SACEC 2021
PAPER and POSTER Programme
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ENVIRONMENTAL PROCESS ENGINEERING		
Title	Author Name	Abstract
Drilling Process and Operation: A Major Contributor to Anthropocene	Monsurat Omolola	Drilling operation during exploration of natural oil and gas has caused a huge damage on the planet, especially to ocean acidification and habitat destruction. Water contamination and hydraulic fracture are major drilling activities with significant negative effects on anthropocene. Application of hydraulic fracturing in unconventional wells to increase the permeability of the porous media induces the slipping of formation bedrock which ultimately results to several earthquakes. The CO2 gas emitted through the gas flare drilling platform and other hydrocarbon gases are major greenhouse gases that contribute immensely to global warming. Limited options of produced water treatment and eventual disposal of drilling wastes to water bodies have been reported to contribute immensely to marine environmental pollution. All these pollution cases pose long and short term danger to the polluted environment. Despite all these challenges, use of fossil fuels as a major source of energy via various technologies has increased rapidly worldwide. Ultimately, without drilling, there is no fossil fuel. However, focus has been on the anthropogenic effects of fossil fuel burning without paying more attention on the process leading to the extraction of the fossil fuel, the drilling operation. In this review, efforts were made to highlight various hazards associated with drilling processes with emphasis on major impact on anthropocene. This is an attempt to safeguarding the planet and provoking the thoughts of stakeholders in the sector.
A Seasonal Characterisation of Acid Mine Drainage in the Mpumalanga Coalfields Region	Janet Smith	In South Africa, sulfide is a large component of many of the natural ore bodies, in particular coal and gold ores. This results in large-scale problems such as acid mine drainage (AMD). AMD run-off or decant can corrode infrastructure and, if allowed to flow unchecked, will infiltrate ground and surface water bodies causing severe negative impacts on the surrounding environment. Sustainable, cost-effective treatment processes could mitigate such AMD problems. However, prior to designing treatment processes, the nature of the problem needs to be comprehensively quantified. In this study, the physical and chemical characteristics of AMD, emanating from two coal sites in Mpumalanga, are described and the ramifications of these properties, for the design of treatment processes, are discussed. The concentrations of total dissolved solids, total acidity, and dissolved iron varied by an order of magnitude between the sites. Reduced rainfall volumes were recorded during the winter months, and seasonal variability of AMD waters was shown in instances where reduced and increased concentrations coincided with increased and reduced rainfall volumes, respectively. Significant concentrations of aluminum, manganese and zinc could impact the effectiveness of active and passive treatment systems and should be considered in the design of a suitable treatment system.
Thermal decomposition modelling of Lignocellulosic biomass via thermogravimetric analysis	Mashau Mafamadi	14 Thermal decomposition of lignocellulosic biomass is a complex procedure as it tends to occur in multiple steps with different reaction rates. In this study, thermal decomposition behaviour of Corn Stover and Sugarcane bagasse were investigated using thermogravimetry (TGA-DTG) technique at heating rates of 20, 30, 40 and 50 0C/min under nitrogen gas flow at 55 mL/min and oxygen gas flow at 15 mL/min. The Flynn- Wall Ozawa (FWO) and Kissinger Akahira Sunose (KAS) models were used to estimate the kinetic parameters such as apparent activation energy, pre-exponential factor and order of reaction in order to be able to design the pyrolytic reactors that will be used for biomass conversion. The apparent activation energies calculated ranged from 44.39 -134.81 KJ/mol using the FWO method, and 22 higher at 87.83 – 282.41 KJ/mol using the KAS method. The activation energies for Sugarcane bagasse was 31.34-120. 82 KJ/mol using the Flynn Wall Ozawa method, while from the Kissinger-Akahira Sunose method it was 58.85 – 250.72 KJ/mol. The Friedman's model was used together with reaction-order model to estimate the order of reaction. The experimental data fitted well with the predicted values showing that the complex degradation process followed a first order reaction for the Corn Stover sample. However, the reaction order model could not best describe the Sugarcane bagasse reaction mechanism as the predicted values from the model did not fit with experimental data indicating that the decomposition consists of simultaneous reactions.
Catalytic fast pyrolysis of woody biomass in a dual fluidised bed to produce high quality liquid fuel and char	Mike Heydenrych	There are several examples of commercial fast pyrolysis operations, but these processes tend to be complex particularly when scaled as well as thermally inefficient. A new fast pyrolysis process is described that has tight thermal integration, resulting in excellent thermal efficiency when converting biomass into liquid fuel and char. Silica sand serves as a heat transfer medium to transfer energy derived from the combustion of pyrolysis gases and char to the pyrolysis zone where solid biomass is converted to non-condensable gas, liquid fuel and char. This, combined with the heat recovery of combustion air, allows tight thermal integration of the processes in a single unit operation. In this paper, the performance of a pilot plant unit is discussed in terms of product mass and energy yield. The value of the char recovery is twofold: first, the char can be used to remediate the soil where the biomass was grown and return minerals to the soil, and second, it serves to sequestrate carbon, which makes the process carbon-negative overall.
Developing mathematical techniques for including hydraulic reactor models into biokinetic models with a focus on constructed wetlands	Ruth Stephenson	Constructed wetlands are engineered systems aimed at utilizing the processes of natural wetlands for wastewater treatment. Biological, chemical and physical processes occur in constructed wetlands which aid the conversion of waste into non-harmful products (Kadlec and Wallace, 2009). To make more effective use of this treatment technology, it is important to understand the inner workings of constructed wetlands (Samsó and García, 2014). Numerical modelling aims to do just that. With a deeper understanding of the various processes, current design criteria can be improved and the efficiency of the treatment technology may be increased (Samsó and García, 2014). This paper gives the development of a new residence time distribution technique to describe the hydraulic behaviour of constructed wetlands and combine it with an existing and widely accepted biokinetic model, the Constructed Wetland Model No. 1.
Continuous Bio-recovery and Bio-reduction of Pb(II) in a 2-stage tank using an industrially obtained consortia as a Bio-catalyst	Jeremiah Chimhundi	The main objective of this study was the continuous bio-recovery and bio-reduction of Pb(II) using an industrially obtained consortia as bio-catalyst. This was achieved through the design and application of a Continuous Upflow Anaerobic Sludge-Blanket Reactor (CUASBR) for the treatment of simulated industrial wastewater. The bioremediation technique applied made use of yeast extract as the microbial substrate and Pb(NO3)2 as a source of Pb(II). The CUASBR was able to treat 80 ppm by 100%, 500 ppm by 98%, 750 ppm by 98%, 1000 ppm by 92%, and 2000 ppm by 22% in 1 day, 5 days, 5days, 7 days, and 9 days, respectively. XRD analyses of the precipitate revealed the presence of Pb, PbS, pyromorphite, apatite, and anglesite.

The Use of Basic Oxygen Furnace Slag as a Substitute for Lime in Acid Mine Drainage Treatment	Tamlyn Naidu	Acid mine drainage (AMD) and basic oxygen furnace slag (BOFS) are both waste products produced in massive quantities throughout the world in the mining and steel industries. These products require extensive treatment before release back into the environment or before reuse in other industries can occur. A method to treat AMD using BOFS was thus conceptualized with the aim of treating AMD and BOFS for further reuse. An investigation into the replacement of lime (a traditional reagent) with BOFS in AMD treatment was conducted in this regard, to determine if BOFS was effective in raising the pH of AMD and subsequently lowering the metal and sulfate content via precipitation reactions. A number of titration experiments were undertaken to determine the extent of treatment and it was found that BOFS is effective in the treatment of AMD. A review study was also done to determine what the mechanism of treatment was. It was found that treatment occurred via hydration and dissociation of BOFS and subsequent precipitation of metal hydroxides, oxides, sulfates, sulfides and silicates in a sludge.
Design, construction and testing of a laboratory-scale membrane distillation bioreactor (MDBR) for water purification	Kavisha Patel	The pulp and paper industry produces a significant amount of wastewater that contains a variety of organic and inorganic contaminants, making it nearly impossible to discharge directly into a water source. As a result of the condition of the untreated mill effluent and strict environmental regulations, significant pressure has been placed to develop suitable technologies capable of treating and reusing this wastewater. This study evaluates the potential of the membrane distillation bioreactor (MDBR) for the treatment and reuse of pulp and paper mill effluent. The MDBR is a wastewater treatment technology combining the conventional membrane bioreactor (MBR) with membrane distillation (MD). This technology is best suited to applications which require a high quality water product and a long residence time for the effective removal of problematic organics. The system alone is potentially able to accomplish wastewater treatment and reuse in one step that is without the need for any post-treatment processes. Such key features make the MDBR an attractive treatment option. The study is still on-going and if successful, results will be presented. The MDBR developed in this study has the potential to improve water quality, reduce sludge production and greatly minimize the discharge of wastewater into rivers and streams.
An analysis of petroleum storage tank emissions and procedures to reduce the resulting environmental impact.	Theasha Naidoo	Climatic factors coupled with urbanization and its dependence on carbon-based fuel for a range of purposes, have highlighted a major concern regarding the rapid increase of hazardous gas emissions globally (Howari, 2015). The abatement of pollution, process impact on health and the environment, and safety protocols of emissions are important emerging issues. Oil and gas industries are significant contributors of volatile emissions. Large-scale accurate monitoring of emissions is difficult to quantify due to its complex nature. Therefore, knowledge from longstanding production process standards is necessary to ensure accurate emissions estimates. The estimation of emissions is also necessary for the implementation of emission control methods which actively work to limit emissions. Atmospheric storage tanks also represent a significant portion of industrial incidents, typically due to its fragility and inability to withstand slight overpressure. Inert gas padding is a safety system implemented in industry to prevent the chemical oxidation of the contents within the tank by controlling the pressure within the storage tanks (U.S. Environmental Protection Agency, 1992). This study reviews the current knowledgebase and handling practices for volatile organic compound emissions from petroleum storage tanks, examines suitable storage operating conditions, and aims to provide strategies for implementation to achieve safe control and handling of emissions by performing calculations based on API 2000 (Ciolek, 2006) and dynamic simulations on ASPEN Plus.
Performance Evaluation of Activated Carbon and Multiwalled Carbon nanotubes for effective removal of BTEX compounds from Industrial Wastewater using Adsorption Process: Comparative Study.	Kedibone Melaphi	Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) compounds are aromatic compounds present in common groundwater and potable water as pollutants. The negative health effects that result from exposure of these pollutants have necessitated research in this direction. This study investigated the adsorptive performance of multiwalled carbon nanotubes (MWCNTs) and macadamia nuts-derived activated carbon (MACs) for the removal of BTEX compounds from synthetic industrial wastewater. The adsorbents were characterised using Fourier Transform Infrared Spectra (FTIR) to check the surface functional groups of the adsorbents, the textural properties were obtained by Brunauer-Emmett-Teller (BET). Scanning Electron Microscopy (SEM) was used to check surface morphology. Activated carbon adsorption capacity was calculated to be 17.59 mg/g, 57.59 mg/g, 55.59 mg/g and 51.59 mg/g for benzene, toluene, ethylbenzene and xylene, respectively. The adsorption capacity of carbon nanotubes was considered low at 17.46 mg/g, 41.63 mg/g 35.23 mg/g and 37.98 mg/g for benzene, toluene, ethylbenzene and xylene, respectively. The adsorption kinetics fitted the pseudo second order for both MAC and MWCNTs, the adsorption isotherms were fitted into the Languirm and Freundlich model. Activated carbon derived from macadamia nut shells proved to be a better adsorbent precursor than multiwalled carbon nanotubes.
Potential of Deep Eutectic Solvents for the Generation of Reactive Oxygen Species	Deborah Adeoye	Many organic processes are initiated and proceed by reactive oxygen species. The technology for the generation of these species in industrial processes over the years has been through metal-catalyzed oxidative reactions that are exposed to non-ionizing radiation. The major drawback has been the non-environmentally friendly nature and toxicity of some of these radiation sources as well as the complete removal of the metal-containing sludge generated from using conventional catalysts. Deep Eutectic Solvents (DESs) have found a wide range of industrial applications due to their tune-able characteristics. These characteristics have made for their excellent applications in the production of pharmaceutics, the removal of heavy metals from wastewater; as electrolytes in electro-deposition processes, biodiesel synthesis, and the dehydration of natural gas among others. The application of DESs in the synthesis of organic compounds as solvent and/or catalyst is still a trendy aspect of research. Some works have shown the ability of certain DESs to generate oxygen atoms during oxygen transfer reactions. This prompted the investigation into its ability to generate other reactive species. This work sought to investigate the potential of DESs for the production of peroxyacids which will eventually facilitate the generation of hydroxyl radicals (•OH). This will further broaden the application of DESs in organic synthesis and degradation processes, as well as wastewater treatment.
Catalytic Pyrolysis of Municipal Solid Waste: Effect of South African synthesized zeolite on PE plastic waste	Olusegun Ayodeji	Zeolite Socony Mobil–5 (ZSM-5) was produced by metakaolinizing a South African kaolin deposit in Grahamstown and mixing it with sodium hydroxide (NaOH), tetrapropylammoniumbromide (TPABr), sodium silicate pentahydrate (Na2SiO3.5H2O) solution, and deionized water to produce mole fractions of 20SiO2:0.05Al2O3:1.5Na2O:2TPABr:200H2O. Scanning electron microscopy (SEM), x-ray diffraction (XRD), and Brunauer–Emmett–Teller (BET) surface area were used to analyze the produced zeolite. The findings revealed that the generated sample was ZSM-5. The synthesized zeolite consists of 179,9 m2/g, 49,262A, and 0,05 cm3/g of specific surface area, pore size, and pore volume respectively. The influence of the produced ZSM-5 on plastic waste was studied at the temperature range from 300 °C to 500 °C. Polythene bags were employed as feedstock for the experiment. The liquid fuel produced from the catalytic pyrolysis was evaluated using a gas chromatograph-mass spectrometer (GC–MS). A significant range of hydrocarbons were obtained as a result of the effective conversion of plastic waste to liquid fuels demonstrated by the results obtained in this study. Kaolin zeolite of South African origin, synthesized into zeolite, has shown excellent promise as a natural zeolite catalytic material for plastic waste pyrolysis.

Facile synthesis of a series of photocatalysts for photocatalytic abatement of 2-chlorobiphenyl	Herman Potgieter	Due to the need to solve global energy crises and environmental problems, there is much interest in the development of efficient and effective semiconductor photocatalysts. ZnO nanoparticles and ZnO-BiOI 10% heterojunction were synthesized through facile synthesis methods. The structural and crystal phases, morphologies, elemental analysis, surface area measurements and optical properties were measured by XRD, SEM, energy dispersive spectroscopy, N2 adsorption-desorption isotherms via the BET method and UV-vis spectroscopy respectively. The photocatalytic activities of the as-synthesized photocatalysts were evaluated in the photocatalytic degradation of 2-CBP under solar simulation. Results obtained showed the superior photocatalytic activity of the ZnO-BiOI 10% composite. This is attributed to the optimum loading of BiOI into ZnO to form a p-n heterojunction which ensured effective charge separation, due to the formation of inner electric fields between two semiconductors.
A NARRATIVE REVIEW OF PLASTIC WASTE PYROLYSIS: CHALLENGES AND OPPORTUNITIES	Zvanaka Senzeni	Plastic waste management (PWM) in South Africa entails mechanical recycling and landfilling. The objectives of this review study are to explore the possibility of using pyrolysis in PWM. The key findings are that most plastic types will result in high oil yield although PET and PVC may not be suitable candidates for pyrolysis due to the corrosive benzoic acid and HCl generated during their pyrolysis respectively and the calorific value (CV) of the produced oil which is also impacted negatively.
Fluidisation behaviours of nanoparticles	Kanku Lubale	The experimental measurement of the pressures in a different region of the fluidized bed; in the plenum chamber, on the bed of the solid material, and above the bed of solid material was performed by using pressure transducers of model S-20, P#10471134 and the inverted manometers to investigate the behavior in the fluidization of samples of size 277 µm, 428 µm, 161 µm, and 338 µm. The applicability of the published correlation such as the Ergun equation was fitted to the experimental pressure drop measured using both measuring methods; the sphericities of the samples were measured using the fitted Ergun equation. The fluidization parameters such as minimum fluidization velocity, voidage, and height were measured from the experimental data and compared with the calculated minimum fluidization parameters obtained from the published correlation. The study on the behavior of the samples was to familiarize with the application of the published correlations in the investigation of the fluidization behavior of 13 nm aluminum oxide nanoparticle in size. Two methods were used during the experiment in the fluidization of nanoparticles materials; acoustic sound fluidization and Vibro-fluidization. During the enhanced fluidization by external forces of aluminum oxide nanoparticle, it was observed that pressure transducers of model S-20, P#10471134 were appropriated for pressure measurement; and the primary size of nanoparticles formed agglomerates, and their fluidization was of agglomerate particulate fluidization. The use of the Richardson and Zaki equation and stoke law in the experimental data was to estimate the size of the agglomerates formed during fluidization associated with mechanical vibration and acoustic sound.
The remediation of carwash wastewater with chemical coagulation and adsorption process	Mujahid Aziz	This study aimed to apply a combined treatment process of chemical coagulation (CC) and adsorption to remove pollutants from carwash wastewater. The process efficiency was evaluated according to the removal of anionic surfactants (AS), turbidity, chemical oxygen demand (COD) and fats, oils, and grease (FOG). CC experiments were conducted using polyferric sulphate (PFS) at different concentrations. Results showed 120 mg/l PFS was the optimal concentration (Turbidity: 99%, FOG, 96%, COD: 79%, AS: 45%). The supernatant of the CC treatment process was applied to the adsorption process using a commercial powdered activated carbon (PAC). The PAC was characterised using Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). Results showed the Freundlich isotherm fitted the data well with a monolayer adsorption capacity of 82.9 mg/g for AS and reached equilibrium within 60 minutes. Adsorption kinetic models investigated showed conformity of the pseudo-second-order (PSO) model to the adsorption of AS. Thermodynamic adsorption parameters showed that the adsorption of AS onto PAC was endothermic and spontaneous. The adsorption mechanism was a combination of chemical and physical adsorption but dominated by chemical adsorption. The combined treatment process achieved an overall removal efficiency of COD: 98.5%, FOG: 100%, AS: 99% Turbidity: 99%, respectively.
Removal of zinc and copper ions from industrial wastewater using bio-waste: a case study on water hyacinth	Nashwa El-tahhan	The investigation presents the result of study on adsorption of zinc and copper from aqueous solutions by dried water hyacinth as a low-cost sorbent. The influence of pH, contact time, adsorbent dosage and initial concentration was studied using batch adsorption experiments. Experimental results indicate that the best contact times for the removal of Zn (II) and Cu (II) using dried water hyacinth were 10 and 60 minutes, respectively. Furthermore, the best pH and dosage of adsorbent were respectively found to be 4 and 3 g for Zn (II), while 6.5 and 1 g were respectively attained for Cu (II). The maximum removal of Zn (II) was 71 % at low initial metal ion concentration of 10 ppm which is equivalent to 0.32 mg/g adsorption capacity and 86% for Cu (II) at 20 ppm which is equivalent to 0.855 mg/g. Langmuir and Freundlich isotherm models were employed in carrying out the equilibrium studies. The experimental data were found to proceed with the Freundlich model for both zinc and copper as evidenced from the higher coefficients of determination (R2) values. The experimental data was also subjected to pseudo-first-order and the pseudo-second-order kinetic models.
What Material Flow Analysis (MFA) and Life Cycle Assessment (LCA) reveals about plastic polymer production and recycling in South Africa	Taahira Goga	Global production and consumption of plastics has increased significantly in recent years. The environmental impacts associated with this trend have received growing attention internationally with single-use plastic packaging responsible for most plastic pollution. Locally, the South African Plastic Pact aims to transform the current linear sector model into a circular system by setting targets for increased recycling rates and recycled content. The aim of this research is to document and quantify the impacts of implementing such circular interventions across the plastic life cycle. Industrial ecology tools, Material Flow Analysis (MFA) and Life Cycle Assessment (LCA), are used to generate mass-based indicators as well as indicators of potential damage such as the global warming potential. An initial carbon footprint analysis revealed that the South African plastic industry generated 17.9 Mt CO2eq. emissions in 2018, with 52% of these due to the local coal-based polymer production process. The end-of-life stage lacks proper waste collection for a third of the population, but contributed only 2% to the total greenhouse gas emissions, with recycling having a minimal environmental impact. Further analysis will reveal the impact of increasing mechanical recycling rates on the material flows of local polymer production and imports as well as the extent to which other environmental impacts can be reduced.
Evaluation of two different reactor configurations for the simultaneous remediation AMD and pretreatment of lignocellulosic biomass.	Nick Burman	A process to simultaneously remediate acid main drainage (AMD) and pre-treat lignocellulosic biomass was investigated. In this lignocellulosic biomass is contacted with AMD, breaking down the carbohydrates in the biomass into sugars which can be utilized as a carbon source by sulfate-reducing bacteria (SRB) to perform dissimilatory sulfate reduction (DSR), which remediates the AMD. The breakdown in carbohydrates pretreats the biomass making it more susceptible to further enzymatic hydrolysis to produce glucose that can be fermented to produce bioethanol or other biochemicals. Two different reactor configurations have been experimentally evaluated: A, biomass first undergoes pretreatment at high temperature (90°C), producing a COD rich stream that is cooled and undergoes DSR in a separate reactor; B. biomass is pretreated and DSR occurs in the same reactor at ambient temperatures (30°C). The performance of these two reactor configurations was evaluated both in terms of the rate of sulfate reduction and the amount of glucose that was released after enzymatic hydrolysis. The amount of glucose released from enzymatic hydrolysis was found to be 22.0g/L for A. and 26.1 g/L for B. The rate of sulfate reduction was found to be 0.019 g/L/day for A. and 0.073 g/L/day for B. This suggests that B. is better suited, although a further evaluation of operating and capital cost of both should be performed to determine which is more economically feasible.

Integrated development and optimization of an organic acid-based hydrometallurgical process for treatment of spent lithium-ion batteries (LIBs)	Sabelo Jeza	Lithium-ion batteries (LIBs) are the heart of the latest technology devices, but these batteries become harmful waste at the end of their life. This study aimed to develop an integrated and optimised acid organic acid-based hydrometallurgical process for the treatment of LIBs to recover metals after end-of-life. Citric acid was selected as the organic acid to leach LIBs; at the constant condition of 95 °C, 750 rpm stirring, S/L ratio of 20 g/L and 2 vol. % H2O2, the effect of lixiviant concentration (0.75 M, 1 M, 1.5 M, 2 M and 3 M) on metal equilibrium extraction was investigated. The concentration of 0.75M resulted in equilibrium metal extractions of 94.3% Li, 95.1% Co, 96.2% Mn and 95.7% Ni after 1 hour. Ni was the first metal to be recovered from a leachate solution using 0.07 M DMG at a pH of 6, followed by the solvent extraction of Mn using 10% D2EHPA at an O/A ratio of 3 and a pH of 5. Mn was stripped from the organic phase using 0.5 M H2SO4 at an O/A ratio of 1.33 followed by hydroxide precipitation. The aqueous phase from Mn solvent extraction mainly consisted of Co which was precipitated using 15 NaOH at a pH of 13.5. Four products yielded include Ni(OH)2 with more than 99.5% purity, followed by 89% Mn(OH)2 product, 97% Li2SO4 product and lastly cobalt hydroxide based product with 68 % Co(OH)2.

REACTION ENGINEERING

Title	Author Name	
An experimentation and modelling study on flue gas desulphurization using Spray Drying Absorption.	Lawrence Koech	An investigation was undertaken to determine the performance of a laboratory-scale spray dryer (semi-dry process) involving flue gas desulphurization (FGD) in order to contribute to the understanding, modelling and design of an industrial process. The study consisted of a systematic experimentation programme with a spray dryer suitable for FGD involving the integration of evaporation, drying and SO2 absorption. The experimentation also involved the evaluation of different sorbents with relevant properties and which are readily available. An important aspect of the experimentation is that process conditions (state variables) within the dryer/absorber space (axial and radial profiles) such as temperature, pressure, velocities, humidity, SO2 concentration were measured accurately in addition to the controlling and output variables, such as flowrates, temperatures, concentrations, and efficiency (calculated). A complete set of results, with a parametric analysis, will be presented from which quantitatively conclusions concerning the contribution of the rate determining steps, namely evaporation, drying and absorption on the efficiency of the FGD process will be discussed. A brief description of a suitable integrated model and comparison of some important experimental results will also be shown.
Optimum Flowsheet Synthesis for the Integrated Gasification Combine Cycle Using Mathematical Modelling	Jude Bonsu	This study proposes a novel approach for the synthesis of an optimal flowsheet for the Integrated Gasification Combined Cycle. The approach entails developing a superstructure which provides options for the optimal gasifier design, and the degree of integration between the air separation unit and gas turbine. The mathematical model based on the superstructure is used in the synthesis of an IGCC plant while exploring three scenarios. Scenario 1 is the simulation of a standard IGCC plant. Scenario 2 is the synthesis and design of an optimal gasifier with a background IGCC process. The decision variables in scenario 2 were the gasifier volume, reactor configuration, steam to coal ratio and the oxygen to coal ratio. The third scenario is the determination of the optimal flowsheet path for the IGCC process. In addition to the decision variables in scenario 2, scenario 3 also determined the optimal integration between the air separation unit and the gas turbine. The objective function for the example is the maximization of the thermal efficiency of the plant. The results show that improvement of 6.79% and 10.96% in the objective function relative to scenario 1 is achieved for scenario 2 and scenario 3 respectively
The potential use of raw iron ore in Fischer Tropsch Synthesis	Samuel Mubenesha	Fischer Tropsch Synthesis (FTS) has been studied in the literature as a greener pathway to cleaner and sustainable hydrocarbons production. FTS has been proven to be a useful technology for integrating into XTL greener processes. However, the cost to upscale laboratory FT formulations to pilot scale is significantly expensive. This work proposes a cheaper and scalable low-temperature Fischer Tropsch iron ore catalyst that is mechanically suited for fixed bed reactors. The most robust solid catalyst recorded in this work; was a single pellet crushing strength of 1833 kPa; which exceeds the recommended single pellet of 620 kPa for commercial spherical alumina and is thus deemed apt for fixed bed reactors [15]. A manufacturing cost analysis of iron ore was estimated to be US$38.45/kg using the CatCost model and the conventionally prepared iron catalyst was US$71.44/kg using the same model. The manufacturing cost estimations of modified iron ore were found to be 46% cheaper than a conventional commercial iron catalyst and equally effective in catalyzing FT reactions. The catalytic performance of the modified iron ore catalyst showed a CO conversion of 72.1% ±4.24, with WGS and C5+ selectivity 48.6% ±1.96 and 83.2%± 5.24, respectively. These findings were comparable (both in CO conversion and product selectivity) to the ones reported by other researchers.
Process intensification in octene hydrogenation: Application of nanocatalysts and ultrasonic irradiation in a slurry phase reactor	Obert Mupomoki	Sonochemistry has been discovered to influence the rate of chemical reactions that experience a lot of mass transfer resistance in slurry phase reactions. Applications of sonochemistry have been developed in virtually all areas of chemistry and related chemical technologies and the hydrogenation of alkenes, which occur in the presences of a metal catalyst such as nickel, palladium, platinum or rhodium is one such reaction of vital industrial importance. In this study, the influence of ultrasonic irradiation on the reaction rate and catalyst deactivation for the hydrogenation of 1-octene using a commercial nanosized Pt/AI2O3 catalyst was investigated. A three phases slurry reactor was used to allow for adequate contact between the solid, liquid and gas phases. To enhance reactor performance and intensify the process, ultrasonic irradiation was used. It is believed that the technology improves contact between the solid, liquid and gas particles in aiding the transfer of materials across phase boundaries. This is done via the generation of cavitation microbubbles, where the growth and collapse of these bubbles generate localized regions of high temperature and pressure. The experimental design was divided into two parts in which the first part investigated both sonicated and unsonicated hydrogenation reactions at varying temperatures. The second part involved sonicated and unsonicated hydrogenation reactions at a fixed temperature for different reaction times whilst reusing the Pt/AI2O3 catalyst. The products of the reaction were analysed using a Shimadzu (2014) gas chromatography system to determine the conversion of 1-octene and the yield of hydrogenated products. Octene conversions of varying proportions were observed and conversions of approximately 97% were realised especially at higher temperatures.
Experimental Study of the Reaction Kinetics for the Production of Xylitol from Xylose Laden Waste Streams	Vassili Revelas	A statistically designed study was conducted to ascertain kinetics of conversion of xylose to xylitol using borohydrogentaion. Batch kinetic experiments were carried out for the reaction of xylose and sodium borohydride in the presence of sodium hydroxide solution. Analysis of xylose concentration- time data showed that the reaction order kinetics with respect to xylose follows a first-order rate law. This finding supports the mechanistic theory that the first hydride transfer is the rate-determining step. The study shows rate constants to be 0.03437 1/s and 0.00976 1/s at 25 0C and 60 0C. Additionally, the activation energy and frequency factor were determined to be 31.7444 kJ/mol and 19146.72, respectively. Furthermore, a two-level factorial design was used to determine the influence of specific parameters, namely: initial xylose concentration, temperature, and reaction time. The analysis of these reaction factors indicated that the most significant factor was time followed by temperature and then concentration. Furthermore, interactions between time and concentration and the three-way interaction were significant.

SEPARATION TECHNOLOGIES		
Title	Author Name	
Performance Evaluation of Freeze Crystallization for recovery of Water and Sodium Sulphate from brine.	Phalakwane Ranathole	Freeze crystallization is used for the treatment of highly saline effluents. Currently scraping ice from cold surfaces is a challenge that needs to be overcome. This investigation focused on a heat exchanger where no ice scraping is needed. The objectives of this investigation were to identify optimum conditions to achieve the following: Pre-cooling of brine from 60°C to ambient temperature; predict the behavior of Na2SO4 and NaCl during freeze crystallization, and calibration of the model through the recovery of water through ice formation. The following conclusions were made: Feedwater with temperatures of 60°C can be pre-cooled through ambient cooling in shallow pans to 10°C above room temperature within a contact time of 30 min; 100 g/L Na2SO4 can be removed only through cooling to its solubility of 45 g/L. The energy consumption for the recovery of 1 500 kg Na2SO4 per day amounts to 18.87 kW; 100 g/L NaCl can be treated only through freezing for recovery of salt due to its high solubility of 290 g/L. The energy consumption for the recovery of 1 500 kg NaCl per day amounted to 132.21 kW in the case of 90% ice recovery. Ice, could be recovered from a 34 g/L salt at -2°C. The ice purity improved over time, due to the improved ice brine separation method.
Performance Evaluation of Activated Carbon and Carbon Nanotubes for Removal of BTEX Compounds from Wastewater using Adsorption Process: A Comparative Study	Olawumi Sadare	Benzene, Toluene, Ethylbenzene and Xylene (BTEX) compounds are aromatic compounds present in common groundwater and potable water as pollutants. The negative health effects that result from exposure of these pollutants have necessitated research in this direction. This study investigated the adsorptive performance of multi-walled carbon nanotubes (MWCNTs) and macadamia nut shell-derived activated carbon (MACs) for the removal of BTEX compounds from synthetic industrial wastewater. The adsorbents were characterised using Fourier Transform Infrared Spectra (FTIR) to check the surface functional groups of the adsorbents, the textural properties were obtained by Brunauer-Emmett-Teller (BET). Scanning Electron Microscopy (SEM) was used to check surface morphology. Activated carbon adsorption capacity was calculated to be 17.59 mg/g, 57.59 mg/g, 55.59 mg/g and 51.59 mg/g for benzene, toluene, ethylbenzene and xylene, respectively. The adsorption capacity of MWCNTs was considered low at 17.46 mg/g, 41.63 mg/g 35.23 mg/g and 37.98 mg/g for benzene, toluene, ethylbenzene and xylene, respectively. The adsorption kinetics fitted the pseudo second order for both MAC and MWCNTs, the adsorption isotherms were fitted into the Languirm and Freundlich model. Activated carbon derived from macadamia nut shells proved to be a better adsorbent recursor than 20 MWCNTs.

PROCESS & MATERIALS SYNTHESIS		
Title	Author Name	
Cellulose films cast from a novel choline chloride and ionic liquid mixed solvent system: Characterisation and comparison	Hester Peters	The potential to use the abundantly available and renewable resource, cellulose, for future plastic film production was explored. Solution-cast films were successfully prepared from a-cellulose sheets dissolved in the ionic liquid (IL), 1-Ethyl-3-methylimidazolium acetate ([EMIm][OAc]), as well as a 50 % (w/w) mixture of choline chloride and [EMIm][OAc]. Although films prepared from the mixed solvent were generally less transparent, they experienced less shrinkage and warpage with time. With both solvent types, higher dissolution temperatures increased the degree of cellulose dissolution. At longer dissolution times fewer matrix defects, e.g. holes, were observed. An optimum in solvent to cellulose ratio was apparent for both systems. At higher solvent ratios, structural film defects tended to increase. The films were characterised using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), thermogravimetric analysis (TGA) and scanning electron microscopy (SEM). These complementary techniques confirmed that films prepared using the mixed solvent could be classified as all-cellulose composites (ACCs) due to the presence of undissolved fibres acting as reinforcement in the matrix. Ultimate tensile strengths of up to 34.2 MPa were recorded for films cast from the pure IL. However, the dissolution temperature had a significant effect on the tensile strength of films cast from the mixed solvent. At 80 °C the film strength was even less than that of the original a-cellulose sheets (3.9 MPa) whereas a dissolution temperature of 105 °C yielded films with tensile strengths of up to 23.5 MPa. Despite the comparably lower tensile strength values of these ACC-type films, they were nevertheless comparable to those of commercial polyolefin films. This work therefore showed that a novel solvent, consisting of a mixture of choline chloride and [EMIm][OAc], can be used to prepare cellulose films with acceptable mechanical properties. The use of the more affordable solvent system made the work innovative and industry friendly.
Structural and surface areas changes of phlogopite leaching residues	Barend du Plessis	By leaching phlogopite with aqua regia, all the metal cations can be removed from the layered structure, leaving an amorphous SiO2 with a surface area of 400-500 m2/g. Empirical models were developed to predict the surface area and conversion as a function of the leaching parameters. The results indicate that the surface area of the residue increases during the course of the leaching process; however, it reaches a maximum and decreases with increasing leaching temperature and/or leaching time. The same conditions increase conversion. With an increase in conversion, XRD and FTIR analyses show that the phlogopite changes to a hydro-phlogopite type mineral and eventually to amorphous silica. By leaching the phlogopite with a strong acid, a silica framework structure is created, which, upon further leaching results in acid hydrolysis, leaving a more compact structure.
Flow sheet synthesis with heat engines for ITM oxygen based gas-to-liquids processes.	Isabella Greeff	In large-scale production of liquids from natural gas, oxygen based autothermal reforming is typically used. This work focuses on substituting the traditional cryogenic air separation for oxygen production, with high temperature ion transport membrane (ITM) separation. ITM oxygen is one of the leading technologies promising to compete with the cryogenic process. The cryogenic air separation process requires significant amounts of power, which is provided by integration of heat engines to convert process heat to power. The main process heat source in the autothermal reformer is the high temperature synthesis gas, typically at temperatures above 900 °C. Steam is used as the working fluid in a Rankine cycle, however this approach suffers from large temperature differences between the process heat source and the working fluid, leading to inefficient conversion of process heat to power. The ITM process on the other hand requires significant amounts of heat. The ITM process integrates well with heat engines using a Brayton cycle wherein air is the working fluid. A new flow sheet for methanol production using autothermal reforming integrated with the ITM oxygen technology is developed and analysed, using energy analysis and comparing process and heat engine efficiencies. It was found that overall plant LHV efficiency was improved from 63.2 to 68.1%.

A novel approach to produce a high purity cellulose product from Sawdust waste material.	Simiksha Balkissoon	Approximately half of the wood processed in the Forestry, Timber, Pulp and Paper (FTPP) sector is accumulated as waste. The concept of a “green economy” encourages industries to employ revolutionary transformative technologies to eliminate waste generation by exploring the development of new value chains. The transition towards an almost paperless world driven by the rise of digital media has resulted in a decline in traditional paper markets, prompting the FTTP sector to reposition itself, and expand their product offerings by unlocking the potential of value adding opportunities from renewable resources such as wood to generate revenue. The production of valuable products from wood waste such as sawdust has been extensively explored in recent years. Wood components such as lignin, cellulose and hemicelluloses, which can be extracted selectively by chemical processing, are suitable candidates for producing numerous high-value products. In this study, a novel approach to produce high value cellulose products such as dissolving wood pulp (DWP), from sawdust was developed. DWP is a high purity cellulose product used in several applications such as pharmaceutical, textile, food, paint and coatings industries. The proposed approach demonstrates the potential to eliminate several complex processing stages, such as pulping and bleaching, which are associated with traditional commercial processes to produce high purity cellulose products such as DWP, making it less chemically, energy and water intensive. The developed process followed the path of experimentally designed lab tests evaluating typical processing conditions such as residence time, chemical concentrations, liquid-to-solid ratios and temperature, followed by the application of suitable purification steps. Characterization of the product from the initial stage was conducted using commercially available DWP grades as reference materials. Chemical characteristics of the products thus far have shown similar properties to commercial products, making the proposed process a promising and viable option for the production of DWP from sawdust.
Thermal and Rheological Properties of High Flow LLDPE Blended with Fischer–Tropsch Wax	Thobile Mhlabeni	Blending polyethylene’s (PE) with different molecular chain configuration and conformations has been used to develop new materials and/or to improve specific properties [1]. Paraffin wax blended with polyethylene has been reported to significantly improve melt processing properties of PE [2]. However, a phase-separated morphology leading to poorer physico-thermal properties has been reported [3]. Therefore, there is a need for basic knowledge on their phase behaviour which is crucial in order to gain fundamental understanding of the processability of the material [3] . This study investigated blends of a 50MFI LLDPE and a low molecular weight Fischer-Tropsch wax at varying compositions. The dynamic scanning calorimetry (DSC) analytical technique was used to study the miscibility behaviour in the wax/LLDPE blends. The analysis revealed the occurrence of melting and crystallization temperature depressions of the LLDPE-rich phase while the melting point of the wax-rich phase was relatively constant. The occurrence of melting-point depression is a good indicator of partial miscibility in the blends. The Hoffmann-Weeks method was also used to investigate the equilibrium melting temperature. It was found to decrease considerably with increasing wax content. The structure of the blends were studied using hot-stage polarized optical microscopy (OM) and X-ray diffraction (XRD). Upon cooling, OM revealed a substantial reduction in the size of LLDPE spherulites with increasing wax content and XRD indicated that this resulted in the formation of cocrystals. Rheological properties of the wax/LLDPE blends in the molten state were investigated at 170ºC. The results showed a decreasing zero shear viscosity for a high-flow LLDPE with increasing wax. This suggests that the addition of wax, together with melting point depression, alters the interfacial properties by improving chain mobility of the LLDPE under the applied shear stress. In this way, the wax perhaps acts as a lubricant for the polymer chains.
COD and turbidity removal from restaurant wastewater using polyethersulfone ultrafiltration membrane containing sawdust-derived cellulose nanocrystals	Amos Adeniyi	An increase in the number of restaurants in major cities is putting more pressure on the municipality's supply of water. Moreover, the wastewater generated needs to be treated to protect the environment and for reuse purposes. Restaurant wastewater is loaded with food, soup particles, and other organic matters like oil and grease. The purpose of this work is to fabricate ultrafiltration (UF) membrane with sawdust-derived cellulose nanocrystals as an additive for the treatment of restaurant wastewater. The membrane was fabricated using the phase inversion technique and made from polyethersulfone (PES) with sawdust-derived cellulose nanocrystals (CNC) as an additive in 1-N-methyl-2 pyrrolidone (NMP) as solvent. Firstly, the percentage of the cellulose nanocrystal was varied and the resulting membranes tested for pure water flux and with synthetic turbid water. The membrane containing 0.075% CNC (PES-CNC) gave the highest turbidity removal and water flux. This was due to the impact on the pore structure as revealed by the SEM images that were analyzed using imageJ and WSxM 5.0 Develop 9.1 Software. The membrane was subsequently used for the treatment of raw restaurant wastewater. The results were compared with that of a UF membrane containing 2% Polyethyleneglycol (PEG400) as an additive (PES-PEG). The two membranes were characterized using a contact angle analyzer, scanning electron microscopy (SEM), Fourier transform infrared (FTIR) and X-Ray diffraction (XRD), Energy dispersive X-Ray (EDX), and pore size distribution. Separation performance was conducted on a dead-end filtration cell. COD was analyzed using a spectrophotometer while turbidity was analyzed with a turbidity meter. Pure water flux for PES-CNC was 288 L/m2/h and 247 L/m2/h for PES-PEG at 0.4 bar. Turbidity removal when synthetic turbid water was tested was 99.98% for PEG-CNC and 99.4% for PES-PEG when the initial turbidity was 120NTU. For raw restaurant wastewater and at 0.4 bar, water flux for PES-CNC was higher by 18%, COD removal was higher by 30% and turbidity removal was higher by 1.5%. Although PES-PEG had a lower contact angle, the pore size distribution and pore structure of PES-CNC were more uniform. PES-CNC membrane shows a great prospect in the treatment of restaurant wastewater.
Mesoporous Transition Metal Oxides as a Catalyst for Fischer-Tropsch Synthesis	Leonard Okonye-Odua	The role of catalysts and catalysis in the development of clean chemical and petrochemical processes and the drive towards sustainable energy production has been established as an indispensable factor. The arrival of novel mesostructured materials with porous interconnected networks can be taken advantage of, their unique properties favor wide-ranging applications. These ordered mesoporous materials have been employed as supports in Fischer-Tropsch synthesis (FTS) reaction studies, where, various features of the catalyst structure are exploited to improve the performance of the catalysts, resulting in a better activity. Mesoporous transition metal oxides have started receiving consideration in a number of reactions, because of their multiple oxidation states, and the effect of the ensuing metal-oxide interfaces on catalytic activity and selectivity. In this light, iron and cobalt mesoporous materials are anticipated to give better activity and hydrocarbon selectivity when compared to other catalytic systems previously used for FTS. This work describes the synthesis, characterization and catalytic evaluation of mesoporous cobalt oxide (Co3O4) for the Fischer-Tropsch synthesis reaction.

Synthesis and Characterization of Carbon Nanotube-Gold/Iron Oxide Nanocomposite (MWCNT-Au/Fe3O4) from Green Tea Leave Extract	Olawumi Sadare	In recent years, the use of green plants extract to synthesize nanoparticles is gaining momentum in research studies as compared to traditional methods due to their ease of processing and environmental friendliness. In this study, we report the synthesis and characterization of gold/iron oxide nanoparticles from green tea leaves extract and attached on the walls, functionalized multi-walled carbon nanotubes (MWCNTs) to form a nanocomposite. The gold/iron oxide nanoparticles were synthesized by reacting green tea leaves extract with iron chloride (FeCl2) and gold (III) chloride (HAuCl4.3H2O) precursors while MWCNTs were commercially obtained and functionalized with a mixture of H2SO4/HNO3 acids. The composite was then cross-linked using N, N-Dimethylformadide (DMF). The surface morphology, functional groups, composition and properties were checked using Scanning Electron Microscope (SEM), Fourier Transform Infrared (FTIR), Transmission Electron Microscope (TEM) and Energy-Dispersive X-ray Spectroscopy (EDXs), respectively. SEM revealed that gold/iron oxide nanoparticles were spherical in shape, while FTIR spectroscopy confirmed the involvement of functional groups that were responsible for the reduction of Au/Fe3O4. TEM analysis confirmed the attachment of synthesized nanocomposite on the walls of carbon nanotubes (CNTs). The MWCNT-Au/Fe3O4 nanocomposites were successfully synthesized from green tea leaves extract.
Automated Design of Industrial Water Systems with Multiple Contaminants	Yannick Moise Ilunga	This paper presents a new automated approach for the optimal design and retrofit of comprehensive water systems with multiple contaminants for minimum freshwater consumption, wastewater generation and overall total water network cost. The optimal wastewater regeneration and distribution of freshwater and wastewater to satisfy process demands and environmental restrictions is simultaneously considered. The regeneration process can either be used for water reclamation to meet the process water quality requirements or to ensure the discharged wastewater meets the quality to the environmental regulations in terms of water quality. A decomposition structure is identified within the water network superstructure formulation which allows for the comprehensive water system to be partitioned into two smaller problems; water-using and water-treating subnetworks. These subnetworks interact only via common flows and boundary conditions thus allowing the problem to be considered as hierarchical design problem. This approach features a fast and robust solution strategy involving the coordination of the exchange of information between the two subnets. It combines insights from graphical techniques and economical game of identical interest with mathematical programming based on a superstructure model formulation which results in a nonconvex MINLP. Complex trade-offs involving operating and capital costs of the two interacting subsystems are captured. The proposed procedure has the advantage of reformulating the original non-convex MINLP by a succession of “easier to solve” convex MINLPs. The solution of the smaller problems is used as a refined starting point for the original nonconvex MINLP. A petrol refinery and pulp and paper plant case studies are used to demonstrate the proposed method. The results indicate a wastewater reduction of up to 50% and considerable savings in fresh water intake and in the total annualized cost.

Metallurgical Process Engineering and Coal		
Title	Author Name	
Phase equilibria study of the Cu-K2O-SiO2-O system in air	Willem Dutoit Malan	In this study, the liquidus of the copper-potassium oxide-silica-oxygen (Cu-K2O-SiO2-O) system at silica saturation in equilibrium with air was studied experimentally between 1273 and 1773 K. Equilibration was carried out in vertical tube furnace, followed by rapid quenching and measurement of phase structures and assemblages using SEM-EDS and electron probe microanalysis technique. The results are in relatively good agreement with calculated liquidus contours from the MTOX database in MTDATA. Therefore, the results from this study may now be used for future thermodynamic assessments.
Model Predictive Control - Mineral Processing Adopts from Petrochem	Kevin Brooks	Model predictive control (MPC) has been a well-established technology in the petrochemical and oil refining industries since the mid-1980s. A survey in 2003 (the latest data publicly available) estimates some 4500 applications, with only 37 being in the mining, minerals and metals (MMM) industry. MMM has been slow to adopt this model-based real-time control and optimisation. Other advanced process control (APC) methods such as rule-based schemes and fuzzy logic were more popular. This paper provides some hypotheses as to why this was the case, as well as describing the change that has occurred in the industry since the late 2000s. A brief introduction to MPC is given, and a literature review of MPC applications in the industry is provided, together with a summary of the benefits claimed from these applications. An examination of both the industrial and academic literature provides some guidance for future applications, technologies and areas for research.

Chemical Engineering Education	Author Name	
Leaving the 20th century behind: Exploring how a community-focused design project responds to the call for decolonising an engineering curriculum	Ashish Agrawal	Student protests starting in 2015 under the umbrellas of #RhodesMustFall and #FeesMustFall further strengthened calls for curricula relevant to the diverse groups of students in the South African university classroom. To this end, the Chemical Engineering Department at a research-focused historically English-language university swopped out a semester-long conventional chemical industry project in the core second-year course for one investigating the treatment and usage of biogas products from anaerobic digestion in an urban informal community. This paper critically analyses the changes that were made in the project to explore the ways in which it meets the aims of decolonising the engineering curriculum. To this end, data in the form of course documents and staff interviews were collected and analysed. Findings suggest that the new project addressed the decolonisation goals by incorporating three elements: valuing students’ voices; connecting learning to the local context; and engagement with the community. A key challenge that was revealed through the findings is that the standard engineering techniques are not always applicable to small-scale community-based projects. Hence, the findings indicate the need for a broadening of engineering knowledge and skills so that they can be applied to local community, as well as industrial and corporate, contexts.
Case study - a critical analysis of the undergraduate Chemical Engineering Programme Qualification mix using Luckett’s Model for an epistemically diverse curriculum	Waseela Mohamed	The School of Engineering at UNISA, a comprehensive university, offers National Diploma and Degree courses through open distance e-learning (ODeL) to students who are interested in becoming professional technicians and technologists in a number of engineering disciplines. A substantial challenge exists for Universities of Technology and Comprehensive Universities in unpacking curriculum for Vocational Qualifications resulting from the measures that have been put in place by the Department of Higher Education and Training. This article evaluates curriculum in an ODeL environment following the review cycle, in order to appraise the epistemic diversity of the new curriculum introduced using Luckett’s (2001) model for an epistemically diverse curriculum. The undergraduate chemical engineering curriculum is conceptualised by categorising learning outcomes for courses across the programme into the different ways of knowing as described by Luckett: propositional knowledge, practical knowledge, epistemic knowledge and experiential knowledge. The author argues that a critical analysis of the programme helps to make explicit the organising principles of curriculum to the curriculum developers and academics that are then able to use the insights to strengthen the design, pedagogy and assessment of the courses in the programme. Keywords: Open distance e-learning (ODeL), epistemic diversity, curriculum development, programme qualification mix

Transforming the Chemical Engineering Curriculum to Gear towards the Fourth Industrial Revolution	Annegret Stark	The world is at the advent of the Fourth Industrial Revolution (4IR). Several entities in South Africa and abroad have recognized the need for curriculum content and delivery transformation to the requirements of 4IR. Hence, a project was initiated by the Schools of Engineering and Education at a South African Higher Education Institution [details removed for peer review], which aims at a fundamental curriculum transformation in engineering, addressing sustainable development challenges. Transforming the engineering curriculum content, structure, and delivery in preparation for 4IR is essential if Higher Education Institutions (HEIs) want to continue providing quality education relevant to locally and internationally required engineering practices. The project focuses on relevant 4IR skills of a future workforce and how these can be fostered through teaching at HEIs. An integral part of engineering education is laboratory work. In this paper, we discuss online experimentation as a possible alternative to physical laboratories, present selected online laboratory platforms and focuses on how online experimentation may foster the development of 4IR skills. A SWOT analysis of online laboratories shows that these allow for more flexibility to conduct an experiment or work remotely, provide opportunities for HEIs to target other student groups and offer them an adaptive environment. However, a move to online laboratories may also come with challenges related to student self-regulated learning and pose threats to accreditation processes. Yet, if HEIs in South Africa want to remain competitive, they need to embrace novel technologies such as online experimentation to advance in the 4IR and remain relevant in a changing world.
Degree Accreditation Report Auto-generation by Logic Encoding and Processing	Manimagalay Chetty	Maintaining the accreditation profile of an academic programme is a key activity in so-called Professional Degrees such engineering, commerce and law. The complexity of the accrediting criteria tends to rise over time as accrediting bodies require quantitative evidence of competence of increasingly specific graduate attributes. Evaluation of graduate attributes may therefore require complex logic processing which challenges the human capacity. This has the negative side effect of discouraging curriculum revision not for pedagogic reasons but simply due to the complexity of evaluating complex logic patterns against a data set whose structure is shifting. These challenges can be overcome through the application of logic encoding and processing. A computing system is better suited to such processing tasks since logic processing is fundamental and well-established to such systems. On the other hand, the efficient representation of a complex accreditation logic rule base then becomes the challenge. This paper describes the representation of the accreditation logic of eight engineering academic programmes at the Durban University of Technology through AutoScholar Advisor System in preparation for evaluation by the Engineering Council of South Africa. It is shown that the system generates accurate reports even with deeply nested logic structures and with changes in curriculum over time.
EFFECT OF THE NEW MAJOR HAZARD INSTALLATION REGULATIONS ON THE SOUTH AFRICAN CHEMICAL INDUSTRY	Motlatsi Mobaso	The Major Hazard Installation (MHI) Regulations of South Africa (2001), promulgated under the Occupational Health and Safety Act no. 85 of 1993 (the Act), regulate the handling by industrial facilities of chemical substances with potential to cause major chemical accidents adversely impacting employees and members of the public. The current set of regulations has become outdated when applied to modern chemical industries and therefore the need arose to revise the regulations in line with international trends, offer increased protection to safety of employees and the public and advise on land-use around industrial facilities. A technical committee assembled by the Department of Employment and Labour effected changes to the regulations, extensive public comment and industry consultation were conducted. This presentation will summarise the amendment process and highlight the main changes between the existing and proposed sets of regulations. Delegates likely work in industries where MHIs are present and may be exposed to potential chemical accidents which put them at risk of injury and death. Delegates will benefit from this presentation's description of the regulatory basis in South Africa (SA) for managing risk (prevention and mitigation) of major chemical accidents.

Other		
Title	Author Name	
The effect of temperature and asphaltene content on the lubricating properties of fuel oils.	Trinity Thobejane	Asphaltenes are components of fuel oils with complex aromatic structures containing heteroatoms (N, O, S) and metals (V, Fe, Ni). Asphaltenes have high aromatics content and the heaviest fraction in fuel oils and contributes to the high viscosity of fuel oils. Fuel oils are passed through pumps, filters, nozzles and other equipment which require good lubricating properties before they reach the burner section. Currently, several users of fuel oils are experiencing problems such as blockages in the fuel oil filters and injector nozzles, increased wear and failures of pumps and, in some cases, decreased calorific efficiency. The HFRR lubricity tester (method ISO 12156-1) was used to perform lubricity tests on fuel oil samples at different temperatures to help improve the current fuel oil requirements for industrial use. Three fuel oil samples with unique characteristics were selected with different asphaltene concentrations to show the effect of the asphaltenes on f friction and wear at different temperatures. Results indicate that the presence of asphaltenes changes the viscosity behaviour of fuel oils, which, in turn affects the lubricity behaviour. Key performance indicators like the wear scar diameter on the ball as well as the wear track on the test disk, showed unexpected results.
An approach for evaluation of friction, viscosity and wear behaviour of polymer base stocks under low humidity Hertzian sliding conditions	Sipho Masilela	Polyalphaolefin (PAO) base stocks have historically proven to possess superior lubricating properties. However, their high production costs place them at a disadvantage. On the other hand, more affordable conventional mineral base stocks pose limited lubricating performance and environmental concerns for modern equipment designs. The development of hydrocracked base stocks with a "plus" (+) has shown great potential to achieve a balance between cost, environmental friendliness and lubrication performance. In this study, friction, viscosity and wear behaviour of a hydrocracked base stock is presented in comparison with solvent refined, hydro-processed and PAO base stocks over a range of selected temperatures. Results demonstrate that the shift towards the use of base stocks with a "plus" will be beneficial in the automotive industry. The hydrocracked base stock demonstrated friction and wear reduction performance similar to that of the PAO, indicating that hydrocracked base stocks can be used in place of PAO base stocks. This behaviour is attributed to free volume and molecular branching of the Group 3+ base stock. Results also show that two base stocks in the same API class produced from different sources of crude can result in different friction and wear behaviour under certain temperature conditions.
Investigation of a Heterogenous Bi-functional Catalyst in the (Trans)esterification of High FFA Feedstock	Linda Maina	There has been growing concern about the depletion of the world's oil reserves as well as the negative environmental impacts fossil fuels pose. Biodiesel is a renewable substitute for diesel compression ignition engines. This study investigates the simultaneous esterification and transesterification of various low-cost feedstocks using bifunctional catalysts. Four catalysts (CaO:Al2O3 ratios of 80:20, 70:30, 60:40, and 50:50) were synthesised via co-precipitation and calcined at 600 °C. Catalysts were characterised using BET. The synthesised catalysts exhibited adequate morphological and catalytic characteristics (pore sizes ≥209 Å; surface areas ≥11 m2/g; pore volumes ≥0.072 cm3/g). High FFA feedstocks (waste palm oil and neem oil) contents were 2.47 to 3.25% respectively and a low FFA feedstock (virgin palm oil) content was 0.67%. Feedstocks underwent trans(esterification) under optimised reaction conditions of 65 °C, 1200 rpm, 2.5 wt% catalyst loading and a methanol to oil molar ratio of 12:1 at a reaction time of 4 hours under reflux conditions. Optimum biodiesel yields of 97.85, 99.51 and 97.63% were obtained from virgin palm, waste palm and neem oil using 80%CaO:20% Al2O3, 70%CaO:30%Al2O3 and 60%CaO:40%Al2O3 bi-functional catalysts respectively

DIMENSIONAL ANALYSIS OF MASS TRANSFER IN HYDROGEN STORAGE TANK	Bongiwe Hem	In this paper, a set of dimensionless numbers important to heat and mass transfer in packed metal hydride beds are identified. Principles of Dimensional Analysis are used. The similarity requirements can be determined through an inspectional analysis of the governing PDEs for the conservation of mass, momentum, and energy. Dimensionless analyses of mass, momentum, and energy balance equations are done to improve and decide on the appropriate variables to be used and how they might be linked. External conditions include similarity of surface roughness, the similarity of temperature distributions at the cooled or heated wall. COMSOL software is used to calculate the dynamics (variation in time) of the hydrogen flow rate into the tank (in absorption case) and out of the tank (desorption case). The calculated flow rates are then associated with dimensionless criteria equations with input operational parameters (charging/discharging pressure) and tank geometry parameters (diameter, length, number of heat transfer plates, dimensions, and positions of the plates).
Mixture rules for product stream blending operations	Walter Focke	The blending of product streams is very, very common in industrial practice. It is used in the food, wine, petroleum, pigment, paint, polymer industries, etc. Before a product is sold, it is analyzed with respect to compliance with respect to a set of critical properties. On delivery, the results are usually supplied to the customer via a COA (certificate of analysis). The manufacturing process often results in product property variations and blending of different batches is necessary in order to meet all specifications. Therefore, the properties of the different batches are usually known and it is desirable to be in a position to predict the results of a blending operation in order to determine in which ratios in which the different streams should be combined in order to get back to within specifications. This requires mixing rules that will allow prediction of the blend property from just knowing the properties of the different streams and the ratios in which they are blended, i.e. without knowing the full composition of the streams. The quadratic Scheffé model is the most common mixing rule applied in practice. However, it is demonstrated that it is not well-suited for predicting the outcome of blending operations. Suitable mixing rules are presented and their predictive performance evaluated on the basis of the API45 octane number data set.

POSTER PRESENTATIONS

ENVIRONMENTAL PROCESS ENGINEERING	Author Name	
The removal of COD & Anionic Surf+A68:A82actants with Chemical	Mujahid	
Simulation studies on syngas and solid carbon production from waste tyre gasification using	Lanrewaju	
fluidization behaviour of Nanoparticles	kanku	
Production of biomass-derived anode material for high-performance sodium-ion batteries	Lerato	
An experimental study on flue gas	Lawrence	
Bioremediation of crude oil contaminated soil	Ifeanyi	
Magnetic induction and nanoparticles effects on anaerobic digestion of industrial wastewater	EMMANUEL	
Treatment of Petroleum Refinery Wastewater by application of combined Electrocoagulation	Mujahid	
Energy recovery from solid waste via plasma	Isabella	
SIMULATION AND MODELLING OF SYNGAS	Cedric Franck	
Valorisation of spent coffee grounds.	Nikita	
IMPROVING THE OXIDATION STABILITY OF	Emmanuel	
A CFD analysis of PET microplastic distribution	Mohammadreza	
CHARACTERIZATION TO DETERMINE SUSTAINABLE TECHNOLOGIES FOR EDIBLE AND	Placxedes	
In pursuit of a low-cost carbon capture option in South Africa	Natsayi	
Potential Impact of the Covid-19 Pandemic on Plastic Medical Waste Management in South Africa: A Narrative Review	Zvanaka Senzeni	
Spent bleaching earth-Answer to sustainable development goals: A Review	Placxedes	

Reaction Engineering		
Title	Author Name	
Non-isothermal Degradation Kinetics and Properties of Pine Sawdust (PSD) via Thermogravimetric Analysis	Ugochukwu	

Separateion Technologies		
Title	Author Name	
Re-looking at Distillation design in the new Anthropocene	Naadhira	
Separation of Noble Gas Mixtures (Xe, Ar and Kr) Using Gas Hydrate Technology	Farai	
Pressure swing adsorption separation of acetylene and ethylene using cement hydrate	Matthew	

Process and Materials Synthesis		
Title	Author Name	
Characterization of empty palm fruit bunch (EPFB) generated bio-oil and the effect of biomass particle sizes on the yield and composition of bio-oil	Ebitei	
Sugarcane bagasse ash derived nano silicon for application in inorganic-organic hybrid bulk hetero-junction solar cells	Fortunate	
Using pinch and exergy principles in analysis and synthesis of reforming flow sheets	Isabella	

Metallurgical Process Engineering and Coal Technology

Title	Author Name	
INTO THE INSIGHT OF ADVANCED ANALYTICAL TECHNIQUES OF COAL: COMPARISON OF SOUTH AFRICAN ATHRACITE AND BITUMINOUS COALS USING 13C SSNMR, FESEM-EDX, WAXRD, AND UATR-FTIR	Major	
A comparison of various leaching and separation methods of Ti and Fe from ilmenite	Herman	
Modelling and simulation of leaching cobalt heterogenite ore in sulphuric acid	Vanessa	

Chemical Engineering Education		
Title	Author Name	
Virtual and Remote Labs: A SWOT Analysis of the Use of Laboratory Teaching Software in Higher Education	Annegret	
A review of various feedstocks utilized in pyrolysis, gasification, and liquefaction processes	Nhlanhla	

Other		
Title	Author Name	
Social-Economic Assessment of valorization of Faecal Sludge into value-added products: Case study of selected products in Johannesburg Metropolis	OLAWUMI	
A Continuous Time Formulation for Solving Long-term Unit Commitment	Malebo	
EFFECT OF CO-DIGESTION OF FOOD WASTE AND COW DUNG ON BIOGAS YIELD	Emmanuel	
Artıfıcıal Neural Network (ANN) for Pressure-Concentratıon- Temperature (P-C-T) Curves of Metal Hydrıdes.	Ziphezinhle	