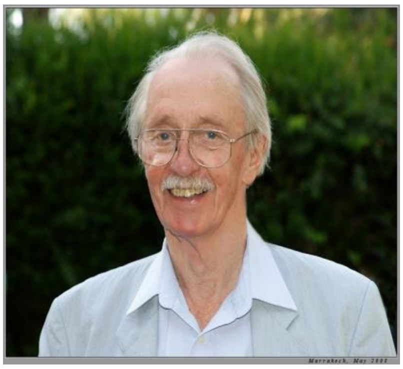
PHOENICS

News

Summer 2008

Editorial



Brian Spalding at The ICHMT international symposium, Marrakech, Morocco May 11 – 16 2008

On May 12 CHT'08 on *Advances in Computational Heat Transfer* opened with a Keynote Lecture by Brian Spalding. The Conference, attended by some 250 delegates, was organized by the International Centre for Heat and Mass Transfer, an institution co-founded by Brian in 1968 and originally based in Yugoslavia to allow scientists from East and West to meet and exchange ideas.

The Meeting, in the words of the organizers, was "planned as a tribute to Professor D Brian Spalding FRS in honour of his 85th birthday and in recognition of his innumerable contributions to computational fluid dynamics and heat transfer".

It was fitting that the occasion coincided with the 40th anniversary of the founding of the ICHMT.

Brian's opening lecture was entitled *Extending the Frontiers of Computational Heat Transfer* in which he outlined work done over the course of his career with reference to those who influenced him in the early days, positive interactions with students, and his strong recommendation that the boundaries of computational heat transfer be further extended by those currently in the field.

The abstract is included below and the full text can be found on www.cham.co.uk.

Abstract

Impelled by both practical necessity and scientific interest, the boundaries of computational heat transfer, and also the relative emphases given to its various aspects, have changed significantly in the past decades; but the pace of change has slowed, in some sectors almost to a standstill. It is argued in this paper that movement can be, and should be, resumed and that its speed should accelerate.

Three particular directions in which extension of boundaries should be made are advocated, namely:

1) stress analysis in solids
2) multi-phase flow and
3) chemically reacting materials

*and it is argued that, in respect of the last two, a shift of emphasis is desirable towards consideration of distributions in **population space.***

Some of the obstacles to making these changes are spelled out. They can be classified as psychological, computational and conceptual, the last of which presents the greatest challenge. Means of removing some obstacles are proposed and briefly demonstrated.

Andrew Pollard, Gordon Mallnson, Brian, Suhas Patankar

Brian demonstrating two-fluid flow to Professor Graham de Vahl Davis Conference Organizer

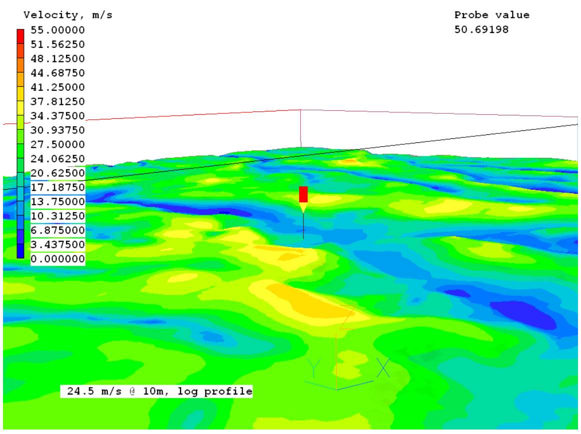
Norberto Fueyo, Brian, Steven Beale

What's New in PHOENICS 2008

Here is a list of updated features since the August 2007 release of PHOENICS.

Objects can be tagged to always be at domain end, and to extend to domain end. Makes changing domain size easier as tagged objects will follow automatically.

For WIND_PROFILE object, profile starts in first un-blocked cell in each column.



FLAIR. Fire and smoke dialogs updated to use current standards terminology.

FLAIR. Diffusers can be rotated about any axes.

Objects can still be selected when grid mesh display is on by holding down Ctrl key.

Contents List:

InForm editor and other utilities now executables, so no need to install TCL.

Drawing of objects in wireframe enabled on per-object basis.

Separate increment size for each direction.

Snap-to-grid feature - objects must be multiples of increment.

Added handling of PHOTON-style PLINE elements.

Save image as jpg file.

MOFOR enabled in parallel.

CVD enabled in parallel.

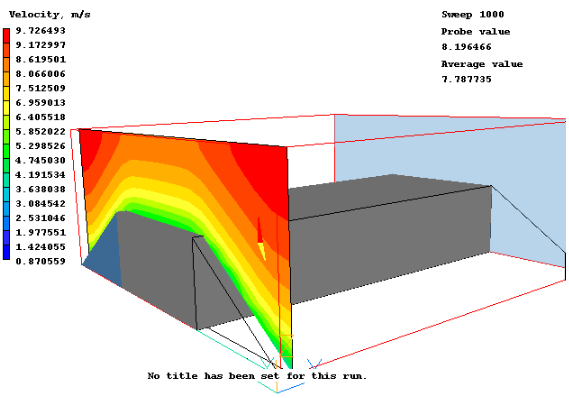
Allow use of { } to denote physical coordinates for variable location in InForm.

Better initial guess at size of F array required, and use of scratch file if expansion fails. Should allow bigger cases to run on 32-bit systems.

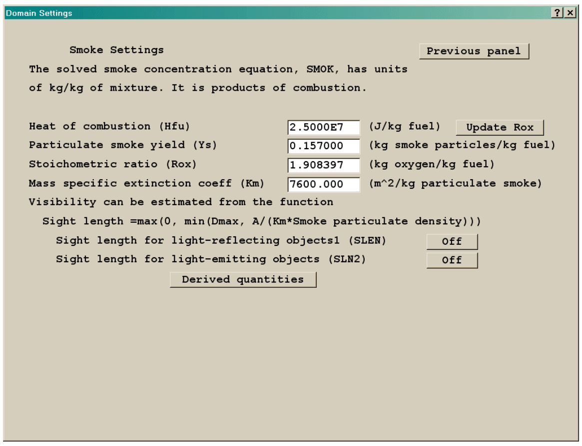
Use of material >= 299 for blockage treats cut cells as blocked and opens un-cut cells. Allows simple angled thin plate treatment.

For more details about the above changes click here

For the WIND_PROFILE object, the profile starts in the first un-blocked cell in each column. Previously it always started at the lower boundary of the object. This makes it easier to introduce wind profiles over terrain objects, as shown simply below



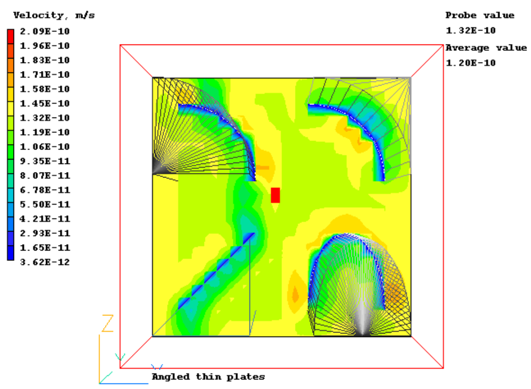
In FLAIR, the fire and smoke dialogs have been updated to use current standards terminology. The Smoke Settings dialog now refers to Heat of Combustion, Particulate smoke yield and Mass specific extinction coefficient. These values can be found in references such as the CIBSE Guide E.



Changes to the Earth Solver

MOFOR has been enabled in parallel PHOENICS. Similarly, CVD has been enabled in parallel PHOENICS.

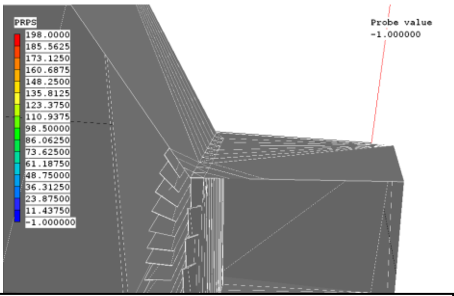
To reference the value of a variable at a specific location, the physical co-ordinates can be enclosed in { }, for example the temperature at (3.2,5.8,2.5) is TEM1{3.2&5.8&2.5}. Previously only cell locations could be given as TEM1[3&8&5].
A better initial guess at the size of the F array required for the case has been provided. If a further expansion fails due to lack of memory, a scratch file is used for temporary storage. This allows bigger cases to run on 32-bit systems without adjustment of CHAM.INI.
The use of material >= 299 for blockage causes cut cells to be treated as blocked and opens un-cut cells. The image shows the detection of a variety of curved surfaces.



Link to complete specification: G:\PHOENICS\d_polis\D_DOCS\tr006\tr006.htm

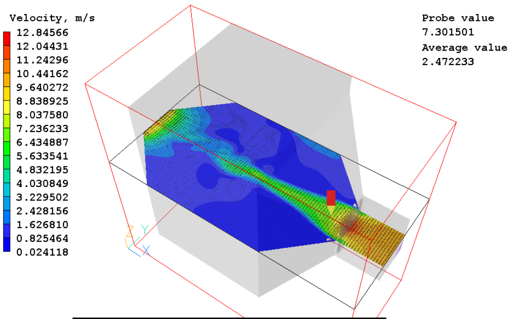
Example of Deflector Blades defined as 'patches' using IN-FORM

The IN-FORM example (below) defines a trial box with entry deflector plates mounted just after the inlet throat of the ductwork. There is a uniform inlet velocity at the 3m x 4m rectangular inlet ductwork of 9.745 m/s.



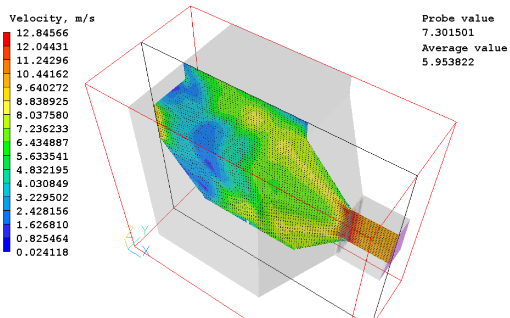
Vertically- and Horizontally-Splayed Blades

The object of the exercise is to improve the circulation of the gas flow using blades at various angles.



Velocity – X plane

The geometry was imported as a solid model. Rather than importing different geometries each time to adjust the deflector blade angles, this was done simply through 'patches' and modification of one or two variables defined as formulae using IN-FORM statements.



Velocity – Y plane

Computer Specification for PHOENICS

We are often requested to provide the specification of a recommended computer system to run PHOENICS.

We have found the Intel Core2 Duo chips run faster than the equivalent AMD dual core. If users are buying new, it is probably as well to buy the 64bit Windows OS (XP or Vista) so that they can make full use of the memory available. For a dual core we would recommend that they get at least 4GB of RAM; or for quad core, 8 or 16GB.

Dell Computers
www.dell.com

The 32bit version of PHOENICS does run slightly faster than the 64bit version under 64bit Windows.

The primary advantage of the 64bit version of PHOENICS is that it can exceed the 2GB limit for individual programs. Ultimately, the RAM requirement is determined by the size of the model the customer expects to create We don't have any specific recommendations for graphic cards. Most modern graphic cards with 256MB memory should perform adequately with PHOENICS. The hardware acceleration on some cards though can lead to refresh problems within the Editor; we have not been able to completely solve this issue, although we do have some 'work-arounds' which we can enable.

Steve Mortimer, email: scm@cham.co.uk

PHOENICS 2008 may now be ordered for 32-bit and 64-bit Windows and LINUX systems, in both sequential- and parallel-processing variants.

The recompilable versions use the INTEL FORTRAN compiler.

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Applications Update

Geert Janssen reports on A2TE's recent application of PHOENICS for a Gas-fired Carrousel Furnace

The pictures show a simulation of a gas-fired carrousel furnace that is used to 'bake' casting cores made out of ceramic material.

The cores are visible as pink cylinders placed above a small conical stand.

The nice thing about this simulation is the combination of convective and radiative heat transfer (the IMMERSOL model has been used). Furthermore a semi-static calculation was done to show the effect of the colder incoming cores, 10 minutes after placing a new core in the furnace (at the right side of the pictures). The more or less spoke-like open areas in the temperature plots show the locations of the gas burners, injecting hot gases at temperatures above 1000°C. The gases leave the furnace through the centre via a ring-like opening near the bottom of the product area.

PHOENICS was used to define the optimum position of the gas burners and the flue gas opening in the centre of the furnace.

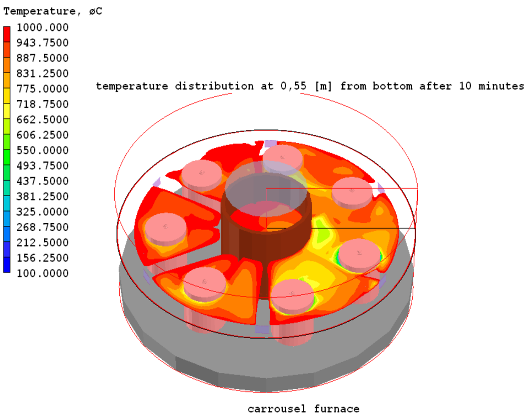

Figure 1 Isometric view

Figure 2 Cross sectional view

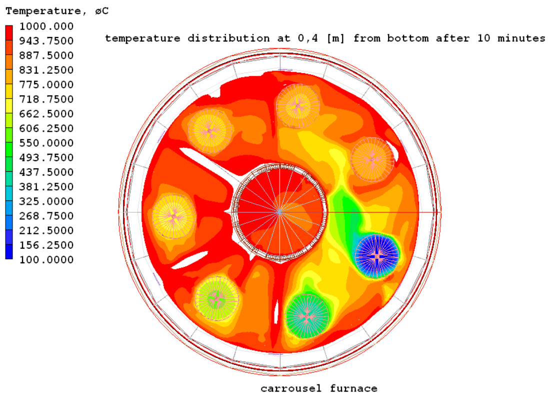

Figure 3 Top view

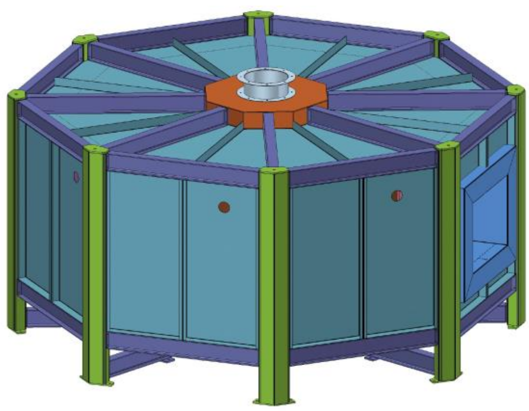

Figure 4 Design of furnace

Ir Geert Janssen A2TE
Email: gjanssen@a2te.nl

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PHOENICS Applications by the Tennessee Valley Authority (TVA)

TVA's Boualem (Bo) Hadjerioua describes three TVA projects where PHOENICS has been used. In the first two examples, several millions of dollars were saved. The full report can be found here:

1. TVA's Colbert Fossil Plant Skimmer Wall

The purpose of this study is to design an optimum skimmer wall at Colbert Fossil Plant (COF) to reduce de-rating due to thermal compliance and debris entrainment in the COF intake channel. The report presents the justification, potential benefits and the proposed design of a skimmer wall at COF.

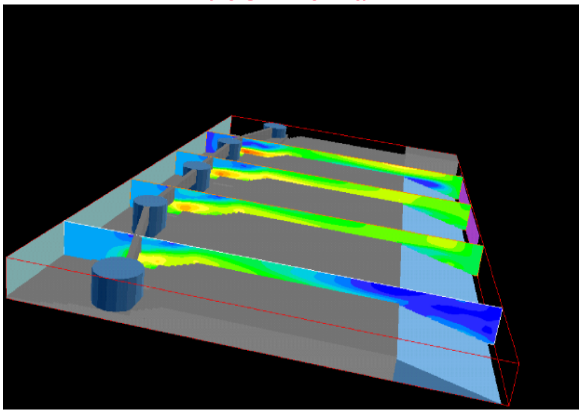
Barge Collecting Debris at COF, 2001

Water temperature monitoring at COF indicates that an improvement in water temperature could be made if water is withdrawn from bottom layers of the Tennessee River. Installing a skimmer wall at the appropriate location and depth would accomplish this goal.

The study determined the optimum location and depth of the skimmer wall to minimize de-rating at COF without any negative environmental impact. COF also experienced a big inflow of debris that affected the plant generation's efficiency. Therefore, by building a skimmer wall, two objectives would be targeted; lowering the intake water temperature during thermal stratification, and blocking the debris from getting in the intake channel. However, it was necessary to justify its implementation and the associated capital cost.

A detailed study of the water temperature profile has shown that if a skimmer wall is built at COF with a bottom elevation at 400 feet, the savings from thermal compliance would have been about $354,000 in 1999. The debris problem at COF cost 80,000 MWh of de-rating at the plant in 2000.

Computed Velocity Profile Contours at Several Locations of the Skimmer Wall



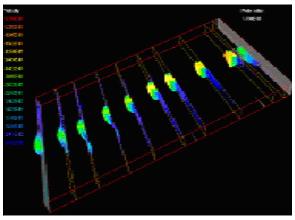
The estimated capital cost to built a skimmer wall at COF is about $1.4 million. Therefore, just the savings from 1999-2000 covered the cost of the skimmer wall, which is expected to last more than 50 years.
Numerical modelling of the intake channel, with skimmer wall bottom at elevation 400 feet, has shown that the maximum velocity below the skimmer wall is 1.5 fps compared to the existing conditions of 0.5 fps. The computed velocity profiles were used to evaluate the 316b issues (fish entrainment/ impingement by intake structures).

2. TVA's Kingston Fossil Plant Multi-Ports Diffusers

A reduction system for control of nitrogen oxides (NO_x) in the air emissions is being implemented at Kingston Fossil Plant (KIF). This new technique uses ammonia to reduce the emissions. The fly ash combustion by-product contains ammonia. The fly ash is sluiced to a series of ponds for settling, and the sluice-water is discharged from the ash pond into the intake channel.

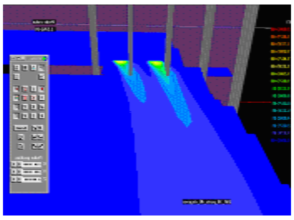
Survey at KIF intake Channel

The maximum ammonia concentration entering the intake channel is predicted to be 2.85 mg/L. At such elevated levels, ammonia can be toxic to aquatic life. It potentially adds to the biological oxygen demand, lowering dissolved oxygen levels and encourages algal blooms. KIF is evaluating alternatives to avoid violating water quality standards for ammonia and prevent potential fish kills.



Velocity Vector taken at Several Intake Channel Sections

One proposed alternative is to route the ash pond discharge into the condenser cooling water discharge, where it would be fully mixed and diluted. The estimated cost for this option is about 8 million dollars. A less costly proposed alternative, costing about 500 thousand dollars, is to discharge from the ash pond through a diffuser system added onto the existing discharge pipes to enhance mixing and dilution in the intake channel.



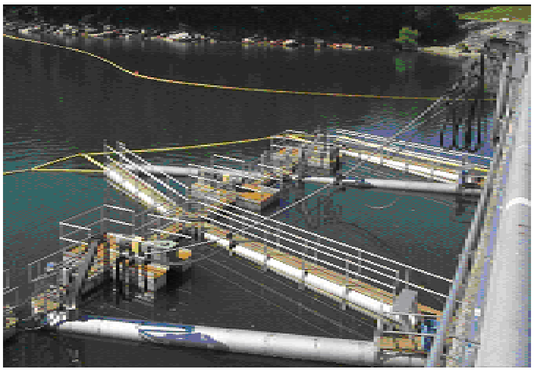
Diffusers Angled at 45 degree, Instantaneous Mixing

A detailed modeling study of the intake channel flow patterns was carried out to optimize the design of the diffuser system to facilitate instantaneous mixing in the intake channel, maximize dilution, and thus, bring the ammonia (NH_3) concentration to acceptable levels in the intake channel. The modeling results show an instantaneous mixing and reduction in NH_3 to about 0.23 Mg/L within 140 feet downstream the diffusers, concentration well below the Criteria Continuous Concentration (CCC) of 0.55 mg/L for KIF intake channel.

3. TVA's Tims Ford Reservoir Surface Water Pumps

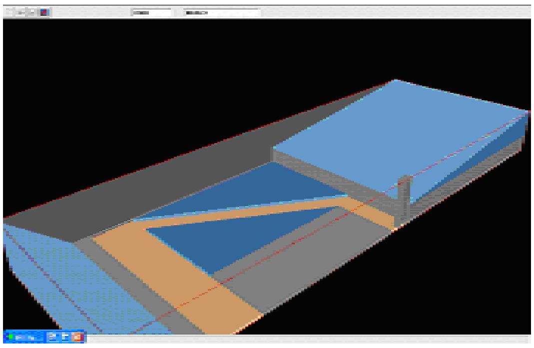
The report describes the numerical simulation of surface water pump performance at Tims Ford Dam. The modeling objective was to evaluate surface water pumps performance under several configurations, pump sizes, and initial propeller velocities.

Surface-water pumps being ssed at Douglas and Cherokee Reservoirs



The goal was to determine an optimum design to maximize the improvement of water temperature and dissolved oxygen (DO) content in hydropower plant releases without disturbing reservoir bottom sediment. The results for two alternatives are presented; a three 12-ft pump and a six 8-ft pump layout.

Model Layout (Base Case)



The modeling of the alternative layouts was evaluated under summer pool elevation with a relatively strong thermal stratification and a relatively high DO content only in the upper few feet of the reservoir. PHOENICS was used to evaluate the flow field, water temperature, and DO improvements. Turbulence was accounted for by using the K-E turbulence model, and the Boussinesq approximation was used to include the domain buoyancy effects. The report presents the modeling results of surface water pump designs, locations, and operating speeds under summer pool reservoir elevation for three and six pump layouts

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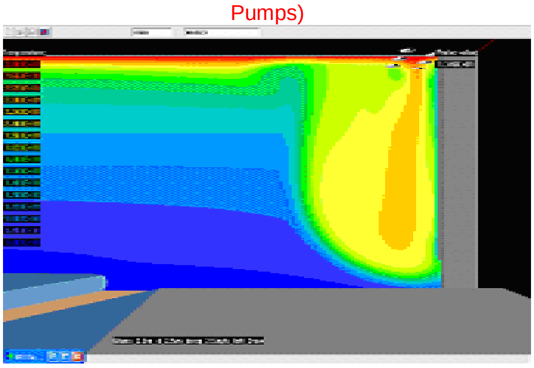
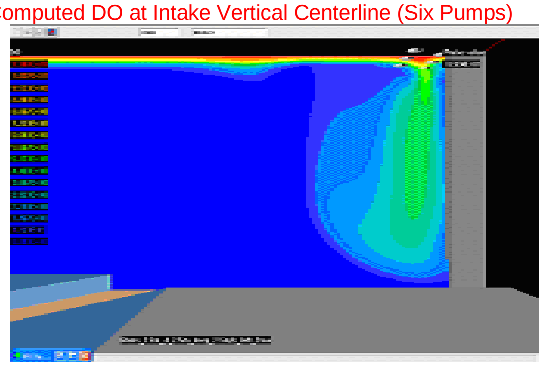
Computed Temperature at Intake Vertical Centerline (Six Pumps)



Computed DO at Intake Vertical Centerline (Six Pumps)



Based on the comparison of several surface pumps layout scenarios, the recommended option of surface water pumps for Tims Ford Forebay Reservoir is the six 8-ft pump layout. Under the June 26, 2003, forebay profile, this option improved the water temperature release by 10.3°F and the DO by 2.0 mg/L.

Boualem (Bo) Hadjerioua
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Redesign of SEN tube for Continuous Casting of Steel

The SEN (Submerged Entry Nozzle) tube in continuous casting delivers liquid steel from a reservoir (Tundish) to the mold for final solidification into slabs. At United States Steel Corporation ("U. S. Steel"), the SEN tube has two port openings from which the steel enters the mold from the tundish. The ports have a down angle to direct the flow down inside the mold and the ports are located slightly above the bottom plane of the SEN, so that there is an internal recess or cup height. Recently, use was made of PHOENICS fluid dynamics software to mathematically model the flow of liquid steel in the mold.

The work involved increasing the useful life of the SEN tube being used at a U. S. Steel plant. Since the tube life was dictated primarily by mold flux attack on the tube refractory at the liquid interface, increased thickness of the SEN refractory wall by reducing the inner bore diameter of the tube, would help to increase the life of the tube. However, when the plants initially reduced the inner bore diameter from 90 to 80mm, the flow speeded up and changed significantly near the liquid surface, such that mold flux powder on the steel surface was being entrapped into the steel, thus reducing steel cleanliness and quality. Mathematical modeling of the flow in the mold was performed to solve this problem.

Using PHOENICS, the flow profile in the mold was computed for the existing SEN design, the unsuccessful reduced bore design and some new proposed designs incorporating the reduced bore technology. The velocity and turbulence values at a plane near the liquid surface were recorded for all the cases. The objective was to match the velocity and turbulence values generated by the proposed reduced bore design as close as possible to that generated by the existing big bore SEN design near the top surface of the liquid, which is the region where the mold flux powder was being entrapped. To model the free surface at the top, the IPSA algorithm was employed. The KE model was used to model the turbulence and a fixed volumetric flow rate condition was imposed at the inlet.

The steel flow pattern at t=25seconds for the current big bore tube is shown in Figure 1 while Table 1 is a partial list of the different SEN designs that were investigated. Version K is the big bore tube, version A is the unsuccessful reduced bore design and version X is a new reduced bore design.

Table 1: Description of all the different SEN tube designs investigated

Tube Type	**Version Index**	Description
Current J Tube	K	Bore 90, Port 70x90, Angle 15, CupHt 66
SmallBore ModifiedPort	X	Bore 80, Port 70x80, Angle 20, CupHt 55
Experimental L Tube	A	Bore 80, Port 70x80, Angle 15, CupHt 66

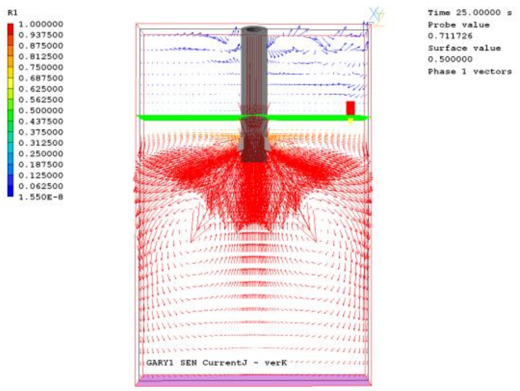


Figure 1: Schematic of the liquid steel flow in the mold from the two-ported SEN.

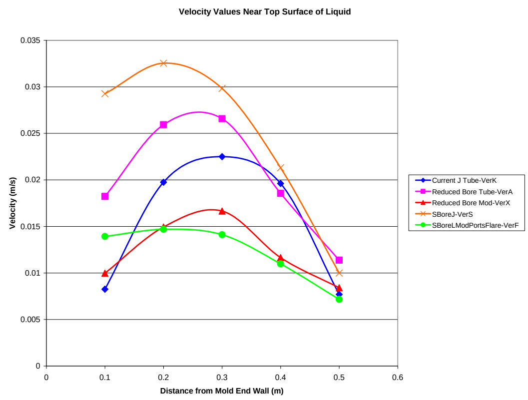


Figure 2: velocity values near top surface of liquid for different SEN designs.

Figure 2 shows the velocity values along a line near the top surface of the liquid in the mold, extending from one end of the mold to the other along the centerline. All the different designs investigated, version X (red line) has the closest match to version K (blue line) the current big bore tube. Version A (pink line), the unsuccessful tube shows higher velocity over most of the surface compared to version K and caused the mold flux entrapment. Thus version X design was trialed in the plant and the tube life index improved from a value of 0.68 to 1.0 i.e. almost 50% improvement and this design has been currently adopted for use at the plant leading to cost savings.

Dr A K Sinha,
Email: ASinha@uss.com

Vascular Profiling at Brigham & Women's Hospital, & Harvard Medical School

Dr Ahmet Umit Coskun, Dr Charles L Feldman, Northeastern University

The Vascular Profiling Laboratory at Brigham & Women's Hospital/Harvard Medical School, under the direction of Charles L. Feldman, ScD, has used PHOENICS to predict the progression of coronary atherosclerosis (fatty deposits in the heart's arteries) in patients and to explore the mechanisms of coronary atherosclerosis in swine with artificially induced diabetes and abnormally high cholesterol.

Dr A U Coskun, the Lab's Technical Director, employed a body-fitted coordinate (BFC) mesh to simulate blood flow through coronary arteries. The original geometry/anatomy was obtained through a combination of x-ray and ultrasound images. Flow rates were obtained by tracking X-ray contrast ("dye") through an artery, and patient specific viscosity was determined from routine blood tests. The entire process was shown to be highly reproducible *in-vivo* [1]. Local sites of low Endothelial (surface) Shear Stress (ESS) determined through the simulations agree well with the sites of coronary artery disease progression [2].

Animal studies have shown that ESS is quantitatively related to the clinical significance of the disease – the lower the ESS the more dangerous the disease build-up is likely to be [3]. These results strongly suggest that the use of CFD to analyze coronary artery flow can lead to a paradigm shift in patient management and can help to prevent heart attacks [4].

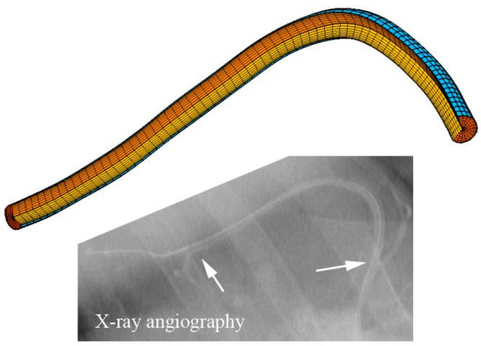


Figure illustrates the grid formed at a coarser density than the one used in simulations for clarity. Body fitted coordinates available in PHOENICS was a natural fit to the complex coronary artery geometries with the disease. The geometry is from a right coronary artery indicated by the arrows in the x-ray angiogram.

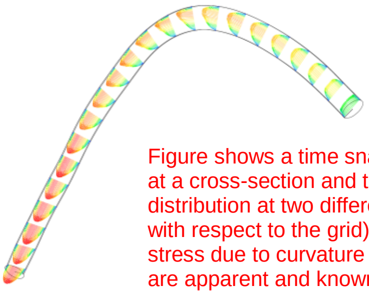
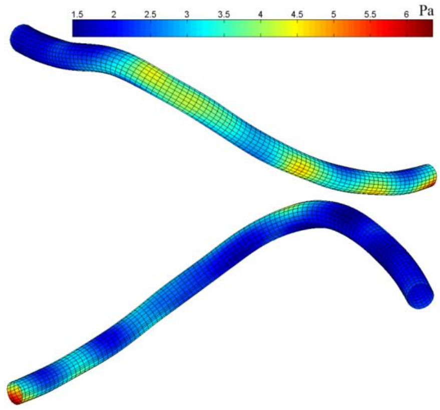


Figure shows a time snapshot of the velocity profile at a cross-section and the surface shear stress distribution at two different angles (front and back with respect to the grid). Local variations of shear stress due to curvature and/or surface irregularities are apparent and known to correlate with progression of coronary artery disease.



1. Coskun, A.U., *et al.*, "Reproducibility of coronary lumen, plaque, and vessel wall reconstruction and of endothelial shear stress measurements in-vivo in humans," *Catheterization and Cardiovascular Interventions*, 60: 67-78, 2003.
2. Stone, P.H., *et al.*, "Effect of endothelial shear stress on the progression of coronary artery disease, vascular remodeling, and in-stent restenosis in humans: In-vivo 6-month follow-up study," *Circulation*, 108:438-444, 2003.
3. Chatzizisis Y. S., *et al.*, "Prediction of the Localization of High-Risk Coronary Atherosclerotic Plaques on the Basis of Low Endothelial Shear Stress: An Intravascular Ultrasound and Histopathology Natural History Study," *Circulation*, 117:993-1002, 2008.
4. Chatzizisis, Y.S., *et al*, "Risk Stratification of Individual Coronary Lesions Using Local Endothelial Shear Stress: A New Paradigm for Managing Coronary Artery Disease," *Current Opinion in Cardiology*, 28:552-564, 2007.

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Pulse Crowned as F1 in Schools World Champions !!

PHOENICS News

The F1 in Schools Technology Challenge is for school children aged 11 to 18 to use CAD/CAM software to design, analyse, manufacture, test and race their miniature F1 car made from balsa wood and powered by CO_2 cylinders.

A sub-set of PHOENICS, the F1 VWT, is used to test prototype designs in a virtual wind tunnel prior to production. For a description of the F1 VWT, see: www.cham.co.uk/DOCS/f1_VWT_Flyer.pdf. The hugely popular and highly competitive F1 in Schools Challenge involves thousands of schoolchildren from all over the world – See: www.f1inschools.co.uk.

After 3 days of intense competition, the 'Pulse' team from Devonport High School for Boys has been crowned "F1 in Schools World Champions!" They also came away from the International Finals held in Kuala Lumpur, Malaysia, with the Fastest Car award, after achieving a track time of 1.064 seconds - a scaled up speed of over 220mph. The judges said Pulse scored well with an impressive portfolio and clinical presentation to clinch the highest points total and scoop the title of "2008 World Champions".

In order to finance the cost of developing the CO2 powered model and their trip to Malaysia, the team managed to raise £11,500 in sponsorship from both local and national companies. Teacher and Team Manager, John Ware, said "I would like to thank all of our sponsors, as well as everyone in Malaysia for making us feel so welcome."

John Ware, Pulse, Devonport High School for Boys
Email: john@pulsef1.co.uk
Web: www.pulsef1.co.uk

Training dates:

CHAM, London: 28th to 30th May 2008

NUS, Singapore 17th to 19th June 2008

CHAM, London: 22nd to 24th July 2008

CHAM, London: 16th to 18th September 2008

See http://www.cham.co.uk/training.php for updated PHOENICS training course dates & programme.

News & Events

Consultancy Manager Appointment

We welcome Mr Paul Emerson to our team here in the UK. Paul joins us from QinetiQ, Farnborough, and now heads up CHAM's expanding consultancy activities in the UK.

As well as targetting the chemical and turbomachinery industries for which his experience will be invaluable (???), he also inherits control of two ongoing DTI and EU projects focussing on nano-particle applications.

Welcome to the deep end Paul !

CHAM still has recruitment opportunities for both technical support and consultancy engineers, so applicants should please send their CV's to phoenics@cham.co.uk marked for the attention of Jill Rayss.

ArcoFluid …

CHAM-Japan will exhibit PHOENICS at DMS in Tokyo.

DMS Tokyo 2008 - 25 to 27 June

http://www.dms-tokyo.jp/dms/english/

Contributions

We are always interested in receiving contributions for the Newsletter from Agents, PHOENICS Users and Students. Please email to PHOENICS@cham.co.uk. Full attribution will be given to all contributions used.