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Intl trade fair for machinery, equipment, materials and services for the manufacturing industry
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Saint Petersburg, Russian Federation
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CAASTING & FOUNDRY PRACTICE

110275 Alternative approach in ceramic shell investment casting of AZ91D magnesium alloy: In situ melting technique
Jafari, Hassan; Idris, Mohd Hasbullah; Oруддini, Ali [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 988, Pages 10] In this research, the possibility of ceramic shell investment casting of a magnesium alloy using in situ melting technique was explored. AZ91D granules were charged into shell investment mould and in situ melted under various processing parameters including heating temperature, flux application, shell mould thickness and permeability. Scanning electron microscopy, energy dispersive X-ray spectroscopy and X-ray diffraction techniques were used to characterise the cast samples. Thermal analysis was employed to further investigate the effect of mould thickness on the solidification behaviour of the metal. It was found that mixing flux with the granules not only reduced the temperature at which melting can be achieved, but it also contributed to produce castings with acceptable surface quality. The use of thinner mould provided higher solidification rate, which is believed to favour in situ melting of the granules. It enabled melting of the granules at 650 °C, which in turn helped to suppress the mould–metal reaction and produce castings with good surface quality. Shell mould permeability showed no influence on suppressing the mould–metal reaction at 650 °C. (24 refs, 13 figs, 2 tables) (AA)

110276 Top side-pouring twin-roll caster for metals strips
Wang, De; Zhou, Cheng [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 916, Pages 9] Three different metals (lead, Al–10(w%) Cu alloy and AA1050) were cast into 100 mm-wide, 2mm-thick strips. Combined with both experimental and numerical results, the surface conditions and microstructure of the strips were investigated to reveal the formation of the melt-pool and its effects on the strips. The results show that, the top side-pouring twin roll casting has ability to apply to the production of different metal strips with various “production windows”. Rolling effect was observed on the strips of Lead and AA1050, and the grains were deformed, while strips of Al–10(w%) Cu alloy were mostly pressed together, with equiaxed crystalline in the microstructure. The steady state can be established easily and quickly, and the higher the melt-pool, the better the strip surface conditions. (16 refs, 11 figs, 3 tables) (AA)

COATING & FINISHING

110277 Microstructure and properties of laser cladding FeCrBSi composite powder coatings with higher Cr content
Wang, Yibo; Zhao, Shusen; Gao, Wenyan; Zhou, Chunyang; Liu, Falan; Lin, Xuechun [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 899, Pages 7] FeCrBSi alloy powder with higher Cr content was used for laser cladding by employing a 3 kW solid-state laser. Ni- and Fe-based alloy powders, which were more resistant to cracking, were added into FeCrBSi alloy powder with higher Cr content to increase the ductile phases, lower thermal expansion coefficient, and reduce the crack sensitivity of the cladding layer. FeCrBSi alloy powder with higher Cr content combined Ni- and Fe-based alloy powder were cladded on the substrates, which yield two different phases. The hard phases of the cladding layer were mainly composed of carbide phase M23C6, and the ductile phases which played a lubrication function in the cladding layer were mainly composed of austenite γ-Fe and γ-Ni. The ductile phases increased by adding Ni- and Fe-based alloy powder into FeCrBSi alloy powder with higher Cr content, and the hard phases become sparser relatively. Smooth cladding layers, which were free of macroscopic pores, cracks and void between the adjacent tracks, were achieved. Therefore, the toughness of the cladding layer was improved, and the crack tendency was reduced. Three kinds of composite powder were obtained. The composition and morphology of the cladding layer were analyzed, and the microhardness between the hard phases and the ductile phases was compared. The average microhardnesses of the three cladding layers varied from HV0.2 760 to HV0.2 950. (15 refs, 15 figs, 2 tables) (AA)

110278 Vibration-assisted dry polishing of fused silica using a fixed-abrasive polisher
Li, Yaguo; Wu, Yongbo; Zhou, Libo; Fujimoto, Masakazu [Int J of Machine Tools & Manufacture,
Glass is a ubiquitous but essential material in everyday life and industry. The most common method for polishing glass involves the use of free abrasives. However, this method is basically non-deterministic and lacks efficiency. Therefore, vibration has been employed to aid fixed-abrasive polishing in our research. It is found that the vibration can increase the material removal rate while maintain surface quality in fixed abrasive polishing. Normalized Preston coefficients that are the index of the polishing capability of a certain polishing process considerably increase in vibration-assisted polishing process. A mathematic model is set up to interpret the increase in material removal rate for vibration process. The modeled results show that the vibration can improve material removal by increasing vibration amplitude in vertical direction while the horizontal vibration contributes little to increasing material removal rate, which agrees well with experimental results. Aside from material removal, surface morphology of polished glass was also modeled for both vibration and conventional processes. Both experimented and simulated morphology evidence that the vibration some periodic structure on polished surface. The possible mechanism in dry fixed abrasive polishing was also chemically analyzed and a probable mechanism is put forward to clarify the material removal in dry fixed abrasive polishing. (30 refs, 14 figs, 4 tables) (AA)

**ELECTRICALS & ELECTRONICS**

**110279 Characterization of electrically-assisted micro-rolling for surface texturing using embedded sensor**
Ng, Man-Kwan; Fan, Zhaoyan; Gao, Robert X; SmithII, Edward F; Cao, Jian [CIRP Annals, v 63, n 1, 2014, Starting Page 269, Pages 4] Electrically-assisted micro-rolling (EAmR) takes advantage of localized heating by loading current through the deformation zone to enhance the texturing capability of Ti-6Al-4V and AA3003-H14. The challenge to achieve a desired deformation pattern is the lack of reliable models to capture the often non-uniform mechanical and thermal behaviors. In this paper, pressure distributions are measured by a custom-designed, tool-embedded sensor. Further more, the effects of current on texturing are first characterized using a coupled mechanical and thermal model. Comparison between modeling and experimental results confirmed the effectiveness of EAmR on texturing and the importance of multi-physics modeling.

**110280 Numerical modelling of electrohydraulic free-forming and die-forming of DP590 steel**
Hassannejadasl, Amir; Green, Daniel E; Golovashchenko, Sergey F; Samei, Javad; Maris, Chris [J of Manufacturing Processes, v 16, n 3, Aug 2014, Starting Page 391, Pages 14] Electrohydraulic forming (EHF) is a high energy rate forming process in which the strain rate in the sheet metal can vary from 5 x 102 to 105 s−1 depending on various factors. Several mechanisms have been reported to cause an improvement in formability in EHF such as material deformation mechanisms, inertial effects and the dynamic impact of the sheet against the die. EHF is a complex high speed forming process and experimental work alone is not sufficient to properly understand this process. To understand the variation of some influential variables in EHF, electrohydraulic die-forming (EHDF) and free-forming (EHFF) of DP590 dual phase steel were simulated in ABAQUS/Explicit by considering the fluid/structure interactions. Three-dimensional finite element simulations were conducted by modelling the water with Eulerian elements with a view to investigating the effect of released energy on the sheet deformation profile history, strain distribution, loading path and damage accumulation type. The Johnson–Cook constitutive material model was used to predict the sheet behaviour and the parameters in this model were calibrated based on experimental test results available for DP590 at various strain rates. The Johnson–Cook phenomenological damage model was also used to predict the ductile failure (damage accumulation) in both EHDF and EHFF. Predicted final strain values and damage accumulation type showed good agreement with the experimental observations. (49 refs, 20 figs, 6 tables) (AA)

**110281 Twisting analysis of ultra-thin metallic sheets**
Pham, CH; Thuillier, S; Manach, PY [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 844, Pages 12] Twisting is one of the deformation mode occurring after springback and characterized by a torsion of a part around the axis aligned with its highest dimension. This phenomenon is experimentally difficult to highlight, because its occurrence has been evidenced in the case of elongated parts, when one of the part dimensions is much higher than
the others, usually of the order of the meter. This leads to complex set-ups and often to scattered experimental results. The aim of this work is to investigate the influence of the blank alignment relative to the tools on twisting magnitude, in order to build a reliable database useful for finite element validation. Firstly, a dedicated device was designed to draw U-shaped rails of length 100 mm, made of ultra-thin metallic sheets, in order to deal with small-size parts. Experiments were carried out for two configurations, one with the sample aligned with the tools and another one with the sample intentionally slightly misaligned with regard to the tools. Accuracy of the measurements is analyzed and reproducibility of the intensity of twisting for both configurations is presented, as well as the relationships between springback of the sections, like opening of the U-shaped rail, and twisting. Parameters influencing the occurrence of twisting are discussed. (23 refs, 17 figs, 3 tables) (AA)

110282 Vaporizing foil actuator used for impulse forming and embossing of titanium and aluminum alloys
Vivek, A; Brune, RC; Hansen, SR; Daehn, GS [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 865, Pages 11] Electrically driven rapid vaporization of thin conductors is known to produce short-duration pressure pulses of high magnitude. This impulse can be used for applications such as high strain rate forming, shearing, collision welding, and springback calibration. Mechanical impulse was developed from aluminum foils of various thicknesses, which were vaporized using a capacitor bank discharge with a maximum charging voltage of 8.6 kV. Peak current was delivered on the order of 100 kA with rise times of about 12 μs. In this work, polyurethane was used as a medium to transfer pressure from the aluminum foil vaporization zone to the workpiece. Fundamental experiments, where AA 3003-H14 aluminum alloy was formed into perforated plates, show that for a given foil thickness, a limit existed over which supplying higher electrical energy from a given capacitor bank did not necessarily result in higher pressure. The magnitude of generated pressure was proportional to the excess Joule heat deposited into the foil before it burst. Although the polyurethane layer helped spread the pressure pulse over a larger area, the resulting pressure distribution remained heterogeneous. Practical applications, such as forming into cavities and embossing into shallow dies, were possible with this method. Sheets of 0.508 mm thick commercially pure titanium were nearly fully formed into a cellphone case die using a hybrid process that combined a quasistatic pre-forming step with a vaporizing foil forming step. Sheets of 0.508 mm thick AA 2024-T3 aluminum alloy were embossed into a die with features of varying depths. Aluminum foils with straight and curved active sections were used as actuators. The curved-section foils resulted in higher conformation of the workpiece to the die in the center region, while the straight-section foils produced better conformity to the die features on the ends. (25 refs, 13 figs, 2 tables) (AA)

110283 Stress relaxation behavior of an Al–Zn–Mg–Cu alloy in simulated age-forming process
Chen, JF; Jiang, JT; Zhen, L; Shao, WZ [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 775, Pages 9] The stress relaxation behavior of age-forming for an Al–Zn–Mg–Cu alloy was studied using a designed device that can simulate the age forming process. The mechanism of stress relaxation was also revealed through calculating thermal activation parameters and analyzing the microstructures. The results suggested that the stress relaxation behavior of the Al–Zn–Mg–Cu alloy in the simulated age-forming process can be divided into three stages according to the stress level. The three stages of stress relaxation are: (i) the initial high stress stage, (ii) the subsequent middle stress transition stage and (iii) the last low stress equilibrium stage, respectively. The deformation activation energies are 132 kJ/mol in the initial high stress stage, 119 kJ/mol in the subsequent middle stress transition stage and 91 kJ/mol in the last low stress equilibrium stage, respectively. The analysis of the thermal activation parameters and microstructures revealed that dislocation creep was the dominant deformation mechanism in the initial and subsequent stages of the stress relaxation; whereas diffusion creep is the mechanism in the last stage of the stress relaxation. Additionally, a special threshold stress phenomena was present in the stress relaxation of the age-forming process, which was scribed to the interaction between precipitation and dislocation in the Al–Zn–Mg–Cu alloy (38 refs, 10 figs, 2 tables) (AA)

WARM FORMING

110284 Simulation and experimental study on thermal deep drawing of carbon fiber woven composites
Zhang, Q; Cai, J; Gao, Q [J of Materials Processing Technology Today, May 2015, 41]
Abstracts

Carbon fiber woven composites are composed of carbon fiber woven and resin matrix. To reduce the manufacture cost, thermal stamping, a new forming technology, was proposed and investigated to fabricate composite part. The mechanical properties of carbon fiber have great influence on the deformation of carbon fiber composites. In this study, shear angle–displacement curves and shear load–shear angle curves were obtained from picture frame test. Thermal deep drawing experiments and simulation were conducted, and the shear load–displacement curves under different forming temperatures and shear angle–displacement curves were obtained. The results show the compression and shear between fiber bundles are the main deformation mechanism of carbon fiber woven composite. The maximum shear angle for the composites in this study is 33°. In the drawing process, the forming temperature affects the drawing force, which drops rapidly with the increasing temperature. The suitable forming temperature in deep drawing of the carbon fiber woven composite is approximately 170 °C. (11 refs, 20 figs) (AA)

Warm deep-drawing and post drawing analysis of two Al–Mg–Si alloys
Ghosh, M; Miroux, A; Werkhoven, RJ; Bolt, PJ; Kestens, LAI [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 756, Pages 11] The increasing use of aluminium alloys in light weight structural applications is restricted mainly due to their lower room temperature formability compared to steels. Forming at higher temperature is seen as a promising solution to this problem. In the present investigation two Al–Mg–Si alloys (EN AW-6016 and EN AW-6061) were deep-drawn at room temperature and 250 °C and their behaviour during drawing were compared. The effect of ram speed, drawing ratio, holding time, and temper was also investigated. Among the parameters investigated temperature was found to have the most significant effect on the force–displacement response. Because anisotropy has been an important concern during the deep-drawing process, this parameter was also investigated by looking at the earing profile. With increasing temperature the amplitude of earing decreased while the number of ears remained the same, indicating that there is no change in anisotropy with temperature. The cup thickness increases from the bottom of the cup to the flange with a local minimum around the mid-height of the wall. (27 refs, 14 figs, 3 tables) (AA)

Dimpling process in cold roll metal forming by finite element modelling and experimental validation
Nguyen, VB; Wang, CJ; Mynors, DJ; English, MA; Castellucci, MA [J of Manufacturing Processes, v 16, n 3, Aug 2014, Starting Page 363, Pages 10] The dimpling process is a novel cold-roll forming process that involves dimpling of a rolled flat strip prior to the roll forming operation. This is a process undertaken to enhance the material
properties and subsequent products’ structural performance while maintaining a minimum strip thickness. In order to understand the complex and interrelated nonlinear changes in contact, geometry and material properties that occur in the process, it is necessary to accurately simulate the process and validate through physical tests. In this paper, 3D non-linear finite element analysis was employed to simulate the dimpling process and mechanical testing of the subsequent dimpled sheets, in which the dimple geometry and material properties data were directly transferred from the dimpling process. Physical measurements, tensile and bending tests on dimpled sheet steel were conducted to evaluate the simulation results. Simulation of the dimpling process identified the amount of non-uniform plastic strain introduced and the manner in which this was distributed through the sheet. The plastic strain resulted in strain hardening which could correlate to the increase in the strength of the dimpled steel when compared to plain steel originating from the same coil material. A parametric study revealed that the amount of plastic strain depends upon on the process parameters such as friction and overlapping gap between the two forming rolls. The results derived from simulations of the tensile and bending tests were in good agreement with the experimental ones. The validation indicates that the finite element analysis was able to successfully simulate the dimpling process and mechanical properties of the subsequent dimpled steel products. (14 refs, 14 figs, 2 tables) (AA)

110288 Local heating method by near-infrared rays for forming of non-quenchable advanced high-strength steels
Lee, Eun-Ho; Hwang, June-Sun; Lee, Chang-Whan; Yang, Dong-Yol; Yang, Woo-Ho [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 784, Pages 10] A forming process by local heating using near-infrared rays (NIRs) is proposed to reduce springback of non-quenchable advanced high-strength steels, such as dual-phase steels, that are not suitable materials for hot stamping. NIR lamps show outstanding cost performance, and the width of the heating area can be controlled by designed reflectors. To confirm the advantages of NIR local heating, DP980 sheets were heated by two methods – NIR local heating and furnace heating, which heats the whole material. V-bending and 2D-draw bending were conducted with heated DP980 sheets. Results showed that NIR local heating has advantages over furnace heating in both shape accuracy and hardness. (17 refs, 18 figs, 2 tables) (AA)

110289 Experimental and numerical analysis of friction in high aspect ratio combined forward-backward extrusion with retreat and advance pulse ram motion on a servo press
Matsumoto, Ryo; Hayashi, Kazunori; Utsunomiya, Hiroshi [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 936, Pages 9] A method for maintaining lubrication in the backward extrusion of deep holes for lightweight structural components is proposed utilizing a servo press and a punch with an internal channel for liquid lubricant supply. In this forming method, the punch is pushed into the specimen with a servo press in a manner that combines pulsed and stepwise modes. Sufficient liquid lubricant is periodically supplied to the deformation zone through the internal channel upon the retreat of the punch. This forming method with pulse punch ram motion was tested in combined forward-backward extrusion process with a high aspect ratio (height/diameter) in this study. The material flow of the aluminum specimen during the extrusion with pulse punch ram motion was investigated to determine the coefficient of shear friction at the specimen–punch interface. The punch wear was assessed by a finite element analysis of the material flow of the specimen during the extrusion with pulse punch ram motion. (13 refs, 18 figs, 1 table) (AA)

110290 Approach to triangular induction heating in final precision forming of thick steel plates
Lee, Kwang Seok; Hwang, Byoungchul [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 1008, Pages 10] An automatic high-frequency (HF) induction-heating (IH)-based triangular heating process was introduced in order to investigate the influence of designing heating patterns on the permanent deformation behavior of an SS400 thick plate. Temperature distribution and permanent plate deformation during triangular heating were predicted based on electromagnetic–thermal and thermal–structural analyses, respectively. Both analytical and experimental permanent deformation values obtained by zigzag-type triangular heating were significantly higher than those by fan-shaped triangular heating, presumably because of the different temperature gradient along the thickness. Proper design of triangular heating pattern appeared to be the most important factor in determining the final shape of the thick plate. All predicted results were in good agreement with the experimentally observed permanent deformation. (23 refs, 18 figs, 2 tables) (AA)
Abstracts

110291 Electrohydraulic trimming of advanced and ultra high strength steels
Golovashchenko, Sergey F; Gillard, Alan J; Mamutov, Alexander V; Bonnen, John F; Tang, Zejun [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 1027, Pages 17] Electrohydraulic trimming (EHT) is a novel method of trimming sheet metal panels and is based upon the electro-hydraulic effect: a complex phenomenon related to the discharge of high voltage electrical current through a liquid. In EHT, electrical energy is stored in a bank of capacitors and is converted into kinetic energy within the liquid and the sheet metal blank by rapidly discharging the stored energy across a pair of electrodes submerged in a fluid. The objective of this paper is to describe the newly developed EHT process, to report the results of early proof-of-concept experiments, and to provide an explanation for the observed results through the use of a numerical modeling technique developed as a part of this work. The key innovation behind the EHT concept is the chamber design, which consists of a narrow fluid channel positioned directly below a sharp trim steel. The narrow channel can transmit fluid pressure very efficiently, and the design has enough inherent flexibility such that it can be used to cut straight lines and can also be applied to more complex curvature. The new, channel chamber design concept was successfully demonstrated for electrohydraulic trimming of Advanced and Ultra High Strength Steels, including DP500 at 0.65 mm thick, DP590 at 1.0 mm thick, DP980 at 1.0 mm and 1.4 mm thick, and AISI 4130 steel at 2.0 mm thick. Separation of the offal from the part initiates in the area of the blank directly above the discharge channel. Further separation along the remainder of the trim line is influenced by a number of factors, including the strength and thickness of the sheet material, the mass density of the sheet material, and the propagation of pressure waves along the fluid channel and their reflection from the walls at the ends of the fluid channel. A numerical model was developed which is able to predict the offal separation mechanism and the sequence of offal separation during electrohydraulic trimming. The developed model incorporates several individual models into one integrated simulation, including models for the plasma channel, the liquid within the fluid channel, the steel chamber and trim blade, and the deformable blank. (40 refs, 25 figs) (AA)

110292 Analysis of sheared edge formability of aluminum
Le, Quochung B; DeVries, James A; Golovashchenko, Sergey F; Bonnen, John JF [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 876, Pages 16] Edge quality produced by shearing processes often leads to reduced material formability which was observed in multiple studies and summarized in the reference literature. The intention to make the sheared edge performance more predictable has motivated development of several experimental techniques such as the hole expansion test and the half dogbone tensile test. The paper presents a detailed review of published results for both of these techniques and illustrates very limited research dedicated to sheared edge performance of aluminum alloys. The experimental study, performed on a broadly used aluminum alloy, 6111-T4, illustrated the effects of cutting clearance on longitudinal, transverse and diagonal orientations of the trim line relative to the rolling direction. For all sheet orientations, increasing the cutting clearance resulted in a substantial reduction in material stretchability along the sheared surface. However, for all investigated conditions a cutting clearance of 5% of material thickness resulted in stretching performance similar to the standard tensile test. In this case the sheared edge does not affect the stretching behavior of tested material. The analysis of material prestrain on sheared surface stretchability for a variety of combinations of minor and major strains indicated that for the widely accepted industry standard gap of 10% of the material thickness, the prestrain has significant effects on stretchability which only gets stronger with increased thinning of the sheet in the prestraining process. For an extended clearance of 40%, the effect of prestrain was less visible indicating that the sheared edge has a stronger effect on these cutting conditions than prestrain. Analysis of the effect of the cutting angle on stretchability indicated that higher elongations were observed with cutting angles of 10° and 20° for broadly used 10% clearance compared to orthogonal cutting with an identical clearance. The results of half dogbone tensile tests were compared with the results of hole expansion tests performed on the same sheet material. This comparison indicated that a substantial amount of localization occurs in the hole expansion test and leads to a much higher hole expansion ratio for small cutting clearances compared to the total elongations observed in tensile tests. However, the local strains measured in the area adjacent to fracture in the tensile test were above the hole expansion ratio. (30 refs, 21 figs, 2 tables) (AA)
INDUSTRIAL ENGINEERING

110293 Dynamic programming approach to GA-based heuristic for multi-period CF problems
Sharifi, Shahram; Chauhan, Satyaveer S; Bhuiyan, Nadia [J of Manufacturing Systems, v 33, n 3, Jul 2014, Starting Page 366, Pages 10] In this paper we have introduced a multi-period cell formation (CF) model which is more computationally challenging than the most comprehensive CF models in the literature. A dynamic programming (DP) based approach coupled with GA-based heuristic is proposed to solve the multi-period problem. Since, the introduced dynamic programming is general and can be applied to any GA-based heuristic with full rejuvenation cycles to solve the multi-period part of the model, we focused only on the DP approach in this paper but have explained the interface with the GA-based heuristic. Illustrative example has been provided that clarifies the application of DP-heuristic. The performance of the DP-heuristic has been evaluated against LINGO and multi period GA-based heuristic. (25 refs, 2 figs, 13 tables) (AA)

110294 Rescheduling of parallel machines with stochastic processing and setup times
Arnaout, Jean-Paul [J of Manufacturing Systems, v 33, n 3, Jul 2014, Starting Page 376, Pages 9] This paper tackles rescheduling for the unrelated parallel machine problem with sequence dependent setup times and different rates of breakdowns or urgent jobs arrivals. The jobs’ processing and setup times are stochastic for better depiction of the real world. A new repair rule which will be referred to as Minimum Weighted Cmax Difference (MWCD) is developed and compared to existing algorithms using simulation. The rules are evaluated based on both schedule quality and stability. Design of Experiments and optimization were used with simulation to generate optimal values for MWCD’s parameter. The results and analysis obtained from the computational experiments proved the superiority of the proposed repair rule MWCD over the other algorithms presented. (26 refs, 12 figs, 5 tables) (AA)

110295 Impact of lot-sizing in multiple product environments with congestion
Kang, Yongha; Albey, Erinc; Hwang, Sangwook; Uzsoy, Reha [J of Manufacturing Systems, v 33, n 3, Jul 2014, Starting Page 436, Pages 9] We present a production planning model for a multiple product single machine dynamic lot-sizing problem with congestion. Using queuing models, we develop a set of functions to capture the nonlinear relationship between the output, lot sizes and available work in process inventory levels of all products in the system. We then embed these functions in a nonlinear optimization model with continuous variables, and construct an approximate solution to the original problem by rounding the resulting fractional solution. Computational experiments show that our model with congestion provides significantly better flow time and inventory performance than a benchmark model that does not consider the effects of congestion. These advantages arise from the use of multiple smaller lots in a period instead of a single large lot as suggested by conventional fixed-charge models without congestion. (48 refs, 4 figs, 7 tables) (AA)

110296 Mean time imbalance effects on unreliable unpaced serial flow lines
Shaaban, Sabry; McNamara, Tom; Hudson, Sarah [J of Manufacturing Systems, v 33, n 3, Jul 2014, Starting Page 357, Pages 9] This paper investigates the benefits of deliberately unbalancing operation time means for unreliable non-automated production lines. The lines were simulated with various line lengths, buffer capacities, degrees of imbalance and patterns of imbalance. Data on two performance measures, namely throughput and average buffer level were gathered, analyzed and compared to a balanced line counterpart. A number of conclusions were made with respect to the ranking of configurations, as well as to the relationships among the independent design parameters and the dependent variables. It was found that the best configurations are a balanced line arrangement and a monotone decreasing order, with the first generally resulting in lower through put and the second leading to lower average buffer levels than those of a balanced line. Preliminary results show that unbalanced lines cope well with unreliability. (35 refs, 9 tables) (AA)

110297 Multi-echelon production–inventory system with supply disruption
Pal, Brojeswar; Sana, Shib Sankar; Chaudhuri, Kripasindhu [J of Manufacturing Systems, v 33, n 2, Apr 2014, Starting Page 262, Pages 15] The article investigates an integrated multi-layer supply chain model consisting of supplier, manufacturer and retailer while supply disruption, machine breakdown, safety stock, maintenance breakdown occur simultaneously. At beginning of the production, manufacturer keeps some raw
Abstracts

materials in stock received from second supplier at high price, as safety stock due to supply disruption of first supplier. Corrective maintenance is done immediately to restore its normal stage when machine breakdown occurs. Stock out situations at manufacturer and retailer are considered due to disruption of production for machine breakdown. The integrated expected costs of the chain in centralized (collaborating) and decentralized (Stakelberg approach) system are compared. A numerical example and its sensitivity analysis are provided to test feasibility of the model. (30 refs, 5 figs, 1 table) (AA)

JOINING & ASSEMBLY

110299 Linear friction welding of Ti–5Al–2Sn–2Zr–4Mo–4Cr alloy with dissimilar microstructure
Ji, Yingping; Chai, Zhenchen; Zhao, Dalong; Wu, Sujun [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 979, Pages 9] Dissimilar linear friction welding of Ti–5Al–2Sn–2Zr–4Mo–4Cr with bimodal and lamellar microstructures was produced. The microstructure evolution of the joint was investigated via OM, SEM, XRD, TEM and microhardness analysis. The temperature field of joint was calculated by a numerical model. The typical microstructures of weld center were recrystallized β grains with some acicular α′ martensites. In the case of thermo-mechanically affected zone, some partial re-crystallization grains formed in severely deformed microstructures, where a mass of dislocations were observed. However, dislocations were rarely found in therecrystallized β grains of weld center, the temperature field of weld joints calculated was consistent with the microstructural evolution. (23 refs, 11 figs, 3 tables) (AA)

110300 Experimental investigation on high strength steel (HSS) tailor-welded blanks (TWBs)
Xu, Fengxiang; Sun, Guanyong; Li, Guangyao; Li, Qing [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 925, Pages 11] This paper aims to investigate mechanical characteristics of the new tailor-welded blank (TWB) components made of high strength steel (HSS). A series of HSS-TWB thin plates with different orientations of weld line are studied through three-point bending tests to evaluate the effects of different design parameters, such as weld line locations and material combinations, on the deformation behaviors. The experimental results exhibit good repeatability of tests. And the relative shift phenomenon between indenter and specimen is observed and analyzed for the TWB steel sheets with different weld line orientations at parallel and 45° to the bending moment, respectively. The results from the experiment include the force versus displacement curves and some detailed photographic images throughout the loading process. It is found that the discrepancy of different combinations is quite noteworthy.
In this paper, the peak force, absorbed energy and bending strength are presented to evaluate the mechanical characteristics of HSS-TWB thin plates with different weld line orientations and material combinations. The comparison demonstrates that the TWB structures with the weld orientation at 45° angle to the bending moment have the greatest advantages of different TWB steel sheets. (11 refs, 12 figs, 5 tables) (AA)

110301 Influence of alloy elements on microstructure and mechanical property of aluminum-steel lap joint made by gas metal arc welding
Su, Yongchao; Hua, Xueming; Wu, Yixiong [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 750, Pages 6] 5052 aluminum alloy sheets and galvanized mild steel sheets were joined in lap configuration by alternate-current double pulse gas metal arc welding with pure Al, Al–5Si, Al–12Si and Al–4.5Mg (wt%) filler wires. The effect of alloying elements on the microstructure of intermetallic compounds (IMC) layers formed between weld seam and steel, and tensile strength of the resultant joints were investigated. The thickness of IMC layer in all samples varied along the cross-section of the joint, the intermediate part of the IMC layer was thicker than the head and root parts. The diffusion of Si into Fe2Al5 sub-layer could restrain the growth of Fe2Al5 sub-layer and IMC layer, and joint’s mechanical property improved with the increasing Si content in Fe2Al5 phase. Due to the high hot crack sensitivity of Al–4.5Mg alloy, cracks generated at the root of joint made with Al–4.5Mg filler, resulting in poor mechanical property. (19 refs, 6 figs, 5 tables) (AA)

110302 Characterization of ultrasonic spot welded joints of Mg-to-galvanized and ungalvanized steel with a tin interlayer
Patel, VK; Bhole, SD; Chen, DL [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 811, Pages 7] Ultrasonic spot welded (USWed) Mg-to-bare steel, Mg-to-galvanized steel and Mg-to-bare steel with Sn interlayer (placed in-between Mg and bare steel) were studied. Weak joining occurred in the USWed Mg-to-bare steel, since Mg and Fe do not react with each other. The intermetallic compounds (IMCs) of MgZn3 and Mg2Zn11, which led to the failure of the joint, were largely present in the USWed Mg-to-galvanized steel joint. The introduction of a Sn interlayer in the USWed Mg-to-bare steel actively worked as an intermediate medium to join Mg to Fe, and led to the presence of a distinctive composite-like Sn and Mg2Sn eutectic structure. The lap shear strength of Mg-to-bare steel with Sn interlayer joint was significantly higher than that of the Mg-to-bare steel and Mg-to-galvanized steel joints. Failure during the tensile lap shear tests occurred mainly in the partial nugget pull-out mode in the dissimilar joints of Mg-to-bare steel with Sn interlayer. All the joints of Mg-to-galvanized steel failed from the interface (cohesive failure). The addition of Sn interlayer resulted in energy saving since the welding energy required to achieve the maximum strength decreased from 1750 to 1500 J in the Mg-to-steel joints. (17 refs, 6 figs) (AA)

110303 Fiber Bragg grating sensors for on-line welding diagnostics
Rodriguez-Cobo, Luis; Mirapeix, Jesus; Ruiz-Lombera, Ruben; Cobo, Adolfo; López-Higuera, Jose-Miguel [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 839, Pages 5] On-line monitoring of an arc-welding process is performed in this paper by means of fiber Bragg grating transducers (FBGs) in two different configurations. FBGs were glued to the plate surfaces next to the weld joint, and a FBG transducer was designed to sense the perturbations in the air surrounding the welding plasma column. Sensitivity to both temperature and vibrations during the process was analyzed during several tungsten inert gas (TIG) welding tests, showing the feasibility of the proposed design to perform an on-line detection of different welding perturbations. To enhance the analysis, a setup based on plasma optical spectroscopy was also employed to allow a comparison among the response of both techniques to the appearance of these perturbations. (14 refs, 6 figs) (AA)

LASERS

110304 Modelling of droplet detachment in the laser droplet brazing process
Jeromen, Andrej; Held, Carolin; Govekar, Edvard; Roth, Stephan; Schmidt, Michael [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 737, Pages 13] The laser droplet brazing process has been recently experimentally considered for the electrical contacting of thermally sensitive components. In this process, a spherical brazing preform, placed in a tapering nozzle, is melted by a laser pulse, detached from the nozzle by a shielding gas overpressure, and deposited on the brazing spot. The detachment of the brazing droplet from the nozzle has been studied theoretically in this paper with the aim of providing guidance for the selection of the main process parameters, i.e. the gas overpressure and the droplet contact angle. The droplet detachment
is described by two models: an algebraic droplet force balance model and a numerical isothermal two-phase fluid flow model. Using the droplet force balance based model, an algebraic expression defining the dependence of the maximum gas overpressure before droplet detachment on the droplet contact angle was obtained. The numerical model was used to determine the droplet detachment occurrence in terms of the main process parameters. Additionally, the nonlinear dependencies of the time of droplet detachment, the detached droplet velocity and vertical position, and the droplet shape on the gas overpressure and the brazing droplet contact angle were defined, and can be used for process parameter selection. It was also found that the detached droplet shape is influenced, beside the gas overpressure and the droplet contact angle, by oscillation of the droplet, which can be significant at droplet contact angle values of less than 75°. Based on comparisons of the modelled and experimental results of droplet detachment time, vertical position of the detached droplet, and its shape, it was concluded that the contact angle of the CuSn11 brazing material on the WC/Co nozzle was, in the experiments, near 105°. Furthermore, comparisons of the results indicated that the laser melting phase of the preform significantly influences droplet detachment, and should therefore be taken into consideration for the improvement of the numerical model. (13 refs, 21 figs, 1 table) (AA)

MACHINE ELEMENTS & MECHANISMS

110305 Further insight into the chip formation of ferritic-pearlitic steels: Microstructural evolutions and associated thermo-mechanical loadings Courbon, C; Mabrouki, T; Rech, J; Mazuyer, D; Perrard, F; D’Eramo, E [Int J of Machine Tools & Manufacture, v 77, n , Feb 2014, Starting Page 34, Pages 13] The main objective of this paper is to clarify the deformation mechanisms of ferritic-pearlitic steels in metal cutting and correlate them to the associated thermo-mechanical loadings. Dry orthogonal cutting tests have been performed on a normalised AISI 1045 steel with coated carbide tools. Experimental evidences of a drastic grain refinement process in the main deformation zones are advanced on the basis of optical microscope, Field Emission Scanning Electron Microscope (FESEM) and Electron BackScattered Diffraction (EBSD). Microstructural evolutions leading to a grain size down to 200 nm and fragmented cementite are especially emphasized. A numerical approach is further employed to target and quantify the loadings applied to the machined material and extract further information on the Secondary Shear Zone (SSZ). Strains amplitude appears to be the driving parameter of these evolutions via a dynamic recrystallisation process promoted by an intense and localised heat generation. The present contribution highlights that in-depth and microscale investigations of chip formation including microstructural aspects are still required. (57 refs, 13 figs, 1 table) (AA)

110306 Geometric error measurement and identification for rotary table of multi-axis machine tool using double ballbar Chen, Jian-xiong; Lin, Shu-wen; He, Bing-wei [Int J of Machine Tools & Manufacture, v 77, Feb 2014, Starting Page 47, Pages 9] In this paper, comprehensive geometric errors, including linkage errors and volumetric errors, of a rotary table are measured totally by employing a double ballbar and obtained by a two-step identification procedure. The derivations of the center of the ball installed on the table are measured in the error sensitive directions with newly developed serial of two axes controlled circular paths. Hence, there are nine results measured from three mounting positions of the ball at the same rotation angle. These results are used to form the identification model based on the homogeneous transformation. Moreover, a sensitivity analysis method is applied to select the optimum installation parameters of the ballbar to diminish the influence of the inaccuracy of the measurement parameters. As the mounting position errors of the socket on the table are inevitable during the installation of the balls, a new correction procedure is developed as well. Finally, an experiment is conducted on the four-axis machining center. The comparison results between the predicted errors and the measured results are shown to verify the proposed method. (21 refs, 14 figs, 1 table) (AA)

110307 Bio-inspired self-sharpening cutting tool surface for finish hard turning of steel Wenping, Jiang [CIRP Annals, v 63, n 1, 2014, Starting Page 517, Pages 4] This research presents the structural analysis and machining results of a 3-D nanostructured coating designed for finish turning of ferrous alloys. The coating
design, inspired from sea urchin and shark teeth architectures, delivers serrated cutting edges and self-sharpening. The coating is realized using cubic boron nitride particles (<2 mm insize) in soft titanium nitride matrix to produce superior tool life and consistent surface finish (<1.6 mm), on-par or better than polished PBN inserts, during finish hard-turning of 4340 alloy steel. This research also discusses mechanism based on coating materials and morphology for reducing surface contact and sliding friction at the tool–workpiece interface. (21 refs, 6 figs, 1 table) (AA)

110308 Characterization of deformation induced surface hardening during cryogenic turning of AISI 347
Aurich, Jan C; Mayer, Patrick; Kirsch, Benjamin; Eifler, Dietmar; Smaga, Marek; Skorupski, Robert [CIRP Annals, v 63, n 1, 2014, Starting Page 65, Pages 4] The use of cryogenic cooling in material removal processes has been reported by several researchers. The objectives were enhanced tool life and an expanded range of machinable materials. In this paper, a novel application of cryogenic cooling is presented: its use achieve direct surface hardening of metastable austenitic steels during cutting. Metastable austenite can transform into martensite due to plastic deformation if a sufficiently low temperature is maintained. In order to use this effect during cutting, cryogenic conditions must be maintained at all times. With this approach, cutting and hardening can be combined in one process. (17 refs, 7 figs, 1 table) (AA)

110309 Evaluative approach to correlate machinability, microstructures, and material properties of gamma titanium aluminides
Settineri, Luca; Priarone, Paolo C; Arft, Martin; Lung, Dieter; Stoyanov, Todor [CIRP Annals, v 63, n 1, 2014, Starting Page 57, Pages 4] Several generations of gamma titanium aluminides have been developed over time, and they are nowadays commercially available. The differences in chemical composition, as well as the thermal treatments, greatly influence the properties of the alloys. This implies considerable effects on the production process performances. Benchmark trials were performed on three g-TiAl alloys: Ti–48Al–2Cr–2Nb, Ti–43.5Al–4Nb–1Mo–0.1B, and Ti–45Al–2Nb–2Mn+0.8vol.%TiB2 XD, focusing on machinability and material characterization. The extremely dissimilar results obtained when turning and milling can be traced back to the different microstructures, as well as to the alloying elements, factors both affecting the mechanical and thermal material properties. (12 refs, 9 figs) (AA)

110310 On the mechanics of chip formation in Ti–6Al–4V turning with spindle speed variation
Chiappini, Elio; Tirelli, Stefano; Albertelli, Paolo; Strano, Matteo; Monno, Michele [Int J of Machine Tools & Manufacture, v 77, Feb 2014, Starting Page 16, Pages 11] Titanium alloys are hard-to-cut materials and need to be machined at relatively low cutting speeds with obvious negative consequences on the profitability of machining. In order to enhance material removal rate (MRR), a strategy that relies on higher depths of cut could be chosen if vibrational issues due to regenerative chatter did not occur. A lot of research was done to suppress regenerative chatter without detrimental effects on productivity. One of the most interesting chatter suppression methods, mainly due to its flexibility and relative ease of implementation, is spindle speed variation (SSV), which consists in a continuous modulation of the nominal cutting speed. Sinusoidal spindle speed variation (SSSV) is a specific technique that exploits a sinusoidal law to modulate the cutting speed. The vast scientific literature on SSV was mainly focused on cutting process stability issues fully neglecting the study of the mechanics of chip formation in SSV machining. The aim of this work is to fill this gap: thus, finite element method (FEM) models of Ti–6Al–4V turning were setup to simulate both SSSV and constant speed machining (CSM). The models consider both the micro-geometry of the insert and the coating. Numerical results were experimentally validated on dry turning tests of titanium tubes exploiting the experimental assessment of cutting forces, cutting temperatures and chip morphology. Tool–chip contact pressure, tool engagement mechanism and the thermal distribution in the insert are some of the analysed numerical outputs because they cannot be easily assessed by experimental procedures. These quantities were useful to compare thermo-mechanical loads of the insert both in CSM and SSSV machining: it was observed that the loads significantly differ. Compared to CSM, the modulation of the cutting speed involves a higher tool–chip contact pressure peak, a higher maximum temperature and higher temperature gradients that could foster the main tool wear mechanisms. (29 refs, 16 figs, 6 tables) (AA)

110311 Novel approach to machining condition monitoring of deep hole boring
Xiao, Wenrong; Zi, Yanyang; Chen, Binqiang;
Abstracts

Li, Bing; He, Zhengjia [Int J of Machine Tools & Manufacture, v 77, Feb 2014, Starting Page 27, Pages 7] In the optimization of deep hole boring processes, machining condition monitoring (MCM) plays an important role for efficient tool change policies, product quality control and lower tool costs. This paper proposes a novel approach to the MCM of deep hole boring on the basis of the pseudo non-dyadic second generation wavelet transform (PNSGWGT). This approach is developed via constructing a valuable indicator, i.e., the wavelet energy ratio around the natural frequency of boring bar. Self-excited vibration occurs at the frequency of the most dominant mode of the machine tool structure. Via modeling dynamic cutting process and performing its simulation analysis during deep hole boring, it is found that the vibration amplitudes at the nature frequency of the machine tool rise with the tool wear. The PNSGWGT that has relative adjustable dyadic time-frequency partition grids, good time-frequency localizability and exact shift-invariance is used to extract the wavelet energy in the specified frequency band. Accordingly, the MCM of deep hole boring can be implemented by means of normalizing the wavelet energy. Finally, a field experiment on deep hole boring machine tool is conducted, and the result shows that the proposed method is effective in the process of monitoring tool wear and surface finish quality for deep hole boring. (20 refs, 11 figs, 2 tables) (AA)

110312 Effect of heat treatment on green machinability of SiAlON compacts
Çelik, Ali; Yaman, Halli; Turan, Servet; Kara, Alpagut; Kara, Ferhat [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 767, Pages 8] SiAlON based ceramics are promising materials for wear applications such as wire extrusion dies, pipe bending rollers, etc. due to their outstanding mechanical properties both at high and low temperatures. To be able to utilize these materials for such applications, they should have specific geometrical details as holes, threads, grooves, etc. for the ease of fixation. Machining of a ceramic component in its green state is one of the most common techniques which enable producing SiAlON wear parts with desired geometries. It is a prerequisite for green machining that the compact should have a sufficient green strength to withstand against stresses at the cutting zone during machining. In this study, the required green strength was obtained by a simple heat treatment step performed between 1100 and 1400 °C. The effect of this process on the microstructure, phase development, strength and machinability of SiAlON green compacts were investigated. It was observed that the compacts heat treated at 1400 °C provide a sufficient strength against damage formation on the machined part and a relatively low tool wear as a result of the formation of fragmented chips during the cutting process. Although these fragmented chips have beneficial effects on the tool wear, they resulted in a relatively poor surface quality in the machined parts. (22 refs, 10 figs, 1 table) (AA)

110313 Analysis of a free machining α+β titanium alloy using conventional and ultrasonically assisted turning
Muhammad, Riaz; Hussain, Mohammad Sajid; Maurotto, Agostino; Siemers, Carsten; Roy, Anish; Silberschmidt, Vadim V [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 906, Pages 10] Rapid advancements in power generation and aviation industries have witnessed a widespread use of titanium and its alloys in many applications. This is primarily due to their excellent mechanical properties including, amongst other, high strength-to-density ratio, outstanding fatigue properties and corrosion resistance with the ability to withstand moderately high temperatures. However, this combination of properties results in poor machinability of the material, increasing the cost of components machined with conventional cutting techniques. Recently, Ti 6Al 2Sn 4Zr 6Mo, a modern titanium alloy with improved mechanical properties, has been introduced as a possible replacement of Ti 6Al 4V in aerospace industry. However, its poor machinability and formation of long chips in conventional turning are main limitations for its wide-spread application. Therefore, a new alloy based on Ti 6Al 2Sn 4Zr 6Mo, namely Ti 6Al 7Zr 6Mo 0.9La, was developed; it shows enhanced machinability generating short chips during metal cutting, which prevents entanglement with cutting tools improving productivity. To further enhance the machinability of this material, a novel hybrid machining technique called ultrasonically assisted turning (UAT) was used. Experimental investigations were carried out to study the machinability, chip shapes, cutting forces, temperature in the process zone and surface roughness for conventional and ultrasonically assisted turning of both alloys. UAT shows improved machinability with reduced nominal cutting forces, improved surface roughness of the machined workpiece and generation of shorter chips when compared to
conventional machining conditions. (37 refs; 16 figs, 2 tables) (AA)

NON TRADITIONAL MACHINING

110314 Simulation model of debris and bubble movement in consecutive-pulse discharge of electrical discharge machining
Wang, Jin; Han, Fuzhu [Int J of Machine Tools & Manufacture, v 77, Feb 2014, Starting Page 56, Pages 10] Debris concentration and bubble volume fraction in the bottom gap between the electrode and workpiece affect the state of consecutive-pulse discharge and the efficiency of electrical discharge machining (EDM). Thus, the mechanisms of debris and bubble movement during consecutive-pulse discharge should be elucidated. However, these mechanisms have not been fully understood because of debris and bubble movement in the machining gap are difficult to simulate and observe. This study proposes a three-dimensional model of flow field with liquid, gas, and solid phases for machining gap in EDM. The mechanisms of debris and bubble movement in the machining gap during consecutive-pulse discharge were analyzed through the model. Debris and bubble movement in consecutive-pulse discharge was observed through experiments. The results showed that the proposed simulation model is feasible. The bubble expansion is the main way that the bubbles exclude from machining gap. Much debris moves outside the machining gap following the excluded bubbles, which is the main way that the debris excludes from machining gap. The bubble expansion becomes strong with the increase of the discharge current and pulse-on time. (17 refs, 14 figs, 1 table) (AA)

110315 Adaptive control of deposited height in GMAW-based layer additive manufacturing
Xiong, Jun; Zhang, Guangjun [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 962, Pages 7] A passive vision sensor system has been developed to monitor the nozzle to the top surface distance (NTSD) in layer additive manufacturing (LAM) using gas metal arc welding (GMAW). The deviations in the NTSD are compensated by the movement of the working flat, and the adjustment of the deposition rate on next deposition layer. After simplification of the controlled process into a linear system, an adaptive control system has been designed to keep the NTSD constant. The effectiveness of the controller is evaluated through deposition of single-bead multi-layer walls, and the experimental results confirm that the process stability can be improved when applying the developed controller. (14 refs, 12 figs, 2 tables) (AA)

110316 Experimental investigation of spark generation in electrochemical discharge machining of non-conducting materials
Jiang, Baoyang; Lan, Shuhuai; Ni, Jun; Zhang, Zhaoyang [J of Materials Processing Technology, v 214, n 4, Apr 2014, Starting Page 892, Pages 7] Electrochemical discharge machining (ECDM), also known as spark assisted chemical engraving (SACE), is an effective micro-machining process for non-conducting materials. Process modeling of ECDM, including spark generation and material removal, is not fully established however. Empirical estimation for discharge energy results in large prediction error of material removal and is hard to experimentally validate. In this paper, an experiment-based stochastic model for spark energy estimation is presented. Tapered tool electrodes were fabricated by electrochemical machining (ECM) to improve the consistency of spark generation. Energy of sparks was experimentally determined and fit into a two-component mixture log-normal distribution to reveal electrochemical characteristics of tool electrodes. A finite element based model was established to correlate spark energy and the geometry of removed material. Material removal was treated as heat transfer problem because electrical energy released by spark generation transfers into thermal energy on the workpiece, resulting in material removal due to thermal melting and chemical etching. Predictions of material removal by the model demonstrated good consistency with experimental results. (20 refs, 11 figs, 1 table) (AA)