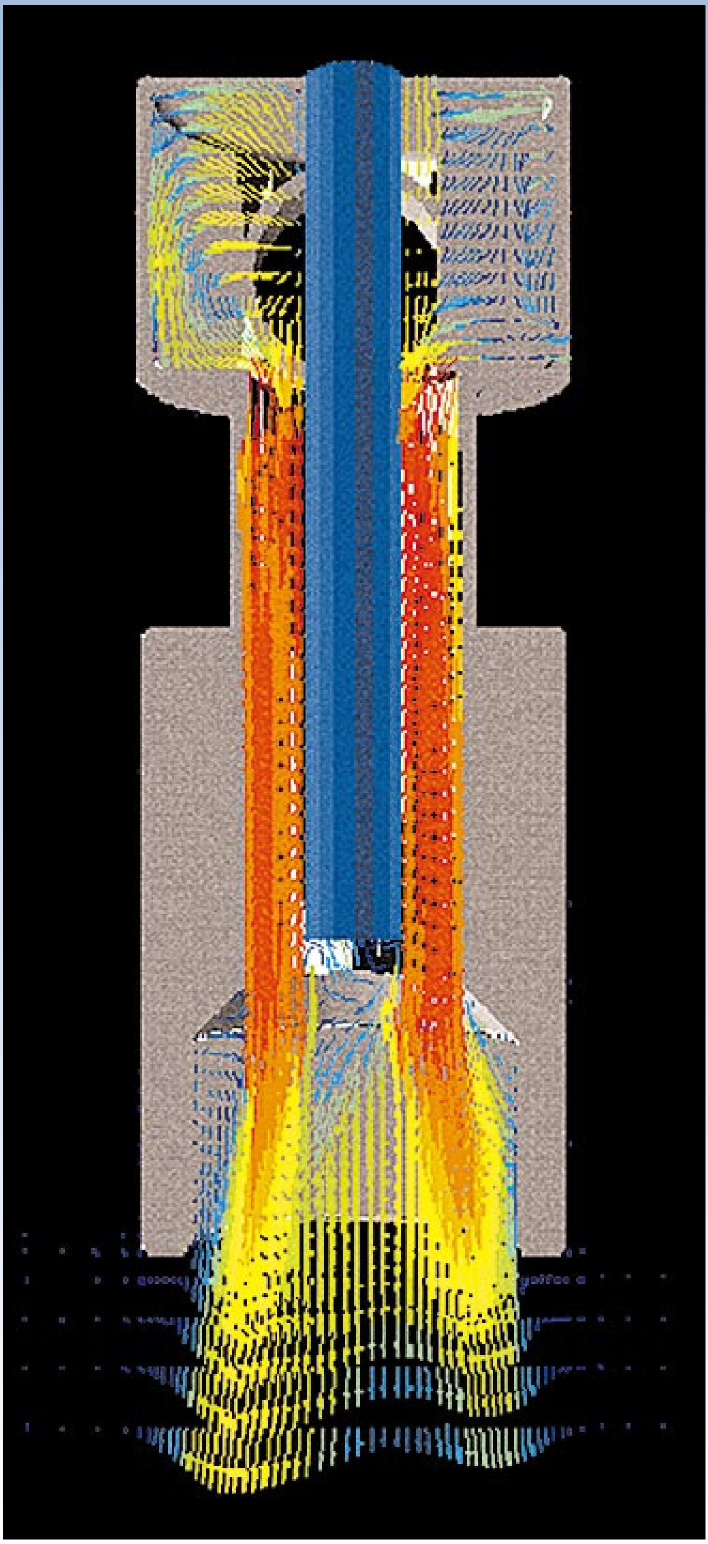
PHOENICS news

CHAM

Spring 1999



NEWS FROM THE WORLD OF COMPUTATIONAL FLUID DYNAMICS

PHOENICS News

Designed & Edited by Peter Spalding
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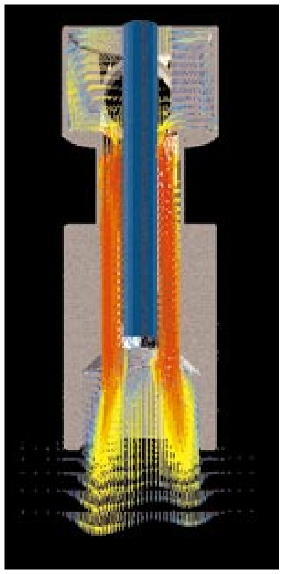

Front Cover:

Furnace Burner
courtesy of Laidlaw Drew Consulting Engineers

See page 10.

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About CHAM's web-site

http://www.cham.co.uk by Professor D Brian Spalding

Condensed from "About CHAM's Web-site" by D B Spalding, Feb '99

The purpose

CHAM is using its web-site as its major means of communicating with customers and with the CFD-using community generally.

CHAM seeks to enable visitors to obtain all the information which they need for understanding the services available from CHAM, the nature and capabilities of CHAM's software; and how they compare with those available elsewhere. The website permits visitors to send messages to CHAM, ask questions, make suggestions, place orders; and download such documents and software modules as they require.

The website home page as it appears today

It is intended that the website shall also enable users of CHAM's software and services to inform the world about their achievements and their potential, whether by way of Applications Album entries, descriptive articles, work-in-progress reports, or links to their own sites.

All the material on display at the website can be provided to purchasers of CHAM's software on the CD-ROM which carries it, being made accessible by way of the POLIS [PHOENICS On-Line Information System] utility. Indeed, anyone who wishes to purchase a CD-ROM containing only the current website material, for detailed study before he or she purchases PHOENICS, is free to do so. In the longer term, it is intended that the website shall be the "Simuserve Emporium", through which customers will procure whichever of the spectrum of CFD-related services they require.

The style

Browser technology is advancing so rapidly, and has so many spectacular features, that it is easy, when designing a website, to become preoccupied with questions of what gimmicks to employ rather than of what messages to convey. The policy which is being adopted by CHAM is to employ as few gimmicks as possible, and to concentrate instead on the messages, making them informative, comprehensive, and comprehensible. The reason is that CHAM believes that persons who choose to visit its website are serious enquirers who want to find answers to their questions with the least possible trouble. They are not persons whose attention is caught only by a dancing image or a startling sound-effect; and they are not so leisured that they can allow their time to be wasted. It is for the latter reason that few of the documents are provided with embedded images; for, although these have merits, once they are on the screen, they do prolong file-loading time. Instead, visitors can choose for themselves whether they wish to see the image.

The present position

Much attention has been devoted to bringing into the website the Applications-Album" material which was formerly visible only to users of POLIS. Each entry has had to be modified however, to some extent, in order that it should appear appropriately when viewed through an Internet browser; and this work is still not quite complete. Many of the examples are quite old; but they have been allowed to remain so that vistors can see that PHOENICS has been solving practical CFD problems from the beginning. CHAM welcomes entries from non-CHAM users.

The second block of material to be taken over from POLIS was that contained in the Encyclopaedia. The 'HTML-ization' of files has been completed and the introduction of copious and helpful hyper-links is well-advanced. When this is complete, the need for the old Satellite and PHOTON "help" files will disappear. The refinement and enrichment of the Encyclopaedia content can now begin.

The pre-existing lecture and tutorial material has also been captured and processed, in part. Some new lectures have also been made accessible. New lectures and presentations will be prepared with subsequent website publication as a requirement.

The highly-important user-support activity has also been given a place on the website; and the task of providing links between its "FAQ" section and the Encyclopaedia has begun. Advice from users as to what they have found useful, and what deficiencies they have experienced, is valued by CHAM.

The future of the website

Although much has been achieved, during the past few months, many of the most promising activities are still only embryonic. Growth can therefore be expected, in the near future, in the following sectors:- The PHOENICS-using Consultants Club; the PHOENICS Journal (which will be available on-line as well as in printed text); the Shareware Operation; and the Simuserve activity. Finally, PHOENICS-users other than CHAM will play an ever-increasing part.

CHAM's Shareware - Download Service Resumes

CHAM's PHOENICS-Shareware service resumed at the beginning of 1999. Distinct shareware offerings will ultimately become available, providing several levels of functionality, The first release will use the PHOENICS-1.5 solver developed in 1991, together with the Virtual Reality front end V2.1, first released released in 1996. Not bad for a Shareware product!

The full capabilities of PHOENICS-1.5 include:-

- Simple Chemically Reacting System (SCRS);
- Non-Newtonian fluids;
- Free-surface flows.

Code compliability means that the user may:

- Manipulate physical models;
- Implement other physical and numerical models;
- Influence most aspects of the solver.

The physical modelling restrictions include:

- Single-phase only;
- No body-fitted-coordinates options.

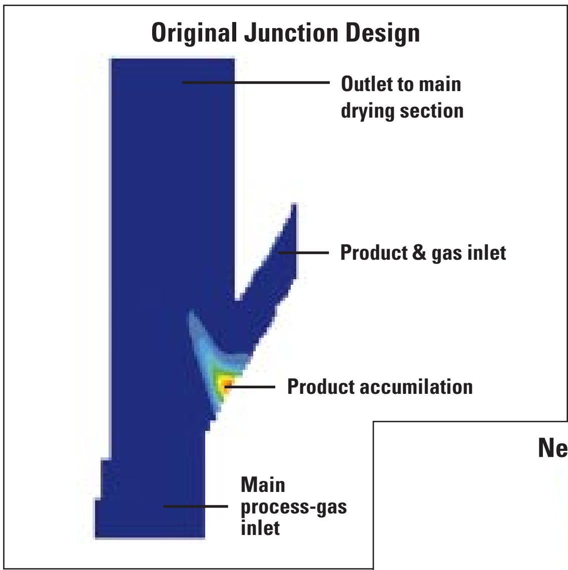
PHOENICS-1.5 is, and will remain, a DOS-based product. The software will run on PC's only directly under DOS.

PHOENICS Shareware can be downloaded from our web-site, namely: **http://www.cham.co.uk**. Click on **'Download'**.

Please note that down-loaders are not automatically entitled to technical support in the use of PHOENICS and should NOT contact the central technical support team. For advice and further information concerning technical support services for Shareware, please liaise with Dr Jeremy Z Wu, via email, at **shareware@cham.co.uk**.

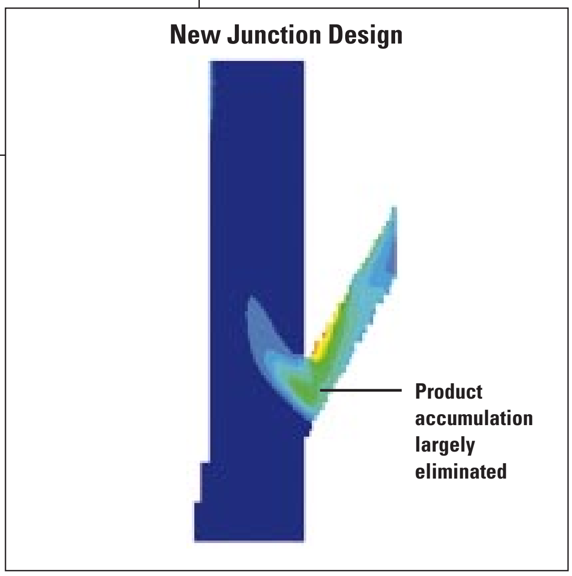
Solutions for Dickinson Engineering

Dr John Heritage reports on a recent Consultancy Team project



A recent project saw CHAM's Consultancy Team participate in the solution of a design problem for Dickinson Engineering. PHOENICS was used to assist in the design of a rectangular-duct junction, which forms part of a pneumatic-conveying dryer.

The product (tobacco leaves) and carrier gas (steam and air) enter the conveyor through an inclined side duct. The side duct forms a junction with the main process duct, which carries hotter dryer gas (steam, air and carbon dioxide) vertically upwards into a gas-product mixing section. The mixture then enters a vertical diffusing duct which serves as the main drying section.



Dickinson's engineers were concerned that, under some operating conditions, there was a build-up of product on the floor of the side duct, near the junction. As well as reducing the efficiency of the whole process, this could introduce the need for periodic shutdowns of the plant for cleaning purposes; the possibility of introducing a removable floor section to minimise downtime was under discussion as a way of reducing the costs of such plant inactivity.

The aim of the CFD study was to see if there was a better way of overcoming the problem.

The main design objectives were:

- **a) to maximise the uniformity of the product across the vertical duct before it enters the drying section;**
- **b) to avoid any blocking of the ducts, or any tendency for the product to agglomerate locally; and**
- **c) to avoid any product deposition on the conveyor walls.**

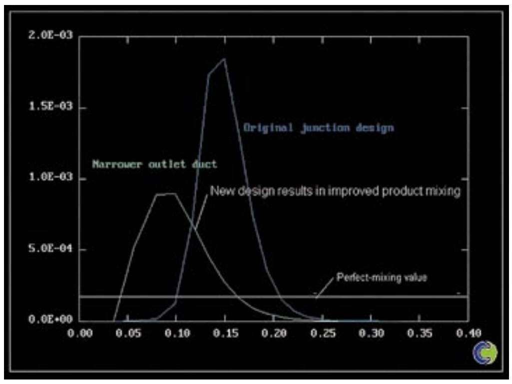
As for many complicated engineering processes, the precise details of every aspect of the behaviour were not known. For instance, an appropriate drag law for shredded tobacco leaves is not readily available, particularly when their water content is variable. However, by using a conventional relationship with a range of different parameters it was possible to consider the extreme cases; this confirmed that the qualitative features of the flow were not dependent on the exact nature of the drag. Fortunately, the main drying takes place after the junction, so changes in behaviour as a result of reduced water content could safely be ignored.

One proposed solution to the product build-up was to decrease the width of the side limb, so as to alter the relative strengths of the two merging streams and remove the injection of product into the slower moving regions near the walls of the main duct. The first task was therefore to simulate the dryer in its existing configuration and assess the effect of changing the aspect ratio of the side limb.

Surprisingly, the results showed that in all cases there was significant product accumulation, typically about 8% by volume, near the exit from the side limb; even reducing the width of the side limb by 50% had little effect! Further simulations with different flowrates also showed that the current values were more or less optimum - CFD supported the experience gathered over many years by the design engineers.

What the simulations could add, though, was a much better understanding of the nature of the flow around the junction. It was this that enabled Dickinson's engineers and CHAM's consultants, working together, to devise a solution to the main problem that would improve the flow pattern and be mechanically practicable to introduce. The original design had a significant widening of the main duct, immediately downstream of the junction: as a result of this, the product stream tended to stay near to the side wall on its own side of the main duct. Simulations showed that maintaining the width of the main duct past the junction would force the product stream to mix much more with the drying gas. This is much the same as a motorway junction: if the slip road becomes an additional lane of the motorway itself, the flow is much smoother than if the oncoming traffic has to mix into the existing lanes immediately. For a motorway, a smooth junction is the aim; for the dryer, greater mixing is desirable.

The contour plots (inset below) of product volume fraction show that the design modification largely eliminates the tendency for product to accumulate on the floor of the side duct; in fact the peak concentration moves to the upper wall, but at a much reduced level. Furthermore, the final figure shows that the peak concentration within the main duct, downstream of the junction, has almost halved, demonstrating the much better mixing of the two streams.



The project demonstrated the benefits of CFD simulations; in particular, a close working relationship between the design engineers and the consultants carrying out the simulations enabled a practical problem solution to be identified quickly, even though it was entirely different from the one envisaged at the start of the project.

For background information contact John Heritage, email: jrh@cham.co.uk

User Support Information

CHAM's user-support operation is now handled by Dr Mike Malin and Mr Herve Miler, who both transferred from CHAM's Consultancy Team during 1998. Dr John Ludwig remains available as a consultant to the support team, and Dr Jeremy Wu has taken special responsibility for dealing with enquiries from the Far East. As discussed elsewhere in this newsletter, CHAM's California office is the first point of contact for technical support in the USA. All users can now visit User Support on CHAM's Website, which includes pages on:

- CHAM's user support policy for technical support;
- How to obtain user support;
- Worldwide support locations;
- Frequently-asked questions;
- Discussion Group;
- PHOENICS Known Problems;
- Bug Reporting;
- PHOENICS Year 2000 Compliance;
- Publications List; and
- User Events.

Of particular interest to users should be the entry Frequently-Asked Questions (FAQ's), which is divided into categories.

User support queries can be directed to our User Support Team by telephone, fax, or by email. Email communications are preferred for the first contact, since this allows CHAM to make a quick classification and assessment of the problem.

IMPORTANT: When requesting User Support, please include the following information:

- Your organisation's name and PHOENICS Maintenance Agreement Number
- Version of PHOENICS being used.
- Details of hardware configuration and operating system.
- Any information that may help CHAM to answer the query, such as problem sketches, Q1 files, GROUND coding, and a clear statement of the problem encountered with PHOENICS.

Users requiring support in resolving convergence problems or implausible solutions are requested to demonstrate the problem on as coarse a mesh as possible before sending their files to CHAM. The model should be simplified as far as possible in terms of dimensionality, physical models (such as turbulence, radiation, etc), physical properties, boundary conditions, removing GROUND, etc. This not only helps CHAM to provide a speedy resolution of the problem, but can help the user identify the cause of the problem himself.

PHOENICS users with a current PHOENICS Maintenance Agreement are entitled to unlimited user support, without further charge. Such user support is however confined to enabling users to run the PHOENICS code modules successfully in a conventional manner, to understand the documentation, and to detect any common mistakes which they may have made. Users who require assistance in setting up new models can avail themselves of CHAM's Extended Consultancy Support Scheme (ECS), as follows:

Users who are fully capable of running PHOENICS modules successfully do however sometimes require assistance of a different kind. For example, they may require general advice about what is the best way to model a particular physical process or equipment item, making use of the available features of PHOENICS. To give this advice, CHAM's support staff may need to spend time in studying the user's specific needs. Alternatively, what needs to be done may be clear, but the user may prefer the work to be done by CHAM personnel, whose greater experience may reduce the time which will be taken. In some circumstances, the user may have started a complicated model-building operation and then run into difficulty; he may then seek CHAM's assistance in the detection and removal of its cause. While eager to provide assistance of these kinds, CHAM's User-Support team does have to make a charge for it, usually based on the number of hours expended. In exceptional cases, when the user agrees that the results of the work can be placed in an open-to-all library, or in the Applications Album, CHAM may share the cost of the work. Work of this kind is normally carried out under an ECS Contract between CHAM and the user's organization. If it should prove that the difficulty arose from a "bug" in the software, CHAM will correct that bug at its own expense.

Dr Mike R Malin, CHAM User Support, Email: *support@cham.co.uk*

CHAM Opens California Office

Dr F Peter Tsai, new General Manager of PHOENICS North America, with Professor D Brian Spalding

CHAM is pleased to announce the opening of its new branch office at California, USA. The office is in the Los Angeles metropolitan area. By establishing this new branch office at the west coast of United States, CHAM illustrates its commitment to serve the PHOENICS users in North America.

The CHAM California office covers the following activities:

- **promoting and selling PHOENICS products;**
- **promoting and selling consulting services based on their use;**
- **to provide first line technical support for PHOENICS users in the USA.**

Dr F Peter Tsai has been appointed as the General Manager of CHAM's California office. In 1987, Dr. Tsai received his PhD from Department of Mechanical, Aerospace, and Nuclear Engineering Department, University of California, Los Angeles (UCLA). He worked for Physical Research Inc. and Adaptive Research Inc before he joined CHAM in June 1998. Whilst at Adaptive Research, he was Development Manager of the CFD software. With his extensive expertise in CFD, he helps CHAM to provide high quality and prompt technical support for US PHOENICS clients. The address and phone numbers of the California office are:-

6520 Scotgrove Drive, Rancho Palos Verdes, CA 90275, USA

Tel: +1 (310) 265-9719, Fax: + 1 (310) 265-9739

Email: *phoenicsna@aol.com*

MICA Roundup

Dr John Heritage outlines the completion of a 3-year EU-sponsored MICA project.

The aim of MICA, namely to create, test and validate a Model for Industrial CFD Applications, has been largely achieved. It has been demonstrated that the use of Virtual-Reality-based user interfaces by people, who may not be 'CFD-literate', is practicable, and may often be a most convenient and economical means for solving their design problems.

The project aimed to harmonise the activities of High-Performance Computer Network (HPCN) centres, - service providers, - and end-users so as to provide a radically better service to industrial and environmental specialists wishing to exploit flow simulation and design analysis. Industrial organisations throughout Europe were represented.

The key elements of MICA were to:-

- construct Virtual Reality interfaces to enable users to specify their problems solely in physical terms;
- use the Internet to transmit the problem specifications to remote specialist centres and return the results to users;
- create the necessary HPCN centres, equipped with simulation software, high-performance (parallel) computers and specialist expertise.

The primary applications were spilt into two sectors: furnace design and the built environment. The furnace applications ranged from coal-fired and glass-smelting furnaces, small industrial ovens and annealing furnaces, to power condensers. The built environment side focussed on environmental and architectural external flows, HVAC and internal environmental flows, hazard assessment and fire modelling,and flows around underwater structures.

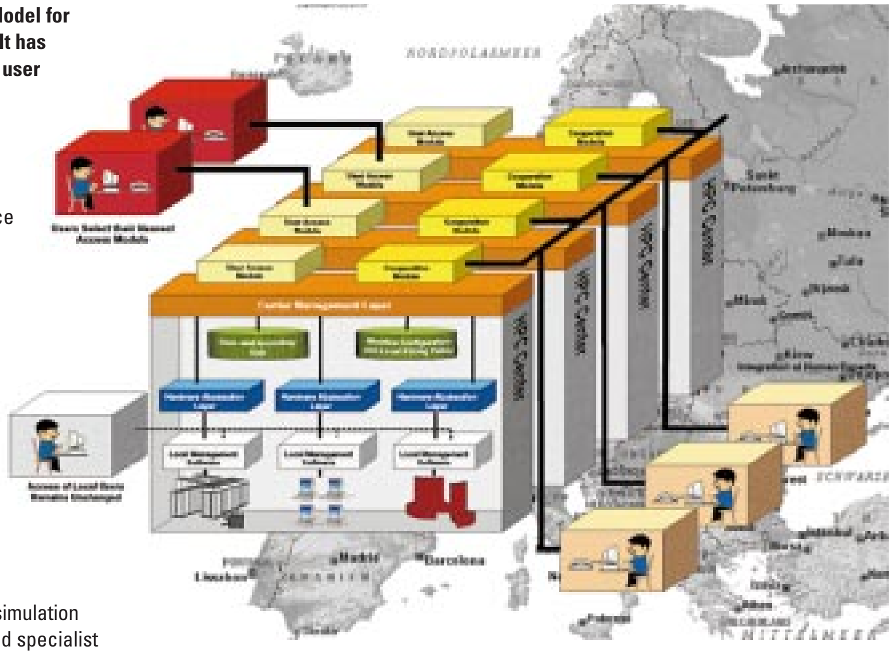
The MICA Partners represented countries across Europe, and the opportunity is taken here to thank:-

- Building Research Establishment (UK)
- Christian Michelsen Research (Norway)
- INRIA (France)
- IST-Lisbon (Portugal)
- Koninklijke Hoogovens (Netherlands)
- LSTM - Erlangen (Germany)
- National Technical University of Athens (Greece)
- Paderborn Center for Parallel Computing (Germany)
- SMHI (Sweden)
- Stork Engineers & Contractors (Netherlands)
- University of Zaragoza (Spain)
- Vattenfall Utveckling (Sweden)
- Wimberley Allison Tong & Goo (UK)

As a result of the MICA initiative, a new company, SIMUSERVE, is being formed through which the MICA activity has been moved forward to commercial reality. Further developments of the MICA concept are now in hand via another EU-funded project, called ADELFI.

Whereas MICA required the clients to possess "front-end" software (supplied by CHAM) for data input and results interrogation, ADELFI intends to provide remote-computing services for clients who possess no more than an Internet-browser program.

ADELFI therefore will facilitate a further step from the current "bucket-and-well" CFD practices (customers buy the software (bucket) and hardware (well) to the "piped-water" technology which will, of course, be the preference of the future.



MICANET (SIMUSERVE) Network Structure

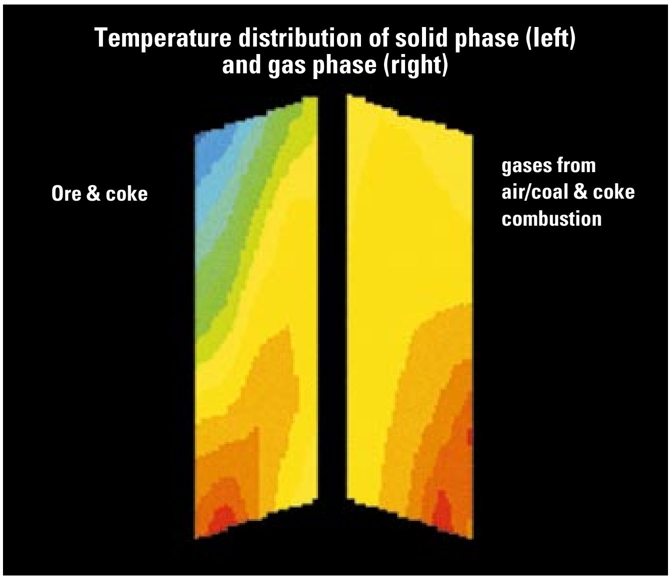
For copies of the MICA Final Report and further information about SIMUSERVE and ADELFI, contact John Heritage via email at jrh@cham.co.uk.

SAFIR

Dr Sergei Zhubrin summarizes the application of another PHOENICS 'first', studying 4-phase flows in a blast-furnace

Extracts from "SAFIR. A computer model of flow, heat and mass transfer, phase change and chemical reaction in the blast furnace, with injected coal or oil - by D.B.Spalding and S.V. Zhubrin"

Summary: A steady-state three-dimensional four-phase model of blast-furnace behaviour is being developed by CHAM within the framework of the EU-funded OSIRIS project. The four thermodynamic phases in question are:- gas, i.e. air and combustion products; the fast-moving particles of coal, coke, liquid-droplets and other "fines" which are suspended in the gas; the slow-moving solids consisting of iron-ore and coke, the faster-moving liquid metal.



Temperature distribution of solid phase (left) and gas phase (right)

The processes accounted for are:- heat, mass and momentum transfer between the phases; consequential phase changes and the chemical reactions which effect oxidation of the fuels and reduction of the ore.

The model is embodied in a special version of the CFD code PHOENICS, called SAFIR, which makes extensive use of two techniques which are unique to that code, namely:-

MUSHAS, which is an acronym for MUltiply-SHAred Space; and PLANT, which allows all the relevant special-modelling features to be supplied compactly by way of formulae inserted into the input file (Q1); the corresponding Fortran-coding counterparts of these formulae are then created automatically. The report provides the problem specification and a description of the computer model.

The developed prediction procedure, consisting of the mathematical model and solution algorithm, is applied to study the operational behaviour of a typical blast furnace. Solutions are presented that predict the three-dimensional velocity, temperature, transfer mass flow rates and concentration distributions of gaseous, solid and liquid phases, under different operating conditions of the furnace; and their realism is discussed.

Summary of the present status of the work: The computer model has been completely created, and produces qualitatively correct predictions of the distributions of the gaseous, liquid and solid materials within the furnace.

Introduction: The development of practicable mathematical model of the blast furnace, that can be generally applied and used for predictive purposes, is becoming increasingly important. Such a model would enable various geometrical configurations, blast and burden conditions to be assessed easily, quickly, economically and reliably and would reduce considerably the amount of physical model and full-field exercise testing required to achieve a satisfactory design.

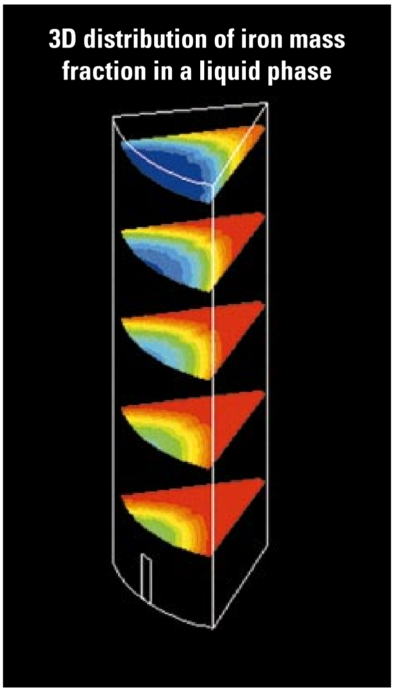
The work described here has been devoted to the development and application of a mathematical model for blast furnaces. The model simulates the physical processes by means of conservation equations for dependent variables of interest. It is applicable to one-, two- and three-dimensional computational domains both for steady and unsteady conditions.

The model recognises that velocities of gas, particulate fines, solid lumps and liquid products of reduction are different and comprises equations for: continuity, momenta, specific enthalpies, phase concentrations, and volume fractions for each of the phases present.

The simultaneous solution of the above equations by means of PHOENICS yields the values of the variables at all internal grid nodes. Full account is taken of interphase mass-, momentum and heat-transfer and an additional coal fines-fraction equation is solved to account for the diminishing radii of the burnt coal particles.

In order to assess the potential of the model, one-, two- and three-dimensional simulations were performed for typical blast furnace under different operating conditions, and the results are presented and discussed…(see full report).

Concluding remarks: This report has brought into existence a computer-based three dimensional model of a blast furnace. It is based upon the consideration of four-phase motion and related heat and mass transfer processes. The model includes simple basic representation of the major chemical reactions and physical features of the furnace.


3D distribution of iron mass fraction in a liquid phase

Results have been presented and are shown to indicate the correct trends. The predictions provide detailed information for each phase present, regarding three-dimensional fields of velocities, of temperatures and of phase compositions. Further work should consist of grid-independence studies and comparison with experimental data, in order to validate the model.

In order to extend the field of applications of the model, additional physical models should be included. The effect of additional chemistry may be introduced through either conventional or multi-fluid approaches. Similarly, radiation heat transfer may be handled by PLANTing the radiation models described elsewhere. The inclusion of any of these models merely increases the number of conservation equations to be solved, but otherwise incurs no significant modification to the present model.

It is expected that the model is flexible enough to allow the shape of, and conditions in, the raceway to be predicted rather than assumed. Similarly, the position and shape of the "dead man" can be calculated. The model, as it now stands, represents the valuable tool which can be used by OSIRIS partners and others, in the future, to advance the state of knowledge significantly. It seems to be an appropriate base to include further multiphase interactions and chemistry. Finally, more work is required to obtain reliable experimental correlations for the interphase heat-, mass-, and momentum transfer, which can then be used to improve the input of the model.

For the complete report on this work, click on the "News' button via CHAM's web site: http//:www.cham.co.uk, and look at the "Progress on In-House Projects" section under "OSIRIS".

What's New in PHOENICS-3.2?

Dr John Ludwig outlines some of the major features in this latest release

The following features are all described in greater detail within the "Getting-started" lecture in the CHAM Web Site:

The PHOENICS -Commander Environment

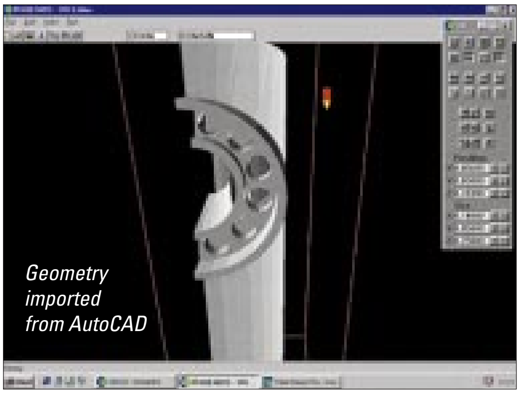
The amalgamation of PHOENICS Commander and VR-Editor/VR-Viewer has been completed. There is now a single environment, which allows access to all modules. The default mode of operation is VR-Editor. Access to the other functions is provided via Windows-style pull down menus.

The Virtual-Reality Editor

The VR-Editor has been rewritten using OpenGL for the graphics rendering. This has brought about a vast improvement in the quality of the image. The hidden-line algorithm in particular is much improved.

The mesh modification has been moved from the Main Menu, Geometry panel to the Mesh Toggle button on the handset. If the mesh is displayed, then clicking on a particular location in the mesh will bring up a dialogue box, which allows changes to be made. The option for geometrical expansion has been added in addition to the previous Power-Law expansions. This can provide a much stronger expansion of the grid.

Many improvements have been made to the object dialogue boxes. They have many more capabilities, and all buttons and data-entry fields have help entries. Help is accessed by clicking on the ? in the top-right of the window title bar, then clicking on the desired button or data entry field.



Geometry imported from AutoCAD

Gas burner geometry courtesy of Laidlaw Drew Consulting Engineers

New objects are colour-coded according to their type. In cylindrical-polar coordinates, polar geometries are used by default.

In addition to the STL format available in Version 3.1, a DXF converter is now provided. Both STL and DXF files are imported via the 'File' + 'Import CAD Data' buttons of the new Commander.

All dialogue boxes are 'aware' of IPSA, ASM, SEM,HOL,SCRS and IMMERSOL; ie, they display the appropriate data entry for those models.

The Data-Input Menu

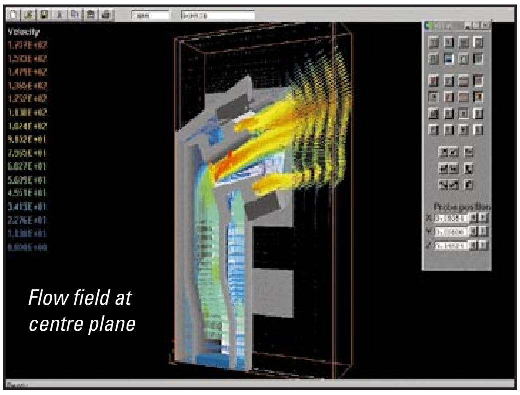
Many detailed changes have been made 'below the surface' of the Main Menu. Many of these are the result of error-correction, or additional protection against conflicting settings or repeated changes of options.

In many places data-entry boxes have been replaced with pull-down scroll-selection lists. This reduces the need for users to need to know what to type in. The help entries have been extended. Access is through ?, as in the object dialogue boxes.

In addition to these 'invisible' changes, many more substantial improvements have been made. The major ones are the full activation of the SCRS (3-Gases) combustion model and full activation of the IMMERSOL radiation model.

The two models are linked, in that turning 3-Gases ON will also turn IMMERSOL on. This allows conjugate heat transfer even with solution of H1. If IMMERSOL is turned off again, conjugate heat transfer is disabled.

A button has been provided in the Main Menu geometry panel to turn PARSOL on and off.



Flow field at centre plane

The Virtual-Reality Viewer

This user interface has been radically revised, so as to take fuller advantage of Windows tools, and to utilise OpenGL. The use of OpenGL has resulted in an improvement in the quality of the graphical display, as in the VR-Editor. The Viewer is entered from the 'Run' + 'VR-Viewer' button of the new Commander.

The function of 'Snap-size', which in 3.1 sets the cutting-plane movement, the contour fill size and the vector length, has been split into three separate functions. These are accessed through the 'Edit' + 'Domain' attributes' menu of the new Commander. In addition, the treatment of PARSOL objects has been improved. The vectors are now plotted at the correct place and the contour filling shows the correct edge of the object.

Other Advancements

As may be seen from the above, much effort has been concentrated upon the improvents to the VR-Editor, VR-Viewer and On-Line Help facilities. Of course, many more advances have been made within the PHOENICS EARTH coding and associated activities. All are listed on CHAM''s web pages and you should particularly look out for information on improvements within:-

PLANT

This is a feature of implanting the model formulations into the executable solver module.

The chief developer of PLANT, Dr Sergei Zhubrin, reports that many capabilities present in version 3.1 and earlier versions have been significantly enhanced and given further exemplifications and emphasis, including:

- **Discretization**
  Time-step specifications
  X-, Y-, and Z-direction grid specifications
  Body-fitted coordinates calculations
- **Terms in equations**
- **Physical**
  Properties of the materials
  Interphase-transport features
- **Initial fields specifications**
- **Non-linear source laws and complex boundary conditions**

What's New in PHOENICS-3.2?

- **Special calculations**
  Reference residuals
  Self-steering under-relaxation
  Limits on variables
  Processing out-puts
- **Convenience features**
  Grid-free operations
  Indexed variable operations
  Logical and conditional operations
- **Marker allocation procedure**

The three pictures shown illustrate the use of the last feature which makes the insertion of complex shapes, moving objects, shape distortions, region specifications, and so forth, especially easy.

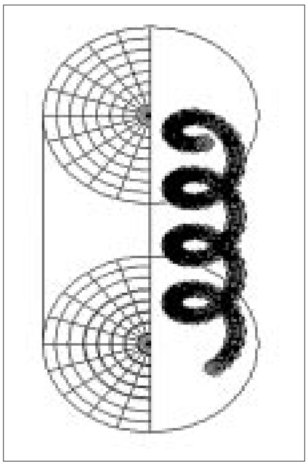


fig 1

The problem shown is the calculation of the flow across the cooling coil of spiral configuration, together with the flow inside the coiled tube itself.

Figure 1 shows that MAP realistically fits the coil shape using a cylindrical polar grid. The velocity vectors are shown in Figure 2 for a cartesian grid. The mainly blue vectors relate to the external flow which, in fact, goes from left to right. The larger coloured vectors show the tube velocities. The red spots show the tube cross-sections as the pipe is intersected by the X-plane.

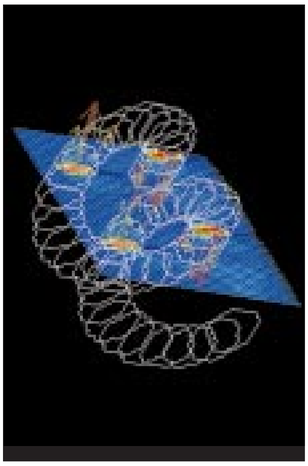


fig 2

For flow predictions, all cell faces at the interface between two marked regions are blocked automatically. Provision is made automatically for the links between tube and shell flows for heat transfer effects.

With PLANT equipped with the MAP feature, it is now quite straightforward and relatively easy to simulate the problem of the kind shown in Figure 3. There, the coil is MAPed inside the cylindrical vessel with two impellers on the shaft.

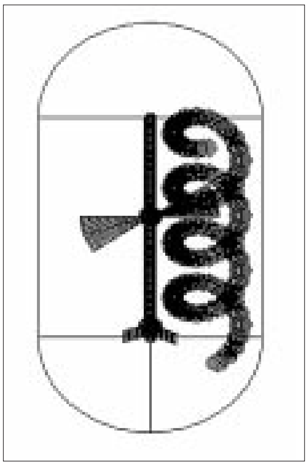


fig 3

For the complete set of the examples and documentation, click on the "Firsts" button via CHAM"s web site, and look at the "PLANT ..." section.

PARAB

The PHOENICS Parabolic option has been extended for supersonic flow applications (see page 11 'Solver Enhancements ...').

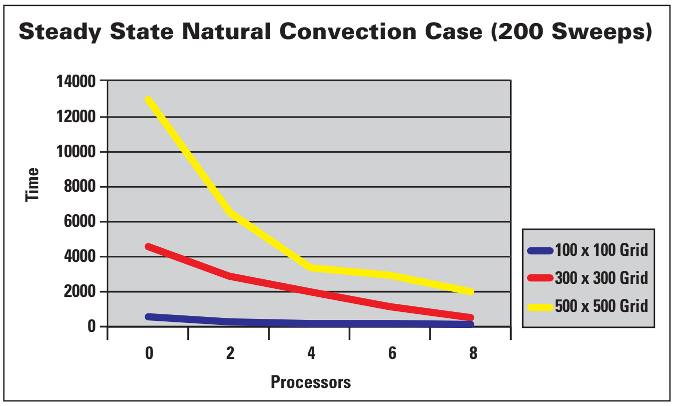
Parallelization

The parallelisation of PHOENICS-3.2 has been extended to include both LINUX and Windows-NT PC clusters, as well as the more established UNIX multi-processor configurations. Test sites, such as Washington State University, have been particularly helpful in providing comparative performance figures. WSU installed PHOENICS on their 8-node LINUX Beowolf cluster, using Intel

100 x 100 grid:	processors				
	1	2	4	6	8
time (s)	472	252	155	132	121
		245	156	131	120
avg.	472	248	156	132	121
speed-up	1	1.9	3.0	3.6	3.9

300 x 300 grid:	processors				
	1	2	4	6	8
time (s)	4678	3910	1994	1530	680
		2583	2103	1047	677
		2412	1368	954	672
			2708	1325	
avg.	4678	2968	2043	1214	676
speed-up	1	1.6	2.3	3.8	6.9

500 x 500 grid:	processors				
	1	2	4	6	8
time (s)	12924	6609	3417	3042	2110
		6629	3441	3111	2337
			3437		2321
avg.	12924	6619	3432	3077	2256
speed-up	1	1.9	3.8	4.2	5.7



Pentium II 400 MHz processors with fast Ethernet switches, running LAM-MPI. Their test problem is a steady state case involving natural convection in a cavity, run for 200 sweeps using different processor and grid configurations,

Although one might expect quite a lot of variation caused by the use of different mixes of systems, the overall trend is very pleasing and shows that large scale calculations can now be realised without the need for high-performance computer resources.

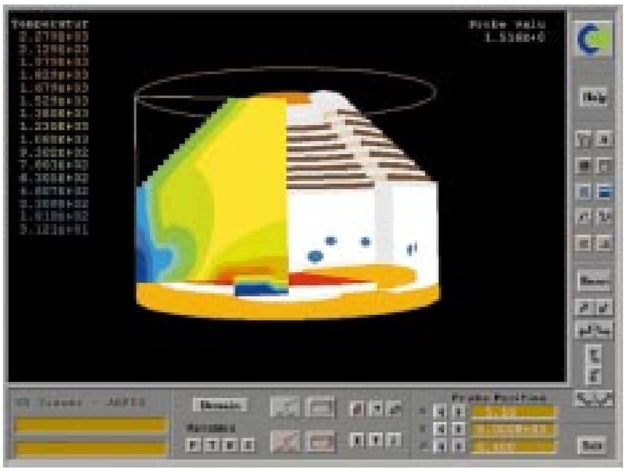
As stated earlier, the above is just a flavour of the more extensive information available via CHAM's website which we hope you will access. If you have any specific questions concerning any aspect of "What's New in PHOENICS-3.2", please contact John Ludwig, Email: jcl@cham.co.uk

For details of how to receive an upgrade to PHOENICS-3.2, and the delivery dates for different computer systems, please contact Ms Michelle Langdon. Email: ml@cham.co.uk

Updating Combustor Design to Meet Modern Environmental Standards

Peter Spalding reports on recent work for Lucas Energy

The disposal of vehicle tyres is an ever-increasing problem and a particularly contentious issue within the EU. During the last decade, such items have been shredded or buried in order to avoid the adverse environmental impact caused by burning them in the open air. There are so many used tyres nowadays that this is no longer an option, and means have had to be devised to burn them without polluting the atmosphere.

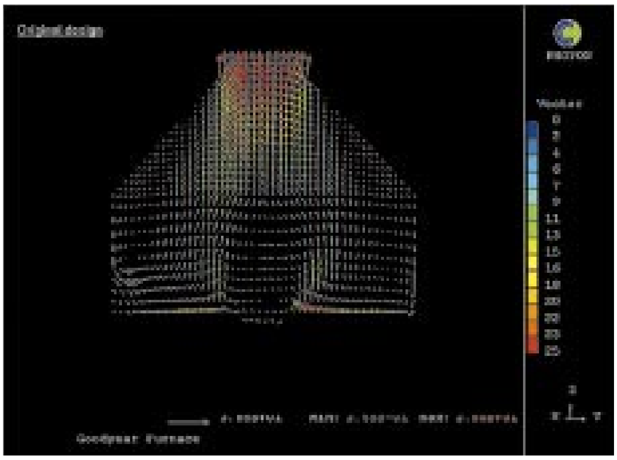


Temperature Profile / Combustor Geometry

During the design stage of a new project for Portugal, Lucas Energy contracted CHAM to study the tyre combustor on two existing installations.

The combustor works by creating a strong cyclonic flow pattern in which combustion is concentrated. This type of flow ensures that the hot combustion products are drawn towards the centre of the chamber, creating a high temperature zone. By this means, the complete breakdown of the different components of the tyre is assured: rubber, carbon filler and steel reinforcement.

The design of the air inlet ports is crucial in the establishment of the cyclone, and also in ensuring the presence of a layer of cool air near the combustor walls, preventing damage to the refractory bricks through overheating.



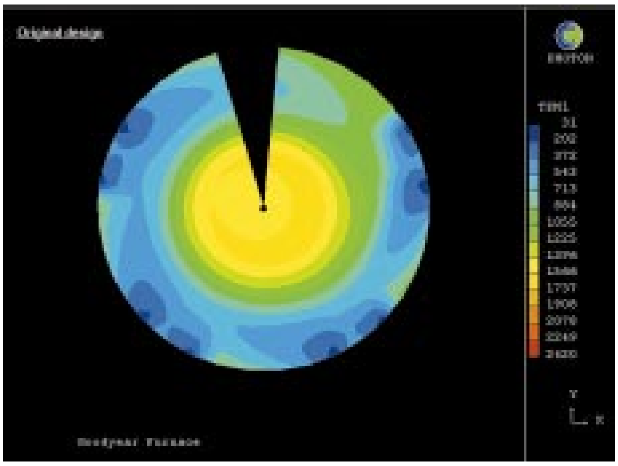
Velocity vectors coloured by temperature

Although a “Belfast” combustor was known to work well, the design was originally made on the basis of a qualitative understanding of the process, backed by years of experience. CFD simulations of this nature were not available in the 1970’s!

The task of upsizing was further complicated by the existence of another, larger combustor in the USA, dating from the same period. This too worked well, but only after retrofitting to adjust the air inlets. It became clear as the investigation proceeded, that confidence in the performance of the new upsized furnace would depend on an understanding of both earlier combustors, including the design modifications.

An unusual project followed. Working closely together, engineers from Lucas Energy and CHAM put together the pieces of the jig-saw, combining the results of PHOENICS simulations with written and anecdotal evidence from 25 years ago. Eventually it was possible to work out what had been changed in the US retrofit, and how it had improved the flow within the combustor. With that understanding, simulations were used to establish an appropriate layout for the air inlet ports in the new Portugese combustor.

Peter Spalding, Email: pls@cham.co.uk



Temperature Profile - Hearth / Inlet NozzlesTemperature Profile

Furnace Burner Nozzle Demonstration Case

From front cover - A recent demonstration case was undertaken on behalf of Laidlaw Drew Consulting Engineers involving the importing from CAD of the geometry of a “troublesome” burner design. PHOENICS was acquired to investigate the oxygen flow pattern in the mixing region and recirculation within the burner.

The burner has a concentric inlet pipe, with fuel fed through the inner pipe. The oxygen is supplied via an inlet perpendicular to the burner axis.

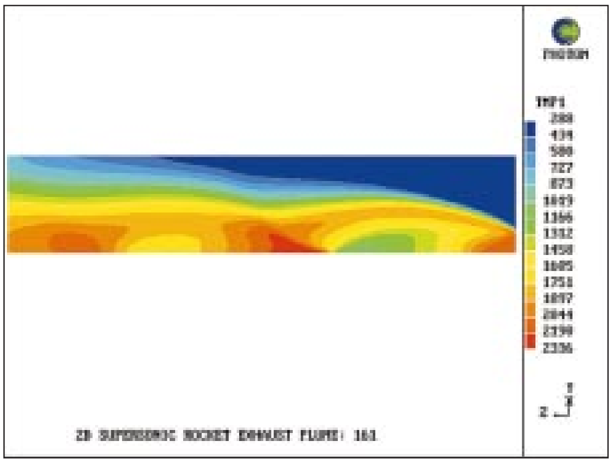
PHOENICS-3.1 was run on a PC/Pentium computer, using a relatively fine 60 x 66 x 66 mesh. Simulation of the existing design is being followed up by an assessment of prepared modifications.

Preliminary results, which were very encouraging, correctly captured areas of severe recirculation and low pressure of particular concern to the client. We look forward to comparing the PHOENICS predictions with further experimental data received from the client.

Contact Alain Grangeret at Laidlaw Drew via email: alain.grangeret@laidlaw-drew.co.uk, or wait to read more next issue...

PHOENICS-Solver Enhancements

For the more rapid solution of underexpanded free jets and wholly supersonic flows



2D Axisymmetric flow profile downstream from rocket exhaust - temperature contours

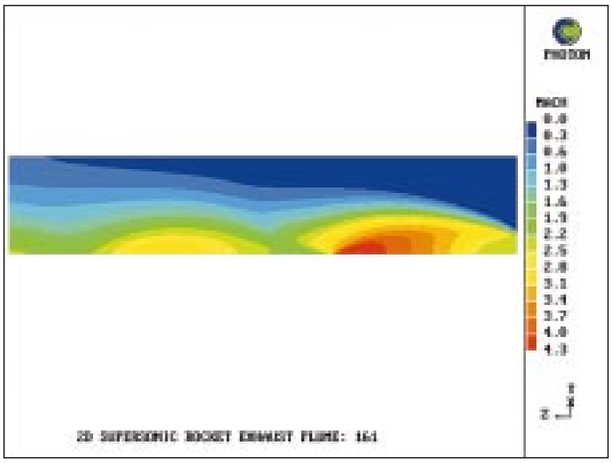
CHAM, in collaboration with consultants, "S&C Thermofluids" and the Defence Evaluation Research Association (DERA), has extended the PHOENICS V3.2 parabolic solver so as to handle underexpanded free jets and wholly supersonic flows with or without a free stream. These type of flows are of especial interest in aerospace and defence applications, and hitherto required solution by means of the PHOENICS elliptic solver. The advantage of using the enhanced parabolic solver for such applications is a massive reduction in computer time relative to the conventional elliptic solver and the capacity to use much finer mesh resolution. For example, S&C Thermofluids report an improvement of 800% for the case of a 3D, turbulent underexpanded rocket exhaust plume exhausting into a supersonic free stream.

The parabolic enhancements were implemented for both two and three dimensions, and comprised:

1. The extension of the parabolic expanding-grid option to account for a streamwise-velocity contribution to the cross-stream convection fluxes.

2. The extension to allow supersonic jets to spread into subsonic regions.

3. The provision of a boundary condition for supersonic free streams, which allows any outgoing waves to pass unreflected through the free boundary.



2D Axisymmetric flow profile downstream from rocket exhaust - mach contours

An important consequence of **1** is that the parabolic solver will now predict wave formation due to the turning of a supersonic stream. The opportunity was also taken to extend the ideal-gas property options in respect of density and temperature, so as to account for the mixing of two different gases.

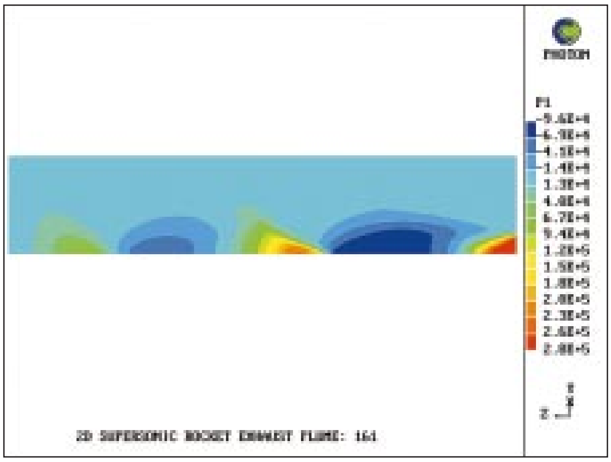
A number of parabolic calculations were carried out by CHAM so as to demonstrate the satisfactory working of the modified solver for both purely supersonic flow (IPARAB=4 option) and underexpanded jets (IPARAB=5 option). The results of these simulations compared favourably with analytical data and/or numerical solutions produced by the PHOENICS Elliptic solver.

The following of parabolic library cases are now available in PHOENICS V3.2:

2d inclined supersonic flow in a duct	**156**
2d supersonic diffuser flow	**158**
2d sonic underexpanded round jet	**159**
3d supersonic underexpanded square	**160**
2d supersonic rocket exhaust plume	**161**
Merging of two supersonic free streams	**162**

In addition, library cases 911 and N113 were provided so as to permit cases 161 and 159, respectively, to be solved by use of the Elliptic solver for ready comparison of solutions and computer runtimes.

The range of testing covered two and three dimensions, laminar and turbulent flow, sonic and supersonic injection, stagnant and moving subsonic and supersonic free streams, and cases involving the solution of conservation equations for the total enthalpy and a species mass fraction. Simulations were also carried out using expanding grids, and in Cartesian and cylindrical-polar coordinates, for square and circular nozzles, respectively. Further testing and validation has been carried out by S&C Thermofluids by applying the solver to chemically-reacting rocket-exhaust plumes.



2D Axisymmetric flow profile downstream from rocket exhaust - pressure contours

Further possible parabolic enhancements are an automatic grid-expansion facility so as to accommodate the plume development more economically; and a partially-parabolic option which allows for embedded subsonic regions, as encountered in highly underexpanded jets.

Information sources:

Dr Mike Malin, Email mrm@cham.co.uk or

Dr A G Smith, S&C Thermofluids, Email tony.smith@thermofluids.co.uk

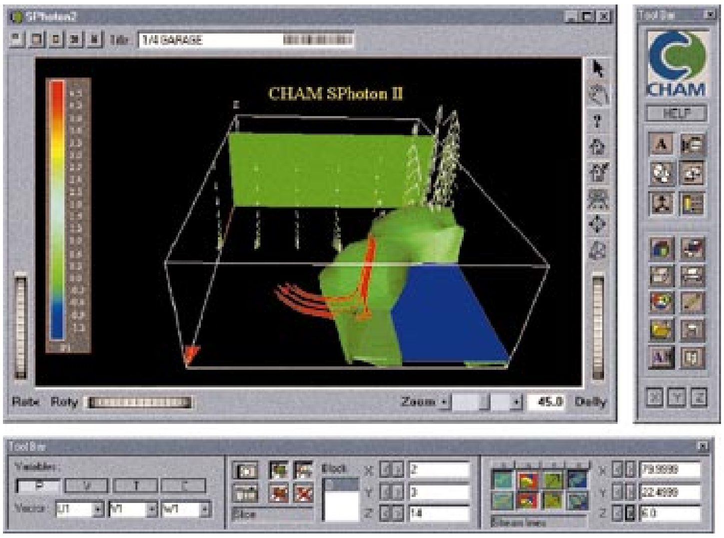
Announcing S-PHOTON-2

A new post-processor for PHOENICS-3.2

PHOENICS 3.2 includes a new post-processing option, 'S-PHOTON-2, originally developed by CHAM's agent, Atos GmbH. Since S-PHOTON's first release last year, the co-operation with CHAM has intensified, resulting in an even more efficient post-processor, based on TGS graphics software.

S-PHOTON-2 includes a state-of-the-art menu system, of similar design to the PHOENICS-VR user interface. It supports the analysis of PHOENICS results based on the use of VR (cartesian or polar) as well as models based on body-fitted co-ordinates and multi-block systems (CCM and GCV).

S-PHOTON-2 enables the display of objects based on PATGEO data or using the new FACETDAT. In both cases the boundary conditions can be separately displayed using hidden shade techniques. Each object can be defined to have a unique colour and transparency. Results can be displayed on grid planes and on arbitrary planes. Contours or iso-surfaces can be animated automatically. Also streamlines can be specified and the flow along them can be animated. S-PHOTON-2 also supports the pre-processing of PHOENICS models by offering the possiblity to preview STL files.



Other features, such as the use of browsers, free definition of default view point, light manipulation, saving GIF, TIFF or postscript files, make S-PHOTON-2 an efficient tool for 3D analysis and visualisation of all kinds of PHOENICS models. S-PHOTON-2 is now available for purchase as an add on. It is currently available for PCs based on Win95/98 and NT. Work is under way to port the code to UNIX machines.

***For further information contact*:**

Peter Spalding, Email: pls@cham.co.uk

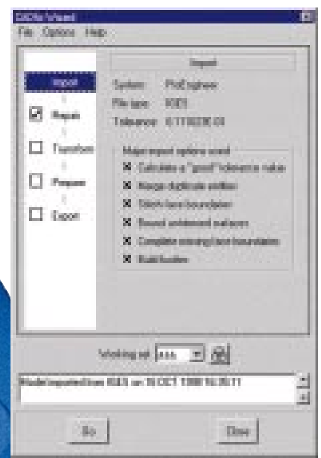
or

Mustafa Megahed, Email: m.megahed@atos-group.de

CHAM signs OEM deal for CADfix

CHAM has signed an OEM agreement with FEGS Ltd, a subsidiary of International TechneGroup Inc, for its CADfix Geometry Model Repair" software. CHAM will offer its clients a low cost CADfix "Wizard-for-PHOENICS Geometry Translator", enabling automatic conversion of IGES file formats into a form suitable for PHOENICS.

The full CADfix suite will also be made available for those clients who wish to read formats other than IGES and those who wish to access the full range of CADfix interactive repair, model transformation, and splitting tools.



With the full CADfix suite, most native CAD formats can be read, ambiguous model situations can be resolved, and advanced model de-featuring and simplification tools enable a repaired model to be transformed to ensure that the data is suitable for the particular PHOENICS application. In addition, splitting tools allow the model to be partitioned for CFD applications.

The full technical specification, plus pricing and licensing terms for the CADfix "Wizard-for-PHOENICS" and the full CADfix product are available from CHAM. Full details will become available via the web. Contact CHAM's web site, or link to FEGS on http://www.fegs.co.uk.

'Draught' Dodging in the Office

PHOENICS Consultants, Flowsolve Ltd, report on a natural ventilation study

The design of ventilation systems plays a crucial part in the comfort of modern office environments. Given the installation and operating costs of mechanically ventilated installations, the economies offered by incorporation of natural ventilation techniques have always appeared attractive.

A recent project for WSP Consulting Engineers concerned the Multi-Disciplinary Research Building, being designed for Imperial College by the architects Foster and Partners, for which the client's specification called for significant areas of the building to be naturally ventilated. In this situation WSP opted to use CFD simulations to verify that natural ventilation could provide sufficiently comfortable environments for the occupants, in a period of typical summer heat, in various regions within the building. WSP commissioned CFD consultants, Flowsolve Ltd, to simulate the air flow in a number of critical areas of the building using PHOENICS.

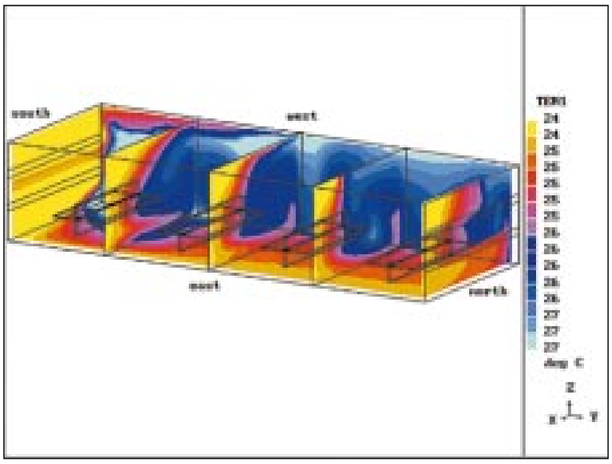


Fig 1 - LARGE OFFICE - Temperature on sections between islands

An area of particular interest was a set of west-facing open-plan offices with floor-to-ceiling glazing on the west wall, featuring openable windows on the north and south walls. Low-energy glass was to be used in the building, with the west windows shielded by reflecting louvres, but solar heat would still enter the offices both as radiation and by convection off the warm window glass. Additional heat would be generated in the offices by computer equipment. This heat would have to be dispersed by the breeze blowing through the windows, consequent upon the defined external condition of a light wind.

The PHOENICS simulations showed that the likely temperature rise in the offices was acceptable, but that the air velocities would be excessive for comfort - papers might tend to blow off desks! This finding prompted a redesign by the architects, in which the openable windows were replaced by floor and ceiling vents along all the exterior walls. Further simulations showed that such an approach would be successful - the satisfactory temperatures would be maintained, excessive air velocities eradicated, and the overall ventilation pattern would be gentle and well-distributed (Figure 1).

Airflows in the entrance hallway and adjacent atrium areas were also simulated; here the model confirmed that natural ventilation alone would be

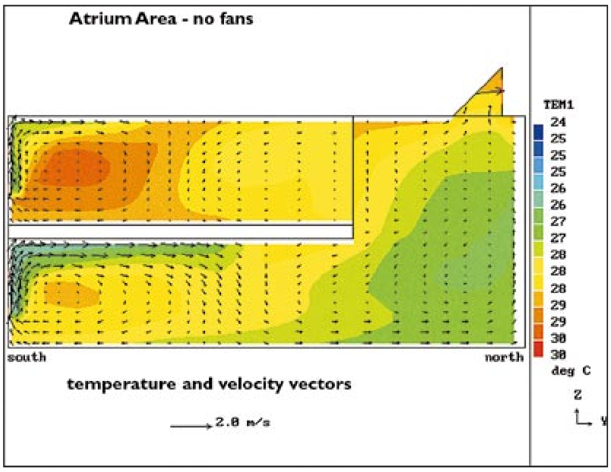


Fig 2 - Sections through west office and social area

inadequate (Figure 2). One solution proposed was the installation of extractor fans in the atrium skylight, and the predictions demonstrated that this remedy would lead to significantly reduced temperatures (Figure 3).

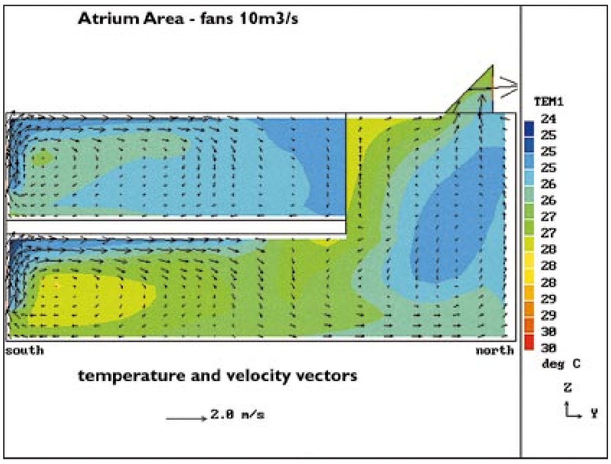


Fig 3 - Sections through west office and social area

An additional feature of the PHOENICS model was its ability to solve for air residence times, so that the freshness of the circulating air could be quantified. The predictions indicated adequate freshness of the air in all areas of the MDR Building which were considered.

Overall, the model predictions proved very reassuring to WSP, dispelling original doubts as to the viability of the natural ventilation arrangements proposed for the building.

In fact, the PHOENICS simulations showed that the ventilation performance was much closer to the client's requirements than might have been expected.

Dr David Glynn

Notices & Events Spring 1999

CHAM

Mr Peter Spalding, UK
Tel: (+44) 181 947 7651

March	15 to 19	Basic & Advanced Course
April	15	PHOENICS-3.2 'Refresher' Course
May	17 to 21	Basic & Advanced Course
May	27	PHOENICS-3.2 'Refresher' Course
June	24	PHOENICS-3.2 'Refresher' Course
July	05 to 09	Basic & Advanced Course
September	09	PHOENICS-3.2 'Refresher' Course
	20 to 24	Basic & Advanced Course
November	22 to 26	Basic & Advanced Course

CHAM - Japan

Mr Yasuaki Tachino, Japan
Tel: (+81) 352 10 93 56

February	10 & 14	Elementary Seminar
February	16	User Seminar
February	18	Osaka Seminar (Elementary/User)
March	10 & 14	Elementary Seminar
	16	User Seminar
	18	Osaka Seminar (Elementary/User)

Flow Consult

Dr Terje Toften, Norway
Tel: (+47) 67 15 07 00

May	05	Introductory & User Seminar

PHOENICS NA

Dr Peter Tsai, USA
Tel: (+1) 310 265 9719

June	07	US PHOENICS Users Meeting, CA
June	08	Overview of PHOENICS-3.2
June	09 to 11	Introductory PHOENICS Course

ATOS

Dr M. Megahed, Germany
Tel: (+49) 201 810 1927

February	22 to 26	Basic & Advanced Courses, Essen
April	19	Grid Generation, Essen
April	21	Basics of CFD, Essen
April	23	PHOENICS-3.2 Update, Essen
June	07 to 11	Basic & Advanced Courses, Essen
July	19 to 20	Multi-phase flow, Essen
July	23	PHOENICS-3.2 Update, Frankfurt
September	20 to 24	Basic & Advanced Courses, Essen
October	18	Grid Generation, Essen
October	20	Basics of CFD, Stuttgart
November	23	PHOENICS-3.2 Update, Stuttgart
November	24 to 25	12th German User Meeting, Stuttgart
November	26	PHOENICS-3.2 Update, Essen
December	13 to 15	Basic Course, Essen

All events listed above are correct at the time of going to press. Please contact your regional office for verification and for details of further events and exhibition news.

PHOENICS Training Course Programme

PHOENICS 3.1 / 3.2 Instruction Courses are run regularly throughout the year here in London. These are 5-day courses split into 3 units. Participants can attend the complete course or individual units, as required. Early registration is advised. See "Notices & Events" above - for special 1-day PHOENICS-3.2 "Refresher" courses.

Unit 1 - Beginner's Introduction (including VR)

Unit 2 - Using PHOENICS (including BFC's)

Unit 3 - Use of FORTRAN (including PLANT)

For full details of the course programme and schedule, and for details of both specialist and on-site courses, please telephone Mr Peter L Spalding at CHAM on: +44-181-947-7651, fax: +44-181-879-3497, or email: pls@cham.co.uk

January	18 - 22
March	15 - 19
May	17 - 21
July	05 - 09
September	20 - 24
November	22 - 26

Notices & Events Spring 1999

YEAR 2000 COMPLIANCE STATEMENT

This is to certify that the PHOENICS software version 3.1 has been tested and neither its performance nor its functionality will be adversely affected by the Millennium date change.

Concentration, Heat and Momentum Limited guarantees that any PHOENICS version from 3.1 or later will be Year 2000 compliant, but any version earlier than 3.1 is not guaranteed to be compliant.

Any queries regarding Year 2000 compliance can be addressed to:

Dr Jeremy Z Wu, email: jzw@cham.co.uk

PHOENICS AWARD

CHAM has sponsored a prize for the best CFD project of the year for the University of Hertfordshire, England. Utilising the university's site licence of PHOENICS, the programme for 31 final year students is supervised by Dr Arne Holdo, Head of the CFD Group in the Faculty of Engineering & Information Science.

It is hoped that Dr Holdo's initiative will form a 'template' for similar awards at other educational sites using PHOENICS.

Preliminary Call For Papers

This is the first announcement for the next International PHOENICS User Conference to be held in Luxembourg in Spring 2000. Details of the Millennium Meeting will be released before end-July 1999. If you would like to make a presentation, please register your interest with Mrs Petula Smith, email ps@cham.co.uk as soon as possible, or respond for general information using the form below.

FAXBACK - +44-181-879-3497 Please use this form to inform us of:-

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☐ *Change of address*

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☐ *Details of the PHOENICS User Conference*

☐ *Enquiries about PHOENICS products / services*

On completing this form, please fax or post to CHAM.

If you would like us to **remove** your name from CHAM's mailing list, please tick this box ☐

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