PHOENICS Newsletter

Dear Reader

PHOENICS on the Cloud (PHOENICS-OTC) is a cost-effective way to run large cases on powerful multi-core systems offered by the Microsoft Azure marketplace (see page 2). To explore the possibilities for yourself go to: https//www.cham.co.uk/_docs/pdfs/phoenics_docs/PHOENICS-OTC2021.pdf.

PHOENICS-2023 the new, annual, code version available to all maintained users and new clients is being created, tested, and documented.

PHOENICS-2023 will contain a further extension to VOF, the widely-used Pasquill-profile classes (coded into the WIND Object (see pg 6), a logarithmic scale feature (see pg 2) and other features. A more detailed description will be available in the Summer Newsletter. For further information please contact sales@cham.co.uk.

CHAM seeks a team member with CFD knowledge looking for an outward-facing position selling, and using, PHOENICS and associated products. The successful applicant will work with our technical staff on site at head office in Wimbledon Village. Full job description: https://www.cham.co.uk/careers_description_sales_2023.php. Please contact hr@cham.co.uk to apply. All applicants must be legally entitled to work in the UK with no restrictions of any kind.

Kind Regards

Colleen Spalding, Managing Director

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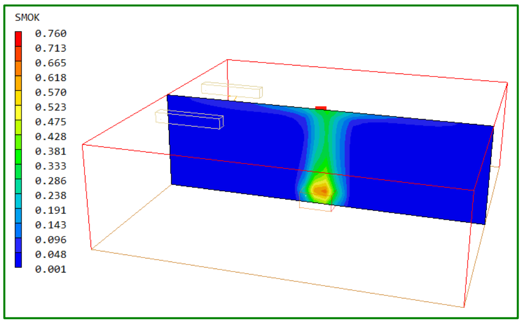
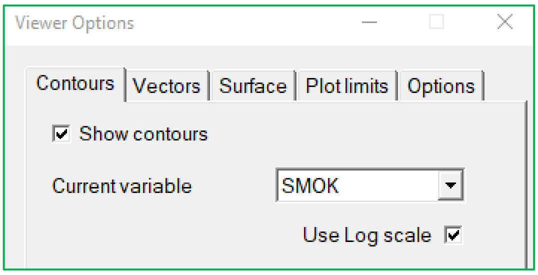
Spring
2023

Contour Plots Using Logarithmic Scale: John Ludwig, CHAM

The logarithmic scale feature described here will be in PHOENICS 2023 to be released later this year. Traditionally, contour plots produced by VR-Viewer have used linear scales. In the majority of cases this is exactly what is needed. There are occasions when the linear scale hides too much detail, especially when the range of contour values spans several orders of magnitude. A typical situation might be smoke spread in a fire.



Here, layering of smoke is masked by the linear scale.

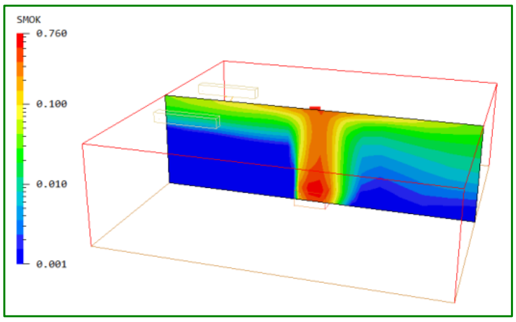


☑ Show contours

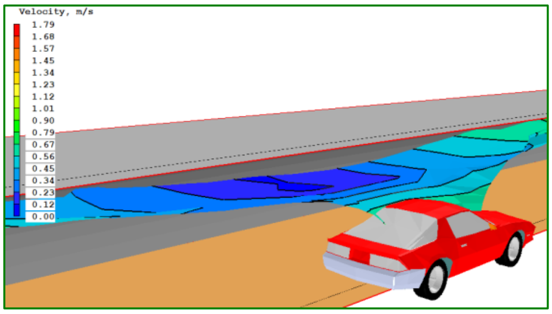
Current variable SMOK

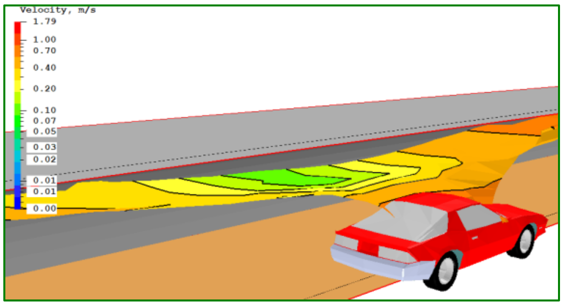
Use Log scale ☑

VR-Viewer has a new tick-box which changes contour to logarithmic scale so that layering becomes apparent.



The logarithmic scales also apply to contours of a variable on an iso-surface of another. The images below show iso-surface of sight-length (SLEN) coloured by Velocity.





PHOENICS on the Cloud

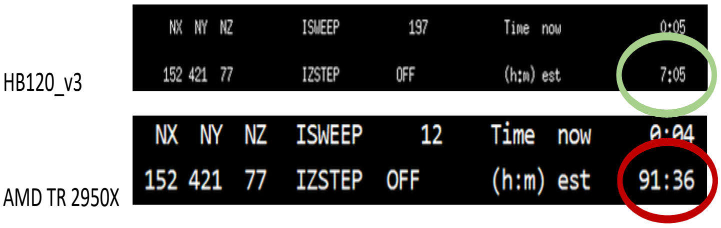
https://www.cham.co.uk/PHOENICS-OTC.php

CHAM's pay-as-you-go PHOENICS-On-The-Cloud (POTC) service 'saved the day' for a mission-critical project supporting the UK's Water Research Centre (WRC) in its use of PHOENICS for independent CFD studies of drinking water reservoirs.

The time required for long transient simulations stretched in-house computing capacity putting the delivery schedule to their customer at risk. Running the cases via POTC provided instant availability and rapid scalability that allowed our teams to meet the strict deadlines.

A simple comparison between running on a local workstation (AMD TR 2950X) and remote server (HB120_v3) noted a speed up of 1200%.

By the time the local machine loaded the case and started running, the remote machine is already at 200 sweeps. At a cost lower than £10 per run, PHOENICS-OTC provides a cost-effective solution to meet stringent production deadlines.



```
NX  NY  NZ   ISWEEP   197    Time  now    0:05
152 421 77   IZSTEP   OFF    (h:m) est    7:05
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NX  NY  NZ   ISWEEP    12    Time  now    0:04
152 421 77   IZSTEP   OFF    (h:m) est   91:36
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Call for Contributions

The next Newsletter will feature articles about the history of CHAM.

If you worked at CHAM, if you have visited over the years, please send your memories (in Word if you would be so kind) to newsletter@cham.co.uk.

As always, please accompany your articles with any photographs you have of the time you were here. Also please put in the dates your memories relate to.

Many thanks and I look forward to hearing from you.

PHOENICS Modelling of COVID Spread in Small Singing Groups:

Dr R P Hornby, email: bob.hornby007@gmail.com

Introduction

COVID 19 is transmitted to humans by the inhalation of aerosols carrying the COVID virus (ref 1). The aerosols can range in size but the focus here will be on the very small aerosols that remain airborne for long periods of time and effectively distribute themselves according to the local air flow conditions. Of particular interest are small singing groups (singing indoors) which are now allowed to take place subject to people being well spaced and the venues well ventilated. However, with the relaxation of rules relating to COVID in the UK, it is likely that one or more of the group could attend with (asymptomatic) COVID. It is therefore important to be able to model how an infection can spread within such a group given the details of the venue environment.

Modelling Assumptions

The focus here is on the distribution of the very small-scale aerosols that are carried in the air for long periods of time. With the group members well-spaced it is assumed that the exhaled air from a person mixes over a short distance into the global airflows within the room. This enables a relatively coarse computational grid to be employed, sufficient just to characterise air flows in the enclosure. In addition, it is considered that an important factor is not just the local concentration of aerosols but the ‘dose’ inhaled over the time of the activity.

Turbulence in the room will enhance mixing and there will be a distribution of turbulence intensity dependent on the room characteristics and turbulence levels entering the room. This can be done using models within PHOENICS but this level of detail is not appropriate to this current illustrative case where a simple enhanced laminar viscosity is used.

The COVID source which can be placed anywhere within or outside the singing group can be static or can move around the group in a specified way.

PHOENICS Modelling

A rectangular room 20m long by 10m wide by 4m high that is typically used as a venue for a singing group of 20 to 30 people will be used as an example. The room has an entrance door which is kept open to allow an air inflow and windows near the opposite end of the room to allow air to flow out. With the current infection rates, it is assumed that 1 of the attendees has (asymptomatic) COVID (see Figure 1). Such groups usually meet for about 2 hours with a half time break of about 20 minutes for refreshments and some social interaction.

The standard 3-D time dependent conservation equations of mass, momentum and energy are solved with PHOENICS using a Cartesian grid and the KOREN numerical scheme. Two concentration equations are used to model the distribution of COVID aerosols and fresh air. The COVID aerosol dose is calculated as the integral with time of the local COVID concentration. The singing group is represented as a heated blockage of given porosity with mass, momentum and energy sources representing exhalation and inhalation due to singing.

PHOENICS Results

The simulation is run for 7200s (2 hrs) and the COVID dosage at specified locations is calculated as a function of time and normalised with respect to the overall maximum dosage. The setup in the room is shown in Figure 1 with the singing group (and COVID source), door, windows and monitored locations marked. The degree to which the room can be claimed to be well ventilated can be shown by contours of inlet air concentration. Figure 2 shows, for example, an early distribution of fresh air concentration, showing how the heat generated by the singing group causes the air to rise thus affecting the COVID aerosol distribution. The half time break is assumed to extend from 3000s (50 mins) to 4200s (70 mins) and during this time the infected person is assumed to move within the group using the path shown. For the purposes of this article the path has been made simple for convenience but any path can be specified.

Figure 3 shows the COVID concentrations at 3000s (50 mins) prior to the half time break and at 3800s (63.33 mins) during the break. The COVID source has been moving around the group spreading the virus. The normalised COVID dose with time at the monitored locations (see Figure 1) is shown in Figure 4. This shows that the COVID dose is, as expected, higher at those locations where the COVID source is close for a longer period. It is also interesting to note that proximity to an open window is not necessarily a safe option if air is exiting that window!

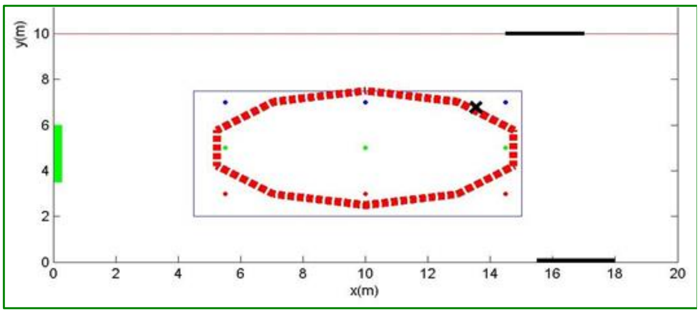


Figure 1. Plan view of the singing room with the door position marked in green and the windows marked in black. The blue inset rectangle is the position of the singers and monitoring positions are marked with red, green and blue dots. The position of the infected person is marked with a cross and the red dotted trajectory outlines the movement of this person during the 1200s(20 min) e break.

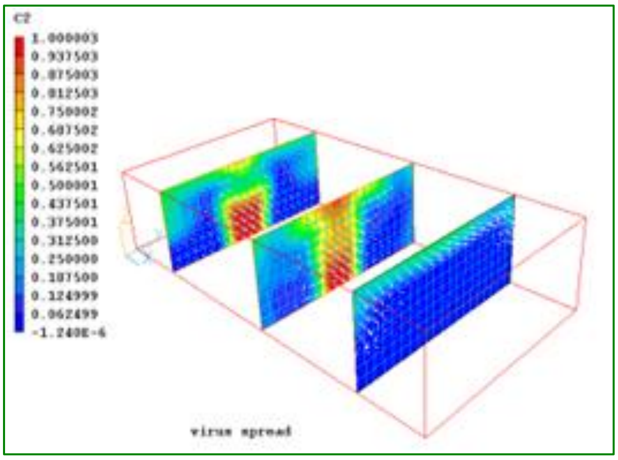


Figure 2. Fresh air concentration at an early stage of the simulation.

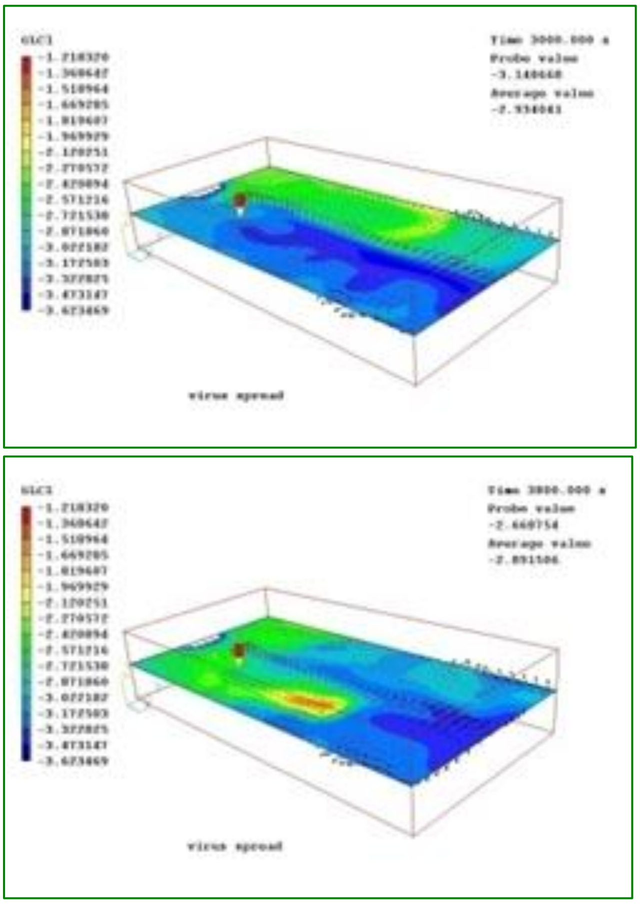


Figure 3. Typical log10 plot of the COVID aerosol concentration (top) prior to the half-time break at 3000s (50 min) and bottom) during the break at 3800s (63.3 min).

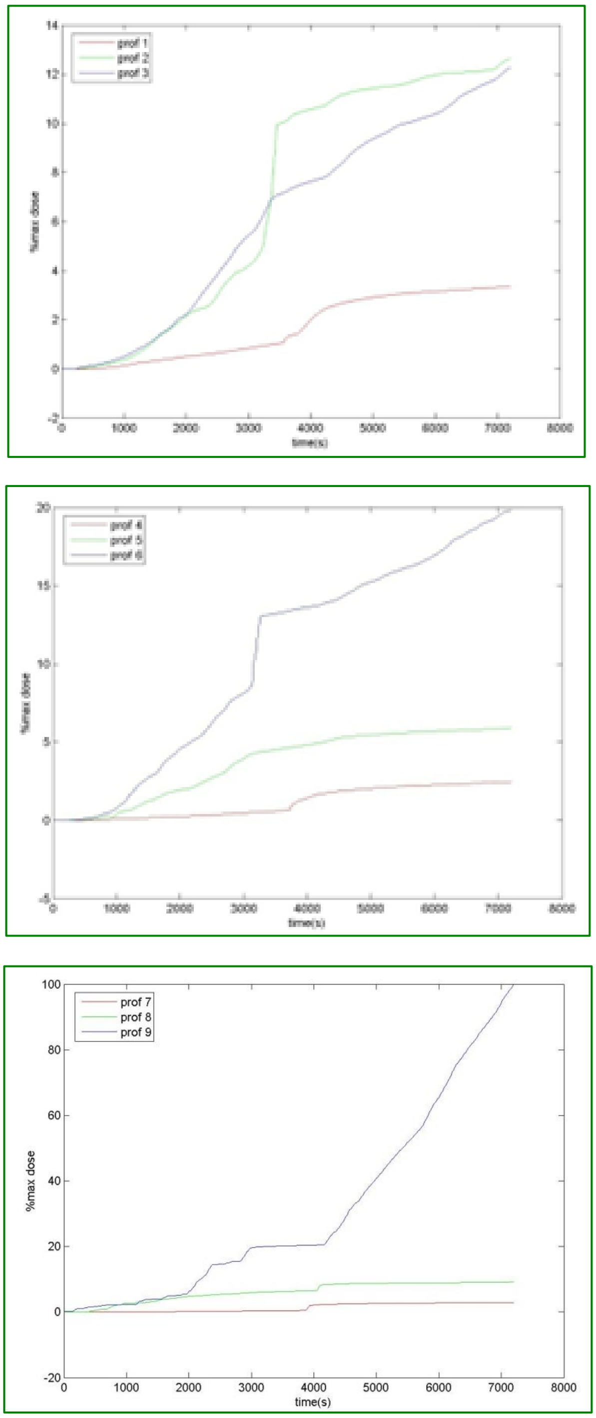


Figure 4. Accumulated COVID dose levels with time as a percentage of the maximum dose. Profiles 1,2 and 3 relate to the leftmost set of dotted positions in figure 1, profiles 4,5 and 6 to the middle set of dotted positions and profiles 7, 8 and 9 to the rightmost set of dotted positions.

Conclusions

PHOENICS has been used to model a small singing group and in particular to illustrate the increased spread of the virus by movement of the COVID source during social interaction at a half-time break in the singing. This type of modelling can be easily extended within PHOENICS to account for different aerosol sizes, turbulence effects and venues with diverse ventilation features.

References

1. Fennelly, K. Particle sizes of infectious aerosols. Implications for infection control. The Lancet Respiratory Medicine 8(9), 914-924, 2020.

Application of PHOENICS for Predicting Ship Resistance: A Brief Summary:

Arne Erik Holdø, Applied Computational Engineering (ACE A/S)
Arne Markussen, Adrian Pavel (PolarKonsult A/S)

Introduction

The traditional approach for predicting ship resistance has been and is still the use of scale-model tests. However, the scale effects in converting the model data to full scale values can be quite significant especially in terms of the large differences that exist between model and full-scale Reynolds numbers since the model tests are frequently based on Froude-number scaling. Because of such issues, naval architects and ship designers have looked towards the application of Computational Fluid Dynamics (CFD) to supplement traditional ship-resistance scale tests. CFD has been used for many areas, amongst them, aircraft design, motor-vehicle design and wind loading on buildings and structures to mention but a few.

A major reason for the slower take up of CFD in ship-hull design has been that ship resistance is not only affected by boundary-layer frictional resistance and ´bluff-body´ pressure differences, but the free surface waves have a significant effect on both hull boundary layers and the pressure differences on the hull. Consequently, it is necessary to carry out two-phase CFD simulations to achieve appropriate modelling conditions. This results in an even larger demand on computing power than is the case for a simpler single-phase application. It is only in comparatively recent years that it has become practical for marine engineers and naval architects to use CFD in this manner despite pioneering work by Visonneau et al (2005 & 2006) in the European Union Project 'EFFORT.'

Commercial CFD programs - such as PHOENICS - are able to simulate the required two-phase flow conditions through adapting its two-phase simulation method based on the VOF (Volume Of Fluid) algorithms for free surfaces. Furthermore, the effect of turbulence is modelled through the use of versions of the well-known two equation turbulence model, although more detailed turbulence models such as the Reynolds stress model can also be used. PHOENICS applies a Cartesian grid system for the simulations and uses a method named PARSOL (PARtial SOLid) to deal with partly-filled computation cells necessary to ensure that the curvature of the hull shape is taken into account within the simulation.

The present work is based on tests of full-scale CFD for ship-design company, POLARKONSULT, Harstad, Norway.

Initial Simulation

A cargo ship of overall length of 80m was chosen for the simulations. A STL file of the hull was supplied as the model object. Initially, the 'core' solver of PHOENICS was used in which the sea surface was simulated as a free slip horizontal plane. Simulation of the flow of water was pictorial results in Figures 1 and 2 show velocities in planes below the sea surface.

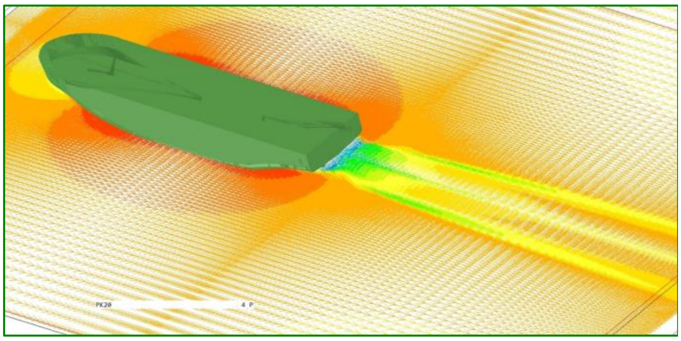


Figure 1 Velocity vectors 0.5 meter below the sea surface from steady state solution with non-flexible sea surface.

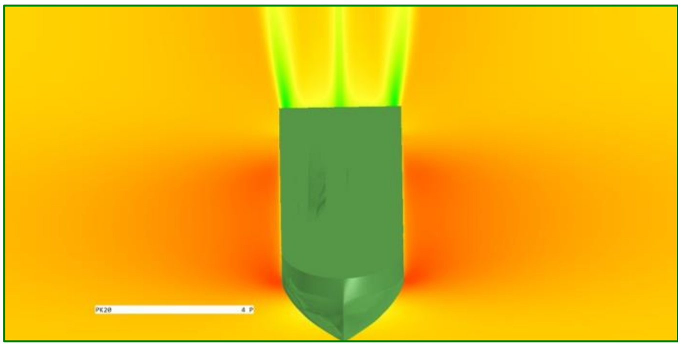


Figure 2 Velocity contours below the sea surface from steady state solution with non-flexible sea surface.

Results from this initial study were for the 12 knots 5.5 m draught case only and gave a drag or resistance value of 134 kN which is less than expected, but not surprising as the wave effects were not yet included.

Simulations with MARINE

In order to achieve more-representative simulation conditions, the 'Marine' SPP (Special-Purpose Product) of PHOENICS was employed. The Marine menu enables the simulation of two-phase flow, permitting the wave-inducing properties of the ship´s hull to be studied. Furthermore, the longitudinal symmetry plane of the ship's hull was used to reduce the computational domain and consequently, the computational effort.

Domain size was chosen to ensure that external boundaries did not disturb the simulation. The inflow boundary was set half a hull length ahead of the hull model, whilst the outflow boundary was located 2.5 hull lengths astern of the model. The free-slip domain side wall was located 5 hull widths from the side of the hull; the bottom of the domain was set at 20m whilst the top of the domain was located 10m above the hull.

The Marine SPP sets up the computational mesh in a different way from standard PHOENICS, but the usual meshing method can be accessed if needed. Importantly, the mesh size next to the hull surface can be determined in the input. Its default value is 1m, but 0.5 m was chosen in the present study.

The most appropriate free surface method for the study was VOF (used in many studies such as Song et al (2021)) and employed by other commercial software packages. The present version of CHAM's VOF method is time dependent; hence simulations are carried out as such. Alternative free-surface models are available within PHOENICS, but the VOF method generated good results for the case considered.

Two hull configuration cases were chosen. The first was with a mean draught at 3.5 m, speed at 12 knots and a trim of 0.964 degrees. The second was also with a speed of 12 knots, but with a draught of 5.5m and zero trim.

In the case of time-dependent simulations, it is usual to study hull resistance behavior with increasing simulation time. It is expected that variation with time will eventually decrease and the result can be considered "converged".

Figure 3 demonstrates this variation of resistance for the first configuration case which was 12 knots and 3.5m water depth and a trim of 0.964 degrees which stabilizes after 1200 time-steps. The result in terms of Drag or Resistance is close to 128 kN with no allowances.

Figure 4 demonstrates the variation of resistance with time step number for the second case which was 12 knots and 5.5m water depth and no trim. It is seen that the Drag eventually stabilizes after 3000 timesteps. The result in terms of Drag is close to 168 kN with no allowances.

Figure 5 shows a typical wave pattern at 12 knots for a draught at 5.5m.

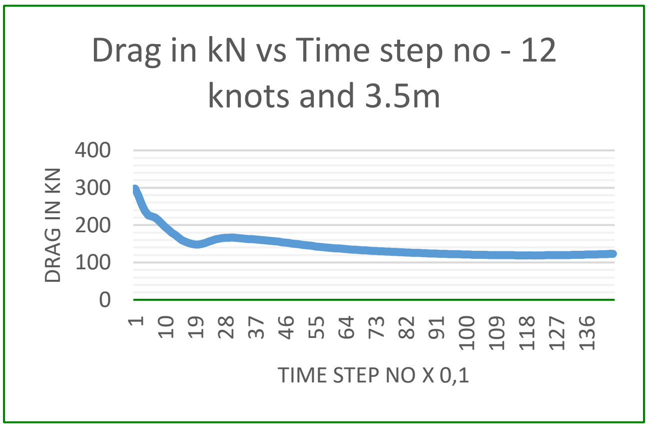


Figure 3 First configuration case with 12 knots and 3.5m water depth and a trim of 0.964 degrees.

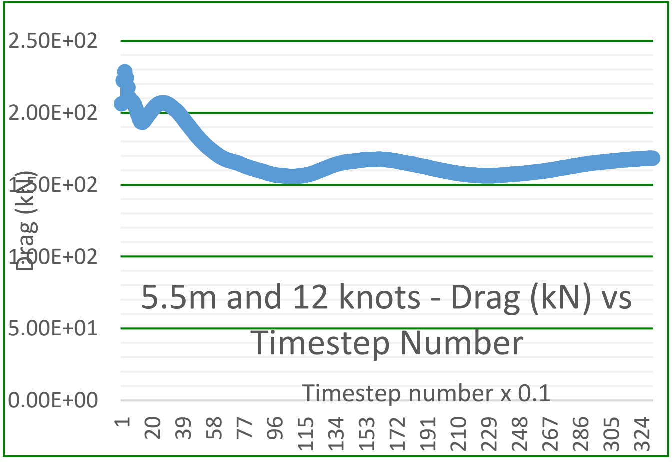


Figure 4 The second case with a speed of 12 knots and a draught of 5.5m with zero trim.

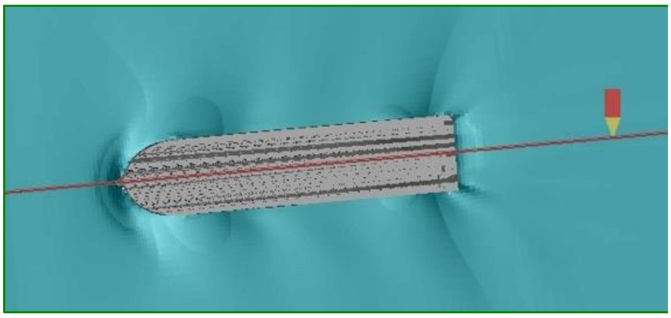
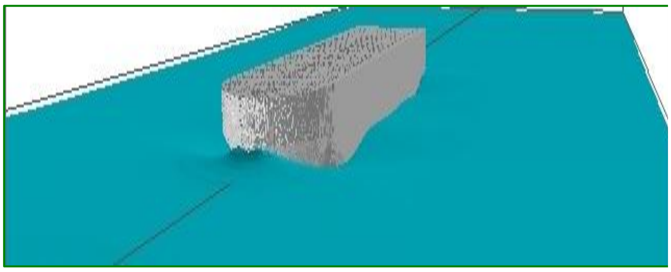


Figure 5 Wave pattern at 5.5m demonstrating large bow wave.



Summary

This article demonstrates some preliminary results using the Marine version of PHOENICS demonstrating full-scale CFD modelling. The results are very close to expected values for drag and resistance. The detailed results that are generated for boundary layer properties, local velocities and pressure, enable naval architects to make alterations to hull designs to reduce drag or improve sea keeping.

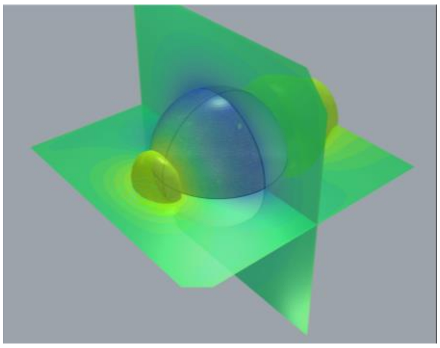
References

Kewei Song, Chunyu Guo, Cong Sun, Chao Wang, Jie Gong, Ping Li & Lianzhou Wang (2021) Simulation strategy of the full-scale ship resistance and propulsion performance, Engineering Applications of Computational Fluid Mechanics, 15:1, 1321-1342, DOI: 10.1080/19942060.2021.1974091

Visonneau, M. (2005). A step towards the numerical simulation of viscous flows around ships at full scale - Recent achievements within the European Union Project EFFORT. Royal Institute of Naval Architecture Marine CFD, Southampton, France.

Visonneau, M., Queutey, P., & Deng, G. B. (2006). Model and full-scale free surface viscous flows around fully-appended ships. ECCOMAS CFD 2006, Egmond aan Zee, Holland.

Flow Past a Sphere with RhinoCFD



RhinoCFD/Rhino Users may be interested in the tutorial on www.cham.co.uk advising how to calculate flow past a sphere.

The Pasquill-Profiles Classes in PHOENICS: John Ludwig, CHAM London, April 2023

Introduction

PHOENICS and PHOENICS-FLAIR are used extensively to model the atmospheric boundary layer (ABL) in wind-engineering applications, such as pollutant dispersion, urban wind-comfort studies, and optimization of wind-farm placement. For such studies, wind inlet profiles and associated boundary conditions can be specified automatically through use of the WIND object in the VR Menu, but only for neutral ambient conditions with a uniform temperature. In PHOENICS-2023, the WIND object has been extended to allow for stable and unstable atmospheric conditions by coding the widely-used Pasquill-stability classes [1,2] into Subroutine GXBLIN of PHOENICS. They define six atmospheric-stability classes labelled from A to F based on wind speed, sun insolation and cloud cover.

Wind speed (m/s)	Daytime Insolation			Night time conditions	
	Strong	Moderate	Slight	Thin overcast >= 4/8 low cloud	<=3/8 cloud
< 2	A	A-B	B	-	F
2-3	A-B	B	C	E	E
3-5	B	B-C	C	D	D
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

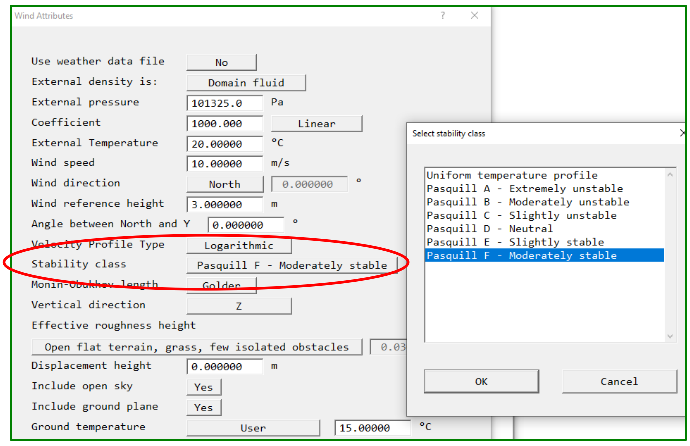
Table 1: Pasquill Stability Classes: A (very unstable), B (moderately unstable), C (slightly unstable), D (neutral), E (slightly stable), F (moderately stable)

For unstable classes, increased vertical mixing occurs because ground solar heating increases the near-surface air temperature, which decreases its density. Neutral class D occurs early morning or evening when this solar heating is negligible and wind speed dominates vertical mixing. For stable classes, solar heating is less than ground cooling, which usually occurs at night, and near-surface air density is increased, which means vertical mixing is suppressed. In modelling the dispersion of hazardous gases, stable conditions are used to represent worst-case scenarios due to reduced mixing and dilution of hazardous gases into the atmosphere. In particular, Class F defines a standard weather condition used in dispersion modelling of toxic substances for land-planning use in the UK and elsewhere.

Implementation in PHOENICS is generic in terms of gravitational and wind directions, and covers Pasquill stability classes A to F inclusive by use of the Monin-Obukhov Similarity Theory (MOST) [3, 4] for specification of boundary conditions. In this first release, no account is taken of MOST in the turbulence transport equations and wall functions, and no provision is made to solve for the energy equation in terms of potential temperature. These extensions will be in future releases.

Activation

The required Pasquill Stability class can be selected directly from the WIND object dialog:



Use weather data file No
External density is: Domain fluid
External pressure 101325.0 Pa
Coefficient 1000.000 Linear
External Temperature 20.00000 °C
Wind speed 10.00000 m/s
Wind direction North 0.000000 °
Wind reference height 3.000000 m
Angle between North and Y 0.000000 °
Velocity Profile Type Logarithmic
Stability class Pasquill F - Moderately stable
Monin-Obukhov length Golder
Vertical direction Z
Effective roughness height
Open flat terrain, grass, few isolated obstacles 0.03
Displacement height 0.000000 m
Include open sky Yes
Include ground plane Yes
Ground temperature User 15.00000 °C

Uniform temperature profile
Pasquill A - Extremely unstable
Pasquill B - Moderately unstable
Pasquill C - Slightly unstable
Pasquill D - Neutral
Pasquill E - Slightly stable
Pasquill F - Moderately stable

Figure 1 Selecting the Stability Class

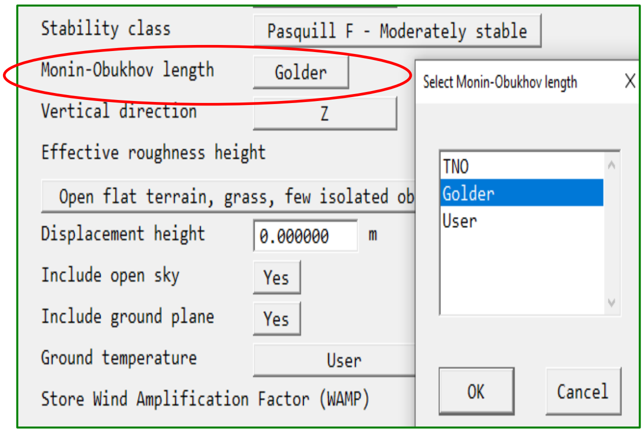
Default setting is for 'Uniform temperature profile'. For an isothermal case the Stability Class item does not appear.

Pasquill Classes and the Monin-Obukhov Length

The Monin-Obukhov (MO) length L is an estimation of height where turbulent buoyancy production is comparable with shear-stress production of turbulence. It can be estimated from measurements; it is positive for stable ABLs, negative for unstable BLs, and infinity for neutral BLs. In practice, the value of L is generally not known, and so must be estimated, for instance by using the most hazardous or dominant Pasquill stability class.

In PHOENICS, the MO length may be specified directly if the value is known. Otherwise, it is estimated automatically using the Pasquill stability classes by means of one of two alternative equations. The first uses the TNO formula given by Bosch [5]. The second allows estimation of the MO length from a power-law formula which can be derived from Golder's nomogram [6].

The selection of MO length only appears after a non-uniform temperature profile has been selected.



Stability class Pasquill F - Moderately stable
Monin-Obukhov length Golder
Vertical direction Z
Effective roughness height
Open flat terrain, grass, few isolated ob
Displacement height 0.000000 m
Include open sky Yes
Include ground plane Yes
Ground temperature User
Store Wind Amplification Factor (WAMP)

TNO
Golder
User

Figure 2 Selecting the Monin-Obukhov length

Concluding Remarks

PHOENICS now has the facility to use Pasquill stability in simulations of ABL's with stable and unstable stratification. This first release will be upgraded at a later stage to faciliitate:

- Density-difference cases, allow the inlet density to vary with height.
- A sky heat-flux boundary condition to compensate for the ground heat flux.
- Modified turbulence-transport equations and wall functions to account for MO theory.
- Option to solve for the energy equation in terms of the potential temperature.
- Provision for a logarithmic temperature profile under neutral conditions.

References

1) Pasquill, F, The Estimation of the Dispersion of Windborne Material. Meteorological Magazine 90: 33–49, (1961).
2) Pasquill, F & Smith, F.B, Atmospheric Dispersion, 3rd Edition, Ellis Horwood Ltd, (1983).
3) Monin, A.S & Obukhov, A.M, Basic laws of turbulent mixing in the surface layer of the atmosphere. Contrib. Geophys. Inst. Acad. Sci. USSR, pages 163–187, (1954).
4) Foken, T, 50 years of the Monin–Obukhov similarity theory. Boundary-Layer Meteorology, 119, 431–447, (2006).
5) Bosch, C. J. H. van den, Weterings, R. A. P. M. (Ed), 2005, Methods for the calculation of physical effects – due to releases of hazardous materials, CPR 14E. (TNO Yellow Book) 3rd edition, 2nd print, TNO, The Hague, The Netherlands, (2005).
6) Golder, D, Relations among stability parameters in the surface layer, Boundary-Layer Meteorology, 3, 47-58, (1972).

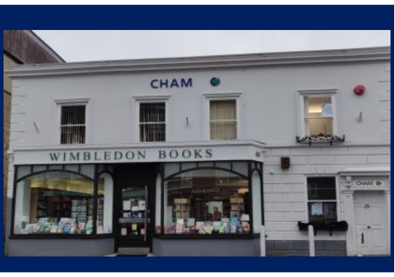
News:

Dipl.-ing Frank Zimmermann a long-term, and loyal, PHOENICS User worked on a project to make visiting concerts possible in Covid times by simulating the aerosol distribution in a concert hall with PHOENICS, FLAIR and GENTRA. This led to a publication in Nature Communications called "The risk of indoor sports and culture events for the transmission of Covid-19" of which he was a co-author. It was published online in August 2021 and can be accessed at https://www.nature.com/articles/s41467-021-25317-9ns.

News from CHAM:

PHOENICS-2023 is available early Autumn from CHAM and via the Cloud. Access our powerful CFD tool on a variety of virtual machines offered by Microsoft Azure. Call us on 020 8947 7651 to learn more.

CHAM's Wimbledon Head Office has had a bit of a facelift.



Contact Us:

CHAM's highly skilled, and helpful, technical team can assist in solving your CFD problems via proven, cost-effective, and reliable, CFD software solutions, training, technical support and consulting services. If YOU have a CFD problem why not get in touch to see how WE can help with the solution? Please call on +44 (20) 89477651, email sales@cham.co.uk or check our website www.cham.co.uk. For PHOENICS on the Cloud (PHOENICS-OTC) call us or contact phoenics.cloud@cham.co.uk

See us on social media sites shown below:

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