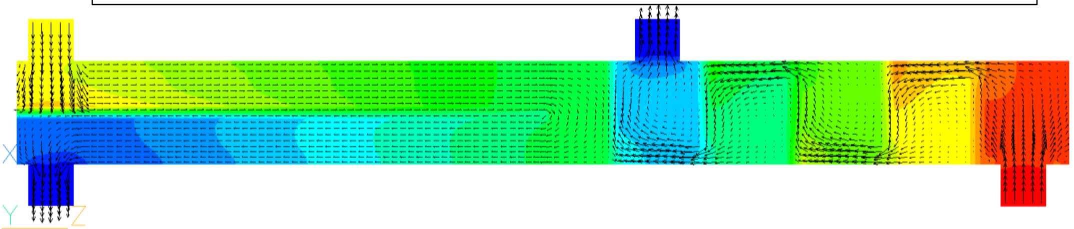
The user is offered a series of drop-down menus from which to select options and enter data, including:

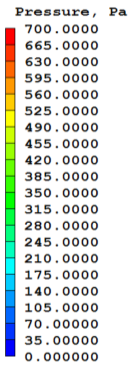
- Flow configuration [eg concurrent or counter-concurrent flow options]
- Geometry options [eg user-defined or TEMA selection]
- Impingement plate options
- Tube pass type [eg type, number, size and layout of tubes]

- Baffle type [eg type, number, size and layout of internal baffles]
- Material properties [eg physical properties, thermal resistances] for tube-side and shell-side fluids
- Initial conditions [especially for time-dependent scenarios]
- Boundary conditions [flow rates, temperature, density, pressure, etc]
- Gravity [orientation]
- Output [display options]
- Steady-state / Transient options
- Numerical settings

**HeatEx** operates on standard PC equipment. For more details, see: www.cham.co.uk/phoenics/d_sapps/Common/docs/PDSCNRIO.HTM#1.1

**HeatEx** generates output files and display defaults automatically – for single- or multi-run cases – with further, user-defined display options and a host of other features available to the more specialist enthusiast.




## 4) Agent News

### 4.1 ACADS-BSG: Australia


***ACADS-BSG, CHAM's agent in Australia, exhibition stand at the recent ARBS Exhibition in Melbourne.***

The main PHOENICS interest shown by visitors to the ACADS-BSG stand at ARBS was modelling the use of jet fans for car park ventilation. Recently there has been an upsurge of interest in this. The Australian code on car park ventilation is descriptive but allows for a performance-based approach using CFD.

The Melbourne Convention & Exhibition Centre buzzed from the opening of the ARBS show until the last visitors were encouraged to leave on 22 May. Visitor numbers were steady across 3 days, totalling 7,774 some 5% higher than the 2012 show.

### 4.2 Shanghai Feiyi: China

During a PHOENICS User Meeting in Hangzhou City, Zheijiang Province, the beta release version of **PHOENICS-2014** was demonstrated.

### 4.3 Champion: Taiwan

PHOENICS Basic Training Course held February 2014.

### 4.4 ACFDA: Canada

A customized PHOENICS training course was conducted in June by Dr Vladimir Agranat of ACFDA in Tomsk, Russia for students and professors at the National Research Tomsk Polytechnic University in the Ecology and Basic Safety Department (http://tpu.ru/en), led by Professors S V Romanenko and V A Perminov. TPU plans to purchase PHOENICS for teaching and research in the area of environmental applications and other uses in other departments. The photo shows Dr Agranat with MSc students.

## 5) PHOENICS Diary

| 2014 | Activity |
|---|---|
| On going | CHAM, London holds regular PHOENICS training courses. Please see www.cham.co.uk or contact sales@cham.co.uk. |
| On going | Shanghai Feiyi, China, holds PHOENICS training courses in various cities across China as well as in Shanghai. Please see www.shanghaifeiyi.cn. |
| On going | C-h-a-m-p-i-o-n, Taiwan provides regular basic and advanced training. See www.cpet.com.tw or contact: sales@cpet.com.tw. |
| On going | Focus Advance Technologies, Malaysia provides training for beginners, intermediate and advanced CFD users. www.focus-technologies.com.my |
| On going | Shanghai Feiyi, China holds PHOENICS training courses in various cities across China as well as in Shanghai. Please see www.shanghaifeiyi.cn. |
| On going | ACFDA, Canada, provides multi-level training to ensure that customers become knowledgeable users of CFD models and PHOENICS CFD software. Training sessions can be at the Toronto office, on client sites or over the internet. Contact info@acfda.org. |
| May 20-21 2014 | Shanghai Feiyi, China, held a PHOENICS User Meeting in Hangzhou City, Zheijiang Province, during which the beta release version of PHOENICS 2014 was demonstrated to those attending. www.shanghaifeiyi.cn. Photographs are included earlier in this Newsletter. |
| May 2014 | ACADS-BSG, Australia, exhibited PHOENICS at the ARBS Exhibition in Melbourne Australia and demonstrated examples of car park fires and applications relevant to the HVAC industry using PHOENICS/FLAIR. www.ozemail.com.au/~acadsbsg. |
| Jun 19-20 | C-h-a-m-p-i-o-n, Taiwan Basic Course. Contact: sales@cpet.com.tw. |
| Jul 1-4 | Arcofluid, France, PHOENICS Training on 3D Modelling of Microfluidic Models at ICMCB, Bordeaux, France. Contact: http://www.arcofluid.fr/ |
| Jul 17-18 | C-h-a-m-p-i-o-n, Taiwan Advanced Course: Flow around Buildings. Contact: sales@cpet.com.tw. |
| Jul 28-1 Aug | Safe Solutions, Brazil, Open Course on Ventilation & Air Conditioning, CESMAC University Centre, Alagoas Brazil, Contact: phoenics@safesolutions.com.br |

| 2014 | Activity |
|---|---|
| Aug 5-7 | C-h-a-m-p-i-o-n, Taiwan Show and Demo in the CFD Conference of ROC. Contact: sales@cpet.com.tw. |
| Aug 14-15 | C-h-a-m-p-i-o-n, Taiwan Basic Training. Contact: sales@cpet.com.tw. |
| Aug 31 – Sep 2 | C-h-a-m-p-i-o-n, Taiwan Show and Demo in the National Conference on Theoretical and Applied Mechanics, ROC. Contact: sales@cpet.com.tw. |
| Aug 10-15 | Professor Spalding has a paper: "Making Computational Heat Transfer and Fluid Dynamics Accessible to All" in the Proceedings of the 15th International Heat Transfer Conference (IHTC15) Kyoto, Japan, August 10-15 2014. http://www.ihtc-15.org/index.shtml. |
| Sep 3-5 | C-h-a-m-p-i-o-n, Taiwan. Exhibition & Demonstration at the SemiConductor Processing Equipment Exhibition. ROC.. Contact: sales@cpet.com.tw. |
| Sep 18-19 | C-h-a-m-p-i-o-n, Taiwan Advanced Course: CFD in Semi Conductors and Optoelectronics Processing Equipment. Contact: sales@cpet.com.tw. |
| Oct 16-17 | C-h-a-m-p-i-o-n, Taiwan Basic Training. Contact: sales@cpet.com.tw. |
| Nov 13-14 | C-h-a-m-p-i-o-n, Taiwan Advanced Course: HVAC. Contact: sales@cpet.com.tw. |