PHOENICS Newsletter

CHAM

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Winter 2021

Dear Reader

We at CHAM wish all Clients, Agents, and Friends made over the years a Happy, Healthy and Prosperous 2022.

We hope that those who celebrated it enjoyed the Christmas period and returned to work rested and relaxed.

We also hope this year moves forward in a more positive and less restrictive way than was the case throughout 2021 and most of 2020; and that governments worldwide find a way of dealing with ongoing variants of this virus which does not involve constantly closing down many aspects of life with the associated confusions and difficulties.

CHAM's offices in Wimbledon Village have remained open since August 2021 to facilitate essential technical, and other, discussions and interactions and so that our staff are able to be in personal contact in our professional working environment. We moved from a 2-day week in 2 separate teams to being open for the full week with appropriate health and safety measures in place so that Colleagues are fully protected.

PHOENICS was 40 last year. We marked the event on our website and with a Newsletter. In non-virus times we may have considered a PHOENICS User Day but it seemed a risky venture given the uncertainty of travel.

We are now moving in to year 40 + 1 and work has begun on PHOENICS-2022 which we hope to have available for distribution to new clients, and all fully maintained users, in the first half of the year. If you have any particular requests with regard to the next, or future, edition/s of PHOENICS please let us know. As for the release date - watch this space!

As always, we would be delighted to receive communications from you for inclusion in future Newsletters:

1. Commercial Users: please send technical articles regarding (non-commercially sensitive) use of PHOENICS.
2. Academic Users: please remember to send your annual report regarding PHOENICS Use in your institutions.
3. R&D Users: we would like to hear from you.
4. All Users: please send news items about presentations featuring PHOENICS, photographs, anything you feel may be of interest (in Word format if you would be so kind) to newsletter@cham.co.uk.

We are compiling a website Testimonials section. If you would like to contribute to this (which would be much appreciated) please email website@cham.co.uk.

We look forward to hearing from you and will continue to work to provide you with our consulting, technical, user support, and other, services.

Thank you.

Kind Regards and, again, a Happy New Year.

Colleen Spalding
Managing Director

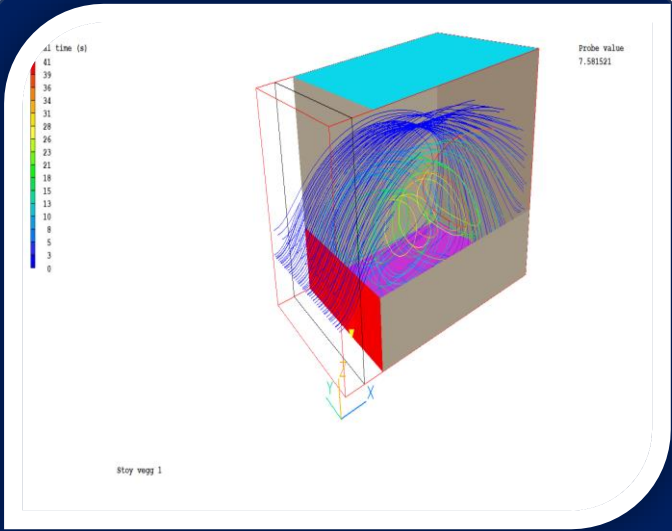
PHOENICS in the Arctic

By Arne Erik Holdø, Professor Emeritus, UIT, The Arctic University of Norway.

In recent years there has been a focus on development of the Arctic regions. Global weather change has made sea transport across the Arctic oceans possible for part of the year enabling shorter sea routes between the Far East and Europe. However, the Arctic is still a cold region and when work has to be carried out, care has to be taken that the exposure to low temperatures does not cause health problems for those carrying out work tasks in these regions.

In Norway, working conditions in the Arctic and other cold regions have to follow the guidelines of the Norwegian Standard NORSOK002. One particular issue that is of concern is so called Wind Chill. In order to comply with the standard, it is essential that the Wind Chill temperatures are calculated so that the working conditions and eventual schedules can be evaluated. Wind Chill is a function of heat loss. Heat loss can take the form of radiation, conduction and convection. For a person this is based on empirical data which give rise to empirical expressions primarily as function of wind speed; in other words the heat loss is considered mainly as a convective loss.

Consequently, this is the reason why mapping local wind velocities or speed values onboard ships or in other working areas is given considerable importance. The Wind Chill temperature is a function of ambient temperature and local wind speed and governs how, and for how long, people are able to perform work in Arctic Regions. PHOENICS has been used with success for determining local velocities and to make sure that work places are as well suited as possible for Arctic conditions.



Part of a simulation for determining wind conditions in a large enclosure where work is being carried out.

Predicting the wind speed here and in other areas will help to ensure that working conditions are suitable and that work can be scheduled in order to achieve completion on time. The allowable exposure to Wind Chill according to NORSOK002 has to be considered and the PHOENICS simulations are therefore of vital importance.

Energy Recovery from Steelmaking By-Product for Material Drying

By Reza Safavi Nick, Primary and Secondary Steelmaking Group, Process Metallurgy Department, Swerim AB, SE-974 37 Luleå, Sweden.

1. Introduction

1.1 Slag heat recovery

Energy recovery from hot liquid slag is one of the underused candidates to increase steel-production energy efficiency. In iron and steel production, slags are the main by-product with respect to mass (90 %). Molten slag forms at 1300 – 1700 °C, and when discharged it carries away a great deal of high-grade heat. The typical energy content of ferrous slags is around 1 to 2 GJ/t of slag at the tapping temperature and part of it is lost due to discharge of the hot slag. The discharged slag is processed either by granulating it directly from the process (a typical method for Blast-Furnace Slag (BFS)) or tapped to a slag pot and transported to the slag-handling area. The transported slag, then, is poured onto the slag dump area. It is important to emphasise that, currently, the energy of the dumped slag is mainly wasted.

1.2 RecHeat technology

RecHeat (Recovery of Heat from molten slag) technology innovation is based on the idea of "as simple as possible to use", heat-exchanger-type technology. Therefore, the apparatus is constructed of simple metal sheets to enhance the energy exchange through a semi-direct contact of slag with the heat-exchange structure surface. Furthermore, for safety, simplicity and practical reasons, air is used as an energy-transport medium instead of water, even though water has better thermal properties. In practice, the slag from the steel plant will be carried to the RecHeat using a slag truck. The slag truck then tilts the slag pot over the designated area of the RecHeat. With such an arrangement, the slag starts to radiate its energy though the surroundings, where the air will be sucked into the apparatus through two separate entrances while it simultaneously heats up the RecHeat structure.

The air at the exit of the RecHeat can then be used for drying purposes. This can be a large gain considering the energy for the drying medium covers 50 – 70 % of the operational costs of the drying process.

2. Geometry, Modelling and Model Set-up

The objective of the current study has been to design an optimum apparatus based on the heat-exchanger concept which can retrieve the energy of the slag using air as the medium for the purpose of drying.

Therefore, the focus of the modelling activity has been to predict the system efficiency by means of computational fluid dynamics (CFD). Such a system can be easily modelled using the Navier-Stokes and energy equations, without any further modification, by means of commercial CFD codes.

2.1 Geometry

Figure 1 shows the overall set-up of the RecHeat in practice. As can be seen, the RecHeat is formed of a heat-exchanger which is then connected to a collector. The heat-exchanger is formed of three layers which are stacked on top of each other; each layer consists of four metallic pallets with five channels each. Moreover, as can be seen in the figure, the outlet of the heat-exchanger is at the end of the collecting pipe (in the left-bottom corner of the figure) while the air is sucked in through the open ports at the other end (the right side of the figure) into the bottom channels.

Figure 1. Heat exchanger and the slag layer; side-, front-, back- and top-view of the apparatus from top to bottom.

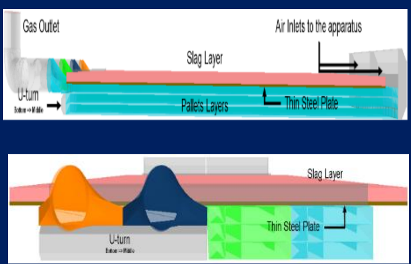
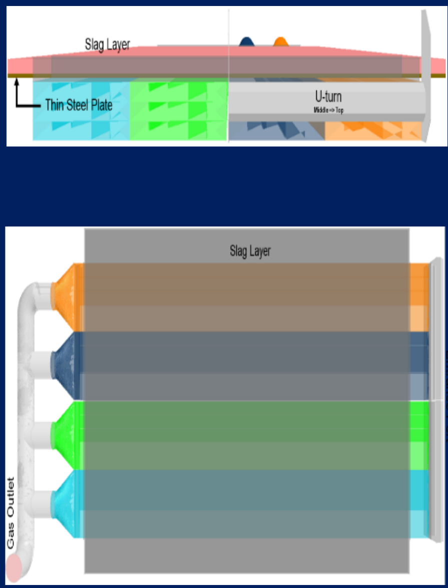


Figure 1 continued:



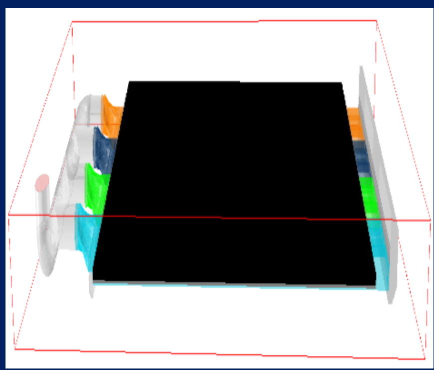


Figure 2 Calculation domain

With such a set-up, the structure of the apparatus heats up, extracting energy from the slag on top while the air entering the system contributes mainly to increase the temperature of the bottom layer at the beginning of the process.

2.2 Modelling Approach

The next logical question will be "what model set-up will more realistically represent the current arrangement". To answer this question, one should consider that the apparatus is designed to suck in the air from the surroundings, which will be affected by the radiative and convective heat during the slag-cooling process. Therefore, it is safe to say, the temperature of the air entering the system could naturally differ as the cooling of the slag progresses.

To be able more realistically to set-up the model, the commercial CFD code PHOENICS proved to be a suitable choice. In this application, the numerical domain always consists of a box shown with red lines in Figure 2. In this model set-up, the outer faces of the red box are treated as a pressure boundary with temperature fixed at the ambient temperature while the bottom face of the exterior is treated as a wall mimicking the ground. Hence, the cooling behaviour of the slag and the transient nature of the air entering the RecHeat could be modelled more realistically.

2.3 Initial and Boundary Conditions

The initial and boundary condition for such a model can be summarized as follows:

Table 1. Model Initial and Boundary Conditions.

	Object	Type	Magnitude	Unit
Boundary Condition	RecHeat Gas Out	Mass Flow Rate	2.5	Kg/s
	Top & Sides Faces	Pressure boundary	Ambient P and T	Pa & °C
	Bottom Face	Wall	Adiabatic	-
Initial Condition	Slag	Temperature	1300	°C
	Air	Temperature	Ambient T	°C

The air flow rate was set to 2.5 kg/s which is equivalent to the expected operational flow rate of the fan and the slag temperature was taken as the average temperature of the slag reaching the testing site. The thickness of the slag is also calculated with respect to the slag-pot volume.

3. Results

The modelling of the RecHeat can be divided into two distinct parts: the structure-heating stage and the heat-exchanging stage.

3.1. The Structure-Heating Stage

In a real process it can be expected that the apparatus temperature is at equilibrium with the surrounding environment.

Therefore, the objective of the first stage of the process is to increase the temperature of the structure to the maximum possible magnitude. By pouring the slag over the structure, the body of the apparatus absorbs the energy of the slag through conduction. Simultaneously, the radiative energy of the slag instantaneously heats up the surrounding air. The sucked-in heated air begins to exchange its energy with the body of the structure as it flows through the apparatus.

Table 2. Temperature magnitude of each pallet in each layer at two instances of the structure heating stage

Top-Layer				Middle-Layer				Bottom-Layer			
126.00	125.04	125.04	127.27	40.66	39.24	40.00	44.29	43.61	41.22	42.51	47.22
392.14	387.60	384.70	372.51	262.99	264.73	259.63	246.12	170.82	175.02	170.53	162.71

Table 2 shows the magnitude of the temperature of each pallet in three layers of the heat exchanger at two instances, the initial stage and the end of the steady-state. As expected, the top layer of the heat-exchanger registers the largest magnitude of the temperature while the middle-layer pallets are, at least, two degrees Celsius colder than the one in the bottom layer. This behaviour, then, reverses at the end of the first stage.

3.2. The Heat-Exchanging Stage

3.2.1. Air Flow Temperature Profile

Figures 3.1 and 3.2 show the temporal variation of the average air temperature at the entrance and exit of the heat-exchanger (HEx) section of the apparatus. As can be seen, the temperature of the air entering the heat-exchanger is still increasing in the magnitude. This corresponds to the energy pick-up from the slag radiation to the environment which continues at the beginning of the transient simulation. However, this behaviour starts to change and the magnitude of the temperature of the air entering the heat-exchanger starts to drop rapidly. On the other hand, at the exit ports of the heat exchanger, the magnitude of the temperature increases further until nearly half way through the simulation.

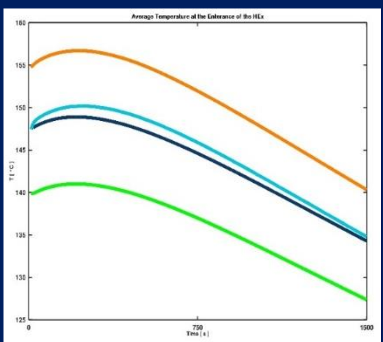


Figure 3.1 Average temperature at the entrance of the HEx

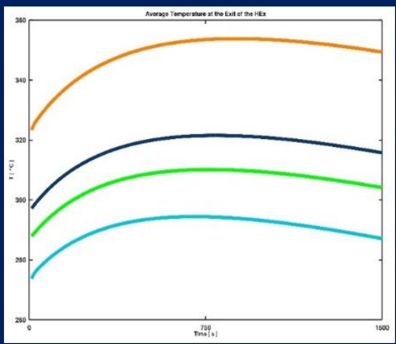


Figure 3.2 Average temperature at the exit of HEx

Figure 4 shows the air temperature at the outlet of the apparatus. As can be seen, the product temperature at the start of the transient period is equal to 328°C which peaks at 350°C and by the end of the simulation (at 1500s) drops to nearly 340°C. The peak occurs 650s into the transient process; at this point the curve reverses its direction.

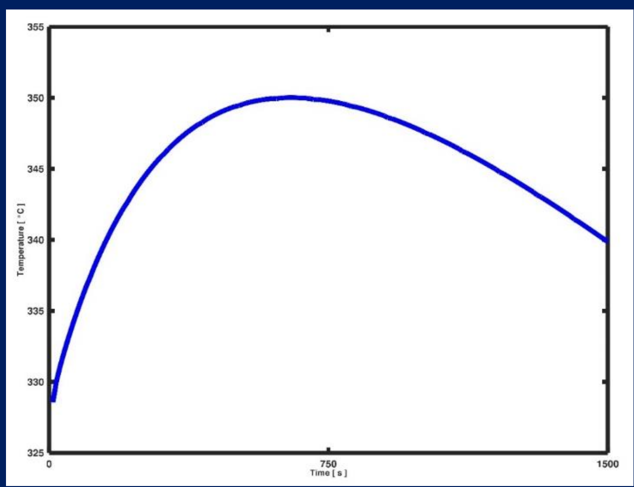


Figure 4 Temperature of the final product (air)

3.2.2. Streamlines and Air Profile

Figure 5 shows the evolution of the temperature of the medium through the heat-exchanger section of the RecHeat.

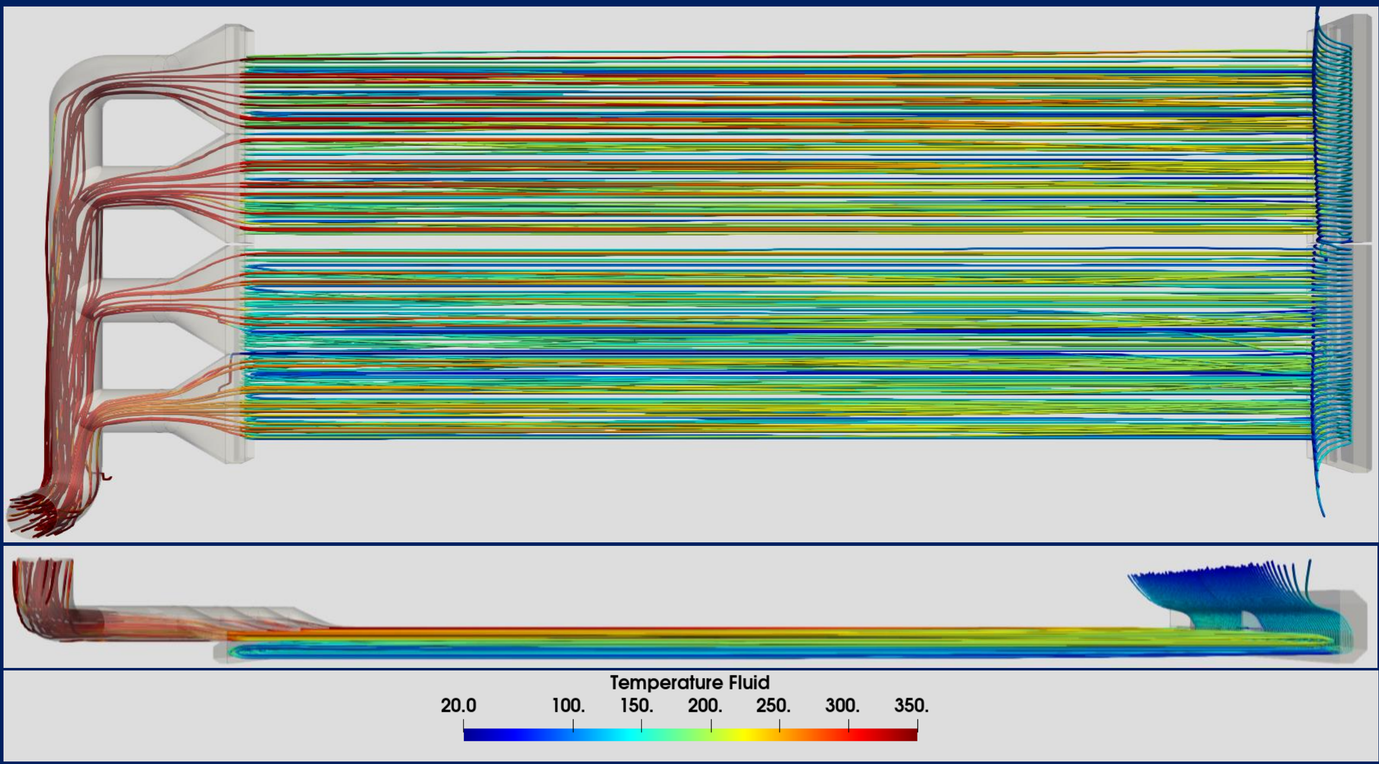


Figure 5 Air streamlines originated from a line across the entrance ports coloured by temperature

As can be seen, the source of the streamlines is chosen at above the entrance ports. Since the radiation effect has regressed, the medium entering the system is nearly at the ambient temperature.

Moreover, the figure shows that the air temperature at the bottom layer of the heat-exchanger section of the apparatus is still not higher than 150°C. This changes by the end of the middle layer. The figure shows that the air temperature reaches 200°C and more at this point; reaching the end of the heat-exchanger section, the temperature of the air is near exit temperature in three of the four sections. Generally, it can be seen that the air temperature of the upper two layers (top-view) is larger in magnitude than the lower two.

4. Conclusions

Two stages are identified during the heat recovery process i.e., the structure-heating and the heat-exchanger stages. In the former stage, the body of the apparatus increases its temperature magnitude while in the latter one, the magnitude of the temperature of the sucked-in air increases passing through each layer of the heat-exchanger section. The model shows that the temperature of layers of the heat-exchanger section of the apparatus is around 170, 250 and 380°C at the end of the structure-heating stage while the average air temperature at the entrance of the heat-exchanger section is less than 150°C.

The temperature magnitudes of the pallets change their slope when the system enters the heat-exchanger stage. This is because the air entering the system starts to absorb the energy deposited into the structures. It was shown that the temperature of the fluid medium changes from [125, 140] degrees of Celsius interval to [260, 340] from one end of the heat-exchanger section to the other at the end of the simulation.

The outlet temperature at the end of the simulation is calculated to be around 340°C which shows at least 200 degrees increase in the temperature of the air entering the apparatus.

References:

The current article is a shortened version of the article: Safavi Nick, R.; Leinonen, V.; Mäyrä, J.; Björkvall, J. Towards Greener Industry: Modelling of Slag Heat Recovery. Metals **2021**, 11, 1144. https://doi.org/10.3390/met11071144

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Acknowledgments: The authors would like to acknowledge and thank Anita Wedholm of SSAB Merox and the Slag-handling staff of SSAB Luleå.

JOB TITLE: Consultancy Engineer with Business-Generation Experience

JOB LEVEL: Intermediate (Over 5 years' commercial experience)

LOCATION: Wimbledon, London, England (www.cham.co.uk)

Position Description

CHAM is seeking an Engineer to join its Wimbledon-based team. The successful candidate will need a strong knowledge of, and interest in, CFD and experience of using this skill within a commercial environment, interacting with colleagues and with clients. Applicants need to possess the legal right to work in the UK. The main task will be outward facing and proactive with regard to generating, and undertaking, Consultancy projects for clients whose needs are many and varied. The work will be carried out using PHOENICS (the original, commercial, CFD software) and other CHAM products. The successful candidate will work with CHAM colleagues on Business Development to attract consultancy projects. They will also interact with those in charge of Product Development, User Support, and Marketing, thus being exposed to, and potentially involved in, a broad range of technical, and client-facing, activities.

Main Tasks:

1) Working to obtain, and carry out, consultancy projects for Clients, worldwide, using PHOENICS.
2) Interacting with clients regarding project completion, writing final reports supporting results obtained, filing all reports and associated modelling on the CHAM system for easy retrieval and reference, and keeping track of time taken and hours charged.
3) Interacting with technical staff at CHAM who have extensive experience of PHOENICS and can assist in arriving at the optimum way to carry out consultancy projects.
4) Documenting all aspects of work undertaken to a high literary, and visual, standard.
5) Performing all tasks to a commercially acceptable level and within prescribed time frames.
6) Interacting with Marketing colleagues to provide materials for use on the Website, in Newsletters, etc.

Necessary Qualifications:

1) Knowledge of, and experience with the wider field of Computational Fluid Dynamics (CFD).
2) Meaningful experience and knowledge of CFD software. Knowledge of PHOENICS would be ideal but, if not, other mainstream CFD-Code experience is essential.
3) Previous experience carrying out CFD Consultancy projects within a commercial environment and with a team of Engineers.
4) Good BSc (minimum) or MSc in Computational Fluid Dynamics, Mechanical, Aeronautical, or other related, Engineering field.
5) Flexibility, proactivity and resourcefulness, plus excellent analytical and problem-solving skills.
6) Ability to perform multiple tasks, to prioritise and record work, and to keep senior staff informed.
7) Excellent communication skills (verbally and written) including experience with Word and Excel and the ability to create reports to a professional standard. 8) Ability to work in a small, collaborative, team environment.

Desirable Skills:

1) Knowledge of PHOENICS and Fortran or other mainstream CFD codes including writing user modules.
2) Experience with Project Management Software and the ability to work within their structure. CHAM offers a competitive salary and benefits to the successful candidate. Applicants(who need to be legally allowed to work in the UK) are invited to send a cover letter and current CV outlining their qualifications for the position to hr@cham.co.uk with the subject heading "Consultancy Engineer Application – (Your Name)".

CHAM accepts direct applications only and does not process submissions via Agencies.

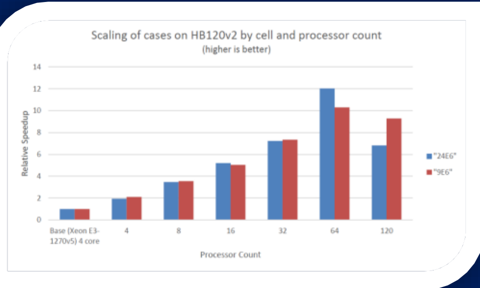
PHOENICS is on the Cloud!

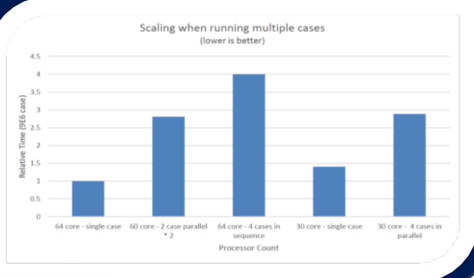
One way in which PHOENICS celebrated its 40th Birthday was to become available on the Cloud via the Microsoft Azure Marketplace.

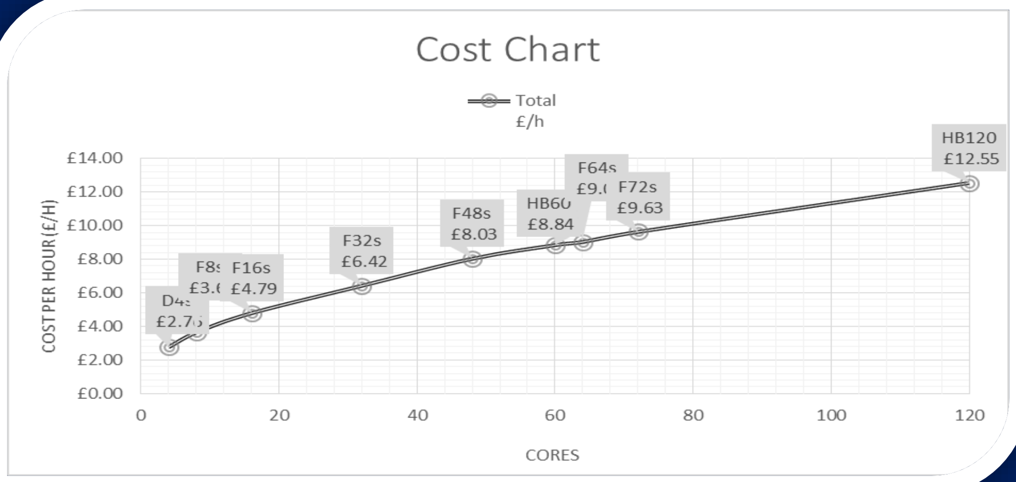
PHOENICS On The Cloud is designed as a fast, cost-effective facility for customers who wish to make short-term or project-based use of PHOENICS without the need to download software or make the up-front financial commitment associated with a formal licence. It is also available to existing customers as an extra resource to supplement their in-house copies; for example, to undertake especially large-scale simulations whilst benefitting from the multi-core, parallel-processing facilities offered by the Microsoft Azure Marketplace.

Why not see if it works for you? CHAM has produced the following link to help you get started: [PHOENICS on the Cloud (cham.co.uk)]

Information below gives data on running speed, costs, etc. The graph on the top right shows scaling achieved for two sample cases of 9 million computational cells and 24 million cells respectively when run on a variety of multi-processor systems. That on the bottom right shows similar benefits that can be achieved when running multiple cases simultaneously on a 120-core VM.







Whilst a 120-core VM can provide quick results for a single case, running two cases concurrently using (say) 60-cores each, or 4-cases using 30 cores each, achieves cost savings of >25%. So, although the cost-per-hour is notionally higher when using larger multi-core VMs, they can be particularly cost-effective for running multiple variations of simulation (e.g. for investigating multiple-wind conditions over a cityscape.)

Contact Us

CHAM provides software solutions, training, technical support and consulting services. Contact: Sales@cham.co.uk. For issues relating to PHOENICS Azure services contact: phoenics.cloud@cham.co.uk or call +44 (0)20 8947 7651.

Should you require any further information regarding our offered products or services please give us a call on +44 (20) 89477651. Alternatively you can email us on sales@cham.co.uk.

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