ManChester CFD

World-leading research and consultancy

INDEX

WORLD-CLASS RESEARCH & CONSULTANCY

Heat, Ventilation and Air Conditioning (HVAC)
Environmental Impact Assessment
Experimental Fluid Mechanics
Biomedical Engineering
Design Optimisation
Multiphase Flows
Aerodynamics
Porous Media
Heat Transfer

ManChester CFD

The 'ManchesterCFD' Team

The 'ManchesterCFD' team is hosted within the University of Manchester and directed by Dr Amir Keshmiri. The 'ManchesterCFD' team is multi-award winning research team with access to world-class experimental and numerical research facilities. The team is actively involved in high-profile research and industrial projects and produces several high-quality publications per year. The consultancy and training division of ManchesterCFD team has been involved in numerous industrial and academic projects and has conducted several specialist training in different aspects of modelling and simulation.

Computational Fluid Dynamics (CFD)

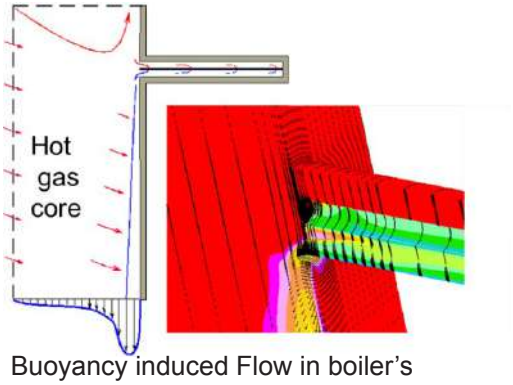
CFD is a process of representing a fluid flow problem by mathematical equations based on the fundamental laws of physics and solving those equations to predict the variation of the relevant parameters within the flow field. Usually the parameters which are solved in CFD are velocity, pressure, temperature and other variables such as turbulence parameters and concentrations of chemical species. Therefore, CFD can provide a cost-effective and accurate alternative to scale model testing. Recent advances in computing power together with powerful graphics and interactive 3D manipulation of models mean that more complex flow problems can be simulated using CFD.

Extensive Industrial Experience

In addition to conducting world-class fundamental research, the ManchesterCFD regularly works with numerous companies in the UK and beyond in a wide range of sectors. Some of the companies which have recently worked on research and consultancy projects with ManchesterCFD team are listed below.

HEAT TRANSFER

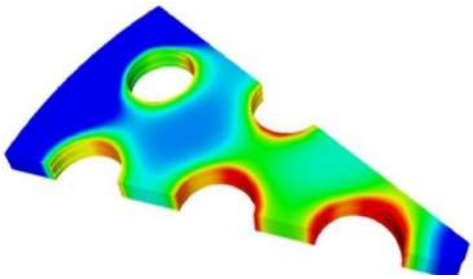
ENERGY



Buoyancy induced Flow in boiler's penetration cavity

Company: EDF Energy, UK

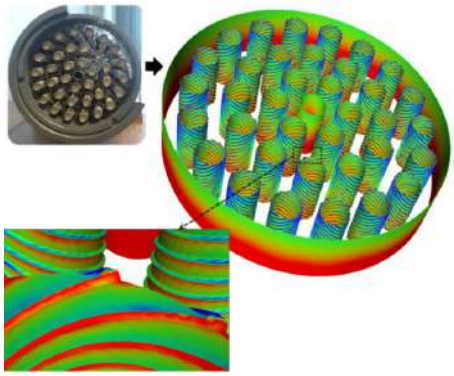
NUCLEAR



Heat transfer analysis of the CO2 coolant in reactor core flow

Company: British Energy, UK

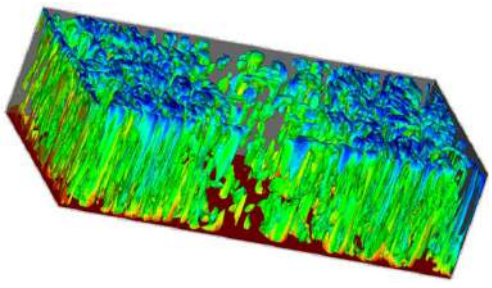
NUCLEAR



Modelling of coolant flow in advanced gas-cooled reactors

Company: Dalton Nuclear Institute, UK

ENERGY



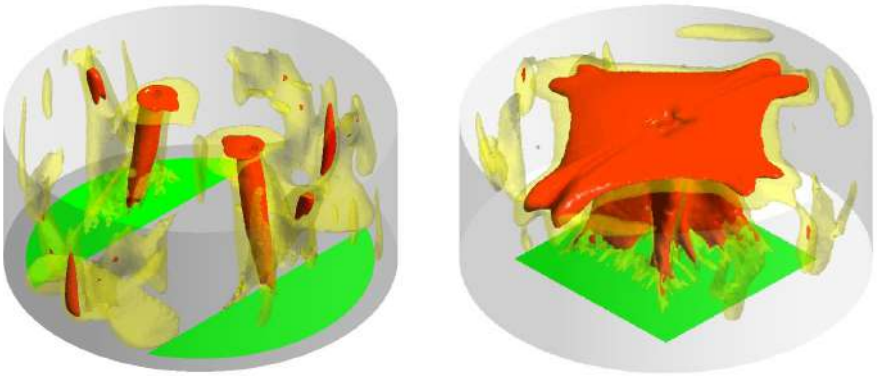
Heat transfer in an inclined cavity simulated by three different CFD Codes

Company: EDF Energy R&D UK Centre

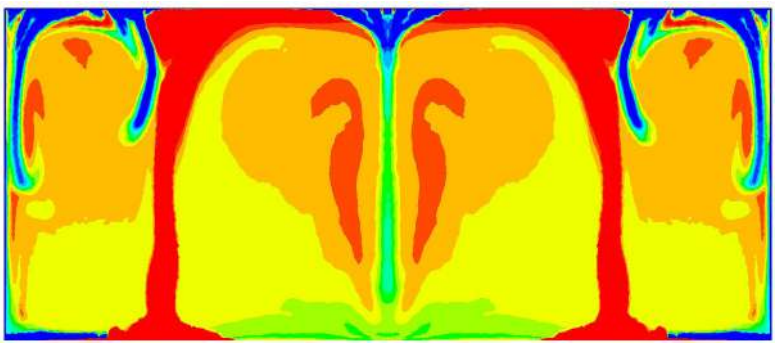
Project: CFD Simulation of Different Heating Elements in a Large Storage Tank

Company: Engie, UK

Brief Description: In this project, a large storage tank was to be simulated in order to design the most efficient heating element configuration. A very viscous fluid was maintained at a high temperature with continuous flow in and out of the tank. The aim was to maximise the natural convection within the tank, find the optimum heating element configuration, reduce the energy consumption and to find the best location to place the temperature probes within the tank. The simulations were successfully conducted for a number of designs and the most efficient configuration based on optimum heat transfer and velocity distributions were selected. All the hot and cold spots within the tank were also identified to provide the best locations to place the temperature probes. In addition, the effects of external wind on the tank was also taken into consideration when deciding on the best heating element configuration, to minimise energy consumption.



Velocity iso-surfaces at 2 different heating elements



Temperature contour and natural convection at the centre of a tank

Relevant ManchesterCFD Publications:

• Shamsabadi, H., Rashidi, S., Esfahani, J.A. & Keshmiri, A., 'Condensation in the presence of non-condensable gases in a convergent 3D channel', Int Journal of Heat and Mass Transfer, 152, 119511.

• Darbari, B., Rashidi, S. & Keshmiri, A., 'Nanofluid heat transfer and entropy generation inside a triangular duct equipped with delta winglet vortex generators', Journal of Thermal Analysis and Calorimetry, 140, 2020, 1045-1055.

• Akbarzadeh, M., Rashidi, S., Keshmiri, A. & Shokri, N., 'The Optimum Position of Porous Insert for a Double-Pipe Heat Exchanger Based on Entropy Generation and Thermal Analysis', Journal of Thermal Analysis and Calorimetry, 139, 2020, 411-426.

• Keshmiri, A., Revell, A. & Darabkhani, 'Assessment of a Common Non-Linear Eddy-Viscosity Turbulence Model in Capturing Laminarization in Mixed Convection Flows', Int. J. Numerical Heat Transfer; Part A, Vol. 69(2), 2016, 146-165.

• Dehghan, M., Shokri, N., Keshmiri, A., Valipour M.S. and Saedodin, S., 'On the Thermally Developing Force Convection Through A Porous Material Under the Local Thermal Non-Equilibrium Condition: An Analytical Study', Int. J. Heat and Mass Transfer, Vol. 92, 2016, 815-823.

• Keshmiri, A., Osman, K., Benhamadouche, S. & Shokri, N., 'Assessment of Refined RANS Models against Large Eddy Simulation and Experimental Data in the Investigation of Ribbed Passages with Passive Heat', Int. J. Numerical Heat Transfer; Part B, Vol. 69(2), 2016, 96-110.

• Keshmiri, A., Uribe, J. & Shokri, N., 'Benchmarking of Three Different CFD Codes in Simulating Natural, Forced and Mixed Convection Flows', Int. J. Numerical Heat Transfer; Part A, Vol. 67(12), 2015, 1324-1351.

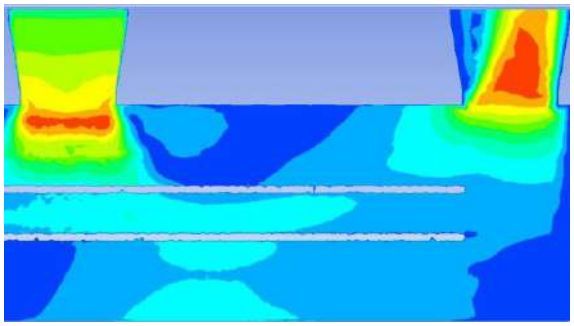
• Keshmiri, A., 'Verification and Validation of three Different CFD Codes in Simulating Natural and Mixed Convection Flows using Two Advanced Eddy-Viscosity Models', Proc. 15th Int. Heat Transfer Conference, 'IHTC-15', Kyoto, Japan, 10-15 Aug 2014, pp. 1-14.

• Keshmiri, A., Darabkhani, H.G., & Erfani, R., 'An Investigation into the Failure of a Non-Linear Eddy-Viscosity Model in Capturing the Laminarization Phenomenon', AIAA Journals; Computational Fluid Dynamics Series, 2013, 1-13, DOI: 10.2514/6.2013-2427.

• Keshmiri, A., 'Numerical Sensitivity Analysis of 3- and 2-Dimensional Rib-Roughened Channels', J. Heat and Mass Transfer, Vol. 48, 2012, 1257-1271.

MULTIPHASE FLOWS AND POROUS MEDIA

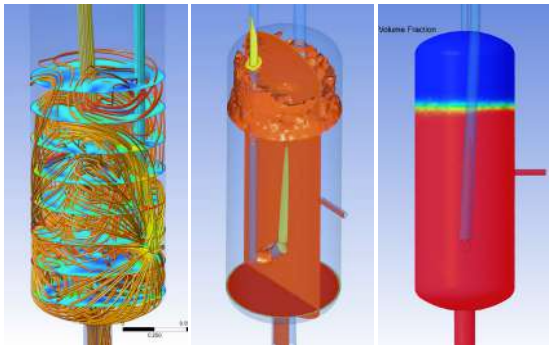
HEALTH&SAFETY



Simulation of an ultra-violet reactor designed for use in waste and clean water processing

Company: Xylem Water Solutions, UK

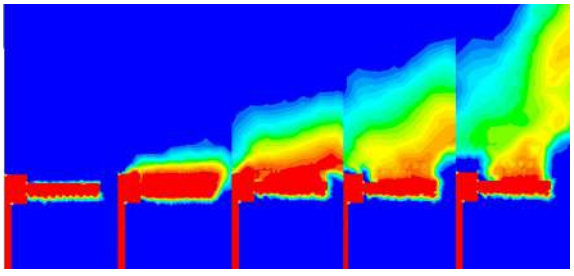
PETROCHEMICAL



Simulation and design optimisation of a large industrial mixing reactor.

Company: Ingevity, USA

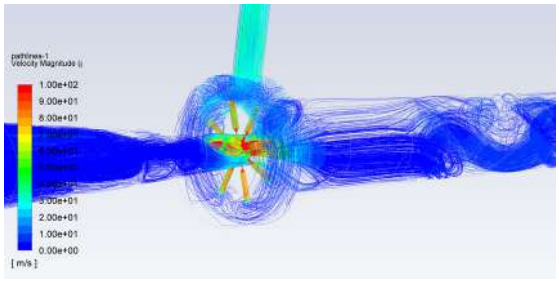
CHEMICAL



Simulation of Radial Gas Spargers in industrial bubble columns

Company: Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany

WATER&UTILITIES



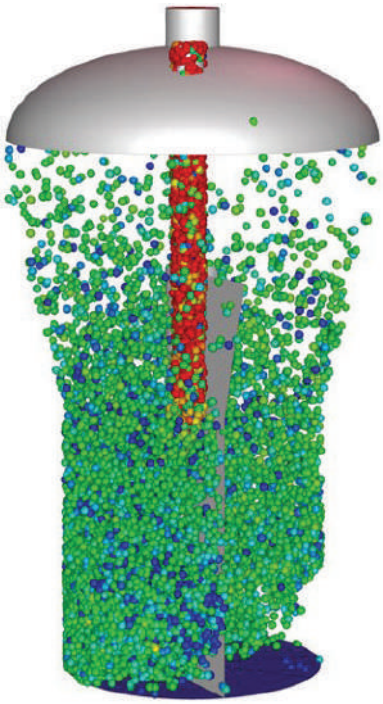
Simulation and design optimisation of a waste-water treatment line.

Company: Oxfiniti, UK

Project: Simulation and Optimisation of an Industrial-Scale Fluidised-Bed Dryer

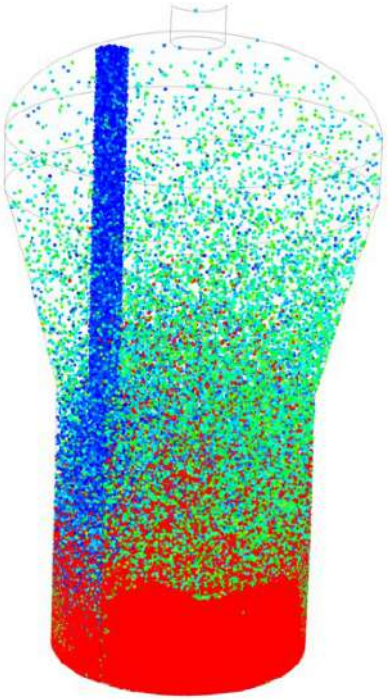
Company: SCG Chemicals, Thailand

Brief Description: For the first time, an industrial-scale Fluidised-Bed Dryer (FBD) for the largest petrochemical company in Thailand was simulated with an aim of obtaining key operating parameters such as temperature and velocity distributions, evaporation rate, moisture level within solid particles and residence time. The physics involved in such a large reactor is extremely complicated and involves multiphase flow, turbulence, heat transfer, evaporation and particle interaction, etc. Most of the methods and techniques used in this project have never been tried before and this project represents the most comprehensive and successful simulation of a fluidised-bed reactor with an industrial-scale application.



Particle diameter distribution

Static pressure iso-surfaces



Particle residence time

Relevant ManchesterCFD Publications:

• Rad, M.N., Shokri, N., Keshmiri, A. & Withers, P., 'Effects of Grain and Pore Size on Salt Precipitation During Evaporation from Porous Media: A Pore-Scale Investigation', J. Transport in Porous Media, Vol. 110(2), 2015, 281-294.

• Akbarzadeh, M., Rashidi, S., Keshmiri, A. & Shokri, N., 'The Optimum Position of Porous Insert for a Double-Pipe Heat Exchanger Based on Entropy Generation and Thermal Analysis', Journal of Thermal Analysis and Calorimetry, 2019 (DOI: 10.1007/s10973-019-08362-x).

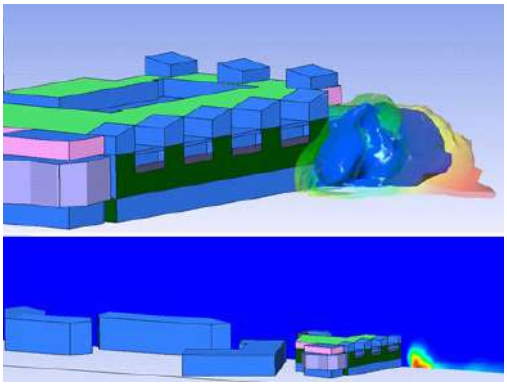
• Dehghan, M., Shokri, N., Keshmiri, A., Valipour M.S. and Saedodin, S., 'On the Thermally Developing Force Convection Through A Porous Material Under the Local Thermal Non-Equilibrium Condition: An Analytical Study', Int. J. Heat and Mass Transfer, Vol. 92, 2016, 815-823.

• Norouzi Rad, M., Shokri, N., Keshmiri, A. & Withers, P., 'Effects of Grain and Pore Size on Salt Precipitation during Evaporation from Porous Media: A Pore-Scale Investigation', Petroleum Abstracts, Vol. 56(7), 2016, 101.

• Shokri, N., Zhou, P. & Keshmiri, A., 'Patterns of Desiccation Cracks in Saline Bentonite Layers', J. Transport in Porous Media, 2015, Vol. 110(2), 2015, 333-344.

HEATING, VENTILATION & AIR-CONDITIONING (HVAC)

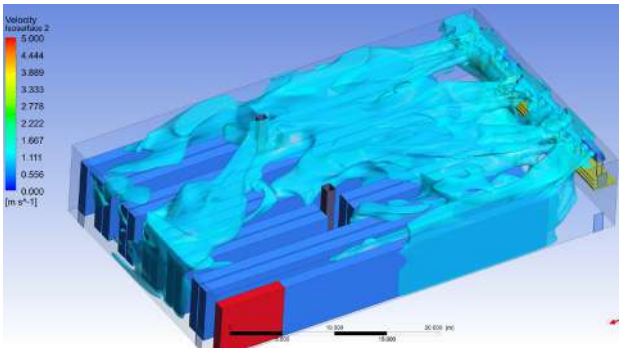
BUILDING SERVICES



Effects of wind on smoke ventilation from a large commercial carpark

Company: McAleer&McGarrity, Ireland

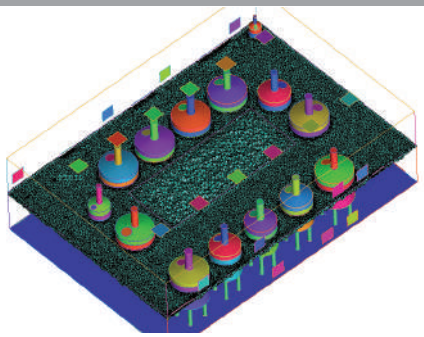
PHARMACEUTICAL



Simulation of the refrigeration system in a large cold store for pharmaceutical application

Company: Piggott&Whitfield Ltd, UK

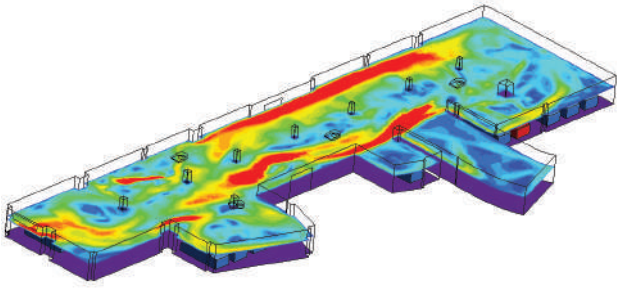
HEALTH&SAFETY



Flow simulation of a cleanroom laboratory

Company: Medical Simulation Ltd, UK

BUILDING SERVICES



Smoke ventilation modelling in a large public car park

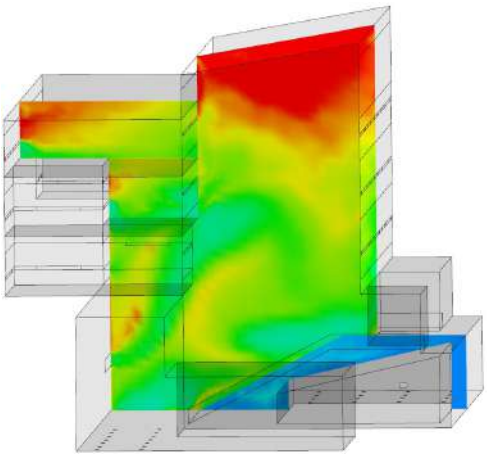
Company: Tourdan Ltd, UK

Project: Ventilation System Design for a Large Academic Building

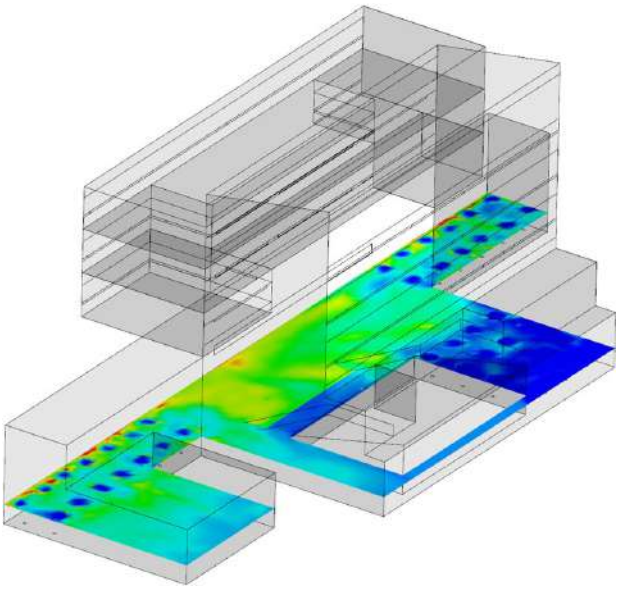
Company: Manchester Metropolitan University, UK

Brief Description: The ventilation system within the Birley Field Academic building (now Brooks Building) at Manchester Metropolitan University (MMU) was designed and modelled using state-of-the-art computational facilities. The aim was to reduce the energy consumption by improving the natural ventilation throughout the building using innovative designs. Our team carried out a number of detailed CFD simulations of the air flow for different atrium designs and scenarios which included different seasons and different occupancies, etc. This project involved a meticulous design of three different atria at different elevations, built to face the prevailing south-westerly wind in Manchester. Environmental Impact Assessment of this building was also evaluated using wind microclimate analysis.

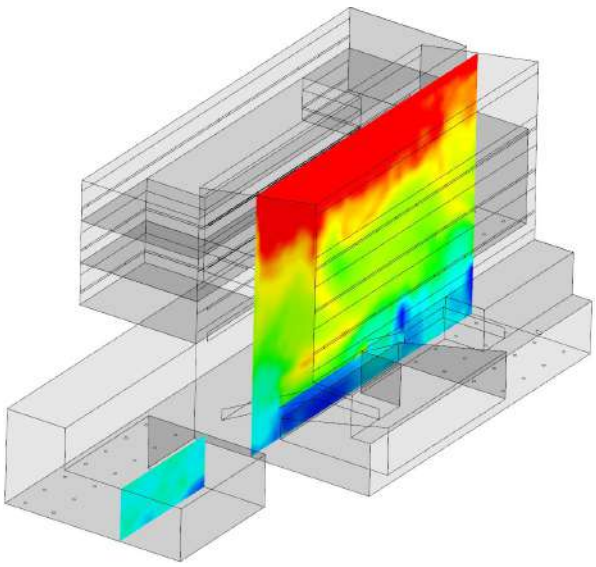
Schematic of the Birley Field academic building in Manchester



Temperature distribution and natural ventilation in an atrium



Velocity distribution within the ground floor and the main foyer



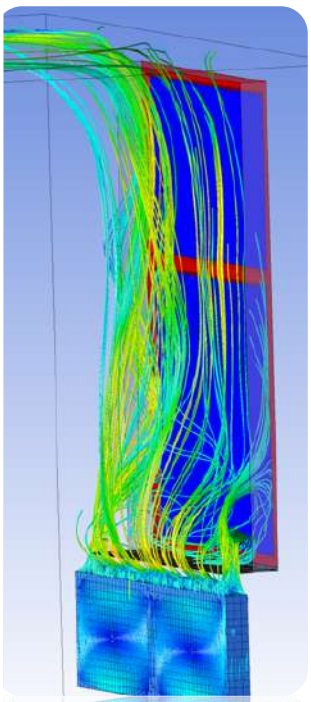
Temperature distribution within the first atrium

Project: Simulation, Validation and Design Optimisation of 'Thermocill™'

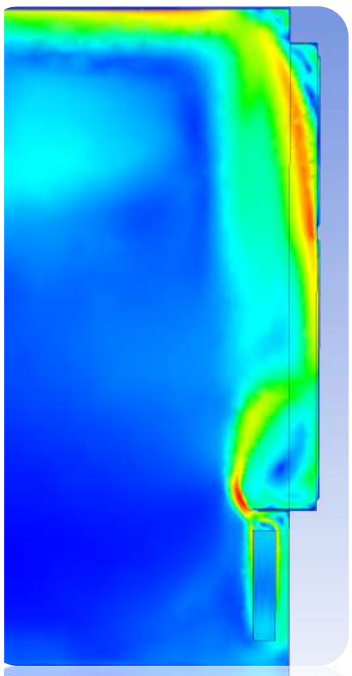
Company: Thermocill, UK

Brief Description: Thermocill is an energy savings product that is designed for installation under the window board and above the radiator in a room. It is made from recycled plastic materials and can be retrofitted to existing homes as well as new builds. In its operation, the product tends to direct the natural convection from the radiator to create a wall of warm air immediately in front of the internal side of the glazed window. In this project, the performance of the Thermocill was investigated based on the previously designed experimental condition. The main aim of the CFD simulation was to assess Thermocill's effectiveness in a typical bedroom consisting of a radiator, a double-glazed window and a door. Several high-fidelity and transient simulations were conducted to reproduce the experimental conditions and to provide an insight into the details of Thermocill's operation, particularly near the window. Subsequently, a design optimisation on several geometrical aspects of Thermocill were carried out. The CFD simulations successfully reproduced the experimental data and led to major changes in Thermocill's design.

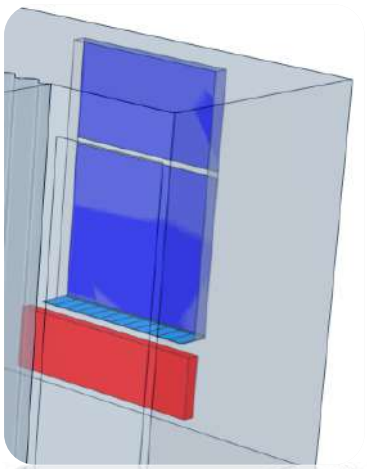
Experimental setup



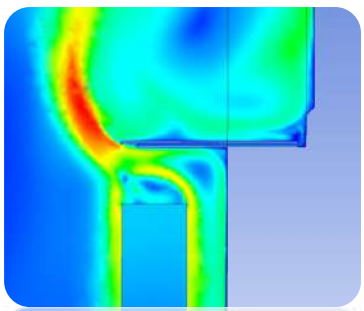
Velocity streamlines around Thermocill



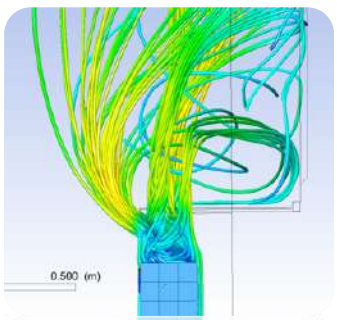
Computational simulations of the hot air velocity and formation of a thermal layer on the window



Computational Model



Velocity Distribution

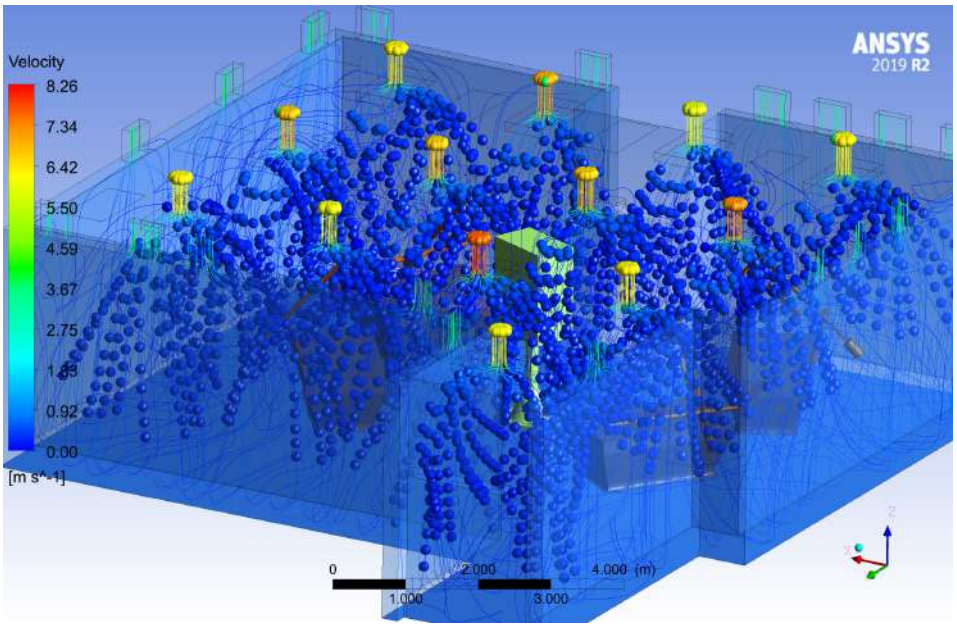


Velocity Streamlines

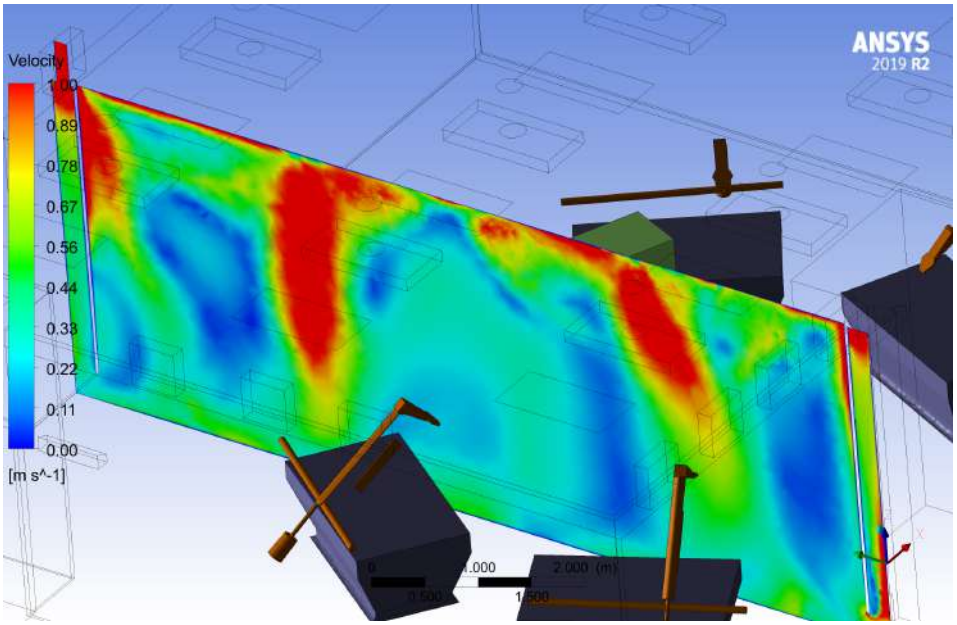
Project: Simulation and Design Optimisation of a Cleanroom Ventilation

Company: Rolls-Royce, UK

Brief Description: The main aim of this project was to investigate the impact of making significant changes to the locations of various components in the ceiling of a large cleanroom. Two different scenarios were carefully modelled, designed and simulated by ManchesterCFD and the efficiency of the ventilation system for both scenarios was assessed. In order to determine the ventilation performance in a cleanroom, details of all filters and all inlets/outlets had to be modelled in detail and the assessment on the performance was carried out using a range of innovative metrics including statistical analysis of individual units within the cleanroom, air freshness in different sections and particle tracking. The changes proposed by Manchester-CFD were subsequently implemented in the cleanroom by the client.



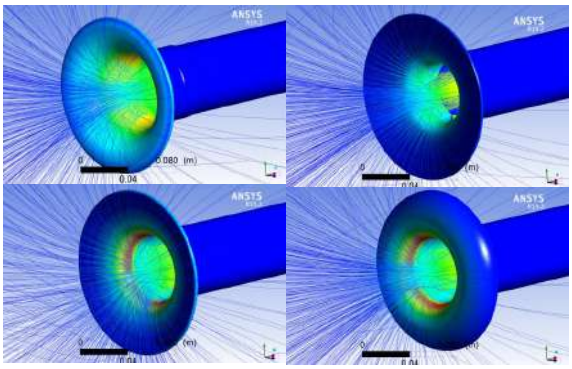
Velocity steamlines showing flow pattern from each inlet



Velocity distribution on a vertical plane across the cleanroom

DESIGN OPTIMISATION

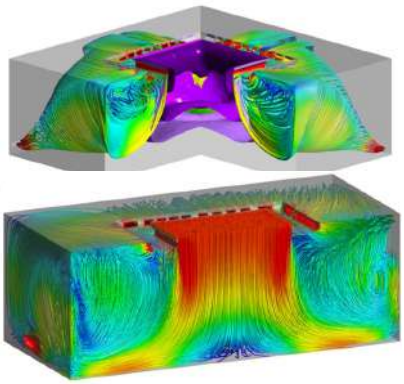
MANUFACTURING



Optimisation of a Local Exhaust Ventilation (LEV) system

Company: AEM Products, UK

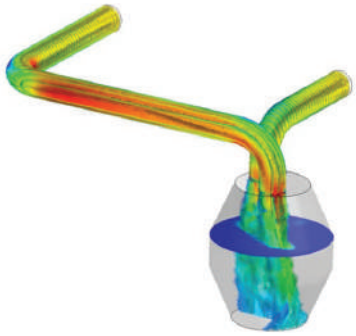
HEALTHCARE



Utilising novel fluid mechanics concept in ultra clean ventilation design for hospitals

Company: Medical Air Technologies, UK

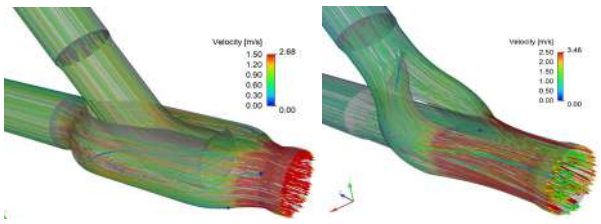
AUTOMOTIVE



Design optimisation of a dual stream engine exhaust system

Company: Ener-G, UK

WATER&UTILITIES



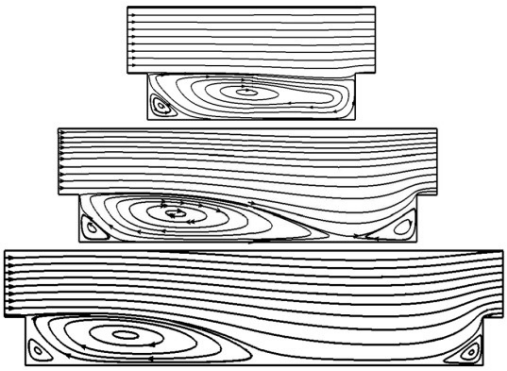
Design and optimisation of an innovative Y-Branch connection pipe

Company: Engmaster Ltd, UK

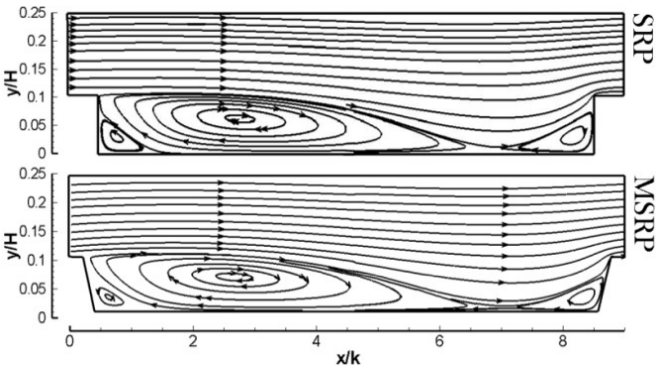
Project: Simulation of AGR Core Flows and Carbon Deposition

Company: British Energy/EDF Energy, UK

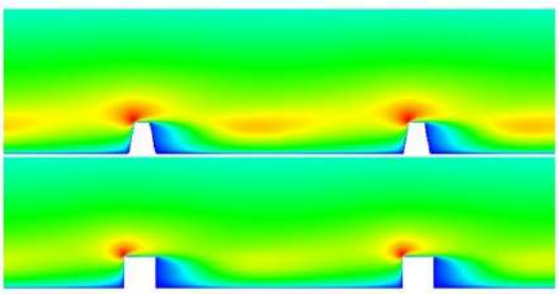
Brief Description: Advanced Gas-cooled Nuclear Reactors (AGRs) are the second generation of British gas-cooled reactors and there are currently seven of them in the UK, all owned and operated by EdF Energy. The core of AGRs consists of hundreds of fuel pins containing the nuclear fuel pellets. The surfaces of these fuel pins are rib-roughened to enhance heat transfer. One of the major operational problems with the AGR fuel pins is associated with the carbon particle deposition between the rib which results in heat transfer impairment and in turn higher fuel pin temperatures. The aim of this project was to analyse the thermal-hydraulic effects of carbon depositions on fuel pins within AGR cores. These depositions represent a major operational problem and result in a reduction in AGR's efficiencies. The outcome of this project led to several journal publications and played an important role in British Energy's understanding of the problem and taking appropriate actions which led to a significant life extension of the AGR stations.



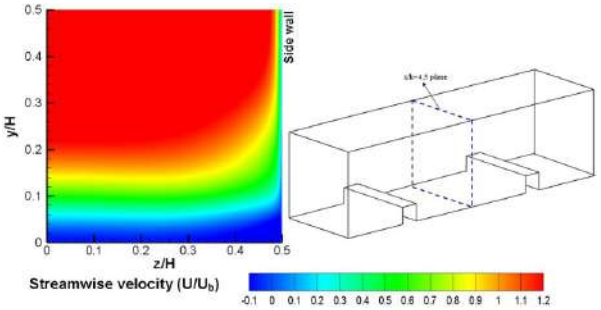
Effects of spacing between the ribs on flow and carbon deposition



Effects of carbon deposition around the rib



Turbulent Kinetic Energy distribution for 2 different configurations



Spanwise velocity distribution in the 3D ribbed channel

Relevant ManchesterCFD Publications:

• McElroy, M., Ruiz-Soler, A. & Keshmiri, A., 'Left Ventricular Assist Devices: Impact of Flow Ratios on The Localisation of Cardiovascular Diseases Using Computational Fluid Dynamics', J. Procedia CIRP, Vol. 49, 2016, 163-169.

• Ruiz-Soler, A., Kabinejadian, F., Slevin, M.A., Bartolo, P.J. & Keshmiri, A. 'Optimisation of a Novel Spiral-Inducing Bypass Graft Using Computational Fluid Dynamics', Nature (Scientific Reports) 7:1865, 2017.

• Keshmiri, A., Ruiz-Soler, A., McElroy, M. & Kabinejadian, F., 'Numerical Investigation on The Geometrical Effects of Novel Graft Designs for Peripheral Artery Bypass Surgery', J. Procedia CIRP, Vol. 49, 2016, 147-152.

• Erfani, R., Keshmiri, A., Erfani, T. & Kontis, K., 'Multiple Encapsulated Electrode Plasma Actuators Effect on Aerofoil-Wake Interaction', AIAA Journals; Plasmadynamics and Lasers Series, 2013, 1-9, DOI: 10.2514/6.2013-2884.

• Keshmiri, A., 'Numerical Sensitivity Analysis of 3- and 2-Dimensional Rib-Roughened Channels', J. Heat and Mass Transfer, Vol. 48, 2012, 1257-1271.

• Keshmiri, A. & Gotts, J., 'Thermal-Hydraulic Analysis of Four Geometrical Design Parameters on Fuel Pins in AGR Core Flows', Int. J. Numerical Heat Transfer; Part A, Vol. 60, 2011, 305-327.

• Keshmiri, A., 'Effects of Various Physical and Numerical Parameters on Heat Transfer in Vertical Passages at Relatively Low Heat Loading', ASME J. Heat Transfer, Vol. 133, 2011, p. 092502-1.

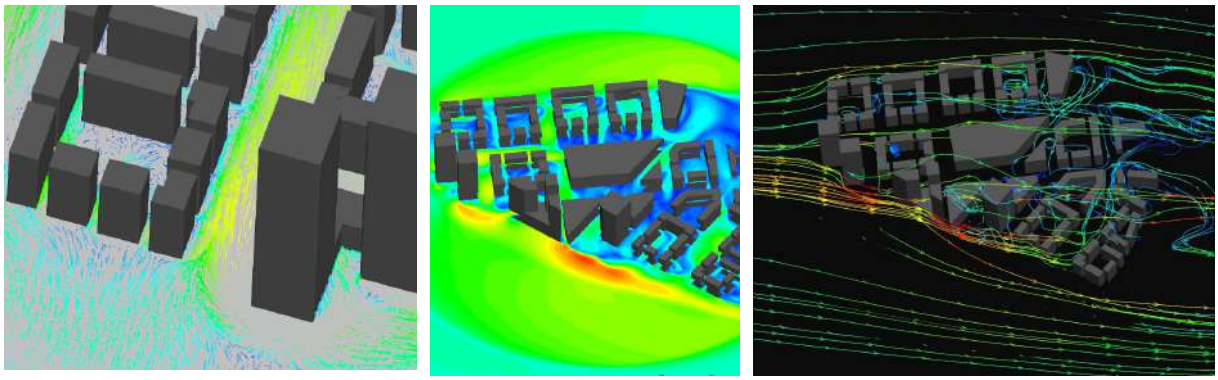
ENVIRONMENTAL IMPACT ASSESSMENTS

ENVIRONMENTAL

Modelling Urban Heat Island (UHI) effects in built-up districts and cities

Company: AECOM, UK

URBAN DESIGN



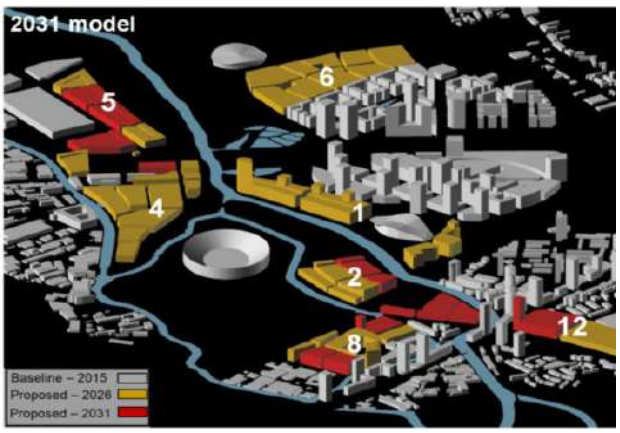
Wind simulation to assess pedestrian comfort in a built-up area

Company: Manchester City Council, UK

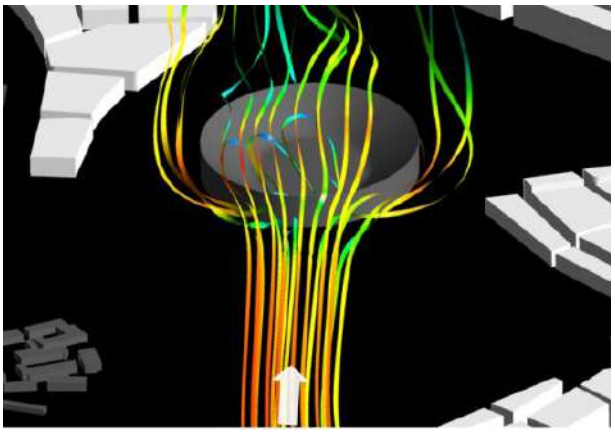
Project: Large Scale Ventilation and Wind Microclimate Analysis of London Legacy Development Masterplan

Company: London Legacy Development Corporation, UK

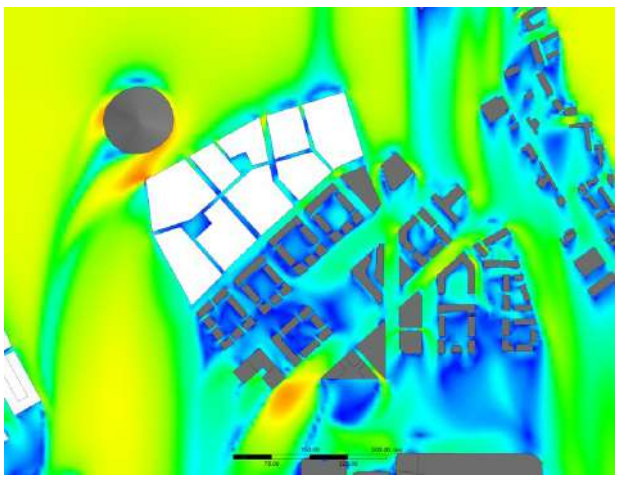
Brief Description: It is somewhat inevitable that, with the construction of new developments, the wind microclimate in the vicinity of the site(s) will be altered. Where new buildings are significantly different in size, form, orientation or height from those in the immediate vicinity, winds can be introduced which may cause discomfort to pedestrians. This project simulates the large scale ventilation and wind microclimate around the Queen Elizabeth Olympic Park and its legacy master plan which includes numerous buildings and developments across a large area. The computational model in this project represents one of the most complicated configurations ever attempted by computer simulations. The Team successfully simulated this masterplan and provided important input into the urban design in this large part of London in order to minimise environmental impact and pedestrian discomfort.

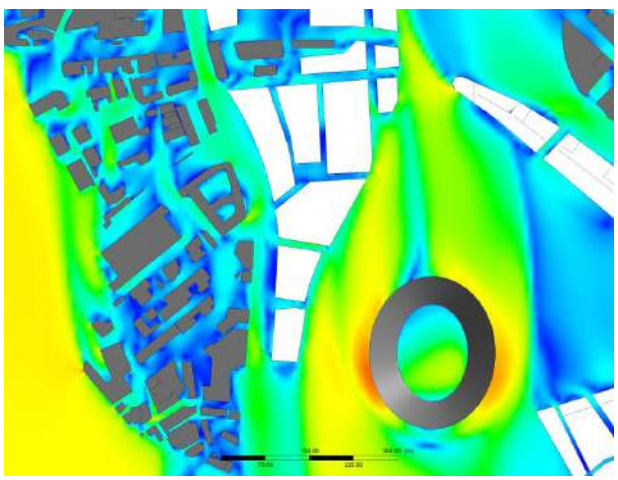


Schematic of the Queen Elizabeth Olympic Park Legacy master plan



Streamlines within the main structures to identify locations to apply mitigating techniques against strong wind levels





Large scale wind microclimate and extreme wind levels around several developments and structures

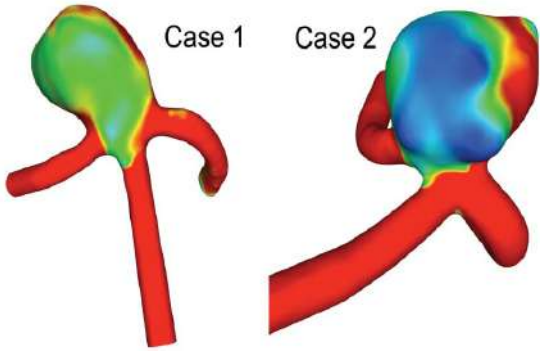
Relevant ManchesterCFD Publications:

• Hassani, A., Azapagic. A., D'Odorico, P., Keshmiri, A. & Shokri, N. 'Desiccation crisis of saline lakes: A new decision-support framework for building resilience to climate change', Science of the Total Environment, 703, 2020, 134718

• Hosseinzadeh, A., Shokri, N. & Keshmiri, A, 'The Role of Turbulence Models in Simulating Urban Microclimate', Proceedings of the 16th UK Heat Transfer Conference (UKHTC2019), 8-10 Sep 2019, Nottingham, UK

BIOMEDICAL ENGINEERING

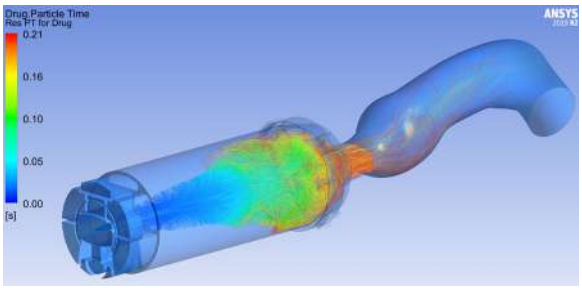
MEDICAL DEVICE



Development of a new biocompatible treatment for intracranial aneurysms

Company: Cardiovascular Institute of Cataluña, Spain

MEDICAL DEVICE



Simulation of a Valved Holding Chamber (HVC) to be used with inhalers

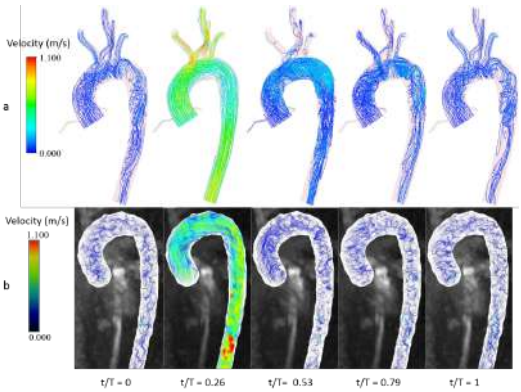
Company: Inhaler+, UK

CARDIOVASCULAR

Predicting regions prone to atherosclerosis in animal models using CFD

Company: Manchester Royal Infirmary, UK

CARDIOVASCULAR



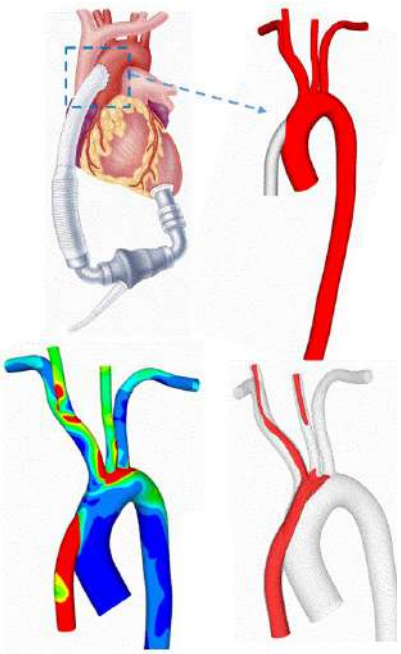
Modelling Atrial Fibrillation (AF) using CFD and comparison against 4D MRI

Company: Manchester Royal Infirmary, UK

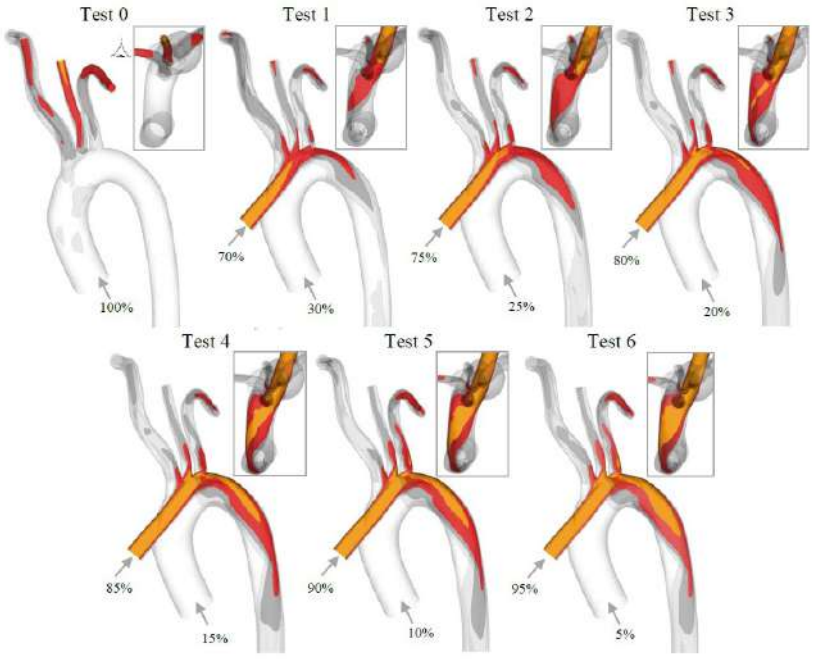
Project: Optimisation of a Left Ventricular Assist Device Cannula

Company: Medical Simulation Technologies Limited, UK

Brief Description: Heart failure is the leading cause of hospitalisation in people over 65. A left ventricular assist device (LVAD) is an option to provide mechanical circulatory support as a 'bridge to cardiac transplantation' or 'destination therapy'. The aim of this project was to assess the effects of different LVAD connection on the blood flow in order to find the optimum cannula connection. The other aim of this work was to assess the effects of LVAD on the severity of heart failure. In this project, a patient-specific configuration, obtained by MRI was converted into a computational model and accurate CFD simulations were carried out for different degree of heart failure. This project resulted in important findings about the surgical configuration and the design of LVAD cannulas.



The ventricular assist device configuration



Time-Averaged Velocity (VAT) distribution for different heart failure severity

Relevant ManchesterCFD Publications:

• Deyranlou, A., Naish, J.H., Miller, C.A., Revell, A. & Keshmiri, A., 'Numerical Study of Atrial Fibrillation Effects on Flow Distribution in Aortic Circulation', Annals of Biomedical Eng., 48 (4), 2020, 1291-1308.

• Satta, S., Mcelroy, M., Langford-Smith, A.W., Keshmiri, A., et al. 'High-Level Nrf2 Activation Promotes Endothelial Detachment-Implications for Acute Coronary Syndromes Triggered by Endothelial Erosion of Plaques', Journal of Vascular Surgery, 56, 2019, 1-71.

• McElroy, M. & Keshmiri, A., 'Impact of Using Conventional Inlet/Outlet Boundary Conditions on Haemodynamic Metrics in a Subject-Specific Rabbit Aorta', Journal of Engineering in Medicine, 232(2), 2018, 103-113.

• Ruiz-Soler, A., Kabinejadian, F., Slevin, M.A., Bartolo, P.J. & Keshmiri, A. 'Optimisation of a Novel Spiral-Inducing Bypass Graft Using Computational Fluid Dynamics', Nature (Scientific Reports) 7:1865, 2017.

• Kabinejadian, F., Ruiz-Soler, A., McElroy, M., Leo, H.L., Slevin, M., Badimon, L. & Keshmiri, A., 'Numerical Assessment of Helical/Spiral Grafts to Improve the Hemodynamics of Distal Graft Anastomoses', Plos One, Vol. 11 (11), 2016, 1-22.

• McElroy, M., Ruiz-Soler, A. & Keshmiri, A., 'Left Ventricular Assist Devices: Impact of Flow Ratios on The Localisation of Cardiovascular Diseases Using Computational Fluid Dynamics', J. Procedia CIRP, Vol. 49, 2016, 163-169.

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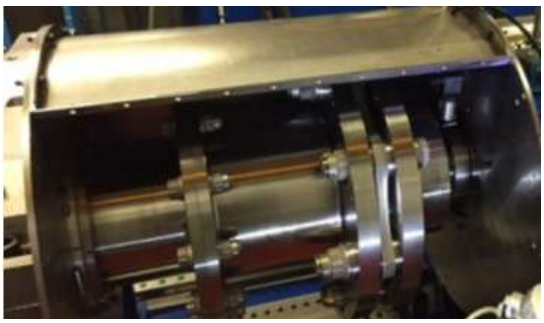
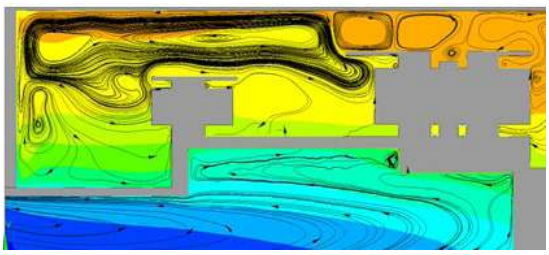
EXPERIMENTS & VALIDATION

AUTOMOTIVE

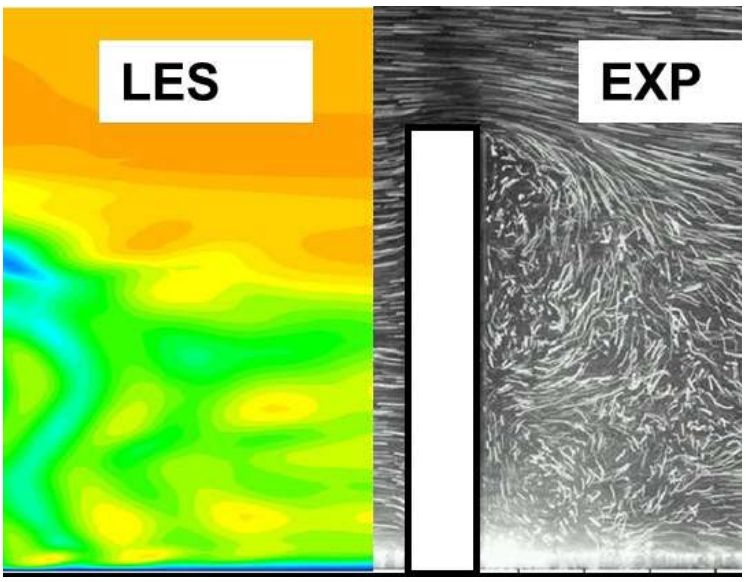




Modelling of automotive coupling systems and validation against experimental data.

Company: John Crane, UK

ENERGY



Computational and experimental analysis of heat exchanger baffles

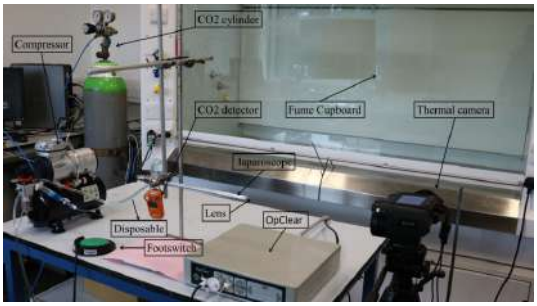
Company: Couette Ltd, UK

Project: Optimisation of a Disposable Design for Cleaning Laparoscope Lenses

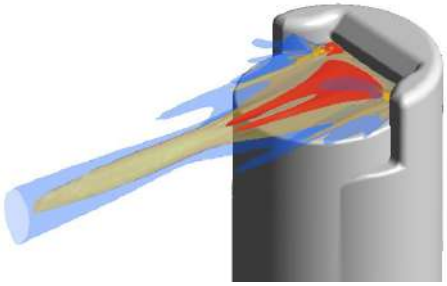
Company: Cipher Surgical, UK

Brief Description: Laparoscopic surgery requires continuously clear vision throughout a procedure. Cipher Surgical has designed a unique device that will clear a laparoscope lens of all fogging, soiling and fluid without removing the scope from the patient for cleaning. The device is a single use disposable sheath and tube set that attaches to the laparoscope. The Disposable is connected to the OpClear® Control Unit that directs carbon dioxide (CO2) and saline into the sheath and across the tip of the laparoscope. ManchesterCFD has conducted several computational simulations and have validated their results using different experimental methods with an aim of improving the performance of the disposable and design new types of disposable to fit on a wide range of laparoscopes. The simulations in this project required meticulous assessment of the saline and CO2 with accurate boundary conditions. Different image processing techniques used to provide a validation tool for the computational simulations.

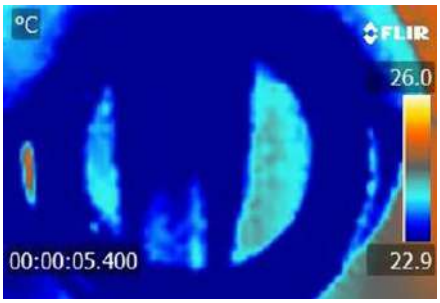
Schematic of the product modelled and optimised by the ManchesterCFD team



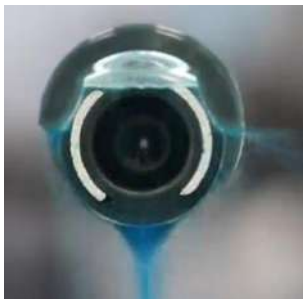
The experimental setup used for validation tests



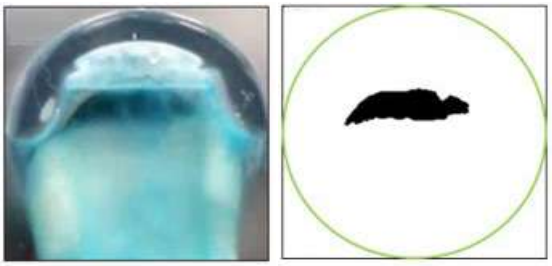
Computational simulations showing velocity iso-surfaces on the surface of the lens



Flow pattern analysis using thermal cameras



Flow analysis using high-speed cameras



High-resolution image processing techniques using customised computer codes

Relevant ManchesterCFD Publications:

• Keshmiri, A., Osman, K., Benhamadouche, S. & Shokri, N., 'Assessment of Refined RANS Models against Large Eddy Simulation and Experimental Data in the Investigation of Ribbed Passages with Passive Heat', Int. J. Numerical Heat Transfer; Part B, Vol. 69(2), 2016, 96-110.

• Thompson, A., Zhai, T., Palazzolo, A. & Keshmiri, A., 'Coupling Guard Temperature and Windage Power Loss: CFD Analysis and Experiments', Proc. 45th Turbomachinery and 32nd Pump Symposia, Houston, Texas, 12-15 Sep 2016.

• Keshmiri, A., Uribe, J. & Shokri, N., 'Benchmarking of Three Different CFD Codes in Simulating Natural, Forced and Mixed Convection Flows', Int. J. Numerical Heat Transfer; Part A, Vol. 67(12), 2015, 1324-1351.

• Keshmiri, A., 'Verification and Validation of three Different CFD Codes in Simulating Natural and Mixed Convection Flows using Two Advanced Eddy-Viscosity Models', Proc. 15th Int. Heat Transfer Conference, 'IHTC-15', Kyoto, Japan, 10-15 Aug 2014, pp. 1-14.

• Darabkhani, H.G., Oakey, J., Zhang, Y. & Keshmiri, A., 'Study of the Flame Structure and Dynamics Using Non-intrusive Combustion Diagnostic Techniques', AIAA Journals; Fluid Dynamics Series, 2013, 1-8, DOI: 10.2514/6.2013-2605.

INNOVATIVE COMMERCIAL PRODUCTS

HeliRidgeGraft

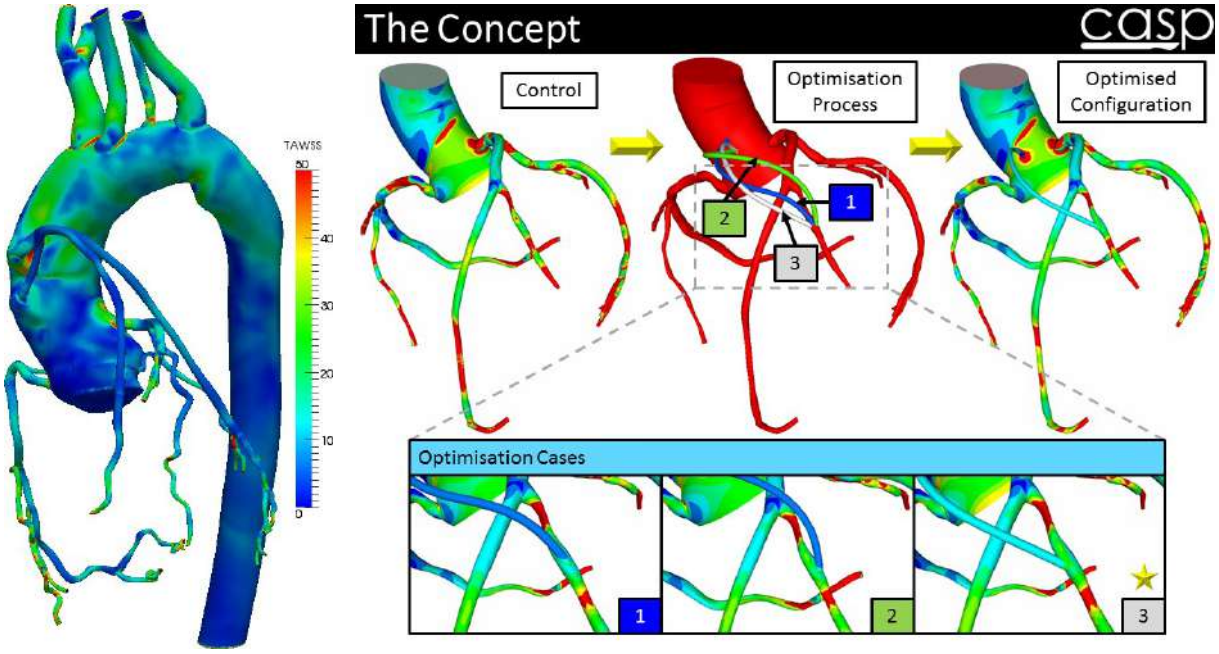
Project: Development of a Revolutionary Bypass Graft (HeliRidgeGraft)

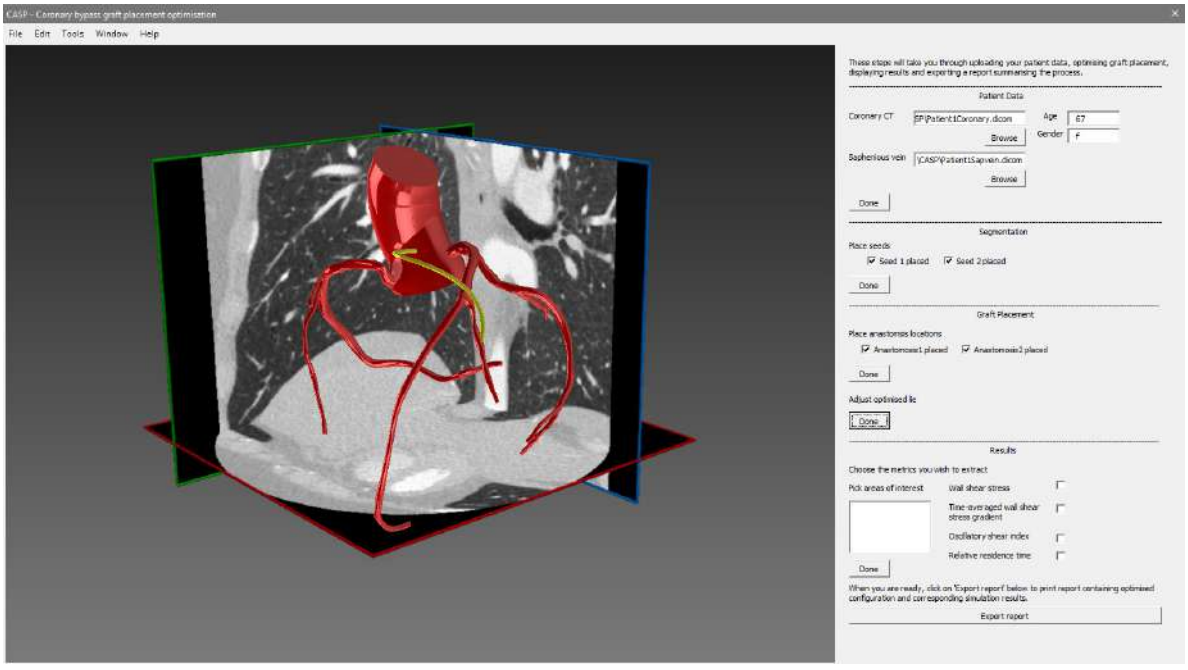
Brief Description: This multidisciplinary project led by ManchesterCFD team has integrated fluid mechanics, biomechanics and biology with cardiovascular surgery to develop a ground-breaking biomedical device, inspired by the nuclear engineering sector. Instead of conventional straight tubes, this novel graft design is based on inducing rotational/helical flow in the bypass graft through a combination of out-of-plane helicity and an internal ridge. The induced helical flow significantly enhances the hemodynamic condition around the junction, hence improving the longevity of the bypass operation. This design improves the longevity of the graft as it tends to retain the natural 'spiral flow' in the artery which is caused by the rotational compressive pumping of the heart and supported by the tapered, curved and non-planar geometry of the arterial system. This project attracted global interest and has received a number of prestigious awards.

www.HeliRidgeGraft.com

Project: Developing the 'First Computer-Aided Surgical Planning' (CASP) Platform

Brief Description: ManchesterCFD has developed a computer software called CASP that uses advanced CFD and medical image processing tools to assist cardiologists and cardiothoracic surgeons with daily clinical practice when planning the optimal placement of grafts used during heart bypass surgery. CASP Technologies Limited was set up in 2018, as a University spinout from research carried out by ManchesterCFD in collaboration with University Teaching Hospital Trust. The software enables tailored treatment for patients and significantly improves the clinical outcomes. This project has so far received grants from prestigious funding organisations such as UK Research Councils (MRC & EPSRC) and has attracted a lot of interest from the medical and engineering communities.





www.theCASP.com

EXPERIMENTAL FACILITIES & TRAINING

In addition to High Performance Computing (HPC) facilities, our group also has exclusive access to wind tunnel facilities at the University of Manchester, which cover the speed range from subsonic to hypersonic flow. The team also has access to the instrumentation and technical skills to undertake both force, and high-quality point, surface, and field measurements for various aerodynamics applications.

The Boundary Layer Tunnel

The “Bob” Wind Tunnel

ManchesterCFD has organised and attended numerous national and international scientific workshops and events in the broad area of CFD and its industrial applications. In addition, ManchesterCFD team offers a range of intensive and customised training courses for companies in various simulation tech-

- Ansys Fluent
- Ansys CFX
- ICEM-CFD
- Ansys Mechanical
- COMSOL
- STAR-CCM+
- Solidworks
- Matlab
- OpenFOAM

Examples of previous training adn workshops organised by ManchesterCFD in different countries

Dr Amir Keshmiri *BEng MSc PhD CEng FHEA FIMechE MIPEM*

- Associate Professor in Computational Fluid Dynamics at the University of Manchester
- Director of ManchesterCFD Team at the University of Manchester
- Head of Faculty Business Engagement at the University of Manchester

Dr Amir Keshmiri is an Associate Professor in Computational Fluid Dynamics in the Department of Mechanical, Aerospace and Civil Engineering (MACE). He is also the Head of Business Engagement in the Faculty of Science&Engineering at the University of Manchester, UK. Amir received his BEng (2005), MSc (2006) and PhD (2010) in Mechanical Engineering from the University of Manchester in collaboration with British Energy and Électricité de France (EdF) R&D in Paris. Following the completion of his PhD, Amir received a prestigious research fellowship to extend his collaboration with industrial partners in the field of heat transfer and thermofluids. He was then invited to lead a CFD team at AECOM, one of the largest engineering consultancy companies in the world. Amir returned to academia as a Lecturer/Senior Lecturer at Manchester Metropolitan University (MMU) and in 2016, he returned to the University of Manchester as an Assistant Professor and Director of Business Engagement.

To date, Amir has been the recipient of numerous prestigious awards and honours, some of the recent examples include the ‘UK Research Council’s (EPSRC) Doctoral Prize’ in 2010, ‘Institution of Mechanical Engineers (IMechE) Thomas Common Award’ in 2013, University’s ‘Rising Star’ award in 2014, and ‘Best Supervisor of the Year’, IMechE’s ‘Young Mechanical Engineer of the Year’ award in 2015, ‘Collaborate to Innovate’ award in 2017 by ‘The Engineer’ magazine, the ‘Frontiers of Innovation in Engineering' by Royal Academy of Engineering (RAEng) in 2018 and the ‘Making a Difference’ award by the University of Manchester in 2019.

Amir is a ‘Chartered Engineer’ and ‘Fellow’ of IMechE. In 2017, in the general election, he was elected as a 'Council Member' of the IMechE for 3 years. IMechE is one of the largest Mechanical Engineering Institutes in the world with over 130,000 members in over 80 different countries. Amir is also an associate editor of the Journal of Research on Biomedical Engineering, published by Nature Springer.

Dr Amir Keshmiri and ManchesterCFD team members have received numerous prestigious awards including:

- Winner of ‘Making a Difference’ Award – University of Manchester (May 2019)
- Winner of 'Frontiers of Development in Engineering' Award – Royal Academy of Engineering (Dec 2018)
- Winner of the 'Collaborate to Innovate' Award - The Engineer (Aug 2017)
- Elected as the 'Council Member - Fellow' – Institution of Mechanical Engineers (IMechE) (May 2017)
- Elected as the 'Fellow of IMechE - FIMechE' – Institution of Mechanical Engineering (July 2016)
- Winner of the ‘Best Supervisor of 2015’ Award – MMU Teaching Awards (June 2015)
- Winner of the ‘Young Mechanical Engineer of the Year’ – IMechE (Apr 2015)
- Winner of the ‘Rising Star’ Staff Award – MMU Staff Awards (June 2014)
- Winner of ‘Thomas Andrew Common' Award – IMechE (May 2013)
- Winner of the ‘Best Photo for the Art of Science’ competition – MMU (Apr 2012)

ROYAL ACADEMY OF ENGINEERING

Manchester Metropolitan University

TEACHING AWARDS

EPSRC
Engineering and Physical Sciences Research Council

Institution of MECHANICAL ENGINEERS

MANCHESTER 1824
The University of Manchester

theENGINEER

MAKING A DIFFERENCE

PROFESSIONAL MEMBERSHIPS

Through official membership of the Mechanical Engineering Institutes in UK and US, all our projects and procedures at ManchesterCFD follow the code of conduct/ethics set out by the UK Institution of Mechanical Engineers (IMechE) and American Society of Mechanical Engineers (ASME). ManchesterCFD is also a member of the International Association Engineering Modelling (NAFEMS), which is a recognised independent authority for sharing and monitoring best practice guidelines for engineering modelling, analysis, and simulation practices.

UNIQUE FEATURES OF OUR SERVICES

Here is a list of the main advantages of working with 'ManchesterCFD' compared to other consultancy companies:

- World-Leading Scientists: A number of multi-award winning engineers and scientists at the ManchesterCFD team will be working on this project, all with numerous world-leading publications and patents.
- Highly Technical/Scientific Report: ManchesterCFD will provide a highly technical/scientific report which can later be used for patents, auditing, marketing and other R&D purposes.
- Future Funding Opportunities: ManchesterCFD is heavily R&D driven and therefore can act as a research partner for future funding opportunities (e.g. InnovateUK, EU, etc) to develop further research, if required.
- Access to Original Simulation Files: All the simulation files and original datasets could be provided to the Company following the completion of the project which would allow the Company to run further tests in-house, should they wish.

SELECTED R&D PUBLICATIONS

- Shamsabadi, H., Rashidi, S., Esfahani, J.A. & Keshmiri, A., 'Condensation in the presence of non-condensable gases in a convergent 3D channel', Int Journal of Heat and Mass Transfer, 152, 119511.
- Hassani, A., Azapagic. A., D'Odorico, P., Keshmiri, A. & Shokri, N. 'Desiccation crisis of saline lakes: A new decision-support framework for building resilience to climate change', Science of the Total Environment, 703, 2020, 134718 (DOI: j.scitotenv.2019.134718).
- Darbari, B., Rashidi, S. & Keshmiri, A., 'Nanofluid heat transfer and entropy generation inside a triangular duct equipped with delta winglet vortex generators', Journal of Thermal Analysis and Calorimetry, 140, 2020, 1045-1055.
- Akbarzadeh, M., Rashidi, S., Keshmiri, A. & Shokri, N., 'The Optimum Position of Porous Insert for a Double-Pipe Heat Exchanger Based on Entropy Generation and Thermal Analysis', Journal of Thermal Analysis and Calorimetry, 139, 2020, 411-426.
- Deyranlou, A., Naish, J.H., Miller, C.A., Revell, A. & Keshmiri, A., 'Numerical Study of Atrial Fibrillation Effects on Flow Distribution in Aortic Circulation', Annals of Biomedical Eng., 48 (4), 2020, 1291-1308.
- Mashayekhi, R., Arasteh, H., Toghraie, D., Motaharpour, S.H., Keshmiri, A. & Afrand, M., 'Heat transfer enhancement of Water-Al2O3 nanofluid in an oval channel equipped with two rows of twisted conical strip inserts in various directions: A two-phase approach', Computers & Mathematics with Applications, 79 (8), 2020, 2203-2215.
- Satta, S., Mcelroy, M., Langford-Smith, A.W., Keshmiri, A., et al. 'High-Level Nrf2 Activation Promotes Endothelial Detachment-Implications for Acute Coronary Syndromes Triggered by Endothelial Erosion of Plaques', Journal of Vascular Surgery, 56, 2019, 1-71.
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- McElroy, M. & Keshmiri, A., 'Impact of Using Conventional Inlet/Outlet Boundary Conditions on Haemodynamic Metrics in a Subject-Specific Rabbit Aorta', Journal of Engineering in Medicine, 232(2), 2018, 103-113.
- Ruiz-Soler, A., Kabinejadian, F., Slevin, M.A., Bartolo, P.J. & Keshmiri, A. 'Optimisation of a Novel Spiral-Inducing Bypass Graft Using Computational Fluid Dynamics', Nature (Scientific Reports) 7:1865, 2017.
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- Kabinejadian, F., Ruiz-Soler, A., McElroy, M., Leo, H.L., Slevin, M., Badimon, L. & Keshmiri, A., 'Numerical Assessment of Helical/Spiral Grafts to Improve the Hemodynamics of Distal Graft Anastomoses', Plos One, Vol. 11 (11), 2016, 1-22.
- McElroy, M., Ruiz-Soler, A. & Keshmiri, A., 'Left Ventricular Assist Devices: Impact of Flow Ratios on The Localisation of Cardiovascular Diseases Using Computational Fluid Dynamics', J. Procedia CIRP, Vol. 49, 2016, 163-169.
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