CIRP ANNALS – GA 2009 in Boston

Keynote Papers

- **Keynote Papers presented during the Opening Session:**

"C": Burrs - Analysis, Control and Removal - J.C. Aurich (2), D. Dornfeld (1), P.J. Arrazola (3), V. Franke, L. Leitz, S. Min (2)

"Dn": Design methodologies: Industrial and Educational Applications - T. Tomiyama (1), P. Gu (1), Y. Jin, D. Lutters (2), Ch. Kind, F. Kimura (1)

"F": Size effects in manufacturing of metallic components - F. Vollertsen (1), D. Biermann, H.N. Hansen (1), I.S. Jawahir (1), K. Kuzman (2)

"M": Interaction of Manufacturing Process and Machine Tool - C. Brecher (2), M. Esser, S. Witt

"S": Surface Technology for Automotive Engineering – K. Bewilogua, G. Bräuer, A. Dietz, J. Gäbler, G. Goch (1), B. Karpuschewski (1), B. Szyszka

- **Keynote Papers presented into the paper sessions:**

"A": Cooperation of Human and Machines in Assembly Lines - J. Krüger (2), T.K. Lien (2), A. Verl (2)

"E": Ion Beam, Focused Ion Beam, and Plasma Discharge Machining- D.M. Allen (1), P. Shore (2), R.W. Evans, C. Fanara, W. O'Brien, S. Marson, W. O'Neill

"G": Industrial Challenges in Grinding - J.F.G. Oliveira (1), E.J. Silva, C. Guo (2), F. Hashimoto (1)

"O": Value Creation and Decision-making in Sustainable Society - K. Ueda (1), T. Takenaka, J. Vancza (1), L. Monostori (1),

"P": Multisensor Data Fusion in Dimensional Metrology – A. Weckenmann (1), X. Jiang (2), K.-D. Sommer, U. Neuschaefer-Rube, J. Seewig, L. Shaw, T. Estler (1)

Papers Sessions

Life Cycle Engineering and Assembly

A1 - Evaluation of scenario-based modularization for lifecycle design
Y. Umeda (2), S. Fukushige, K. Tonoike
STC A, 58/1/2009, p.
Keywords:Lifecycle, Modular design, Evaluation
Abstract: Although modular design is a key technique for lifecycle design, effectiveness of modularity on environmental consciousness is not clear. This paper proposes an evaluation method of modular product from the viewpoint of resource efficiency. First, a product is modularized by applying our modularization method based on its lifecycle scenario. Second, the modular structure is evaluated by assuming that each module goes through preferable

lifecycle paths (e.g., upgrading, reuse, and closed-loop recycling) designated by the scenario but unmodularized components go through unpreferable paths. This paper also illustrates a case study in order to discuss effectiveness of the proposed method.

A2 - Recycling Process Planning for the End-of-Life Management of Waste from Electrical and Electronic Equipment
S. Rahimifard, M.S. Abu Bakar / D. J. Williams (1)
STC A, 58/1/2009, p.
Keywords:Planning, Recycling, Process Planning
Abstract: The ever-increasing amount of Waste from Electrical and Electronic Equipment (WEEE) has become a common problem due to the significant environmental and health impacts associated with inappropriate End-of-Life (EoL) management. The current ad hoc applications of WEEE recycling are often based on limited knowledge and cannot cope with the complex range of materials and products in such waste. A knowledge-based approach has been utilised to investigate the realisation of a recycling process planner which aims to determine the most suitable EoL options for WEEE. A number of case studies have been used to show that a 20-30% improvement on economical and environmental performance could be achieved through adoption of such a systematic approach to recycling process planning.

A3 - Environmental impact analysis of composite use in car manufacturing
J.R. Duflou (2), J De Moor, I. Verpoest, W. Dewulf
STC A, 58/1/2009, p.
Keywords:Lifecycle, Analysis, Composite
Abstract: Taking the restrictions imposed by the EU ELV directive into account, the use of non-recyclable composite components in car manufacturing is not obvious. However, from a life cycle engineering perspective the introduction of composites in car design is not necessarily negative in terms of additional environmental impact. An extensive life cycle analysis for a reference car design was conducted to study the effects of replacement of conventional steel structures by lightweight composite alternatives. The obtained results reveal the need for a nuanced attitude towards more intensive use of composites in car design. The sensitivity of the analysis results for the used carbon fibre production method is documented, indicating significant improvement potential based on emerging, less energy consuming production methods.

A4 - Effects of Globalisation on Carbon Footprints of Products
I.T. Hermann, M.Z. Hauschild (2)
STC A, 58/1/2009, p.
Keywords:Manufacturing; Lifecycle; Carbon dioxide emissions
Abstract: Outsourcing of production from the industrialised countries to the newly industrialised economies holds the potential to increase wealth in both places, but what are the environmental costs of the globalised manufacturing systems? This paper looks into the changes in carbon footprint of manufactured products when production is moved from United Kingdom or Denmark to China and uses environmental input-output analysis to calculate the carbon footprint in the bilateral trade between these countries. The results show that differences between the European and Chinese production systems can lead to substantial increases in the carbon footprint of the traded products, even without including the CO2 emissions from the associated transportation.

A5 - Experimental and numerical appraisal of Self Piercing Riveting
E. Atzeni, R. Ippolito, L. Settineri (2)
STC A, 58/1/2009, p.
Keywords:Aluminium, Joining, Self Piercing Riveting
Abstract: Self Piercing Riveting (SPR) has become an interesting alternative joining technique for difficult to weld materials. A limitation of this technology is still the heavy experimental procedure needed for joint optimisation. In this paper, an experimental activity on Al6082-T4

sheet metal samples has been conducted to achieve a better understanding of the process. The joining process and the tensile tests have then been simulated using a FE code to predict deformed shape, failure mechanism (e.g. crack propagation, rivet pull-out) and shear resistance of the joint. Results show how this procedure can be a powerful tool for joint optimisation.

A6 - Grasping leather plies by Bernoulli grippers
G. Dini (1), G. Fantoni, F. Failli
STC A, 58/1/2009, p.
Keywords:Automation; Handling; Bernoulli gripper
Abstract: The automated grasping of leather products presents many critical aspects mainly due to their very low stiffness and to the possibility of producing imprints on their delicate surfaces. To overcome such problems, this paper proposes the use of contactless grippers instead of more traditional vacuum cups or fingered grippers. In particular, the main objective of this investigation is the measurement of the performance of different gripper configurations whose lifting force is generated by a high-speed air flow passing between the gripper and the leather ply.

A7 - Automatic programming of robot-mounted 3D optical scanning devices to easily measure parts in high-variant assembly
G. Reinhart (1), W. Tekouo
STC A, 58/1/2009, p.
Keywords:Assembly, Quality assurance, Automatic robot programming
Abstract: In times of increasing product variance and demand for highest quality, 100% inspection of parts is often mandatory along the supply chain and the incoming goods control of assembly processes, respectively. A promising approach to reach this goal is the use of robot-assisted measurement systems. However, such systems require high efforts to program the robot for every new part and thus are seldom implemented in high-variant assembly systems. Consequently, this work proposes a system for automated programming of robot-mounted optical scanning devices. Additionally, algorithms to automatically extract measurement features and generate collision free robot scanning paths from CAD models are described.

A8 - Opportunistic Maintenance based on Fuzzy Modelling of Component Proximity
W. Derigent, E. Thomas, E. Levrat, B. Iung (2)
STC A, 58/1/2009, p.
Keywords:Maintenance, fuzzy logic, proximity measure
Abstract: Conventional maintenance strategies on a single component are being phased out in favour of more predictive maintenance actions. These new forms of maintenance are emerging today for better controlling the global performances of the whole system all along its life cycle. They are anticipative in nature allowing developing non-already-planned maintenance actions or to move earlier or later a planned maintenance action. It leads to investigate opportunistic interventions by considering, for example, the direct environment of a given component to be maintained in order to run additional maintenance actions on other components considered enough closed (proximity principle). Thus, this paper presents a new fuzzy methodology to assess component proximity in the design phase to impact design out maintenance. The methodology is applied on an industrial case study

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A9 - Maximizing utilization rate of office automation equipment by intraoffice circulation
S. Takata (1), K. Tsubouch
STC A, 58/1/2009, p.
Keywords:Life cycle design; Product reuse; Intraoffice circulation
Abstract: The utilization rate of products, which indicates the extent to which product functionality has been exhausted, must be improved to increase eco-efficiency of the products. In this paper, we propose an intraoffice circulation model that can increase the

utilization rate of office automation equipment. The manufacturer makes a contract with an office to provide the required functionality for a certain period. An office would require machines in each section. In our model, machines are periodically reallocated among the different sections with different user characteristics. The algorithm for optimizing circulation plan is developed using genetic algorithm. The model is applied to the use of copiers installed in a university office. The results verify the effectiveness of our model for reducing the environmental load.

A10 - Functional Process Adjustments to Reduce No-Fault-Found Product Failures in Service Caused by In-tolerance Faults
Prakash, L.E. Izquierdo, D. Ceglarek (1)
STC A, 58/1/2009, p.
Keywords:quality; service; lifecycle
Abstract: This paper presents a methodology to determine optimal process adjustments, which prevents manufacturing products from falling into in-tolerance fault regions (a subset of No-fault-Found events) taking into consideration product and process adjustments constraints. The proposed methodology utilizes the design relationship between KPCs and KCCs to determine process functional adjustments. The methodology is illustrated through three product and process design configurations, uncoupled, decoupled and coupled.

A11 - Mill-Knurling as an alternative to laser welding for automotive drivetrain assembly
H. Coban, A.K.M. De Silva (2), D.K. Harrison
STC A, 58/1/2009, p.
Keywords:Mill-Knurling, Laser welding, Drivetrain
Abstract: A novel technique for drivetrain assembly -“mill-knurling and press-fitting (MKPF)” is proposed as an alternative to laser welding or bolting. This joining technique involves the press fitting of two mating surfaces, one with mill-knurled teeth and the other which is of a relatively softer material, enabling it to flow over the teeth making a joint. This process is applied within the rear axle differential subjected to fluctuating torque loads. Experimental analysis and simulation is used to compare the functional feasibility and the potential benefits of mill knurled joints with laser welded and bolted joints currently used in differential/bevel gear assembly.

Cutting

C1 - Laser-Assisted Micro Milling of Hard-to-Machine Materials
S. Melkote, M. Kumar, F. Hashimoto (1), G. Lahoti (1)
STC C, 58/1/2009, p.
Keywords:Micromachining, Laser assisted, Hybrid process
Abstract: There is a need for developing hybrid micro manufacturing processes capable of generating three dimensional micro scale features in hard-to-machine materials. This paper deals with the development of the Laser-Assisted Micro Milling process for which a novel 4-axis machine has been designed and built. This paper presents the results of experiments on laser-assisted micro milling of hardened A2 tool steel (62 HRc). The dimensional accuracy of the micro milled feature and surface finish obtained with and without laser heating are compared and discussed. Scientific explanations for the different observations are given.

C2 - Mechanistic Modeling and Accurate Measurement of Micro End Milling Forces
S.S. Park, M. Malekian / T. Hoshi (1)
STC C, 58/1/2009, p.
Keywords:Force, Milling, Modeling
Abstract: Micro milling operations can fabricate miniaturized components with high relative accuracy. Since micro machining operations are different than conventional macro machining processes, due to the large negative rake angle and elasto-plastic effects, it is important that

the modeling of micro end milling forces incorporates the dynamics of the tool, ploughing and elastic recovery. This study examines the mechanistic modeling of shearing and ploughing domain cutting regimes to accurately predict micro milling forces. The tool dynamics are indirectly identified by performing receptance coupling analysis. Furthermore, the Kalman filter compensation method is used to precisely measure the forces to obtain the cutting constants.

C3 - 6-axis Control Ultraprecision Microgrooving on Sculptured Surfaces with Non-rotational Cutting Tool
Y. Takeuchi (1), Y. Yoneyama, T. Ishida, T. Kawai
STC C, 58/1/2009, p.
Keywords:Microgroove; Ultraprecision machining; 6-axis control
Abstract: New optical devices with multi-functions such as diffraction and focusing have been recently required to miniaturize optical systems and to decrease cost. However, their shape is generally very complicated. Typical example is a curved microgroove on a 3-dimensional complex surface. To machine the shape, a non-rotational cutting tool is employed in the study. In case of machining microgrooves on sculptured surface with a non-rotational cutting tool, 6-axis control is inevitable to control tool attitude and tool direction. The study deals with the development of CAM system for 6-axis control ultraprecision microgrooving.

C4 - Wear and thermal behaviour of CVD á-Al2O3 and MTCVD Ti(C,N) coatings during machining of AISI 4140 steel
R. M'Saoubi (2), S. Ruppi
STC C, 58/1/2009, p.
Keywords:Coatings; Machining; Growth texture
Abstract: The wear properties CVD á-Al2O3 layers with (101 2), (101 4) and (0001) growth textures were compared with MTCVD Ti(C,N) layers in single point turning of AISI 4140 steel. The experimental coatings were investigated with respect to thermal behaviour, deformation and wear. Substantial texture effects on wear performance of the á-Al2O3 layers were observed. A clearly enhanced ability of (0001) textured layer to undergo uniform plastic deformation was confirmed. The Ti(C,N) layer exhibited a more uniform plastic deformation than the á-Al2O3 layers. The observations were interpreted in the light of thermal, mechanical and frictional conditions occurring at the tool-chip contact interface.

C5 - Application in milling of coated tools with rounded cutting edges after the film deposition
K.-D. Bouzakis (1), S. Gerardis, G. Katirtzoglou, S. Makrimallakis, A. Bouzakis, R. Cremer, H.-G. Fuss
STC C, 58/1/2009, p.
Keywords:Coatings, Cutting edge roundness, Wear
Abstract: Sharp cutting edges of coated tools are often rounded to increase their stability. In the described investigations coated cutting edges of cemented carbide inserts were variously rounded by grinding. The coating thickness distributions in the transient region between tool flank and rake were determined by an appropriate evaluation of ball cratering tests using confocal microscopy. The cutting performance of the tools was examined in milling at different cutting speeds and chip lengths, which were adjusted based on FEM calculations. The results demonstrated that even cutting edges with slightly revealed substrate can effectively withstand the cutting loads.

C6 - CVD Diamond Coatings on Geometrically Complex Cutting Tools
E. Uhlmann (1)
STC C, 58/1/2009, p.
Keywords:Machining; CVD Diamond Coating; Wear Analysis
Abstract: The manufacturing of chemical vapour deposition (CVD) diamond coated shaft type cutting tools is demanding due to the complex design of the cutting edges and the cobalt

content of the cemented carbide. The influencing parameters of substrate, pre-treatment and diamond film on the tool cutting performance are discussed. The optimised manufacturing route of CVD diamond coated thread milling drills is identified with the use of material and tribological tests. Following the optimised production of the tools, the thread milling drills are then applied in the machining of AlSi17Cu4Mg, whereby the tool performance is characterised with respect to their wear behaviour, the process forces and temperatures as well as the workpiece quality.

C7 - Digital Microscope Observation of the Initial Stage of Cutting Monocrystalline Silicon
T. Inamura (2), Y. Shishikura, N. Takezawa
STC C, 58/1/2009, p.
Keywords:Simulation, Micromachining, Molecular dynamics
Abstract: Digital Microscope (DM) for local zooming of finite element solutions has been proposed and applied to cutting simulation of monocrystalline silicon with no preexisting defect. The DM has revealed that cutting performance is strongly dependent on the size of a workpiece. The DM has also revealed that a microcrack appears instantaneously for any depth of cut around a cutting edge but its evolution to a macro crack depends on the depth of cut. A critical depth of cut for macrocrack evolution can be estimated on the basis of data obtained using the DM.

C8 - Improving Surface Integrity in Orthogonal Machining of Hardened AISI 52100 Steel by Modeling White and Dark Layers Formation
D. Umbrello, L. Filice (2)
STC C, 58/1/2009, p.
Keywords:Cutting, Finite element method, Surface Integrity.
Abstract: In machining of hard parts, surface integrity is one of the most specified customer requirements. Often, the major indication of surface integrity are surface roughness and residual stresses. However, the material microstructure also changes in machined hardened steels, and it must be taken into account for improving product performance. In this paper, a hardness-based flow stress and an empirical model for describing the white and dark layers formation were developed and implemented in a FE-code. The proposed model was validated by comparing the predicted results with the experimental evidences.

C9 - A Finite Element Modeling Approach to Predicting White Layer Formation in Nickel Superalloys
S. Ranganath, C. Guo (2), P. Hegde
STC C, 58/1/2009, p.
Keywords:Machining, nickel alloy, white layer
Abstract: This paper presents a FE-based model to predicting critical parameters for the formation of white layer and bent grains in finish-machining of a nickel superalloy. A “piece-wise” Johnson-Cook model was constructed for describing the material flow behavior. Chips predicted and collected during orthogonal turning tests show clear shear banding even under low-speed. The machined surfaces contain a distorted layer with elongated grains. The ratio of edge radius to uncut chip thickness is found to be the most dominant factor in determining the amount of plastic strain in the machined surfaces, which is believed to be the cause for white layer and bent grains in low-speed machining of nickel alloys.

C10 - A Novel Hybrid Predictive Model and Validation of Unique Hook-shaped Residual Stress Profiles in Hard Turning
Y.B. Guo, S. Anurag, I.S. Jawahir (1)
STC C, 58/1/2009, p.
Keywords:Residual stress; Cutting; Ploughing
Abstract: Hard turning produces a unique hook-shaped residual stress (RS) profile characterized by surface compressive RS and subsurface maximum compressive RS. However, how and why this unique RS profile is generally produced is not well understood.

This paper presents a novel hybrid predictive model which simulates the process-induced unique RS profiles in hard turning. The key findings are: (a) Ploughed depth is a major influencing factor in producing the machining-induced RS profile; (b) A unique hook-shaped RS profile is produced when the ploughing depth reaches a threshold (critical) value; and (c) The predicted hook-shaped RS profiles are validated experimentally.

C11 - Analysis of the influence of tool type, coatings, and machinability on the thermal fields in orthogonal machining of AISI 4140 steels
P.J. Arrazola (3), I. Arriola , M.A. Davies (2),
STC C, 58/1/2009, p.
Keywords:Energy Balance, Machinability, Temperature
Abstract: Micro-thermal imaging was used to determine the amount of heat flowing into the tool, chip and workpiece during orthogonal cutting at speeds up to 400 m·min-1. Two AISI 4140 steels with different machinability ratings and three types of tools were compared: (i) uncoated with zero degree rake angle, (ii) coated with -6º rake angle and (iii) coated with chip breaker. A control volume approach was used to estimate the energy partition from thermal images and energy outflow was compared to direct measurement of the cutting power. This provides a new physical tool for examining machinability, tool-wear and subsurface damage.

C12 - Process Adapted Structure Optimization of Deep Hole Drilling Tools
D. Biermann, M. Kersting, N. Kessler / K. Weinert (1)
STC C, 58/1/2009, p.
Keywords:Deep hole drilling, Finite element method (FEM), Cutting tool development
Abstract: In order to machine boreholes having a high length-to-diameter ratio, deep hole drilling methods are applied. Especially when drilling ductile materials, the removal of cooling lubricant and chips can be hindered by long chips which block the inside of the chip mouth. In order to increase the volume flow rate of the cooling lubricant and chips, the chip-mouth cross section of a commercially available state-of-the-art BTA (Boring and Trepanning Association) boring tool was analyzed. Structure topology optimization was applied to reduce the drill head material without the drill head losing its stiffness to maximize the chip mouth cross section. Finally, new drill head design was developed and verified through experimental investigations.

C13 - Model for Surface Topography Prediction in Peripheral Milling considering Tool Vibration
M. Arizmendi, F. J. Campa, J. Fernández (3), L. N. López de Lacalle, A. Gil, E. Bilbao, F. Veiga, A. Lamikiz / L. De Chiffre (1)
STC C, 58/1/2009, p.
Keywords:Milling, surface topography, tool vibrations
Abstract: This paper presents a model for the prediction of surface topography in peripheral milling operations taking into account that the tool vibrates during the cutting process. The model includes the effect of tool vibrations in the equations of the cutting edge paths, which are transformed into equivalent polynomial equations and solved for discrete positions along the feed direction by applying a standard root finder. Through this procedure, surface topography generation is simplified with respect to other models in literature. The model allows the topography, the roughness values and the form errors of the milled surface to be predicted. Cutting test results show good agreement with model predictions.

C14 - Temperature Control and Machine Dynamics in Chip Breaking using CNC Toolpaths
S. Smith (1), B. Woody, W. Barkman, D. Tursky
STC C, 58/1/2009, p.
Keywords:Cutting, temperature, computer numerical control (CNC)
Abstract: The use of oscillating CNC toolpaths has been shown to provide a reliable chip breaking alternative to conventional methods. This paper builds on that work by assessing the effect of the oscillating toolpaths on the temperature during the cutting process. Keeping the

interface temperature below a critical threshold reduces tool wear. This is particularly useful for machining in difficult materials where tool wear is an issue, and for materials which are pyrophoric. Thermal imaging results show a reduction in temperature for oscillating toolpaths. However, the choice of cutting conditions is affected by the capability of the machine tool to achieve the commanded toolpaths.

C15 - Tool Path Optimization for Free Form Surface Machining
I. Lazoglu (2), C. Manav, Y. Murtezaoglu
STC C, 58/1/2009, p.
Keywords:Computer Aided Manufacturing (CAM), Simulation, Milling
Abstract: This article presents a novel approach to generate optimized tool paths for free form surfaces that are commonly used in automotive, aerospace, biomedical, home appliance manufacturing and die/mold industries. The developed tool path optimization approach can handle various objectives under multiple constraints. Due to anisotropic geometry of free form surfaces, tool paths become one of the most critical factors for determining cutting forces. Here, the concept of force-minimal tool path generation is introduced and demonstrated for free form surfaces. Nowadays, process planning engineers must select the tool paths only from a set of ordinary tool paths available in CAM systems. These standard tool paths available in CAM systems are generated based on geometric computations only, not considering mechanics of processes, and most often these paths are away being optimum for free form surfaces. Here, a new methodology is introduced the first time for generating the tool paths based on process mechanics for globally minimizing the cutting forces for any given free form surface.

C16 - Characterization of the Dry High Speed Drilling Process of Woven Composites Using Machinability Maps Approach
S. Rawat, H. Attia (2)
STC C, 58/1/2009, p.
Keywords:Cutting; Defect; Drilling; Machinability
Abstract: Damage to woven carbon fiber composites and high tool wear are the main challenges in drilling processes. The effect of speeds and feed rates on the damage mechanisms; namely, delamination, surface roughness, fiber pullout, thermal damage, hole circularity and hole diameter error were established using a newly introduced concept of machinability maps. Using an instrumented tool, the cutting temperature was measured. The results showed that the effect of tool wear on the quality maps can be established through the changes in the thrust and cutting forces.

C17 - Optimum process parameters to produce green ceramic complex parts
T. El-Wardany, R. Barth, J. Holowczak, W. Tredway, L.J. Chen (2)
STC C, 58/1/2009, p.
Keywords:Ceramic, milling, Finite element method (FEM)
Abstract: The fragility of green ceramic compacts introduces considerable difficulties during green or bisque machining. This paper demonstrates methods developed to manufacture thin wall–thin floor, complex green ceramic parts to close tolerance. Hybrid finite element (FE)/mechanistic models were utilized in the development of the greenmachining process. An FE model was used to define cutting edge geometry and machining parameters that would reliably produce crack free parts. Mechanistic model was used to direct cutter path generation of a 5-axismilling machine having a large axial depth of cut, and to prevent edge chipping. The optimized cutter path eliminated any need for hand work before densifying the machined part.

C18 - A New Cutting Method for Bone Based on Its Crack Propagation Characteristics
N. Sugita, T. Osa, R. Aoki, M. Mitsuishi(1)
STC C, 58/1/2009, p.
Keywords:Biomedical material cutting, Machinability, Fracture analysis

Abstract: The goal of the paper is to develop a machining process for biomaterials. Efficiency, mechanical stress, and precision are crucial parameters in the machining of living tissues, such as bone. The authors observed and analyzed the fracture of and crack propagation in bone, since crack generation cannot be avoided in bone machining, due to the brittle nature of the workpiece. A new cutting method is proposed based on the determined crack propagation characteristics. Through the use of this method, the required machining energy was decreased by utilizing the new insights concerning crack propagation and the surface roughness was improved, owing to the small finishing depth of cut.

Design

Dn1 - An integrated knowledge reference system for product development
A. Bernard (1), Y. Xu
STC Dn, 58/1/2009, p.
Keywords:Knowledge management; Evaluation; Product development
Abstract: Global product development enables companies to increase knowledge sharing. Consequently, Knowledge Management (KM) is a key issue in the improvement of the product development process. This paper aims to analyze the knowledge evolution process in product development activities and to propose an integrated knowledge reference system. Based on knowledge characterization of vector and finite state machines, knowledge maturity and knowledge value are discussed, and knowledge and the product are linked by tasks and contexts. The knowledge reference system shows a mutually benefiting relationship between knowledge and the product and is thus an effective tool for KM in product development.

Dn2 - Evolutionary Product Line Design Balancing Customer Needs and Product Commonality
S.L. Chen, R.J. Jiao, M.M. Tseng (1)
STC Dn, 58/1/2009, p.
Keywords:Design, Product, Evolution
Abstract: Product lines need to constantly evolve in response to market and technology changes. The diverging forces from marketing and engineering entail an intricate balance between satisfying changing customer needs and maintaining commonality in product platforms. This paper reports an evolutionary approach for product line design. Discrete choice analysis and product commonality indices are developed to evaluate the ‘fitness’ of a product line from marketing and engineering, respectively. Product line adaptation is formulated as a multi-objective optimization problem, whereby a solution framework based genetic algorithms is developed and implemented with a case study of notebook product line design.

Dn3 - A platform for facilitating mass collaborative product realization
M. Fathianathan, J.H. Panchal, A.Y.C. Nee (1)
STC Dn, 58/1/2009, p.
Keywords:Product Design, Distributed Design, Mass Collaboration
Abstract: In today’s networked world, a recent trend is to tap onto the vast human resource available online for performing various tasks. The resulting phenomenon is known as mass collaboration where large numbers of people collaborate to perform various tasks. The availability of human resource on the network presents opportunities to tap onto the competencies of people outside of the core team in product realization. However, new mechanisms are necessary to facilitate mass collaborative product realization. This paper proposes and evaluates a platform that provides different mechanisms for harnessing the collective intelligence of large numbers of people in product realization.

Dn4 - Focussing Product Innovation and Fostering Economies of Scale based on Adaptive Product Platforms

G. Schuh (2), M. Lenders, J. Arnoscht
STC Dn, 58/1/2009, p.
Keywords:Development, Standardization, Platform Management
Abstract: Current concepts to achieve product commonality follow static approaches. To achieve economies of scale, standards are defined across the product program. However, these standards typically need to be compromised at new product introductions due to unforeseen innovations and economies of scale decrease over time. Accordingly platform standards need to be re-defined. This paper presents an approach for adaptive product platforms. Degrees of freedom in product and process design are managed pro-actively based on functional and technological models. This way adaptivity towards product innovation can be ensured. The concept of adaptive modular platforms is explained based on a practical application.

Dn5 - Virtual Prototyping enhanced by a Haptic Interface
S. Ha, L. Kim, S. Park, C. Jun, H. Rho (1)
STC Dn, 58/1/2009, p.
Keywords:Virtual Prototyping, Haptic Interface, Design, Simulation
Abstract: In this paper, we present a haptic prototyping system using a torque-feedback dial, which allows one to estimate the haptic behaviors of the mechanical dial knob in the design process interactively. The system produces various high fidelity haptic effects based on the torque-feedback dial such as jog dial, detent, barrier, and a combination of these behaviors. It can be used to determine the most desirable knob behavior and physical properties for consumer electronics including automobile, washing machine, radio, and game controller. In addition, we have conducted experiments analyzing the haptic behavior's affect on the user's emotions and reactions.

Dn6 - A Mixed Reality Environment for Collaborative Product Design and Development
S.K. Ong (2), Y. Shen
STC Dn, 58/1/2009, p.
Keywords:augmented reality, computer aided design, modelling
Abstract: This paper presents a mixed reality (MR) environment for collaborative product design and development. This MR collaborative environment is based on a client/server architecture where multiple users can create and modify product features in a 3D physical space simultaneously. A tri-layer model representation scheme is designed to facilitate product creation and visualization. Intuitive feature manipulation methods and grid-and-snap modes have been designed to support solid modelling in the MR environment. Bi-directional communication between the MR environment and the CAD system ensures any modifications made by one user are propagated to the views of other users for maintaining design data consistency.

Dn7 - New Potentials for Virtual Product Creation by utilizing Grid Technology
R. Stark, H. Hayka, D. Langenberg / F.-L. Krause (1)
STC Dn, 58/1/2009, p.
Keywords:Product development, predictive engineering, grid technology
Abstract: Efficient virtual product creation combined with predictive engineering requires high-capacity computing and communication technologies as well as fast and transparent supply of knowledge, information and data. For this purpose, grid technologies offer great potentials for virtual product creation. One objective of grid computing is to perform more realistic simulations for better prediction of effects with reduced costs. This paper describes the approach and methods how engineering analysis problems in product development and manufacturing can be solved in the flexible context of CAE applications and grid computing infrastructure. The presented results are partly achieved in a joint project with partners from research and industry.

Dn8 - Axiomatic Functional and Object-Oriented Product Design Framework
M. C. Leu (1), J. C. Wu, X. F. Liu

STC Dn, 58/1/2009, p.
Keywords:Design, Axiomatic, Concurrent Engineering
Abstract: This paper describes an axiomatic functional and object-oriented design framework for co-design and co-analysis of product functions, physical structures, and their mapping relations. This design framework consists of Function Model, Object Model, Information Flow Model, and Axiomatic Design Model. These models are constructed level-by-level and side-by-side to form a concurrent and coordinated design paradigm. The components of the resulting design are reviewed by the design team, summarized in a task assignment table, and allocated to respective disciplinary engineers for detail design. This methodology enables mechanical, electronic, and software engineers to collaborate and develop mechatronic products in a concurrent and integrated fashion.

Dn9 - A Synthetic DNA Based Approach to Design of Adaptive Systems
Y. Jin, G.E. Zouein, S.C-Y. Lu (1)
STC Dn, 58/1/2009, p.
Keywords:Design, Synthesis, Bio-inspired Design
Abstract: Development of large engineered systems involves large amount of investments. Yet the value of these systems decreases significantly as requirements and environments change. For mission critical systems the capability of adapting to unpredictable situations is the key for success. While the importance of system adaptability has been recognized, little research has been done for “design for adaptability”. We take a “naturalistic design” approach to developing adaptive “lifelike” systems by exploiting natural “design” processes and mimicking its DNA based way of capturing, representing and applying “design” information pertaining to needed functions and changing operational situations. The concepts and examples of this approach are discussed.

Dn10 - Complexity in Design of Technical Systems
S.C-Y. Lu (1), N.P. Suh (1)
STC Dn, 58/1/2009, p.
Keywords:Design; System; Complexity
Abstract: This paper discusses the complexity of technical systems resulted from engineering design. We defined the “overall difficulty” of such a system as consisting of “inborn complication” due to customer needs and external constraints as well as “acquired complexity” associated with uncertainty in satisfying the functional requirements caused by design decisions. An ideal design should lead to the least difficult technical system by minimizing inborn complication and eliminating acquired complexity. To achieve this design ideality, strategies of using the Axiomatic Design theory and the Design-Centric Complexity theory are introduced to guide the creation and improvement of complex time-independent and time-dependent technical systems.

Dn11 - A Design Method for Systematic Safety Integration
R. Ghemraoui, L. Mathieu (1), N. Tricot
STC Dn, 58/1/2009, p.
Keywords:Design Methodology, Safety, Inherent Barriers
Abstract: In the discipline of product design, safety barriers implementation for risk reduction usually intervene in the end of the design process, in the detailed design stage, and are rapidly increasing in variety, size, complexity and sophistication. In fact, there is no formal method to set safety requirements in the early design from knowledge abstraction. This paper looks at the problem of synthesizing safety solutions in the early design process. A structured method is proposed for systematic safety requirements definition through experience feedbacks and technical solutions analysis. The application to the agricultural hitching system, the three-point hitch, is then developed. Finally, the requirements formulation and their impact on the solution are explained.

Dn12 - Three typical failure scenarios of the mind process of design from the Axiomatic Design perspective
M. Nakao (2), K. Tsuchiya, K. Iino
STC Dn, 58/1/2009, p.
Keywords:Failure, Axiomatic, Design
Abstract: Review of several failure databases from software, hardware, and service industries and analysis of the failure cases from the Axiomatic Design perspective led to identifying three typical failure scenarios of the mind process of design; uncoupled but unrealized, coupled but over-simplified, and coupled and complex designs. Failure due to coupled and complex design occurred in all databases at rates of 10 to 40%. Recent large-scale computer systems have especially expanded the number of functional requirements beyond human capability of recognizing their interference, and failure from such causes amounted to 30 to 40% of all cases of software industry.

Dn13 - Evolutionary Multi-objective Design Optimisation with Real Life Uncertainty and Constraints
R. Roy (2), Y. T. Azene, D. Farrugia, C. Onisa, J. Mehnen
STC Dn, 58/1/2009, p.
Keywords:Design, Optimisation, Uncertainty
Abstract: This paper presents the application of a robust evolutionary multi-objective evaluation technique for design optimisation in constrained problems with real life uncertainty. The design optimisation approach handles uncertainty using statistical formulations. The approach handles uncertainties associated both with design variables and design criteria. Constraints violation within the neighbourhood of a design is considered as part of a measurement for degree of feasibility and robustness of a solution. An industrial case study is presented on long product rolling system to minimise thermal effects and mechanical stress. The case study incorporates real life design variable tolerance and model sensitivity and process uncertainties.

Electro-Physical & Chemical Processes

E1 - Electrochemical superabrasive machining of a nickel-based aeroengine alloy using mounted grinding points
D.T. Curtis, S.L. Soo, D.K. Aspinwall (2), C. Sage
STC E, 58/1/2009, p.
Keywords:Hybrid machining, electro chemical machining (ECM), grinding
Abstract: Brief design and manufacture considerations are detailed for a hybrid electrochemical grinding unit adapted from a vertical machining centre using a 40,000rpm spindle and 500A DC generator. Subsequently, experimental work is presented on the influence of tool bond systems, superabrasive grit type and electrical parameters when simultaneous ECM/grinding Udimet 720 using 10-15mm diameter plain points. Single layer electroplated CBN tools produced G-ratios and maximum normal cutting forces of ~451 and ~45N respectively compared to ~128 and 557N for equivalent diamond wheels. Data on workpiece roughness and overcut are also presented as are initial results for a fir tree shaped tool.

E2 - Electrochemical micromachining of microstructures of micro hole and dimple array
D. Zhu (1), N.S. Qu, H.S. Li, Y. B. Zeng, D.L. Li, S.Q. Qian
STC E, 58/1/2009, p.
Keywords:Electro Chemical Machining (ECM), Micromachining, Microstructure
Abstract: This paper proposes a method of electrochemical micromachining of micro hole or dimple array, in which a patterned insulation plate coated with metal film as cathode is closely attached to workpiece plate. When voltage is applied across the workpiece and cathode film over which the electrolyte flows at high speed, hole or dimple array will be

produced. The proposed technology offers unique advantages such as short lead time and low cost. The effect of process parameters on the microstructure shape was demonstrated numerically and experimentally. Arrays of holes or dimples of several hundred micrometers diameter have been produced.

E3 - Micro Electrochemical Machining for Complex Internal Micro Features
C.H. Jo, B.H. Kim, C.N. Chu(2)
STC E, 58/1/2009, p.
Keywords:Electro chemical machining (ECM), Micromachining, Internal feature
Abstract: The application of micro electrochemical machining (ECM) for the micromachining of internal features is investigated. By controlling pulse conditions and machining time, micro features are machined on the side wall of a micro hole. These methods can easily machine a micro hole with larger internal diameters than the entrance diameter, which is very difficult to do by the conventional processes. A micro disk-shaped electrode with an insulating layer on its surface is also introduced to machine microgrooves inside the hole. This method is similar to the turning lathe process. The purpose of this study was to confirm the various possibilities of making complex internal structures in a micro hole by micro ECM.

E4 - Shaped tube electrochemical drilling of good quality holes
S. Ali, S. Hinduja (1), J. Atkinson, M. Pandya
STC E, 58/1/2009, p.
Keywords:ECM, deep hole drilling, STEM
Abstract: This paper is concerned with the shaped tube electrochemical drilling (STED) of small diameter cooling holes in turbine blades. Following an initial identification of the common defects occurring in STED, a partial factorial design of experiments (DOE) was carried out to identify the more important process parameters that affect hole quality. For these process parameters, a full factorial design of experiments was conducted to study their effects not only on hole diameter but also on hole taper. Guidelines and equations for determining appropriate operating conditions to drill a good quality hole are presented for one drill diameter.

E5 - Experimental study aiming to enhance the surface finish of fused deposition modeled parts
L.M. Galantucci (1), F. Lavecchia, G. Percoco
STC E, 58/1/2009, p.
Keywords:Rapid prototyping, fused deposition modelling, surface finish
Abstract: Fused deposition modeling (FDM) is an additive technology that suffers badly from low surface quality, requiring hand finishing for even the most basic levels of part quality. In this paper the authors study the influence of FDM machining parameters on acrylonitrile butadienestyrene (ABS) prototypes surface finish. The surface finish of products after the modification of extrusion parameters has been measured and processed through designed experiments. The chemical post-treatment does not require human intervention and has led to a significant improvement in surface finish at the expense of a negligible change in the prototype size.

E6 - Designing Direct Printing Process for Improved Piezoelectric Micro Devices
S.P. Bathurst, S.G. Kim (1)
STC E, 58/1/2009, p.
Keywords:Micromachining, Piezo-electric, Direct printing
Abstract: The integrated use of thin film lead zirconate titanate (PZT) for micro-scale devices and transducers has been limited due to the coupled nature and process constraints of the current manufacturing processes for PZT. Direct printing of PZT would eliminate many of these couplings and constraints by providing controllable drop-on-demand deposition. This paper presents the design interaction analysis that leads to the development of an optimized drop-on-demand deposition process as a novel manufacturing process for PZT thin films. The

uncoupled nature of this new deposition method enables the design of a new class of PZT micro-devices that has not been possible with current processing techniques.

E7 - Quantifying the degree of particle melt in Selective Laser Sintering ®
N. Hopkinson (1), C.E. Majewski (1), H. Zarringhalam (2) / T.H.C. Childs
STC E, 58/1/2009, p.
Keywords:Rapid, Selective Laser Sintering (SLS), Polymer
Abstract: This research highlights the fact that individual particles are melted to different degrees during Selective Laser Sintering ® (SLS) of Nylon 12. Many particles comprise an un-melted core, surrounded by a melted and crystallised mass that bonds with other particles. Methods to quantify the Degree of Particle Melt (DPM), including Differential Scanning Calorimetry (DSC) analysis and optical microscopy analysis, are compared against each other and against mechanical properties of parts manufactured under different conditions. The results show that the derived DPM has a close correlation with mechanical properties. This represents a new depth of understanding of the SLS process.

E8 - On the formation of laser induced self organizing nanostructures
G.R.B.E. Römer, A.J. Huis in 't Veld (3), J. Meijer (1), M.N.W. Groenendijk
STC E, 58/1/2009, p.
Keywords:Laser micro machining, Nano manufacturing, Steel
Abstract: Laser induced self organizing rippled nanostructures on steel are formed by femto-second laser pulses. They are applied as hydrophobic surfaces. A low fluence results in 'regular ripples' with a spatial repetition of 300 - 500 nm, orientated perpendicular to the laser polarization direction. In twinned areas 'pre-ripples' with much smaller wavelength (about 150 nm) are observed, with a different orientation. We found indications that the energy absorption depends on the crystal orientation and that pre-ripples are only formed at very low fluence. Pre-ripples initiate on secondary carbides or on grain boundaries. At higher energy, regular ripples initiate in areas with pre ripples; at even increasing fluence disordered structures are obtained.

E9 - Laser Droplet Generation: Application to Droplet Joining
E. Govekar (2), A. Jerič, M. Weigl, M. Schmidt (3)
STC E, 58/1/2009, p.
Keywords:Laser, Joining, Droplet
Abstract: In laser droplet joining, a drop of the desired size (and temperature is generated on demand from a metal wire and deposited on a joining spot by a laser pulse. Droplet energy and volume are used to create a material-to-material joint. In this article, the laser droplet generation process, process parameters and a system for laser droplet generation and joining are described. Applicability of the novel laser droplet joining technology is demonstrated with various examples: spot joining of thin metallized parts, spot joining of dissimilar materials and continuous droplet joining of zinc-coated steel sheets.

E10 - Computational Fluid Dyanmics Analysis of Working Fluid Flow and Debris Movement in Wire EDMed Kerf
A. Okada (2), Y. Uno, S. Onoda, S.Habib
STC E, 58/1/2009, p.
Keywords:Wire EDM, Flow, Computational fluid dynamics
Abstract: In wire EDM, better exclusion of debris from the machined kerf is very important to obtain a stable machining performance. The purpose of this study is to investigate the fluid flow in the kerf and better jet flushing conditions of working fluid from the nozzles. The flow field and the debris motion in the kerf were analyzed by computational fluid dyanamics (CFD) simulation, comparing with the observation by high-speed video camera. The influence of flow rate of working fluid from nozzles and the nozzle stand-off distance on flow field in the kerf and debris particle motion were discussed.

E11 - High Aspect Ratio Micro Hole Drilling Aided with Ultrasonic Vibration and Planetary Movement of Electrode by Micro EDM
Z.Y. Yu (2), Y. Zhang, J. Li, J. Luan, F. Zhao, D. Guo
STC E, 58/1/2009, p.
Keywords:Micromachining, EDM, High aspect ratio micro hole
Abstract: When a micro hole is drilled deeply by EDM, the viscous resistance in the narrow discharge gap causes difficulty in the removal of debris and bubbles from the working area, leading to frequent occurrences of abnormal discharges and resulting in extensive electrode wear. This paper presents a new method of drilling high aspect ratio micro holes by EDM, in which the planetary movement of an electrode, with enhancement from ultrasonic vibration, provides an unevenly distributed gap for the debris and bubbles to escape from the discharge zone easily. Micro holes with aspect ratio of 29 have been drilled.

E12 - Influence of the Pulse Shape on the EDM performance of Si3N4-TiN Ceramic Composite
K. Liu, D. Reynaerts, B. Lauwers (1)
STC E, 58/1/2009, p.
Keywords:Electrical Discharge Machining (EDM), Ceramics, Si3N4-TiN
Abstract: This paper describes the influence of the EDM discharge pulse shape on the machining performances and material removal mechanisms of Si3N4-TiN. Dramatic differences of material removal, ranging from classical melting to chemical decomposition, are observed by applying different pulse shapes such as the iso-energetic or relaxation type discharge pulses. It not just leads to the change of surface texture and machining performances, but also has influences on the ceramic properties. An EDM strategy is developed for the production of ceramic components in Si3N4-TiN and validated through the fabrication of a high temperature mesoscopic gas turbine.

E13 - Sinking EDM Simulation by Determining Discharge Locations Based on Discharge Delay Time
K. Morimoto, M. Kunieda (2)
STC E, 58/1/2009, p.
Keywords:Electrical discharge machining, Simulation, Discharge delay time
Abstract: This paper describes the development of a sinking EDM simulation method by determining discharge locations. The simulation repeats the routine modelling of the process of each discharge consisting of: determination of discharge location, removal of electrodes, generation and displacement of debris particles, and tool electrode feeding. The spot with the shortest discharge delay time calculated probabilistically assuming that an exponential distribution applies is searched for and this is determined to be the discharge location. The tool electrode feed is also determined based on discharge delay time like actual feed control. Electrode shapes and gap width distributions simulated for different working surface areas agreed with experimental results.

Forming

F1 - Investigation into a new hybrid forming process: incremental sheet forming combined with stretch forming
G. Hirt (2), B. Taleb Araghi, G.L. Manco, M. Bambach
STC F, 58/1/2009, p.
Keywords:Sheet Metal, Incremental Forming, Hybrid Incremental Sheet Forming
Abstract: Asymmetric Incremental Sheet Forming (AISF) is a process for the flexible production of sheet metal parts. In AISF, a part is obtained as the sum of localised plastic deformations induced by a simple forming tool that moves under CNC control. Three main problems exist in AISF: material thinning, geometric accuracy and the process duration. These limits restrict the range of applications of AISF. This paper focuses on a new hybrid

process, the combination of AISF and stretch-forming. First results are presented that show the positive impact of this hybrid process on the process limits.

F2 - Single Point Incremental Forming of Polymers
P.A.F. Martins, L. Kwiatkowski, V. Franzen, A.E. Tekkaya (2), M. Kleiner (1)
STC F, 58/1/2009, p.
Keywords:Incremental Forming, Polymer, Cold Forming
Abstract: The aim of the present paper is to evaluate the possibility of producing low-cost, small-batch, polymer sheet components by means of single point incremental forming (SPIF) at room temperature. During the research work, five different thermoplastic materials were incrementally formed into cones with an increasing wall angle on a conventional CNC milling machine. In designed experiments, significant process parameters were found, and influential material properties were identified. The experimental results confirm that SPIF of commercial polymer sheets at room temperature has potential for the manufacture of complex parts with very high depths.

F3 - Increasing the part accuracy in dieless robot-based incremental sheet metal forming
H. Meier, B. Buff, R. Laurischkat, V. Smukala
STC F, 58/1/2009, p.
Keywords:Incremental sheet metal forming, Robot, Accuracy
Abstract: Roboforming is a dieless, incremental, robot-based sheet metal forming process for cost-effective manufacture of prototype parts and small batch sizes. Its principle is based on flexible shaping by means of a freely programmable path-synchronous movement of two industrial robots driving workpiece-independent forming tools. The novelty of this process leads to a huge need for further research. The main task is to increase the geometrical accuracy which is primarily influenced by the compliance of the involved serial robot structures and the springback effects of the workpiece. An offline model-based and an online sensor-based strategy to increase part accuracy are presented.

F4 - Numerical and Experimental Investigation into Cold Incremental Rolling of Doubly Curved Plates for Process Design of a New LARS(Line Array Roll Set) Rolling Process
D.S. Shim, D.Y. Yang (1), K.H. Kim, M.S. Han, S.W. Chung
STC F, 58/1/2009, p.
Keywords:Incremental forming, Sheet metal, Roll
Abstract: The line array roll set (LARS) rolling process is a new incremental sheet metal rolling process for effective manufacture of doubly curved metal plates. In this study, design equations were developed to predict the curvatures of formed plate shapes with complex curvatures using the experimental data. A series of experiments with various curvatures have been performed. The comparison of the finite element computation results with the design equations has shown that the design equations can be effectively used for process design of forming processes in forming of doubly curved plates over a wide range of input curvatures.

F5 - A New Lubricant Carrier for Metal Forming
M. Arentoft (2), N. Bay (1), P.T. Tang, J.D. Jensen
STC F, 58/1/2009, p.
Keywords:Friction, Lubrication, Cold forming, Alloy plating
Abstract: A lubricant carrier for metal forming processes is developed. Surfaces with pores of micrometer size for entrapping lubricant are generated by electrochemical deposition of two, insoluble, pure metals, of which one subsequently is etched away leaving 5 µm layers with a sponge-like structure. The pores will act as lubricant reservoirs during severe forming processes. The deposited micro porous layer is evaluated by friction tests in form of ring compression tests and double cup extrusion tests. Furthermore the anti-seizure properties are investigated by single cup extrusion at high reduction and excessive stroke comparing with conventionally lubrication using phosphate coating and soap.

F6 - Evaluation of coefficients of friction in hot stamping by hot flat drawing test
A. Yanagida, A. Azushima(1)
STC F, 58/1/2009, p.
Keywords:Hot stamping; Friction; Steel
Abstract: The coefficient of friction in hot stamping was measured using a tribosimulator. Simulative experiments were carried out using SPHC steel and 22MnB5 steel under dry conditions. The coefficient of friction of 22MnB5 steel was higher than that of SPHC steel. The obtained coefficients of friction was effective for use in numerical simulations by finite element analysis. The obtained coefficients of friction under lubricated conditions for both steels were lower than those under dry conditions. It could be understood that the use of lubricants is effective for decreasing of the stamping load and die wear.

F7 - Strip-on-Cylinder Test Apparatus for Die Wear Characterization
J. Cao (2), R. Zhou, Q. Wang, Z. C. Xia / K. Weinmann (1)
STC F, 58/1/2009, p.
Keywords:Wear, Sheet metal, Strip-on-cylinder test apparatus
Abstract: This paper presents a novel strip-on-cylinder test apparatus specifically aimed at characterizing die wear in sheet metal forming. The novelty lies in the design of wear tracks and the integration of the corresponding measurement method via the white light interferometer with nano-scale accuracy. Experimental results are presented. This apparatus enables a fast and accurate evaluation of wear amount under controlled contact pressure, relative sliding speed and lubrication condition. The results can be used to establish a die wear severity index map for industrial applications and to assist in the selection of die materials or coating methods.

F8 - Modelling of the Mannesmann effect
A. Ghiotti, S. Fanini, S. Bruschi (2), P.F. Bariani (1)
STC F, 58/1/2009, p.
Keywords:Damage, Modelling, Tube Piercing
Abstract: The paper presents a new model of the Mannesmann Effect. The model is based on a novel damage law that takes into account the effects of pre-existing defects in the working material. Thanks to this feature, the model is capable of making accurate predictions of the location where the fracture will appear under the action of external loading as well as of the time it takes to be generated. An application of the model to a rotary tube piercing operation carried out at elevated temperature is presented and commented.

F9 - A New Approach to Study Material Bonding in Extrusion Porthole Dies
E. Ceretti (2), L. Fratini(2), F. Gagliardi, C. Giardini
STC F, 58/1/2009, p.
Keywords:Extrusion; Bonding; FEM
Abstract: Porthole die extrusion processes are widely spread even for most recent industrial applications. In turn knowledge base is often linked to make best expertise rather than to scientific fundaments. In the last years several FE models were developed but actual material bonding was not taken into account. In the paper a new approach is presented determining the critical value of the bonding criterion from flat rolling experiments and modelling the actual welding occurring in extrusion of complex profiles. The criterion was tested considering an industrial porthole die extrusion process and experimental parts were analysed to validate the proposed approach.

F10 - Bending–rolling combinations for strips with optimized cross-section geometries
P. Groche (2), J. Ringler, T. Abu Shreehah
STC F, 58/1/2009, p.
Keywords:Bending, Rolling, Linear bend splitting
Abstract: Sheet metal with optimized cross-sections open up new possibilities, e.g. in lightweight design by minimizing weight without reducing product’s strength or stiffness, in

heat transfer performance and in economic usage of resources. Shape rolling processes are state of-the-art for profiles with variable thickness in transverse direction. The challenge for a successful process is a homogeneous material flow in strip direction. Even if several shape rolling steps are used, geometric restrictions still exist. These restrictions can be reduced by applying a combination of bending and rolling processes. The basic principle as well as theoretical and experimental results will be discussed in this paper.

F11 - Prevention of oxidation in hot stamping of quenchable steel sheet by oxidation preventive oil
K. Mori (2), D. Ito
STC F, 58/1/2009, p.
Keywords:Hot Stamping, Sheet Metal, Quenchable Steel
Abstract: Oxidation in hot stamping of quenchable steel sheets heated in an electrical furnace was prevented by coating the sheets with an oxidation preventive oil. A solid film is generated on the surface of the sheet by drying the coated sheet, and the film changes into a liquefied film having an oxidation barrier at elevated temperatures. Hot hat-shaped bending of the coated sheet was performed to examine the properties of the products. For the bent products, the oxidation preventive oil was effective, the shape accuracy was very high and the hardness increased to a level of 1.5GPa in tensile strength.

F12 - Deformation of Oxide Scale on Steel Surface during Hot Rolling
H. Utsunomiya, S. Doi, K. Hara, T. Sakai, S. Yanagi / M. Kiuchi
STC F, 58/1/2009, p.
Keywords:Rolling, Steel, Surface, Friction
Abstract: Although oxide scale has significant influence on surface quality of hot-worked products, deformation of the scale during hot working has not been understood sufficiently. The authors propose an experimental technique to observe the scale as hot-worked using glass coating, in this study. Immediately after hot rolling at 1273K, glass powder was sprinkled over a mild steel sheet. The glass coating suppresses further oxidation and separation of the scale from the steel. Scanning electron microscopy revealed that the scale deforms uniformly if the reduction is small (r <20%). If the reduction is high (r>30%), steel is extruded through cracks in the scale to the outermost surfaces. The friction between the rolls and the sheet decreases with increasing scale thickness when the scale does not deform uniformly.

F13 - Investigation on induction heating for hot stamping of boron alloyed steels
R. Kolleck, R. Veit, M. Merklein, J. Lechler, M. Geiger (1)
STC F, 58/1/2009, p.
Keywords:Forming; Hot stamping; Heat treatment
Abstract: Within hot stamping of quenchenable steels the blank is heated up to austenitization temperature, transferred to the tool, formed rapidly and quenched in the cooled tool. Essential for the complete process is the heating of the blank which is currently carried out with roller hearth furnaces. As a consequence of rising energy costs new and more time and energy effective heating systems are needed. The paper presents investigations on induction heating as an alternative heating technology. Results concerning the process windows as well as materials characteristics and grain structure will be presented and discussed.

F14 - Sheet metal forming of piezoceramic-metal-laminar structures – simulation and experimental analysis
W.-G. Drossel (3), S. Hensel, B. Kranz, M. Nestler, A. Goeschel (3) / R. Teti (1)
STC F, 58/1/2009, p.
Keywords:Sheet metal, forming, piezoceramic-metal-laminar structures
Abstract: Adaptive systems with piezo-electric components offer significant opportunities for the active control of dynamic behaviour. Vibration and acoustics control as well as structural health monitoring are also possible. However ineffective production technologies prevent industrial applications. The authors are therefore proposing the integration of piezo-modules

inside a double-layer sheet. The use of semi-cured adhesive avoids shear-forces being transferred to the piezo-modules during forming. After forming the adhesive will cure and the transfer of piezo-electric strain to the sheet is made possible. A detailed finite-element-model incorporating the electro-mechanical characteristics of the piezo-modules has been developed. The simulation results were validated experimentally.

F15 - Autonomous on-line system for fracture identification at incremental sheet forming
A. Petek, K. Kuzman (2), B. Suhac
STC F, 58/1/2009, p.
Keywords:forming; system; fracture identification
Abstract: Before starting, the production forming processes require real experiments in order to accurately define forming limits. For this reason and because incremental sheet metal forming technology requires a relatively long production time, an autonomous on-line system for fracture identification has been developed. The system is a versatile tool for the identification of the location and time of the occurrence of the fracture, without human influences or oversight. The system is based on an investigation of the forming forces, responsive to very small variations, appearing during the forming process, and works effectively with different material types, material thicknesses and product shapes.

F16 - Closed-loop feedback control of product properties in flexible metal forming processes with mobile tools
J.M. Allwood (2), O. Music, A. Raithathna, S.R. Duncan
STC F, 58/1/2009, p.
Keywords:feedback, control, forming
Abstract: The accuracy of flexible forming processes with mobile tools is generally insufficient for industrial needs. Modern stereovision cameras should allow geometric feedback to improve accuracy, but to date it has been assumed that on-line control is in practice impossible because non-linear process models are too slow. This paper demonstrates for the first time that an appropriate process model can be formed from a set of spatial impulse responses found by linearisation around a pre-planned tool-path. This allows on-line feedback control of part geometry. A general formulation is presented, and is evaluated through application to an axisymmetric incremental sheet forming process.

Grinding

G1 - Characterization and Modelling of the Grinding Process of Metal Matrix Composites
A. Di Ilio, A. Paoletti, D. D'Addona (2)
STC G, 58/1/2009, p.
Keywords:Grinding; In-process measurement; Metal matrix composite
Abstract: In this paper, some relationships for modelling force components, cutting energy and workpiece surface roughness in grinding of metal matrix composites, are proposed. To this end, experimental data obtained from tests carried out on a horizontal surface grinder are employed. Grinding wheels based upon alumina abrasive were used and aluminium alloy samples reinforced with silicon carbide were ground. The empirical models obtained could be utilised to predict how the cutting parameters affect the grinding process and the machining quality of these non traditional materials. The influence of shape, orientation and content of the reinforcement on material grindability is taken into consideration.

G2 - Magneto-Abrasive Machining for the Mechanical Preparation of High-Speed Steel Twist Drills
B. Karpuschewski (1), O. Byelyayev, V.S. Maiboroda
STC G, 58/1/2009, p.
Keywords:Drilling, Cutting edge, Magneto-abrasive machining
Abstract: In this paper tests about the magneto-abrasive machining (MAM) influence on the

micro geometry of the tool cutting edges and the surface quality of high-speed steel (HSS) twist drills are presented. It is shown that MAM makes it possible to reproduce defined roundness of the cutting edges and corner edges of the drills and improves the tool surface quality. The optimally rounded cutting corner edge of the drill makes it possible to avoid the run-in period of the drill and increases the stability of the cutting edge substantially. This results in an improved wear behaviour and higher tool life of the drill.

G3 - Specific Energy in Grinding of Tungsten Carbides of Various Grain Sizes
Y.H. Ren, B. Zhang (2), Z.X. Zhou
STC G, 58/1/2009, p.
Keywords:Grinding; Specific Energy; Modeling
Abstract: The objective of this study is to investigate specific energy in grinding of tungsten carbides of various grain sizes. Through the construction of a mathematical model, the study demonstrates the correlation of specific energy with the grinding process parameters and the material property parameters for the tungsten carbides. The study also examines material removal mechanisms and surface finish in grinding of such materials using scanning electron microscopy, X-ray diffractometry and energy dispersive spectrometry techniques, etc. The study concludes that specific energy is related not only to grinding process parameters, but also to the physical-mechanical properties of the workpiece material.

G4 - An integrated monitoring method to supervise waterjet machining
D.A. Axinte (2), M.C. Kong
STC G, 58/1/2009, p.
Keywords:Waterjet machining, monitoring, process malfunctions
Abstract: The paper reports on development, calibration and exploitation of an integrated energy-based monitoring method for waterjet machining. The main advantage of the method resides in its ability to simultaneously monitor the level of output (at nozzle), active (cutting through) and passive (not cutting) waterjet energy thus enabling its budgeting. Relying on multiple acoustic emission sensors, the monitoring solution was implemented on the harsh waterjet environment to detect process malfunctions (e.g. jet penetration, nozzle clogging) and by adjust cutting conditions (e.g. feed speed) to result in improved accuracy and quality of machined surfaces.

G5 - Wheel Collapse in Grinding
J. Badger / J. Webster (1)
STC G, 58/1/2009, p.
Keywords:Grinding, Machinability, Roundness.
Abstract: An investigation was made into the phenomenon of wheel collapse, where power increases steadily with attritious wear until a critical value is reached, upon which power drops rapidly to a steady-state value and the wheel loses its roundness. Causes and mechanisms were investigated, along with the relationships between amount of material removed at collapse, power at collapse, post-collapse steady-state power, cooling, wheel self-sharpening, and G-ratio. Examples from laboratory tests and production tests are used. Practical recommendations are given for delaying or eliminating collapse.

G6 - Micro Grinding Tool for Manufacture of complex Structures in brittle Materials
J.C. Aurich (2), J. Engmann, G.M. Schueler, R. Haberland
STC G, 58/1/2009, p.
Keywords:Grinding, Microstructure, Micro tool
Abstract: This paper presents a novel micro shaft grinding tool with cylindrical tool tip diameter between 13 and 100 microns. The manufacturing of the tool itself is carried out on a prototype desktop machine. The shaping of the tool is accomplished by grinding the tool tip directly onto the cylindrical carbide tool shank. During tool grinding, the tool shank rotates in a micro spindle with air-lubricated bearings, leading to high concentricity and low run-out.

The tool tip is electrically nickel plated with diamond grains. During first experimental tests of the tool, very low surface roughness values and sharp edges without burrs were achieved.

G7 - Engineered Wheels for Grinding of Optical Glass
C. Heinzel , K. Rickens / H. Trumpold (1)
STC G, 58/1/2009, p.
Keywords:Grinding, Tool, Precision
Abstract: This paper focuses on the evaluation of topographical parameters characterizing the influence on the behaviour and finally the process results by applying engineered diamond wheels in machining hard and brittle materials. Here, coarse-grained, single-layered diamond grinding wheels with electroplated abrasive layers and active-brazed, defined grain pattern have been dressed by a special conditioning process and used in precision grinding experiments on optical glass. The characterization of the abrasive layer topography was done by two topographical parameters, the specific total grain plateau area A'G,total and the average grain cutting edge width bG,a, determined by 3D-profilometry of replicated abrasive layers after each dressing step.

G8 - Continuous Workpiece Speed Variation (CWSV): model based practical application to avoid chatter in grinding
D. Barrenetxea, J.I. Marquinez, I. Bediaga, L. Uriarte (3) / R.Bueno (1)
STC G, 58/1/2009, p.
Keywords:Grinding chatter, Centerless, Simulation
Abstract: The continuous variation of rotation speeds provides a means of avoiding chatter instability in different machining processes. This paper presents a time domain dynamic model that simulates chatter vibration during infeed centerless grinding for any continuously variable work rotation speed strategy. As a result of taking machine dynamics and main non-linear effects of the process into account, part roundness error is predicted for the whole grinding cycle. Lastly, experimental results have validated the model and verified that adequate speed variation strategies are capable of avoiding chatter and improving workpiece roundness and roughness, both for infeed and throughfeed centerless grinding.

Machining

M1 - Rotary-axial spindles for ultra-precision machining
X.-D. Lu, M.P. Paone, I. Usman, B. Moyls, K. Smeds, G. Rotherhofer, A.H. Slocum / W.T. Estler
STC M, 58/1/2009, p.
Keywords:Spindle, Magnetic Bearing, Precision
Abstract: By combining pressurized fluid journal bearings with a novel magnetic thrust bearing, a rotary-axial spindle design is presented to achieve both rotary motion for cutting and mm-range linear motion along the axial direction for feeding. The advantages of such rotary-axial spindles include stiffer structure loops, fewer components, higher accuracy and resolution, and less heat generation. Our first prototype has demonstrated 9000 rpm, 600 N axial load capacity, 100 N/µm dynamic stiffness, 1 mm axial stroke, and 5 nm resolution. These are significant improvements over aerostatic spindles of comparable size.

M2 - A study on the development of a multi-purpose spindle system for quality productive machining
M. Soshi, H. Ishiguro, K. Yamazaki (1)
STC M, 58/1/2009, p.
Keywords:Spindle, design, multi-purpose machining
Abstract: A compact multi-purpose spindle for multi-tasking machine tools has been developed such that it can provide high power and torque for lower speed ranges while it rotates at high speeds for light duty machining. The innovative design based on the dual direct

drive concept has been adopted such that the size of the spindle can stay the same as a conventional spindle of its class. For optimizing the design process, a method based on the complete virtual approach using 3D solid models has been studied and developed. Machining performance has been verified through a physical prototype.

M3 - Dynamic stiffness enhancement of direct-driven machine tools using sliding mode control with disturbance recovery
Y. Altintas (1), C.E. Okwudire
STC M, 58/1/2009, p.
Keywords:control; drive; linear motor
Abstract: This paper presents a disturbance adaptive discrete sliding mode controller for feed drives equipped with linear motors. The control law is expressed as a function of friction and cutting force disturbances which are estimated from the motor force and control states. The accurate prediction of disturbance forces is used to actively compensate low frequency machine tool structural modes which are within the bandwidth of the controller. The proposed control system is experimentally demonstrated on a high performance linear drive, which exhibited high bandwidth and significant increase in dynamic stiffness compared to classical cascaded control methods.

M4 - Energy optimized jerk-decoupling technology for translatory feed axes
B. Denkena (1), P. Hesse, O. Gümmer
STC M, 59/1/2009, p.
Keywords:Machine tool, Adaptronic, Jerk-decoupling
Abstract: Dynamic feed axes for machine tools are usually optimized for high jerk rates. This, however, might lead to excitations of the machine frame due to reaction forces of the linear motor. This paper describes the development of a jerk-decoupled feed axis with an innovative guidance system and energy-optimized spring-damper-elements. An accomplished system simulation is based on an energy observer applied to accomplish the energy-optimal design of an example jerk-decoupled feed axis. The simulatory results are verified at a test bed using adjustable adaptronic components. A concluding verification proves the positive effects of this technology without negative effect on the accuracy.

M5 - A Method for Direct Evaluation of the Dynamic 3D Path Accuracy of NC Machine Tools
B. Bringmann (2), P. Maglie
STC M, 58/1/2009, p.
Keywords:Dynamic, Measuring instrument, Accuracy
Abstract: Fast and high-quality machining operations require high dynamic path accuracy of the machine tool in use. Complementary to the work done on NC path planning and mechatronic simulation, in this paper a device is introduced for direct 3D measurements of dynamic path deviations at the Tool Center Point (TCP). With it, linear as well as rotary axes can be tested in one setup, thus dynamic parameters such as jerk and acceleration limits can be set homogeneously for obtaining the required dynamic path accuracy. Relevant Eigenfrequencies of the machine can be identified. Measurement method, uncertainty estimation and result evaluation are explained in this paper.

M6 - Modeling and Simulation of 5-Axis Milling Processes
E. Budak (2), E. Ozturk, L.T. Tunc
STC M, 58/1/2009, p.
Keywords:Milling, Force, Stability
Abstract: 5-axis milling is widely used in machining of complex surfaces. Part quality and productivity are extremely important due to the high cost of machine tools and parts involved. Process models can be used for the selection of proper process parameters. Although extensive research has been conducted on milling process modeling, very few are on 5-axis milling. This paper presents models for 5-axis milling process geometry, cutting force and

stability. The application of the models in selection of important parameters is also demonstrated. A practical method, developed for the extraction of cutting geometry, is used in simulation of a complete 5-axis cycle.

M7 - Analytical prediction of chatter stability in ball end milling with tool inclination
E. Shamoto (2), K. Akazawa
STC M, 58/1/2009, p.
Keywords:Chatter, Stability, End milling
Abstract: The paper presents an analytical method to predict chatter stability in ball end milling with tool inclination. The chatter stability limits in ball end milling without the tool inclination have been predicted in the previous study by deriving directional milling force coefficients and then solving a simple quadratic equation. However, the tool is generally inclined and not perpendicular to the cut surface in practice. Therefore, a new method is developed to compute the directional milling force coefficients with considering the tool inclination. It is confirmed that the chatter stability predicted by the proposed method agrees well with the experiments.

M8 - Five-Axes Accuracy Enhancement by Compact and Integral Design
C. Brecher (2), P. Utsch, C. Wenzel
STC M, 58/1/2009, p.
Keywords:Accuracy, Conceptual design, Error budget
Abstract: The increasing complexity of micro parts requires high-precise five-axes machining. Since the available systems are significantly limited in their accuracy, the Fraunhofer IPT has developed a five-axes grinding machine for achieving spatial working accuracies of 3 µm. The development focus, as described in the following, was set especially on decreasing the error activating cantilevers by simply reducing the component sizes (compact design) and implementing an integral design consequently. Due to an extensive machine error budget with sensitivity analysis, specific error influences have been identified and accuracy enhancements have been carried out, exemplarily by integrating hydrostatic bearings into a torque drive.

M9 - Fast reacting maintenance of forming tools with a transportable machining unit
H.-C. Möhring / H.K. Tönshoff (1)
STC M, 58/1/2009, p.
Keywords:Machine, Calibration, Digitising
Abstract: In sheet metal forming damages of the free formed tool surfaces occur due to wear or foreign bodies. Fast reacting maintenance is necessary to avoid bottlenecks in workpiece supply of subsequent production steps. A transportable hybrid kinematics machining unit has been developed for repair processing of metal forming tools near the production line. This paper describes strategies to improve the positioning accuracy of the machining unit and methods for optimised surface digitising with an integrated touch probe. Calibration of the hybrid kinematics is based on an enhanced kinematics model which allows the description of geometric errors, compliance and thermal effects.

M10 - A High Performance Tilting Platform Driven by Hybrid Actuator
H. Shinno (2), H. Yoshioka, M. Hayashi
STC M, 58/1/2009, p.
Keywords:Actuator, Control, Rotary motion
Abstract: Multi-axis controlled machine tools require a tilting rotary table or a tilting spindle head. In order to realize an ultraprecision multi-axis machine tool, it is an important issue to develop a high performance tilting platform. This paper presents a newly developed hybrid actuator-driven tilting platform. The hybrid actuator is constructed by integrating a pneumatic rotary actuator and a couple of voice coil motors. Performance evaluation results confirm that the platform provides high precision and high torque motions.

M11 - Numerical and Experimental Analysis of Transient State Micro-bounce of Aerostatic Guideways Caused by Small Pores
T. Aoyama (2), K. Koizumi, Y. Kakinuma, Y. Kobayashi
STC M, 58/1/2009, p.
Keywords:Bearing, Design, Vibration
Abstract: Aerostatic guideways have been applied to precision machine elements. Recently, downsizing and the increased use of high-density technology in IT devices have generated demand for higher accuracy in aerostatic guideways. It has been pointed out that the micro-bounce occurs when the slider passes over the aerostatic guideway with small pores. This transient state micro vibration decreases the accuracy of aerostatic guideways and, thus, it is now expected to be suppressed. The purpose of this study is to analyze the micro–bounce mechanism of aerostatic guideways caused by pores, and to propose new designs for the suppression of micro-bounce.

M12 - Design method for machine tools with bionic inspired kinematics
R. Neugebauer (1), W.-G. Drossel (3), S. Ihlenfeldt, C. Harzbecker (3)
STC M, 58/1/2009, p.
Keywords:Design, Kinematic, Machine
Abstract: Complete processing in one machine calls for a configuration targeting major process stability as well as a structure geared towards accuracy and dynamism. The compromise between potential dynamism and machine size can be improved by using redundant drives. The advantageous use requires the specialization on partitioning of the complete motion. With the presented algorithm the reactive sectioning of a multidimensional motion into two components with different dynamic characteristics succeeds. This provides a useful basis for the application of the principle of dynamic sectioning for a suitable design of drive redundant machine structures. This paper describes models, simulation tools and the method of the development process.

M13 - Sensorless Automated Condition Monitoring for the Control of the Predictive Maintenance of Machine Tools
A. Verl (2), U. Heisel (2), D. Maier, M. Walther
STC M, 58/1/2009, p.
Keywords:Condition Monitoring, Servosystem
Abstract: Modern manufacturing systems are characterised by numerous interacting machine tools each with sophisticated maintenance. In order to be competitive, it is possible to reduce the system downtime by applying Sensorless Automated Condition Monitoring (SACM). This paper presents newly developed and tested SACM-algorithms based only on signals which are available in position controlled drives such as position, speed and motor current. The algorithm is based on comparing current characteristic parameters with those which were taken when the machine was new.

M14 - Design Optimization and Development of CNC Lathe Headstock to Minimize Thermal Deformation
M. Mori(2), H. Mizuguchi, M. Fujishima (3), Y. Ido, N.Mingkai, K. Konishi
STC M, 58/1/2009, p.
Keywords:Thermal error, Design method, Accuracy
Abstract: This paper has investigated an approach to reduce and compensate thermal displacement for high accuracy NC lathes. An efficient design and optimization method is proposed for a headstock structure design of NC lathes to minimize the thermal displacement of the spindle center position. Compared to the existing empirical methods, this method saves development time and cost. The Taguchi method and FEA method are used to identify the optimal headstock structure. The proposed method is verified by evaluating the spindle center transition of the headstock according to the optimization results.

Production Systems and Organizations

O1 - A Unified Representation Scheme for Effective PSS Development
Y. Shimomura, T. Hara, T. Arai (1)
STC O, 58/1/2009, p.
Keywords:CAD, Simulation, Service Engineering
Abstract: A method for designing service activity and product concurrently and collaboratively is proposed. Design of services and products should be integrated in order to maximize customers' value, considering the mutual effects of synergy, alternative and complementarity. First, a fundamental unified representation scheme of human process and physical process in service activity is given. Second, the authors propose a method to evaluate these processes with Quality Function Deployment (QFD) manner, used widely in product design. In the rest of this paper, the authors describe a detailed process to represent unified of human processes and physical processes by applying the proposed method to an actual service case. As a consequence, maximization of customer value by the proposed method can be expected.

O2 - Changeability of strategic and tactical production concepts
P. Schönsleben / H.-P. Wiendahl (1)
STC O, 58/1/2009, p.
Keywords:Flexibility, Decision Making, Operations Management
Abstract: Changes in the market entail increasing flexibility requirements in product quality and delivery. As a consequence, sales, production, and supplier networks must be able to be adapted quickly. This holds for both physical and organizational structures and processes as well as their IT support (e.g., PPC software). The paper shows what networks, facility layouts, or planning & control systems are more suitable for certain requirements than for others. The differences come to light even within a company, such as when the finished product business shows different characteristics from the semi-finished product business or the spare parts business. In some cases flexibility potentials can be utilized to align resource management to different characteristics. In other cases there still are technical, methodological, and cost constraints.

O3 - A strategic framework for firm networks in the manufacturing industry: an empirical survey
E. Mazzola, M. Bruccoleri, G. Perrone (2)
STC O, 58/1/2009, p.
Keywords:Co-perative manufacturing, Management, Production
Abstract: Firm networking is becoming more and more the most important competitive strength in nowadays competitive environment. Such an evidence is partially neglected by the classical strategic analysis of firms competitiveness which mainly looks at the firm strength and weakness not in relationship with its capacity to build competitive networks. For such a reason, in the last years, many theoretical approaches have stressed the importance of networks to gain competitive advantage. In this paper the most significant theories on firm networking are reviewed and an innovative strategic framework that mainly underlies at firm networks organization proposed. Very briefly, it is argued that networks are differently organized according to three basic strategic objectives: to gain efficiency; to collect knowledge; to pursue globalization. The proposed framework has been tested within the manufacturing industry through an empirical survey conducted on 93 case studies.

O4 - Designing the reverse network for WEEE in Denmark
M. Grunow, C. Gobbi / L. Alting (1)
STC O, 58/1/2009, p.
Keywords:Reverse; logistics; optimization
Abstract: In the challenging implementation of the European Directive on Waste of Electrical

and Electronic Equipment (WEEE), the different fractions of waste at the individual collection stations must be assigned to the collective schemes which perform the waste treatment for the producers of the products. An approach is developed which provides an assignment which is efficient and fair for all the involved actors, e.g. the producers, the municipalities, and the collective schemes. We present an optimization-based decision support tool, which was developed for the coordinating government institution in Denmark, and numerical results for the current configuration.

O5 - Autonomously controlled production systems—Influence of autonomous control level on logistic performance
B. Scholz-Reiter (2), M. Görges, T. Philipp
STC O, 58/1/2009, p.
Keywords:Production, Control, Autonomy
Abstract: Autonomous control intends to improve production systems performance by distributed and flexible coping of complexity. Different autonomous control levels and control strategies are evaluated. The evaluation system benchmarks the level of logistic target achievement related to the level of complexity and the level of autonomous control. Based on real production data, simulation models were built. The level of autonomous control in these models is increased stepwise by expanding the number of autonomously controlled elements. For each level of autonomous control, three control strategies are implemented and compared to the performance of conventional control.

O6 - Maintaining Constant WIP-Regulation Dynamics In Production Networks with Autonomous Work Systems
N.A. Duffie (1), L. Shi
STC O, 58/1/2009, p.
Keywords:Production, Control, Analysis
Abstract: In this paper, a method is presented for information sharing in production networks with large numbers of autonomous work systems for the purpose of maintaining constant dynamic properties when the structure of physical order flows between the work systems is omni-directional and variable. It is shown that information sharing is necessary if undesirable behaviors such as oscillation or slow response are to be avoided. A method for designing the dynamic properties of such networks is presented along with a method for distributed computation and communication of information needed to locally compensate for the expected order flows from other work systems.

O7 - Manufacturing Capacity Planning Strategies
O. Ceryan, Y. Koren (1)
STC O, 58/1/2009, p.
Keywords:Optimization, Decision Making, Reconfiguration
Abstract: When planning for a new manufacturing system to produce several products over a planning horizon, firms usually face an important decision regarding how to select the optimal quantity and portfolio of product-dedicated and flexible capacities. Flexible systems may alleviate the unfavorable effects of demand uncertainties, however they require higher investment costs compared to dedicated systems. In this paper, we formulate the optimal capacity selection problem and perform numerical studies to provide insights on how these decisions are affected by the investment costs, product revenues, demand forecast scenarios and volatilities over the planning period.

O8 - Progressive Modelling - An Enabler of Dynamic Changes in Production Planning
M. Ismail, H. ElMaraghy (1)
STC O, 58/1/2009, p.
Keywords:Production; Planning; Optimization
Abstract: The prevalence of change propagating from the market conditions to the lowest level of functional activities of Manufacturing Planning and Control (MPC) systems, and vice

versa, urges a commensurate supportive modeling approach. Progressive Modeling – a novel and integrated problem solution approach – is introduced to handle the new challenges resulting from the dynamic nature of today's manufacturing environment. It analyzes and decomposes the problem into several interacting components, builds a change-ready mathematical model and optimizes its solution. Aggregate production planning problem with a numerical example is used for demonstration and illustration.

O9 - Producer Decision-making in Markets with Network Externalities
K. Ueda (1), N. Nishino, T. Takenaka
STC O, 58/1/2009, p.
Keywords:Decision making, Agent simulation, Network externality
Abstract: Markets with network externalities, by which more users make a product more valuable, such as mobile telephone and internet service markets, have been growing rapidly. In such markets, the value of products is created through dynamic interaction among consumers and producers. This paper presents analyses of the mechanisms of their interaction in a market with network externalities, particularly addressing producers' decision-making. A simple decision-making model is constructed and examined using multi-agent simulation, game theoretic analysis, and experiments using human subjects. Results show that incomplete information among consumers might encourage new product market growth. Additionally, we discuss producer strategies for a product introduction plan, comparing results with real world data.

O10 - Increased transparency within and beyond organizational borders by novel identifier-based services for enterprises of different size
L. Monostori (1), E. Ilie-Zudor, Zs. Kemény, M. Szathmári, D. Karnok
STC O, 58/1/2009, p.
Keywords:Production; Information; Auto identification
Abstract: Recent trends in production call for efficient means of tracking and tracing within and beyond company borders. The pioneering track-and-trace solutions introduced by large companies can, due to their expenses as well as their lack of flexibility, hardly be the preferred choice for networks of smaller enterprises, and the mainstream of today's new off-the-shelf business integration platforms is not targeting the small business sector either. The paper highlights the key problems to be overcome for the successful introduction of lean but extensible entry-level track-and-trace solutions and presents the concept and first pilot application results of the ongoing, EU-funded R&D project TraSer.

O11 - Machine Tool Capability Profile for Intelligent Process Planning
S.T. Newman, A. Nassehi / A.N. Bramley (1)
STC O, 58/1/2009, p.
Keywords:CAPP; CAM; Resource Modeling
Abstract: An optimized metal cutting process plan can only be developed with an accurate capability profile of a machine tool. Based on the information within this profile, a manufacturing decision making process can ascertain the time and production cost of parts. In this paper, a standardized methodology for modelling manufacturing resources is realized to enable accurate representation of actual resources and custom constraints. An example case study demonstrates the application of the machine tool capability profile through the selection of available cutting tools rather than using nominal cutting tools.

O12 - The machine tool model - a core part of the digital factory
T. Kjellberg (1), A. von Euler-Chelpin, M. Hedlind, M. Lundgren, G. Sivard, D. Chen
STC O, 58/1/2009, p.
Keywords:machine tool, model, ontology
Abstract: Machine tool models – the core parts of manufacturing systems – are important for many purposes during development of new or existing systems, from investment, through process planning, NC, layout design, usage, to end of life. Today a lot of important machine

tool information is not managed and stored for easy reuse. A machine tool modelling approach is presented and structured in line with principles for generic standards utilizing a manufacturing system ontology for modelling machine tool concepts. It forms a contribution to management of information and knowledge in manufacturing.

O13 - Optimization of preventive maintenance and spare part provision for machine tools based on variable operational conditions
G. Lanza, S. Niggeschmidt, P. Werner / H. Weule (1)
STC O, 58/1/2009, p.
Keywords:Maintenance; Reliability; Spare parts management
Abstract: The reliability of machine components depends on their operational conditions. In order to maximize this reliability, the preventive maintenance intervals and the provision of spare parts have to be adapted to the individual load collectives. Up to now, there has been for different machine components no comprehensive approach to quantify the effect of load collectives and to adapt the respective actions accordingly. This paper presents a method which calculates the optimal time for preventive maintenance and spare part provision by a stochastic optimization algorithm based on a load-dependent reliability model.

O14 - Holonic Quality Control Strategy for the Process Chain of Bearing Rings
G. Goch (1), M. Dijkman
STC O, 58/1/2009, p.
Keywords:Quality, Production, Control
Abstract: In a process chain, workpiece quality features may be affected by several sub-processes. Hence, an optimisation of quality features throughout the process chain requires a process-wide approach, which also adapts the flexibility concerning the arrangement of the sub-processes. This paper presents a holonic control strategy for a process-wide optimisation of selected workpiece quality features. In particular, the modelling and optimisation procedure are designed such that a rearrangement or extension of the process chain involves no intervention in the control strategy. The approach is demonstrated along the production of bearing rings, regarding especially geometric quality features affected by distortion phenomena.

O15 - Modelling the complexity of manufacturing systems using nonlinear dynamics approaches
N. Papakostas, K. Efthymiou, D. Mourtzis (2), G. Chryssolouris (1)
STC O, 58/1/2009, p.
Keywords:Modelling, Stability, Scheduling
Abstract: This paper investigates the complexity and the stability of manufacturing systems, introducing concepts based on discrete event simulation and nonlinear dynamics theory. A set of manufacturing models, characterized by different production configurations and part routings, are simulated and evaluated through a series of experiments, employing diverse workload patterns. The results are used for, a) determining the sensitivity of a manufacturing system to workload changes, b) measuring the complexity of a manufacturing system and c) discussing measures to control the complexity of a manufacturing system based on the proposed simulation-based approach

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O16 - Managing Variations in Products, Processes and Manufacturing Systems
H. ElMaraghy (1), A. Azab, G. Schuh (2), C. Pulz
STC O, 58/1/2009, p.
Keywords:Design, Process, Variation
Abstract: Manufacturers seek customers' satisfaction by increasing products variety and customization while striving for agility and productivity. Large variations in products scope and production scale are evident. A hierarchy of parts/products variants is introduced to illustrate the propagation of variations. A unified approach that links products design to manufacturing processes, through variation-oriented data structures and planning

methodologies, and capitalizes on commonalities, is presented. The use of variation assessment metrics is demonstrated. Methods for manufacturing systems design for variation are discussed. Lot-size capping is introduced to manage variations in batch sizes and product mix. A gearbox case study is used for illustration.

Precision Engineering & Metrology

P1 - Uncertainty of reference frames characterized by real time optical measurements:
J.M. Linares, J.M. Sprauel, P. Bourdet
STC P, 58/1/2009, p.
Keywords:Uncertainty, Geometric Modelling, Computer Assisted Orthopaedic Surgery (CAOS).
Abstract: In total knee arthroplasty, real time optical measurements are now carried out to improve the implantation of prostheses. The final alignment of prostheses is however influenced by the choice of points probed by the surgeon, and by the measurement accuracy. A Monte Carlo method has been developed, to simulate a whole set of measurements. To estimate the uncertainties of the resultant angles between the two parts of the knee prosthesis, this data has then been treated with the algorithms implemented in Computer Assisted Orthopae-dic Surgery programs. Such results were also obtained through uncertainty propagations based on the GUM.

P2 - Precision and fast measurement of 3D cutting edge profiles of single point diamond micro-tools
W. Gao (2), T. Asai, Y. Arai
STC P, 58/1/2009, p.
Keywords: Metrology, Alignment, Tool
Abstract: A measuring instrument, which consists of an atomic force microscope (AFM) and an optical alignment probe, is designed and constructed for precision and fast measurement of 3D cutting edge profiles of single point diamond micro-tools. A focused laser beam is employed as a reference for automatic and fast alignment of the AFM cantilever tip with the micro-tool cutting edge. Experiments are carried out to demonstrate the ability of the instrument for alignment and measurement of a round-nose micro-tool with a nominal nose radius of 1.5 μm. The cutting edge sharpness, nose radius and edge contour out-of roundness of the micro-tool are evaluated.

P3 - Fabrication and Configuration of Carbon Nanotube Probes in Atomic Force Microscopy
F.Z. Fang (2), Z.W. Xu G.X. Zhang (1), X.T. Hu
STC P, 58/1/2009, p.
Keywords:Atomic force microscopy (AFM), Nanotube, Focused ion beam (FIB)
Abstract: A novel method of producing carbon nanotube (CNT) probes using electron beam induced Pt deposition is proposed for application in atomic force microscopy (AFM). Focused ion beam milling and irradiation processes are utilized to precisely control the nanotube probe's length and orientation. It is confirmed that the stiffness of nanotube probe would not degrade AFM image resolution if its lateral force constant is larger than 0.086 N/m. The nanotube probe can detect an edge with 88 degrees vertical angle. It is found that the nanotube probes with fullerene-like cap end present higher imaging resolution than those with an open end.

P4 - Low-cost interferometric compensation of geometrical errors
A. Balsamo (1), P. Pedone, E. Ricci, M. Verdi
STC P, 58/1/2009, p.
Keywords:Coordinate Measuring Machine (CMM), Geometry Error compensation, Interferometry
Abstract: Numerous interferometric techniques to compensate machine geometrical errors

have been presented and successfully applied. However, the issue of equipment and labour costs still remains. This project aims at cutting such costs while keeping good metrology. The basic idea of the proposed technique is the interferometric measurement of independent lines: unlike laser trackers and tracers, which measure while pointing, with this technique only straight line interferometric measurements are carried out, omitting the need for high accuracy pointing and for a very isotropic target retroreflector. Thorough simulation shows that a well designed experimental plan is key to success.

P5 - Uncertainty determination for CMMs by Monte Carlo simulation integrating feature form deviations

J-P. Kruth (1), N. Van Gestel, P. Bleys, F. Welkenhuyzen

STC P, 58/1/2009, p.
Keywords:Coordinate measuring machine (CMM), Measurement, Uncertainty, Form deviation

Abstract: Reliable quality control is impossible without specification of the measurement uncertainty. For Coordinate Measuring Machines (CMMs), Monte Carlo uncertainty evaluation allows to integrate the many task specific uncertainty influences. Incorporating the influence of feature form deviations in such simulations is difficult. This paper shows that limited sampling in combination with feature form deviations is often the most important uncertainty contributor for CMM measurements. A method that determines uncertainties for feature measurements on CMMs is proposed. The influence of feature form deviations is taken into account. The method is integrated in CMM software. The results are validated on actual workpieces.

P6 - Applications of Dimensional Micro Metrology to the Product and Process Quality Control in Manufacturing of Precision Polymer Micro Components

G. Tosello, H.N. Hansen (1), S. Gasparin

STC P, 58/1/2009, p.
Keywords:metrology, uncertainty, micro manufacturing

Abstract: Precision manufacturing of micro injection moulded (µIM) components presents challenges in terms of quality control due to the miniaturization of product dimensions and tolerances. This paper addresses product compliance with specifications, focusing on tolerances of dimensions and position on µIM components selected from industrial production. Two systems were analysed: a tactile coordinate measuring machine (CMM) with sub-micrometer uncertainty and an optical CMM allowing fast measurements suitable for in-line quality control. Product quality control capability, measuring uncertainty and calibration guidelines are discussed for both systems. Finally, a new approach for the manufacturing of hybrid micro polymer-metal calibrated objects is proposed.

P7 - Vibration-desensitized fiber-diffraction interferometer for industrial surface measurements

J. Park, J. You, S.-W. Kim (2)

STC P, 58/1/2009, p.
Keywords:Optical, Measurement, Vibration

Abstract: We describe an industrial interferometer designed to conduct high-precision surface measurements in the presence of severe vibration. The principle of common-path interferometry is realized by devising a single-mode fiber waveguide that generates the reference wave directly from the measurement wave, enabling removal of the temporal wavefront fluctuation caused by vibration. In addition, a continuous-scanning phase-measuring method is adopted to isolate spurious vibration residuals in interferometric fringes captured using a high-speed digital camera. Experimental tests prove that the proposed interferometer is suited for in-line measurements of large mirrors, silicon wafers, and flat display panels with no excessive ground isolation for anti-vibration.

P8 - On-the-fly calibration of linear and rotary axes of machine tools and CMMs using a tracking interferometer
H. Schwenke (2), R. Schmitt, P. Jatzkowski, C. Warmann
STC P, 58/1/2009, p.
Keywords:Compensation, Accuracy, Machine Tools
Abstract: Abstract Lasertracer technology has been introduced successfully in industry for complete geometry calibration of three-axis ma-chines. Currently, however, applications are limited to linear axes and data acquisition is performed statically with the machine at a standstill. Recent research has extended use of the Lasertracer to measurements during continuous operation of the machine (on-the-fly): Measuring time is shortened and the number of sampling points is increased drastically. Another application is the calibration of rotary axes: Using the same hardware and mathematical principles, it is possible to calibrate rotary axes in 6 degrees of freedom. The paper describes measurement set-ups, presents experimental data and compares the data with results from static measurements.

P9 - Position and contour detection of spatially curved profiles on the basis of a component-specific scale
J. Fleischer (2), C. Munzinger, G. Lanza, D. Ruch
STC P, 58/1/2009, p.
Keywords:Quality Assurance, Positioning, Measurement
Abstract: Flexible and automated small-batch production requires a high degree of facility adaptability for the product to be manufactured. Here spatially curved profiles pose a particular challenge in terms of the exact positioning and the assurance of component quality during the machining process. This paper describes the concept and implementation of a metrological approach to the positioning of spatially curved tube profiles for profile machining. Single laser markings put on the component surface are combined into a component-specific scale. The design of the markings is derived systematically considering the boundary conditions. The component-specific scale also constitutes the basis for an incremental identification of the profile contour, allowing for flexible inline quality assurance for almost any type of curved profile contours. Profile geometries can be described regardless of contours by means of cubic spline interpolation.

Surfaces

S1 - Chemical and Mechanical Balance in Polishing of Electronic Materials for Defect-Free Surfaces
H.S. Lee, H.D. Jeong (2)
STC S, 58/1/2009, p.
Keywords:Polishing, Mechanism, Chemical Mechanical Polishing (CMP), Electronic material
Abstract: Chemical mechanical polishing (CMP) technology is faced with the challenge of processing new electronic materials. This paper focuses on the balance between chemical and mechanical reactions in the CMP process that is required to cope with a variety of electronic materials. The material properties were classified into the following categories: easy to abrade (ETA), difficult to abrade (DTA), easy to react (ETR) and difficult to react (DTR). The chemical and mechanical balance for the representative ETA-ETR, DTA-ETR, ETA-DTR and DTA-DTR materials was considered for defect-free surfaces. This paper suggests the suitable polishing methods and examples for each electronic material.

S2 - Mechanisms in Polishing of Silicon Based Advanced Ceramics
F. Klocke (1), R. Zunke
STC S, 58/1/2009, p.
Keywords:Polishing; Ceramic; Mechanism
Abstract: Advanced ceramics with high surface quality and integrity are of increased interest in mould and die making and optics. The demanded qualities are widely ensured by polish-

ing. However, due to the great variety of parameters and interactions the removal mechanisms are still not fully understood. Therefore, polishing processes of silicon based advanced ceramics are investigated. It is shown that depending on the slurry the material removal mechanisms differ. Observed effects can be explained by dominating mechanical or chemo-mechanical removal. This is discussed based on the phenome-nological analysis of experimental results using advanced metrology (AFM, SEM, TEM).

S3 - Performance of Water-soluble Fullerenol as Novel Functional Molecular Abrasive Grain for Polishing Nanosurfaces
Y. Takaya (2), H. Tachika, T. Hayashi, K. Kokubo, K. Suzuki
STC S, 58/1/2009, p.
Keywords:Surface, Polishing, Fullerenol molecular abrasives
Abstract: We propose a novel chemical-mechanical polishing (CMP) technique for use as the planarization method in the Cu damascene process for the fabrication of next-generation semiconductors. Water-soluble fullerenol, which has attractive features such as a 1-nm grain size, high water dispersibility in a molecular level and metal free, is used in this technique. Chemical process analysis reveals the chemical and mechanical functions of water-soluble fullerenol molecules as abrasive grains. Experimental results show that Cu-surface roughness was improved from 20 to 0.6 nm RMS by using C60(OH)36 fullerenols as functional molecular abrasive grains to achieve better polishing performance than conventional processes.

S4 - Electrochemical Dissolution of Biomedical Grade Ti6Al4V: Influence of Stress and Environment
A. Chandra (2), J.J. Ryu, P. Karra, P. Shrotriya, T. Weik
STC S, 59/1/2009, p.
Keywords:Surface, stress, Electrochemical dissolution
Abstract: Stress dependent electrochemical dissolution is identified as one of the key mechanisms governing surface degradation in fretting and crevice corrosion of biomedical implants. In the current study, material removal on a stressed surface of Ti6Al4V subjected to single asperity contact is investigated to identify the influence of contact load, in-plane stress and environment on wear damage. A range of known stress levels are applied to the specimen while its surface is mechanically stimulated in different non-reactive to oxidizing aqueous environments. Evolution of surface degradation is monitored, and its mechanism is elucidated. Implications to life prediction of orthopedic implants are discussed.

S5 - Surface Generation of Superior Hydrophilicity for Surgical Steels by Specific Grinding Parameters
H. Ohmori (2), K. Katahira, J. Komotori, Y. Akahane, M. Mizutani, T. Naruse
STC S, 58/1/2009, p.
Keywords:Grinding, Biomedical, Electrolytic in-process dressing (ELID)
Abstract: In the present study, electrolytic in-process dressing grinding was performed on surgical steels (type 420J2 stainless steel) and the processing characteristics and resulting surface properties were evaluated. In particular, we used different grinding abrasives to investigate the effect of grinding parameters on the surface hydrophilicity of the processed workpieces. The results confirmed that surfaces processed with alumina abrasives in a grinding fluid at temperatures over 50ºC have the highest hydrophilicities. Furthermore, they also exhibit excellent corrosion resistance.

S6 - Prediction of shape deviations in machining
E. Brinksmeier (1), J. Sölter
STC S, 58/1/2009, p.
Keywords:Machining; Residual stress; Shape deviation
Abstract: During machining the workpiece surface layer is plastically deformed and acts as a source of residual stress for the entire cross section of the workpiece and as a consequence

shape deviations occur. In this paper a new method to predict the shape deviation of machined workpieces with complex geometry is proposed. It combines experimental results of machining workpieces with simple geometries with finite element simulations. This is achieved by making use of the known source stresses in simple parts. The new approach is validated and applied to predict the shape deviation of a ground linear rail guide.

S7 - Application of strength properties determined by nanoindentations to describe the material response in micro- and macro-indentation
N. Michailidis (2), M. Pappa
STC S, 58/1/2009, p.
Keywords:FEM simulation, Hardness, Nanoindentation
Abstract: The application of materials' strength properties determined by nanoindentations to describe analytically micro- and macro-scale procedures such as Vickers, Rockwell and ball indentation is investigated. Various materials were tested by nanoindentations and their stress-strain curves and hardness were determined by appropriate evaluation of the related measurements' results via FEM-based algorithms. Based on these properties, the contact geometry between the indenter and the specimen during micro- and macro-indentations, as well as the remaining impression dimensions after unloading were defined via FEM-supported calculations. The correlation between experimental and computational results concerning the hardness values and impression data was satisfactory.

S8 - Pneumatic Non-Contact Roughness Assessment of Moving Surfaces
D. Grandy, P. Koshy (2), F. Klocke (1)
STC S, 58/1/2009, p.
Keywords:metrology, surface, monitoring
Abstract: Conventional pneumatic gauging technology is adapted for non-contact roughness estimation by relating the frequency content of the back-pressure signal to the microgeometry of the surface moving lateral to the nozzle. The technique is shown to be capable of rapid areal characterization of surfaces with roughness down to 0.8 micrometer Ra, and at speeds as high as 200 m/min. In light of the air jet being inherently impervious to the obscuring influence of machining debris and cutting fluid, the significant potential of the system for in-situ application in a machine tool environment is demonstrated.