

Abstracts book

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[1] ***The Effect of The Temperature Gradient on The Thermocapillary Droplet Flow in a Vibrating Fluid Inside a Rotating Cylinder***

Yousuf Alhendal (College of Technological Studies (CTS), Public Authority for Applied Education and Training (PAAET), Kuwait), Sara Touzani (Mechanical Materials and Structures, and Industrial Processes Modeling, Mohammed V University in Rabat, Morocco) and Fatimah Alqallaf (Independent researcher).

*Abstract*

Using a computational fluid dynamics (CFD) approach, the thermocapillary isolated droplet process rising in a vibrating liquid in a rotating 3D cylinder in zero gravity environment was analyzed and numerically presented. The two-phase flow tracking technique, known as volume-fluid (VOF) method, has proven to be an effective means of examining the interaction between liquids. It has been discovered that temperature gradients can have a substantial impact on the motion of thermocapillary bubbles or droplets. In this case, the droplet is driven from the cold region to the hot region by the Marangoni effect brought on by the temperature difference.

[3] ***A NOVEL MULTISCALE THERMAL METHODOLOGY FOR APPLICATION IN AEROSPACE TRANSMISSION SYSTEMS***

James Layton (Univeristy of Nottingham), Benjamin Rothwell (Univeristy of Nottingham), Stephen Ambrose (Univeristy of Nottingham), Humberto Medina (Univeristy of Nottingham) and Carol Eastwick (Univeristy of Nottingham).

*Abstract*

Environmental targets for reducing emissions in the aerospace industry require the development of more efficient engines which impose a greater thermal load on the transmission system. Accurately accounting for heat sources in the system, such as hydrodynamic lubrication regimes, are essential for the design of effective thermal management. This paper develops a framework which integrates the Reynolds methodology for hydrodynamic lubrication with CFD, describing the coupling methodology and verified on two-dimensional journal bearing case at various operating parameters.

[4] ***Steady-state Modelling of Heat Exchangers for Refrigeration Applications***

Giovanni Roberti (Università di Bologna - DIN -Department of Industrial Engineering), Michael Giovannini (Università di Bologna - DIN -Department of Industrial Engineering), Luca Molinaroli (Department of Energy, Politecnico di Milano) and Marco Lorenzini (Università di Bologna - DIN -Department of Industrial Engineering).

*Abstract*

This work deals with the steady state modelling of counterflow brazed plate heat exchangers for refrigeration applications. The main challenges of the stationary approach are the definition and tuning of the iterative algorithm required for the non linear system of equations. The model is experimentally validated, and a variable step size gradient descend algorithm is evaluated to reduce the number of iterations carried out. Some tuning parameters are defined in the framework of an optimization procedure to enhance the accuracy of the model.

[5] ***INVESTIGATION ON HEAT TRANSFER CHARACTERISTICS OF LOCAL HOT SPOT ON THE HIGH-POWER ELECTRONIC CHIP SURFACE***

Zongguo Xue (Chongqing University), Yunfei Yan (Chongqing University), Chenghua Zhang (Chongqing University) and Jinxiang You (Chongqing University).

*Abstract*

The heat dissipation of local hot spot with high heat flux is always a serious challenge, which will seriously threaten the service life and operation efficiency of high-performance electronic devices. In this work, we proposed that utilize the conceptual design of local variable density for micro-jet heat sink to achieve accurate and effective cooling of local hot spot areas. The hybrid of the local variable density design of jet nozzle and the micro pin fin arrays can significantly improve cooling performance of the local hot spot region. The research results show that the novel design can solve the heat dissipation of 700 W/cm2, the design concept exhibits excellent cooling characteristics in both thermal and hydraulic performance.

[6] ***SINGLE-PHASE PRESSURE DROP AND HEAT TRANSFER IN MICRO-PIN FIN HEAT EXCHANGERS***

Ali H. Zaidi (Brunel University London), Mohamed Mahmoud (Zagazig University), Atanas Ivanov (Brunel University London) and Tassos Karayiannis (Brunel University London).

*Abstract*

Single-phase flow of HFE-7100 in a micro-pin fin heat sink was investigated and the results described in this paper. Both adiabatic and diabatic experiments were carried out at a system pressure of 1 bar, inlet fluid temperature of 19 ⁰C and Reynolds number ranging from 86 to 850. Different existing correlations of friction factor and Nusselt number were evaluated and assessed. A good agreement between the present results and some correlations was found.

[7] ***LOW-PRANDTL NUMBER HEAT TRANSFER FLUIDS IN PACKED-BED HEAT STORAGE***

Eike Alexander Schmidt (Karlsruhe Institute of Technology), Margaux Zehnder (Karlsruhe Institute of Technology), Frank Fellmoser (Karlsruhe Institute of Technology) and Klarissa Niedermeier (Karlsruhe Institute of Technology).

*Abstract*

In this contribution, low-Prandtl number fluids are investigated for the use as heat transfer fluid in packed-bed heat storage systems. At the Karlsruhe Liquid Metal Laboratory (KALLA), liquid metals, mostly heavy metals such as lead-bismuth or tin, are used. They are excellent heat transfer fluids and are used in concentrating solar power plants or in nuclear power plants, where high heat loads are supposed to quickly and efficiently be cooled. Above that, KALLA is looking into using liquid metals as heat transfer fluids in packed-bed heat storage systems, making use of their excellent heat transport capabilities and the wide liquid phase temperature range. This work highlights the ongoing work with regard to experimental demonstration of the technology and related fundamental heat transfer investigations.

[8] ***Effect of Partial Heating on Natural Convection in a Cubical Cavity with an Internal Obstacle: A URANS Study***

Constantinos Katsamis (EDF Energy R&D UK), Timothy Craft (The University of Manchester), Hector Iacovides (The University of Manchester) and Dean Wilson (The University of Manchester).

*Abstract*

The performance of advanced RANS turbulence models using different near-wall treatments is assessed in the computation of a natural convection flow occurring in a cubic cavity with a partially heated inner obstacle. The flow field has a Rayleigh number of 1.4× 10^9 at which recent experimental data have been published. The time dependent 3D computations apply eddy-viscosity (k-ε,k-ω based) and advanced Reynolds stress transport models (EB-RSM). The predictions returned from a recently developed variant of the analytical wall function combined with either high-Re or low-Re k-ε formulation are assessed. The low-Re k-ε AWF combination leads to substantial predictive improvements of the Nusselt number levels on the active walls despite the coarse grid resolution adopted.

[9] ***A NOVEL FEED-FORWARD NEURAL NETWORK FOR FLOW BOILING PATTERN PREDICTION***

Joseph Widgington (Brunel University London), Fang Wang (Brunel University London), Atanas Ivanov (Brunel University London) and Tassos Karayiannis (Brunel University London).

*Abstract*

Microscale flow boiling presents a promising solution to emerging cooling requirements in many applications. Predicting flow boiling patterns could play a key role in the development of new engineering design tools for predicting heat transfer rates and pressure drops. A novel feed-forward neural network architecture was developed to classify flow boiling patterns in the microscale, in which each transition boundary was considered with its own Forward Neural Network within the overall architecture. The network was then compared to new flow boiling pattern data using HFE-7100 for heat fluxes and mass fluxes between 3.2-132.4 kW/m² and 100-1000 kg/m²s, respectively.

[10] ***A NUMERICAL STUDY OF THE IMPACT OF BEND CURVATURES TO FLOW PATTERNS IN NATURAL CONVECTION LOOPS***

Milan Mihajlovic (The University of Manchester).

*Abstract*

Natural convection loops are used in passive heat exchange systems in many applications, such as nuclear reactor cooling and photovoltaic cells. The fluid flow patterns observed in loops exhibit complex nature in certain geometric configurations even for moderate values of the Rayleigh number. We report the results obtained from 2D unsteady laminar numerical simulations on the impact of bend curvatures on fluid flow patterns in convective loops with the horizontal heater and horizontal cooler (HHHC) configuration

[12] ***CONDENSATION ON A VERTICAL PLATE WITH SINUSOIDAL MICROFINS – FURTHER CONSIDERATIONS***

John Rose (Queen Mary University of London) and Lei Chai (Brunel University London).

*Abstract*

Recently-published experimental data for condensation of nitrogen on a vertical plate with sinusoidal fins and a subsequent analytical approach showed that, in the ranges of the data, the heat transfer coefficient increased as both pitch and height of the fins decreased. While the analytical result agreed well with the data, the resulting equation indicated that the heat transfer increased indefinitely as the pitch approached zero, as did a correlation given in the experimental paper. The present work addresses this deficiency and provides a result which may be used to determine optimum fin pitch and height.

[13] ***MORPHOLOGICAL TRANSITIONS IN FROZEN COLLOIDAL DROPLETS***

Prasenjit Kabi (UNIVERSITY COLLEGE LONDON), Simrandeep Bahal (UNIVERSITY COLLEGE LONDON), Mohammed Alabdullatif (UNIVERSITY COLLEGE LONDON), Jianhui Zhang (University College London) and Manish K. Tiwari (UNIVERSITY COLLEGE LONDON).

*Abstract*

The use of thermal gradients to self-assemble colloidal particles into ordered structures, also known as ice templating, is well understood. Freezing colloidal droplets leads to complex shapes which is of both scientific and technological significance. While frozen pure water droplets show a sharp tip at their apex, colloidal droplets show a flat top morphology. Preliminary experiments with colloidal suspensions of alumina show an array of morphological features, based on initial particle concentration. The present work attempts a parametric investigation with implications in droplet based ice templating.

[15] ***Dynamic Analysis of Adsorption Heat Transformation: A Dimensionless Model Approach for Comparative Evaluation of Sorption Bed Designs***

Amir Zivariravan (Department of Mechanical Engineering, KU Leuven, 3000, Leuven, Belgium), Giulio Santori (School of Engineering, The University of Edinburgh, Edinburgh EH9 3FB, United Kingdom) and Alessia Arteconi (Department of Mechanical Engineering, KU Leuven, 3000, Leuven, Belgium).

*Abstract*

This research has concentrated on examining the dynamic behaviour of the adsorption process through numerical techniques. It explores a distinctive approach that facilitates a comparative analysis across diverse sorption bed designs, such as diverse heat exchangers with varying geometric characteristics and different arrangements of sorptive material. By a dimensionless lumped parameter model, the research not only offers computational efficiency but also provides a versatile framework for comparing sorption bed designs under different operating conditions.

[16] ***HEAT TRANSFER MODELLING OF GRANULAR FLOW IN POROUS MEDIA***

Seohee Jang (University of Manchester), Shirin Golkaram (University of Manchester) and Yasser Mahmoudi (University of Manchester).

*Abstract*

This study employs discrete element modelling to investigate the heat transfer phenomena within granular flow across various porous shape scenarios. The result showed that spline with staggered shape exhibited highest maximum and average temperature with longer duration compared to other porous shape scenarios. In addition, the agglomeration of solid particles in the interstitial region of porous structure was predicted in all scenarios. This study underscores the potential for optimising porous structures to enhance the heat transfer in granular flow systems.

[17] ***QUALIFICATION AND TESTING OF MATERIALS AND COMPONENTS FOR APPLICATIONS IN FUSION***

Marius Wirtz (Forschungszentrum Jülich), Daniel Dorow-Gerspach (Forschungszentrum Jülich), Mauricio Gago (Forschungszentrum Jülich) and Gerald Pintsuk (Forschungszentrum Juelich).

*Abstract*

The extremely harsh environment in future fusion reactors puts strong demands on the selection of materials and actively cooled in-vessel components in view of operational and economic requirements. Up to now, materials research in the field of thermonuclear fusion has been done primarily in laboratories and in test facilities that have focused on individual effects only, such as thermal fatigue, thermal shocks during transient events, plasma exposure, and neutron irradiation tests. Today, emphasis is also laid on synergistic effects such as high thermal loads under plasma exposure or the combination of thermal and neutron wall loads. This paper will give an overview of the work done in this field at Forschungszentrum Jülich during the last years.

[18] ***Study on heterogeneous condensing flow characteristics in turbine cascade***

Yuying Yan (University of Nottingham) and Pengfei Hu (University of Nottingham).

*Abstract*

Particles in wet steam induce heterogeneous condensation. This study investigates how changes in particle concentration and size affect the flow characteristics of heterogeneous condensation. The results show that increasing particle concentration leads to higher thermodynamic losses and outlet humidity at the turbine blade. Conversely, decreasing particle size reverses these effects. Notably, at a particle concentration of 1×1016m-3 and a size of 1×10-9m, thermodynamic losses decrease by 15%, and humidity by 6%, compared to homogeneous condensation.

[19] ***IMPROVED PERFORMANCE OF DROPLET-BASED ELECTRICITY GENERATORS USING SPECIALLY SHAPED SUBSTRATES***

Huachen Su (University of Nottingham) and Yuying Yan (University of Nottingham).

*Abstract*

As an emerging technology, droplet-based electricity generators (DEGs) have been continuously developed in recent years and has been investigated in areas such as increasing the voltage generated by a single droplet, integration with different systems, etc [1]. The aim of this study is to investigate the potential of DEG for generating frequency. In this work, conical DEGs are investigated to explore their effect on the performance of DEGs. The experiments used three different angles of conical copper plate as substrates, in addition to a group of flat substrates as a control group. The use of conical DEGs requires little in the way of droplet size and height compared to schemes that use superhydrophobic surfaces to increase frequency.

[20] ***INVESTIGATING COLLOIDAL STABILITY OF NANO-ENHANCED PHASE CHANGE MATERIAL UNDER THERMAL CYCLING***

Mohammed Alabdullatif (Nanoengineered Systems Laboratory, Department of Mechanical Engineering, University College London (UCL)), Prasenjit Kabi (Nanoengineered Systems Laboratory, Department of Mechanical Engineering, University College London (UCL)), Priya Mandal (Nanoengineered Systems Laboratory, Department of Mechanical Engineering, University College London (UCL)), Stavroula Balabani (FluME, Department of Mechanical Engineering, University College London (UCL)) and Manish Tiwari (Nanoengineered Systems Laboratory, Department of Mechanical Engineering, University College London (UCL)).

*Abstract*

We investigate the role of rationally selected surfactant and nanoparticle surface treatment on the stability of a Al2O3/Eicosane nanosuspension as a phase change material. The resulting better dispersion of Al2O3 led to superior stability of the nanosuspension under multiple heating/freezing cycles, and suggesting excellent thermophysical properties. The nanosuspension with functionalized nanoparticles and sodium dodecylbenzene sulfonate (SDBS), as a surfactant showed better stability compared with pristine Al2O3. The present work provides a route to enhance the performance of nanosuspensions as phase change materials (PCMs) for thermal management.

[21] ***FUNCTIONALIZED COVALENT ORGANIC FRAMEWORKS FOR ICE NUCLEATION INHIBITION***

Simrandeep Bahal (1. Nanoengineered Systems Laboratory, UCL Mechanical Engineering, University College London, London, WC1E 7JE, UK), Vikramjeet Singh (3. Manufacturing Futures Lab, UCL Mechanical Engineering, University College London, London, E20 2AE, UK) and Manish K. Tiwari (1. Nanoengineered Systems Laboratory, UCL Mechanical Engineering, University College London, London, WC1E 7JE, UK).

*Abstract*

Development of passive icephobic surfaces are highly desirable due to their energy, economic and safety implications in various sectors such as aircrafts, wind turbines, power lines and infrastructure. Among few, inhibiting ice nucleation is one of the most primitive strategy in designing effective icephobic surfaces. In this work, we show that surface-grown covalent organic frameworks (COFs) with pore size approx. 1.8 nm can effectively inhibit the nucleation of ice due to nanoconfinement effect. The effectiveness in delaying ice nucleation is further enhanced by post-functionalisation with flexible alkyl chains. It is observed that the flexibility and molecular chain length can also affect the ice nucleation on such surface and this work can help in advancing the design for practical solution against undesirable icing on surfaces.

[22] ***EFFECT OF VISCOSITY ON VOID FRACTION OF A GAS-LIQUID FLOW IN VERTICAL PIPE***

Keziah Magit (Faculty of Engineering, University of Nottingham, University Park, NG7 2RD, UK), Buddhika Hewakandandamby (Faculty of Engineering, University of Nottingham, University Park, NG7 2RD, UK), David Hann (Faculty of Engineering, University of Nottingham, University Park, NG7 2RD, UK) and Wigdan Kisha (Faculty of Engineering, University of Nottingham, University Park, NG7 2RD, UK).

*Abstract*

The determination of various multiphase flow parameters, such as heat transfer coefficient and pressure gradient, is significantly influenced by void fraction. A comprehensive understanding of void fraction behaviour, coupled with precise prediction, is crucial for designing efficient equipment that can lead to increased production rates in the petroleum industry. Given the prevalence of higher viscous liquids in the petroleum sector, this study focuses on investigating void fraction in vertical pipes using gas-liquid mixtures with a viscosity range of 4.8-234 mPa·s. The research explores the impact of superficial gas velocity and liquid viscosity. The results showed a good agreement between the predicted and experimental data

[23] ***Numerical Modelling of Condensation Phenomena for Subcooled Flow Boiling Applications***

Jakub Cranmer (University of Manchester), Giovanni Giustini (University of Manchester), Alex Skillen (University of Manchester) and Ryan Tunstall (Rolls-Royce).

*Abstract*

A methodology is presented for the investigation of the hydrodynamic and heat transfer effects of subcooled flow boiling phenomena. We employ interface capturing simulation with mechanistic calculation of the local rate of phase change. The numerical accuracy of the methodology is demonstrated for the modelling of condensation, by considering the case of heat-controlled collapse of a spherical vapour bubble surrounded by subcooled water. Our results demonstrate excellent agreement with the analytical solution.

[24] ***ADVANCEMENTS IN EXPERIMENTAL INFRASTRUCTURE FOR LEAD FAST REACTOR RESEARCH: THE VLF AND PHRF FACILITIES***

Giorgio Khalil Youssef (Ansaldo Nucleare, Universita' Sapienza di Roma), Rossella Bonetti (Ansaldo Nuclear), Michele Frignani (Ansaldo Nucleare), Marco Caramello (Ansaldo Nucleare), J. Liao (Westinghouse), C. Stansbury (Westinghouse), G. Macpherson (Frazer-Nash) and R. Watkins (Frazer-Nash).

*Abstract*

This paper presents the development and operation of experimental infrastructure at Ansaldo Nuclear, dedicated to advancing research in lead fast reactor (LFR) technology. The infrastructure comprises two key facilities: the Versatile Lead Loop Facility (VLF) and the Passive Heat Removal Facility (PHRF). This paper discusses the conceptualization, design, and operational aspects of these facilities, highlighting their significance in advancing the understanding and development of advanced reactor technologies, particularly LFRs

[25] ***Investigating RANS Predictions for Heat and Mass Transfer in Turbulent Flow Across a Backward-Facing Step***

Khalid Alraddadi (Thermo-Fluids Research Group, School of Engineering, The University of Manchester, Oxford Road, M13 9PL Manchester, UK), Abdelmagid Ali (Thermo-Fluids Research Group, School of Engineering, The University of Manchester, Oxford Road, M13 9PL Manchester, UK), Hector Iacovides (Thermo-Fluids Research Group, School of Engineering, The University of Manchester, Oxford Road, M13 9PL Manchester, UK) and Dominique Laurence (Thermo-Fluids Research Group, School of Engineering, The University of Manchester, Oxford Road, M13 9PL Manchester, UK).

*Abstract*

As part of a flow accelerated corrosion project, a qualitative validation of 4 RANS models for mass and heat transfer coefficients (Sherwood and Nusselt numbers) is conducted, by reference to a recent experiment (Re\_H=16-24,000, Pr = 0.707, Sc = 2.28). The friction coefficient and velocity profiles, missing in the mass transfer study, are compared with data from DNS and experimental studies at higher and lower Re values.

[26] ***A COUPLED MOLECULAR-CONTINUUM FRAMEWORK FOR MULTISCALE SIMULATIONS OF BOILING***

Mirco Magnini (University of Nottingham), Edward Smith (Brunel University London), Gabriele Gennari (University of Nottingham) and Gavin Pringle (EPCC, University of Edinburgh).

*Abstract*

Boiling is a perfect example of a multiscale process where molecular-level physics giving rise to bubble nucleation interact with larger-scale boundary layers determined by the outer system boundary conditions. We present a novel multiscale simulation method which merges Molecular Dynamics (MD) and Computational Fluid Dynamics (CFD) descriptions into a single modelling framework, where MD resolves the near-wall region where molecular interactions are important, and a CFD solver resolves the bulk flow. We model the progressive heating of a Lennard-Jones fluid via contact with a solid wall until a vapour bubble nucleates in the MD region of the domain and grows by entering in the CFD domain. Our results show that an incompressible CFD flow model based on the Volume Of Fluid (VOF) method with interphase mass transfer calculated via the Hertz-Knudsen-Schrage equation is sufficient to obtain seamless coupling of phase fraction, velocity and temperature fields, with the hybrid MD-CFD framework yielding bubble dynamics closely matching those of MD alone.

[27] ***THE APPLICATION OF PHASE CHANGE MATERIALS IN FOOD PRESERVATION USING INDIRECT TYPE SOLAR DRYER (ITSD)***

Lucong Han (University of Nottingham) and Yuying Yan (University of Nottingham).

*Abstract*

Traditional food storage methods often lead to problems such as energy waste and the inability to maintain food quality over the long term. Phase change materials (PCM) have the advantages of high energy storage density, energy saving, and environmental protection. This article provides a recent overview on the use of PCMs in indirect solar drying. This study details the working principles, materials, equipment, and main findings of ITSD. Paraffin wax became the most prevalent PCM, and PCM demonstrated a remarkable ability to significantly extend drying duration.

[28] ***THERMAL MANAGEMENT CHALLENGES OF LI-ION BATTERY PACKS USING PARTIAL IMMERSION COOLING: ANALYZING PRESSURE DROP AND TEMPERATURE DISTRIBUTION***

Pouyan Talebizadehsardari (Faculty of Engineering, University of Nottingham), Alasdair Cairns (Faculty of Engineering, University of Nottingham), Antonino La Rocca (Faculty of Engineering, University of Nottingham), Surojit Sen (Faculty of Engineering, University of Nottingham) and Andrea Pacino (Faculty of Engineering, University of Nottingham, Nottingham, U.K.).

*Abstract*

In this study, a partial immersion cooling system is used for cooling a battery pack equipped with cylindrical Li-ion batteries considering various flow rates of the coolant. The partial immersion method is used to reduce the total weight of the battery pack and thus increase the power density. A tiny gap of 2 mm is considered between the cells to have a high cell density. Both pressure drop and temperature distribution are evaluated to find the optimum conditions of the cells. Different flow rates of the coolant as well as heat generation rates of the cells are evaluated to achieve the temperature target with the lowest pressure drop. The results show that during fast charging (15 kW), considering the coolant flow rate of 21.5 lpm, the average temperature of 33°C can be achieved in the battery pack while the hot spot temperature is 51°C. While for the heat generation rate of 3kW, the average temperature of 33.8°C can be achieved using the flow rate of 2.15 lpm.

[29] ***Direct numerical simulations of forced and mixed convection flows in a reactor vessel auxiliary cooling system (RVACS)***

Jundi He (The University of Sheffield), Shuisheng He (The University of Sheffield), Graham Macpherson (Frazer-Nash Consultancy), Dillon Shaver (Argonne National Laboratory) and Elia Merzari (The Pennsylvania State University).

*Abstract*

Direct numerical simulations (DNS) of forced and mixed convection flows in a simplified geometry representing the reactor vessel auxiliary cooling system (RVACS) have been conducted utilising the open-source solver Nek5000. The RVACS is a key facility for heat removal in the 4th generation design reactors and it is of importance for its design and optimisation to inspect and understand the flow and heat transfer physics within the facility. Several interesting phenomena have been identified: (i) heat transfer and turbulence are both enhanced in the downward (buoyancy-opposing) and upward (buoyancy-aiding) sections; (ii) Buoyancy-induced recirculation is established in the bottom cavity in the mixed convection case and turbulence is locally enhanced; (iii) The influence of buoyancy on the turbulence in the first (upper) flow separation is relatively small in comparison to the second (lower) one. In addition to the detailed study of flow physics, the DNS dataset is also used as reference data for a RANS CFD benchmark exercise organised by the Collaborative Computational Project in Nuclear Thermal Hydraulics (CCP NTH: https://ccpnth.ac.uk/).

[30] ***DNS of Magnetohydrodynamic Rayleigh-Bénard Convection with Applications in Fusion Thermal Hydraulics***

Jake Ineson (University of Manchester), Alex Skillen (University of Manchester) and Aleksander Dubas (UKAEA).

*Abstract*

Direct numerical simulation of incompressible, inductionless magnetohydrodynamic Rayleigh-Bénard convection is conducted for Rayleigh numbers up to 10^6, a Prandtl number of 1 and for a range of Hartmann numbers in the interval 0<Ha<64. First- and second- order statistics are collected for the velocity, temperature and electrical current, forming a high-resolution DNS database. The resolution of these results is ensured post-simulation by comparing the mesh-spacing and time-step with Kolmogorov length- and time- scales respectively. The Nusselt number is computed as a function of the Hartmann number, quantifying the heat transfer performance of this flow. A negative trend is observed between the Nusselt and Hartmann numbers.

[31] ***FULLY-RESOLVED INTERFACE CAPTURING SIMULATIONS OF SINGLE BUBBLE GROWTH AND MICROLAYER FORMATION ON AN ISOTHERMAL SUPERHEATED SURFACE IN POOL BOILING CONDITIONS***

Borja Diaz-Guardamino (The University of Manchester), Giovanni Giustini (The University of Manchester) and Hector Iacovides (The University of Manchester).

*Abstract*

This paper delves into the intricate dynamics of bubble microlayers by conducting fully-resolved simulations of single-bubble growth phenomena in pool boiling conditions using OpenFOAM. A comprehensive parametric analysis is presented, exploring the influences of fluid superheat, solid surface wettability (quantified by the contact angle of a specific fluid-surface combination), and the impact of superheat of the solid surface during bubble growth.

[32] ***URANS STUDY OF THERMAL TRANSIENTS IN A T-JUNCTION PIPE***

Minto Kavyan (University of Manchester), Hector Iacovides (University of Manchester), Alex Skillen (University of Manchester) and Andrea Cioncolini (Guangdong Technion-Israel Institute of Technology).

*Abstract*

High cycle thermal fatigue (HCTF) induced cracking in the turbulent thermal mixing areas of T-junction piping systems is a vital safety concern in the nuclear power plants. We present a URANS study (with conjugate heat transfer) of hot thermal transients (linear ramp over a short period, for different Froude numbers 0.4 to 0.9, at the branch pipe inlet) through a T-junction configuration (working fluid is water), having constant ratio of mass flow rate (main / branch, 5:1). The analysis indicates that small Froude number transients lead to potential risk of thermal fatigue. Additionally, complex physical phenomena in these flows are also explored.

[33] ***Conjugate Heat Transfer Analysis of Floating Photovoltaic Panels with Hybrid Natural Convection Cooling Loops and Solar Filter***

Bayu Sutanto (Thermo-Fluids Group, School of Engineering, University of Manchester), Hector Iacovides (Thermo-Fluids Group, School of Engineering, University of Manchester), Adel Nasser (Thermo-Fluids Group, School of Engineering, University of Manchester), Andrea Cioncolini (Department of Mechanical Engineering (Robotics), Guangdong Technion – Israel Institute of Technology) and Imran Afgan (Department of Mechanical and Nuclear Engineering, Khalifa University).

*Abstract*

Floating photovoltaic panels have several advantages such as using the open water surface instead of large land areas. Exploiting the water body as a heat sink to cool the panels offers an additional advantage, leading to increased efficiency. This study focuses on the development of a numerical model for a hybrid system that combines a natural convection cooling loop with a solar filter feature. This added feature decreases the temperature of photovoltaic cells and optimises the spectral distribution of the incoming solar radiation. A conjugate heat transfer analysis shows that the cooling system is highly effective in dissipating heat and maximising the electrical output of floating photovoltaic panels. The study also optimises the thickness of the cooling channel to assess the effectiveness of nanofluids.

[34] ***POLYMER MATERIALS IN PULSATING HEAT PIPES: CHALLENGES AND OPPORTUNITIES***

Volfango Bertola (University of Liverpool).

*Abstract*

The present work discusses the use of polymer materials in the fabrication of two-phase passive thermal management systems such as pulsating heat pipes, with an analysis of their limitations and technical challenges. Although heat transfer systems are usually built with metals due to their excellent thermal properties, there is an increasing interest in replacing metallic materials with polymers and composites that can offer cost-effectiveness, light weight and high mechanical flexibility. On the other hand, polymer materials suffer from poor thermal conductivity, poor wettability, viscoelasticity, selective permeability to moisture and incondensable gases, as well as ageing.

[35] ***Modelling Sprays of Liquids into Gases and Vapours***

Amy Jardine (University of Manchester), Hector Iacovides (University of Manchester) and Tim Craft (University of Manchester).

*Abstract*

This paper presents comparisons of Computational Fluid Dynamics (CFD) techniques for modelling the flow, heat and mass transfer of pressuriser sprays. Experimental data obtained in a pressuriser test-rig facility at the University of Manchester has been used to validate a range of Eulerian, multiphase modelling techniques with a focus on establishing methods for modelling sprays in an industrial context. The two fluid method was found to recreate the unique shape of sprays driven through a plain orifice with cross wires when applied to a RANS or LES approach, showing promise in the modelling of sprays in the nuclear industry.

[36] ***Development of a Coarse-grid Methodology for Heat Transfer Calculations in Prismatic HTGR Fuel Assemblies***

Bo Liu (Science and Technology Facilities Council), Charles Moulinec (Science and Technology Facilities Council) and Stefano Rolfo (Science and Technology Facilities Council).

*Abstract*

This paper presents a coarse-grid Computational Fluid Dynamics approach, initially developed for light-water reactors and now extended to prismatic High-Temperature Gas-cooled Reactor fuel assemblies. This method, known as Subchannel CFD, combines the strengths of traditional subchannel codes and CFD. It offers CFD-like 3-D predictions at a substantially reduced computational cost, potentially allowing for cost-effective simulations at the reactor core scale.

[37] ***DYNAMIC MODELLING OF LATENT HEAT THERMAL ENERGY STORAGE UNITS BASED ON PLATE-TYPE HEAT EXCHANGERS***

Hector Bastida (School of Chemical Engineering, University of Birmingham) and Adriano Sciacovelli (School of Chemical Engineering, University of Birmingham).

*Abstract*

To effectively analyse the interaction of thermal energy storage units within complex energy systems, accurate yet simplified models are essential. Although three-dimensional models offer accurate simulation results, these demand significant computational resources. Following this line, a low-order, one-dimensional dynamic model for latent heat thermal store is presented. The store unit is based on plate-type heat exchangers to facilitate heat exchange between the heat transfer fluid and the phase change material.

[38] ***MATERIAL-LEVEL EXPERIMENTAL EVALUATION OF SOIL-BASED THERMAL ENERGY STORAGE FOR SOLAR-POWERED ADSORPTION REFRIGERATION SYSTEM***

Ehsan Baniasadi (Aston University), Yetenayet Bekele Tola (Jimma University), Ahmed Rezk (Aston university), Abed Alaswad (Aston university) and Muhammad Imran (Aston university).

*Abstract*

Integration of concentrating solar collectors with thermal energy storage systems, can enhance the performance of solar thermal adsorption refrigeration systems. In this research, soils sourced from the central rift valley of Ethiopia were investigated for thermal energy storage. Therefore, emphasis was on heat capacity and thermal diffusivity to assess thermal storage capacity and charging/discharging agility. The study analyses soil samples from representative locations (Koka, Bote, and Meki) and examines their thermophysical attributes across varying grain sizes. The results reveal associations between porosity, heat capacity, and thermal diffusivity, providing valuable insights for energy-efficient systems. The specific heat capacity ranges from 0.86 to 1.44 J/g°C, while thermal diffusivity varies between 0.38 and 0.54 mm²/s. These findings contribute to sustainable energy practices and inform soil-based thermal management strategies. It is observed that utilising soil as a low-cost sensible heat storage and integrating it with solar thermal collectors and photovoltaic panels to power adsorption refrigeration system, high solar fractions can be achieved. Soil appears to be a technically viable heat storage medium, facilitating extended operating periods and efficient early starts of the system.

[41] ***CONJUGATE HEAT TRANSFER ANALYSIS OF A POUCH CELL LI-ION BATTERY PACK USING MINI CHANNEL COLD PLATES WITH A U-SHAPED CONFIGURATION***

Pouyan Talebizadehsardari (Faculty of Engineering, University of Nottingham), Alasdair Cairns (Faculty of Engineering, University of Nottingham), Antonino La Rocca (University of Nottingham) and Surojit Sen (Faculty of Engineering, University of Nottingham).

*Abstract*

In this study, a cold plate with U-shaped channels is investigated to cool the adjacent pouch cell Li-ion batteries. The U-shaped cold plate consists of two parallel sets of channels with seventeen mini channels to cover the whole surface area of the batteries. The thermal management system is evaluated based on the maximum and uniformity of the surface temperature of the batteries. The uniformity of the fluid flow distribution inside the mini channels is also investigated to reach a uniform temperature distribution on the surface of the batteries. The important geometrical features of the U-shaped channels are studied toward a higher performance of the system. The cold plates are designed based on the electrical requirements for placing the bus bar as well as the safety of the battery pack operation. The material of the cold plate is peek which can tolerate the expansion of the pouch cell batteries during charging. Due to the low thermal conductivity of peek material, the thickness of the cold plate is considered as small as possible. The results show that for the flow rate of 1 LPM and flow inlet temperature of 25 °C and the heat input of 16 W (8 W for each side) for the batteries, the average and maximum surface temperature of the batteries are achieved at 28°C and 30°C, respectively, showing the acceptance of the employed U-shaped cold plate. A uniform temperature distribution is achieved across the surface of the battery except the centreline. By increasing the heat generation to 32 W, the average and maximum temperatures raise to 31 °C and 35 °C, respectively, which are still in the acceptable range.

[42] ***TOWARDS THE IMPLEMENTATION OF LOOP HEAT PIPES IN AUTOMOTIVE BATTERY THERMAL MANAGEMENT SYSTEMS***

Marco Bernagozzi (University of Brighton), Anastasios Georgoulas (University of Brighton), Nicolas Miché (University of Brighton) and Marco Marengo (University of Pavia).

*Abstract*

This paper presents the results of a series of investigations aimed to aid the implementation of a battery thermal management system for electric vehicles based on loop heat pipes. The LHPs can passively transfer heat from the battery pack to a remote chiller, without consuming parasitic power. Experiments demonstrate that the proposed solution can enable fast 3C charging and maintain satisfactory battery temperatures from -20°C to 50°C ambient. Compared to passive air cooling, the system reduces peak temperatures during fast charging by 7.9°C and more than doubles battery lifetime. The results highlight the potential of passive two-phase heat transfer for automotive thermal management.

[43] ***VALIDATION OF UNSTEADY RANS AGAINST LES CALCULATIONS FOR PREDICTING NATURAL CIRCULATION STALL PHENOMENA WITHIN A TEST FACILITY LOOP***

Deacon Marshall (Rolls-Royce), Heather Davies (Rolls-Royce), Joseph Hegarty (Rolls-Royce), Sophie Brown (Rolls-Royce), Ryan Tunstall (Rolls-Royce) and Alex Skillen (University of Manchester).

*Abstract*

Unsteady Reynolds-Averaged Navier-Stokes (URANS) computations have been validated against analogous Large Eddy Simulation (LES) benchmark cases concerning a Natural Circulation (NC) loop. Simulations were run to achieve a statistically steady state before transient events were introduced to the loop flow. Both cold flow injection with varying mass flow rates, and zero heater power transients were considered. For the first injection case, presented within this abstract, both models observed a decrease in mass flow and temperature within the loop, with recovery occurring shortly after the injection was stopped. The URANS data exhibits a temperature offset at both the heater and cooler outlets, approximately 2.5% below the LES throughout the transient. The mass flow comparison also demonstrates how the URANS results follow the general flow behaviour of the LES, indicating URANS is capable of predicting whether the perturbation will stall the loop.

[44] ***NUMERICAL INVESTIGATION OF THE MAINLY AXIAL FLOW IN MIXED CONVECTION REGIME WITHIN TUBE BUNDLES***

Rodrigo Vicente Cruz (Curiosity Team, Pprime Institute, CNRS – Univ. Poitiers – ISAE/Ensma), Cedric Flageul (Curiosity Team, Pprime Institute, CNRS – Univ. Poitiers – ISAE/Ensma), Eric Lamballais (Curiosity Team, Pprime Institute, CNRS – Univ. Poitiers – ISAE/Ensma), Vladimir Duffal (EDF R&D, Fluid Mechanics, Energy and Environment), Erwan Le Coupanec (EDF R&D, Fluid Mechanics, Energy and Environment) and Sofiane Benhamadouche (EDF R&D, Fluid Mechanics, Energy and Environment).

*Abstract*

Wall-resolved Large-Eddy Simulation (WRLES) is carried-out to investigate the turbulent mixed convection in the upward flow within tube bundles, a configuration representative of a real scenario in a nuclear reactor. A database of first and second-order turbulence statistics is set-up. Interesting physical phenomena triggered by the buoyancy forces in the spatially developing flow are also highlighted.

[46] ***Application of PCM in External Walls of Typical Residential Buildings in the UK and Their Impact on Building Energy Consumption***

Yue Zhang (University of Nottingham) and Siddig Omer (University of Nottingham).

*Abstract*

This paper examines Phase Change Materials (PCM) in UK residential buildings to improve energy efficiency, focusing on a detached house in Nottingham. It assesses three PCM types on external walls'inside andoutside, considering energy consumption impacts. The research uniquely simulates different housing forms—detached, semi-detached, and flats. By adjusting external wall boundary conditions to mirror varied thermal environments. It explores how these conditions affect heat dissipation in each building type. The research shows that the application of PCMs to the inner and outer walls of the building can effectively reduce the heat loss of the building and thus reduce the building energy consumption. PCM RT24 HC has the best performance among the three selected PCMS. In addition, for detached building, Semi-detached building and Flat, adding PCM to the outer wall of the building has the best effect, which can achieve 11.66%, 8.97% and 12.13% of building energy consumption reduction, respectively.

[47] ***A Simple Transient Approach to Measuring Thermal Contact Conductance at Low Contact Pressures***

Matt Lenahan (University of Oxford), Andrew Owen (University of Oxford) and David Gillespie (University of Oxford).

*Abstract*

Limited data exists for thermal contact conductance h\_c between surfaces which may contact lightly, such as differential thermal expansion at sealing faces. This paper describes a transient experimental technique to measure h\_c between rough surfaces contacting at low pressures, allowing data to be gathered quickly and effectively using standard apparatus. It produces comparable results to the bulk steady-state method several orders of magnitude faster, whilst being simple to implement, both physically and computationally. Overall measurement uncertainty is estimated in the range 0.40%-6.88% for h\_c = 100-100,000 W m-2 K-1.

[49] ***Analytical model and comparative fluid analysis tool for screen and sinter wick heat pipes***

Thomas Werner (Newcastle University), Volker Pickert (Newcastle University) and Yuying Yan (University of Nottingham).

*Abstract*

Heat pipes have grown to become a pivotal technology in the development of high-level thermal management systems. Their functionality relies on the two-phase circulation of an active fluid within a hermetically sealed metal envelope. An internal porous structure is used to pump the liquid condensate back to the evaporator via capillary action. To predict their maximum thermal load capacity at a given temperature, many numerical models have been postulated and experimentally tested over the past five decades. Until now, however, there is no freely available tool utilizing these developed models to aid in wider design, application and research of heat pipes beyond very basic sales tools. In this paper, a fully parametric analysis tool to predict the performance of both sintered and mesh heat pipes is presented. Its target use is aimed at aiding both the commercial design and manufacture of heat pipes as well as more fundamental research and development, creating a versatile modelling tool for rapid parametric analysis. Additionally, its user interface is aimed to be simple enough to be accessible to engineers who have not previously worked with heat pipes but may be considering them for new commercial applications. The program has the ability to estimate the optimal wall thickness, wick thickness and fill volume for a given heat pipe outer diameter to aid in their design and manufacture.

[50] ***THERMAL HYDRAULIC SAFETY CONSIDERATIONS, METHODS AND RESEARCH FOR HIGH-TEMPREATURE GAS-COOLED REACTORS (HTGRs)***

Xiaoxue Huang (The University of Sheffield) and Shuisheng He (The University of Sheffield).

*Abstract*

A literature review is conducted on the approaches that High Temperature Gas-Cooled Reactor (HTGR) vendors, designers and R&D engineers have used to justify their safety features or claims. Sources of information include the open literature, including, published journal papers, conference proceedings, technical reports, and Phenomena Identification and Ranking Tables (PIRTs) available and general websites. This report focuses on the thermal fluid aspects, with brief discussion of neutronic behaviours, of HTGRs and aims to provide information and guidance for vendors on their design and licensing efforts as well as researchers for future endeavours. The scope includes identification of the important phenomena, and a summary of the current understanding and prediction capabilities of the phenomena. The report also includes recommendations for further developments in modelling/prediction approaches for HTGRs.

[52] ***EVAPORATION IN THIN WATER FILM UNDER REDUCED PRESSURE CONDITIONS: HEAT AND MASS TRANSFER CHARACTERISTICS***

Sarvjeet Singh (Indian Institute of Technology, Jodhpur), Hardik Kothadia (Indian Institute of Technology, Jodhpur) and Prodyut Chakraborty (Indian Institute of Technology, Jodhpur).

*Abstract*

The leakage in the nuclear reactor containment due to fracture/thermal stratification can cause the leakage of high-pressure fluid into the low-pressure environment. This results in the high pressure drop and phase change from liquid to vapour. This physical phenomenon is called flash evaporation; to avoid any accidental mishap, it is important to study it. This work investigates the thermodynamic phenomena of liquid film flash evaporation through an experimental inquiry. Results suggested that significant water vaporization occurs during the initial stage of the flashing, which results in a large temperature drop. The large superheat value makes the process more violent and increases the flashing intensity

[53] ***Heat Transfer simulation in encapsulated phase change materials for high-temperature energy storage application***

Han Wang (The university of Manchester), Yasser Mahmoudi Larimi (The university of Manchester) and Mohammad Jadidi (The university of Manchester).

*Abstract*

Encapsulated Phase Change Materials (EPCM) offer a promising solution to the escalating demand for sustainable energy storage solutions. However, challenges persist in ensuring the structural integrity of EPCM during operational cycles, particularly regarding thermal distribution and the accumulation of localized stresses. This study presents an innovative simulation model based on Large Eddy Simulation (LES) to address these challenges. By integrating advanced thermodynamic principles into the OpenFOAM platform, a hybrid solver is developed, allowing for a comprehensive analysis of EPCM behaviors. Preliminary results highlight stress hotspots in conventional EPCM designs, providing insights for design optimizations aimed at enhancing structural resilience. These findings contribute to the broader objective of advancing EPCM technologies for efficient and reliable energy storage applications.

[54] ***EFFECT OF ASPECT RATIO ON NATURAL CONVECTION HEAT TRANSFER INSIDE ENCLOSURE WITH NANOFLUIDS USING TWO-PHASE EULERIAN-EULERIAN MODEL***

Leelasagar Koneti (Indian Institute of Technology Hyderabad) and Venkatasubbaiah K (Indian Institute of Technology Hyderabad).

*Abstract*

In the present work, Numerical investigation is performed to analyse the influence of the aspect ratio of a rectangular enclosure on flow and heat transfer with Cu-H2O as a nanofluid using the Eulerian-Eulerian model. The enclosure considered is differentially heated, with top and bottom walls insulated. The aspect ratios (AR=H/W) of the enclosure considered in this study are 0.5, 1.0 and 2.0. All the governing equations are discretised with the help of finite difference methods. The flow and heat transfer study is conducted at three different aspect ratios for various Grashof numbers (Gr =1000 to 1000000) and nanoparticle volume fractions (Фs=1% to 3%). The enhancement in heat transfer performance is observed as the aspect ratio increased from 0.5 to 2.0 at a specific Grashof number. The heat transfer augmentation is also observed by increasing the Grashof number and volume fraction at a particular aspect ratio.

[55] ***Novel Composite Adsorbents to Enhance Heat and Mass Transfer in Adsorption Cooling and Desalination Systems***

Handsome Banda (Aston University), Ehsan Baniasadi (Aston University) and Ahmed Rezk (Aston university).

*Abstract*

Graphene nanoplatelets (GNPs) with high thermal diffusivity have demonstrated the ability to enhance the thermal characteristics of adsorbents, while ionic liquids (ILs) with hydrophilic properties have exhibited notable sorption and thermal attributes. This research endeavours to explore a novel composite adsorbent incorporating a combination of few-layered GNP and IL variants, specifically ethyl-methylimidazolium methane sulfonate (EMIMCH3SO3) and ethyl-methylimidazolium chloride (EMIMCl), along with the binder polyvinyl alcohol (PVA) to create composites denoted as GP-CL-30 and GP-CH3SO3-30, CP1 to CP9, each containing 30% IL content. These composites are to be compared against the benchmark adsorbent silica gel. The premise is that by leveraging the superior thermal properties of GNP and the stability and solvation characteristics of ILs, the water production and cooling efficiency in adsorption-based cooling and desalination processes can be enhanced. Initial findings have shown a substantial enhancement in thermal diffusivity of the composites by 167%, which is 76 times higher than that of silica gel, along with increased water uptake of 0.9648 kg/kg compared to 0.3534 kg/kg for silica gel.

[57] ***Multi-Objective Optimization of the Thermal Management of Electric Vehicle Using Cold Plate Technology***

Ahmed Mahmood (University of Leeds), Raihan Muhammad F.B. (University of Leeds), Timothy Cockerill (University of Leeds), Greg DeBoer (University of Leeds), Harvey Thompson (University of Leeds) and Jochen Voss (University of Leeds).

*Abstract*

Effective thermal management systems are essential for extending the lifespan and enhancing overall performance of the Lithium Ion (Li-Ion) battery packs used in electric vehicles (EVs). Accordingly, a novel Computational Fluid Dynamics (CFD)-enabled multi-objective optimization (MOO) approach for thermal management of Li-Ion battery modules using cold plates is proposed. This is used to optimize successfully the mini-channel cold plates’ geometrical parameters in terms of the key performance metrics: battery maximum temperature (Tmax), temperature standard deviation (Tσ) and pumping power (Pp).

[58] ***Navigating the challenges: Optimizing fired heaters with air preheaters***

Edward Ishiyama (HTRI), David Oakley (HTRI), James Kennedy (HTRI), Simon Pugh (HTRI) and Hans Zettler (HTRI).

*Abstract*

Incorporating air preheaters (APHs) into refinery heaters boosts furnace efficiency but introduces notable challenges such as the need for additional space, the risk of corrosion and leakage due to flue gas acid dew points, changes in adiabatic flame temperature, higher NOx emissions, and modifications in radiant section heat flux which can impact the operation run length. Through a case study, we highlight these issues and emphasize the importance of adopting a comprehensive approach to modernizing refinery heaters, balancing efficiency gains with the mitigation of potential challenges.

[59] ***STUDY OF NATURAL CONVECTION OVER VERTICAL AND INCLINED FIN ARRAYS***

Abdulrahman Almuwailhi (The University of Manchester), Adel Nasser (The University of Manchester), Hector Iacovides (The University of Manchester) and Ahmed Alamoudi (The University of Manchester).

*Abstract*

Rectangular fins play a crucial role in many cooling applications, particularly in the realm of electronics, mechanical, and solar applications. This study focuses on the conjugate heat transfer analysis of natural convection over arrays of parallel fins attached to either vertical or inclined heated surfaces. This arrangement is relevant to the passive cooling of PV cells. The objective is to first validate the numerical method using experimental data for vertical arrays and then to apply the resulting methodology to the investigation of the effect of the angle of inclination.

[61] ***ANALYSIS OF HEAT EXCHANGER MODELS UNDER DRY, WET, AND FROST CONDITIONS FOR THE EVAPORATORS OF HEAT PUMPS***

Özer Bağcı (Netherlands Organisation for Applied Scientific Research (TNO)), Richard Kemp (Netherlands Organisation for Applied Scientific Research (TNO)) and Andries van Wijhe (Netherlands Organisation for Applied Scientific Research (TNO)).

*Abstract*

This study presents an analysis of an evaporator model of an air-to-water heat pump under dry, wet, and frost conditions, with more focus on dry and wet conditions in terms of validation. ε-NTU method and Colburn-j factor were used for closure to avoid iterations. The roughly estimated fin and tube external temperature was used to opt for external phases. In the case of condensation, latent heat was used as additional source, and in the case of frost, frost layer was used as a feature causing thermal resistance and local loss to pressure. Despite some underprediction, the model provides valuable candidacy for use in a heat pump system model in dynamic conditions.

[62] ***EXPERIMENTAL ANALYSIS OF FILM HOLE WALL HEAT TRANSFER ‎USING TRANSIENT LIQUID CRYSTALS***

Abdallah Ahmed (Fluids and Thermal Engineering research group, Faculty of Engineering, The University of Nottingham), Edward Wright (Fluids and Thermal Engineering research group, Faculty of Engineering, The University of Nottingham) and Yuying Yan (Fluids and Thermal Engineering research group, Faculty of Engineering, The University of Nottingham).

*Abstract*

Film cooling plays a crucial role in creating effective cooling systems for gas turbine blades, which are ‎necessary to meet thermal protection standards to achieve high thermal efficiency. This study was ‎conducted to experimentally evaluate detailed heat transfer coefficients within a representative ‎geometry, provide contours of internal surface Nusselt number, and circumferentially average Nusselt ‎number along the entry length of the channels. The Transient Liquid Crystal technique has been ‎implemented to study the heat transfer distributions over the wall of the film hole. The test section ‎representing the film cooling hole was a cylindrical channel and it had a length of 5 jet diameters. The ‎experimental tests have been conducted at a wide range of Reynolds numbers (30,000–60,000), inclination ‎angle (0o -135o ) and rotation angle (0o -135o ). The effect of channel entry configuration was also varied ‎between sharp, filleted, and chamfered. Results showed that the sharpness of the nozzle was directly ‎related to the magnitude of the entry length separation and reattachment heat transfer enhancement. ‎When the inclination angle was introduced, it was discovered that there was a reduction of the reattachment ‎heat transfer enhancement, but an overall increase in heat transfer could be achieved, with most ‎enhancement shown for an inclination angle of 45°. While varying the rotation angle illustrated that the most ‎significant impact was within one diameter in length from the channel entry, with overall reductions in ‎heat transfer when varied by more than 90°.‎

[65] ***Pressurized CO2 activation of waste jute stick for enhanced CO2 capture applications***

Md Amirul Islam (Kyushu University), Tahmid Hasan Rupam (University of Missouri-Columbia) and Bidyut Saha (Kyushu University).

*Abstract*

Activated carbon could be used for CO2 capture, although its effectiveness depends on several factors including pore structure, surface area, and the presence of certain functional groups. In this study, several activated carbons were synthesized from waste biomass (jute stick) by utilizing CO2 with a novel pressure varying method. Remarkably, elevated CO2 pressures during the activation process resulted in increased activation yields and improved porosity in the synthesized activated carbons. Additionally, these activated carbons exhibit exceptional CO2 adsorption capacities, rendering them viable candidates for utilization in the major CO2 emission sources, notably industrial exhaust streams.

[67] ***THE ROLE OF BUBBLE DYNAMICS IN THE ENHANCEMENT OF FALLING FILM REFRIGERANT BOILING***

Bradley Bock (University of Pretoria), Josua Meyer (Stellenbosch University) and John Thome (JJ Cooling).

*Abstract*

The nature of the heat transfer enhancement seen in the boiling of thin falling liquid films is still a matter of some debate. This paper is a preliminary experimental investigation into the role bubble dynamics play, focusing on the bubble departure diameters and bubble growth after departure while sliding in the falling films. The bubble departure diameter did appear to be materially affected by the falling film conditions in comparison to pool boiling, while the bubble sliding growth was less clear.

[68] ***Multi-objective robust operation-optimization of gas turbine system installed in industrial combined cycle gas power plant***

Waqar Muhammad Ashraf (Department of Chemical Engineering, University College London, Torrington Place, London, UK), Muhammad Ahmad Jamil (Mechanical & Construction Engineering Department, Northumbria University, Newcastle Upon Tyne, NE1 8ST, UK), Syed Muhammad Arafat (Department of Mechanical Engineering, The University of Lahore, Lahore 54000, Pakistan), Akhtar Muhammad (Department of Mechanical Engineering, UET, Lahore, Pakistan), Ghulam Moeen Uddin (Department of Mechanical Engineering, UET, Lahore, Pakistan), Muhammad Wakil Shahzad (Mechanical & Construction Engineering Department, Northumbria University, Newcastle Upon Tyne, NE1 8ST, UK) and Vivek Dua (Department of Chemical Engineering, University College London, Torrington Place, London WC1E 7JE, UK).

*Abstract*

The gas turbine power plants are included in the net-zero energy scenario to meet the peak energy demand. The energy efficiency improvement of the gas turbine system can further strengthen to achieve the net-zero goal with the optimal consumption of natural gas. In this paper, we formulated a multi-objective optimization problem that integrates the interpretable data information integrated neural network (DINN) based process models for thermal efficiency, power and turbine heat rate, and the problem is solved by two-step robust optimization approach under various plant capacities for optimizing the operation of the gas turbine system.

[69] ***Using CFD to Improve the Heat Transfer Performance of an Oil Spray cooling System for an Electric Motor by varying the Inclination Angle***

Henry Allan-Jones (University of Birmingham), Anil Taskin (University of Birmingham) and Mehdi Jangi (University of Birmingham).

*Abstract*

This paper develops a validated Computational Fluid Dynamics (CFD) model for the oil spray cooling of an electric motor with hairpin windings, and investigates the effect of nozzle inclination angle on heat transfer performance. The results show that the optimum inclination angle for nozzles in the bottom half of the motor housing is 22.5°, and this can be attributed to a higher local Reynolds number on the lower part of the windings. The results also show that and that the optimum inclination angle could depend on the position of the nozzle with respect to the circumference of the motor housing

[71] ***AN EXPERIMENTAL STUDY OF LAMINAR JUNCTURE FLOW DOWNSTREAM OF THE SURFACE-MOUNTED SQUARE CYLINDER***

Hamid Malah (Institute of Applied Mathematics and Mechanics, Peter the Great St. Petersburg Polytechnic University) and Sara Ramzani Movafagh (Faculty of Engineering and Technology, Saint-Petersburg State Institute of Technology).

*Abstract*

This work is devoted to experimental study of free convective flow parameters, around an adiabatic square cylinder, which mounted on heated vertical plate. Here the size of cross section of square cylinder is equal to 0.4 [m]. The cylinder crosses the arising thermal boundary layer thickness, although the aspect ratio of cylinder is preserved equal to 1. The main goal of presented work includes preforming the experimental study to investigate characteristics of laminar free convection heat transfer in downstream region of the cylinder. In addition, the results of numerical simulation in this case are provided to verify obtained experimental data.

[72] ***Computational magnetohydrodynamics codes for the development of liquid metal breeding blankets in magnetic fusion reactors***

Alessandro Tassone (Sapienza University of Rome), Lorenzo Melchiorri (Sapienza University of Rome), Sonia Pignatiello (Sapienza University of Rome), Simone Siriano (Sapienza University of Rome) and Gianfranco Caruso (Sapienza University of Rome).

*Abstract*

Liquid metal (LM) system and components are investigated in nuclear fusion R&D programmes worldwide for near-term implementation in technological demonstrators. Unique challenges are posed to the development of this technology in magnetic fusion reactors due to the onset of magnetohydrodynamic (MHD) effects. The role of numerical tools for the prediction of LM MHD flows is discussed and so its impact in the development of breeding blanket concepts. Results achieved with computational fluid dynamics and system thermal-hydraulic codes at Sapienza University of Rome are described.

[73] ***NUMERICAL STUDY OF OIL JET COOLING FOR HAIRPIN WINDING MOTORS IN ELECTRIC VEHICLES***

Waruna Maddumage (Queen Mary University of London, London, United Kingdom), Souad Harmand (Universit´e Polytechnique Hauts-de-France, France), Alasdair Cairns (University of Nottingham, Nottingham, United Kingdom) and Amin Paykani (Queen Mary University of London, London, United Kingdom).

*Abstract*

Oil jet cooling and hairpin winding have become increasingly popular in electric machine design. Combining the two technologies resulted in improved motor designs with high power density and efficiency. This study examines the effect of jet configuration, nozzle diameter, and flow rate on heat extraction performance using high-fidelity numerical simulations. Results show that the axial jet, although superior in heat extraction, performs poorly at low inlet velocities. Therefore, a minimum velocity threshold is necessary.

[75] ***FLEXIBLE POLYMERIC PULSATING HEAT PIPES: FABRICATION TECHNIQUES AND THERMAL PERFORMANCE INVESTIGATION***

Nicolas Miche (Advanced Engineering Centre, School of Architecture Technology and Engineering, University of Brighton), Ayse Candan Candere (Department of Mechanical Engineering, Karadeniz Technical University), Francois Clemens (Advanced Engineering Centre, School of Architecture Technology and Engineering, University of Brighton), Marco Bernagozzi (University of Brighton), Anastasios Georgoulas (Advanced Engineering Centre, School of Computing Engineering and Mathematics, University of Brighton), Volfango Bertola (Laboratory of Technical Physics, University of Liverpool), Orhan Aydin (Department of Mechanical Engineering, Karadeniz Technical University) and Marco Marengo (Department of Civil Engineering and Architecture, University of Pavia).

*Abstract*

This paper presents an overview of recent research on flexible polymeric pulsating heat pipes (PPHPs). Two promising fabrication techniques are explored - selective transmission laser welding and stereolithography (SLA) 3D printing. The thermal performance of PPHPs manufactured using these methods is experimentally investigated, including the impact of microgravity conditions and bending on the laser-welded design. Key findings show that the SLA technique enables precise control over complex geometries, while the laser-welded PPHPs demonstrate effective thermal performance even in microgravity. Non-uniform channel configurations are found to promote fluid circulation and enhance heat transfer. This work highlights the potential of polymeric PHPs for flexible electronics cooling and disposable applications.

[76] ***Study of Boiling Heat Transfer and Two-Phase Flows using Physics-Informed Neural Networks***

Darioush Jalili (Department of Fluids and the Environment, The University of Manchester), Amir Keshmiri (Department of Fluids and the Environment, The University of Manchester) and Yasser Mahmoudi (Department of Fluids and the Environment, The University of Manchester).

*Abstract*

This work implements a physics-informed neural network (PINN) technique for evaporative phase change and other two-phase flow scenarios involving heat transfer. The present study initially considered the case of a single gas bubble rising in a quiescent fluid, wherein the PINN methodology achieved a maximum error of 3.6% in positional accuracy. Investigations were performed for both the classical Stefan and Scriven cases. For the Scriven case study, the transfer learning capabilities of the PINN algorithm were assessed. A maximum PINN prediction error of 6.1% compared to the analytical solution was revealed when tasked with modelling fluid properties where no observation data was provided. Finally, the process of film boiling was studied using PINN methodology. Ultimately, this work serves to demonstrate application of PINNs for boiling problems where inferred parameters can aid in reconciling cost-effectiveness with model accuracy.

[77] ***Heat Pumps: Enablers of Decarbonization - Assessment of the use of artificial neural networks to detect and diagnose some soft faults in heat pumps***

Chiara D'Ignazi (Dipartimento di Energia - Politecnico di Milano) and Luca Molinaroli (Dipartimento di Energia - Politecnico di Milano).

*Abstract*

This paper aims to explore the use of artificial neural networks for soft fault detection and diagnosis in a water-to-water heat pump. Unfaulty and faulty operational data are collected from a dedicated experimental campaign. The artificial neural networks are first trained o unfaulty conditions to allow them to predict some of the operational parameters that are usually measured in a heat pump during normal operation. Then, their potentiality in detecting and identifying faults is assessed by comparing the parameters measured under faulty conditions with those predicted by the trained artificial neural networks.

[78] ***Integrated Two-Phase Immersion Cooling of Electric Vehicle Batteries with Organic Rankine Cycle***

Adam Wilkes (School of Engineering, University of Birmingham), Anil Taskin (School of Engineering, University of Birmingham), Raya Al-Dadah (School of Engineering, University of Birmingham) and Saad Mahmoud (School of Engineering, University of Birmingham).

*Abstract*

Two-phase immersion cooling has the potential to maintain electric vehicle batteries at uniform temperatures thus offering effective battery thermal management. In this study, the effects of changing the refrigerant used, and varying the space between each battery cell were investigated using Computational Fluid Dynamics (CFD) simulations. Results showed that all used refrigerants achieved similar temperature distribution, but R245fa achieved the highest power from cooling 27,000 battery cells, the maximum number used in Volvo lorries, by enabling the production of electricity using organic Rankine cycle.

[80] ***Numerical Simulation of Hydrogen Absorption in Metal Hydride with Internal Fin and Embedded Heat Transfer Fluid Channel***

Dae Yeob Lee (University of Manchester), Yasser Mahmoudi (University of Manchester), Vincenzo Spallina (University of Manchester) and Amir Keshmiri (University of Manchester).

*Abstract*

Metal hydrides (MHs) offer promising hydrogen storage solutions, yet their slow reaction kinetics due to the low conductivity of MHs hinders absorption time. This study conducts transient heat and mass transfer simulations during MH absorption using computational fluid dynamics. Enhanced heat transfer is introduced through internal fins and heat transfer fluid. The effects of different reactor configurations and a parametric study of cooling fluid for the MHs absorption are explored. The installation of internal fins reduced hydrogen absorption time by 15%, while increasing heat transfer fluid flow reduced absorption time by 19.3%.

[81] ***EVALUATION OF AMMONIA-SALT MIXTURE REACTIONS***

Jake Locke (University of Warwick), Steven Metcalf (University of Warwick), George Shire (University of Warwick) and Robert Critoph (University of Warwick).

*Abstract*

This work investigated ammonia-salt reaction using TGA. Three samples were manufactured containing BaCl2, BaBr2 and a 50:50 molar ratio of BaCl2 and BaBr2. The results confirmed the existence of a binary salt mixture with sorption characteristics different from the individual salts. The mixture did not appear to form several obvious complex compounds with ammonia, but instead underwent sorption over a large temperature range in a similar way to physical adsorption. This suggests that salt mixtures are a promising candidate for use in heat pumping and thermal storage applications.

[82] ***Harnessing Microwave and Heat Exchanger for Enhanced Hydrogen Desorption in MgH2 Hydride Storage System***

Davoud Lanbaran (Mechanical Research Group, School of Engineering, University of Kent), Dan Dan (School of Mechanical Engineering, Beijing Institute of Technology, China), Zhen Wu (School of Chemical Engineering and Technology, Xi’an Jiaotong University, China) and Bo Li (Mechanical Research Group, School of Engineering, University of Kent).

*Abstract*

The desorption process in hydrogen storage, particularly in metal hydrides, poses challenges regarding efficiency and desorption speed. This study explores the utilization of microwave energy to accelerate the desorption process, thereby yielding hydrogen as a feasible option for energy storage. Numerical simulations were conducted using COMSOL Multiphysics software and the finite element method (FEM) in this research. The analysis compares two heat application methods for metal hydrides: conventional heat exchangers and concentrated microwave heating systems. The objective is to assess and contrast the effectiveness of various hydrogen release techniques in minimizing desorption time. Results indicate that employing microwave energy at 100 W and 2.45 GHz significantly reduces desorption time from 105 to 39 minutes, compared to applying 100 W/m2 of heat via a heat exchanger. This reduction addresses the challenge of hydrogen release, marking a substantial advancement in energy storage technology.

[83] ***Probing Hydrodynamic and Thermal Behaviour of Volatile Drops Impacting Hot Surfaces Near the Leidenfrost Point***

Yutaku Kita (King's College London).

*Abstract*

We investigated hydrodynamic behaviour of a volatile drop (FC-72) impinging onto a heated substrate and accompanying heat transfer in the vicinity of the Leidenfrost point, the temperature above which liquid drops are lifted by their own vapour due to instant evaporation. A combination of temperature sensitive paint (TSP) and high-speed cameras allowed us to capture drop impact and local surface temperature distributions simultaneously. We have successfully captured temperature variations which indicated wetting/ drying regions over a range of temperatures across the Leidenfrost point.

[84] ***BIOMASS-DERIVED 2D AND 3D PHOTOABSORBERS: INSIGHTS INTO HEAT PROLIFERATION FOR ENHANCED PHOTOTHERMAL INTERFACIAL SOLAR STEAM GENERATION (ISSG)***

Choon-Yian Haw (School of Energy and Chemical Engineering, Xiamen University Malaysia, Selangor Darul Ehsan, 43900, Malaysia.).

*Abstract*

The present work investigates the superior performance of 3D carbonized palm fiber photoabsorbers in interfacial solar steam generation (ISSG), surpassing 2D counterparts by 103.7% in solar-to-heat conversion efficiency. With 2D evaporation at 1.171 kg m-2 h-1 and 3D at 1.869 kg m-2 h-1, our focus is on understanding heat proliferation within the photothermal zone. Utilizing heat transfer module in COMSOL, we unveil heat propagation mechanisms and losses, shedding light on novel biomass photoabsorbers' potential for efficient solar-driven steam generation and water purification systems.

[85] ***Direct contact gas to solid, high pressure moving packed bed heat exchanger for Pumped Thermal Energy Storage***

Alexis Dole (SynchroStor).

*Abstract*

SynchroStor is developing a new concept of grid scale Pumped Thermal Energy Storage technology. The company has received a grant funding from the Department for Energy Security and Net Zero to develop a megawatt scale demonstrator of the system.

The technology is based on a number of technology breakthrough including: - Reversible reciprocating compressor expander - Direct contact high pressure moving packed bed heat exchanger - Gas lock system able to pressurize and depressurize solid media from atmospheric pressure storage silo to the pressurized heat exchanger

In this presentation the speaker will provide - Description of the PTES system architecture - Focus on the operating principle of the heat exchanger within the storage application - Latest results of analysis of the thermos-dynamic performance of the heat exchanger - A high-level techno-economic comparison with alternative heat exchangers

[87] ***BUBBLE COALESCENCE DURING NUCLEATE BOILING OF BINARY MIXTURES FROM ARTIFICIAL CAVITIES***

Ningxi Zhang (University of Edinburgh), Dani Orejon (University of Edinburgh), Jionghui Liu (University of Edinburgh) and Khellil Sefiane (University of Edinburgh).

*Abstract*

This study investigates pool boiling and bubble behaviour of Novec7000, Novec649, and their binary mixtures. Utilizing a paired artificial cavity coated with superhydrophobic Glaco, bubbles horizontal coalescence sequences reveal a dependence on the mole fraction of the binary mixture. As the mole fraction (X\_i) increases, bubble horizontal coalescence transitions from dual pinning onto the surface to depinning. The evaporative heat flux was calculated across varying mole fractions of the binary mixture. Detailed analysis indicates that binary mixtures significantly impact bubble coalescence compared to isolated bubble dynamics.

[89] ***CFD Modelling of Lead Solidification and Natural Convection for the Westinghouse Lead-cooled Fast Reactor***

Dean Wilson (The University of Manchester), Hector Iacovides (The University of Manchester), Emre Tatli (Westinghouse Electric Company LLC), Paolo Ferroni (Westinghouse Electric Company LLC) and Sung Jin Lee (Fauske & Associates LLC).

*Abstract*

Motivated by the current development of the Westinghouse Lead-cooled Fast Reactor, this study presents transient CFD simulations of solidification within a pool type vessel cooled externally by the forced convection of air using STAR-CCM+. Results indicate the melting-solidification model within STAR-CCM+ can reproduce the solidification front as it moves past a mock-up LFR fuel bundle included within the vessel. However, comparisons with experimental data reveal that the CFD under-predicts the solidification rate and thus further work is required to address these discrepancies.

[90] ***REFLECTING HYDROTHERMAL WAVES FROM FLOW MEASUREMENT IN SESSILE DROPLET***

Fei Duan (Nanyang Technological University).

*Abstract*

Hydrothermal waves have been reported in the droplet with the phase change, they can be spontaneously observed at the droplet interface of a sessile droplet. We have conducted the experiments with the support of thermography and particle image velocimetry to link the hydrothermal waves with the flow in a droplet under evaporation conditions. The splitting and merging of the hydrothermal wave patterns can be explained with the flow field as the droplet contact angle decreases during drying.

[91] ***THERMAL PERFORMANCE EVALUATION OF LITHIUM POLYMER BATTERIES: A COMPARISON OF PCM AND PCM WITH METAL FOAMS, FOR THERMAL REGULATION***

Aanandsundar Arumugam (Università degli Studi della Campania “Luigi Vanvitelli”), Bernardo Buonomo (Università degli Studi della Campania “Luigi Vanvitelli”), Oronzio Manca (Università degli Studi della Campania “Luigi Vanvitelli”), Monika Ignatowicz (KTH Royal Institute of Technology) and Rahmatollah Khodabandeh (KTH Royal Institute of Technology).

*Abstract*

This study endeavours to address the thermal concerns related to rechargeable batteries of electric vehicles by isolating them from external climatic conditions and controlling temperature spikes caused by battery operation. Using a three-dimensional model the thermal regulation of cylindrical lithium polymer-based battery modules is numerically analysed for various cases of hybrid cooling mechanisms with two different C-rates of 0.5C and 1C respectively.

[92] ***HEAT CONDUCTIVITY FOR THE ALUMINIUM SCRAP IN A DE-COATING FURNACE***

Ainul Izaharuddin (KTP Research Associate in Thermal and Fluid Modelling and Design, Aston University), Ahmed Rezk (Senior Lecturer, Aston University), Tim Hordley (R&D Engineer, Mechatherm International Ltd.), Muhammad Imran (Senior Lecturer, Aston University) and Stuart Allen (Technical Director, Mechatherm International Ltd.).

*Abstract*

The aluminium scrap parameters in a de-coating furnace need to be examined in terms of the time and density of the scrap charged in that furnace. The current industrial challenge is to find the effective heat required to de-coat the aluminium scrap before the next scrap is charged. This may be quantified by determining the effective thermal conductivity (k-value) relative to scrap density, and this may be derived from calculating the general heat transfer coefficients during trials. The understanding of the heat transfer coefficient for the aluminium scrap inside a de-coating furnace is examined at a predefined operating temperature of 550℃.The k-value is identified through the experimental work that is presented here. This work develops a better understanding of the heat transfer behaviour during aluminium scrap piles de-coating, hence better simulation accuracy and energy efficiency studies.

[94] ***SYMMETRY CRITERIA FOR THE EQUALITY OF INTERIOR AND EXTERIOR HEAT CONDUCTION SHAPE FACTORS***

Kyle McKee (Department of Mathematics, Massachusetts Institute of Technology) and John Lienhard (Department of Mechanical Engineering, Massachusetts Institute of Technology).

*Abstract*

In several geometries, the two-dimensional heat conduction shape factor of the interior of a simply connected region (Ω) is exactly equal to that of its exterior (ℝ\Ω) under the same boundary conditions. Recent work has conjectured that this equality must always hold. We present a counterexample to that conjecture and provide a sufficient condition for interior-exterior shape factor equality by exploiting a beautiful and little-known symmetry method due to Hersch [1] which we introduce in a tutorial manner.

[95] ***Single bubble nucleate pool boiling for climate friendly cooling solutions***

Marilize Everts (University College London), Matthias Welzl (University of Bayreuth) and Dieter Brüggemann (University of Bayreuth).

*Abstract*

The global attempt to decarbonise the transport sector, combined with our dependency on vehicles, created research opportunities for new technologies and developments and thermal management is a vital focus area. Nucleate pool boiling is known for high heat transfer coefficients and is an attractive direct cooling method. The purpose of this study was to investigate single bubble dynamics R1336mzz(Z) and R245fa for different saturation temperatures and heat fluxes. It was found that the bubble growth rate significantly increased with an increase in heat flux and decrease in pressure, while there was only a slight increase in the departure diameter. The higher surface tension of R1336mzz(Z) led to an increased bubble departure diameter compared with R245fa, while the bubble growth rate also increased and the bubble growth time decreased.

[96] ***A NON-DIMENSIONAL HEAT TRANSFER ANALYSIS OF PCM SOLIDIFICATION***

Amrita Sharma (University of Birmingham, UK and Indian Institute of Technology Jodhpur, India), Hardik Kothadia (Indian Institute of Technology Jodhpur, India), Shobhana Singh (Indian Institute of Technology Jodhpur, India) and Yongliang Li (University of Birmingham, UK).

*Abstract*

The present experimental investigation analysed the non-dimensional heat transfer study for the phase-changing phenomena during the phase change material (PCM) solidification. Thermal performance is characterized by measuring the degree of subcooling through solid Stefan number and measuring the superheating of the PCM at the onset of freezing through liquid Stefan Number. Meanwhile, a parameter termed as the dimensionless temperature is included to represent the instantaneous bulk-to-fusion temperature difference concerning Fourier number. It is found to be an inverse function of the initial Stefan Number.

[97] ***FLOW BEHAVIOUR AND WALL TEMPERATURE DISTRIBUTION OF LOW CONCENTRATION BUTANOL-WATER MIXTURE FLOW BOILING UNDER DIFFERENT FLOW ORIENTATION***

Arif Widyatama (University of Edinburgh), Mandi Venter (University of Pretoria), Jaco Dirker (University of Pretoria), Daniel Orejon (University of Edinburgh) and Khellil Sefiane (University of Edinburgh).

*Abstract*

The aim of this study is to investigate the flow boiling characteristics of butanol water mixture under different flow orientations. Here, a 5% v/v butanol-water mixture was chosen as a working fluid. Next, a one-sided coated rectangular channel for an aspect ratio of 20 and with a hydraulic diameter of 571 µm was used as the test section under three different flow orientations (horizontal flow, vertical upward flow and vertical downward flow). The results show that flow orientation influences the characteristics of the flow pattern and the wall temperature distribution with vertical downward flow being dominated by the vapour phase. This phenomenon in vertical downward flow will lead to the occurrence of dry out that increases the wall temperature along the channel.

[98] ***FASTT - AN ALTERNATIVE TO HEATPIPE AND MICROCHANNEL HEAT TRANSFER TECHNOLOGIES***

William Alexander (ACPI Ltd.).

*Abstract*

Foil And Slot Thermal Transfer (FASTT) uses precision, solid foils to transport heat from high flux sources to low flux sinks such as ambient air. Earlier research utilised simple lumped parameter models to determine system performance. This paper describes recent three dimensional time transient finite element analyses, which have been used to examine system behaviour in more detail. The results support the earlier findings that FASTT can provide high thermal flux throughput, but over much wider temperature ranges than existing technologies, such as those based upon microchannels or heatpipes.

[99] ***NUMERICAL MODEL AND DEMONSTRATION OF A THERMAL BRINE CONCENTRATOR FOR CLEAN WATER PRODUCTION***

Akanksha Menon (Georgia Institute of Technology), Walter Parker (Georgia Institute of Technology) and Jordan Kocher (Georgia Institute of Technology).

*Abstract*

Desalination has emerged as a technology solution to meet the global demand for clean water by treating saline water sources. One of the major drawbacks of desalination is that it generates a hypersaline by-product or brine that must be managed. In this study, a thermal brine concentrator based on air gap diffusion distillation (AGDD) is presented that uses a counterflow heat exchanger design and plastic surfaces for high-salinity desalination. A numerical model is developed to predict the performance of AGDD under a range of operating conditions, and an experimental prototype is designed to demonstrate continuous operation. The results show that a multi-pass AGDD system can achieve an overall water recovery of ~70% and gain output ratio of 7 (corresponding to latent heat recovery of 88%) with an initial feed salinity of 70 g/kg. Overall, the system outperforms its thermodynamically similar counterpart, air gap membrane distillation (AGMD), by eliminating heat and mass transport resistances associated with the membrane.

[103] ***NATURAL CONVECTION OF DIFFERENTIAL HEATED CAVITY WITH POLYMER ADDITIVES***

Tzu-Hsuan Chiu (National Tsing Hua University) and Chao-An Lin (National Tsing Hua University).

*Abstract*

This study aims to investigate viscoelastic natural convection flow using the general pressure equation, considering Rayleigh (Ra) numbers ranging from 104 to 107, Weissenberg (Wi) numbers ranging from 1 to 100, and a maximum elongation length (L2max) equal to 10 and 500. The results indicate that at low elasticity effects (Wi=10), there is a slight increase in both maximum horizontal and vertical velocities, resulting in higher heat transfer. Conversely, high elasticity effects (Wi=100, L2max=500) led to a decrease in heat transfer compared to its Newtonian counterpart. The presence of polymer generated opposing stress near the wall, resulting in a decrease in vertical velocity and, consequently, heat transfer.

[105] ***Latest improvements in additively manufactured aerospike rocket engine***

Elena Lopez (Fraunhofer Institute for Material and Beam Technology IWS), Samira Gruber (Fraunhofer Institute for Material and Beam Technology IWS), Alex Selbmann (Fraunhofer Institute for Material and Beam Technology IWS), Maximilian Buchholz (TUD Dresden University of Technology), Lukas Stepien (Fraunhofer Institute for Material and Beam Technology IWS), Christian Bach (TUD Dresden University of Technology) and Frank Brückner (Fraunhofer Institute for Material and Beam Technology IWS).

*Abstract*

This research addresses the exploration of additive manufacturing for an aerospike breadboard engine, utilizing laser powder bed fusion (PBF-LB/M) with INCONEL®718 powder. The process was assessed through material characterization and non-destructive testing such as computed tomography. Geometric features were also studied to determine overhang and accuracy, shaping the design of the aerospike breadboard engine. The study also discusses general results on surface roughness reduction and shape accuracy, which was found to cause notable reductions in propellant mass flow rates in prior tests in 2019.

[106] ***Mechanical Treatment of Agglomerated Ca(OH)2/CaO Particles during Thermal Energy Storage Reactions***

Salem Alotaibi (Kuwait University/ KNPC), Abdullah Alajmi (Kuwait University) and Sorour Alotaibi (Kuwait University).

*Abstract*

The reversible reaction of CaO/Ca(OH)2 for thermochemical thermal energy storage system has shown a great potential for applications in concentrated solar power (CSP) plants. However, the reversibility of the reaction is still lacking due to many factors, one of them is the formation of agglomeration. The goal of this paper is to investigate the effectiveness of mechanically crushing of agglomeration after each cycle on the efficiency and stability of the reaction. It has been found that crushing of agglomeration had led to more stable powder bed, more loose powder with larger surface area, which resulted in an increase in the generated heat, and the captured CO2.

[107] ***OPTIMIZATION OF UV-C RADIATOR TO ENHANCE MECHANICAL PROPERTIES OF IRRADIATED SEMI-FINISHED POTATO TUBER FOR EXTENDED STORAGE PERIOD***

Addis Jembere (University of Agriculture in Krakow) and Tomasz Jakubowski (University of Agriculture in Krakow).

*Abstract*

The efficacy of surface treatment technology is highly dependent on the dimensional and operational parameters. UV-C is a commonly used surface treatment technology for semi-processed crops. This paper makes use of a simultaneous optimization approach for multi-objective function so as to obtain the best possible combination of variables in the irradiation process (UV-C dose, storage period, and distance from the light) that offer maintained properties of semi-finished potato tuber.

[108] ***MANUFACTURING OF A COST-EFFECTIVE FLAT COPPER WATER LOOP HEAT PIPE***

Tayyab Mamtaz (Newcastle University), Richard Law (Newcastle University) and Ryan Mcglen (Boyd Technologies).

*Abstract*

This paper presents the development of a novel copper-water flat evaporator loop heat pipe (fLHP) model with compact evaporator dimensions of 60x40x5 mm for electric car batteries thermal management. The fLHP can operate both with and against gravity, transporting up to 250 W (25.6 W/cm2 ¬) when aided by gravity and 120 W (12.3 W/cm2) when operating against gravity. The maximum transport distance tested was 1.5 m. An optimised filling ratio of 4.5ml was determined which minimised the overall thermal resistance of the fLHP (0.116 K/W at X W power input).

[109] ***PERFORMANCE OF HDPE AND VACUUM-INSULATED CENTRAL PIPES FOR COAXIAL HEAT EXHANGERS IN GEOTHERMAL SYSTEMS***

Tassos Karayiannis (Brunel University London) and Jan Kubacka (GA Drilling).

*Abstract*

The thermal performance of a deep borehole coaxial heat exchanger with High-Density Polyethylene (HDPE) and vacuum-insulated central tubing (VIT) is presented in this paper. The analysis was performed for a wellbore equipped with a casing steel pipe of external diameter 198.52 mm and 10.36 mm thick. The central pipe consists of an HDPE tube 139.7 mm in outside diameter and 25.7 mm thick or two coaxial steel tubes, the first having an outside diameter of 139.7 mm and 10.5 mm thick, with the inner tube having an outside diameter of 101.6 mm and a thickness of 6.65 mm giving the same inner diameter of 88.3 mm as the HDPE tube. The gap between the steel pipes was maintained at different partial vacuum pressures. The depth was up to 5 km. Water was used as the working fluid. It was found that the VIT outperforms the HDPE for deep wells with the advantage diminishing for more shallow heat exchangers. A partial vacuum of 10 Pa does not demonstrate any relevant improvements over a gap maintained at normal atmospheric pressure, while the yield can be significantly improved when the pressure is reduced to 1 and 0.1 Pa.

[110] ***CONTROLLING DROPLET SIZE DENSITY DURING DROPWISE CONDENSATION ON SILICONE OIL GRAFTED SURFACES***

Anam Abbas (The University of Edinburgh), Gary Wells (The University of Edinburgh), Glen McHale (The University of Edinburgh), Khellil Sefiane (The University of Edinburgh) and Daniel Orejon (The University of Edinburgh).

*Abstract*

We present a hydrophobic functionalization method based on silicone oil grafting on a solid substrate to promote dropwise condensation closely related to heat transfer efficiency improvement. While independently of the grafting parameters adopted hydrophobicity of the surface and dropwise condensation is achieved, the different functionalisation procedure, such as oil viscosity, volume and application method, can actually impose different droplet-surface interactions. A high viscosity oil grafted surfaces empower the lowest of the contact angle hysteresis (CAH) and hence very mobile smaller sized droplets can be easily removed from the surface, creating space for new droplets to nucleate, grow, coalesce and shed. Whereas low viscosity oils and low number of layers impose a greater contact angle hysteresis (CAH) with the consequent increase on the size of the shedding droplets. The control of the droplet size distribution during condensation phase-change is then here proposed based on the grafting parameters adopted.

[111] ***Analysis of thermal stratification in a liquid sodium test facility***

Matthew Falcone (University of Sheffield), Ashish Saxena (KTH) and Shuisheng He (University of Sheffield).

*Abstract*

Numerical simulations of a test facility for sodium-cooled fast nuclear reactors are performed using RANS and LES to better understand these reactors' thermal stratification and mixing-jet phenomena. A thermal transient is simulated in which the temperature of the inlets, located at the bottom of the domain, decreases rapidly. Thermal stratification occurs above the outlet due to limited thermal mixing. The flow from the inlets is in the form of three jets, which are a significant source of temperature fluctuations due to the instability of the jets themselves and the interactions between them. The magnitude of the fluctuations remain elevated due to the delayed decrease in temperature near the bottom of the domain.

[112] ***Optimising Thermal Performance: A Novel Approach to Battery Cooling in Electric and Hybrid Vehicles***

Thamasha Samarasinghe (Brunel University London), Mihalis Kazilas (Brunel University London) and Stuart Lewis (TWI Ltd).

*Abstract*

The study explores thermal management strategies for Li-ion batteries crucial for Electric Vehicles and Hybrid Electric Vehicles, highlighting the challenges posed by thermal runaway and uneven temperature distribution. Active and passive cooling mechanisms are evaluated, with existing systems facing issues of weight and complexity. Addressing these limitations, a novel composite casing with variable thermal conductivity is proposed, featuring strategically placed copper pins for enhanced heat dissipation. Experimental and simulation results demonstrate the effectiveness of this approach, emphasizing its potential for improving efficiency and safety in Li-ion battery systems. Overall, the study advocates for innovative thermal management solutions to meet the demands of evolving vehicle technologies.

[114] ***SCOPING ANALYSES FOR THE DEFINITION OF NEW EXPERIMENTS FOR NATURAL CONVECTION AT HIGH RAYLEIGH NUMBERS.***

Juan Uribe (EDF R&D), Sofiane Benhamadouche (EDF R&D), Antoine Morente (EDF R&D), Pauline Rotach (EDF R&D), Jean-Luc Vacher (EDF DIPNN), Myeong-Seon Chae (PSI) and Domenico Paladino (PSI).

*Abstract*

Passive safety systems in nuclear reactors rely on gravity as driving force for transferring heat from the core or a hot region into a large reservoir thanks to natural circulation. They are designed to function without the intervention of the operators for several hours or days. Given the large scale of the current SMR designs, the Rayleigh number is expected to be in the order of 10^15. Currently, there are very few experiments that have reached such a high number, so new experiments are necessary to validate thermal hydraulics codes used to predict such behaviour in an accident scenario. The paper shows preliminary calculations using Computational Fluid Dynamics (CFD) to help sizing a new experimental set up at the PANDA facility (PSI, Switzerland) within the OECD/NEA PANDA project.

[115] ***Embedded large eddy simulation of partially premixed hydrogen flame: Study of injector nozzle geometry***

Hengyang Li (University of Manchester), Yasser Mahmoudi (University of Manchester) and Mohammad Jadidi (University of Manchester).

*Abstract*

This study used Embedded Large Eddy Simulation (ELES) and steady diffusion flamelet to model partially premixed hydrogen flame under a modified converging injector nozzle design with the flame structure and NOx emission analysed. The numerical results have revealed that adding a converging section at the injector outlet has minimal impacts on the mixture formation but despite a higher central flame temperature, results were evident that this modification improves the overall combustor’s NOx emission from the reduced flame length and accelerated H2 consumption.

[116] ***Direct Photo-Thermoelectric Conversion Based Mid-Infrared Detection***

Simon Wredh (Singapore University of Technology and Design), Mingjin Dai (University of Birmingham), Kenta Hamada (Tokyo University of Agriculture and Technology), Md Abdur Rahman (Singapore University of Technology and Design), Nur Qalishah Adanan (Singapore University of Technology and Design), Golnoush Zamiri (Singapore University of Technology and Design), Steve Qing Yang Wu (IMRE A\*Star), Nancy Lai Mun Wong (IMRE A\*Star), Wenhao Zai (IMRE A\*Star), Zhaogang Dong (IMRE A\*Star), Wakana Kubo (Tokyo University of Agriculture and Technology), Qi Jie Wang (Nanyang Technologial University), Jeol Yang (Singapore University of Technology and Design) and Robert Simpson (University of Birmingham).

*Abstract*

We will introduce our photo-thermoelectric (PTE) mid-infrared detector, which operates at room temperature and has the potential to revolutionise integrated photonics, microspectrometry, and hyperspectral imaging. Heat transfer and mid-infrared absorption have both been optimised in the microscale device to maximise its spectral sensitivity. The planar design reduces complexity and enables facile fabrication at the microscale. Through resonant absorption at a hot p-n junction of a thin-film thermocouple we achieve near-perfect infrared absorption resulting in good responsivity and detection speed. The planar design lends itself to industrial scaling and, thererore, we foresee our detector design finding wide application in infrared fingerprinting of polutants, bioimaging, and security.

[117] ***SOLAR DESALINATION INNOVATIONS: A COMPARATIVE ANALYSIS OF PYRAMID AND INCLINED SOLAR STILL***

Haseeb Yaqoob (Mechanical Engineering Department, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia) and Hafiz Muhammad Ali (Mechanical Engineering Department, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia).

*Abstract*

Domestic-scale solar stills are designed, manufactured, and examined for comparison. This study explores the practical investigations of two distinct solar still designs, namely the inclined and pyramid solar stills. These configurations encompass the conventional passive solar still, the actual daily yield of the inclined solar still is 71.9 ml/h, and the 113 ml/h from the pyramid solar still. So, the pyramid solar still is better than inclined, and its productivity can be increased by incorporating active devices, ultrasonic fogger, thermoelectric devices, and heaters.

[118] ***Additive Manufacturing for Thermal Management applications: advantages and current limitations***

Giacomo Favero (University of Padova), Gianluca Slaviero (University of Padova), Shengqi Zhang (Xi’an Jiaotong University), Adriano Pepato (INFN, Padova, Italy) and Simone Mancin (University of Padova).

*Abstract*

Additive Manufacturing opens novel frontiers in thermal science but it also comes with several challenges, This work presents a few applications of the metal additive manufacturing to different heat transfer problems: single phase forced convection, pool boiling, and solid-liquid phase change.

[119] ***ENHANCEMENT FOR LAMINAR FLOW USING STATIC IN-TUBE DEVICES***

Hamzah Sheikh (Centre for Flow Processing (CALGAVIN Ltd)), William Osley (Centre for Flow Processing (CALGAVIN Ltd)), Stephen Pitt (Centre for Flow Processing (CALGAVIN Ltd)), Oluwatobiloba Henry (University of Birmingham), Andrei-Leonard Nicusan (University of Birmingham), Jonathan Seville (University of Birmingham), Adriano Sciacovelli (University of Birmingham) and Peter Droegemueller (Centre for Flow Processing (CALGAVIN Ltd.)).

*Abstract*

The heat transfer benefits of static in-line enhancement devices for tubular heat exchangers in laminar flow have been investigated using experimental and theoretical approaches. A high viscosity heat transfer facility was used to characterise an existing wire matrix insert (hiTRAN) and a new plate type insert (hiVISC), with additional studies using CFD. Positron emission particle tracking (PEPT) was employed to visualise flow in an otherwise opaque system. hiTRAN and hiVISC® inserts displayed higher efficiency heat transfer in low Reynolds number laminar flows in comparison to commonly used alternative insert designs.

[120] ***On the numerical prediction of the evaporation rate of a horizontal water span***

Quentin Royer (IMFT/Safetykleen), Romain Guibert (IMFT), Pierre Horgue (IMFT), Adam Swadling (Safetykleen) and Gérald Debenest (IMFT).

*Abstract*

A comprehensive analysis of the existing numerical models addressing the dynamics of water vapor flux across an air-water interface has been conducted. Additionally, we introduce a novel model based on the empirical friction velocity of the air over a water surface. This new model is used to predict evaporation rates in the context of wind tunnel experiments where water tanks are subjected to controlled drying conditions.

[121] ***UNDERSTANDING BUBBLE GROWTH MECHANISM(S) OF HIGH VOLATILE FLUID USING ADVANCED GRAIDENTS-BASED DIAGNOSTICS***

Alok Kumar (Indian Institute of Technology, Bombay) and Atul Srivastava (Indian Institute of Technology, Bombay).

*Abstract*

This study investigates the plausible growth mechanism(s) and dynamical parameters of single vapor bubble during nucleate boiling regime of high volatile fluids under varying subcooling conditions. Dichloromethane (DCM) has been chosen as the high volatile　fluid　in the boiling experiments. The plausible bubble base growth mechanism(s), microlayer and/or contact line evaporation and the dynamical parameters of the vapor bubbles have been mapped through simultaneous application of thin film interferometry and high-speed rainbow schlieren deflectometry. The experimental observations reveal that unlike conventional fluids, like water, DCM displays a bubble base growth mechanism that is primarily dominated by contact line evaporation and thermal diffusion effects across the superheated thermal layer enveloping the growing vapor bubble. Irrespective of the surface wettability, no distinct microlayer could be observed beneath the growing DCM vapor bubble through thin film interferometry observations. Detailed force balance analysis shows a transition from downward to upward forces facilitating bubble departure beyond 0.9 departure time (td).

[123] ***EXTENDED HEAT TRANSFER MODEL OF A JACKETED BATCH STIRRED TANK REACTOR***

Rachael C. Lowe (University of Leeds), Peter J. Heggs (University of Leeds), Tariq Mahmud (University of Leeds) and Keeran Ward (University of Leeds).

*Abstract*

An extended thermal model for jacketed batch stirred tank reactors (STRs) has been expanded for applications to both non-reactive and reactive systems. It is not only able to replicate the predicted process temperature profile by the reduced thermal model, but also provides information about how the jacket outlet temperature and the heat flows vary with time. It is revealed that values of the overall heat transfer coefficient obtained from experimental data and the reduced thermal model inherently include several thermal effects not covered in the model equations and thus should not be used to predict other experimental equipment, process and ambient conditions.

[124] ***OPTIMIZING HEAT TRANSFER EFFICIENCY: EXPERIMENTAL ANALYSIS OF WIRE-COIL INSERTS IN RECTANGULAR TUBES UNDER NON-UNIFORM HEAT FLUX CONDITIONS***

Fatima Zohra Benouis (Polytechnic university of Cartagena, Spain UPCT), Alberto Egea (Polytechnic university of Cartagena, Spain UPCT), Ruth Herrero-Martín (Polytechnic university of Cartagena, Spain UPCT) and Alberto Garcia (Polytechnic university of Cartagena, Spain UPCT).

*Abstract*

This experimental study analyzes heat transfer and friction factor in a rectangular duct utilizing coiled wire inserts. The experimental setup involved water as the working fluid, with Reynolds numbers spanning from 500 to 10000, covering laminar, transition, and turbulent flow regimes. A comparative study was conducted between experimental pressure drop data and existing correlations from open literature for an empty duct, demonstrating a notable agreement. Furthermore, the study delves into the impact of employing wire coil inserts on heat transfer enhancement. The results revealed that the utilization of coiled wire inserts led to significative increase in both heat transfer and friction factor within the channel.

[126] ***OPTIMIZATION OF A TRANS- CRITICAL HEAT PUMP CYCLE USING A MIXTURE OF PROPANE AND BUTANE INTEGRATED WITH AN INDUSTRIAL DRYER***

Patrick Widdows (Delft University of Technology), Sikke Klein (Delft University of Technology), Rene Pecnik (Delft University of Technology) and Jurriaan Peeters (Delft University of Technology).

*Abstract*

An integrated heat pump & dryer system is proposed. Moist air exiting the dryer is used as a heat source for the heat pump, but also to pre-heat ambient air. The heat pump performance is optimized by considering a trans- critical cycle with different mixtures of propane and butane. The mixture composition of 12.5% propane and 87.5% butane yields a CoP of 4.05 (vs. 3.96 for pure butane). The optimal performance can be traced back to better glide matching in the evaporator and reduced irreversibility generation in the valve.

[127] ***PREDICTION OF FOULING BY CALCIUM PHOSPHATE IN A COOLING WATER SYSTEM USING MACHINE LEARNING***

Monica Tirapelle (Hexxcell LTD), Parag Patil (Hexxcell LTD), Emilio Diaz-Bejarano (Hexxcell LTD) and Francesco Coletti (Hexxcell LTD).

*Abstract*

Fouling in cooling water systems of power plants generates a progressive decay in overall condenser performance that leads to severe economic penalties. This work focuses on studying fouling by calcium phosphate using a new machine-learning (ML) framework. Specifically, we will discuss the most relevant variables impacting deposition and develop an ML-based model that accurately predicts phosphate deposition.

[128] ***DEVELOPMENT OF SILICONE POLYMER COMPOSITES WITH HYBRID BN AND SIC FILLERS FOR IMPROVED THERMAL CONDUCTIVITY***

Hongnan Zhang (University of Nottingham), Ruqaiyah Khan (University of Nottingham), Bo Li (The University of Kent) and Fang Xu (University of Nottingham).

*Abstract*

The rapid evolution of electronic devices has resulted in increased heat generation, highlighting the demand for polymer composites with high thermal conductivity. However, traditional polymer composites typically exhibit low thermal conductivity at room temperature. This study enhances thermal conductivity of silicone polymer composites by adding Boron Nitride (BN) and Silicon Carbide (SiC) fillers. BN and SiC were aligned first and infiltrated with silicone together with nano-BN to further improve thermal conductivity.

[129] ***A NUMERICAL INVESTIGATION ON THERMAL MANAGEMENT SYSTEM DESIGN FOR 4680 CYLINDRICAL LITHIUM-ION BATTERIES***

Zeyu Sun (University of Oxford), Yongxiu Chen (University of Oxford) and Paul Shearing (University of Oxford).

*Abstract*

This study proposes a battery thermal management system (BTMS) for the 4680 battery module using a double-layer cold plate design, with aerogel utilized as a heat insulation material between the cells. A 2-dimensional finite element model is established to simulate both the thermal behaviour of battery cells and the heat transfer and hydrodynamic characteristics within the system. The design parameters of this proposed cooling strategy were globally optimized using the Multi-Objective Particle Swarm Optimization (MOPSO) algorithm, coupled with a surrogate back propagation (BP) neural network model to reduce computational cost.

[130] ***DYNAMIC SIMULATION AND PERFORMANCE COMPARISON OF TWO-STAGE AND SINGLE-STAGE HEAT PUMPS WITH INTERMEDIATE TEMPERATURE CONTROL***

Zahra Hajabdollahi (University of Liverpool) and Zhibin Yu (University of Liverpool).

*Abstract*

This paper presents the dynamic simulation of an air-to-air heat pump using OpenModelica, with R1234yf as the refrigerant. The study evaluates the performance of a two-stage heat pump and compares it with a single-stage heat pump by analyzing the coefficient of performance (COP) in both configurations. In both the single-stage and two-stage heat pumps, the condenser temperature is controlled to maintain a temperature of 65°C. Additionally, the intermediate temperature in the two-stage system is actively controlled to enhance the COP. The results highlight the differences in efficiency and performance between the two systems, providing insights into the advantages of using a two-stage configuration with R1234yf.

[131] ***Experimental validation of two numerical models of a solar-powered multiple air jets impingement tube heater***

Hadi Tannous (Doctoral Researcher), Valentina Stojceska (Brunel University London) and Savvas Tassou (Brunel University London).

*Abstract*

This paper validates experimentally two numerical models of solar-powered tube heater that uses air impingement jets to heat steel tubes in the powder-based coating process as they move axially. A test rig is built to evaluate the thermal performance of the tube heater and validate both, its ANSYS FLUENT Dynamic Mesh model which simulated a moving target and ANSYS FLUENT Transient Thermal model which simulated a moving heat source. Results showed the experimental results to agree with those of the numerical models with an R2-value of 0.983-0.997 and error fit of 3-10% for tube velocities of 0.033-0.1 m/s.

[132] ***Numerical analysis of a thermal energy storage system with phase change material based on plate heat exchanger with roll-bond design***

Meixi Liu (University of Birmingham), Adriano Sciacovelli (University of Birmingham) and Lorenzo Ciappi (University of Birmingham).

*Abstract*

This study investigates numerical performance of the latent heat thermal energy storage (LHTES) system based on plate-type heat exchanger with roll-bond (RB) pattern. A detailed 3D CFD model was developed to evaluate the PCM melting performance in the charging process of the LHTES unit. These investigations are beneficial for the optimum design of the RB pattern for thermal energy storage (TES) applications.

[133] ***EVALUATING THE GREENHOUSE GAS EMISSIONS REDUCTION POTENTIAL DUE TO THE USE OF HEAT PUMPS***

Roshan Hehar (University of Birmingham), William Burges (University of Birmingham), Thomas Fender (University of Birmingham), Jonathan Radcliffe (University of Birmingham) and Neha Mehta (University of Birmingham).

*Abstract*

This study investigates the deployment of heat pumps to decarbonise domestic space heating in the United Kingdom. This study develops a novel modelling tool that includes hourly ambient temperature, dwelling characteristics at a local authority-level, and electricity grid carbon intensity data. This is to evaluate the potential reduction in greenhouse gas (GHG) emissions associated with the adoption of air source heat pumps compared to conventionally used natural gas boilers. Key factors influencing the reduction in the GHG emissions included electricity grid carbon emissions, split of houses (between detached, semi-detached and terraced), and the total number of houses in the local authorities.

[135] ***RADIO FREQUENCY CALCINATION OF GYPSUM FOR SUSTAINABLE WALLBOARD PRODUCTION***

Jacob Tjards (Georgia Institute of Technology), Kristian Lockyear (Georgia Institute of Technology) and Srinivas Garimella (Georgia Institute of Technology).

*Abstract*

Drywall is used in the construction of most modern buildings. However, the production process requires significant water and energy consumption and results in 1.05 million tons of carbon emissions per year. To improve the sustainability of the drywall industry, Radio Frequency (RF) calcination of gypsum for drywall manufacturing is investigated. Calcination of gypsum with varying initial free moisture content, at changing power levels, and with varying humidity is tested, and the calcination percentage and final calcium sulfate hemihydrate fraction are determined. A model for predicting the calcination extent to within 7.5% is developed. Recommendations are made for future work in this area to transition the process to an industrial level.

[137] ***Distributed Fibre Optic Sensors for Solid-Liquid Phase Change Detection in Thermal Energy Storage Applications***

Chao Wang (University of Kent), Wei Han (University of Kent) and Bo Li (University of Kent).

*Abstract*

This paper presents a distributed optical fibre sensor for real-time detection of solid-liquid phase changes in thermal energy storage material (n-octadecane). The sensor probes, made by splicing a no-core fibre (NCF) between two single-mode fibres (SMFs), form a sensor array. Due to differing refractive indices (RI) of solid and liquid n-octadecane, the array exhibits a step-like output power change during phase transitions. Optical fibre sensors are crucial in phase change energy storage materials as they offer precise, real-time monitoring and can be integrated into various systems with minimal intrusion. Experimental results confirm the sensor's ability to monitor phase changes, highlighting its potential to enhance thermal energy storage systems and advance distributed optical fibre sensing technology.

[138] ***Heat Pumps: The solution to many of humankind’s essential challenges***

Matthew Hughes (Massachusetts Institute of Technology) and Srinivas Garimella (Georgia Institute of Technology).

*Abstract*

This study evaluates the potential of heat pumps to decarbonize different end uses, including cold chain food storage, space conditioning, water purification, and thermal energy storage. Prior experimental research and reduced order models are used to evaluate reductions in primary energy consumption or carbon emissions. Realistic pathways to implement heat pumping at the residential scale are discussed.

[141] ***ACOUSTIC ENHANCEMENT OF MALTODEXTRIN DROPLET DRYING: INSIGHTS FROM MODELLING AND EXPERIMENTAL OBSERVATIONS***

Faridatul Ain Mohd Rosdan (School of Chemical and Process Engineering, University of Leeds), Peter J. Heggs (School of Chemical and Process Engineering, University of Leeds) and Tariq Mahmud (School of Chemical and Process Engineering, University of Leeds).

*Abstract*

This study reveals that the drying of acoustic levitated maltodextrin droplets is enhanced compared to suspended droplets. Heat and mass transfer dynamics are investigated during the drying of levitated droplets by combining mathematical modelling and experiments. The mathematical model previously predicted experimental data for the suspended droplets to within 4%. Results demonstrate that the heat and mass transfer coefficients of the model must be increased by a factor of 1.625 to improve the alignment between the predicted and levitated experimental data for different maltodextrin concentrations and initial droplet sizes.

[142] ***TEMPERATURE PREDICTION OF HEAT SINK BASE INTEGRATED WITH COPPER FOAMPHASE CHANGE MATERIAL USING MACHINE LEARNING FOR THERMAL MANAGEMENT APPLICATIONS***

Ahmad Al Miaari (PhD) and Hafiz Ali (Associate).

*Abstract*

Advancement devices such as photovoltaics, batteries, and electronics are being utilized in a more compact and efficient manner. However, more heat is generated inside these devices, which can elevate the temperature levels and cause efficiency reduction or even device failure. Phase change material with high latent heat of fusion can passively cool and maintain the temperature of devices at a proper level. Yet its low thermal conductivity affects the thermal management process. Adding metallic foam has shown a great improvement in the thermal conductivity. However, many parameters such as phase change material volume fraction, foam material porosity, heat flux and other may affect the final thermal conductivity and final thermal management process. Numerical and experimental work are needed to investigate different varying parameters on the thermal management process which can be resource and time consuming. To address this problem and minimize the need for experimental and numerical work, artificial neural network is proposed to predict the temperature of a heat sink base at new PCM volume fractions of 0.5 and 0.9 integrated with copper foam of 0.95 porosity subjected to 8 W heating load respectively. The neural network was trained based on data from a prior experimental study. This study involved subjecting the heat sink to varying heating loads of 8 W, 16 W, and 24 W, in combination with phase change material and copper foam. Specifically, two types of copper foam were examined one with a porosity of 0.95, and another with a porosity of 0.97. Different volume fractions of phase change material at 0.6, 0.7, and 0.8 were investigated. The machine learning algorithms performance is evaluated by means of mean squared error and coefficient of determination (R2). Results showed that the model was successfully trained with low mean squared error values of 0.003, 0.0025, and 0.0038 on the training, validation, and testing sets respectively. Moreover, an R2 score of 0.999 was attained across all sets respectively. To test the robustness of the model, a simulation dataset is fed to the trained NN to predict the temperature of the heat sink. The predicted temperatures of the heat sink are then compared to real temperatures collected experimentally. A small error of an average 3 °C is seen with mean squared error of 0.8031 and R2 score of 0.9956. The trained model is then used to predict the temperature of the heat sink at new phase change material volume fractions of 0.5 and 0.9 that was not experimentally explored. Results showed increasing the volume fraction to 0.9 can further reduce the temperature of the heat sink to 33.5 °C.

[143] ***Can Enhanced Geothermal Systems Decrease the Cost of a Decarbonised Sector-Coupled European Energy System?***

Lukas Franken (University of Edinburgh).

*Abstract*

Enhanced Geothermal Systems (EGS) hold high potential as a generating technology, but cost reduction uncertainties persist. To assess EGS’s potential role in the context of this uncertainty, we here address the following question: How much cost reduction is required for EGS to be competitive in a highly decarbonised European energy system and how crucial is heat (co-)generation? To do so, we employ the sector-coupled energy system model PyPSA-Eur and optimise investment and dispatch over a full year, while incorporating EGS at different cost levels and as a generator of electricity only, low-grade heat and power or low-grade heat only. Our findings indicate that with heat generation, EGS deployment accelerates by approximately 15 years. Assuming cost reductions projected by a recent paper, this yields an installed capacity of ~100 GW borehole capacity by 2030 (equalling approximately 30% cost reduction). However, electricity generation only becomes competitive with cost assumptions for 2035 (50% cost reduction), unlocking a market exceeding 1 TW borehole capacity across Europe.

[144] ***DIRECT THERMAL MANAGEMENT FOR LITHIUM ION BATTERIES***

Mark Turner (University of Cambridge), D. Ian Wilson (University of Cambridge), Stuart Clarke (University of Cambridge), Michael Sargent (University of Cambridge) and Giles Prentice (bp).

*Abstract*

Fast charging of Lithium Ion Batteries in Electric Vehicles is important to reduce ‘range anxiety’ among motorists. However, fast charging generates considerable heat, which must be removed to avoid battery degradation at high temperatures. Direct thermal management, where the cells are in contact with a dielectric liquid to cool them, offers the potential for more efficient heat transfer. However, these fluids generally have less favourable physical properties compared to water. We present some a new experimental flow system to quantify the heat transfer performance of dielectric fluids and as part of a project to identify strategies for improvement.

[145] ***EXPLORING THE POTENTIAL OF MACHINE LEARNING IN COMBUSTION ENGINE OPTIMIZATION***

Amirali Shateri (University of Derby), Zhiyin Yang (University of Derby) and Jianfei Xie (University of Derby).

*Abstract*

This study integrates machine learning (ML) with computational fluid dynamics (CFD) to optimize the performance of engine combustion process. Three ML models are compared: Random Forest Regression (RFR), Gaussian Process Regression (GPR), and Neural Networks (NN). The findings show that the GPR model outperforms the others in terms of accuracy, as indicated by metrics like Mean Absolute Error (MAE), Mean Squared Error (MSE), Pearson Coefficient (PC), R-squared (R2), and lower uncertainty values. Additionally, the selected ML model significantly speeds up the computational process, around 21.6 times faster than traditional CFD solvers, while accurately capturing momentum and thermal characteristics. The optimization results highlight the importance of critical parameters, such as turbulence kinetic energy (TKE) and tumble-y, in enhancing engine efficiency by improving fuel-air mixing and reducing emissions.

[146] ***Influence of external process fluid injection on the conveying behaviour of screw pumps with decreasing spindle pitch***

Oliver Obst (Universitaet Kassel, Technische Thermodynamik), Marian Lottis (Universitaet Kassel, Technische Thermodynamik) and Andrea Luke (Universitaet Kassel, Technische Thermodynamik).

*Abstract*

External process fluid injection into the screw pump with a progressive spindle pitch counteracts the decrease in delivery rate at high gas volume fractions (GVF) and increases both the volumetric and isothermal efficiency. In experiments with a progressive spindle, the injection position, injection volume flow, rotational speed, differential pressure and gas content are varied to determine the impact of process fluid injection on the conveying behaviour. Pressure-side injection shows the highest improvement potential in the experimental investigations. This result is confirmed by measured local state variables (p, T).

[147] ***EFFECT OF INTERFACIAL FORCE ON FLOW BEHAVIOR AND LIQUID FILM THICKNESS IN THREE-PHASE TAYLOR FLOW***

Faysal Khaleel (University of Birmingham), Fahad Al-Gburi (University of Birmingham), Yulong Ding (University of Birmingham) and Jason Stafford (University of Birmingham).

*Abstract*

This study investigates the effect of interfacial force on the flow behaviour and liquid film thickness in three-phase Taylor flow using the MPPICInterFOAM solver. Within this solver, the interface force model was modified to prevented particle penetration through the gas-liquid interface. Simulations demonstrated that increasing the interfacial force coefficient significantly increases film thickness by up to 25%, within the study range, and alters particle distribution within liquid slugs. These findings contribute to optimizing three-phase flow parameters for advanced heat transfer applications such as nanofluids and chemical microreactors.

[148] ***Numerical Modelling of Multi-Phase Taylor Flow with Nanoparticles using MPPIC-VOF approach for Heat Transfer Enhancement***

Fahad Al-Gburi (School of Engineering, University of Birmingham), Faysal Khaleel (School of Engineering, University of Birmingham), Yulong Ding (School of Chemical Engineering, University of Birmingham) and Jason Stafford (School of Engineering, University of Birmingham).

*Abstract*

This study numerically investigates heat transfer characteristics of multi-phase Taylor flow containing nanoparticles in millimetric channels using a newly customised OpenFOAM solver, thermalMPPICInterFOAM. Simulations were conducted to analyse the thermal field and average Nusselt numbers for four cases, which are single-phase flow, two-phase Taylor flow, and three-phase flow with and without thermophoretic and Brownian motion effects. Results showed that while Taylor flow improved heat transfer, adding 100 nm nanoparticles at low volumetric concentration of 10^(-4) decreased efficiency due to nanoparticle migration effects. This outcome indicates the need for further optimization of nanoparticle concentration and diameter in nanofluid cooling systems.

[149] ***ENHANCING HEAT TRANSFER IN MICRO PIN FIN HEAT SINKS USING FLOW OSCILLATIONS***

Henry Baker (Newcastle University), Jonathan McDonough (Newcastle University) and Richard Law (Newcastle University).

*Abstract*

There is a growing need to develop high flux cooling solutions to address thermal management challenges in a range of applications, including data centres, power electronics and microprocessors. Micro pin fin heat sinks are a state of the art liquid phase cooling solution, but high heat transfer coefficients remain dependent on high flow rates, leading to large pumping costs. This paper investigates the use of oscillating flows in micro pin fin heat sinks to enhance heat transfer at lower net flow rates. Brightfield micro particle image velocimetry was used to assess flow patterns and the turbulent kinetic energy was measured around 9 different micro pin designs. Once the flow became fully reversing the turbulent kinetic energy plateaued. The best performing pin was the 750 μm triangular pin with a normalised turbulent kinetic energy of 1.7.

[150] ***PERFORMANCE OF AN AMBIENT-TEMPERATURE-SOURCE STEAM-GENERATING HEAT PUMP***

Adewale Odukomaiya (AtmosZero), Jeffrey Milkie (AtmosZero), Nickolas Roberts (AtmosZero), Meha Setiya (AtmosZero), Kelly P. Ryan (Colorado State University), Joe Huyett (Colorado State University) and Todd M. Bandhauer (AtmosZero; Colorado State University).

*Abstract*

Globally, most electricity is still generated using fossil fuels, however, the share of electricity generated from renewables continues to grow rapidly. As electricity grids across the world decarbonize, electrifying end-uses that are currently fossil fuel fired presents a promising path towards decarbonization. Next generation heat pumps are a viable solution for decarbonizing fossil fuel fired steam boilers. In collaboration with the Colorado State University, AtmosZero has built a prototype ambient-temperature-source, steam-generating heat pump system operating from 15°C heat source and providing steam at temperatures as high as 150°C. Here, we present on the experimental performance of the as-built prototype system.

[151] ***EXPERIMENTAL STUDIES ON TWO-PHASE HFE-7000 FOR BATTERY THERMAL MANAGEMENT***

Amin Balazadeh Koucheh (Sabanci University), Ali Sadaghiani (Sabanci University), Ahmet Cenk Ünlü (Rinnova Automotive Technologies LTD) and Ali Koşar (Sabanci University).

*Abstract*

Heat transfer with liquid immersion represents a highly emphasized thermal solution to consider. In various technological and industrial applications, liquid immersion heat transfer can be applied without the need for additional equipment. The only consideration needed is to adjust the material specifications to our desired settings. In our case, we examined Lithium-Ion Batteries for heat generation with 1C discharge for the cooling system and investigated the optimal cooling method for the batteries. We conducted a series of tests to compare the effects of liquid immersion cooling on batteries. Additionally, we utilized air cooling to demonstrate the cooling potential compared to an air-cooled design. Due to its dielectric and thermal properties, we selected HFE-7000 for our thermal management system. A comprehensive analysis of the batteries' heating coefficients under different C-ratings was also essential, as it exponentially affects the batteries' heat rate. Our findings indicate that liquid immersion maintains battery temperature better than air cooling, resulting in a more uniform temperature distribution among batteries. The data obtained from charged and discharged batteries is valuable for designing under specified conditions.

[154] ***Numerical analysis of laminar and permanent thermal natural convection in a closed enclosure with different conditions.***

Mayouf Si Abdallah (University of M'Sila), Sihem Bouafia (University of M'Sila) and Haiem Si Abdallah (Higher National School of Renewable Energies, Environment and Sustainable Development, BATNA).

*Abstract*

In this study, we present a numerical analysis of laminar and permanent thermal natural convection in a closed enclosure with different conditions using FORTRAN language. The resulting system of algebraic equations was then solved using the iterative method with the Gauss-Seidel algorithm and relaxation. The results are presented in the form of isotherms, velocity and stream lines as a function of the Rayleigh number, as well as the Nusselt number. The findings indicate that an increase in the Rayleigh number leads to a higher convective heat transfer within the enclosure.

[155] ***RECENT PROGRESSES ON FUNDAMENTALS AND APPLICATIONS OF COMPUTATIONAL-ANALYTICAL INTEGRAL TRANSFORMS***

Renato Machado Cotta (Federal University of Rio de Janeiro - UFRJ), Paulo Couto (Federal University of Rio de Janeiro - UFRJ), Gianfranco de Mello Stieven (Federal University of Rio de Janeiro - UFRJ) and Carolina Palma Naveira-Cotta (Federal University of Rio de Janeiro - UFRJ).

*Abstract*

The present lecture reviews the analytic-based methodology known as the Generalized Integral Transform Technique (GITT) for convection-diffusion problems, focusing on recent progresses on fundamentals, such as the single domain formulation and the nonlinear eigenvalue problem base, which are more closely reviewed. Also, its recent application in direct-inverse analysis in petroleum reservoir simulation is illustrated.

[157] ***A COMPARISON OF HEAT TRANSFER DURING FREE CONVECTION CONDENSATION OF STEAM ON HORIZONTAL COPPER INTEGRAL FIN AND PIN-FIN TUBES***

Hafiz Muhammad Ali (KFUPM).

*Abstract*

Condensation heat transfer is obtained on integral fin and Pin-Fin horizontal Copper tube using steam. Finned Copper tube having fin height and thickness of 1mm each and longitudinal pitch of 1.5mm was used while Pin-Fin tube had Pins of 1mm thickness and height while circumferential thickness was taken as 0.8mm at the root circle and 1.2mm at the top with circumferential and longitudinal pitch as 1mm and 1.5mm respectively. Results reveal that heat transfer rate increases with the introduction of fins on the outside of tubes. The results for heat transfer due to steam condensation is found to be best for Pin-Fin tube while integral fin tube shows higher heat transfer performance than that of plain tube.

[158] ***THERMAL METAMATERIALS FOR COOLING FLEXIBLE POLYMER SUBSTRATE ELECTRONICS***

Joel Yi Yang Loh (National University of Singapore), Chun Fei Siah (National University of Singapore) and Yeow Kheng Lim (National University of Singapore).

*Abstract*

Thermal metamaterials can effectively redistribute heat through simple designs, offering a cost-efficient solution for cooling flexible electronics, which often suffer from low thermal conductivity in their polymeric substrates like polyimide. A simple sensu-fan design can reduce a 350°C central heat source by nearly 250°C while maintaining a high temperature of ~90°C throughout the fan structure, with an optimal cooling effect achieved by varying the fan's thickness logarithmically. A linear thickness profile is however ideal for achieving a high temperature of 96°C at the fan blades. These findings suggest that using less material in specific thickness profiles can effectively distribute thermal energy across a polymer substrate. Additionally, a thermal cloaking shield made from the sensu fan can block heat conduction to sensitive areas, making the structure ideal for managing heat distribution without exceeding the limitations of flexible substrates.

[159] ***A MACHINE LEARNING APPROACH FOR THE PREDICTION OF FLOW BOILING HEAT TRANSFER COEFFICIENTS IN SMALL TO MICRO-TUBES***

Nima Nazemzadeh (Hexxcell Ltd.), Francesco Coletti (Hexxcell Ltd.) and Tassos Karayiannis (Brunel University London).

*Abstract*

Flow boiling in microchannels plays an important role in the future of cooling systems. However, to design efficient devices that exploit the benefits of latent heat cooling, it is necessary to develop a detailed understanding of the several complex phenomena that interact with each other and are extremely challenging to capture mathematically with physics-based models. This study explores the application of machine learning (ML) algorithms to demonstrate their predictive abilities in the absence of detailed deterministic knowledge. The work leverages the extensive Brunel Two-phase Flow Database to extract the explanatory variables needed for predictions and uses various regression models to predict the heat transfer coefficient in single small to micro tubes with diameters ranging from 0.52 to 4.26 mm. The preliminary results demonstrate that the ML algorithm can predict accurately, albeit caution is needed when extrapolating beyond the ranges of the data used for training.