EPSRC
Engineering and Physical Sciences
Research Council

UNIVERSITY OF LEEDS

EPSRC Centres for Doctoral Training
Poster Evening

Thursday 5th May 2016
17:15-18:45
University of Leeds

Contents

Welcome to the EPSRC Centres for Doctoral Training Poster Evening

Professor Peter Jimack
Dean of the Faculty of Engineering

The EPSRC Centres for Doctoral Training (CDT) at Leeds bring together diverse areas of expertise in order to train researchers to address a wide range of problems in engineering and physical science. They draw on world class and internationally recognised research across three Faculties and provide students with the knowledge and skills through which to address today's global issues and prepare them for future challenges. The Faculties of Engineering, Environment and Mathematics and Physical Sciences provide the following integrated MSc/PhD programmes, students from each programme will be showcasing their work:

- Bioenergy
- Complex Particulate Products & Processes (CP3)
- Fluid Dynamics
- Integrated Tribology
- Nuclear Fission – Next Generation Nuclear
- Tissue Engineering & Regenerative Medicine – Innovation in Medical & Biological Engineering

Poster Evening Overview

Welcome – Prof Claire Honess, Dean of Postgraduate Research Studies	17:15-17:25
2014 Cohorts' Team Project and 2015 Cohorts' PhD Project Posters	17:25-18:25
Poster Prizes	18:25-18:45

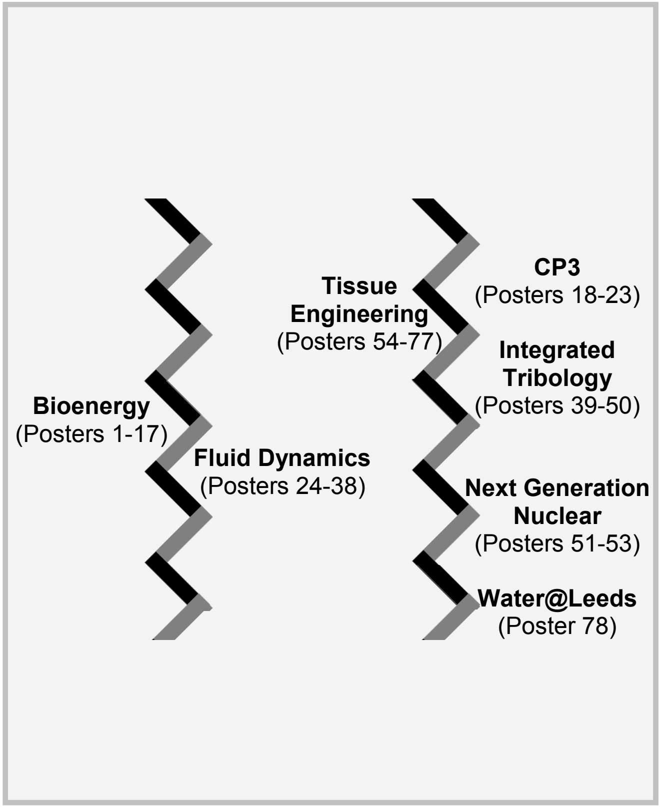
Prizes will be awarded to the best posters from the following 5 categories and will be judged by the below members of staff:

- Fluid Dynamics
- Bioenergy
- Tissue Engineering
- CP3, NGN and Tribology
- Overall prize

Judge	CDT	Group to Judge
Prof Harvey Thompson	Fluid Dynamics	Bioenergy
Dr Jim Young	NGN	Tissue Engineering
Prof Jenny Jones	Bioenergy	CP3, NGN and Tribology
Dr Claire Brockett	Tissue Engineering	Fluid Dynamics
Prof Claire Honess	N/A	Overall prize

Floor Plan

Venue: Level 5 Mechanical Engineering



Bioenergy 2014 Cohort

1. Diarmaid Clery **mn09dc@leeds.ac.uk**

Carbon-negative power generation using BECCS

Bioenergy is a carbon neutral alternative to fossil fuels. It is beginning to be trialled successfully as a replacement for coal in power stations such as Drax, in North Yorkshire. If bioenergy can be used with carbon capture and storage (CCS) technology it will permanently remove carbon dioxide from the atmosphere, whilst generating electricity.

We are already exceeding levels of carbon dioxide that have been identified as safe and recoverable by environmental scientists. Therefore this combination bioenergy and CCS could be an essential part of the energy mix needed to save our planet from the dangers of global warming.

The two technologies are beginning to be used on a large scale individually to reduce carbon dioxide emissions, however have not yet been combined to absorb carbon dioxide from the atmosphere. Therefore, my research looks at the potential for combining these two technologies. I am examining the possible effects that bioenergy by-products may have on the carbon capture process. This includes measuring the different gases and impurities released in the burning of biomass and assessing their effects on the chemicals used for the carbon dioxide capture process. I hope that this research will enable a smooth uptake of these combined technologies.

2. Luke Conibear **pmlac@leeds.ac.uk**

Quantifying the air quality impacts of solid fuel interventions in low and middle income countries

Combustion of solid fuels for cooking and heating is widespread across Low and Middle Income Countries (LMICs) with large but poorly quantified impacts on ambient air quality. Over the past 15 years there have been substantial changes in residential energy use due to electrification schemes and implementation of large-scale clean cookstove interventions. We investigate the impacts of changing residential solid fuel combustion over the period 2000 to 2015 on ambient particulate air quality. We synthesise information on the location and size of solid fuel interventions. We assess the impacts of such changes on air quality using the Weather Research and Forecasting Model with Chemistry (WRF-Chem) regional air quality model, remote aerosol monitoring networks, and satellite observations. Our study will inform the potential for solid fuel interventions to improve ambient air quality and human health.

3. Andrew Dyer **cm09acd@leeds.ac.uk**

Production of high quality bio-oil by catalytic upgrading of pyrolysis vapours from biomass and plastic wastes

This research aims to produce high quality bio-oils from biomass and plastic waste using catalytic upgrading of pyrolysis vapours. Biomass has the potential to replace fossil fuels for many applications if cost effective ways are developed to convert the material into a convenient form. For bio-oils this means the product needs to be stable, non-corrosive, of high energy density and a liquid with an appropriate viscosity and boiling point. These properties are often poor in bio-oils, produced by pyrolysis of biomass. This is mainly caused by a high proportion of oxygen in the compounds which make up the oil.

Catalytic upgrading can be used to increase the removal of oxygen and can also control the distribution of products collected from the pyrolysis process. Ideally hydrocarbon compounds in the range C5-C12 would be favoured with a low yield of polycyclic aromatic hydrocarbons.

The initial research will focus on the use of metal promoter modified zeolite catalysts for upgrading of bio-oil from pyrolysis of white wood pellets in a two stage fixed-bed reactor at temperatures around 500°C. At a later stage screw kiln and fluidised bed furnaces will be used for further research. Plastic and biomass co-pyrolysis will also be investigated to discover how C/H ratios affect the catalytic upgrading of bio-oils.

4. Gillian Finnerty **pmglf@leeds.ac.uk**

Analysis of process water following hydrothermal carbonisation of macroalgae

Hydrothermal carbonisation of macroalgae results in a process water rich in soluble organic hydrocarbons containing C6 sugars and organic acids. This study compares the composition of the process water from the processing of a kelp (Saccharina latissima), a microalgae (Chlorella Vulagaris) and a fucoid (Ascophyllum nodosum) following hydrothermal processing at different temperatures. Hydrothermal processing was performed using a high pressure batch reactor at temperatures ranging from 200-250oC. Analysis of the process water is challenging and a number of analytical techniques have been investigated to identify different compound classes. The methods included here involve NMR of the HTC process water samples diluted in deuterium oxide, and hence allow the comparison of the total sugar, polyphenolic and VFA content within the samples. This investigation has resulted in a greater understanding of the degradation routes of seaweed polymers under hydrothermal conditions and identified the potential for production of high value chemicals.

5. Oliver Grasham **ee11og@leeds.ac.uk**

Emission reductions at WWTPs via thermochemical H2 and N2 production from biogas and nitrogenic aqueous waste streams

Aim of the research: To assess the potential of reforming bio-gas/methane to hydrogen and nitrogen using nitrogenic aqueous waste-streams from the wastewater treatment process (urine and digestate liquor), with the aim of improving the energy demand of the sewage treatment process, resulting in a reduction in GHG emissions and facilitating a sustainable hydrogen pathway.

Short summary: Nitrogen removal is the single most energy intensive component in sewage treatment; increasing the energy demand in the activated sludge process (ASP) by 60-80%. Consequently, there is a significant effort to mitigate the financial and carbon intensity of doing so. One option is to divert the nitrogenous material before it has the chance to enter the ASP. 80% of the total N-load originates from human urine and 15 -20% from recycled AD digestate liquor. This research proposes the use of these for hydrogen production. Revising the conventional technology of steam methane reforming, these streams would replace pure steam to reform biomethane to hydrogen and the nitrogenous material to gaseous N2.

Expected Outcomes: 1)Energy savings can be made at the wastewater treatment works and facilitate an improved energy balance, demonstrated through flowsheet modelling of complete WSP. 2) Nitrogenous reforming reagents will 'top-up' hydrogen production whilst emitting nitrogen in its harmless and inert gaseous form. 3) Considerable reduction in GHG emissions is expected as N2O release associated with conventional ASP operation is avoided. 4) There are expected barriers to be overcome brought about by catalyst degradation due to sulphuric compounds contained in reagent options.

6. Hana Mandová **pmhm@leeds.ac.uk**

Global Suitability of Bioenergy in Steelmaking

Iron and steel making is one of the most emission and energy intensive industries, responsible for almost 7% of the global CO2 emissions.[1] Around 73% of global steel is produced via Blast furnace and Basic oxygen furnace (BF-BOF) route,[2] which requires nearly 1t of fossil fuels for every tonne of produced steel to generate electricity used in the process, transport materials, but primarily as a reducing agent for the chemical reduction of iron ore to molten hot metal. The current world steel production struggle has put emission reduction in this sector off the priority list in the near-term; however, the issue of sustainability cannot be ignored long-term. Strategic use of alternative fuels, such as biomass, can be achieved cost effectively, if conducted in the right setting. The purpose of this work is to identify countries for which the use of biomass in the ironmaking stage of iron and steelmaking is suitable and potentially economically appealing. This is done via introducing a Global Suitability Index (GSI), which for 42 countries considers whether the country has significant steel production, excess biomass resources and governmental support for the use of the alternative fuel. This quantitative index addresses the need to look at the bioenergy in steelmaking opportunity from the global perspective. The results are particularly beneficial for investors and policy makers seeking to use biomass efficiently and make sensible decisions about introducing biomass resources in ironmaking.

References:

[1]Worldsteel Association, Steel's Contribution to a Low Carbon Future and Climate Resilient Societies, Worldsteel Position Paper, 2015.

[2]Worldsteel Association, Steel Statistical Yearbook 2015, 2015.

7. Japhet Oladipo **pmjoo@leeds.ac.uk**

Hydrogen and syngas production from steam reforming of waste wood pellets

Thermo-chemical conversion of biomass represents a major sustainable route to producing syngas from a source that is renewable and CO2-neutral. The addition of steam via steam reforming of the biomass increases the stoichiometric hydrogen yield through promotion of the water gas shift reaction. In this study, hydrogen-rich syngas was produced by steam reforming of waste wood pellets using catalysts with 10 wt.% and 20 wt.% nickel loading with different catalyst supports including alumina, dolomite, silica and zeolite. The experiments were carried out using a two stage, pyrolysis-reforming fixed bed reactor. The process conditions were kept constant, including the pyrolysis temperature of 500°C and the catalytic reforming temperature at 750°C respectively and steam flow rate at 6.64 g h^{-1}.

The results showed that the 20 wt.% nickel dolomite catalyst produced the highest amount of syngas from the thermal processing of the biomass at 43 mmolsyngas g^{-1} which was 33% higher than the 20 wt.% nickel alumina catalyst at 29 mmolsyngas g^{-1}. The results also showed that 20 wt.% nickel zeolite produced the highest amount of carbon dioxide from the thermal processing of the biomass at 44%vol which was 16% higher than the 10 wt.% nickel zeolite at 28%vol.

8. Kiran Parmar **pmkpa@leeds.ac.uk**

Integration of Hydrothermal Carbonisation with Anaerobic Digestion: Opportunities for Valorisation of Digestate

Anaerobic digestion (AD) is an established technology in the United Kingdom, with opportunities for developing hydrothermal processing technology for enhanced biofuel production. Digestate, a by-product from AD, is currently disposed to land, however it is likely that new legalisation will come into place into the UK limiting disposal options. Therefore, the overall aim of the research is to identify the potential of hydrothermal carbonisation (HTC) to treat and valorise digestate from AD. The main objectives are to understand the influence of feedstock composition on the products from HTC including process water dissolved organics and hydrochar properties. The processing of digestate from anaerobic digestion of four waste streams have been investigated by hydrothermal carbonisation. Feedstock include agricultural waste (AGR), secondary sludge (SS), residual municipal solid waste (MSW) and vegetable, garden and fruit waste (VGF) digestate. The potential for increased biogas yields from process water recirculation have been demonstrated and the potential applications for the hydrochar include use as a fuel (biocoal), adsorbent or soil additive. Further work will assess the fate of inorganics and recovery of valuable nutrients, such as phosphorous. HTC delivers a promising method to convert digestate into a safer, higher quality product with multiple uses while improving AD efficiency and operator revenue by increasing biogas yields. This approach helps to meet renewable energy targets and creates significant economic gain to the bioenergy and bio-economy sector. This approach also has environmental benefits by reducing the disposal of digestate to land which mitigates heavy metal leaching and fugitive methane emissions.

9. Lee Roberts **pmljr@leeds.ac.uk**

Additives to Mitigate Slagging and Fouling

During biomass combustion, the inorganic components in the fuel are converted to ash. Depending upon its composition, it can become soft, and even molten, when exposed to the high temperatures of combustion. This softened ash can solidify when it comes into contact with a cooler surface, sticking to it and creating a deposit. These deposits can occur on boiler walls, where there is high radiant heat transfer (slagging), and on heat transfer surfaces as it is transported from the combustion zone into lower temperature regions of the boiler system (fouling). This increases metal temperatures, and can accelerate corrosion, leading to a shorter system life. Soft particles can also weld together, resulting in agglomeration: this is undesirable, particularly for fluidised bed combustion, as this can lead to defluidisation and a complete loss of power. Deposition will reduce the efficiency of a boiler, and in severe cases, the boiler will need to be taken offline for maintenance: this is estimated to cost the global utility industry several billion pounds a year. One approach to tackle these problems is to add additives to the fuel, in order to change the composition of the ash after combustion, and hence the nature of the deposit. Additives have been shown to help increase deposit shedding and removal, and reduce agglomeration. This project aims to understand the impact of a particular additive on different types of biomass, through characterisation of the ash and deposits, mechanical testing, microscopy, pilot scale testing and modelling.

10. Charlotte Stead **ts13chs@leeds.ac.uk**

Introducing biodiesel into rail transport: An economic appraisal of Indian Railways

India is a fast-growing emerging economy and has the potential to become one of the largest economies of the world. Rapid economic growth is associated with environmental problems and India is not different from other countries in this regards. With the continuous use of fossil fuels, pollutants and greenhouse gases are causing global warming and damaging humankind's health. Alternatives must be found. Indian railways is a huge consumer of fossil fuels with a strong modal share in passenger and freight transport; there is the potential for the use of alternative fuels such as biodiesel and electricity, but at present there is little research on this subject. Bearing this in mind the following objectives are considered:

-To assess the financial and economic feasibility of using biodiesel and compare to petro diesel
-To identify the optimum level of biofuel blend to fuel the locomotives
-To investigate whether domestically frown of imported feedstocks are most beneficial for India
-To conduct a comparative study with electricity as an alternate energy carrier
-To investigate the barriers and possible solutions in implementing the biodiesel
-To assess the lessons which can be learned from road transport and applied to rail
The proposed project with combine technical modelling and measurement. Economic feasibility will provide a comprehensive picture of the transition from fossil fuel to biofuels. The results are expected to be directly transferable to stakeholders and policymakers.

Bioenergy 2014 Cohort

11. Robert White **pmrww@leeds.ac.uk**

Can biodiesel waste create a substitute for natural gas?

As a consequence of the last decades surge in biodiesel production, glycerol (glycerin) has become a waste product of the biodiesel industry. The excess glycerol from biodiesel production has caused glycerol prices to plummet.
Consequently, the cost of glycerol disposal is greater than the market value of most glycerol products. A potential solution to increase the sustainability and profit of the biodiesel industry is to use glycerol to produce a methane rich gas that can act as substitute natural gas (SNG).
In this project, a catalytic glycerol methanation route is offered in order to produce SNG. The route is based on low temperature steam reforming and methanation reactions. The SNG could provide support via: meeting in situ heat and power demands of the biodiesel refinery through gas combustion, economic support by gas sales through feed in tariffs or grid exportation, increasing sustainability by utilising waste products. A key factor for success is avoiding the high temperatures used with current glycerol steam reforming in fixed and fluidised bed reactors. This requires a catalyst which promotes steam reforming and methanation. Experiments will be based on the design, characterisation and activity measurements of appropriate active metal centre catalysts and support. Furthermore, process design parameters such as pressure, temperature and steam to carbon ratio, will be optimised to promote low temperature CO methanation.

Bioenergy 2015 Cohort

12. Richard Birley **pmrib@leeds.ac.uk**
Julius Gane **pmjga@leeds.ac.uk**

An experimental study of pre-treated briquette fuels with control

Briquettes are energy resources obtained from biomass (biological materials) and plays a crucial role in addressing environmental issues in the energy and power industry. They can also help in securing future needs of energy and power, therefore energy from biomass has now become a crucial part of policies globally. As part of the evolving policies, negative impacts caused during combustion of biomass, such as; operational and toxicity hazards have also become a growing concern in order to mitigate negative environmental health repercussions. In this work, pre-treatment of briquette fuel was studied; looking at impacts on fuel properties and emissions, in a way to mitigate the negative consequences in using briquette fuels. The study initially explored literature on municipal solid waste wood (as potential feedstock for briquette fuels) and their chemical compositions; and how this may affect hazard issues. The experiment included a control fuel type (standard waste wood) and two pre-treatment test fuel types (one pre-treated by washing and the other with a commercial additive). The results showed that using an industrial additive as pre-treatment of waste wood fuel can mitigate emission consequences that may be associated with burning briquette fuels. Other fuel properties were also improved through pre-treatment.

13. Ella Blanquet pmebl@leeds.ac.uk
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Jennifer Spragg pmjss@leeds.ac.uk

Pyrolysis-gasification of Biomass Feedstocks

Catalytic pyrolysis and gasification processes were carried out using three biomass feedstocks: waste wood, MSW and SRC willow. Pyrolysis was found to be most effective with willow and MSW, producing a bio-oil from MSW with properties comparable to diesel, and a highly phenolic bio-oil with willow, potentially suitable for chemical feedstock applications. Waste wood produced a mixture of undesirable compounds during pyrolysis, but was the most suitable feedstock for gasification, producing the highest total yield of gas, and the largest concentration of syngas and hydrogen.

14. Natalie Brown pmnkb@leeds.ac.uk
Iram Razaq pm13ir@leeds.ac.uk

Utilisation of Fish Waste by Anaerobic Digestion & Oil Extraction

A vast amount of fish waste is generated every year from fishing and aquaculture. At present this waste is under-utilised and treated as an end waste product. To reduce the cost of disposal, a method needs to be implemented to treat the waste and recover energy and nutrients. Anaerobic digestion and extraction of fish oils are both methods that can be used to produce higher value products. Using the Buswell equation, the biomethane potential of anaerobic digestion of fish waste and sludge are calculated. The elemental composition of the feedstock is determined along with the metal and phosphorous content. The results of the Buswell calculations show that fish waste and sludge are both feasible feedstocks for producing biomethane from anaerobic digestion as they produced 0.35 l/gVS and 0.47 l/gVS respectively. However, the need for biomethane potential tests to be carried out is evident as the Buswell equation calculates the maximum potential theoretical yield, not the actual yield. Extraction of fish waste was done using chemical soxhlet extractions and physical gravity extractions. The solvent extractions used a methanol:chlororform 3:1 and hexane to remove lipids from dry fish waste. The physical extractions were heat treated and left raw. The potential to use fish waste to extract oil is high. The yield from physical extractions is high at 26% product yield on an as received basis. The physical extraction oils blend well with diesel up to 50% fish oil content and have a high carbon content suitable for burning. Extracting oil from homogenised settled fish waste which does not need pre-processing before blending makes it financially viable and a good use of waste products.

15. Christopher Holt pmch@leeds.ac.uk
Samantha Sime cm11sls@leeds.ac.uk

Biochars for Adsorption of Environmental Contaminants

Biochars are a high carbon product produced from the thermal decomposition of biomass in a limited supply of oxygen. They have many potential applications such as being used for water treatment and as a method of removing CO2 from post-combustion gas streams. Two biochars (Straw and Wood) produced by gasification and three lignite chars (tested for comparison) produced by Torftech Capital were characterised for surface area and porosity, and for surface oxygen functionality. The chars were also tested for CO2 uptake ability. The char which proved most promising was activated using chemical and physical activation, which is used to increase the surface area and porosity. These were then characterised and tested for CO2 uptake using the same methods as the original experimental.

16. Christian Michelbach pmcam@leeds.ac.uk
Nicola Wood pmnjw@leeds.ac.uk

Straight Used Cooking Oil as a Fuel in HGVs – Fuel Injector Deposit Analysis

The use of straight used cooking oils as an alternative to diesel fuel offers a huge environmental advantage, in particular the reduction of CO2 emissions, when compared to petroleum diesel and biodiesels produced through transesterification. However, the greater viscosity of Straight Used Cooking Oil (SUCO) has led to problems associated with poor atomization and air fuel mixing within the combustion chamber, leading to fuel injector deposits and associated problems such as poor drivability, increased fuel consumption and increased emissions. Through the use of spectroscopic and imaging techniques we report the distribution and chemical composition of SUCO derived fuel injector deposits formed under real world driving conditions. Two Euro VI emissions compliant 44 tonne HGVs were run on C2G (Convert2Green) Ultra Biofuel (a renewable fuel made from processed SUCO) for a period of 6-10 months, used directly in a purpose modified diesel engine. SEM imaging reveals the presence of deposits on the nozzle and needle of the injector although no nozzle holes are reported to be significantly blocked. EDX analysis reveals the presence of predominantly carbonaceous deposits with high levels of sodium and zinc. FTIR analysis confirms the presence of metal carboxylate and metal oxide deposits in strong agreement with previous literature. We therefore conclude that trace metals present in the fuel, particularly sodium and zinc, are contributing significantly to the formation of SUCO derived fuel injector deposits.

17. Daisy Thomas **py11dbt@leeds.ac.uk**

Charlotte Weaver **pmcwe@leeds.ac.uk**

Weiyi Yao **pmwy@leeds.ac.uk**

What is the Biomass Resource Available to Leeds City Council, and how can its use be maximised?

In the current global climate, it is important for local planning authorities to try to incorporate locally produced bioenergy into their development plans. Before this can be done, the biomass available must be assessed, the possible technologies considered, and the business models analysed. This study quantified a number of different biomass wastes available to Leeds City Council, as well as the future potential of these resources. The annual current biomass potential was calculated to be (55±8)×103 tonnes per annum, equivalent to (19±7)×107 MJ/year or 2±0.7 MWe (electricity generation equivalent). In addition, a potential future annual quantity of biomass was calculated for scenarios where LCC made certain changes to the way they operate. The mass and energy in this case were calculated to be (90±9)×105 tonnes and (20±5)×109 MJ/year respectively, equivalent to 210±50 MWe. A technological analysis indicated both Anaerobic Digestion and Combustion technology represent the best options for treating the currently available and future biomass.

A subsequent analysis also revealed that the council faces significant near-term financial and policy barriers regarding their future operations, and that such barriers could be addressed by implementing a Joint Venture, Public-Private Partnership commercial model. Overall there is enough biomass resource available to Leeds City Council for both small and large scale energy production. Our results suggest that for large scale technologies, non-recyclable wood wastes and high moisture content wastes could be sent to the Veolia Recycling and Energy Recovery Facility for incineration and an anaerobic digestion (AD) plant situated in or near Leeds, respectively.

18. Abdulrehman Ajina pmaaj@leeds.ac.uk

Gum Formation and Deposition Tendency in Ternary Gasoline Surrogates

Gasoline, or petrol, is a complex mixture of hydrocarbons used in spark-ignition (SI) engines. Post combustion materials deposit on engine internal parts and affect vehicle mechanical performance as well as fuel economy. Current solutions rely on the use of deposit control additives (DCA) to reduce deposit formation. Much previous research has aimed to identify the origin of the deposits formed on internal metal surfaces of engines (e.g. in the combustion chamber (CC), on intake valves (IV), and port fuel injectors (PFI)). Unsaturated species within the fuel complex undergo oxidation reactions and produce a non-volatile, high molecular weight product (gum), which may deposit during injection and combustion. Special formulation of toluene reference fuel (TRF) have been developed to mimic gasoline properties. We will show how stainless steel coupons immersed into the gasoline surrogate can be used to examine the deposition of TRF oxidation products and to study the influence of DCAs on deposition.

19. Robert Hooley pmrh@leeds.ac.uk

Evaluating the electron beam sensitivity of calcium carbonate based materials

Calcium carbonate is a common material, most often encountered as biominerals such as seashells, or in the environment as geological minerals. It appears as three crystalline anhydrous polymorphs, but related hydrated, amorphous or poorly crystalline forms are also known. Calcium carbonate is of widespread interest as both a structural biomaterial and for its environmental and industrial importance, with applications including polymer fillers, carbon capture and pharmaceutical excipients, leading to extensive research into its formation and properties. Transmission electron microscopy (TEM), both Scanning (STEM) and Conventional (CTEM) can be used to probe the structures and compositions of a variety of calcium carbonate based systems, allowing for a greater understanding of their formation and function. Whilst a heavily researched material, calcium carbonate is well known for its sensitivity under electron irradiation in both CTEM and STEM, limiting the amount of analytical information that can be extracted without damaging the region of interest. The aim of this research is to probe the electron beam induced degradation in order to understand both the damage pathways, and the conditions under which damage occurs. Through this investigation, it will then be possible to propose experimental conditions under which beam damage is minimised or eliminated, allowing for repeatable and reliable analytical electron microscopy of calcium carbonate based materials in both CTEM and STEM.

20. Mohammed Jeraal **cm09mij@leeds.ac.uk**

Examining phase separation during the multi-component melt crystallisation of synthetic detergents

Synthetic detergents have recently become a popular alternative to traditional soaps due to a higher stability in hard water and a reduced tendency to cause irritation upon skin contact. During the manufacture of synthetic isethionate detergents, the multi-component melt product typically exhibits a solid state phase separation when precipitated. This results in the formation of hard, spherical micro-particles which are abrasive to the end consumer and increase equipment wear during downstream processing. In this research, a coconut based soap ingredient was first analysed via GC-MS, to determine the chemical species on which a model system could be developed. A solid-liquid phase analysis of lauric and myristic acid, the two most abundant materials in the coconut blend, was then executed via DSC. The ensuing phase diagram shows how the composition of these species affects the phase behaviour of any resulting binary mixture. It is planned to create a similar binary phase diagram for the corresponding lauric and myristic isethionate detergents. Pure samples of these materials are not commercially available. A laboratory scale synthesis rig was therefore created to simulate the industrial manufacturing process. A titrimetric metric analysis of initial produce indicated conversion rates in excess of 80%. In succeeding works, a combination of X-ray diffraction techniques, blend rheology and other process analytics will be used to characterise the physical structure of the isethionate products, whilst simultaneously identifying the formation mechanism of the undesired particulate phase.

21. Thokozile Kathyola **pm13tak@leeds.ac.uk**

Structural Elucidation of Calcium Carbonate in Industrial Formulations with X-ray Absorption Spectroscopy

Calcium carbonate (CaCO3) is a versatile chemical widely used in industry with applications spanning construction, pharmaceuticals, food, coatings and fuels in addition to its natural geologic and biological occurrence. Several polymorphs of CaCO3 exist with calcite being the most prevalent and stable. Our understanding of why and how particular polymorphs form and change as a function of environment is incomplete. Furthermore, while all forms of CaCO3 share similar chemical structures, it can be difficult to probe the 3D arrangement of disordered systems or interfacial structure of CaCO3 with a surrounding medium. Therefore, we have characterised crystalline polymorphs (calcite, aragonite and vaterite) and amorphous forms of CaCO3 with X-ray absorption spectroscopy (XAS). XAS provides element specific information on the bonding between an absorbing atom and its nearest neighbours as well as on the arrangement of atoms up to a distance of ~10 Å from the central absorber. This makes XAS sensitive to both ordered and disordered systems. Furthermore the experimental configuration can be adjusted to tune the sensitivity of the technique to probe the bulk as well as surfaces/interfaces of a material. Our measurements show how thorough characterisation of CaCO3 polymorphs can be used to understand advanced industrial formulations of CaCO3.

22. Paul Lewis **pmpml@leeds.ac.uk**

Shear Rate and Cooling Modelling for Crystallisation of Wax

The wax antiperspirant deodorant (APDO) stick is one of the most popular formats for applying antiperspirant/deodorant in North America. APDO sticks contain a mixture of crystalline materials as the core structural components namely hydrogenated castor oil, stearyl alcohol and petrolatum. Work has been carried out to investigate the thermal behaviour and crystallisation of stearyl alcohol and petrolatum and hydrogenated castor oil.

In this present study, the phase diagram between binary mixtures of the three components has been determined using DSC and the associated change in rheology has been characterised.

A study of the change in rheology against temperature has been carried out for the individual components. In the future temperature vs rheology change profile can be fed into a CFD model where the mixing between the cold active phase and hot molten wax phase can be modelled.

23. Yefeng Li **ccd5yl@leeds.ac.uk**

Engineering of Assemblies of Inorganic Particles

Particulate materials play a critical role in a number of industrial sectors such as chemicals, foods, pharmaceuticals, and consumer products. The properties of the particulates involved are critical not only to the product performance but also to performance and reliability of associated manufacturing processes. Nano-particles, with particle size less than 1, tend to be difficult for users to handle; therefore they are often assembled into larger granules for ease of handling and to allow controlled delivery in their desired function. Engineers who manufacture granules want to be able to control and predict the structures formed and ultimately predict the functional performance of the granular products. In order to do this they need to understand how the nano-particle properties and the manufacturing process conditions affect the assembly and consequently the developed structure of the granules. This project will investigate the ability to create structured assemblies of nano-particles with properties that are tailored for their application. Spray drying will be the primary process investigated. It will also require manipulation of the particle-particle interactions in the suspensions before they are dried and development of an understanding of how these properties effect the drying transformation. This project is largely experimental; it requires a thorough understanding of manufacturing processes and colloidal systems involved, as well as associated analytical characterization techniques. Models will also be developed to help understand the systems and predict their behaviour.

24. William Booker **scwb@leeds.ac.uk**

Modelling Internal Wave Focussing

Confined internal wave systems with tilted walls can lead to the evolution of a spatial singularity called an internal wave attractor. The existence of this singularity is the result of wave energy focusing, that is the wave energy becomes localised on small spatial scales. Ocean ridges such as the Luzon strait can support such energy localisation, which can lead to an understanding of ocean mixing in such a place.

Laboratory observations have been shown to match location predictions of wave attractors despite being a result of an inviscid, ideal fluid model. We develop a structure preserving discontinuous numerical method for internal gravity waves.

We examine the linearised, inviscid Euler-Boussinesq model and its associated Hamiltonian structure and then derive a discontinuous finite element method that preserves this structure. This leads to a non-dissipative numerical method which will not hinder the evolution of these wave attractors. We use harmonic wave solutions to verify that the method preserves the Hamiltonian structure and the discrete energy of the internal wave system.

25. Caitlin Chalk **mm11c2c@leeds.ac.uk**

A Smoothed Particle Hydrodynamics investigation of an experimental debris flow

A debris flow is a gravity driven flow where both solid and fluid forces play a vital role in the dynamics. Such flows have the destructive power of avalanches and the fluidity of a sediment laden water flood. The interaction of both solid and fluid forces means that debris flow dynamics are extremely complicated and di□cult to model. A comparison is presented between a physical model debris flow of a monodispersed sand and a mathematical model. The experiment consists of the instantaneous release of a saturated sand mass via a lock gate down an inclined flume in a dam break scenario. Particle Image Velocimetry and structure-from-motion techniques are used to monitor the flow and obtain velocities, shear strain rates and a full digital reconstruction of the free surface. These are then compared to a Smoothed Particle Hydrodynamics (SPH) mathematical model, which is able to incorporate a variety of rheological laws to describe the flow behaviour. Initial results suggest that the use of a frictional Mohr-Coulomb rheology is best suited to simulate the experimental flow, as opposed to cohesive models involving a yield stress. The SPH model is implemented both with and without pore water pressure terms, highlighting the need for a deeper investigation into the role of pore water pressures.

26. Thomas Goodfellow **mn11tjr@leeds.ac.uk**

Low Order Models of Layer Formation in Double Diffusive Convection

Fluid dynamical systems with the tendency to form patterns have been the subject of much scientific interest over the years. One of the most interesting patterns is that of layers or 'staircases', which appear to form from a disordered turbulent state. Thermohaline staircases for instance are found in the oceans as mixed, almost neutrally stratified layers of salinity and temperature with steep gradient interfaces.

A minimal representation can be constructed to study the weakly non-linear behaviour of such double-diffusive systems. A heavily truncated Fourier series solution is employed to convert the governing system of PDEs into a system of ODEs. This system is numerically integrated using a 4th order Runge-Kutta scheme to determine the minimum number of modes required for the formation of layers, and to gain an insight into their interactions.

27. Inna Gorbatenko **pm09ig@leeds.ac.uk**

Turbulent Combustion and Auto-ignition of Alternative Fuels

The current trend of downsizing and turbo-charging engines to reduce fuel consumption increases the possibility of engine knock and therefore requires fuels which are more resistant to auto-ignition. Auto-ignition can be defined as the onset of self-sustained combustion of the mixture in the absence of an external source of ignition, such as a spark or flame. The addition of bio-fuels such as bio-ethanol and bio-butanol to conventional gasoline can reduce greenhouse gas emissions and probably offer a better knock resistance than traditional fossil fuels, thereby improving engine performance. However, it is debatable which bio-fuel offers the most benefits in terms of overall potential.

This research will investigate the effects of such alcohol fuel blends with gasoline and Toluene Reference Fuel (TRF) mixtures on ignition delay times and excitation times. Ignition delay times are in the range of milliseconds and will be obtained through experimental work on a Rapid Compression Machine (RCM). However, excitation times, during which the heat release occurs, are of the order of microseconds and can only be obtained through numerical simulations.

The study will determine the reactions that are significant in determining the two times. They are incorporated in the theoretical detonation peninsula and provide a more fundamental approach to the prevention of engine knock than use of Octane Numbers.

28. Evaldas Greiciunas **scegr@leeds.ac.uk**

Modelling Novel Heat Exchangers for Aircraft Thermal Management

Future aircrafts face an appreciable technical challenge to design thermal management systems (TMS) of adequate capacity within installation constraints (e.g. size, efficiency, thermal signatures, etc.). Various heat exchangers (HE) are key components within aircraft TMS, and the achieved heat transfer performance for a given size, and flexibility of physical shaping, have a strong determining effect on overall system performance and feasibility. Novel manufacturing techniques (e.g. ALM) will be used to provide exciting opportunities for innovative HE geometry. Numerical approaches are used to develop validated models of existing and conceptual HE designs using experimental data. This study explores the physical aspects affecting the HE performance at all ranges of design feature levels. Current focus of the project is to learn how to predict the flow within the HE when it enters transitional Reynolds regime. The project involves working alongside BAE Systems and a specialist HE supplier.

29. Robert Kelly **scrk@leeds.ac.uk**

Turbidity current dynamics and their control on submarine channel development

Turbidity currents can transport vast amounts of sediment for thousands of kilometres across the ocean floor. Their main conduits are seafloor channels. However, the hydrodynamic-morphodynamic relationship between turbidity currents and their containing channels, involving several different feedback systems, is poorly understood. Processes dictating the evolution of the channel (over long timescales) and the structure of individual currents (over relatively short timescales) are interlinked. However the scales of co-dependency of flow and topography are unknown. It is therefore unapparent to what extent flow dynamics and the development of a channel are pre-determined. A novel experimental setup enables an investigation into the role of channel sinuosity in both flow dynamics and channel evolution. Numerical simulations, validated against the laboratory work, allow further examination of the effect of various flow conditions on channel morphology.

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30. Hannah Kreczak **mm10hek@leeds.ac.uk**

Rates of chaotic mixing in models of fluid devices

The use of mathematical and computational models to investigate mixing in mixing devices is essential in establishing design criteria to increase efficiency without the need to build a prototype testing all possible configurations.

“Mixing” is a term used when fluids undergo stirring and diffusion. If the diffusive effects are small, stirring is needed to accelerate the mixing process to achieve a homogeneous state. When the fluid flow is laminar, and thus lacking in turbulent structures to help with mixing, chaotic stirring can create the desired “striations” which help speed up the action of diffusion. However, the stretching and folding of fluids can be very complicated even in simple fluid flows. General computational methods in fluid dynamics use a grid to capture the behaviour of fluids, but the fast rates of stretching in chaotic flows can result in large errors even when an extremely fine grid resolution is implemented. Therefore, the study of mixing in chaotic flows can be tackled using dynamical mathematical models, where the trajectories of fluid parcels are described by continuous or discrete time functions.

This poster highlights the some methods in dynamical systems and how they are used to study mixing and presents a selection of regimes with varying dynamics and resulting mixing rates; islands of unmixed fluid, non-uniformity in the stretching rates and the presence of boundaries.

31. Godwin Madho **py09gm@leeds.ac.uk**

Using data assimilation techniques to validate fluid flow models

Many studies run high resolution simulations to compare results against experimental data. In our study we aim to keep the accuracy of high resolution runs while reducing computational cost. This can be achieved using a data assimilation method. Here we use an Ensemble Kalman Filter (EnKF) to combine low resolution runs with experimental data. The Lorenz Model will be used to cross-validate our version of EnKF written in Python against the Matlab™ version available online at http://enkf.nersc.no/, which was originally developed for oceanography. We aim to use EnKF to assimilate rotating annulus data for experiments done at the Atmospheric, Oceanic and Planetary Physics (AOPP) department of the University of Oxford using the MORALS code created at AOPP. The aim of the project is to test the cost-effectiveness and the speed of the technique, as well as its predictive power in experiments exhibiting increasingly complex flows. This work will be then considered for application to plasma physics at Culham Centre for Fusion Energy (CCFE).

32. Jacob van Alwon **scjva@leeds.ac.uk**

Experimental and Numerical Modelling of Aerated Flows Over Stepped Spillways

Stepped spillways have been shown to be efficient overflow structures for large raised reservoirs. They dissipate large amounts of energy, which prevents scour at the foot of the dam, reducing the size of the required stilling basin. They also entrain large amounts of air into the flow which prevents cavitation and plucking damage, reducing the need for maintenance. Current practice is to use physical scale models to predict flow characteristics over stepped spillways. While the have limitations, especially in predicting air entrainment, reservoir engineers prefer physical to numerical models as these limitations are better understood. Numerical modelling has the potential to predict flows over stepped spillways more accurately and at a lower cost than physical models. However, the accuracy of these models must be proven before they are used for the design and maintenance of stepped spillways. This project will aim to evaluate the ability of several numerical modelling techniques to predict free surface aeration over stepped spillways. The models will be validated using free surface profile and pressure measurement s from experimentation. The experiments will be designed so that the steps are close to prototype scale with an air entrainment device placed upstream of the steps. The flow will be either aerated or non-aerated so the numerical modelling results and pressure distributions can be compared.

33. Georgina Williams **scgw@leeds.ac.uk**

Segregation in high concentration flows

Particle segregation and associated problems such as inertial migration are of interest to a wide range of problems from industrial processes such as suction dredging and hydraulic conveyancing, to natural systems where sands and gravels are injected into surrounding sediments forming kilometre scale pipes and associated lateral networks. Segregation and inertial migration have long been studied in pipes but predominantly at low or very low concentrations, and typically for small particles that are in the Stokes regime. A key question is whether segregation processes vary as a function of particle size, shape and polydispersivity, particularly at high concentrations (volumetric fractions of several tens of percent).

This project utilises laboratory models to consider the differences in the fluidisation features observed and collect pressure velocity and concentration data to characterise the system. In conjunction with the experimental programme, numerical simulations using the Lattice-Boltmann Method coupled to Direct Element Modelling will be utilised to examine the underlying processes of segregation within high concentration flows in conduits. Comparison can be made with the deposits of high concentration flows (likely approaching the packing limit) in natural systems where the type and magnitude of segregation can be readily observed.

34. Sam Williams **scsw@leeds.ac.uk**

Experimental Simulation of Atmospheric Downbursts

The atmospheric downburst is born from a complex interaction of microphysics and dynamics in convective clouds. Evaporation induces regions of negatively buoyant air, which in combination with precipitation loading from hydrometeors (rain, hail, graupel etc.), force air downwards. Through baroclinic instabilities, the leading edge of the downdraught forms a vortex ring which can then impact the ground and diverge radially. The leading edge of the radially-propagating winds are known as the `gust front', and are often responsible for the peak surface winds associated with convective storms.

Motivation: The interaction of the downburst with the surrounding environment is important from: i) an engineering perspective – downbursts are responsible for unconventional wind loading and hazardous windshear that can affect infrastructure (particularly off-shore), ground transportation (e.g. lorries) and aircraft. ii) an atmospheric perspective – the interaction with the gust front has important implications for the generation of subsequent convection and the uptake of surface particles, including dust, which in turn affects cloud formation and radiative forcing. Despite the importance of downbursts in engineering and atmospheric physics, there are still some fundamental features that remain poorly understood.

Impact: Recent work by Rooney (2015) combined theory of buoyant thermals with axisymmetric gravity currents to propose a similarity solution that could be applied to downbursts. A novel and unique experimental study conducted at the University of Leeds tested this theoretical framework. Results show that the major features of Rooney (2015) are reproduced in the laboratory but with several important inconsistencies concerning the importance of flow symmetry of the descending downburst and the influence of the vortex ring in the impact zone.

35. Jenny Wong **mm09j2w@leeds.ac.uk**

Two Phase Flow in the Earth's Core

Seismic observations have revealed the existence of a stably-stratified layer 150 kilometres thick located above the inner core boundary (ICB). The density of this so-called 'F-layer' increases with depth, in contrast to what is expected for a well-mixed core. It is not known how the dynamics of maintaining such a layer can be explained. The liquid outer core is composed of an alloy, predominantly iron and a lighter component. Overall the Earth is cooling over time, therefore liquid iron in the outer core solidifies onto the inner core and the lighter material remains in the liquid. A key issue is the presence of buoyant lighter material left at the ICB would disturb the stably-stratified layer: how is this compatible with the observations? As a consequence, the aim of this project is to develop a self-consistent, fluid dynamical model of the convective process occurring in the F-layer that is able to explain the current observations. A systematic approach to building such a model will be taken, in which a box-model of thermal convection will be considered first. This will then be extended to simulate thermochemical convection. Previous thermal and thermochemical convection models have failed to explain the F-layer, so we therefore consider a layer containing a slurry as a possible scenario. Here, heavy iron-rich particles precipitate downwards from the liquid and freeze onto the inner core, displacing the lighter material upwards. This allows convection without disturbing the stably-stratified layer.

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Influence of Viscoelasticity on Spray Performance

The influence of fluid elasticity on spray performance has been studied. This poster reports on the theoretical, numerical and experimental aspects of this MSc project. The use of polymers additives is known to influence the jet breakup and spray performance. Using dilute polymer solutions lead to the inhibition of satellite drops. Average size and distributions of droplets from different nozzles is of interest to many industrial applications (e.g. medical and agricultural sprays). Using Malvern Instruments Spraytec laser diffraction system, investigations into drop size distributions from hollow cone and flat fan spray nozzles with Newtonian fluids are compared to a variety of different probability distributions. The drop size distributions show a good correlation to the gamma distribution and this is validated by the theory. On a smaller scale, capillary break up of a jet has been investigated analytically with the results being used in an axisymmetric numerical code. The basis of this code uses the theory behind the slender jet equations. This has been further developed to include effects of elasticity using the Oldroyd-B model. Comparisons to experimental results from the Rayliegh Ohnersorge Jetting Extensional Rheometer (ROJER) used to characterise the rheology of low viscosity fluids under extensional flow, show a good correlation with the jet evolution of the numerical model. Further work is being done to investigate the spray performance of polymeric fluids and see whether capillary break up and relaxation times are a good measure of spray distribution, with the aim of linking the numerical and experimental data to available theoretical knowledge.

37. Paul Allen scpaa@leeds.ac.uk
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Optimisation of Nozzle Design for Bubbly Flow in the continuous Casting of Steel

Continuously casted steel accounts for over 95% of production worldwide. Argon gas injected into the molten steel removes impurities and considerably affects the flow patterns. Large free surface perturbations can lead to slag entrainment, but flow is required near the surface to prevent solidification. Additionally, entrapment of argon bubbles can lead to adverse effects. The study of the flow patterns inside the continuous caster and the design of the nozzles used to inject the molten steel is, therefore, crucial to industry. Three patterns are observed depending on casting speed and argon injection rates: Single, double and triple roll patterns. A stable 'double roll' is optimal for casting, but the system is highly sensitive to its parameters. As a result of its high temperature (1700K) and opaqueness, molten steel is difficult to model experimentally. Thus, experimental data is obtained using a water-air model. This provides insight into the flow patterns that emerge, because of dynamic similarities of molten steel and water. The water-air model is used to perform a parametric study on the port angle on the nozzle for different casting speeds and gas injection rates. Additionally, a variety of computational models are used: A 2-dimensional simplification is modelled in ANSYS CFX using a volume of fluid multiphase method with a free surface, A full 3-dimensional model is created in ANSYS FLUENT with a Lagrangian particle tracking modelling individual bubbles and finally, a Cahn-Hilliard Navier Stokes based theoretical model is developed and solved using the finite element package Firedrake.

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Quantification of Sediment Laden Flows

Sediment laden flows are ubiquitous in both natural and industrial fluid flows. The understanding and quantification of these flows is of practical interest in many industries; particularly mining, food, nuclear, oil, and pharmaceutical. Deposition of sediment in pipelines, leading to possible blockages, is a major concern in these industries due to the cost, practicality, and hazards associated with cleaning the pipelines, particularly in the nuclear industry.

This project considers determining the relationship between the settling characteristics of particles suspended in a medium, and the pipe velocity at which point the particles begin to form a bed, known as the critical transport velocity. The settling characteristics of particles in static (no shear) and turbulent suspensions are assessed using analytical techniques and numerical schemes. Additionally, pipe flow behaviour is determined through the use of advanced computational fluid dynamics, to model the flow over a range of velocities, and assess the critical transport velocity. Validation is achieved for both models through pipe flow and static settling experiments, using a combination of optical and acoustic instrumentation.

39. Marcello Cadeddu mcadeddu1@sheffield.ac.uk

Investigation of the Fan Blade Root Contact

The interface between the blade root and disc slot on the fan assembly has been identified as a key tribological contact that restricts commercial gas turbine engine development. The Rolls-Royce dovetail joint is designed to allow relative movement of the two parts, in order to permit the blade to move to its least stressed position while the engine is operating. Ensuring a low friction contact at the interface to guarantee relative movement is vital with respect to engine safety, as if the blade sticks to the disc premature fatigue failure may occur. For this reason, dry film lubricant (DFL) is applied onto the surface since fluid lubrication is not suitable for the application. As the cost related to the maintenance of this solid lubricant represents a considerable issue for the company, this research aims to find a coating solution with improved life. A fan blade root has been inspected before re-lubrication to analyse the wear mechanism and the failure modes of the coating. Furthermore, a test rig has been designed to test new coating systems with the aim of finding a new potential material with improved performance.

40. Matt Harmon Mharmon1@sheffield.ac.uk

Understanding Application and Mechanisms of Lubricants and Friction Modifiers in the Wheel/Rail Interface

This poster will display the main aims and objectives of my PhD as well as including a rough schedule of work that I will be undertaking. Managing the friction level at the wheel rail interface has been occurring since railways were created. Keeping the friction at the optimum level can reduce energy requirements, wear, RCF, noise and vibration. The benefits of friction modifiers are reasonably well reported in papers in a variety of journals across the world, but there is limited research when it comes to understanding the behaviour of friction modifiers. For example, how friction modifiers interact with contaminants already present on the rail, or how far down the track from point of application the effects of friction modifiers are seen are both areas of research that is currently lacking. My current project looks at scalability between different test rigs with particular focus on friction modifiers. A mini traction machine, a twin disc tester and a full scale rig are all used to conduct similar tests in order to look at scaling. This is an important area as it is important to know how results from laboratory tests are affected by field conditions.

41. James Makin **j.t.makin@leeds.ac.uk**

Characterising the use of Acoustic Emissions as a sensing technique in a tribochemical context

Acoustic emission is the phenomena whereby transient elastic waves are generated by the sudden rapid release of energy within a material. This release can occur from numerous potential mechanisms, such as a deformation processes, induced stress or strain. These propagating stress waves can be detected on the surface through the use of an appropriate sensor, with a portion of the stress waves falling within the frequency range of the order of 10 – 1000 kHz. Frequencies within this range can be detected by piezoelectric materials which transform the vibrational energy into a voltage that can be measured. Unlike other non-destructive testing techniques, AE measures events stimulated from within the material itself and as such it is widely used as a fault detection methodology, it has previously been shown that the analysis of the acoustic emission signals can give an insight into wear mechanisms and the interface of a contact. This work focuses on the acoustic emission response when MoDTC is used as an additive for a steel/steel ball on disk contact. It has been found that there is a direct correlation between the lubricant/additive coupling and the acoustic emission signal that is produced. It has also been shown that as a tribofilm forms there is a noticeable change in the acoustic emission signal which is indicative of the change. It can clearly be seen that there is a direct link between the acoustic emission signal and the additive/ lubricant used in the contact, further work will look further into the capabilities of acoustic emission sensors and determine the maximum sensitivity for measuring tribochemical interactions.

42. Olivia Manfredi **Ofmanfredi1@sheffield.ac.uk**

Determination of Engine Oil Viscosity using an Ultrasonic Sump Plug

The viscosity of engine oil considerably affects the performance of an automotive engine. Viscosity of engine oil in thin layers between bearings is governed by shear rate and pressure, thus preventing the use of conventional viscometers to replicate such conditions. In-situ real time measurements would provide experimental results that have previously been unavailable due to the relatively inaccessible nature of the internal combustion engine configuration without invasive modification.

Methodology: When a shear wave strikes a solid fluid boundary, the proportion reflected depends on the viscosity of the liquid. Normally ultrasonic viscometers require direct coupling of the piezo-element to the fluid, or the use of a non-metallic coupling medium. A new approach [1] uses a matching-layer to couple sound from the sensor, through a metal bearing shell and into oil. This means the technique can be used on real bearing materials. In this work, a sump plug from a VW polo engine has been replaced with a miniaturised ultrasonic viscometer. The plug is steel with a matching magnesium layer and a piezo-element bonded to the outside face. The piezo was pulsed using a continuous wave. The wave bounces back and forwards inside the plug. Each reflected wave is superimposed giving a standing wave pattern. The tightly packed peaks in the signal correspond to resonance of the plug. The trough that occurs at around 5Mhz corresponds to the matching layer resonance. At this frequency the system is sensitive to oil viscosity. The vehicle was driven over a range of conditions to vary engine loads. The standing wave formation was monitored throughout and used to determine the oil viscosity.

Reference: [1] Schirru, M., Mills, R., Dwyer-Joyce, R.S., Smith, O., and Sutton, M., (2015), Viscosity measurement in a lubricant film using an ultrasonically resonating matching layer, Tribology Letters

43. Alan Martin **Atmartin2@sheffield.ac.uk**

Investigating Fundamental Processes in Erosive Wear by Water Droplets

Water Droplet Erosion (WDE) affects a number of devices and parts including steam turbine blades, aero-engine compressor blades, and wind turbine blades. WDE has become the life-limiting condition for both wind turbines and low pressure steam turbine blades. As blade diameters increase, tip speeds increase too. In wind turbines, erosion can lead to blade failure in 2-5 years. In steam turbines, brazing of stellite “shields” fail at the braze interface; unbalancing the turbine which can lead to catastrophic failure. Advanced erosion is visible to the human eye as craters hundreds of micrometres deep. Advanced erosion is a runaway effect; once a rough surface is generated, droplets are able to penetrate flaws and widen them by hydraulic action; a so-called “water hammer”. It is currently not clear how a nominally smooth surface becomes roughened by water droplets to lead to advanced erosion [1]. To produce erosion damage experimentally, water droplets must impact a test coupon at hundreds of metres per second. Periodic mass loss measurements provide erosion rate. Qualitative analyses by light and SE microscopy can provide information on how the material microstructure is influenced by damage mechanisms.

Reference: [1] J. E. Field, J. J. Camus, M. Tinguely, D. Obreschkow, and M. Farhat, “Cavitation in impacted drops and jets and the effect on erosion damage thresholds,” Wear, vol. 290–291, pp. 154–160, 2012.

44. Mahdiyar Nejadhamzeeigilani **mn11mn@leeds.ac.uk**

Effects of lubrication contaminants on friction and wear

The effect of oxidation and contaminants such as fuel on engine lubrication has attracted significant interest as engine lubrication is critical factor of automotive performance and longevity [1-2]. Around 25% of automotive engine friction occurs in the valve train, with an estimated 80-85% of the friction losses taking place at the cam follower and the rest due to stem and valve guide, bearings, tappet and tappet bore [3-4]. This project aims to investigate how engine lubrication contaminants such as gasoline affects the tribology of the lubricant within valve train system. The study will focus mostly on the interface between the cam and follower to explore how gasoline affects the characteristics of the lubrication in these interfaces. At present 2 hour long high frequency reciprocating pin-on-plate tests using a Cameron Plint TE77 have been performed on lubricants diluted with gasoline concentrations of 0% to 12% at 25°C. The study will progress by performing tests in higher temperatures, 40+°C to see how the results are affected by temperature. Friction and wear results will also be examined in relation with tribochemical analysis and the effect of gasoline on the oil itself will be studied.

References:
[1]Soleimani, M. et al. Engine oil acidity detection using solid state ion selective electrodes. Tribology International. 2013, 65(0), pp.48-56.
[2]Kaleli, H. and Yavasliol, I. Oil ageing - drain period in a petrol engine. Industrial Lubrication and Tribology. 1997, 49(3), pp.120-126.
[3]Ofune, M. et al. Development of valve train rig for assessment of cam/follower tribochemistry. Tribology International. 2015, (0).
[4]Kano, M. Super low friction of DLC applied to engine cam follower lubricated with ester-containing oil. Tribology International. 2006, 39(12), pp.1682-1685.

45. Nadia Salman mnnsa@leeds.ac.uk

Movable Cellular Automata for Multi-Scale Modelling of Tribosystems

The Movable Cellular Automata method is used and developed to produce effective and reliable predictive simulation models of friction and wear processes. Tribosystems are modelled as a whole system, including surfaces in contact and interactions between them, in a single simulation on the mesoscopic scale, which bridges the gap between the atomistic and continuum viewpoints.

Engineers deal with the large scale problems while physicists and material scientists deal with the very small scales, as shown in the figure. This model uses an integrated approach which helps bridge this gap and optimize tribological systems; help reduce loses and energy costs in many mechanical systems in industry.

MCA is feasible on the nano and micro-scales and can effectively simulate the inhomogeneities in material characteristics and plastic deformation, but it is not efficient at the macro-scale. However, it can be coupled with continuum methods such as the finite elements method. Due to the mobility of the automata and the ability of changing their state, MCA is capable of effectively modelling many material processes including friction and wear.

46. Muhammad Sohail Siddiqui mnmsas@leeds.ac.uk

Additive interactions for improved tribological performance

Reduction in fuel consumption and tighter environmental restrictions on the combustion emission products are among the key challenges of automotive industry which can be addressed by developing more efficient and environmental friendly lubricant additives [1]. Additives are used in engine lubricants to minimize the boundary friction value [2]. Zinc dialkyldithiophosphate (ZDDP) is an effective anti-wear additive used in the formulation of the lubricant but at the same time it also increases the boundary friction coefficient [3]. ZDDP is the main source of phosphorus in the lubricant which suppresses the catalytic activity by deactivating the catalyst components and reducing its efficiency to convert CO to CO2 [4]. This research will reveal the friction and wear performance of an additive along with reduced concentration of ZDDP by using unidirectional pin on disk arrangement.

In this ongoing research initially the interaction of base oil (BO) with ZDDP has been studied. Three different concentration of ZDDP was analyzed with BO i.e. BO + ZDDP (X wt. %), BO + ZDDP (Y wt. %), BO + ZDDP (Z wt. %) and then each concentration of ZDDP is further studied with three different concentration of additive (A) i.e. BO + ZDDP + A (conc. 1), BO + ZDDP + A (conc. 2). BO + ZDDP + A (conc. 3). Concentration of both ZDDP and additive plays crucial role in controlling frictional behavior. Frictional analysis with reduced concentration of ZDDP will open new research venues in order to improve the useful life of the catalytic converter.

Integrated Tribology 2014 Cohort

47. Leon Wechie **mnlwe@leeds.ac.uk**

Additive Chemistry Influence on Tribological Behaviour of Nitrided EN31 Steel

Introduction: Gas nitriding is a thermochemical surface treatment involving the diffusion of nitrogen into steel creating an effective case-hardened layer by changing the chemistry and the microstructural phases of the steel. Advantages are an increase in surface hardness and wear-resistance. Although lubricant chemistry is shown to reduce friction and wear in a nitrided tribological system [1], it has not yet been fully appreciated how different lubricant additives can influence the tribological, physical, and chemical properties of the formed tribofilm. The focus in this presentation is on detergent/ ZDDP effect on tribological performance of a nitrided steel.

Methodology: EN31 steel plates and pins were gas nitrided. Tribological tests were performed using the Cameron Plint TE77 reciprocating pin-on-plate tribometer under boundary lubrication regime. Both the pin and plate were immersed in the lubricant of interest at a heated temperature of 110°C. A range of different oils containing different detergents and ZDDPs were tested to assess the tribochemical reactions at the nitride steel surface.

Results: Results suggest that detergent/ ZDDP interactions have complex impact on friction and wear. In this poster these results will be discussed in reference to the nitrided layer properties. Future work will focus on characterizing the chemical species formed within the wear region (tribofilm) that may attribute to this observed tribological behaviour.

Reference: [1] Yue, W., Gao, X., Wang, C., Li, X., Wang, S. and Liu, J. (2012). Synergistic Effects between Plasma-Nitrided AISI 52100 Steel and Zinc Dialkyldithiophosphate Additive under Boundary Lubrication. Tribology Transactions, 55(3), pp.278-287.

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Studying the Effect of Bony Prominences on the Development of Pressure Ulcers

Pressure ulcers present a growing concern to the health services with up to 10% of admitted patients affected with them. In addition to the reduced quality of life experienced, the NHS is faced with significant related costs. Pressure ulcers are skin lesions caused by continuous pressure over bony prominences. They are caused by pressure, shear and friction, or a combination of all three acting at the skin interface. Temperature and moisture conditions at the skin as well as intrinsic factors (weight) also affect the development of pressure ulcers. A bespoke modular skin friction test machine, with a laser to measure displacement, was used to assess the tribological properties of a skin-textile system. Porcine skin models along with hemispherical bone models (5mm -20mm in depth) were tested. Tests were conducted under dry conditions and in the presence of a hydrogel based emollient. Tangential force measurements and displacement were taken and hysteresis loops were produced which showed energy dissipation in the skin. As the size of the bony prominence increased there was a general increase in friction in the systems with emollient in both thin and fat skin. Both elastic deformation and sliding was confirmed in the fat and thin skin models with edge loading noted mainly in the thin skin samples. Deformation was noted to be more dominant under moist skin conditions with gross sliding playing a greater role in the dry skin model. Fat skin displayed broader hysteresis indicating the recovery of more energy upon relaxation and less elastic deformation.

49. Heather McLaren **mnhem@leeds.ac.uk**

William Pulfrey

Thomas Holditch

David Brown

Understanding the Interaction between Bike Tyres and Tram Tracks

Cyclists often have accidents when navigating tram rails. In cities like Sheffield, this causes damage to people and their property and is a huge cost to local government. Incidents generally involve bike tyres slipping on rails or dropping into the rail groove, yet little is known about the interaction between bike tyres and rails. Pendulum tests were carried out to find the friction coefficient in different conditions, which simulated wet weather or traffic emissions on the rail in a city. The best and worst-case values were used to model forces in the contact. The results aligned with expectations: the track became more slippery with water or oil. Road tyres have the most grip, which is likely due to their larger apparent contact area. The approach angle of the bike as it crosses the track affects the likelihood of the tyre slipping or getting stuck. Friction and sliding forces were calculated for different sized wheels and it was seen that a smaller approach angle reduced the friction force. The results show that oil or water on the track reduces the friction between the track and tyre, which means that the minimum safe angle also reduces and slipping is much more likely. Further tests can be done with real cyclists to confirm that a bike will slip into the groove at the expected angle. This is more complicated as in real life there are many other factors at work, such as the rider's confidence and the influence of traffic conditions.

50. Mattia Lai **MLai3@sheffield.ac.uk**

David McCausland

Emanuele Repetto

Real time monitoring of engine lubricant properties

In situ oil viscosity measurement were performed on a 4 stroke electrical generator via ultrasound to demonstrate the viability of ultrasonic measurements of oil viscosity and film thicknesses in a running engine. A matching layer was used to enhance the sensitivity of the device via the superposition of ultrasonic waves. A sump plug was modified with a thermocouple and piezoelectric transducer. Pulses of ultrasound were applied and the echoes monitored through the transducer. The generator was operated under various loads to allow for the impact of engine vibration to be monitored.

51. Shafeeq Ahmed **pm10s3a@leeds.ac.uk**

Hetero-aggregation of complex particulate slurries

The “2012 National Audit Office Report” estimated that the legacy waste clean-up would be ~£67.5bn by 2035, but now the estimation has increased to be ~ £87bn. A lack of fundamental understanding of the nuclear waste material (sludge) has hindered the timely progression of many sludge decommissioning programmes. Part of the complexity results from the heterogeneous make-up of the legacy waste. Containing a multitude of insoluble and soluble species, there is a lack of characterisation and rheological data to effectively support due diligence activities when formulating a solution to the problem. Therefore, an investigation into the aggregation of solids representing sludge waste encountered in the nuclear industry was done, with the express purpose of examining the stability and then the flowability of a heterogeneous particulate sludge. The initial stages of experimentation focused on the interaction between silica spheres and irregular shaped alumina particles. The alumina particles used were significantly larger in size than the silica particles. To control the particle-particle interaction potential, the zeta potential of the particle species was measured across a range of pHs. By adjusting the pH it was possible to control the dispersion-aggregation state of the bi-disperse system. At low pHs the alumina-silica interaction was noted to be strongly attractive (alumina +ve, silica –ve), whilst at neutral pHs the interaction force weakened and eventually became repulsive in basic conditions as the surface potentials on both particles were negative. These interactions were verified using quartz crystal microbalance with dissipation monitoring.

52. Katherine Bailes **pmkab@leeds.ac.uk**

Polymer Solutions for the Mobilisation and Immobilisation of Heavy particles

When nuclear waste is transported in pipes, it quickly settles due to its high density and forms a bed. This may lead to blockages which are of particular concern to the nuclear industry as access for maintenance is difficult. This work explores the shear thinning characteristics of xanthan solutions, with the intention of creating an additive to help keep the particles suspended. It is necessary that this is possible at low concentrations to minimise the amount of additional waste created. Concentrations of up to 1% xanthan were tested at a range of shear stresses. It was found that the zero shear viscosity increased by up to 100,000 times while the infinite shear viscosity remained fairly constant. Particles up to 0.1mm in diameter and 10 kg/m-3 take over 30 minutes to settle 1 mm in 1% xanthan in water. Although this should include most of the particles, further investigation is necessary to determine is this would be suitable. Additional challenges include whether the material could be degraded at the end of the transportation and if this would occur too quickly in the waste environment.

53. Lee Mortimer **pmlfm@leeds.ac.uk**

Effect of four-way coupling on the turbulence field in multi-phase channel flows

This work investigates the effect of a solid, spherical particle phase on the surrounding carrier fluid (water) in a turbulent channel flow. The fluid phase properties are chosen to represent a flow typical of the nuclear waste industry. It is modelled using the direct numerical simulation code, Nek5000, at a shear Reynolds number of 180. A Lagrangian particle tracker has been implemented to simulate the dispersed phase, capable of carrying out two-way coupling and inter-particle collisions (four-way coupling). In order to investigate the effect which the four-way coupled particulate phase has on the turbulence field, mean fluid velocities and turbulent intensity statistics are recorded. The work demonstrates that the introduction of two-way coupling does indeed impact slightly on the turbulence field. Specifically, it reduces the mean velocity profile and increases the streamwise turbulence intensity in the near-wall region. Upon the introduction of inter-particle collisions, the flow statistics studied show a negligible response. Collision density distributions are studied and a temporal migration to the near-wall region is observed. Finally, a preliminary agglomeration model is implemented whereby particles colliding above a certain arbitrary kinetic energy are considered bound. This system is demonstrated for the four-way coupled flow with temporal distributions of agglomerate counts presented. Further work will include extending this model to more closely simulate real-world agglomeration events, in order to investigate how this mechanism affects the turbulence field.

54. Sumaiya Al Hinai **mnsasa@leeds.ac.uk**

Histological and immunohistochemistry (IHC) comparison of mesenchymal stem cell (MSC) in knee osteoarthritis

Introduction: Osteoarthritis (OA) is a biomechanically related progressive degenerative disease that results in cartilage fibrillation, fissuring, associated subcondoral bone (SCB) changes and joint inflammation of soft tissue. Approximately 80% of over 75s suffer from OA with higher prevalence in females. Total Knee replacement (TKR) remains the only treatment for end stage OA. Mesenchymal stem cells (MSCs) are promising source for cellular therapy that can regenerate and restore cartilage however the effect of resident MSCs in OA development is poorly understood. Native MSCS have been identified in SCB and synovial fluid (SF) to have the phenotype.

Aim: To compare histological features and distribution of CD271+ MSCs between medial (more damaged) and lateral (less damaged) areas of OA tibial plateaus.

Methods: Tibial plateaus from total knee replacement (TKR) for OA (n=7) were fixed at 10°C in 4% formalin and decalcified in EDTA. Decalcification was monitored by X-Ray sample flexibility and followed by another fixation. The samples were further dissected before wax embedding. Following embedding 5 mm sections were cut and slides were stained with H/E (for gross morphology) or immunohistochemistry with anti-CD271.

Result: Characteristic features of cartilage damage were observed in each sample. Medial areas showed fissures, flaking of cartilage and areas of complete cartilage loss. Cartilage depleted areas corresponded with area of SCB thickening. Initial results indicate CD271+ MSCs are responding to cartilage damage and associated SCB changes.

Future work: CD271+ MSCs can be harvested from knee SCB for sorting, expansion and transcriptional profile analysis.

55. Catherine Colquhoun **mncc@leeds.ac.uk**

Manipulating the properties of hydrogels to promote ependymal cell migration, proliferation and differentiation for spinal cord repair

Despite the prevalence of spinal cord injury and its costly impact on society, treatment remains limited. Following injury, the main obstacles to repair include neuronal loss, demyelination of axons via oligodendrocyte reduction, and the formation of a glial scar comprised of astrocytes.

Ependymal cells (ECs) have been identified as potential targets for the repair of such injuries as these have shown the ability to differentiate into astrocytes, oligodendrocytes and potentially neurons following injury to the central nervous system.

This projects aims to direct the migration, proliferation, and differentiation of endogenous ECs along favourable lineages using a variety of scaffolds with varied mechanical properties, functionalisation and drug release.

56. Gavin Day **mngad@leeds.ac.uk**

Development of Experimental and Computation Methods to Model Vertebroplasty

Vertebral fractures account for over 700,000 reported fractures each year in the United States, causing pain, loss of vertebral height due to its collapse and increased risk of fracture in the adjacent levels. Using vertebroplasty has allowed large reductions in the pain experienced, however, some controversy remains over outcomes including which patient groups benefit most. To tackle this Finite Element (FE) analysis can be used to understand the characteristics of patient subsets. The work presented details the development of methods both experimental and computational to model augmentation of bovine tail vertebra. The former includes the creation of vertebral fractures using material testing machines, acquiring the stiffness of the vertebrae and augmenting the vertebrae with PMMA cement. Computationally the methods involve an automated approach to converting μCT scans into 3D FE models and modelling augmented vertebrae. Currently a good agreement has been found between experimentally and computationally derived stiffness's for intact vertebrae. Vertebroplasty methods have been able to augment vertebrae with clinically relevant volumes of cement which are able to be masked and models generated. The methods developed will allow for human in vitro vertebroplasty studies to be carried out and accurate augmented vertebral models to be generated.

57. James Holland **bs13j3h@leeds.ac.uk**

The development of sterilisation strategies for acellular nerve grafts

Peripheral nerve injuries are highly prevalent in the UK, resulting in long term patient morbidities and an associated economic burden. Microsurgical implantation of autologous graft material is the current standard intervention; however full functional restoration is rare, partly due to a limited supply of appropriate autograft material. Alternative repair methods have been considered, for example guidance conduits fabricated from synthetic materials (e.g. PLA, PCL/PGA). Unfortunately, these materials are inadequate substrates for supporting cell growth and therefore promoting full restoration of function. A process has been developed to remove the cells from porcine peripheral nerves using low concentration SDS, providing an alternative graft. The composition and biomechanical properties of acellular nerves have been shown to be similar to fresh nerves, indicating significant promise in this approach. One barrier to their widespread adoption is the sterilisation of such scaffolds. Little is known about the effect of tissue sterilisation methods on the biological and mechanical properties of acellular extracellular matrix scaffolds. This project aims to determine the effect of different sterilisation strategies on acellular nerves, including both established (e.g. γ-irradiation, E-beam, ethylene oxide) and novel (e.g. supercritical CO_2, $CuCl_2$ and H_2O_2) methods. The hypothesis is that one or more of the sterilisation strategies will maintain the biochemical and biomechanical properties of the tissue. This study will also aim to elucidate the effects of sterilisation methods on extracellular matrices and cell attachment & differentiation.

58. Kwan Choi Kwan **mnkck@leeds.ac.uk**

Engineering Mechanically Competent Constructs for Cartilage Repair

Repair of cartilage defects is a major clinical need. Approximately 10,000 people undertake surgical treatment due to severe cartilage defects annually in the UK. Cartilage has limited repair capacity; any damage untreated could worsen and eventually leads to osteoarthritis. Current surgical treatments present limitations and have a high risk of defect recurrence therefore a new, effective solution is required. One possible strategy is to implant a functional tissue engineered construct as a replacement for the damaged cartilage. A new method has been recently devised that uses compressive loading to generate constructs with similar mechanical and histochemical properties to native cartilage. Utilising this method, this project aims to determine if there is a specific range of cellular deformation that promotes optimal matrix deposition in maturing constructs. In addition, the corresponding overall construct strain used to produce desired cellular deformation will be defined. To investigate these objectives, constructs will be grown by seeding bovine synoviocytes on non-woven polyethylene terephthalate scaffolds and subjecting them to compressive loading using a bioreactor. The mechanical and biochemical characteristics of the constructs will be measured at different time points during construct development. Matrix quality and quantity will be determined at each time point, along with confocal visualisation of the constructs under compression, to determine whether a specific range of cellular deformation produces optimal matrix deposition in relation to the corresponding construct strain. Such findings could improve the maturation of constructs and the understanding of the use of mechanical stimulation in cartilage tissue engineering.

59. Kenny Man **mnkklm@leeds.ac.uk**

Pre-treatment of stem cells with a Novel HDAC inhibitors to enhance bone tissue engineering efficacy

Our continuously ageing population suffers from bone damage caused by trauma, cancer, congenital defects or common age-associated diseases, such as osteoporosis. The ability to generate new bone is still a major clinical need. The key for bone tissue engineering is to effectively control and divert stem cells differentiation down the osteogenic lineage. One way to control stem cell gene expression is the control of the coiling/uncoiling of DNA around histones. Histone deacetylase (HDAC) proteins play a key role in epigenetics and their inhibitor compounds (HDACi) are well researched for cancer treatments. Novel HDAC3 selective inhibitor MI192, has proven its potential in leukaemia, and rheumatoid arthritis treatments. Inhibition of HDAC3 is linked to osteogenic differentiation. This project aims to optimise the pre-treatment condition of MI192 on stem cells both in vitro and in vivo to enhance the efficacy of bone tissue regeneration. We will also utilize different in vitro (such as MicroTissue system) and in vivo models in this project. The MicroTissue system enhances the cell seeding efficiency on scaffolds creating a construct with a higher osteogenic potential compared to conventional seeding methods. In vivo we will evaluate the repairing/of critical bone defects using HDACi pre-treated stem cells and 3D porous scaffold in a long bone defect model. The pre-treatment of stem cells with HDACi to enhance osteogenesis is a novel solution for bone regeneration that could be patented and clinically translated, directly improving patient's quality of life and help to relieve the related social and economic burden on our society.

60. Katrina Moisley **bs10k5m@leeds.ac.uk**

Bone repair using collagen membranes and autologous cells: Comparison between bone marrow aspirate and platelet-rich plasma

Background: The average cost for patients suffering from fractures following motor vehicle accidents has been estimated at £10,000 per case. The fastest, most effective current treatment involves a two-stage reconstructive process, but there is a strong clinical need to streamline the procedure. One solution could be to use the induced membrane (IM) which forms around the PMMA cement spacer as a basis for a biomimetic scaffold. This scaffold will act as a guided bone regeneration device that can be loaded with bone marrow aspirate, as source of mesenchymal stem cells (MSCs), and platelet-rich plasma (PRP), as a source of osteogenic growth factors.

Results: Histological analysis uncovered the IM's bi-layer structure including a dense cellular layer and a thicker, spongy fibrous layer. Clinical analysis of bone marrow aspirate (based on donor age, gender, aspirated volume and nucleated cell count) were unable to predict MSC quantities which proved to be a very rare and highly variable cell population.
We have also been able to optimize the PRP method, generating a 'pure' platelet plasma which has a 10-fold enrichment of platelets compared to a four-fold increase in commercial products. Commercial PRP was also found to enrich leukocytes and neutrophils making it not only suboptimal, but also potentially detrimental to bone regeneration.

61. Halina Norbertczak **mnhtn@leeds.ac.uk**

Evaluation of decellularisation processes for the intervertebral disc for disc replacement

The intervertebral discs, located between the vertebrae of the spine, play a vital role in load transmission and joint articulation. Disc degeneration occurs as a result of the natural ageing process, trauma or a combination of the two. As a result the mechanical properties of the discs deteriorate and back, neck and referred pain may result, adversely impacting on the individual's quality of life. Current treatments such as surgical fusion of the vertebrae and total disc replacements have limitations and this has led to research and development of tissue engineered solutions with the aim of producing biological implants for the repair and replacement of degenerate discs. One approach is to utilise tissue decellularisation technologies to remove the DNA and other cellular components of native tissues, leaving an acellular extracellular matrix scaffold which is non-immunogenic when implanted into the recipient. This project aims to extend the decellularisation technology to the production of acellular xenogeneic intervertebral discs. A decellularisation protocol is under development which utilises a combination of physical, chemical and enzymatic treatments. The resulting method should not significantly alter the biological and mechanical properties of the tissue. Qualitative and quantitative tests will assess protocol effectiveness for example; biochemical, histological, immunohistochemical and biomechanical tests. It is anticipated that an acellular biological implant will restore mechanical function and allow infiltration of the recipient's cells which will remodel and maintain the scaffold.

62. Heather Owston **bs11heo@leeds.ac.uk**

Investigating the Potential of Periosteal Cells for Bone Regeneration

Surgical interventions for large bone defects remain suboptimal. Autograft bone is the 'gold standard' material to fill defects, however, risks involve insufficient graft volume and donor site morbidity. Therefore, new surgical techniques are needed, the production of a tissue engineered 'hybrid graft' is a new potential approach. This involves mesenchymal stem cells (MSC) being combined with a bone scaffold, which will be contained to a defect site by being wrapped in a membrane. MSCs are known to be pivotal to the bone regeneration process, here, the potential of periosteal derived MSCs are investigated as a new source of bone regenerating cells. Periosteal MSCs have been shown to be more proliferative than BM MSCs in tissue culture. After the first passage BM MSC population doublings plateau, whereas, periosteal MSCs continue to divide up to 20 population doublings. Samples of iliac crest bone (autograft material) has been imaged in comparison to a commercial bone scaffold to act as control images for future experiments. Flow cytometry was used to compare the antigen expression of periosteal and BM MSCs, known positive MSC markers were expressed on periosteal MSCs in combination with the lack of expression of negative markers. Three markers of interest were also tested in order to investigate whether differential marker expression between periosteum and BM MSCs. However, no definitive differences were shown at this time. In conclusion, periosteal MSCs have been shown to have greater proliferative potential compared to BM MSCs, suggestive this source has potential for use in clinic.

63. Georgina Webster **mngw@leeds.ac.uk**

Development of acellular allogeneic nerve grafts for peripheral nerve reconstruction

Peripheral nerve injuries affect 1 in 1000 of the population. The most common form of intervention is microsurgical repair, with autografts used to bridge defects greater than 1-2 cm. However, autografts are associated with significant limitations, including sacrificing a functional nerve, and adequate sensory and motor function is rarely restored. The poor outcome reflects insufficient autograft availability for major reconstruction and microsurgical failure to address regeneration at the cellular level. Implantable nerve guides aim to provide physical guidance to regenerating axons and concentrate neurotrophic and neurotropic signals. Synthetic and natural materials have been studied extensively for this purpose, but the number of commercially available products is confined to a relatively small number of biodegradable materials, including collagen I, III and IV, PLA, PGA and PLGA. Current research focuses on recapitulating the properties of native peripheral nerve extracellular matrix (ECM) to improve cell attachment and provide cellular support to regenerating axons, and the addition of neurotrophic factors to augment trophic support. However, even with these additional factors, autografts have still demonstrated superior outcomes in small animal studies. Decellularised peripheral nerve grafts offer potential as an alternative to both autografts and nerve guides, providing a physically compatible, non-immunogenic scaffold for regeneration. Although this has not been considered in detail, some clinical evidence supports the use of decellularised human nerves (Avance® nerve graft). This project aims to develop a decellularised human peripheral nerve graft that retains the biological and mechanical properties of native ECM, providing a native guidance environment for peripheral nerve regeneration.

64. Aaron Zammit-Wheeler **mnazw@leeds.ac.uk**

Development of a label free cell separator for autologous stem cell enrichment for skeletal repair

Autologous mesenchymal stem cell (MSC) therapies in regenerative medicine offer potential solutions to complex clinical challenges, such as fracture non-union and repair of critical bone defects. Current techniques used to isolate MSCs rely on centrifugation or antibody coupled microbeads. These have limitations due to high costs, lack of specificity and unknown cellular effects in solid tissue. This project aims to develop a device which is able to separate MSCs from a mixed population derived from bone marrow or orthopedic "surgical waste" tissue in intraoperative time. An end product of an enriched population of MSCs with minimal cell manipulation will be delivered. This project comprises four distinct objectives, the development of selective binding and subsequent controlled cell release, development of fluidics-based technology for cell enrichment, identification of further binders to alternative MSC surface markers and characterisation of enriched cell populations at each stage. The implantation of MSCs with a bone lineage potential will promote healing within the patient without the need for surgical intervention. The novel solution to sort these cells from tissue, which would otherwise be discarded, offers great clinical benefit with minimal effort. Identification of other MSC surface markers offers a platform technology for marker-specific cell enrichment, which potentially offers healing for a wide range of tissue types.

65. Jack Brewster **mnjrb@leeds.ac.uk**

Neural tissue engineering using cell-instructive graphene scaffolds

There is an unmet clinical demand for neural tissue repair and replacement, due to the increasing prevalence of neurodegeneration in our aging society as well as treatment of severe damage to neural tissues. However, regenerating neural tissues remains a most challenging task. Studies from ours and other groups have recently shown the mechanical properties of neuron-supporting substrates in vitro and extracellular matrix in vivo can have profound influence on neuronal cell functions. Such findings bear important implications to the development of new generations of biomaterials and particularly fabrication of novel neuronal cell-instructive scaffolds in advancing neural tissue engineering. Graphene is a two dimensional material, and its lateral dimensions can be readily adjusted with different thickness tuned from single to multiple monolayers, porous structure and flexural rigidity. Due to its mechanical properties and electrical conductivity, graphene has been considered to be attractive in fabricating biomedical materials, and indeed has been demonstrated for its use in biomedical applications and potential for neural interface.

66. Emily Davies **mnejd@leeds.ac.uk**

Characterisation and Modelling of Clinically Relevant Mechanical Damage of the IVD

Back pain is a common problem, with it being the cause of around 19 million physician visits and it costing approximately $20 million in the US alone per year. Intervertebral disc (IVD) disorders are thought to be a contributor to back pain. There are a number of methods for diagnosing back pain, these include magnetic resonance imaging (MRI) and a discography. A discography includes the injection of a radio-opaque dye into the nucleus pulposus (NP). At best there is a 50-60% chance of a positive outcome, however this does not take into account the effects of the needle during this invasive procedure (i.e. through puncture). It has recently been suggested that this technique contributes to degeneration in the spine. A number of other surgical interventions, such as annular tears and microdiscectomy, can also lead to unwanted damage. The aim of this project is to produce experimental models of a surgical intervention, followed by computational models of that same intervention based on image data (allowing for image-specific models). The computational models can be validated through the use of the experimental data. The results of the models will be assessed for clinical relevance of the damage mechanism through regular discussions with clinical collaborators at Leeds General Infirmary (LGI).T his project enables the opportunity to find an optimal approach to such invasive procedures, with the hope to reduce the degeneration effects.

67. Richa Gandhi **mnrg@leeds.ac.uk**

In Vivo Imaging of Pathological Vascular Remodelling In Rodents Using Positron Emission Tomography

There is a growing trend to implement *in vivo* molecular imaging more widely in the context of cardiovascular diseases. The aim of this investigation is to determine the potential utility of pre-clinical positron emission tomography (PET) imaging in studying the molecular mechanisms of two different diseases in rodent models: atherosclerosis and abdominal aortic aneurysm (AAA) disease. In particular, PET imaging will be used to localise and monitor pathological vascular remodelling non-invasively with ^{18}F-fluorothymidine (^{18}F-FLT), the use of which will be demonstrated for the first time in AAA models. The image analyses will be studied for their potential role in predicting therapeutic response by building upon an approach using novel calcium channel inhibitors to reduce the progression of AAA in rodent models. ^{18}F-FLT activity is known to correlate with cell proliferation, as its expression is reflective of the characteristic synthesis phase of cell division. It is predicted that ^{18}F-FLT will allow for a more accurate understanding of underlying biological mechanisms by comparing regions with different tracer uptake distributions and attempting to identify patterns of treatment response via histopathological analysis. This information could potentially be used to facilitate the planning and tailoring of more disease-specific therapies. Assessing the efficacy of ^{18}F-FLT can thus help to demonstrate a promising push towards minimising pathological vascular remodelling in AAA disease, whilst expediting treatment development and patient management.

68. Benjamin Golland **mnbhg@leeds.ac.uk**

Fibre-reinforced hydrogels with fibre alignment at the molecular and microscopic scales for SCI repair

Clinical need: Spinal cord injury (SCI) affects around 1000 people in the UK yearly (NHS England, 2013) with 40,000 currently afflicted (BMJ, 2016). Treatment cost is approximately £1 billion annually (Spinal Research, 2011) with individual lifetime costs as high as £3.5 million (WHO, 2013). Symptoms include loss of mobility, impaired bodily functions and poor mental health (WHO, 2013). There is currently no recognised treatment to regenerate damaged spinal cord. SCI is characterised by initial trauma and a secondary biological reaction. Scar formation is fibrotic and glial, featuring invading fibroblasts, collagen and activated astrocytes (Yuan & He, 2013). Axons are physically unable to penetrate scar tissue and chemically inhibited due to proteoglycan overexpression by astrocytes (Jones et al., 2001). Attempting to control the mechanical environment using material-based regenerative therapies may lead to enhanced repair.

Research challenges: A multidisciplinary approach aims to develop an ECM-mimicking polymeric device engineered at nano-, micro- and macroscopic levels of material organisation. Research strategies include:

-Identifying a self-assembly peptide system with inherent biofunctionality and nanofibre-forming capability
-Combining self-assembling peptide technology with a nano-/microfibre manufacturing process to create a porous, fibrous architecture in which fibre orientation and morphology are appropriately configured
-Integrating the fibre-based construct into a novel hydrogel for superior mechanical performance and tissue-like behaviour under physiological conditions
The target outcome will be a structural support with axon growth-encouraging fibre alignment within a mechanically-tuneable, hydrated environment. The research involves development of a new sub-micron fibre spinning technology capable of supporting peptide self-assembly, materials characterisation and the development of new structure-property relationships and investigation of neural cell responses.

69. Megan Hanson **mnmha@leeds.ac.uk**

Musculoskeletal analysis of activity for healthy ageing

With an aging population, the ability to maintain good health throughout life is a priority of the BBSRC, EPSRC and MRC as a way to reduce the ever increasing costs of health care. The main focus of this project is to understand how aging influences the musculoskeletal system in order to maintain physical activity for longer, promoting healthy ageing. It is known that as BMI and age increases, the range of motion of joints and power output decreases. This may lead to pain, and therefore reduction in activity and weight gain causing the cycle to repeat leading to an increased risk of heart disease, stroke and diabetes amongst other illnesses.

Working with industrial partners, a unique rowing apparatus will be tested and developed in order to optimise function of the musculoskeletal system with ageing. The project will use detailed biomechanical motion analysis to assess how to reduce adverse loading during rowing in order to prevent damage to joints by mechanical changes to sporting equipment so as to benefit not only the user but also the manufacturer of such equipment.

70. Trang Nguyen **mntkn@leeds.ac.uk**

Engineering biological bridges to reconnect a severed spinal cord

Spinal cord injury (SCI) creates immediate and long-term physical and emotional pain for 1,000 patients every year, in the UK. The poor intrinsic regenerative potential and inhibitory microenvironment of the lesion, after injury, has resulted in slow progress in the development of effective treatments. Emergency surgical care and intensive rehabilitation remains the standard treatment; however, this is painful and patients are often permanently paralysed. This project seeks to enhance the regenerative process and recovery of sensorimotor function by use of a decellularised peripheral nerve graft to bridge complete spinal cord transections. In a combinatorial approach, the graft will be used alongside vertebral fixation, electrical stimulation, and chondroitinase ABC in a rodent model of spinal cord transection. In order to achieve this aim, development of in vitro and in vivo assays will be used to test and optimise the regeneration conditions around the lesion. Electrophysiological, immunohistochemical, mechanical analysis, and functional rehabilitation techniques will also be considered. Particular research challenges include the transfer of peripheral nerve repair research into the central nervous system. Also, the implementation of a vertebral fixation device in a rodent model has rarely been performed in current literature. Thus, a bespoke device will need to be designed and biomechanically evaluated. A singular therapy is unlikely to be able to cure spinal cord injury. A combinatorial approach represents a promising arena of research to accelerate us closer to this goal, and reduce the suffering and socio-economic burden on patients, their families, and the healthcare system.

71. Alice Philipson **cm10a2p@leeds.ac.uk**

Rapid label-free separation of specific stem cell populations for autologous cell therapies

There are vast potential uses for stem cells in regenerative therapies addressing clinical challenges in oncology, Parkinson's disease, spinal cord injuries, bone, muscle or cartilage defects and diabetes. Using autologous stem cells is advantageous due to their accessibility and safety but a major limitation is the isolation of the rare stem cell population in adult tissues containing many other different cell-types. The ability to separate and concentrate autologous cell subpopulations intraoperatively and without the need for labelling would avoid in vitro cell manipulation and costly cell expansion which could provide an accelerated translation to clinic. This project will use remote dielectophoresis, where an electric field is coupled into a microfluidic channel using surface acoustic waves, combined with biosensor-based technology using protein-binding proteins (Adhirons) to capture stem cells via surface marker recognition. Specifically, the project will investigate: surface chemistry for cell capture and release; markers for stem cell selection; specificity and sensitivity of the methodology; the ability of the cells to retain their multi-lineage potential post-separation and how the two separate technologies can be combined into one single device. The methodology proposed will use nanofabrication/ photolithography/fluidic channel prototyping to manufacture the device, as well as establishing multi-lineage potential of the isolated cell cultures to determine the specificity and selectivity of the device. This research will benefit researchers and patients alike, as the isolation of specific stem cell populations will assist in the elucidation of regenerative mechanisms as well as delivering a minimally manipulated, enriched population of specific stem cells for therapeutic purposes.

72. David Rochelle **mndcr@leeds.ac.uk**

Development of a biomechanical foot and ankle simulator for evaluation of interventions for chronic ankle instability (CASE Project – with Xiros)

Introduction: Two million people suffer an ankle sprain every year in the US, up to 40% of which suffer chronic ankle instability. Chronic ankle instability ultimately progresses to post-traumatic osteoarthritis in 60% of those cases. There has been much debate on the paradigm of this condition and the pathology of ongoing instability, ranging from functional to mechanical impairment. It is likely that numerous factors contribute to the recurring condition.

Research Questions:

-What are the joint contact forces during an ankle sprain?
-What ligaments are most affected during a sprain event?
-How does impairment of the ligaments affect joint stability?
-Does synthetic reconstruction of the ligaments improve stability?

Methods: This study will mechanically characterise the ligaments of the ankle. The normal and instable biomechanics of the ankle will be determined to assist the development of an experimental simulator to assess the loading and motion of the ankle joint complex under normal and adverse loading conditions. The effectiveness of synthetic ligament repair to restore joint stability and biomechanics will be evaluated through a parametric study exploring intervention size, position and fixation.

Impact: Through the development of biomechanical models for the natural and sprain/ instability conditions we can further our understanding of the mechanical environment in the ankle and the strains within the tissues under adverse conditions which is critical for informing future treatment strategies. The application of these models to synthetic repair materials will allow the development of tools to predict pre-clinically the mechanical function of these interventions.

73. Amy Smith **mnasm@leeds.ac.uk**

Tissue repair capacity of Prototype Antimicrobial-Releasing Scaffold

Advanced biomaterials have been designed to aid the regeneration of soft tissue lost during surgery, disease or infection. They are expected to play key roles in the future of periodontology, oral surgery and implantology. Bacterial infection is a common complication which can prevent successful tissue integration and cause failure of medical implants. Misuse of antibiotics has led to the concerning spread of antimicrobial resistance (AMR) so alternative approaches are required to minimise the risk of bacterial contamination. PhotoTherixTM is an advanced bioresorbable polymer scaffold equipped with photodynamic therapy (PDT) technology aimed for use in maxillofacial applications. Typically, an antimicrobial PDT agent is loaded in its inert form and then activated locally through a light source if infection should occur. To enable translation to clinical use, this study aims to investigate how the scaffold architecture and antimicrobial functionality are affected by its chemical, physical and mechanical properties. The incorporation and controlled release of various PDT agents will be studied for their bactericidal effectiveness through various biochemical assays. Evaluation of the cell viability of the scaffold will be performed to determine tissue regenerating capabilities and cell-scaffold relationships. If the technology is established, it could also be extended to the treatment of chronic wounds. The resulting prototype would have a great impact on the health industry by improving patient outcomes, reducing the health economic burden and controlling the spread of AMR.

74. Africa Smith De Diego **mnassd@leeds.ac.uk**

Rapid label-free separation of specific stromal cell populations for autologous cell therapy in musculoskeletal disease

Musculoskeletal diseases represent the second greatest cause of disability worldwide. Future strategies include the use of stem cells to seed engineered scaffolds in order to repair the damaged tissues. For this, the patients' cells are usually harvested and manipulated in the laboratory to obtain a clinically relevant number of cells for seeding. This process requires time and cell manipulation which can have an impact on the patients' safety and on the final cost of the therapy. In order to make this approach easier and more cost-effective, there is a need for devices enabling label free separation of stem cells in real intra-operative time. By using remote dielectrophoresis, where an electric field is coupled into a microfluidic channel using surface acoustic waves, cells can be separated with minimal manipulation. Proof of concept of this technology has already been achieved using yeast cells and dental pulp cells. The aim of this project is to scale up this device in order to deliver the cell separation in intra-operative times while maintaining osteogenic potential. The device will be first optimised with the use of finite element modelling of microfluidics and tested with a complex mixture of cells. After separation, the cells will be tested by seeding them on scaffolds and investigating expression of osteogenic markers. After in vitro validations, cell seeded scaffolds will be implanted into athymic rats with calvarial defects. Bone repair following cell separation will be compared to that obtained with magnetic activated cell sorting.

75. Luke Souter **mnlso@leeds.ac.uk**

Mechanical Properties and in vivo Imaging of Perineuronal Nets

Spinal cord injury recovery, as well as memory retention in Alzeimer's diseased mice have been shown to improve when perineuronal nets are enzymatically removed, reactivating plasticity. This makes them an interesting therapeutic target for enhancing neuronal repair and regeneration. Perineuronal nets are a molecular assembly of extracellular matrix molecules tethered to the surface of a defined population of neurons that regulate plasticity in the central nervous system (CNS). This project aims to understand how the formation of perineuronal nets could change the microenvironment and local mechanics of the neuronal surface, therefore affecting neuronal behaviour. The structure of perineuronal nets are condense and compact, different to other matrices of similar chemical composition that are considered softer. Interestingly the CNS is one of the softest organs in the body and is very sensitive to mechanical changes. Initially, regional differences of perineuronal nets in the brain will be characterised using glycan isolation, biochemistry and size-exclusion chromatography. Then the biophysical properties will be measured using neuronal cultures, atomic force microscopy, rheology and imaging. The biophysical and biochemical analyses will then be correlated and used to create a biomimetic surface that simulates perineuronal nets and has a biophysically tuneable surface. This will allow neuronal behaviour to be studied in relation to changes in biophysical properties. A probe will be designed to image perineuronal nets *in vivo* using MRI. This work will help identify how biophysical properties affect the CNS, which may eventually be used towards translational therapies for spinal cord injury and Alzeimer's disease.

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Spinal Cord Injury: How Does Stabilisation Affect Outcomes?

In the UK, 1000 people per year get spinal cord injuries. An initial injury is followed by a biological cascade resulting in lifelong disability. Treatment is expensive, costing £1 billion per year, yet results in few improvements. Following spinal cord injury, the spine is often surgically stabilised. However, scientific evidence supporting stabilisation is contradictory. It is plausible that changing the mechanical environment of the spine has consequences on the spinal cord. For instance, altering progression of the degenerative cascade after injury, and maybe changing the capacity of the cord to regenerate. This project aims to replicate spinal cord injury and its stabilisation in both 3D cellular and animal models. Results will help ascertain whether stabilisation is beneficial post-injury. Initially, experimental methods to mimic spinal cord injury will be developed. This will involve applying loads using different methods. An optimal method would cause reproducible injury of a pre-determined extent. Then, the effects of stabilisation on this injury will be explored. In cells, this will comprise applying different mechanical stresses and/or strain. In animals, this encompasses design and manufacture of spinal stabilisation device(s) with different levels of rigidity. Different stabilisation conditions will be compared to each other, and to unstabilised controls. This will help determine whether stabilisation has benefits or negative impacts upon spinal damage and regeneration. Overall, understanding whether stabilisation is beneficial to spinal cord injury patients will help guide clinical practice. If changes to stabilisation cause better functional outcomes, this may help improve function in spinal cord injury patients.

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Characterising variations in foot and ankle mechanics using statistical shape modeling and a novel multibody model

Problems associated with variations in foot posture and function affect a large proportion of the population ranging from the sedentary with a high body-mass-index to active triathletes[1, 2]. Both “high-arch” and “flat” foot-types have been linked to acute lower extremity injuries and chronic conditions such as knee osteoarthritis[3]. The precise relationship between foot posture and pain remains unclear however. The aim is to develop a method to characterise variations from normal in foot and ankle biomechanics, using a statistical shape model and a multibody model. Statistical shape modeling has been used to segment structures and geometric variations in hip and knee images [4] but this technique has not been applied to the foot and ankle previously, due to the complexity of the multiple anatomical structures present. Musculoskeletal multibody modeling has the potential to model internal pathological changes in foot and ankle mechanics. With inputs from medical imaging, motion capture, and force plate data, it is possible to characterise normal and potentially pathological variation in the foot and ankle with the potential for identifying future treatment targets.

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Biofilms and disinfection by-products in a water distribution system in Colombia

Biofilms in drinking water distribution systems (DWDSs) a major concern because they are related to deterioration of drinking water quality. Drinking water and biofilm samples were collected in 9 sampling points within a DWDS in a city in Colombia. Samples of pipes were taken during leakage repair activities to enable recovery of the biofilm, while drinking water samples were collected from the nearest household to each site. Microbial communities were characterized in both biofilm and water samples by pyrosequencing of extracted DNA. Content of dry biomass and total organic carbon (TOC) were also measured in biofilm samples. Temperature and concentrations of chlorine, TOC and total trihalomethanes (TTHMs) were measured in drinking water samples. Sampling points were characterized by water age, pipes age, and pipes material. Statistical tests were carried out to identify associations between microbiological data, water quality variables and DWDS properties. Proteobacteria was the dominant phylum in water and biofilm samples, similar results have been obtained in other areas with temperate weather, which may indicate that conventional water treatment processes act like a “filter” that favours the presence of specific microbial communities to phylum level. Microbiological data were not associated with any water quality parameter, which may be related to the complexity of the studied DWDS. Relative abundance at species level in both water and biofilm samples were correlated to water age, habitat, and water age and habitat combined. Results of sequencing analysis represent a step forward on the application of suitable tools to study microbiological aspects of DWDSs.

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