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DISRUPTIVE INNOVATION IN MANUFACTURING ENGINEERING TOWARDS THE 4TH INDUSTRIAL REVOLUTION

March 25 - 28, 2014 | Stuttgart, Germany | Abstracts



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Wilhelm Bauer, Carmen Constantinescu,
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Imprint

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FOREWORD



We welcome you to the 8th International Conference on Digital Enterprise Technology – DET 2014 – sponsored by the International Academy for Production Engineering (CIRP) and organized by the Fraunhofer Institute for Industrial Engineering IAO in Stuttgart in partnership with the University of Bath. The conference focuses on the need to find a common understanding of what role Digital Enterprise Technologies (DET) will play in disruptive innovation within the manufacturing sector.

DET 2014 specifically aims to provide an international forum for the exchange of leading-edge scientific knowledge and industrial experience directly relating to the development and integration of DET and the impact this will have on the 4th Industrial Revolution. The topics addressed cover the entire lifecycle of product, factory and manufacturing processes, beginning with product design and development, followed by the engineering of factories, machines, equipment and technical processes, through to the commissioning and ramp up of production. These topics will be complemented by a look at manufacturing operation, maintenance and facility management, as well as the recycling and reuse of products and materials, factory overhaul and the environmentally compatible dismantling of production plant.

The aim of the Industry Day on the first day of the conference is to initiate a dialogue between people in the industry, technology providers and members of the scientific community.

We are pleased to welcome renowned experts from all over the world and would like to thank all speakers for their contributions.

We hope that DET 2014 will provide valuable insights to stimulate you in your work and look forward to many inspiring presentations, lively discussions and interesting points of view.

Prof. Dr.-Ing. Wilhelm Bauer

Prof. Dr.-Ing.
Carmen Constantinescu

Dr.-Ing. Olaf Sauer

Prof. Paul Maropoulos

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PRODUCT AND PROCESS 1

*Keywords: Sustainable Procurement;
Procurement Strategies; Low-Cost Country Sourcing*

Assessment of dynamics and risks in supplier selection processes

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Increasing competitive pressure in the production sector has led to considerable changes in the global competitive structure. Currently, companies attempt to counteract cost pressure by increasing their global outsourcing activities as well as focusing on their core competencies. Hence, global procurement has gained increasing importance among general purchasing activities of companies and is predicted to have an increasing influence on future cost development. Due to this development, companies are looking for new suppliers in low-wage countries. However, companies have to consider negative effects in the fields of quality, service level, and counterfeiting or plagiarising of merchandise. Therefore, cost savings in low-wage countries can only be achieved through major efforts during the planning and the realisation phase of the supplier selection process. Purchasing companies lack systematic assistance in analysing the procurement object and the economic environment of potential supplier candidates. This paper presents a two-step approach dealing with the issue of global procurement in low-wage countries and how this issue is faced taking the business environment into account. In the first step, a method is described using the help of a requirement profile for suppliers and a cost structure analysis to select potential suppliers. In the second step, an approach for modelling and identifying potential dynamics and risks related to the acquisition of new suppliers in low-wage countries is developed.

Keywords: Automotive manufacturing; Product development; Collaborative framework Supply chain; Process modelling; Knowledge management

An Integrated Decision Making Framework for Automotive Product Development with the Supply Chain

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It is evidenced that manufacturing firms in order to be more competitive in market, must continuously update their product offers in order to better satisfy the customers' requirements. Management should use the supply chain features more frequently, as the increased rate of product introductions, demands more from a business and needs more efforts to deliver the new products effectively and efficiently. To deliver the products at the targeted cost, time, and quality, the supply chain must be aligned with New Product Development (NPD) decisions. This will allow the manufacturing firm to overcome problems such as (partially) failed product launches due to the lack of product availability because of insufficient capacities. The integrated NPD-Supply Chain Management (SCM) enterprise has the benefit of increased supply chain capability, thus increasing the effectiveness of new product introductions and improves enterprise's performance. This research mainly focuses on automotive sector due to its supply chain environment being the subject of extensive research within its product development integration. The research also introduces the development of a framework that integrates flow of activities within the manufacturing enterprises and shows that this contributes all the business functions. It also aims to focus on using current modelling tools to represent the product development processes of its Original Equipment Manufacturer (OEM) and its suppliers. ...

Keywords: Uncertainty; CMM; Simulation

An exploration into measurement consistency on coordinate measuring machines

Per Saunders, University of Bath, UK; Alan Wilson, National Composites Centre, Bristol and Bath Science Park, UK; Nick Orchard and Neil Tatman, Manufacturing Technology, Rolls-Royce plc, Derby, UK; Paul Maropoulos, University of Bath, UK

In high precision industry, the measurement of geometry is often performed using coordinate measuring machines (CMMs). Measurements on CMMs can occur at many places within a long and global supply chain. In this context it is a challenge to control consistency, so that measurements are applied with appropriate levels of rigour and achieve comparable results, wherever and whenever they are performed. In this paper, a framework is outlined in which consistency is controlled through measurement strategy, such as the number and location of measurement points. The framework is put to action in a case study, demonstrating the usefulness of the approach and highlighting the dangers of imposing rigid measurement strategies across the supply chain, even if linked to standardised manufacturing processes. Potential mitigations, and the requirements for future research, are outlined.

Keywords: Digital manufacturing; Feature-based inspection; CAI; CMM

CAI MODEL FOR PRISMATIC PARTS IN DIGITAL MANUFACTURING

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The objective of this paper is to discuss the feature-based inspection planning on CMM in a wider context, within a digital manufacturing concept. The digital manufacturing is a novel approach to manufacturing in which all elements of manufacturing process are built using computer based simulation with a 3D visualization. For each element in the process (product/part, tool, fixture, machine, measuring sensor, etc.) a solid model is built and the whole manufacturing chain is simulated in order to provide digital verification. STEP standard as an enabler of feature based manufacturing is presented in detail along with belonging application protocols, considering prismatic parts engineering and manufacturing. The case study on the feature-based CAPP/CAM/CAI model in a manufacturing SME is shown to depict the practical advantages, followed by the research recommendations for the improvement of the existing model.

PRODUCT AND PROCESS 2

*Keywords: Dynamic pricing;
Centralized distribution center; Stochastic demand*

Storage pricing and allocation in a Headquarter-managed centralized distribution center

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Hong Kong*

A headquarter-managed centralized distribution center (HQ-CDC) is considered in this study to serve multiple subsidiaries with stochastic demands. Dedicated space is reserved for each subsidiary for the duration of a time period, with re-allocation permitted at the beginning of each period. The subsidiaries are also allowed to fulfill their storage needs by supplementing their reserved spaces with leased spaces at any time point but with a higher price. The paper compares two pricing policies: the constant pricing where the unit space price remains constant and dynamic pricing where the HQ-CDC is allowed to adjust the space price. A series of numerical studies is conducted. The results show that the group company's total cost is significantly reduced by the implementation of the dynamic pricing policy. The results also reveal that the implementation of the leased space leads to a more flexible space utilization in the HQ-CDC and reduces the group company's total cost especially in face of large demand and high demand fluctuation.

*Keywords: Railway Manufacturing; Welding;
Vision System; 3D Motion Simulation*

3D Digital Reconfiguration of an Automated Welding System for a Railway Manufacturing Application

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Advanced Production Technology; Naples, Italy; Luigi Nele,
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Industrial Production Engineering, University of Naples Federico
II, Naples, Italy*

In the last years, efforts have been focused towards new approaches for the automation of gas metal arc welding process parameters. In this framework, an innovative welding system based on a 3-axis motion device and a vision system consisting of a video camera, a laser head and a band-pass filter has been developed and implemented to recognize the desired features of weld joints, such as geometry and dimensions, and automatically adapt the welding process parameters according to these features. This paper focuses on a real case study of the railway manufacturing industry related to the welding process of a bogie frame. Through the employment of 3D Motion Simulation, the identification of a suitable reconfiguration of the system through the substitution of the 3-axis motion device by means of an industrial robot is studied in a totally digital framework. Simulation of the welding process allows calculation of robot kinematics, collision detection and motion planning.

Keywords: Design change; network analysis, ontology

A Novel Product Representation to Highlight Cross-Assembly Dependencies and Product Robustness

Blake A. Kendrick, Stephen T. Newman, Vimal Dhokia, Department of Mechanical Engineering, University of Bath, Bath, United Kingdom

Manufacturing industry has traditionally used Bill of Materials (BOMs) and Product Lifecycle Management (PLM) tools to track components and sub-assemblies within a product. These apply a hierarchical structure to product assemblies and sub-assemblies. Impacts of change to one or more components can easily be traced throughout the assembly tree; however, changes impacting another component not directly or explicitly connected to the first are not considered. Here the authors present the novel Kendrick Reticulated Ontology Model (KROM), a mesh component network to highlight cross-assembly dependencies. Nth-order connections are considered through user inputted links between otherwise unconnected components. Unexpected emergent behaviours can therefore be anticipated. Network analysis was applied to the resulting graph, quantifying the design's robustness through centrality measures. Considering both product components and assembly associated tooling and jigging demonstrates the true propagating impact of design change. It is shown that core component connectedness order is changed when tooling becomes part of the network. This is particularly significant when considering the regular omission of tooling in BOMs. Here, a disconnection between Design Engineering and Production Engineering after design finalisation has been determined and a solution presented.

Keywords: Optimisation; Production; Workflow; Evolutionary Algorithms

Evolutionary optimisation of production workflows

Herbert, L., DTUC Compute, The Technical University of Denmark Matematiktorvet, Lyngby – Denmark; Hansen, Z.N.L. and Jacobsen, P., Management Engineering, The Technical University of Denmark Produktionstorvet, Lyngby –Denmark;; Cunha, P., Instituto Politécnico de Setúbal, Portugal

We present an evolutionary optimisation technique for stochastic production processes, which is able to find improved production workflows with respect to arbitrary combinations of numerical quantities associated with the production process. Working from a core fragment of the BPMN language we employ an evolutionary algorithm where stochastic model checking is used as a fitness function to determine the degree of improvement of candidate processes derived from the original process through mutation and cross-over operations. We illustrate this technique using a case study where a baked goods company seek to improve production time while simultaneously minimising the cost of waste.

PRODUCT AND PROCESS 3

Keywords: Virtual Reality; Product Development; Conjoint Analysis; Customer Integration Business-to-Business Marketing; Disruptive Innovation

Virtual Reality based Conjoint Analysis for Early Customer Integration in Industrial Product Development

Klaus Backhaus, Jonas Jasper, Katharina Westhoff, Institute for Business-to-Business Marketing, Münster, Germany; Jürgen Gausemeier, Michael Grafe, Jörg Stöcklein, Heinz Nixdorf Institute, Paderborn, Germany

Disruptive innovations of products and production systems have the potential to provide a leap in value for existing and new customers. However, companies in industrial markets face two major problems when bringing innovations to markets. First, companies often lack systematic customer integration in the product development process. Second, disruptive innovations break with existing technologies and are therefore regularly beyond the scope of customers' imagination due to its complexity and level of novelty. Hence, when customers evaluate new product concepts, they often cannot fully capture its benefits. By addressing these two problems, companies can promote the efficiency of the product development process and thereby the success of disruptive innovations.

Keywords: Personal Excellence; Self-Assessment; Lean Logistics

LOPEC – Logistics Personal Excellence by continuous Self-Assessment

Andreas Jäger and Wilfried Sihm, Fraunhofer Austria Research GmbH, Vienna, Austria; Jörg Bauer and Vera Hummel, ESB Business School, Reutlingen University, Stuttgart, Germany

In a knowledge society where demands for skills, competencies and knowledge constantly increase and change, lifelong learning is a key strategy to adjust people's performance capabilities to new requirements and guarantee employability in the world of work. Good examples for this are the current changes in the logistics environment. Regularly, new services and processes close to production were taken into the portfolio of logistics enterprises, so the daily tasks are changing continuously for the skilled works.

LOPEC aims in developing and offering special-tailored training for „Lean Logistics“ and required basic skills for skilled workers on shopfloor level. Needed know-how for today's challenges in logistics will be transferred. Another aspect of LOPEC is the development and use of a „personal excellence self-assessment“ that allows a person to assess and thus improve his/her own level of maturity in employability skills. Thus, LOPEC is aiming at people enhancement as entry ticket to Lifelong Continuous Learning by increasing the maturity level of personal logistic excellence. A common European view for „Logistics personal excellence“ for skilled workers will ensure that the final product is an open product, using international, pan European validated standards. As results LOPEC will provide training modules for post-secondary education in the area of LEAN logistics, required basics skills and offers transparency of personal excellence with a personal self-assessment software solution, regarding the personal maturity level of hard and soft skills at any time. ...

Keywords: direct toolpath; graph theory; cloud points; roughing

Direct toolpath generation based on graph theory for milling roughing

Daniela Popescu, Florin Popister, Sorin Popescu, Calin Neamtu, Mircea Gurzau, Technical University of Cluj-Napoca, Cluj-Napoca, Romania

The paper presents a tool path generation methodology for roughing operation based on the oriented graph theory. The cutting areas are identified using an original method that is based on a bicolor and binary map. The toolpath is generated using the searching Dijkstra algorithm inside a graph in order to find the single-source shortest path. The method was employed in order to be applied on ordered and/or unordered point clouds. The entire algorithm was implemented into a mathematic calculus solution which allows the import of point clouds and its processing until the final NC code is generated.

Keywords: Body-in-white; geowelding; dimensional accuracy

Valuable Use Cases towards a Generic Model of Geo-station Welding

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(Team of Carmen Constantinescu)*

To ensure a robust mass production, the automotive industry relies on computer aided tolerancing to guarantee the dimensional quality of the vehicles' body-in-white. One of the challenges for computer aided tolerancing is the accurate modelling of the positioning for joining processes in the body-in-white production. The research work presented in this paper analyses three use-cases, on which different approaches of modelling of the so-called geo-stations are investigated, aiming at improving the deviation prediction based on the geo-station modelling. The examples show that the measurement values are met most accurately, if the positioning processes of the geo-station are taken into account as the dominant impact factor in the simulation.

PRODUCT AND PROCESS 4

*Keywords: Assembly line design; Multi-objective;
Alternative process configurations*

Multi-Criteria Assembly Line Design under Demand Uncertainty

Nikolaos Papakostas, George Pintzos, Christos Giannoulis, Nikolaos Nikolakis, George Chrysosolouris, Laboratory for Manufacturing Systems and Automation, Dept. of Mechanical Engineering and Aeronautics, University of Patras, Patras, Greece

Assembly line design methodologies have been extensively researched during the past four decades. Different definitions of problems have been established together with different approaches on how they are solved. However, in the automotive industry, most companies still use simple tools and methods for solving these problems. These tools can be spreadsheet applications and simulation tools that simply assist engineers in distributing the processes into different workstations that do not provide actual decision support. Furthermore, most approaches take into account only a few goals and constraints, either providing non-realistic solutions or no decision support to production engineers, beyond the distribution of processes. This paper proposes an assembly design algorithm that takes into account both time and cost parameters for the generation of different line alternatives; the algorithm, taking into account industrial requirements, uses multiple products of different demand profiles in the same line in order to provide support for multi-variant or multi-product systems. Finally, the possible alternative configurations of processes are taken into account so as to integrate the balancing of the line with process design and equipment specification.

Keywords: Case-based reasoning; knowledge reuse; FMEA

Usage of case-based reasoning in FMEA-driven software

*Gabriela Căndeia, Universitatea Lucian Blaga Sibiu, Sibiu, România;
Stefania Kifor, R&D Department, ROPARDO SRL, Sibiu, România;
Carmen Constantinescu, Fraunhofer Institute for Industrial Engineering (IAO), Stuttgart, Germany*

Failure Mode and Effect Analysis (FMEA) is among the most widely used safety analysis procedures in the various industries. The procedure is generally perceived as complex and time-consuming, hindering an effective reuse of previous knowledge. In this paper we present an innovative usage of knowledge system into FMEA process using the ontology to represent the knowledge in order to reduce the time and effort associated with this analysis. Knowledge system is built to serve multi - projects work that nowadays are in place in any manufacturing or services provider, and knowledge must be retained and reused at the company level and not only at project level. Collaboration is assured through web-based GUI that supports multiple users access at any time. Initial results confirm the viability of this system for industrial application.

Keywords: Feature; Adaptive manufacturing; Process planning

A machining feature information model for dynamic manufacturing planning

*Xu Liu, Yingguang Li, Qiang Li,
College of Mechanical and Electrical Engineering, Nanjing University
of Aeronautics and Astronautics, Nanjing, China*

This paper presents an information model that facilitates responsive changes to the dynamics of machining features in 2.5/3D machining. The model consists of basic information that remains unchanged throughout the manufacturing process and also adaptive information that may be redefined in response to changes in manufacturing resources. A suite of solutions have been developed to enable adaptive feature interpretation to the real time process plans without frequently re-recognising and re-planning that is common in current industrial practice. Examples will be provided to demonstrate the feasibility and potential benefits of the developed methodology.

*Keywords: RFID; optical identifier;
optical indicator; product life-cycle; low-cost*

Low-cost extension of information transparency throughout the product life-cycle via optical identification and quality indication

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Growing needs for data transparency are experienced in production networks, calling for individual product traceability and accurate information on actual state, quality or history of the individual product. Special challenges arise when “low-tech” network members, retailers or customers are likewise to be served during the product life-cycle, or in case low unit prices or tight profit margins require highly cost-efficient solutions. In line with the latter, the paper examines the integration of optical identifiers with optically perceptible quality indicators as an alternative to sensor-equipped RFID, including new designs not yet covered by implemented solutions. Following a separate survey of the two combined technological domains, possibilities of synthesis are examined from the point of view of optical codes, as their (semi) automatic acquisition and subsequent processing presents the key value added to most present-day indicator-only labels. As different targeted application ranges, e.g., supply chain members of different size, may require different pre-implementation surveys, the paper includes a collection of acceptance aspects for all of the identified user groups.

LIGHT CONTROLLED FACTORY 1

Keywords: Thermal modelling; Light Controlled Factory (LCF); Temperature measurement

Identification of Key Temperature Measurement Technologies for the Enhancement of Product and Equipment Integrity in the Light Controlled Factory

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Thermal effects in uncontrolled factory environments are often the largest source of uncertainty in large volume dimensional metrology. As the standard temperature for metrology of 20°C cannot be achieved practically or economically in many manufacturing facilities, the characterisation and modelling of temperature offers a solution for improving the uncertainty of dimensional measurement and quantifying thermal variability in large assemblies.

Technologies that currently exist for temperature measurement in the range of 0-50°C have been presented alongside discussion of these temperature measurement technologies' usefulness for monitoring temperatures in a manufacturing context. Particular aspects of production where the technology could play a role are highlighted as well as practical considerations for deployment.

Contact sensors such as platinum resistance thermometers can produce accuracy closest to the desired accuracy given the most challenging measurement conditions calculated to be ~0.02°C however other technologies can provide valuable information. Non-contact solutions would be most practical in the light controlled factory (LCF) and semi-invasive appear least useful but all technologies can play some role during the initial development of thermal variability models

Keywords: Composite Materials, Hand Layup, Augmented Labour

Intelligent Composite Layup by the Application of Low Cost Tracking and Projection Technologies

Matthew Such, Carwyn Ward, Advanced Composites Centre for Innovation and Science, University of Bristol, Bristol, UK; Windo Hutabarat, Ashutosh Tiwari Manufacturing and Materials Department, Cranfield University, Cranfield, UK

Hand layup is still the dominant forming process for the creation of the widest range of complex geometry and mixed material composite parts. However, this process is still poorly understood and informed, limiting productivity. The paper seeks to address this issue by proposing a novel and low cost system enabling a laminator to be guided in real-time, based on a predetermined instruction set thus improving the standardisation of produced components. Within this paper the current methodologies are critiqued, and future trends are predicted, prior to introducing the required input and outputs, and developing the implemented system. As a demonstrator a U-Shaped component, typical of the complex geometry found in many difficult to manufacture composite parts, was chosen and its drapeability assessed by the use of a kinematic drape simulation tool. An experienced laminator's knowledgebase was then used to divide the tool into a finite number of features with layup conducted by projecting and sequentially highlighting target features, while tracking a laminator's hand movements across the ply. The system has been implemented with affordable hardware and demonstrates tangible benefits in comparison to currently employed laser-based systems. It has shown remarkable success to date, with rapid Technology Readiness Level advancement. This is a major stepping stone towards augmenting manual labour with further benefits including more appropriate automation.

Keywords: Augmented Reality; Shop floor; Product lifecycle management

**A novel approach for the combined use
of AR goggles and mobile devices
as communication tools on the shopfloor**

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Existing and evolving trends and paradigms in manufacturing like mass customisation and personalisation require better communication between product-production design and customisation and production execution. More specifically, the lack of feedback from and to the shopfloor can lead to lower quality and increased production times. In state of the art industrial practices, the most common visual interface devices for communication include control unit terminals, TFT monitors mounted over work stations as well as the growing trend of mobile PCs and tablets. New technologies like Augmented Reality (AR) have also been considered in academic research for process simulation and operator guidance and training. This paper proposes a novel use of AR goggles coupled with other mobile devices for the communication of people working on the shopfloor with people in the engineering offices. The proposed methodology tries to address the challenges in the use of both technologies (and their respective interfaces) by presenting an integrated approach; the use of a mobile device as an input device and as fiducial marker for the positioning of a virtual screen in front of the user. After the presentation of the concept, its advantages and disadvantages when compared to current practices as well the rest of the relevant academic work are depicted. The technical implementation to be realised by the authors is also described including specific software frameworks that will be used. ...

Keywords: laser tracker; uncertainty; network; metrology; optimization

Laser Tracker Position Optimization

Zheng Wang, Alistair Forbes, Paul Maropoulos

This paper presents a laser tracker position optimization code based on the tracker uncertainty model developed by the National Physical Laboratory. The code is able to find the optimal tracker positions for generic measurements involving one or a network of many trackers and an arbitrary set of targets. The optimization is performed using pattern search or optionally, Genetic Algorithm (GA) or Particle Swarm Optimization (PSO). Different objective function weightings for the uncertainties of individual points, distance uncertainties between point pairs and the angular uncertainties between three points can be defined. Constraints for tracker position limits and minimum measurement distances have also been implemented. Furthermore, position optimization taking into account of lines of sight within complex CAD geometry have also been demonstrated. The code is simple to use, and can be a valuable measurement planning tool.

LIGHT CONTROLLED FACTORY 2

Keywords: Machine tool metrology; 5-axis machine tool capability; On-machine Measurement (OMM); On-machine Verification (OMV); On-machine Probing (OMP) High precision manufacturing; Sample final inspection

Comparison of the measurement performance of high precision multi-axis metal cutting machine tools

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High precision manufacturers continuously seek out disruptive technologies to improve the quality, cost, and delivery of their products. With the advancement of machine tool and measurement technology many companies are ready to capitalise on the opportunity of on-machine measurement (OMM). Coupled with business case, manufacturing engineers are now questioning whether OMM can soon eliminate the need for post-process (CMM) inspection systems. Metrologists will however argue that the machining environment is too hostile and that there are numerous process variables which need consideration before traceable measurement on-the-machine can be achieved.

In this paper we test the measurement capability of five new multi-axis machine tools enabled as OMM systems via touch-trigger probing. All systems are tested under various operating conditions in order to better understand the effects of potentially significant variables. This investigation has found that key process variables such as machine tool warm-up and tool-change cycles can have an effect on machine tool measurement repeatability. New data presented here is important to many high precision manufacturers considering using their manufacturing equipment as measurement devices as well as for production.

Keywords: Laser beam melting; Modelling; Additive Manufacturing

Simulation of the Laser Beam Melting Process – Approaches for an Efficient Modelling of the Beam-Material Interaction

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Currently, the main field of application of additive manufacturing processes is shifting from research laboratories to production facilities. Simulation models can foster this transition by providing support in process development and design. This paper introduces approaches to modelling the beam-material interaction in laser beam melting on a level of detail that allows the simulation of the whole build-up process of parts, not only of single laser tracks. Thus both the achievable result accuracy and the needed calculation time are discussed. For this purpose, fundamental correlations to link process characteristics with model parameters are explained. Subsequently, four modelling approaches are analysed. After an introduction of the well-known method of applying a uniform load on a whole layer compound, the developed methods are discussed which allow modelling the beam-material interaction on a more detailed level. Thereby, the focus lies on the ability to model load gradients perpendicular to the build direction. This article is completed with a discussion of simulated temperature curves for selected monitoring points using two different modelling approaches.

Keywords: information management; production control; simulation

Short-term cyber-physical Production Management

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For most manufacturing companies a high adherence to delivery dates is their main logistic target. In consideration of the fact that production plants are getting more networked and complexity is increasing very much, this is a huge challenge for the production manager. The research project "ProSense" was initiated in order to optimize the production planning and control in times of an integrated production and to assist the production manager in his decisions. The focus of the paper is on the short-term part of "ProSense". In the paper the new approach of the short-term assistance of the production manager by using latest technologies will be described. Its goal is to support the production controller of a manufacturing company by providing prioritized short-term actions on a tablet computer. New sensor technologies, big data processing and simulation are enablers for providing possible actions for achieving a stable production in the upcoming week and therefore meeting the customer agreed date. The paper will outline how possible short-term actions can be identified and how they have an impact on the production schedule. Furthermore, the paper will deduce in what areas the application of short-term actions for the upcoming week is reasonable. These short-term actions basically affect the following fields of production: capacitive and organizational bottleneck in the production, work in process and the adherence to delivery dates. With the help of intelligent visualization the application on the tablet computer will display the effects of a performed action on the screen and therefore be an optimal basis for decision for the production controller.

Keywords: Dynamic wheel alignment; Wheel loading; Light-controlled automation Depth imaging; Object recognition; Kinect; Xtion

Dynamic alignment control using depth imagery for automated wheel assembly

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This paper presents a novel method for dynamic alignment control using infrared light depth imagery to enable automated wheel loading operation for the trim and final automotive assembly line. A key requirement for automated wheel loading is to track the motion of the wheel hub and simultaneously identify the spatial positions and angular orientations of its alignment features in real-time on a moving vehicle body. This requirement is met in this work, where low-cost infrared depth-imaging devices like Microsoft Kinect™ and Asus Xtion™, vastly popular in the gaming industry, are used to track a moving wheel hub and recognise alignment features on both the wheel hub and the wheel in real time in a laboratory environment. Accurate control instructions are then computed to instruct the automation system to rotate the wheel to achieve precise alignment with the wheel hub and load the wheel at the right time. Experimental results demonstrate that the reproducibility error in alignment control satisfies the assembly tolerance of 2mm for the wheel loading operation, and thus the proposed method can be applied to automate wheel assembly on the trim and final automotive assembly line. The novelty of this work lies in its use of depth imaging for dynamic alignment control, which provides real-time spatial data in all 3 axes simultaneously as against the popularly reported RGB imaging techniques that are computationally more demanding, sensitive to ambient lighting and require the use of additional force sensors to obtain depth axis control data. ...

Keywords: Part-to-part assembly; Robotic machining; Thermally compensated measurement Measurement planning; Embedded metrology

Large Volume Metrology Technologies for the Light Controlled Factory

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In the Light Controlled Factory part-to-part assembly and reduced weight will be enabled through the use of predictive fitting processes; low cost high accuracy reconfigurable tooling will be made possible by active compensation; improved control will allow accurate robotic machining; and quality will be improved through the use of traceable uncertainty based quality control throughout the production system. A number of challenges must be overcome before this vision will be realised; 1) controlling industrial robots for accurate machining; 2) compensation of measurements for thermal expansion; 3) Compensation of measurements for refractive index changes; 4) development of Embedded Metrology Tooling for in-tooling measurement and active tooling compensation; and 5) development of Software for the Planning and Control of Integrated Metrology Networks based on Quality Control with Uncertainty Evaluation and control systems for predictive processes. This paper describes how these challenges are being addressed, in particular the central challenge of developing large volume measurement process models within an integrated dimensional variation management (IDVM) system.

FACTORY 1

Keywords: Distributed Manufacturing; Search System; Viral Phenomenon

Production Resource Search using the Viral Phenomenon: Concept Introduction

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A significant challenge in a distributed production organisation is finding suitable production resources. In this study, we develop the concept of a production resource search system that can be used to organise a distributed manufacturing system in a global environment.

The system is based on internet technologies and autonomous work systems, which are the building blocks of a dynamically organised production system. These building blocks encapsulate functionalities and competencies of management and manufacturing operations and an autonomous information system that supports autonomous decision-making and cooperation within the network. The developed search system thus focuses on finding suitable autonomous work systems. The internet viral phenomenon is used to automatically extend the search domain and exploit internet real-time capabilities. Thus, the search domain is not limited by a searcher's knowledge about it.

An offer for the production of a product is directly sent to only a few potential work systems, which automatically pass it to related work systems. Thus, the offer is distributed rapidly and effortlessly throughout the network. Work systems benefit from such a system by always being informed about all the offers. The individual work systems automatically match the offer to their capabilities and respond with a bid to the production initiator (the searcher). ...

Keywords: Capacity planning; Reconfigurable assembly systems; Machine learning

Capacity planning and resource allocation in assembly systems consisting of dedicated and reconfigurable lines

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Companies with complex product portfolio often face capacity planning problems due to the diversity of the products and the fluctuation of the order stream. High volume products can be produced cost-efficiently on dedicated assembly lines, but the assembly of low-volume products in such lines involves high idle times and operation costs. Reconfigurable assembly lines offer reasonable solution for the problem; however, it is still complicated to identify the set of products which are worth to assemble in such a line instead of dedicated ones. In the paper a novel method is introduced that supports the long-term decision to relocate the assembly of a product with decreasing demand from a dedicated to a reconfigurable line, based on the calculated investment (sometimes the relocation needs additional investments, as well) and operational costs. In order to handle the complex aspects of the planning problem a solution approach is proposed that combines discrete-event simulation and machine learning techniques. The feasibility of the approach is demonstrated through the results of an industrial case study.

*Keywords: Intelligent Maintenance Systems;
Spare Parts Supply Chains; Supply Chain Coordination;
Supply Chain Management; Integration Architecture*

Integration Architecture of Intelligent Maintenance Systems and Spare Parts Supply Chain Planning

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Global competition has led to more complex production systems, in which efficient maintenance is critical for operational competitiveness. The effects of poor maintenance levels can have huge economic impacts in such production systems. To avoid this problem, it is necessary, on one hand, to be able to estimate maintenance needs in advance, thus be able to avoid unforeseen breakdowns and production interruption. On the other hand, management and planning of spare parts supply chain systems become more important due to the difficulty of ensuring spare parts availability while keeping reasonable inventory and transportation costs. To address both points, research in the domains of Intelligent Maintenance Systems (IMS) and Advanced Planning Systems (APS) for spare parts supply chains have been arising in recent years, providing means to forecast device failures by the analysis of sensorial inputs, resulting in the ability to forecast maintenance and spare parts needs more precisely. The integration of IMS and APS makes it also possible to adapt the machine parameters according to the reactivity of the spare parts supply chain and to enable its usage until the spare parts are available. ...

*Keywords: Process Reliability; Reliability Evaluation;
Reconfigurable Manufacturing System*

Research on Reliability Evaluation of Reconfigurable Manufacturing System

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It is a crucial task to evaluate the reliability of manufacturing process in product development process. Process reliability is a measurement of production ability of reconfigurable manufacturing system (RMS), which serves as an integrated performance indicator of the production process under specified technical constraints, including time, cost and quality. An integration framework of manufacturing process reliability evaluation is presented together with product development process. A mathematical model and algorithm based on universal generating function (UGF) is developed for calculating the reliability of manufacturing process with respect to task intensity and process capacity, which are both independent random variables. The rework strategies of RMS are analyzed under different task intensity based on process reliability is presented, and the optimization of rework strategies based on process reliability is discussed afterwards.

FACTORY 2

*Keywords: Kinect; Deictic Gestures;
Computer Supported Collaborative Work*

Integrating Pointing Gesture Detection for enhancing Brainstorming Meetings using Kinect and PixelSense

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Microsoft PixelSense is able to detect multitouch input and tagged objects as well, which makes it suitable to be used in net-based brainstorming sessions within small teams. However, any gestures above the table cannot be detected, which makes net-based brainstorming sessions less intuitive. Thus, we present a solution how Kinect can be used together with PixelSense to overcome this limitation without interference between the two devices.

*Keywords: Manufacturing; Simulation;
Information and Communication Technologies*

Simulation in Manufacturing: Review and Challenges

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Simulation comprises an indispensable set of technological tools and methods for the successful implementation of digital manufacturing, since it allows for the experimentation and validation of product, process and system design and configuration. Especially in today's turbulent manufacturing environment, which is affected by megatrends such as globalisation and ever-increasing requirements for higher degree of product customisation and personalisation, the value of simulation is evident. This keynote paper investigates the major milestones in the evolution of simulation technologies and examines recent industrial and research applications and findings. Based on this review, the identification of gaps in current practices is presented, and future trends and challenges to be met on the field are outlined. The considered simulation methods and tools include CAx, Factory layout design, Material and Information flow design, Manufacturing Networks Design, Manufacturing Systems Planning and Control, Manufacturing Networks Planning and Control, Augmented and Virtual Reality in product and process design, planning and verification (ergonomics, robotics, etc.). The evolution, advances, current practices and future trends of these technologies, industrial applications and research results are discussed in the context of the contemporary manufacturing industry.

Keywords: Conceptual Design; Self-Optimisation; Production Planning

Conceptual Design of a Self-Optimising Production Control System

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Current production control systems cannot react appropriately to unknown situations (e.g. the dispatch of rush jobs). They are only able to react on known situations with a predefined behaviour. In this paper the paradigm of self-optimisation will be transferred to the production control level by using a procedure model to design a self-optimising production control system. The production control is then able to react autonomously on changing operational conditions and to deduce new reaction strategies for occurring faults or disturbances. A rule based decision model is the core of the conceptual design. It is based on known and possible future faults and deduces reaction strategies. Simultaneously to them, a simulation model will be proposed, that simulates and evaluates suitable strategies.

SIMULATION BASED-APPLICATIONS (DREAM) 1

Introduction to “Simulation based application Decision support in Real-time for Efficient Agile Manufacturing” – DREAM

Cathal Heavey, University of Limerick, Limerick, Ireland.

The scale and complexity of the modern manufacturing systems make essential the integration of predictive simulation modelling and optimisation methodologies into routine decision making processes. To address this challenge, DREAM will offer a radically new and extensible approach to simulation application engineering, leveraging state-of-the art research on simulation and simulation based optimization.

The objectives are:

1. To increase the competitiveness of European Manufacturing Companies through the provision of multi-level just-in-time simulation based application decision support.
2. To engineer a semantic free open simulation application development platform to promote simulation based applications by European Manufacturing Companies, IT consultants, Open Source community and Researchers.
3. To address the multi-faceted barriers to the adoption of advanced simulation decision support technologies by manufacturing companies, especially SMEs, by developing methodologies to address system knowledge management and human-system interaction challenges.
4. Using the semantic free simulation application platform to implement novel applications to support decisions at multi-levels in European Manufacturing Companies.

Keywords: Simulation; Embedded Systems; Open-Source

Simulation based decision support systems: An industrial end-user based requirement gathering process

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Modern manufacturing systems are growing in scale and complexity and increasingly require integrated predictive modelling and optimisation methodologies to support routine decision making processes. The engineering of a free open source simulation modelling platform is the basis of the DREAM project, a Framework Programme 7 initiative co-funded by the European Commission. This paper reports on the capture of requirements for DREAM from four industrial end-users. These industrial end-users' requirements and accompanying pilot cases drive the research, technology and development work in the project. The users vary in size from micro-SME to multi-national and global organisations and by industry; from semi-conductor manufacturing, medical device design and manufacture to industrial machine manufacture and pre-process/prototype manufacturers. To capture requirements from the organisations a methodology was developed which is reported on in the paper. Its outcomes provide the basis for the subsequent open-source software development. In particular, the work assessed the various partner needs in the pre-coding, simulation application development, simulation application use and data-analytics areas which cover the end-to-end usage of a simulation based decision support system.

Keywords: System Knowledge Capturing; SysML; Simulation

Modeling of System Knowledge for Efficient Agile Manufacturing: Tool evaluation, selection and implementation scenario in SMEs

Carmen Constantinescu, Désirée Dienes, Fraunhofer Institute for Industrial Engineering (IAO), Stuttgart, Germany; Davide Matarazzo, Institute for Human Factors and Technology Management, IAT, University of Stuttgart, Germany; Emmanuel Francalanza, CERU, Department of Industrial and Manufacturing Engineering, Faculty of Engineering, University of Malta, Malta; Martin Bayer, Leotech GmbH, Leonberg, Germany

In the manufacturing world, knowledge is fundamental in order to achieve effective and efficient real time decision making. In order to make manufacturing system knowledge available to the decision maker it has to be first captured and then modelled. Therefore tools that provide a suitable means for capturing and representation of manufacturing system knowledge are required in several types of industrial sectors and types of company's (large, SME). A literature review about best practice for capturing requirements for simulation development and system knowledge modeling has been conducted. The aim of this study was to select the best tool for manufacturing system knowledge modelling in an open-source environment. In order to select this tool, different criteria were selected, based on which several tools were analyzed and rated. An exemplary use case was then developed using the selected tool, Systems Modeling Language (SysML). Therefore the best practice has been studied, evaluated, selected and then applied to an industrial use case by the use of a selected opens source tool.

Keywords: Simulation and optimization;
open source software; job shop scheduling

Implementing ManPy, a semantic-free open-source Discrete Event simulation package, in a Job Shop

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The cost of acquiring commercial simulation packages is considerably high and this might explain why organisations are often reluctant to make further investments on training and retraining of employees on simulation modelling. Ironically, the level of benefit derived from simulation is highly dependent on experimental, analytical and statistical skills of the user. These cost and skill requirements make simulation an unattractive decision support tool to SMEs and small multinational organisations.

Proposed in this study is ManPy, a semantic-free open-source approach to discrete event simulation (DES), such that users with different levels of skills can derive considerable benefits from simulation. ManPy eradicates the high investments required for simulation modelling by making it possible for low skilled users to benefit from readily available generic modelling objects which are contributed to an open source platform by highly skilled simulation practitioners, statisticians and academics. Another benefit of ManPy is the ability to integrate with other enterprise planning tools for system knowledge extraction and real time simulation input data. ...

SIMULATION BASED-APPLICATIONS (DREAM) 2

Keywords: Supply chain; routing flexibility; demand disaggregation; algorithm-based simulation; discrete event simulation

Simulation-based Decision Support Tools for Demand Disaggregation in a Supply Chain characterised by High Routing Flexibility

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Routing flexibility is a key process feature in supply chains characterised by complex hierarchy at different manufacturing levels. When routing alternatives exist, controlling the supply chain to ensure uniformity and quality of the production outcome becomes a significant challenge, also from a demand planning perspective. In this paper, the demand planning problem at a supply chain operating in the semiconductor industry is investigated. Special attention is paid to mid-term demand planning when production orders are not yet finalised and aggregated demand forecast is considered. Within this planning frame, the demand planners face the difficult task of disaggregating aggregated demand into finer granularity products in order to generate provisional production plans that will be used to foresee potential capacity adjustment requirements. The demand disaggregation process entails routing decisions that also incorporate restrictions occasionally imparted by final customers on eligible routes for a specific product type. Historical demand patterns and routing constraints currently constitute the main decision drivers in the demand disaggregation process; likewise, the only objective accounted for is the timely satisfaction of customers' orders. ...

Keywords: Digital Factory, JITIR, Planning

Information Support and interactive planning in the Digital Factory: Approach and industry-driven evaluation

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Routing flexibility is a key process feature in supply chains characterised by complex hierarchy at different manufacturing levels. When routing alternatives exist, controlling the supply chain to ensure uniformity and quality of the production outcome becomes a significant challenge, also from a demand planning perspective. In this paper, the demand planning problem at a supply chain operating in the semiconductor industry is investigated. Special attention is paid to mid-term demand planning when production orders are not yet finalised and aggregated demand forecast is considered. Within this planning frame, the demand planners face the difficult task of disaggregating aggregated demand into finer granularity products in order to generate provisional production plans that will be used to foresee potential capacity adjustment requirements. The demand disaggregation process entails routing decisions that also incorporate restrictions occasionally imparted by final customers on eligible routes for a specific product type. Historical demand patterns and routing constraints currently constitute the main decision drivers in the demand disaggregation process; likewise, the only objective accounted for is the timely satisfaction of customers' orders. However, disregarding capacity constraints and ignoring incoming future demand characterised by more stringent routing requirements leads to uncapacitated production plans which might cause significant lateness in the orders' production. ...

Keywords: Simulation; CMSD; knowledge extraction

Test Implementation and Initialisation of a Simulation model using CMSD

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This paper describes a test implementation of the Core Manufacturing Simulation Data (CMSD) information model and the integration and initialisation of a simulation model in a newly developed Simulation Engine. The cost of developing, implementing and using simulation technology is high. The costs of integrating simulation models with other manufacturing applications are even higher. There is always a need to enable data exchange and sharing between simulation applications and other software applications. The idea of the CMSD effort is to facilitate the above using neutral, reusable data structures for managing actual production operations and for simulating the performance of the manufacturing system. To address the problem of time consuming pre-coding for DES projects, a knowledge extraction tool is currently being developed. The knowledge extraction tool will read data from several resources of an organisation and output it in a format that is applicable for simulation purposes. The format that we adopted follows the CMSD standard in order to describe simulation related data. In this paper we present the modelling of a complex production line of our industrial partner with the CMSD standard and the development of the translator in ManPy so that it can read the CMSD information model and run the simulation.

Keywords: Discrete Event Simulation; Open-Source Software; SimPy; ManPy; Modelling Flexibility

From COTS simulation software to an open-source platform: a use case in the medical device industry

George Dagkakis, Ioannis Papagiannopoulos, Cathal Heavey, Enterprise Research Centre, University of Limerick, Limerick, Ireland; Anna Rotondo, John Geraghty, Paul Young, Enterprise Process Research Centre, School of Mechanical and Manufacturing Engineering, Dublin City University, Dublin, Ireland; Rob Holland, Boston Scientific Cork Limited, Cork, Ireland

The implementation of Discrete Event Simulation (DES) – based decision support tools in complex manufacturing environments could prove of invaluable help to industrial practitioners involved in cross-functional decision processes at multiple hierarchical levels. The increasing number of decision variables, their stochastic nature and the non-linearity of their mutual relationships theoretically make simulation a preferred modelling approach for a great variety of manufacturing systems as strict simplifying assumptions are not necessarily required and the models' detail level can be tuned according to the analysis purposes. However, recourse to Commercial Off-The-Shelf (COTS) simulation packages to develop and implement simulation-based solutions in real manufacturing environments usually presents significant cost-of-ownership (COO). Along with license costs, modelling flexibility and sustainability represent fundamental issues raised by industrial engineers that adopt COTS simulation packages. In order to promote the use of DES in production related decision making processes and reduce the associated COO for manufacturing companies, an open-source simulation platform, ManPy, has been developed. ManPy consists of a library of DES objects implemented in SimPy. ...

SYSTEMS, IT AND INTEROPERABILITY 1

*Keywords: Manufacturing Execution Systems;
ICT for Manufacturing; Interoperability; Industrie 4.0*

Information Technology for the Factory of the Future – State of the Art and Need for Action

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Information and Communication Technology (ICT) is a key factor for the factory of the future – acting as an ‘enabling technology’, as it were. For production, ICT is a tool, not an end in itself. In the future, the shop floor will be increasingly supported by ICT components, which, in turn, will start to network themselves. In the following article, some of the areas of current activity and the effects of the increasing use of ICT will be described.

Keywords: AutomationML; OPC-UA; Mapping; Transformation

Interoperability between OPC-UA and AutomationML

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OPC-UA (OPC Unified Architecture) is a platform-independent standard series (IEC 62541) for communication of industrial automation devices and systems. It specifies the exchange of real-time information of production plant data between control devices or IT systems from different manufacturers. OPC-UA includes an information model that allows users to organize data and their semantics in a structured manner. The information model is a full-mesh network of nodes with their properties and relations. In general, users create the information model for their OPC-UA servers manually or implement vendor-specific automatisms.

AutomationML (Automation Markup Language) is an upcoming open standard series (IEC 62714) for describing production plants or plant components. It is an XML based data format especially designed for the exchange of plant engineering information. The format interconnects engineering tools of different disciplines and lifecycle phases, from plant construction over mechanical and electrical design to virtual start-up. AutomationML uses CAEX (IEC 62424) as top level format. CAEX provides object-oriented concepts such as classes and instances, and the possibility to describe arbitrary meshes.

The goal of this contribution is to simplify the creation of OPC-UA information models by examining the analogies between AutomationML and the OPC-UA information model. ...

Keywords: Model-Engineering; Conformance tests; Test generation

Automatic Conformance Test Generation based on a Verified Model of a Bus System Standard

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To ensure the conformity of field devices to the corresponding bus-system standard, a so called conformance test is introduced. This conformance solution checks the conformity of devices by testing standardized functionalities that must be fulfilled.

The quality, i.e. the Correctness and the Coverage of the tests, is decisive for the device conformity to the standard and hence the interoperability between devices from different manufacturers. The test Correctness can be achieved by eliminating existing error sources which can be categorized into two groups: First, programmatic errors during the test implementation. Second, conceptual errors due to a wrong interpretation of the standard or the standard itself has a defect. While programmatic errors can be significantly reduced by deploying a test development tool, the conceptual error still remains an issue. An approach that assures test Correctness is introduced in this paper.

The approach is based on generating test cases from the validated model of the standard. The purpose of the validation is to eliminate defects in the standard such as unreachable state definitions. For this, functionalities described in the standard (e.g. communication start-up) have to be modelled first using a formal description language. Since bus-system standards are generally expressed in a hybrid form consisting of natural languages, tables and pictures, rules for modeling a standard are introduced. ...

Keywords: Business Model Patterns; Value Chain Risk Assessment; Business Process Operationalization

Pattern-based Business Model Development for Cyber-Physical Production Systems

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Supported by sensors, Cyber-Physical Systems obtain information from their physical surroundings and provide them to internet services that in turn can directly affect the physical world. Already today, such interconnected systems enable improved or novel business processes within the value creation along the product life cycle. The application of CPS in production systems leads to Cyber-Physical Production Systems (CPPS) or the Smart Factory, respectively. In such an environment products, production resources as well as processes are each individually characterised by the special qualities of CPS. The current and future business potentials of production networks with decentralized coordination are enormous. However it is difficult for companies to keep track of the risks and chances of CPPS and develop according business models. Therefore in this contribution a methodology for the pattern-based development and realization of business models in the context of Cyber-Physical Production Systems is presented. The methodology comprises three main modules that cover the most important aspects of business models for CPPS. In the first module patterns of established business models are gathered and their applicability in the context of CPPS is examined. The resulting library is then extended with patterns explicitly dedicated to CPPS and represents the base for a development procedure model. In the second module the developed business models are assessed with regard to their risks. ...

SYSTEMS, IT AND INTEROPERABILITY 2

Keywords: Manufacturing; cloud; softwareengineering; requirements; architecture; service orientation; IT

Cloud-based Platform to facilitate Access to Manufacturing IT

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Today information technology is one of the main enablers of efficient production due to its ability to support manufacturing planning, execution, and optimization. However, most of the tools that provide these features are extremely complex and require on-site installation, individual configuration, administration, maintenance, etc. In many cases, the costs and efforts involved are too high for small and medium sized enterprises (SMEs) to bear. As a result, such companies are often unable to exploit the full potentials of manufacturing-related software systems. To overcome this problem, an IT infrastructure has been developed at Fraunhofer IPA which makes it easier to access manufacturing IT. The associated IT services, which are also accessible to SMEs, offer features for product tracking, process monitoring and control, etc., and are embedded in a cloud-based infrastructure, configurable to specific factory demands and accessible via apps (e.g. mobile devices).

This paper addresses the relevant infrastructure requirements, such as security, equipment integration, IT service management, workflow management and execution as well as user-specific app configuration. The basic architecture of the developed infrastructure is then discussed on the basis of these. The concept of engineering apps is taken as an example to underline the main benefits of such an infrastructure.

Keywords: Perishable supply chain; Internet auction; Cloud computing

Cloud-based Auction Tower for Perishable Supply Chain Trading

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Perishable supply chain trading (PSCT) involves typical activities that transfer perishable products among supply chain participants. Enhancing the traversal of perishable products through supply chains is essential for improving the standard of living and economic development. This study proposes a cloud-based auction tower to provide offline and online auction services for exchanging perishable products between suppliers and buyers. Product information service is designed to allow a huge kinds of perishable products be represented and sold through the auction tower. The flexible auction server enables the deployment of many auction mechanisms. Dashboard-enabled information visibility and traceability facilitate operations and decisions of auction participants. The adoption of cloud computing achieves “pay-as-you-go” and “pervasive-to-access” implementation. The use of the auction tower leads to significant improvement in transaction capacity, market efficiency and effectiveness as well as supply and demand information visibility.

Keywords: information management, big data, decision support

A solution for information management in logistics operations of modern manufacturing chains

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One dominant feature of the modern manufacturing chains is the movement of goods. Manufacturing companies would remain an unprofitable investment if the supplies/logistics of raw materials, semi-finished products or final goods are not handled in an effective way. Both levels of a modern manufacturing chain –actual production and logistics- are characterized by continuous data creation at a much faster rate than they can be meaningfully analyzed and acted upon manually. Often, instant and reliable decisions need to be taken based on huge, previously inconceivable amounts of heterogeneous, contradictory or incomplete data.

The paper will highlight aspects of information flows related to business process data visibility and observability in modern manufacturing networks. An information management platform developed in the framework of the EU FP7 project ADVANCE will be presented.

Keywords: Competences; Skill; Cyber-Physical Systems

Competences for Cyber-Physical Systems in Manufacturing – first Findings and Scenarios

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This paper presents research findings on competence needs for Cyber-Physical Systems (CPS) in manufacturing. These are from studies of the German Federal Ministry of Education and Research's initiative for early identification of skill needs (FreQueNz) as well as the Office of Technology Assessment at the German Bundestag (TAB). The findings are partly statements on possible future developments as – at least according to the mentioned studies during their periods of inquiry – the degree of CPS implementation in enterprises has been fairly low. Further development of CPS competence needs depends on which combinations of technologies and work organization will come to prevail in the enterprises in the course of broader implementation. As this seems rather open, two of the studies distinguish at least two ideal scenarios with regard to possible directions of competence developments.

Within the first scenario more and more decisions would be taken by IT which would control the production employees. These are expected to intervene into the process in case of malfunctions only but cannot develop the respective competences during the trouble-free process. Within the second scenario the technology would serve as decision-supporting system to employees still expected to optimize and able to intervene into the process. ...

PRODUCT AND PROCESS 5

*Keywords: Product Lifecycle Management;
Quality Management; Inspection Planning*

Digital Planning of Harmonised Quality Testing Activities throughout the Product Life Cycle

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Contemporary companies tend to avoid quality testing activities as they are regarded as non-value-adding efforts. Nevertheless, certain quality tests are mandatory to ensure the product quality to the customer. In order to reduce financial efforts and avoid testing overhead, quality testing activities need to be planned and harmonised throughout the entire product life cycle. The following paper focuses the development of a digital configuration system for quality testing activities throughout the product life cycle. To identify all important inspection processes, an overview of life cycle-orientated quality testing activities is presented. Thereafter, a development concept for the digital configuration system is introduced. The scope of the paper includes the digitalised process of planning quality testing activities in context of product lifecycle management applied within developing and producing companies running volume production.

*Keywords: Product Lifecycle Management;
Knowledge Management; Process Chain; Semantics*

Process-Oriented Semantic Knowledge Management in Product Lifecycle Management

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Product Lifecycle Management (PLM) focuses on management of product data and processes across their lifecycle stages. One of the key features of PLM is the management of knowledge collected during product development. Reduced time to market, a better collaboration and savings are expected benefits of PLM amongst others. The implementation of a PLM System inside a company can be a hurdle because of the heavy change of the company structure during introduction.

Most PLM solutions are based on one integrated product model that stores product data and shares these data with all contributors. However, the access of product data by different expert domains can be challenging when domain expert knowledge is necessary to understand it. This leads to a communication overhead that increases cost, product development time and thus time to market due to the need for contact to experts.

To deal with comprehensible knowledge throughout the product lifecycle phases and thereby eliminate communication overhead, this paper presents a process-oriented and integrated semantic solution that supports interoperability of knowledge during all phases of the product lifecycle. Based on shared ontologies and product models, collaborators of product chains have the ability to define their own extensions to the underlying models and ontologies. ...

Keywords: Interoperability; Collaborative engineering; PLM connector

Towards a PLM interoperability for a collaborative design support system

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Because of the increasing complexity of systems, their variability, and constant evolution of customer needs, engineering design has become more and more challenging and requires the collaboration between heterogeneous teams holding expertise in specific design-tasks. Thus, design outcomes of each expert field have to be put together without affecting the global design integrity. Typical enterprise application integration solutions propose dedicated tools which allow the coupling between engineering software by mapping data representation from one tool to another. This may result in a considerable mass of one-to-one interlinked software, which cannot provide an overall coherence between data. In this paper we propose a prototype enabling the interoperability between PLM systems and external engineering tools, with respect to the coherence concerns mentioned previously.

FACTORY 3

*Keywords: manufacturing systems;
context-aware manufacturing; ontology*

Towards a role-centric and context-aware information distribution system for manufacturing

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ICT platforms, in the manufacturing context, provide a number of tools, such as sensors, wireless networks, mobile devices, MES, ERP and information management systems in order to support shop-floor and back-office personnel. There is a need for the vast amount of information gathered and generated by such ICT systems to be utilized in a manner that can truly speed up production processes and facilitate immediate reaction to issues and shortcomings. This study presents an ontology-based approach for context modelling that has been developed by taking into account the main factory objects such as products, processes, resources, production units and enriches them with context information. The proposed context ontology aims at defining a fundamental data model for context extraction in a manufacturing environment. Moreover, the concept of a generic architecture and the key components for role-based and context aware information distribution is also described. An industrial application scenario, for the proposed role-centric and context-aware architecture, is described.

*Keywords: Data Distribution Service (DDS),
Industrial robots, Manufacturing automation*

Evaluating a prototype approach to validating a DDS-based system architecture for automated manufacturing environments

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Data Distribution Services (DDS) are emerging as communication systems in manufacturing environments. One of the key features of a DDS based system is the ability to regain performance levels after the introduction or removal of a DDS participant. In implementing a DDS participant to an existing system, message transport speed and message latency is often sacrificed due to protection problems in OEM software. Validity and suitability for integration of OpenDDS specifically, a manufacturing system is evaluated by defining two implementation scenarios; a flexible approach with a dedicated DDS participant application, and a high speed approach integrating the OpenDDS API directly in the target application. The system is validated by monitoring performance, efficiency and robustness in use and implementation. This result is part of a system architecture, developed for project Smart Industrial Robotics (SInBot), that focuses on maximizing the efficient use of mobile industrial robots during medium sized production runs.. This modular system architecture is based on distributed intelligence and decentralized control to enable online reconfiguration of industrial robots in manufacturing facilities.

*Keywords: electrical contacts; laser beam welding;
genetic algorithm; electro-thermal FEM*

Optimisation of Weld Seam Configurations Using a Genetic Algorithm

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The main task of high performance electrical contacts is the transmission of electrical power with low power dissipation. The decisive value to calculate the electrical losses of a contact is the resistance of the contact configuration. The electrical resistance can be decreased applying laser welded connections. This promising joining technology offers the opportunity to vary the contact area as well as its position in the joining zone. Especially the geometrical shape of the contact area enables a high potential to reduce the contact resistance. This work presents a method to optimise the geometrical shape of the weld seam in order to minimise the resistance of the electrical contact. A solution is proposed to calculate the optimum weld seam shape by the use of a genetic algorithm (GA) linked with an electro-thermal FEM simulation. The genetic algorithm compiles alternative weld seam shapes while the FEM simulation determines their electro-thermal properties. The optimised result is further verified within an experimental study. The proposed method is applied to design the electrical contacts between battery cells of a high voltage automotive battery system for electric and hybrid electric cars.

*Keywords: Energy optimization; Path planning;
Robot kinematics; Robot dynamics*

Minimising energy consumption for robot arm movement

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Robots are widely used in industry due to their efficiency and high performance. Many of them are operating in the manufacturing stage of the production line where the highest percentage of energy is consumed. Therefore, their energy consumption became a major focus for many robots manufacturers and academic research groups. Nevertheless, the optimisation of that consumption is still a challenging task which requires a deep understanding of the robot's kinematic and dynamic models. This paper proposes an approach to develop an optimisation module using Matlab to minimise the energy consumptions of the robot's movement. With the help of Denavit-Hartenberg notation, the approach starts first by solving the inverse kinematics of the robot to find the set of feasible joint configurations required to perform the task, solving the inverse kinematics is usually a challenging step which requires in-depth analyses of the robot. The module then solves the inverse dynamics of the robot to analyse the forces and torques applied on each joint and link in the robot. After that, a calculation for the energy consumption is performed for each configuration. The final step of the process represents the optimisation of the calculated configurations by choosing the one with the lowest power consumption and sends the results to the robot controller. ...

SYSTEMS, IT AND INTEROPERABILITY 3

Keywords: Machine tool monitoring, Scheduling, Mass Customisation

Machine availability monitoring for adaptive holistic scheduling: A conceptual framework for mass customization

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Although the market started expressing the need for high product variety three decades ago, manufacturing systems have not kept the pace with these social and economic developments. Modern industrial shop-floors are highly affected by the ever-increasing product variety and volatile market demands introduced by the currently established mass customisation paradigm. The increasing complexity in manufacturing activities and the high unpredictability requires immediate reactions to emerging disturbances for reducing bottlenecks, avoiding brake-downs of critical equipment and idleness in order to increase the productivity and the company's competitiveness. The framework proposed in this research work includes machine monitoring techniques for the near real-time identification of machine status, in order to allow a predictive maintenance engine to diminish machine tool failures. Moreover, an adaptive short-term scheduling mechanism is fed by the monitoring data for the refinement of production schedules based on the current and future conditions of the shop-floor. Data acquired from a multi-sensory pilot installation together with information directly retrieved from the machine tool's controller are fused and comprise the input to subsequent software modules. ...

Keywords: Digital factory; Collaborative innovation; Open communication

Engineering innovation factory

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The complexity of product realization has increased significantly due to the requirements on ecological and social as well as economical sustainability. This has led to an increased demand on innovations concerning new materials and product- and process technologies, as well as on new business models for a better utilization of products and materials. Most innovations occur through a learning process where various actors, individuals as well as organizations, take part. Breakthroughs do not necessarily occur within the research or development departments, they are equally likely to occur during production or utilization. The challenge thus lies in providing platforms and tools for cross-divisional, collaborative innovation and for sharing Best Practices.

This paper describes an initiative at KTH Royal Institute of Technology for supporting the integration of various company disciplines and external expertise through a collaborative framework. In this framework, industry and academy can collaborate, supported by modeling, simulation and visualization during the innovation process. The approach combines theories and methods concerning innovation and digital factories and emphasizes aspects concerning learning, communication and collaboration.

Keywords: failure management, Industry 4.0, production ramp-up

Concept of a Failures Management Assistance System for the Reaction on Unforeseeable Events during the Ramp-Up

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In new product development processes the ramp-up phase is the most critical. For the first time the new product will be produced under standard production conditions. Thereby companies are facing enormous challenges relating to new products: increasing product and process complexities, less time-to-market and highest quality requirements. In addition to this, shorter product lifecycles cause frequent ramp-ups. Companies must develop skills to conquer these challenges especially in terms of developing professional ramp-up expertise. The transfer from prototype to scalable product causes many different unpredictable failures. Those failures require a strong failure management to guarantee the planned time-to-market. Key element in effective failure management is communication in this high interdisciplinary process. Today failure management in most companies is realized in task force mode. There is no system support from right failure notice, right failure classification and failure allocation to the right person to the point of effective support finding a solution as well as failure solution documentation. In addition to that there is no transparency about work in progress and allocated failures. The outcome of this is loss of time and inadequately documentation of failures which again causes loss of time. ...

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