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Paper abstracts

Smart, Sustainable Manufacturing in an ever-changing world

9 March 2022 to 10 March 2022

Stellenbosch, South Africa

Organised by
Department of Industrial Engineering
Stellenbosch University

Table of contents

C4 11:00

Error! Reference source not found. Ramesh Kuppuswamy (University of cape town) and Sofian Eljozoli (University of cape town). *A Kinematics Study of Diamond Abrasives and Nickel-Ions on an Electroplating Process towards Enhancing the Quality of a Super-abrasive Grinding Wheel.*

Abstract. The development of materials creates a need to establish innovations on the electroplating process particularly towards enhancing the process efficiency and improving the adhesion strength between the substrate and the plating. The Nickel-Diamond (Ni-D) plating process for the super-abrasive grinding wheel uses a plating bath contains suspended diamond particles and grinding wheel as cathode, Nickel as anode. The low quality of electroplated grinding wheels is often a result of non-uniform along with a poor adhesion between the abrasive particles and the substrate. Often, this results in scrap of the Ni-D electroplated component and enhances the wastage of resources: material and time. In Ni-D plating process there are two common techniques is applied to keep particles suspended in the electrolyte and facilitate the co-deposition process include: Firstly, Physical dispersion of particles in the plating bath which can be achieved by bath agitation. Secondly, chemical dispersion of particles using cationic surfactants by a process called electrophoresis. The type of agitation has a role in keeping the particles suspended in the plating bath and flow of the solution at the cathode surface is critical when considering the migration/adsorption process of the particles. The composition and morphology of the deposition be altered by the type of agitation employed. Past research have found that increased agitation generally enhances the number of particles in the metal deposit. However, excessive agitation, resulting in turbulent flow, may lead to a lower quantity of particles in the metal deposit. This may be explained by vigorous hydrodynamic forces in the electrolyte removing the particles from the cathode surface before they can be entrapped in the metal deposit. This paper studies the kinematics of the diamond abrasives and nickel ions that are liberated from the anode and bonds to the grinding wheel by using a newly devised propellers for enhancing a better adhesion with reduced plating time and enhanced process efficiency. The paper discusses all forces acting on diamond particle moving through the plating solution by using offset vertical flow mounted mixer for suspension ,several anodes a round the grinding wheel and grinding wheel is placed at the centre of the plating bath, to predict the diamond particle movement in order to find an optimum propeller shape and its speed for achieving a uniform distribution of diamond particles into nickel onto the grinding wheel surface as well as controlling the concentration of diamond abrasive in the coated layer.

C5 13:50

Error! Reference source not found. Ramesh Kuppuswamy (University of cape town), Fungai Jani (University of cape town) and Samiksha Naidoo (University of cape town). *Research Endeavors Towards Development of an Intelligent Grinding System.*

Abstract. The advent of additive manufacturing has created a paradigm shift in material processing, consequently secondary operations such as grinding have gained new momentum towards imparting the desired properties for engineering components. A control of grinding and process parameters is vital in ensuring efficiency and minimal wastage, saving on manufacturing and material cost as well as reducing operator error by making use of artificial intelligence, machine learning, efficient data transfer and optimal parameter control. This research unveils the development of an intelligent grinding system for processing a selective laser sintering based Ti6Al4v engineering component and paves the foundation for use on a wide variety of super-alloy materials. The developed system started with a theoretical platform (designed for future physical implementation), which used a semi-empirical-analytical model (for feature-extraction) at its core, allowing for prediction of grinding behavior, based on workpiece material, wheel type and wheel-work interface parameters. The developed model was coded into MATLAB; with three notable outputs of the system being: residual stress, workpiece surface temperature and a unitless Coefficient B (described later). An intelligent database (made in Microsoft Access) was made to

support the system by allowing for storage and cross-referencing of data. Important data in the table include material, wheel, and coolant information, as well as system outputs and operatorinputs. This database provided the basis for optimization of parameters. Graphical User Interfaces (GUIs) were created for the intelligent database (Access), system (MATLAB), and for data acquisition (DeweSoft). These three interfaces were connected, allowing for easy navigation and inputs from the operator. Signals were also eliminated through use of discrete wavelet transformations and moving average filters, enabling statistical analysis such as kurtosis coefficients and Werner's force model. A feature correlation engine was built using artificial intelligence: based on neural networks (NN) and mathematical optimization models. The theoretical system led to successful practical implementation, creating a system that can monitor, analyze, and adaptively control grinding parameters on a live basis. Through a rigorous designed experimentation process, results showing a great reduction in grinding burn and a much lower presence of residual stress; display that the system performed effectively and successfully. The development of this system will aid heavily in sustainable manufacturing and in improving manufacturing outputs from the grinding process.

B4 11:00

Error! Reference source not found. Christian Basson (University of KwaZulu-Natal), Glen Bright (University of KwaZulu-Natal), Jared Padayachee (University of KwaZulu-Natal) and Sarp Adali (University of KwaZulu-Natal). *Investigation of Predictive Maintenance algorithms for rotating shafts under various bending loads.*

Abstract. Condition monitoring plays an important role with regard to forecasting structural failure of shafts in Advanced Manufacturing Systems (AMS). Repairs affect the downtime of machines considerably due to scheduled maintenance. The waste product of scheduled maintenance are parts that are treated as exhausted components for disposal. The disposed parts contain Residual Useful Life (RUL). Operational costs due to scheduled maintenance can be reduced through Condition Monitoring (CM) parameters that are utilized in Predictive Maintenance (PdM). The study utilizes logistic regression Machine Learning (ML) algorithm to predicting specific classification markers as a relevant step to monitor the health of a bright-steel shaft under various bending loading. Various loading conditions were monitored and compared, employing Principal Component Analysis (PCA). Predictions were tested by utilizing K-Means and DBSCAN clustering techniques. The Logistic Regression (LR) machine learning algorithm was employed to determine the prediction accuracy under various loads. A shaft was rotated under various bending loads which followed the experimental methodology of the R.R. Moore fatigue test. The goal of the experiment was to determine the prediction accuracy under various loads. Prediction scores for K-means clustering showed a overall decrease in accuracy in the increase of cluster numbers and the prediction accuracy showed increases and decreases for DBSCAN clustering with the increase of loading for various cluster selection.

A5 13:30

Error! Reference source not found. Jörg Niemann (Hochschule Düsseldorf), Dominik Kretschmar (Hochschule Düsseldorf), Claudia Fussenecker (HS Düsseldorf) and Martin Schlösser (University of Applied Sciences Düsseldorf). *Development of an academic training course for future service engineers.*

Abstract. Modern business models are increasingly seen as a source of outstanding organizational performance and competitive advantage that either synergizes with the previous business model or completely replaces the previous strategy. For enabling this transition the paper describes an advanced model to master the digital business transformation. Based on a literature review, and practicioneers the paper identifies useful methods and tools which are used in modern industrial companies. Based on the findings the papers presents an edcuational training course on academic level for the education of future service engineers. The course will be offered for students and professionals with a large number of practical exercises to meet the needs in the academic education and the transition of (classical)engineers towards the new rising business and job profile of a service engineer.

B3 17:00

Error! Reference source not found. Elif Ocakci (Continental Teves AG & Co. oHG) and Jörg Niemann (Hochschule Düsseldorf). *Resources collaboration and optimization in industry 4.0 environments.*

Abstract. In order to act competitively, efficiently and economically on the market, it is of great importance for companies to continuously optimize their capacity planning. In this context, developments in the field of Industry 4.0 have steadily gained in importance in recent years. Many companies are increasingly investing their human and machine resources towards Industry 4.0 readiness to increase the performance of their entire value creation process. Production systems can, for example, re-order materials themselves or request repairs. The operational planning processes are therefore subject towards these technological changes.

The paper examines these changes with focus on capacity planning processes under Industry 4.0 and how this affects the ability to forecast future production resources requirements. The paper will evaluate the economic added value resulting from investments in Industry 4.0-based capacity planning and what the technological developments mean for the capacity optimization of human resouces and machines in such production environments.

C5 14:10

Error! Reference source not found. Ramesh Kuppuswamy (University of cape town), Samiksha Naidoo (University of cape town), Fungai Jani (University of cape town) and Quintin de Jongh (University of cape town). *Towards configuration and development of an Augment Reality (AR) enhanced Intelligent Grinding System (IGS) for Ti6Al4V alloy.*

Abstract. Research has shown that an intelligent grinding system (IGS) improves the reliability and maintenance of grinding operations, as it has the capabilities for real time monitoring and failure prediction. This research addresses the additional feature towards enhancing IGS, through Augmented Reality (AR) techniques. AR provide a visual monitoring and failure prediction mechanism, as an overlay to the IGS. This improves the on-line support offered to the operator and has the potential to greatly influence the down time, reliability, quality and inspection of grinding operations.

The grinding of the Ti6Al4V alloy results in high temperatures experienced between the grinding wheel and the work interfaces. Previous research conducted on IGS, found that operators generally use the acoustic emission (AE) signals and grinding force signatures as a check for characterizing the grinding process. By implementing a prediction model into the grinding process, and complimenting this with AR, operators can rely on accurate guides which serve as an early warning detection system for grinding failures such as: grinding wheel wear and grinding burn. In this study the grinding spark characteristics such as: color, length of spark, density of spark was used as a measure for establishing the grinding process behavior. An infrared radiation pyrometer detects the radiation over a specific range, and the voltage signal was used to represent the spark temperature. The prediction of the time to reach grinding burn, under several conditions, was established using an artificial neural network (ANN) method. The ANN model is fed with the experimental data and the model was trained to make the predictions of the burn time. Acoustic emission signals were used to predict the grinding wheel wear. Grinding experiments were conducted on samples at different grinding conditions such as: wheel speed, table feed rate, depth of grinding and volume of ground material. The models were successfully used to predict the cases of normal and faulty grinding processes. To create the AR environment in the IGS system, an Intel Realsense D435i camera was used to capture the object's depth and dimensions. The image was further processed with the software OpenCV-Python and the errors were analyzed. Conclusively, the prior research investigations on AR and IGS systems, indicate that it could accurately track the grinding process and extract useful information regarding the failure mechanisms of the grinding wheel and workpiece and the system works in near real time.

C1 11:30

Error! Reference source not found. Ramesh Kuppuswamy (University of cape town), Quintin De Jongh (University of cape town) and Matthew Titus (University of cape town). *A Force Controlled Polishing Process Design, Analysis and Simulation Targeted for the Selective Laser Sintered Aero-Engine Components.*

Abstract. Polishing is a key manufacturing process used on engineering components, where limitation of friction, wear, and tear, is critical. Aerospace components such as vane blades and aerospace seals are refurbished after every 5000 flight hours with powder metal deposition, followed by grinding and polishing, to restore their initial dimensions, features and characteristics. The dispensed powder have a blend of high hardness and strength, fused to the base components to restore original features. As a result, the polishing process offers unlimited challenges. Application of excessive polishing force induces edge chipping of refurbished components, while the application of lower polishing force increases polishing time. Control of the polishing process parameters: impinging particle velocity, angle of impingement, abrasive size and concentration decides process behaviour. This paper describes the design, analysis and development of an Aero-lap polishing machine and its associated process. The process is designed to meet the ductile regime polishing conditions for SLS processed Ti6Al4V alloy. The machine and algorithm are configured to administer the fracture characteristics and wear mechanism. Theoretical calculations and simulations of the process, based on contact mechanics, are used to support the process and machine designs. An abrasive media mixing unit has been made as part of the device, which stirs pre-mixed abrasives with water, increasing moisture content, to achieve more desirable polishing conditions. Two different media for the abrasive particles have been considered: (i) an inorganic material (thermoplastic) and (ii) an organic material (gelatin). These are both loosely adhered with a combination of SiC and #3000 Diamond powder. The thermoplastic powder is fed through a temperature-controlled nozzle arrangement to enhance its fluidity characteristics when polishing. At glass transition temperature, the thermoplastic powders become more fluid (a desirable property) for performing the damage free polishing actions. It should be noted that the fluid conditions of the thermo-plastics avoid the chipping damage on the workpieces. This temperature increase is not required in the gelatin powder (as it is already a very flexible media at room temperature). The organic substance has a lesser impact on the environment and requires less set-up time than the thermoplastic. Multiple simulations of the process are created in SolidWorks to support the efforts of machine development, process design and analysis, as well as to characterize this system at a nanoscale.

C2 15:00

Error! Reference source not found. Wesley Dharmalingum (UKZN), Jared Padayachee (UKZN), James Collins (UKZN) and Glen Bright (UKZN). *The Development and Inverse Kinematics of a 5 DOF Parallel Kinematic Architecture Machining System.*

Abstract. Innovative solutions to South Africa's economic challenges are required in order provide a better future for the country. One area of challenge, lies in the manufacturing industry. The building of a manufacturing business typically requires a significant financial outlay and risk.

The cost of good equipment can be prohibitively high for the prospective business owner. Manufacturing systems have traditionally been built on a serial architecture which, requires significant bulk to provide the necessary rigidity for manufacturing applications. The bulk adds to the cost of the machine and reduces portability. Adding to the cost of machines is the development of proprietary software to run the machine. Apart from the fact that most of this type of equipment is imported, further adding the cost, the expertise to maintain and train operators is also imported

This paper presents the research and development of a novel architecture parallel kinematic machine (PKM) for machining purposes. Parallel architectures offer several promising advantages over the more traditional serial machines. They offer more rigidity for less weight. They can move more rapidly within the workspace. Like with all things, there are some trade-offs. PKMs have a reduced workspace for the same size of machine and there are commonly singularities within the workspace. They also present several challenges in their kinematic descriptions and programming.

The presented machine offers five degrees of freedom and is suitable for drilling and milling tasks. It has been designed to overcome the challenges of weight and cost of traditional machines.

Modern technologies and open source software availability aids in development of the necessary controllers at a reduced cost compared to proprietary methods. As an initial step in the process, an inverse kinematic study of the PKM is discussed in the paper.

B2 14:00

Error! Reference source not found. Fahmi Bellalouna (University of Applied Sciences Karlsruhe) and Robin Langebach (University of Applied Sciences Karlsruhe). *Application of Augmented Reality for the Training in the Field of Refrigeration and Air-Conditioning.*

Abstract. Augmented Reality (AR) technology is one of the key technologies in the digital transformation area. AR is the technology that enables the overlaying of physical objects with computer-generated virtual perceptible data in real time to provide an interactive user experience in the real environment. This technology is currently used in many business fields such as engineering, education, medicine, logistics and transport either for experimentation or productivity. Due to the rapid development of display hardware and mobile devices in terms of performance, as well as the rapid development of the range of functions, the implementation of powerful augmented reality applications for industrial applications has become easier. This paper presents an use case of an AR training application for an ammonias crew compressor asset using the Video-See-Through AR method. The intention of this use case is to show the benefits and potential of AR technology for teaching and training complex technical systems in terms of increasing learning efficiency. The paper discusses the gathered experiences in the course of the use case and during the use of the AR training application in the university and in the industry.

A3 16:00

Error! Reference source not found. Titanilla Komenda (Fraunhofer Austria Research GmbH), Jorge Blesa Garcia (University of Applied Sciences Technikum Wien), Maximilian Schelle (Fraunhofer Austria Research GmbH), Felix Leber (University of Applied Sciences Technikum Wien) and Mathias Brandstötter (JOANNEUM RESEARCH Forschungsgesellschaft mbH). *Sustainable utilization of industrial robotic systems by facilitating programming through a human- and process-centered declarative approach.*

Abstract. The lack of practicable flexibility in a necessary market-driven need for modifying production systems inhibits resilient application of industrial robots but also of collaborative human-robot work systems. This paper presents an approach of how declarative programming can be applied for sustainable industrial robotic system integration by semi-automatically creating and modifying the robotic system's control programme – not only focusing on the manipulator but rather taking into account the end-effector, sensors as well as peripheral equipment.

Changes in product design, number of units to be produced or the economic degree of automation and thus deployment of personnel, require changes or modifications in the industrial robotic system's control programme. These modifications are mostly carried out by qualified personnel which increases dependency and contradicts concepts of flexibility. This has led to a number of research activities developing automated or semi-automated programming approaches for robotic systems. While most of the approaches only focus on the manipulator itself and a robot-oriented way of programming, meaning the creation of explicit motion and execution commands, some approaches already focus on different process models, such as task-, problem- or data-orientation, resulting in declarative programming languages or the development of data exchange formats such as AutomationML and corresponding ontological semantics for interpreting those data formats.

Despite of those different approaches targeting the objective of simplifying industrial robot programming, a recent review on industrial robot programming methods showed that there is no common benchmark to evaluate these developments. In addition, non are applied in industrial settings. This leads to the question of whether a lack of evaluation criteria has hindered implementability of those programming methods in an industrial context, or whether a definition of industrially relevant criteria for the application of intuitive programming techniques is key to their applicability.

In this sense, this paper presents a concept of a semi-automated and problem-oriented programming approach of industrial robotic systems based on a declarative process description as well as an evaluation approach in quantifying the sustainable potential of applying declarative programming in an industrial setting. In addition, the authors present their open-access approach of declarative programming and modifying industrial robotic systems on an industrial use-case while also giving a critical evaluation on the benefits and drawbacks of the presented approach.

B3 16:00

Error! Reference source not found. Dominik Kretschmar (University of Applied Sciences Düsseldorf), Jörg Niemann (University of Applied Sciences Düsseldorf), Carsten Deckert (University of Applied Sciences Düsseldorf) and Adrian Pisla (Technical University of Cluj-Napoca). *Development of a system simulation of the sustainable impact of product service systems.*

Abstract. Sustainable thinking in a business context will play an increasingly important role and will be one of the most important trends in the upcoming years. Besides societal and political impacts, market logics and customer needs and thus entrepreneurial thinking will be influenced. PSS can be seen as a type of sustainable business model.

The impact of business models, especially in context of PSS, and organizational sustainability efforts continues to be a major issue. With systems theory allowing to focus on the dynamics of business organizational systems, and an impact model of PSS-BM and sustainability aspects.

Regarding this, the research question which should be answered in this essay is “How can an impact model be designed that shows the sustainable impact of product service systems?”

For this purpose, sustainability indicators are compared and elaborated to transfer them with an example PSS BM into a business dynamics model, which represents the interrelationships of the three sustainability dimensions (economic, ecological, and social) and the business model elements.

Due to that, users of this model can quickly adapt the organization to changing environmental conditions. This flexibility is especially important, due to ever shorter product life cycles and allows to run through different sceneries.

A1 11:30

Error! Reference source not found. Thomas Bergs (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Sebastian Apelt (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Malte Becker (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Alexander Beckers (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University) and Sebastian Barth (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University). *Identification of residual development efforts in agile ramp-up production.*

Abstract. Due to high dynamic markets and changing customer requirements, agile product development is increasingly finding its way into the development of physical products. The following transfer (after the Design Freeze) of a planned and still unstable manufacturing process into stable series production is the goal of ramp-up production and confronts manufacturing companies with different challenges. A currently high level of changes to the product geometry and the planned manufacturing system due to not achieved requirements in late phases of the ramp-up production (Residual Development Efforts - RDE) results in time-consuming and cost-intensive changes to the product and manufacturing system, which leads to failure to achieve ramp-up targets. The goal of current research is therefore to increase the agility of ramp-ups and to integrate the ramp-up production into the phase of agile product development. This offers the potential to use the increased dynamics of the product development process and the knowledge already generated for the validation and stabilization of the manufacturing process. However, due to the integration of ramp-up production into product development, there are additional far-reaching effects of the product and technology uncertainties prevalent in agile product development on the design of agile ramp-up production. Additional uncertainties regarding the product geometry due to non-finalized designs (prior to design freeze) and the resulting uncertainties regarding the probability of use and achievement of the requirements of the manufacturing technologies initially result in additional residual development efforts. Furthermore, the interactions between the manufacturing technologies in the manufacturing system are thus subject to additional uncertainties, which also leads to increased RDEs. To meet this challenge, it is necessary to analyze prevailing uncertainties and predict their impact on potential changes in agile ramp-up production. Therefore, a methodology is presented, which enables the analysis of the effects of product and technology uncertainties and thus the identification of product and process-related changes (RDE) in agile ramp-up production.

A1 11:50

Error! Reference source not found. Thomas Bergs (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Alexander Beckers (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Sebastian Apelt (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University), Tim Hommen (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University) and Sebastian Barth (Laboratory for Machine Tools and Production Engineering WZL of RWTH Aachen University). *Cross-Process Modeling for the Design of Manufacturing Process Sequences under Consideration of Model Uncertainties.*

Abstract. The cost optimized manufacturing of components represents a central success factor for manufacturing companies. For this purpose, the required final state characteristics of components must be manufactured at the lowest possible efforts. These efforts depend on the companies' targets and may include the costs of the whole manufacture as well as environmental impacts caused by the manufacturing processes. Each manufacturing process of a process sequence has an influence on both, the final state characteristics of the component and the efforts, so that an improvement of individual processes in a process sequence does not have to lead to the technical and economical (global) optimum. To take this challenge (reaching global optimum) into account, a systematic procedure to combine different models of single manufacturing processes to cross-process models under consideration of the individual model uncertainties and their effects on cross-process models is presented. These cross-process models predict the final state characteristics of a component considering all manufacturing processes of the process sequence. For validation, the systematic approach is applied to a manufacturing process sequence for the manufacturing of indexable inserts.

C5 14:30

Error! Reference source not found. Alexander Wenzel (Institute of Production Systems and Logistics, Leibniz University Hannover, Germany), Torben Lucht (Institute of Production Systems and Logistics, Leibniz University Hannover) and Peter Nyhuis (Institute of Production Systems and Logistics, Leibniz University Hannover). *Hybrid Production Principles: A Framework for the Integration in Aircraft Manufacturing.*

Abstract. Production processes in aircraft manufacturing are characterised by high safety and quality standards as well as increasing individual customer requirements. In addition, these production processes are usually marked by rigid cycle times and a lack of flexibility potential. Due to these constraints, the increasing number of variants in flow production leads to considerable efficiency deficits in the form of high utilisation losses. Conventional approaches to handling variant diversity within flow lines (e.g. vertical separation of variant-neutral and variant-specific product components) reach their limits with complex products because the low proportion of standardised, variant-neutral components alleviates the actual advantages of line production. Hybrid production principles, e.g. a flow-line-based production with bypasses to modular workshops, in combination with a production planning and control (PPC) configuration tailored to these principles, offer high logistics and economics potential for multi-variant aircraft manufacturing. A logistics oriented description of the system behaviour of hybrid production principles does not exist, yet. However, this is necessary in order to investigate possible effects on logistics performance depending on the principles applied. This paper therefore identifies and describes factors influencing the selection and design of hybrid production principles with regard to production organisation and the associated intralogistics and PPC. Based on this, a holistic framework for the integration of hybrid production principles in future-oriented aircraft manufacturing is presented.

C4 11:20

Error! Reference source not found. Alpheus Ngwako Maponya (University of Johannesburg) and Prof Rudolph Laubscher (University of Johannesburg). *The effect of minimum quantity lubrication on selected surface integrity attributes when machining grade 4 titanium alloy.*

Abstract. Titanium is one of the most widely used materials in the aerospace industry. This preference is due to its high strength-to-weight ratio when compared to other high-strength metals. However, titanium is classified as a difficult to machine material in terms of surface integrity due to inherent characteristics. Hence, the purpose of this study is to investigate the effect of minimum quantity lubrication (MQL), conventional flood cooling, and dry cutting conditions on selected aspects of surface integrity when turning grade 4 titanium alloy. This includes investigating cutting parameters that yield the lowest cutting forces, the lowest surface roughness, and the highest compressive residual stresses.

MQL parameters such as nozzle distance, airflow rate, and lubricant flow rate were varied. The cutting parameters such as feed rate, cutting speed, depth of cut, and cutting distance were kept constant at 0.2 mm/rev, 125 m/min, 1 mm, 20 mm respectively. A CNMG 12 04 08 XF coated straight grade ceramic carbide Sandvik Coromant insert was used for the turning process. The effect of each MQL parameter on the output response was analyzed using the Taguchi and grey relation method (L9 orthogonal array with 3 factors and 3 levels of MQL).

The mean value analysis showed that the overall optimal parameters are a 50 ml/hr lubricant flow rate, 30 mm nozzle distance, and a 31 l/hr airflow rate. The individual output analysis showed that the optimal parameters that yield the lowest resultant cutting force were found to be a 90 ml/hr lubrication flow rate, 30 mm nozzle distance, and a 37 l/hr airflow rate. The lowest average surface roughness (Ra) values were observed at a 90 ml/hr lubrication flow rate, a 20 mm nozzle distance, and a 31 l/hr airflow rate. The optimal parameters that yield the largest compressive residual stresses were found to be a 50 ml/hr lubrication flow rate, a 30 mm nozzle distance, and a 31 l/hr airflow rate. A comparison study results showed a 19.7 % reduction in the resultant force, a 42.5 % improvement on the average surface roughness (Ra), and the largest compressive residual stresses under MQL cutting conditions. From the results of this study, it can be seen that MQL improved the cutting forces, exhibited a good surface roughness, and yielded the highest compressive residual stresses. This further supports the percieved benefits of the MQL strategy.

A3 16:40

Error! Reference source not found. Alexej Simeth (University of Luxembourg) and Peter Plapper (University of Luxembourg). *Artificial Intelligence based robotic automation of manual assembly tasks for intelligent manufacturing.*

Abstract. Increasing product customization and shortening product life cycles in an ever-changing world is challenging for automation. This is especially true for assembly tasks, requiring a high level of perception, skill, and adaptability. With the rise of smart manufacturing, intelligent manufacturing, and other aspects related to Industry 4.0, the hurdles for automation of the aforementioned tasks are getting reduced. Especially Artificial Intelligence (AI) is expected to enable smart and flexible automation since it is possible to deduct decisions from unknown multidimensional correlations in sensor data, which is critical for the assembly of highly customized products.

In this research paper, three different conventional and AI-based glue detection models are proposed with the target to automate a gluing process in a manual assembly of highly customized products in a batch size one production scenario. A conventional, one-dimensional rule-based model, and two hybrid models using a support vector machine image classifier (SVM) and either Tamura features or convolutional neural network (CNN) feature extraction are presented and compared. The obtained results demonstrate the efficiency and robustness of AI-based algorithms, as the CNN and SVM hybrid model outperforms the other two approaches achieving a prediction accuracy of >99% at the fastest classification speed.

A5 14:30

Error! Reference source not found. Ovidiu Popa (Technical University of Cluj-Napoca), Cristina Mihele (Technical University of Cluj-Napoca), Rus Felician (Technical University of Cluj-Napoca), Cristian Fagarasan (Technical University of Cluj-Napoca) and Adrian Pisla (Technical University of Cluj-Napoca). *Hybrid approach on the project development management within automotive industry.*

Abstract. The automotive industry is one of the most spread and synergic industries in dynamic markets, gathering around many different sectors from material extractions to robotics and cloud computing. The current research analyses the influences and particularities of project management and identifies the challenges and advantages of the two principal methodologies in software development projects within the automotive industry, Agile and Waterfall.

Once with I4.0 and worldwide digitalization, the global software development industry becomes a very significant and dynamic pilar in the contemporary environment. It is more and more evident that almost all machines for our lives become interconnected and more intelligent. From ordinary smartphone to complex, innovative aeroplanes, the automotive industry is part of global digitalization. The software development industry evolution has two essential characteristics: agility and speed. These aspects have a real impact in all other industries, including software development, practically in any product or process development.

In the last 30 years, automotive development started to focus on vehicle's brain capabilities significantly. Automation and controls represented the start of the software development industry in the automotive world, but today, logic and the car's computers started to work with artificial intelligence. The complexity and the development dimensions are many times increased, and the industry took significant steps forward. The safety aspects of the vehicle are crucial for the entire product development. For this reason, the industry has many regulations and standards that ensure the product's quality and safety. Therefore, in automotive, the software development is not aligned with the general software development from the speed and agility point of view.

In the paper is considered the evolution and the excellent approach of the project management within the automotive industry based on the involved risk management, focused on some aspects of reducing methodological disadvantages, aiming for a sustainable solution identification that may ensure the delivery of reliable and flexible software products. The impact of the envisaged methodology on the quality standards and project documentation is considered a vital part of automotive software development. By influencing the product development lifecycle, there is an opportunity to develop a structured framework that can be adopted to build software products more flexibly and agilely.

B6 15:30

Error! Reference source not found. Anika Wacht (University of Applied Sciences Duesseldorf), Stefan Kaluza (Hochschule Düsseldorf) and Philipp Fleiger (Hochschule Düsseldorf). *CCU in Cement Industry - Aspects of the Production of E-Fuels by Upcycling Carbon Dioxide.*

Abstract. This work deals with the process chain from captured carbon dioxide (CO2) from a cement plant towards the production of e-fuels, including arising challenges and opportunities with the objective to reduce CO2 emissions. First, it is demonstrated to what extend a certain Carbon Capture and Utilization (CCU) process chain can contribute to the reduction of CO2 in an industrial sector like the cement industry. In the cement industry in particular, there is a high demand in reducing emissions due to the irreplaceable raw material limestone. Then, an overview of applicable technologies for the required processes within the process chain from CO2 capture to e-fuel is given. Thereafter, mass and energy balances for the process chain are calculated based on the emissions released from a Best Available Techniques (BAT) cement plant: The resulting amounts of educts, products and electricity are calculated. Furthermore, an evaluation of the selected process chain and the calculations is carried out with the focus on technical aspects, showing that the production of e-fuels as a CCU measure in the cement industry represents a promising option to reduce CO2 emissions.

B6 16:10

Error! Reference source not found. Marcel Stöhr (Düsseldorf University of Applied Sciences) and Thomas Zielke (Hochschule Düsseldorf). *Machine Learning for Soft Sensors and an Application in Cement Production.*

Abstract. Soft Sensors are predictors for measurements that are difficult or impossible to obtain by means of a physical sensor. A soft sensor delivers virtual measurements based on several or many physical measurements and a mathematical or numerical model that incorporates the physical knowledge about the interdependencies. In industrial processes, control, optimization, monitoring, and maintenance can benefit from the application of soft sensors. In recent years, Machine Learning (ML) has proven to be very effective for building soft sensors for industrial applications. We work on modelling dynamical processes for which the measurements of the physical variables are available as time series over long periods. In this article we present work on the comparison of different ML methods for modelling dynamic processes with the objective of predicting certain output variables. In particular, we compare approaches using Recurrent Neural Networks (RNN) and Convolutional Neural Networks (CNN) using real process data from a cement production plant and from the operation of a gas-fired absorption heat pump. Our results suggest that CNNs are superior to RNNs in terms of the accuracy achieved and the computing resources needed for the model training. We discuss the metrics for the performance assessment and the hyperparameter that are used to optimize the models.

The main application focus of our work is on the optimization of the cement production process. The cement sector is the third-largest industrial energy consumer. There is a high potential for energy savings and for the reduction of CO2 emissions by optimizations of the production process. In modern factories all operational events and all measurements are digitally recorded. However, direct measurements inside a cement ball mill, for example, are hardly possible. The grain size of the material, a crucial parameter, has to be determined offline. This is a manual operation with a relatively low sampling rate. Previous research has shown that the grain size can be estimated using soft sensors developed with a data-driven approach. In practice, a sustainable deployment of this technology has not been achieved yet. The main problems are long-term drifts of process parameters, insufficient robustness with respect to situations not covered by the training data, and lack of transparency of the model behaviour for the responsible process operators.

We present first results of our research aimed to improve the robustness of a soft sensor for grain size in the cement production.

B5 14:10

Error! Reference source not found. Dorit Struckmann (Institute of Production Systems and Logistics, Leibniz University Hannover), Cihan Cevirgen (Institute of Production Systems and Logistics, Leibniz University Hannover), Julian Becker (Continental AG), Omar Arian (Continental AG) and Peter Nyhuis (Institute of Production Systems and Logistics, Leibniz University Hannover). *Development of a Procedure Model to Compare the Picking Performance of Different Layouts in a Distribution Centre.*

Abstract. An efficient order picking process is required to realize short-term and on-time deliveries in distribution logistics. The selection of a suitable warehouse layout as well as an efficient picking strategy needs to be dependent on an evaluation of the picking performance. The paper presents a procedure to compare variable layouts of distribution centres regarding their picking performance by using a small data set. In particular, the implementation of pick face areas in the front area of the warehouse is investigated. By picking out of a pick face area, the replenishment for this area is necessary as an additional process step. This kind of two-step picking are used in practise, but there is no quantitative way to assess the impact on the picking performance depending on the layout of the distribution centre. A calculation method to determine theoretically the picking performance is developed by using process times based on movement data and average distances to the areas of the layout. Furthermore, the comparison of the layouts with pick face area and without pick face area is focussed and a description of a procedure to determine the optimal size of the pick face area is given. A further aspect by developing the procedure model is the selection of the articles to be stocked in this area. For these articles, picking time savings are expected due to shorter distances to the pick face area. However, the additional replenishment processes must be considered by comparing the picking performance. The developed calculation method compares the picking times between one-step and two-step picking processes with pick face area by considering different variants of warehouse layouts. To apply the generated procedure, a case study in the automotive industry is conducted. The example shows improvements of picking performance through pick face areas. Finally, the presented process model enables the comparison of different layouts regarding their picking performance and provides an approach to determine pick face areas.

B1 11:30

Error! Reference source not found. Claudia Fussenecker (HS Düsseldorf), Karin Wolff (Stellenbosch University), Deborah Blaine (Stellenbosch University) and Jörg Niemann (HS Düsseldorf). *Did the Covid-19 Pandemic Improve Engineering Education? – A South African – German Perspective.*

Abstract. The Covid-19 pandemic has been influencing every aspect of the globalized world since its breakout. Not only is the economic environment changing rapidly, but also global Higher Education is facing a disruptive change. The way students are educated and knowledge is transferred and perceived had to be adapted, leading to Emergency Remote Teaching (ERT). Along with the challenges of the ever-changing demands in HE engineering education as a result of digitalization and Industry 4.0, a new set of qualifications for future engineers is required. Further, the given circumstances due to the covid-19 pandemic have put further pressure on the education system and created new obstacles. Deficiencies in areas such as a shortage of qualified professionals and the lack of technical job-specific skills can have a negative impact on innovation and, therefore, also for the well-being of industry, the economy and society in the long run. However, did something good come out of this pandemic in regard to engineering education? Did students acquire skills which might help them to become better engineers in the future? Further, what happened to the teaching skills of the university staff? Did the ability to manage a crisis and adapt to new circumstance improve teaching? What kinds of setbacks were experienced?

This paper draws on engineering student and staff survey data from the University of Stellenbosch, South Africa and Düsseldorf University of Applied Sciences, Germany. The survey takes a holistic approach and considers the incontestable relationship between three key facets of the educator's mandate: to facilitate the development of knowledge, citizenship and skills, by providing cognitive, affective and systemic support aligned to the epistemological, ontological and praxis dimensions of the curriculum. The survey then sought to determine how ERT has affected academics and postgraduates (in many cases, they are one and the same) in their professional, personal and practical lives. It asked four key questions about the effect of ERT on the working environment, the implementation of communication measures, and comments on challenges and successes. These responses were analysed using the broad categories of cognitive, affective and systemic dimensions of academic work. The generated data was then analysed to reveal key insights into both shared and differing challenges and successes across the North-South divide.

C2 14:40

Error! Reference source not found. Roman Funke (Professorship Micromanufacturing Technology, Chemnitz University of Technology, 09107 Chemnitz, Germany) and Andreas Schubert (Professorship Micromanufacturing Technology, Chemnitz University of Technology, 09107 Chemnitz, Germany). *Coefficient of static friction of turn-milled high-friction surfaces – investigations on the influence of joint pressure and load direction .*

Abstract. Experimental studies on turn-milling are carried out, focusing on the generation of friction-increasing surface microstructures. Since the magnitude of the transmittable force in friction-locked connections is determined by the product of the applied normal force and the coefficient of static friction (COF), such surfaces are of great interest in industrial applications.

Single-edged TiAlN coated cemented carbide end milling cutters with a diameter of 6 mm are applied to structure annular end faces of cylindrical specimens made of the steel 1.7225 (42CrMo4) in quenched and tempered (+QT) heat treatment condition. Face turned specimens made of the steel 1.0503 (C45) are used as counter parts. The experiments are conducted on a 5-axis machining centre KERN Pyramid Nano applying MQL. Two different tool types with sharp and chamfered corners are utilised at constant process parameters: vc = 100 m/min, fz = 0.125 mm, frad = 0.2 mm. Furthermore, the joint pressure is increased in increments of 50 MPa between 100 MPa and 300 MPa. For the tools with the sharp corner three different tool inclination angles β = 15°, 30° and 45° are examined in order to create asymmetric roughness profiles. The coefficient of static friction is determined using a torsion test bench. During each bench test two specimens are coaxially fastened and loaded with a specific normal force. Subsequently, the specimens are rotated against each other by an angle ϕ = 5°. Both directions of rotation are conducted to determine a possible directional dependency of the static friction.

Surfaces machined with tools with the sharp corner at β = 45° lead to the highest COF, independent of the joint pressure. The mean values range between μ = 0.48 and μ = 0.52. The application of chamfered tools involves values between μ = 0.31 and μ = 0.38. The tool inclination angle has only little influence on the results. At β = 15° a COF of μ = 0.43 is achieved, at β = 30° the COF is μ = 0.44. Changing the direction of the rotation during the bench tests entails a considerable reduction of the static friction. For β = 15° and 30° values of μ = 0.22 and μ = 0.21 mean a reduction of 50 %. Even for the symmetric profile (β = 45°) the coefficient of static friction is almost halved with μ = 0.26. Further investigations have to be done to explain the causes for this effect.

A5 13:50

Error! Reference source not found. Adrian Pisla (Technical University in Cluj-Napoca), Laurentiu Nae (Digital Twin), Calin Vaida (Technical University in Cluj-Napoca), Eduard Oprea (Digital Twin), Bogdan Gherman (Technical University in Cluj-Napoca), Michel Deriaz (Yumytech Sàrl) and Doina Pisla (Technical University in Cluj-Napoca). *Modern Approaches in Shortening the Lead Time in Innovation for Young Emerging Companies.*

Abstract. OThe paper represents the preliminary findings in developing a multirole, innovative digital platform entitled "WisdomOfAge", as a Learning Management System (LMS) addressing to the economic and technological dimension of a company (especially start-ups) in reaching competitive manufacturing advantage.

The platform is developed within the frame of an EU project 2], offering finance to support retired seniors' active living. The project capitalizes the existing trend of having an aging population within the EU, in parallel with a gap in number and quality of skilled workers. The multirole digital platform creates a unique synergic solution that copes with the coexistence of different technological cultures using the resourceful retired seniors' expertise to compensate the lack of knowledge and experience required by a lot of newly established companies. "WisdomOfAge", is meant to create an efficient but pleasant environment for seniors and companies to easily overcome the retirement moment, when the professional activity is abruptly interrupted, leading to feelings like: out of business, lack of purpose, lack of achievements and a lot of unallocated time.

B1 12:30

Error! Reference source not found. Cristian Fagarasan (Technical University in Cluj-Napoca), Ciprian Cristea (Technical University in Cluj-Napoca), Cristina Mihele (Technical University in Cluj-Napoca), Ovidiu Popa (Technical University in Cluj-Napoca), David Ciceo (International Airport "Avram Iancu" Cluj) and Adrian Pisla (Technical University in Cluj-Napoca). *Kanban in software development – the role of leadership and metrics.*

Abstract. Traditional software development organizations that usually rely on the Waterfall model have rigid processes that can be difficult to change. The problem of how software products should be implemented has been debated for many years. One of the most critical challenges is the management processes that can ensure the customer desired level of quality and optimize the use of the organization's resources.

Kanban represents one of the most well-known approaches that bring Lean manufacturing principles, philosophies and tools into software development organizations. This study analyses the leadership behind the Lean methodology, based on which the Kanban software implementation method has been created, by doing a thorough literature review focusing on lean leadership principles that can optimize the software delivery and its implementation. Lean practices can be applied in almost any domain like accounting, services industry, product services, and even software development. Two basic concepts stay at the core of the Lean model that can be employed at any organization level. The first one is focused on eliminating waste by optimizing processes and systems, and the second one focuses on maximized customer value. Consequently, it can be affirmed that Lean is focused on maximizing customer value with a minimum amount of waste.

A case study is presented in the paper that shows the Kanban implementation at a software development company. The practical case of the Kanban adoption is analyzed, highlighting the link between the leadership principles and the process development flow. Finally, key performance indicators are identified and instituted to guarantee the continuous improvement of the software delivery model.

The software development projects driven by the Kanban project management approach reported essential improvements such as waste reduction, team communication and collaboration enhancement, work in progress diminishment, productivity-boosting, better delivery predictability and project visibility. Therefore, the type of leadership influences the software development projects performance. The findings suggest that Kanban is an effective method that can be used for enhancing the software development delivery model and team performance.

A5 14:10

Error! Reference source not found. Sinegugu Tshabalala (Tshwane University of Technology) and Khumubulani Mpofu (Tshwane University of Technology). *Opportunities Presented by Industrial 4.0 Revolution to Revitalize the Railway Sector: A Review.*

Abstract. The Industry 4.0 paradigm presents a significant transformation in the way products are produced or how supply chains are managed. This is seen through the rapid growth and expansion of the Internet, information exchange and autonomous systems for the resolve of accomplishing collective goals. These opportunities can revitalize the railway sector specifically, in passenger and freight transportation. The paper is a review of how Industry 4.0 concepts such as internet of things (IoT), big data analytics, artificial intelligence and block chain can do for the following areas of the railway ecosystem: Smart signaling and operations automation, automatic fare collection systems.

The paper will review the technologies and opportunities presented by the technologies in the three described areas of the railway ecosystem. The review will intensely focus on how the technology will assist in revitalizing the rail sector. This section will also touch social economic issues such as local manufacturing (localization), job creation and skills development (I4.0 related skills). In freight transportation, the paper will describe what this means for enterprises and how this can make the use of rail more attractive.

Next will be a brief section, reviewing broader issues that still torment the railway sector such as vandalism and theft, but with other technologies such as advanced materials and drone surveillance, may provide solutions.

Finally, the paper will detail the existing challenges and compare them to future research directions. The concepts discussed in this paper will aim to stimulate new ideas in the effort to realize the fourth industrial revolution in a manner than will spark early adoption.

Industry 4.0 technologies are rapidly evolving mainly in first world countries and industry sectors such as manufacturing and railway are seeing the benefits. This growth has opened opportunities for substantial financial investment into these technologies and industry sectors. Tech companies are rapidly becoming billion dollar industries. South Africa has a great potential to be the fourth industrial revolution hub for Africa. The paper will be a catalyst in generating ideologies that will not only seek to revitalize the railway ecosystem but also develop locally produced tech ecosystems that solve Africa's problems. Without reinventing the wheel, these tech ecosystems can bring forth opportunities in local manufacturing of components and systems, beginning a revolution that change Africa for the better.

A1 12:10

Error! Reference source not found. Alexander Muetze (Leibniz University Hannover, Institute of Production Systems and Logistics), Simon Lebbing (Leibniz University Hannover, Institute of Production Systems and Logistics), Simon Hillnhagen (Leuphana University Lüneburg, Institute of Product and Process Innovation), Matthias Schmidt (Leuphana University Lüneburg, Institute of Product and Process Innovation) and Peter Nyhuis (Leibniz University Hannover, Institute of Production Systems and Logistics). *Modeling Interactions and Dependencies in PPC. An Approach to a Holistic Description.*

Abstract. In PPC, there are many interactions and dependencies that are difficult for the practical user to keep track of. These insecurities often lead to a configuration of PPC, which is locally optimized but not optimally carried out in the overall context of a company's target system. With a specially developed description and modeling approach, the interactions between PPC tasks, procedures, and logistical objectives are shown transparently to support the holistic and target-oriented design of PPC in perspective.

The interdependencies presented in this paper have been compiled by contributions of various authors and transformed into a unified descriptive logic. In order to provide a comprehensive understanding of the interactions and interdependencies within PPC configuration, three levels of detail have been defined: First, the logistical objectives have to be examined in isolation. In this process, the central interdependencies at the level of the logistical objectives must be identified and presented in causal diagrams. The created impact network of interdependencies then serves as a basis for investigating the impact and interaction of PPC tasks. For each of the tasks then, primary and secondary interdependencies must be identified and visualized transparently with the help of isolated causal diagrams. On the final level of detail, the object of investigation has to change from task-specific to procedure-specific interdependencies, presenting (specific) input and output variables and impacts.

Within the scope of this article, an overview of the identified levels is given. For this purpose, the focus is exemplary on in-house production planning and control and the PPC task of order release.

B5 13:50

Error! Reference source not found. Fabian Dietrich (Stellenbosch University), Louis Louw (Stellenbosch University) and Daniel Palm (Reutlingen University). *Prototypical blockchain solution for mapping complex products in dynamic supply chains.*

Abstract. The blockchain technology represents a decentralised database that stores information securely in immutable data blocks. Regarding supply chain management, these characteristics offer potentials in increasing supply chain transparency, visibility, automation, and efficiency. In this context, first token-based mapping approaches exist to transfer certain manufacturing processes to the blockchain, such as the creation or assembly of parts as well as their transfer of ownership. However, the decentralised and immutable structure of block-chain technology also creates challenges when applying these token-based approaches to dynamic manufacturing processes. This paper proposes the adoption of token blueprints and logically coupled non-fungible token. Like this, this architecture enables the mapping of complex products in dynamic supply chains that require the mapping and auditability of changeable assembling processes on the blockchain. Finally, the paper demonstrates the practical feasibility of the proposed approach based on a prototypical implementation created on the Ethereum blockchain.

C4 12:10

Error! Reference source not found. Preyin Govender (Stellenbosch University), Deborah Clare Blaine (Stellenbosch University), Natasha Sacks (Stellenbosch University) and Devon Hagedorn-Hansen (Stellenbosch University). *Evaluating the relationship between powder characteristics, defects, and final build properties for LPBF WC-Co .*

Abstract. While additive manufacturing (AM) of WC-based cemented carbides is currently an active area for research and development, commercialisation of this technology is not yet established nor stable enough for integration into the tungsten carbide industry. Efforts to date have focused primarily on establishing AM parameters for producing defect-free, high quality cemented carbides, however little attention has been afforded to the role of powder characteristics in this endeavour. This research focuses on evaluating the link between powder characteristics, defect formation and the final properties of WC-Co (12wt% and 17wt% Co) builds, manufactured by laser powder bed fusion (LPBF). Commercially available, spray dried and agglomerated WC-Co powders, typically used for high velocity oxygen fuel (HVOF) coating, were used to manufacture the WC-Co builds using LPBF with build parameters commonly reported in literature. Three different WC-Co powders were investigated, two with 12wt% Co and the other with 17wt% Co. Powder characteristics such as particle size and shape, bulk density and flowability were evaluated to establish the influence on the spreadability and powder bed characteristics, determined using a custom powder spreadability test rig. Thereafter, simple build shapes were manufactured using LPBF with identical build parameters for each powder. Post-build defects were evaluated and related back to the precursor powder characteristics and powder spreadability properties. Refinement of printing parameters was then performed in order to determine the influence and sensitivity of powder characteristics to the build integrity for LPBF WC-Co.

B5 14:30

Error! Reference source not found. Fabian Dietrich (Stellenbosch University), Mario Angos Mediavilla (Reutlingen University), Daniel Palm (Reutlingen University), Ali Turgut (Reutlingen University), Thorge Lackner (Reutlingen University) and Wyhan Jooste (Stellenbosch University). *Feasibility assessment of 5G use cases in intralogistics.*

Abstract. The fifth mobile communications generation (5G) can lead to a substantial change in companies enabling the full capability of wireless industrial communication. 5G with its key features of providing Enhanced Mobile Broadband, Ultra-Reliable and Low-Latency Communication, and Massive Machine Type Communication will support the implementation of Industry 4.0 applications. In particular, the possibility to set-up Non-Public Networks provides the opportunity of 5G communication in factories and ensures sole access to the 5G infrastructure offering new opportunities for companies to implement innovative mobile applications. Currently there exist various concepts, ideas, and projects for 5G applications in an industrial environment. However, the global rollout of 5G systems is a continuous process based on various stages defined by the global initiative 3rd Generation Partnership Project that develops and specifies the 5G telecommunication standard. Accordingly, some services are currently still far from their final performance capability or not yet implemented. Additionally, research lacks in clarifying the general suitability of 5G regarding frequently mentioned 5G use cases. This paper aims to identify relevant 5G use cases for logistics and evaluates their technical requirements regarding their practical feasibility throughout the upcoming 5G specifications.

A2 14:40

Error! Reference source not found. Howard Theunissen (Nelson Mandela University), Theo Van Niekerk (Nelson Mandela University) and Jan Harm Pretorius (University of Johannesberg). *Design and construction framework to enable the modular block building methodology to broaden South African oceans economy.*

Abstract. From the design to final completion of sea trials, the complexity of a ship is built into every aspect of the build. From planning the purpose of the ship and its economic viability, to the level of technology used in the design and build, where it will be built and the production flow of the build, is all linked and restricted by the capability and capacity of the shipyard. The modern era of technology, design methods and computer capabilities (CAD/CAM), has enabled multiple sites to contribute towards the total build. This has facilitated for modular sections (blocks) of ships being built in different locations, with the blocks fitting together when shipped to one location for final assembly. This type of cooperative methodology is often preferred by large government contracts where it is desired that the build benefit as many in the industry as possible, not just one shipyard. Additionally, each shipyard may have a speciality area of production that will lead to a more cost effective "block" being built, saving on overall costs. This ultimately leads to a cheaper, better quality and faster construction of the ship. A qualitative and quantitative, mixed methods research methodology approach was used to identify the South African industry capabilities using a questionnaire that was developed to engage the maritime industry and identify capabilities, needs and future requirements. This paper will; Review the knowledge design and construction areas required for ship building and apply the knowledge areas to propose a multi-site modular block building framework for South African shipbuilding.

C1 11:50

Error! Reference source not found. Rumbidzai Muvunzi (Tshwane University of Technology), Khumbulani Mpofu (Tshwane University of Technology) and Ilesanmi Daniyan (Department of Industrial Engineering, Tshwane University of Technology, Pretoria, South Africa). *An overview of additive manufacturing opportunities in transport equipment manufacturing.*

Abstract. Many companies keep high levels of spare parts inventory as a measure to maintain high service levels. The challenge with this practice lies in the storage costs and the probability of other parts becoming obsolete in the warehouse. This leads to high costs and losses. On the other hand, Additive manufacturing (AM) is a cost effective approach for producing spare parts in low volumes when they are required. This is mainly because physical inventory can be replaced by digital inventory, which can easily be altered. Also, AM is a flexible technology which allows for direct manufacturing from digital models without the need for tooling. In the transport manufacturing sector, much of the application of AM in spare parts production has been explored mainly for the aerospace and automotive sector and there is limited literature on the rail industry. Hence, the aim of this paper is to investigate the application of AM to produce spare parts for the rail industry. A typical benchmark component was used as a case study. The process chain of producing the part using AM was compared with the conventional process from a technical and economic perspective. The results of the study are useful in providing cost effective approaches of increasing local production of spare parts using available technologies.

B6 16:30

Error! Reference source not found. Adrian Burkart (ESB Business School, Reutlingen University, Germany), Günter Bitsch (ESB Business School, Reutlingen University, Germany) and Imke Hanlu De Kock (Department of Industrial Engineering, University of Stellenbosch, South Africa). *Development of a conceptual framework for integrating intelligent-product structures into a flexible manufacturing system.*

Abstract. Recent trends in production technology show an increasing individualisation of products with a high variety. In combination with shorter product lifecycles, this results in smaller lot sizes, increasing order numbers, and rising data and information processing for manufacturing companies. To cope with these trends, an integrated management of the products and manufacturing information is necessary through a "product-driven" production system. Intelligent products that are integrated as an active element within the control and planning of the manufacturing process can represent flexibility advantages for the system. However, there are still challenges regarding system integration and evaluation of product intelligence structures. In light of these trends, this paper proposes a conceptual framework for defining, analysing, and evaluating intelligent products within the area of flexible assembly systems. It begins with a classification of the existing problems in the assembly, which are allocated with intelligence levels of products to select the required capability for the product. By allocating the problems to intelligence levels, a use case specific solution of the required product capabilities can be identified. In addition, it presents a requirements profile for the design and IT infrastructure of intelligent products. Results are presented in terms of an assignment of different application areas, linking the problem with the target intelligence class and, depending on the intelligence class of the product, suggesting requirements for implementation. The conceptual framework is evaluated by utilising a case study in a learning factory. Here, the model-mix assembly is controlled actively by the workpiece carrier in terms of transferring the variant-specific work instructions to the operator and the collaborative robot. The resulting system thus enables a better exploitation of the potentials through less frequent errors and shorter search times. Such an implementation has demonstrated that the intelligent workpiece carrier represents an additional part for realising a cyber-physical production system (CPPS).

A3 16:20

Error! Reference source not found. Marc Euchner (Reutlingen University) and Vera Hummel (Reutlingen University). *Productivity driven dynamic task allocation in human-robot-collaboration for assembly processes .*

Abstract. The numerous challenges, such as mass customisation, globalisation and digitalisation, also pose major challenges for Industry 4.0 in the industrial environment. Smart collaborative robotics, which has been identified as a key technology, still lags behind expectations. The synergies that arise from combining strengths of humans and robots offer many possibilities for adapting work systems to the new challenges. Despite the high potential of HRC, the technology has not yet become established in the production environment. An ergonomic and economic consideration of HRC still reveals potential for improvement in order to promote the widespread use of collaborative robots. While the technology is primarily intended to support humans ergonomically, new stresses arise, such as a forced posture, monotonous work or the feeling of machine-determined work. In addition to the ergonomic burdens, the currently applicable safety standards still severely restrict the economic use of collaborative robots at the present time. Based on the biomechanical limit values specified in TS15066, a working speed that would enable economic use is not achievable in most cases. Therefore, collaborative robots are mostly used in a coexistence or cooperation rather than in a collaboration. This paper describes an approach that enhances developed methods considering ergonomic optimisation by combining it with economic improvement of human-robot collaborations by means of semi-autonomous group work. Based on the ergonomic and economic criterias within a work system, the task allocation of a workplace will be adjusted. Productivity describes the relationship between output and input. Productivity could be increased by reducing the input or by increasing the output. This method aims to increase output by dynamically allocating work tasks based on productivity. By comparing actual and target times, individual assembly processes are taken over by the robot or handed over to the human. The method is intended to help cushion the impact on productivity in the event of a resource failure through dynamic task allocation. In addition to optimising output, the aspects of semi-autonomous group work should also increase employee motivation. In summary, it can be said that the developed method should contribute to the ergonomic and economic use (e2use) of collaborative robots in assembly.

A2 15:00

Error! Reference source not found. Tabea Marie Demke (Leibniz University Hannover, Institute of Production Systems and Logistics), Alexander Mütze (Leibniz University Hannover, Institute of Production Systems and Logistics) and Peter Nyhuis (Leibniz University Hannover, Institute of Production Systems and Logistics). *Production Controlling Governance to Ensure Homogenous Information Systems and Targeted Decision-Making Processes.*

Abstract. To increase the effectiveness and efficiency of (digital) production controlling, information systems are useful tools to provide and display required information. In terms of condensing information related to production logistics, logistic models and frameworks like the Supply Chain Operations Reference (SCOR) model provide a collection of Key Performance Indicators (KPIs). The transfer of KPIs from logistic models to effective information systems faces the challenge of providing user-specific and appropriate information through individual key figures on strategic, tactical and operational levels. Additionally, a missing structural and procedural organization of (digital) production controlling prevent an effective information management and consequently homogenous and targeted decisions within the context of production controlling. To exploit the potential of data-driven production based on the transformation of raw data into useful information with the aim of an effective information management, an approach for a production controlling governance is presented below. This approach systematizes corporate strategies, organizational structures, the production controlling process, KPIs resulting from logistic models and information needs to ensure homogenous information systems and targeted decision-making processes in the context of production controlling.

C3 17:00

Error! Reference source not found. Ilesanmi Daniyan (Department of Industrial Engineering, Tshwane University of Technology, Pretoria, South Africa), Khumbulani Mpofu (Tshwane University of Technology, Pretoria), Felix Ale (National Space Research & Development Agency, Abuja, Nigeria) and Rumbidzai Muvunzi (Tshwane University of Technology, Pretoria). *Design and Finite Element Analysis of a Novel Brake Beam of a Railcar.*

Abstract. The brake beam is an important component of the brake beam assembly and railcar suspension system. A properly designed brake beam will enable effective transmission of the braking force via the brake shoes to the the outer tread of the rail wheels. In this study, the Finite Element (FE) method was employed for investigating the performance of a novel brake beam design. The Finite Element Analysis (FEA) of the component is to ensure that the component possess satisfactory strength and rigidity vis-à-vis the functional requirements. This was done in the Solidworks 2018 environment using the von Mises stress and failure criterion for the evaluation of stress induced in the component member.

The results obtained from the manual calculations and simulations of the motor torque and angular velocity of the motor agree significantly, thus, indicating that the suitability of the design data for implementation. The FEA of the brake beam indicates that the material selected for the brake beam possesses adequate satisfactory strength and rigidity to withstand the stress induced without yielding to failure or undergoing permanent deformation. This study provides the for the brake beam which can assist during the manufacturing phase of the component

C5 13:30

Error! Reference source not found. Nokulunga Zamahlubi Dlamini (Department of Industrial Engineering, Tshwane University of Technology, Pretoria, South Africa), Khumbulani Mpofu (Department of Industrial Engineering, Tshwane University of Technology, Pretoria, South Africa), Ilesanmi Daniyan (Department of Industrial Engineering, Tshwane University of Technology, Pretoria, South Africa) and Boitumelo Ramatsetse (University of Wits). *An overview of the manufacturing systems: a literature survey.*

Abstract. To date manufacturing industries aims at achieving a growing variation of tailored, superior, high excellence and quality products in flexible sets. The transition from traditional machine systems to current reconfigurable machine (RM) requires consistency in achieving the requirements brought by the changes on the market demand, product life cycle and flexibility.

This manuscript presents a literature review about the manufacturing system. The paper highlights the concepts of RM, dedicated machine (DM) and flexible machine (FM). It also highlights the application areas as well as the methodology and tools, by existing works. The search of the articles was conducted by inserting search strings in scientific search engines and academic databases to find relevant contributions on the analysed topic. The trend of the literature shows a gradual shift from dedicated machines to flexible machines and now reconfigurable machines. It is envisaged that the findings of this work will provide an insight into the requirements for the development of sustainable and reconfigurable manufacturing systems.

A4 11:00

Error! Reference source not found. Lukas Stratmann (FIR at the RWTH Aachen University), Gerrit Hoeborn (FIR at the RWTH Aachen University), Prof. Dr. Volker Stich (FIR at the RWTH Aachen University), Ruben Conrad (FIR at the RWTH Aachen University), Dr. Felix Optehostert (Industrie 4.0 Maturity Center GmbH) and Minh Phuc Phong (FIR at the RWTH Aachen University). *A framework for leveraging twin transition in the manufacturing industry.*

Abstract. The manufacturing industry consumes 54% of global energy and attributes for 20% of global CO2 emissions demonstrating the industry's role as global driver of climate change. Therefore, reducing its carbon footprint has become a major challenge in the manufacturing industry as its current consumption is not sustainable. Industrie 4.0 presents a chance to transform the prevailing paradigms of industrial value creation and advance sustainable developments. By using information and communication technologies for the intelligent networking of machines and processes, it has the potential to reduce energy and material consumption and is considered a key contributor to sustainable manufacturing as proclaimed by the European Commission in the term "twin transition". As organizations still struggle to utilize the potential of Industrie 4.0 for a sustainable transformation, this paper presents a framework to successfully align their own twin transition. The framework is built upon three key design principles (micro level: leverage eco-efficient operations, meso level: facilitate circularity and macro level: foster value co-creation) derived using case study research by Eisenhardt, and four structural dimensions (resources, information systems, organizational structure and culture) based on the Industrie 4.0 Maturity Index. Eleven interconnected areas of action are defined within the framework and offer a holistic and practical approach on how to leverage an organization's twin transition. Within the conducted research, the framework was applied to the challenge of information quality and transparency required for high-value secondary plastics in the manufacturing industry. The result is a digital platform design that enables information transactions for secondary plastics and establishes a circular ecosystem. This shows the applicability of the framework and its potential to facilitate a structured approach for designing twin transitions in the manufacturing industry.

A3 17:00

Error! Reference source not found. Jan Schuhmacher (ESB Business School - Reutlingen University) and Vera Hummel (ESB Business School - Reutlingen University). *Development of an AI-based method for dynamic affinity-based warehouse slotting using indoor localisation data.*

Abstract. In industrial warehouse environments, the allocation of storage locations to goods, also known as slotting, is often based on static historical information (turnover frequency, quantities to be stored, etc.) of the corresponding stored goods. These static slotting methods relying on historical planning data often lead to deficits such as storage capacity bottlenecks or long process times for logistics staff in the warehouse to pick the required assortments of goods. These shortcomings often appear only subliminally in warehouse environments, while the causes of these performance losses cannot be (quantitatively) proven. Therefore, a method for dynamic affinity-based slotting of shelf racks has been developed, which uses artificial intelligence algorithms and enables continuous monitoring of performance-relevant parameters and influencing factors. An indoor localization system is used to generate close-to-real-time location and movement data of logistic staff during order picking processes. By applying k-Means cluster analysis methods, the localization data from the indoor localization system can be used in combination with other data sources (e.g. customer orders to be fulfilled, historical performance data etc.) for picking pattern recognition to achieve an optimized slotting in terms of process times and storage capacity. In addition, a graphical user interface for monitoring target variables as well as heatmaps for visualizing the frequency or duration of stay of employees in the corresponding warehouse areas have been implemented. The developed method specifically uses the potentials of AI in the area of data processing and preparation of possible decision alternatives based on close-to-real-time data for human decisions in the sense of hybrid (human/machine) decision-making. This can facilitate implementation in industrial warehouse systems by increasing acceptance. For a practice-oriented development and demonstration of the method, a demonstrator has been developed and set up at Werk150, the factory of the ESB Business School on the campus of Reutlingen University.

B3 16:20

Error! Reference source not found. Thomas Gittler (inspire AG), Lasse Plümke (ETH Zurich), Francesco Silani (ETH Zurich), Pietro Moro (ETH Zurich), Lukas Weiss (inspire AG) and Konrad Wegener (ETH Zurich). *People, Process, Master Data, Technology: Data-centric Engineering of Manufacturing Management Systems.*

Abstract. Production enterprises increasingly revert to digitization and data to gain insights and transparency in manufacturing environments. With the growing adoption of the Industrie 4.0 paradigm, the digital transformation of factories is in full swing. IIoT platforms, production management and manufacturing execution systems are installed in more and more production plants, which requires costly acquisition and customization. A significant number of implementation projects fail in intermediate or late stages due to disregard of master data and movement data design. Master data design implies intricate shop floor process reengineering, whereas movement data design relates to a data-centric approach between systems and process engineering. This study proposes a framework for the digital transformation of manufacturing systems from a data-centric engineering perspective. It specifically considers data-related pitfalls and their avoidance for digitization initiatives, and proposes a multi-step approach to align digital transformation projects with their expected benefits during design, development and implementation. It is intended to support, challenge and guide practitioners for the initiation and execution of digital manufacturing excellence efforts. The framework was developed, applied and validated in a digital transformation project for a high-variance manufacturing enterprise.

C4 11:50

Error! Reference source not found. Rodney Genga (UNIVERSITY OF THE WITWATERSRAND), Daniel Glaser (Council for Scientific and Industrial Research (CSIR), National Laser Centre), Patrick Rokebrand (C3 Analytics, LLC), Lesley Cornish (UNIVERSITY OF THE WITWATERSRAND), Mathias Woydt (MATRILUB (Materials, Tribology, Lubrication)), Arno Janse van Vuuren (Nelson Mandela University) and Claudia Polese (UNIVERSITY OF THE WITWATERSRAND). *LASER SHOCK PEENING: A NbC BASED CERMET ENHANCEMENT ALTERNATIVE FOR IMPROVED GCI INTERRUPTED FACE-MILLING.*

Abstract. Niobium carbide (NbC) was investigated as an alternative to tungsten carbide (WC), due to WC supply constraints, increasing cost, health implications, limited high oxidation resistance and lower chemical wear particularly during machining of Fe alloys. Compared to WC, NbC has similar hardness, higher melting point and significantly lower solubility in Fe alloys. However, cobalt bonded NbC grades have poorer mechanical properties than WC-Co, whereas nickel bonded NbC competes with WC-Co. Sub-stoichiometric NbC0.88 has higher hardness than stoichiometric NbC. In this study, attempts to improve the properties and machining performance of NbC based cermet cutting inserts during grey cast iron (GCI) (BS 1452/GG35) face milling were made by spark plasma sintering (SPS), use of sub-stoichiometric NbC (NbC0.88), Cr3C2 and Mo2C additives and laser shock peening (LSP). The microstructure, hardness, fracture toughness, elastic modulus and shear modulus were investigated and evaluated with the machining performance of WC-Co, NbC0.88-Co and NbC0.88-Ni cermet-based inserts. Additions of Mo2C, coupled with SPS, significantly refined the NbC0.88-Ni/Co cermet's carbide grain size from ~5.0 µm to <9.0 µm, increasing the hardness (by ~4GPa) and wear resistance. Laser shock peening (LSP) improved the fracture toughness of all the inserts, from 10% (in the SPS WC based in cermets) to ~100% (in the LPS NbC based cermets). Uncoated cutting inserts were manufactured from the sintered cermets in an SNMA shape (12.7x12.7x4.3 mm, 1.6 mm nose radius), and used for interrupted face-milling of GCI at cuttings speeds ranging from (vc) of 100 m/minute (400 rpm) – 500 m/minute (2000 rpm) and depths of cut (ap) of 0.2 – 1.0 mm. The insert wear was measured after every pass and was analyzed by annular dark field scanning transmission electron microscopy (ADF-STEM). Cutting temperatures were measured using a high-speed thermal camera and forces using a Kistler dynamometer. During machining at vc=200 m/minute and ap=1.0 mm, WC-Co inserts had the lowest flank wear rate (FWR), although, LSP significantly improved the tool life of the NbC0.88-Ni inserts, significantly reducing the FWR from 148.63 µm/minute to 99.79 µm/minute (by ~33%) and the average resultant force from 1257N ± 15N to 535N ± 15N. During machining at vc= 500 m/minute and ap= 0.2 mm, LSP significantly lowered the FWRs

of the NbC0.88 inserts, giving better tool life than all the WC based inserts. Generally, LSP improved the NbC0.88 inserts' tool life, reducing the flank wear rate by up to 33% during roughing and 63% during finishing.

C3 16:40

Error! Reference source not found. Ralph Hensel (AUDI AG), Thomas Mayr (AUDI AG) and Mathias Keil (AUDI AG). *Data Analytics in Industrial Engineering for Economic Sustainability: A Use Case on Planning and Controlling of Rework.*

Abstract. Currently, Industrial Engineering (IE) is predominantly focusing on planning and rationalization of production processes and as such cannot live up to management's expectations of improving the company's overall productivity holistically to guarantee the company's economic sustainability. Studies in the automotive industry are proving that about 30% of the productivity are hidden in additional manufacturing times, such as rework. These activities are not value-adding and should be avoided to realize the ideal of a zero-defect production, but still contributing to the quality-equitable completion of the product. In order to improve the company's overall productivity, early error recognition and correction becomes increasingly important to reduce quality defects caused by the product, either the constructional design or the supplier itself, and the process, such as technological disruptions or human errors. With this, the determined planning, optimization, and control of the rework processes moves into the scope of Industrial Engineering. Rework activities are characterized by its unpredictable occurrence probability, especially regarding error causes and consequential rework tasks as well as respective execution times. Due to a lack of methods, for Industrial Engineering it is almost impossible to fulfill these ambitious responsibilities, though. The presented article will bridge this gap and introduces a methodological approach using Data Mining-methods to analyze recorded product- and process-related quality data in the automotive industry, firstly to determine optimization potential for improvement of production processes and the product itself as well as its components. Secondly, the presented approach not only helps to predict expectable rework efforts, but also to target the number of employees required in car development projects in an early planning phase. Apart from that, the statistical rework data gathered by the MES systems, can also be used by Industrial Engineering for staff planning and operational control of the rework processes in series production. Besides the descriptive statistics used for diagnostic analyses of effort drivers for rework, regression trees were built for a vehicle-specific rework duration forecast, which will be presented, too. These prediction-models were fed with different pre-shaped datasets to gather information about the performance of the forecast, concerning variation and outliners. In conclusion, the prerequisites for the sustainable integration of the introduced concept in Industrial Engineering's operational practice will discussed.

C1 12:10

Error! Reference source not found. Eduard Relea (inspire AG - IWF ETH Zürich), Lukas Weiss (inspire AG - IWF ETH Zürich) and Konrad Wegener (inspire AG - IWF ETH Zürich). *Dimensional stability of mineral cast for precision machinery.*

Abstract. Machine tools employ a variety of materials for their structures: cast iron, welded steel, natural stone, ultra-high performance concrete (UHPC), and mineral cast (MC). Mineral cast is a composite material with an epoxy matrix and various aggregates as a filler, and has been successfully employed for machine tool structures for over 30 years. For this work, mineral cast specimens were tested by completely immersing them in fluids, so that the conditions to which mineral cast is exposed during machining can be simulated. Test specimens with standard dimensions of 80 × 80 × 400 mm were first immersed in demineralized water or grinding oil for 900 hours and then dried out for 800 hours in a climate test chamber at constant ambient conditions of 20°C and 50% air relative humidity. The change in length of the mineral cast specimens during the drying out period was recorded in order to determine the rate of the shrinkage of the specimens during the drying out process. The shrinkage of the sample was measured by the difference in the length of the sample before and after the drying out process.

B4 11:20

Error! Reference source not found. Stefan Laubscher (Stellenbosch University) and Johannes Jooste (Stellenbosch University). *Analysis and Modelling of the Track Quality Index of Railways.*

Abstract. Public transportation is vital to an urban area's sustainability. The benefits associated with rail transportation make it an attractive public transport option for commuters. Efficient maintenance and asset management are required to ensure the condition of railway infrastructure remains at a sufficient level for railway operations to continue without delays or disruptions. A known cause of deteriorating railway tracks is ineffective or absent maintenance practices. Technological advancements have led to an increase in available data. In the railway industry, geometry measurements associated with the track quality index (TQI) of the permanent way are examples where high volumes of data are generated and collected. TQI is an indicator of track condition based on five rail geometric irregularities. Changes in track geometry cause track irregularities, which reduce the quality of railway tracks. Big data associated with TQI pose challenges during the analysis phase. This paper investigates the track geometry parameters that are measured as part of the TQI and the methods currently used to analyse these measurements for maintenance purposes. A quantitative approach is followed, which includes a literature exposition about track geometry parameters and its use, as well as a case study of segments of the railway network in Cape Town, South Africa. As part of the case study, a new method of analysis is proposed. The proposed method makes use of data mining techniques along with ArcGIS software and network spatial analysis that take the network characteristics of a railway network into account. The proposed method of analysis aims to improve on existing methods to improve decision-making by railway technicians and to ultimately improve the permenant way predictive maintenance and asset management strategies.

B4 11:50

Error! Reference source not found. Adquate Masikati (Stellenbosch University), Johannes Jooste (Stellenbosch University) and Cornelius Fourie (Stellenbosch University). *A project management framework for the modernisation of passenger railway depots in developing countries.*

Abstract. Passenger railway organisations in developing countries have been operating old rolling stock for decades. With the advancement and complexity of modern technology, these organisations are required to renew their fleet. However, there are no guidelines that can help these organisations to implement a disruptive technological transition from old, dilapidated depots to the desired state that can support new technology in new rolling stock fleets. This paper develops a project management framework for modernising passenger railway depots to support the new rolling stock fleet and realise efficiency gains. To realise efficiency gains, the railway depots are viewed as large technical systems. Data was collected by conducting a systematic literature review and interviews with subject matter experts from industry. The project environment for railway depots is multi-disciplinary hence the framework is developed to be robust for accommodating different project landscapes. Due to the complexity of railway systems, the framework offers the necessary flexibility to accommodate different project dynamics. The feedback mechanism in the framework ensures project control without compromising on flexibility. The goal of modernisation is to achieve sustainability through a number of objectives, namely supportability, interoperability, systems performance improvement, maintenance optimisation and productivity improvement. These objectives are integrated in a customised work breakdown structure which forms part of the framework and which facilitates concurrent execution of projects by different teams in a closely coordinated decentralised framework. With the developed project management framework, the process of modernisation becomes integrated, the delivery performance is improved and lean methodologies are easily implemented thereby improving the competitiveness of the modernisation plan.

B5 13:30

Error! Reference source not found. Gabriel da Silva (Stellenbosch University), Anton Basson (Stellenbosch University) and Karel Kruger (Stellenbosch University). *Opportunities for Visualising Complex Data by Integrating Virtual Reality and Digital Twins.*

Abstract. The digital twin concept is becoming more commonplace in various industries, such as manufacturing and production. A digital twin is a digital representation of a physical system and reflects selected aspects of the reality of the physical system in a digital environment. Digital twins are typically used to support data led decision making, such as in monitoring and managing operational aspects. The digital twins of complex systems collect a large amount and variety of data from the physical system, which presents to the user the challenge of integrating and visualising the data to understand the physical twin's own actions and its interactions with its environment. Virtual reality is visualisation technology that has become more easily available over the past few years. Virtual reality places the user in a 3-D environment which, using the proper equipment, they can interact with and manipulate. This paper explores the opportunities that virtual reality presents as a visualisation tool to aid in the interpretation of complex digital twin data. The paper also explores the challenges and opportunities offered by the integration of digital twins and virtual reality, where the integration goes beyond off-line visualising of the data and even to facilitating a user's interaction with the digital twin and, thereby, the physical system. The paper concludes with suggestions of avenues for further research into the integration of virtual reality and digital twins.

A1 12:30

Error! Reference source not found. Alexander Wasserman (Stellenbosch University), Karel Kruger (Stellenbosch University) and Anton Basson (University of Stellenbosch). *ARTI-based Holonic Manufacturing Execution System Using the BASE Architecture: A Case Study Implementation.*

Abstract. As part of industry's drive to adopt Industry 4.0 technologies in manufacturing processes, intelligent automated manufacturing has become largely sought after. With defining features such as robustness, reconfigurability and scalability, the Holonic Manufacturing System (HMS) approach shows great potential to satisfy Industry 4.0 requirements. There has been considerable development in the field of reference architectures for use in the development of holonic systems. The most notable of these reference architectures is undoubtedly the Product-Resource-Order-Staff architecture, with its recent revision – the Activity-Resource-Type-Instance (ARTI) architecture.

This paper presents an ARTI-based holonic control system, implemented using the Biography-Attributes-Schedule-Execution (BASE) architecture, for a manufacturing system. The BASE architecture guides the development of digital administration shells for resources, and while the architecture was originally intended for human resources, it is deemed suitable for implementing the different holon types of the ARTI architecture. The implementation is done for the control of the Fischertechnik Industry 4.0 Training Factory, a small-scale manufacturing system.

The complexity of the case study, which comprises several interacting subsystems, provides a good basis to evaluate the ARTI and BASE architectures for HMS development. The paper reports that the ARTI architecture provides a well-defined structure for the conceptual design of HMSs, while the BASE architecture effectively supports the implementation of ARTI-based HMSs with minor additional development required.

A6 16:10

Error! Reference source not found. Travis Defty (Stellenbosch University), Karel Kruger (Stellenbosch University) and Anton Basson (Stellenbosch University). *Possibilities and challenges for human-system integration in the South African manufacturing context.*

Abstract. South Africa, a developing country, over the last decade has seen a decline in production value and employment in the manufacturing sector for many reasons; one being the failure to effectively integrate Industry 4.0 (I4.0) technologies with low-skilled workers to reap the performance bene-fits from both. In the context of South Africa and other developing economies, creating and retaining jobs for a large, under-skilled workforce is considered a priority. While the I4.0 development focus has predominantly been on enhancing automation, it is evident that human workers still provide dexterity, adaptability and decision-making capabilities that cannot be substituted by current technologies. This paper summarises the possibilities of human-system integration (HSI) for improving worker training and assignment, quality assurance and traceability of manual operations, data acquisition for decision making, and the health and safety of workers. Furthermore, it identifies challenges for effective human-system integration related to information and communication technology infrastructure, technology acceptance, investment strategies, risk and safety policies, and system reconfigurability. Though many challenges exist to realize HSI developments, the possibilities discussed in this paper motivate the future development and evaluation of such HSI applications.

B2 14:40

Error! Reference source not found. Till Gramberg (Düsseldorf University of Applied Sciences), Karel Kruger (Stellenbosch University) and Jörg Niemann (Düsseldorf University of Applied Sciences). *Augmented Reality for Operators in Smart Manufacturing Environments: A Case Study Implementation.*

Abstract. The fourth industrial revolution, or Industry 4.0, is gaining momentum globally and in various sectors. The Industry 4.0 vision promises smart and highly-connected digital and physical systems, and relies on the effective integration of some key enabling technologies – amongst which is Augmented Reality (AR). AR is a digital medium that involves virtual objects and computer-generates elements that appear in one or more layers over the real world environment. The integration of production data with customized AR experiences promise great benefits for operators in the manufacturing sector and beyond.

This paper describes the case study implementation of an integrated AR experience for operators in a smart manufacturing environment. The case study uses a Microsoft Hololens II AR system, with Vuforia Studio software, to integrate an operator with the operation and control of a Fischertechnik Learning Factory 4.0 miniature manufacturing system.

The case study implementation demonstrates an integrated AR experience capable of: identifying components of the real-world manufacturing system using QR code detection and shape screening; visualizing multi-media data objects; visualizing real-time IoT production data; and sending operator commands via the AR system to affect the manufacturing system operation. In light of the case study results, the paper also discusses the possibilities and challenges for the deployment of AR in real manufacturing environments.

A4 11:20

Error! Reference source not found. Yafet Haile-Melekot (Düsseldorf University of Applied Sciences), Karel Kruger (Stellenbosch University) and Jörg Niemann (Düsseldorf University of Applied Sciences). *Virtual Reality for Interacting with Manufacturing System Digital Twins.*

Abstract. Globally, and across several sectors, the Industry 4.0 vision of smart, highly-connected systems is starting to be become reality. Amongst other key enabling technologies, Industry 4.0 relies on the advancement of Digital Twins (DTs) and Virtual Reality (VR). DTs are accurate virtual representations of the structure, behaviour and state of physical systems. In recent years, the DT concept has received notable research attention in the field of manufacturing systems as a means to support data-led decision making, optimization and enhanced control. VR entails the creation of immersive virtual, simulated environments, which has great potential for visualization of – and interaction with – DT models and data.

The paper describes the development of a VR experience that is integrated with the DT of a physical manufacturing system. The VR experience is developed using HTC Vive hardware and Unity software, and integrated with a Fischertechnik Learning Factory 4.0 miniature manufacturing system.

The presented VR experience allows users to view, navigate and interact with a digital model of the physical manufacturing system. Furthermore, real-time production data of the physical system can be visualized in the virtual environment and the user can affect the operation of the physical system through control commands. Lastly, the paper discusses the possibilities and challenges for deploying such VR experiences in real manufacturing environments.

B2 14:20

Error! Reference source not found. Günther Schuh (Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University), Thomas Scheuer (Fraunhofer-Institute for Production Technology IPT) and Jannik Herding (Fraunhofer-Institute for Production Technology IPT). *Systematization of Technological Capabilities for the Connected Adaptive Production.*

Abstract. Increasing networking in production and the complexity of new technologies are presenting companies with ever greater challenges. To survive in this dynamic environment, companies can develop into agile, learning organizations by implementing suitable Industry 4.0 solutions. Many companies have already developed an understanding of the fundamental principles of connected adaptive production and recognized the added value for maintaining long-term competitiveness. However, systematic implementation remains a challenge. Often, there is a lack of deeper understanding of the capabilities to be built to unlock the full potential of Industry 4.0 solutions. In particular, the required technological capabilities regarding resources and information systems in companies reflect a wide range of possible applications. For the targeted selection of measures towards the connected adaptive production and their successful implementation, companies need a structured overview of the required technological capabilities. Therefore, this paper presents a model for systematizing the technological capabilities of manufacturing companies for the realization of connected adaptive production.

C3 16:20

Error! Reference source not found. Julian Hermann (ESB Business School, Reutlingen University), Anton Basson (University of Stellenbosch), Konrad von Leipzig (University of Stellenbosch) and Vera Hummel (ESB Business School, Reutlingen University). *Indoor positioning using a single PTZ camera.*

Abstract. The market for indoor positioning systems for a variety of applications has grown strongly in recent years. A wide range of systems is available, varying considerably in terms of accuracy, price and technology used. The suitability of the systems is highly dependent on the intended application. This paper presents a concept to use a single low-cost PTZ camera in combination with fiducial markers for indoor position and orientation determination. The intended use case is to capture a plant layout consisting of position, orientation and unique identity of individual facilities. Important factors to consider for the selection of a camera have been identified and the transformation of the marker pose in camera coordinates into a selectable plant coordinate system is described. The concept is illustrated by an exemplary practical implementation and its results.

B4 12:10

Error! Reference source not found. Ilicia Van Breda (Stellenbosch University), Johannes Jooste (Stellenbosch University) and Vera Hummel (Stellenbosch University; Reutlingen University). *A gamified learning approach based on systems modelling for understanding the effects of asset management decision-making.*

Abstract. Engineering asset management is a broad and multidisciplinary field with a variety of interconnected facets. Asset management encompasses a large spectrum of risk, finance, operations, and maintenance factors that make managing assets a complex and integrated multidisciplinary process. An industrial and educational challenge is to provide holistic insight and training in a comprehensible way for developing practitioner and learner understanding and knowledge about the larger system's effect within an organisation and practical implications of decision-making across the multidisciplinary facets of an organisation's asset management activities.

In this paper, it is argued that gamification presents a suitable alternative for addressing this challenge. Arguments are presented in support of gamification, based on the success of existing games within industrial environments and the respective state of the art. The paper presents the design and development of a simulation-based gameplay of asset management using an architecture for bidirectional learning for serious game development. The gameplay is based on a fictitious organisational environment with four players, each assuming a diverse role and making decisions within the organisation's asset management system. System modelling methods are used to develop the underlying game model. System dynamics modelling within the Vensim and AnyLogic software tools are used for simulating asset management dynamics and to illustrate the downstream organisational effects based upon each player's decisions and gameplay inputs. The paper concludes with feedback from industry practitioners, following the playing of the game, supporting its potential to enhance and simplify the learning related to the dynamics associated with asset management decision-making.

A6 15:30

Error! Reference source not found. Duncan W. Gibbons (Stellenbosch University) and Andre F. van der Merwe (Stellenbosch University). *The Application of ArchiMate for Planning the Implementation of Manufacturing Management Systems.*

Abstract. This paper investigates the use of a model-based approach for planning the implementation of manufacturing management systems. Manufacturing management systems such as ERPs, MESs and PLMs are defined by various standards and frameworks and are developed and implemented based on the specific industry they are to be operated within. Such implementations require conformance to large document-centric requirement sets and are depicted in cumbersome vendor-specific specifications. This paper utilizes the ArchiMate language and notation for planning such implementations and engaging stakeholders prior to domain-specific implementation.

B3 16:40

Error! Reference source not found. Günther Schuh (Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University) and Bastian Studerus (Fraunhofer Institute for Production Technology IPT). *Derivation of Requirements for the Formation of Collective Target Systems for Technology-based Cooperation between Manufacturing Corporates and Startups.*

Abstract. Disruptive innovations are putting incumbent manufacturing companies under increasing pressure to defend their competitive position in globalized markets. To withstand this pressure, they can form cooperation agreements with startups aiming for the creation of technical innovations and, thus, ensuring access to technologies and growth. Due to organizational differences and an insufficient explication of cooperation objectives, these cooperation pose a major challenge for both partners. In this paper, the authors discuss the status-quo in the formation of entrepreneurial target systems and, thereby, systematically derive corporate as well as startup-specific cooperation deficits. Based on the analysis of creating individual target systems, a first attempt is taken to elaborate requirements for the development of a model to form collective target system for the cooperation between corporates and startups. Subsequently, model characteristics for the derivation of joint targets and requirements are discussed to enable a

comparison between corporates and startups. The development of a concept for a requirements comparison based on a collective cooperation target system supports corporates and startups to ensure the fulfilling of the competitive advantage.

A4 11:50

Error! Reference source not found. Eric Lutters (University of Twente) and Roy Damgrave (University of Twente). *Accuracy in Digital Twinning; an exploration based on asset location.*

Abstract. Establishing a digital twin usually aims to develop a twin into a correct, encompassing, and well-aligned representation of the reality under consideration. This may be adequately possible for systems that are limited in scale, scope, number of perspectives and complexity -quite like 'traditional' modelling. Here, simulations, examinations, or disquisitions based on the digital twin may be adequately transferable to reality. However, even for the simplest system, it is impractical to prove that the digital twin fully coincides with reality.

The endeavours involved in realising digital twins for complex, dynamic, and emergent systems are intrinsically open-ended. This essentially results in deficient and unfinished approximations of reality, rendering the digital twin an interface to the real world that is meaningful and useful, yet imperfect.

Given the fact that digital twins can impossibly mimic actuality exactly, it is essential to identify and find ways to deal with the inaccuracies and incertitudes involved in how a digital twin maps a delineated object/aspect system in the real world. The disparity between the twin and (emergent) system under consideration exists in the manifestation of the system (i.e., its objects and parameters), but certainly also in the alteration of the system over time. In both cases, disparities emerge from incomplete representations or misrepresentations, systematic and random errors, but foremost from flawed modelling and from repercussions of unanticipated or unprecedented stressors. The foremost issue, however, is how discordant a twin can be to still be useful or reliable in decision making.

Reasoning from this decision making, this publication aims to explore how digital twins can explicitly cope with the inevitable misalignments with reality. The publication relies on the metrology-idiom to dissect the constituents of accuracy and incertitude in relation to digital twins. With that, the publication explores how a digital twin for a manufacturing environment can associate with asset location data, although this data is provided concurrently by dissimilar sources with varying precision, reliability, intervals, and probability. The publication shows that a feasible and meaningful way to integrate these data sources in the digital twin is foremost instigated by the simulations, what-if scenarios and decision making that will use the digital twin as their basis. Consequently, the treatise argues that the development of the digital twin should not be driven by the sheer availability of data and data sources, but rather by the envisaged role the digital twin will have in future decision making.

A4 12:10

Error! Reference source not found. Roy Damgrave (University of Twente) and Eric Lutters (University of Twente). *Simultaneous multi-stakeholder digital twinning for anticipated production environments.*

Abstract. Establishing, monitoring or changing production environments involves significant time, efforts and investments. Digital Twins, Digital Prototypes and Digital Masters, provide different perspectives on these production environments. An additional step is needed to utilize these perspectives effectively and efficiently as tooling in the development trajectory and operation of production environments. This activity can be considered 'digital twinning' and enables to anticipate and experience the behaviour of envisaged production environments, while substantially reducing technical, logistic, and financial risks. But since these digital support systems are merely tools related to a production environment, the effectiveness and quality of the

outcome is depending on the way the tool is configured and used for digital twinning. This paper focusses on providing a framework that oversees the configuration possibilities that different configurations of a digital twin and digital prototype have. The framework structures the way these tools are configured, depending on the use condition and demands of the stakeholders, and consequently what their functionality is.

B2 15:00

Error! Reference source not found. Markus van der Westhuizen (Department of Industrial Engineering, University of Stellenbosch), Konrad von Leipzig (Department of Industrial Engineering, University of Stellenbosch) and Vera Hummel (Logistics Management, ESB Business School, Reutlingen University). *Augmented Reality Combined with Machine Learning to Increase Productivity in Fruit Packing.*

Abstract. This paper studies the benefits of using Augmented Reality and Machine Learning in the agricultural industry for the purpose of fruit classification. During fruit classification colour plays a vital role in determining fruit quality and attractiveness. It is for this reason that technology in agriculture is being adopted that can visually grade produce. The downside is that the bulk of the new technology is automation driven, which may result in a significant growth in unemployment. Therefore, technology which offers collaboration between employees and visual technology, in the form of Augmented Reality using the HoloLens 1, was studied. Augmented Reality requires strong data analytical support because the effectiveness of Augmented Reality is directly proportional to the quality of the information utilised. To ensure accurate data analytics Machine Learning was used. To study Augmented Reality and Machine Learning in agriculture these two technologies were used to classify avocados in terms of both fruit grade and size. Machine Learning was implemented using Microsoft Azure which was used to grade the fruit. This was done by providing 1053 photos of avocados to Microsoft Azure from which the Machine Learning algorithm could learn how the fruit was to be graded. To determine the size of the avocado the number of pixels and the distance of the avocado from the HoloLens was used. An Augmented Reality and Machine Learning prototype was implemented, and the time taken to pack an avocado box was taken. It was found that there was a packing speed increase of 29.87% and a decrease in the packing speed variation of 96.2% when the prototype was implemented. Doing a t-test it was quantified that the increase in packing speed was statistically significant. Therefore, it can be concluded that the use of Augmented Reality and Machine Learning can be used to aid employees to improve tasks in the agricultural industry.

C3 16:00

Error! Reference source not found. Tanja von Leipzig (Spatialedge; Stellenbosch University), Jacques du Toit (Spatialedge) and Frank Ortmann (Spatialedge). *Driving big data capabilities and sustainable innovation in organisations.*

Abstract. Big data can not only provide a glimpse into the current state of a business, but may also provide a foundation for discovering new business opportunities, driving process improvement and innovation and ultimately improving the bottom line. However, realising this explicit value from big data is not without challenges. It is estimated that few big data endeavours succeed, with only a small portion of analytic insights actually delivering measurable business value. The challenges are multifaceted, including factors such as a lack of an overall big data strategy, lack of buy-in from executive management, resistance to technology adoption, inadequate technical and soft skills and team structures, and poorly-directed investments. Without an understanding of the current landscape or state of the art as far as technology and advanced analytics are concerned, along with a clear roadmap, organisations will find it more difficult to realise the value that big data promises.

In this paper we address some of the uncertainties and challenges faced by organisations with respect to big data, by presenting a model to facilitate and accelerate their efforts. The model evaluates an organisation's capabilities with regards to data centricity and provides an actionable roadmap for the implementation and improvement of big data endeavours. This enables organisations to focus their efforts on creating value from big data, where the model informs continuous efforts in improving organisational efficiency and effectiveness, and driving sustainable innovation.

A2 14:20

Error! Reference source not found. Daniel van Niekerk (Stellenbosch University), Karel Kruger (Stellenbosch University) and Anton Basson (University of Stellenbosch). *Interface Holons in the BASE architecture for human-system integration in Cyber-Physical Systems .*

Abstract. The Biography-Attributes-Schedule-Execution (BASE) architecture is a holonic reference architecture that was developed to integrate human workers into Industry 4.0 environments. The architecture guides the development of Human Resource Holon Administration Shells (BASE shells), which raise humans to a Cyber-Physical System (CPS) level so that they can interact with other CPSs. Existing research on the BASE architecture has already shown how interface services can be used to enable the cyber-physical interfacing between humans and their associated BASE shells. This paper extends this research by introducing dedicated Interface Holons in the BASE architecture. Interface Holons encapsulate interface services provided by cyber-physical interfacing resources, such as sensors, loudspeakers, augmented/virtual reality systems, etc. The details of the BASE architecture plugins required in Interface Holons are discussed. Furthermore, standard inter- and intra-holon communication protocols between the BASE shells of Interface Holons and Human Resource Holons are explained.

B6 15:50

Error! Reference source not found. Theolan Pillay (University of Kwazulu Natal), Glen Bright (University of KwaZulu Natal), Christian Basson (University of Kwazulu Natal) and Avern Athol-Webb (University of Kwazulu Natal). *An Unorthodox Forming Procedure to Achieve Single Minute Exchange of Die (SMED) – Cold Roll Forming.*

Abstract. Intricate and complex production systems are incorporated across vast platforms, ranging from hand-held computer devices to the much larger scaled aerospace industry. Given the contrast of manufacturing environments, the cost implications to business organisations are significant due to machine downtime. Non-Value-Added activities such as tool change-over and tool setup need to be streamlined, contributing to the efficiency of production in an Advanced Manufacturing System (AMS). This paper considers the cold roll forming (CRF) process within the automotive industry and aims to examine the implementation of a revised forming procedure to achieve tool change-over in a singular minute. A South African automotive accessories manufacturing company was considered where tool change-over of the tube mill is achieved in 500 minutes. The application of a unique die design is aimed at replacing the multiple rollers with a singular tool to address the non-value-added activity of tool change-over and addressing the disadvantages of the conventional CRF process. The Cage forming operation was selected as a possible approach in achieving a low-cost flexible and AMS to produce ERW tubes.

A2 14:00

Error! Reference source not found. Peter Kuhlang (MTM ASSOCIATION e. V.), Martin Benter (MTM ASSOCIATION e. V.) and Maria Neumann (MTM ASSOCIATION e. V.). *Bridging the gap between digital human simulation to standard performance with Human Work Design.*

Abstract. One major task in industrial companies is designing human work processes. Productivity and ergonomic factors are key performance indicators for this task. To measure and improve these indicators, practitioners use different methods to analyse and design work processes. Most methods either focus on productive or ergonomic aspects, but not both. Furthermore, they require a lot of manual effort regarding data collection and interpretation. These factors limit the number of industrial workplaces that are designed in a productive and ergonomic way.

The process building block system MTM-HWD® is one method that was developed specifically to allow an integrated analysis of both productive and ergonomic aspects. However, applying MTM-HWD® still requires considerable effort.

The application effort for methods such as MTM-HWD® can be reduced by automatically interpreting digitized human motion data. Motion data digitally depicts human movements. The data includes, for instance, joint positions, covered distances or object interactions. Particularly the technologies human simulation and virtual reality are suitable for generating or interpreting motion data.

This article shows how motion data that originates from human simulations can be used to derive a partially automated MTM-HWD® analysis. The technologies thus reduce the required manual effort for MTM-HWD®. This way, human work processes can be designed to be productive and ergonomically sound, without increasing the required design effort. To clarify the process the article primarily focusses on the simulation software imk ema.First, the article shows the necessary information for a creating a MTM-HWD® analysis. It then dissects, which information can be generated automatically by human simulations tools and which data has to be added manually. By manually adding the information that cannot be determined automatically, it is then possible to derive a MTM-HWD® analysis. To clarify this process, an example is shown using the software imk ema.

C2 14:00

Error! Reference source not found. William Makhetha (Stellenbosch University), Gerrit Ter Haar (Stellenbosch University), Thorsten H Becker (Stellenbosch University) and Natasha Sacks (Stellenbosch University). *Understanding the Structural Integrity and Post-processing of LPBF as-built Ti-6Al-4V Parts: A Literature Review.*

Abstract. Despite the exponential increase in research and industrial application of laser powder bed fusion (LPBF), Ti-6Al-4V parts produced still fail to meet the structural integrity of most functional requirements in the as-built conditions. The major drawbacks are high surface roughness, high residual stresses, martensitic microstructure, high porosity and anisotropic material properties. The drawbacks are a result of the inherent nature of a typical LPBF process characterised by rapid heating and cooling and line-by-line and layer-by-layer processes. To provide more insight and confidence in the LPBF technology, the causes of these drawbacks must be carefully investigated. This involves the integration of three factors: technology, skills and industry requirements. Currently, such understanding is not widely available. The focus is usually separated (on materials and processes or standardisation and qualification capabilities) instead of being integrated. This paper is a two-fold literature review of firstly, the LPBF output parameters (resultant part characteristics), which are critical to the structural integrity of Ti-6Al-4V produced by LPBF and secondly, the potential problem-solving strategies for the martensitic microstructure, porosity, residual stresses and surface roughness. The methodology used involved a triangulation of the literature followed by an inclusion-exclusion criterion of the relevant literature. The outcome of this work was a contribution towards a better understanding of the technology to boost the industry confidence in additive manufacturing.

C2 14:20

Error! Reference source not found. Zamukuhle Luthuli (Stellenbosch University), Kristiaan Schreve (Stellenbosch University) and Oelof Kruger (National Metrology Institute of South Africa). *Towards a Virtual Optical Coordinate Measurement Machine.*

Abstract. Optical coordinate measuring machines offer portability and the ability to capture vast quantities of data points quickly. But traceability of measurements in these systems is difficult since they are fraught with many challenges affecting the uncertainty of measurements. The VDI German standard is used for verification of these systems using non-complex artefacts that are easy to measure and have already been calibrated with other traceable measuring machines. ISO 10360-13 were only released in 2020. However, neither the VDI nor ISO standard cater for freeform surfaces. The Virtual CMM technique solves the problem of traceability of freeform surface measurements. This technique has only been applied to tactile CMMs and articulated arm optical CMMs, also known as discrete point systems, since they measure one point at a time. This research paper reports on the development and application of the Virtual CMM technology to a stereovision scanning optical coordinate measuring system.

A6 15:50

Error! Reference source not found. Quirin Gärtner (Technical University of Munich) and Alexander Dorth (Technical University of Munich). *Overview of Design Dimensions for Ambidexterity in Manufacturing Innovation Management.*

Abstract. Continuous improvement is a core process within innovation management of manufacturing systems. Innovation managers are constantly trying to improve manufacturing systems with regard to the target criteria reliability, variability and productivity. Manufacturing units must be able to deal with complex and volatile environmental circumstances and at the same time act both exploratory and exploitative in order to produce both incremental and radical innovations. The organizational ability to achieve this under these circumstances is called ambidexterity. To address the growing challenge of continuously increasing manufacturing efficiency while at the same time identifying, developing and integrating radical technology concepts into the manufacturing system, the need for ambidexterity in manufacturing has increased enormously in recent years and imposes a severe challenge on many manufacturing units. Therefore, this paper presents an organizational approach to enable ambidexterity in manufacturing innovation management by identifying the most important organizational dimensions for designing such an innovation management and ensuring long-term competitiveness.

B1 11:50

Error! Reference source not found. Lennard Holst (Institute for Industrial Management (FIR) at RWTH Aachen University) and Volker Stich (Institute for Industrial Management (FIR) at RWTH Aachen University). *Typology and Implications of Equipment-as-a-Service Business Models in the Manufacturing Industry.*

Abstract. In the manufacturing industry, technological developments around cyber-physical systems create completely new possibilities for generating value for customers. An essential part of these developments are Equipment-as-a-Service business models (EaaS), which promise growth with existing customers even in saturated markets and in which the interests of manufacturers and providers are aligned. However, different types of EaaS business models must be differentiated in manufacturing industry, especially with regard to the risk transfer from the customer to the provider. In this paper, a typology for different EaaS types is developed based on grounded research. Furthermore, practical implications are derived that should help with the necessary EaaS transformation, that has been previously outlined by the EaaS typology.

B1 12:10

Error! Reference source not found. Rofhiwa Nemukula (University of Johannesburg) and Daniel M Madyira (University of Johannesburg). *Investigating the Shuttering Index of Coal Fines Briquettes Produced with Natural Binders.*

Abstract. Coal is the primary raw material used in the energy sector today. Significant amounts of coal fines waste are generated during the coal processing process. Waste coal fines have no economic value. As a result, they are disposed of in landfills or underground. If coal fines are not properly managed, they have a negative environmental impact such as spontaneous combustion, groundwater contamination, acid mine drainage, and wind-driven air pollution. When inhaled, coal fines, can cause lung disease (black lung disease) and other health problems. However, coal fines have the potential to be used as a source of energy. This study discusses various methods for recovering energy value from coal fines produced by the South African coal mining industry. The aim of this work was to produce coal fines briquettes using natural binders such as cactus that can be used in domestic cooking and other industrial applications. Briquettes were produced that exhibited good shuttering values about above 80%.

C1 12:30

Error! Reference source not found. Sphiwe Simelane (University of Johannesburg) and Daniel Madyira (University of Johannesburg). *Effect of Mercerization on Coconut Fiber Surface Condition.*

Abstract. The use of natural fibers requires that they should be treated in preparation for their use in Natural Fiber-reinforced polymer composites. This paper reports on the effects of sodium hydroxide (NaOH) treatment on the surface of coconut fibers. The fibers were subjected to 5%, 10%, 15% and 20% NaOH concentrations and soaked for 4 hours. They were then thoroughly rinsed and allowed to dry in open air for 7 days after which time they were dried in an oven for 30 minutes. Untreated and treated coconut fibers were observed under the Scanning Electron Microscope and it was noted that the surface structure of the fibers was modified differently by the different NaOH concentrations, and the resultant colour of the treated fibers got darker as the solution concentration increased, and the texture felt rougher to the touch as a result of the erosion of the fiber surface. Further, the increase in alkali concentration striped the surface of more constituents thus exposing “pits” and other surface components rendering the surface rough.