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ditions (depth of cut and cutting speed) on 1018 steel. The experiments show that laser power and depth of cut have a significant effect on the forces in micro grooving of 1018 steel.

MEP-07: Adaptive Raster Cutter Path Scheduling for Free-form Surface Machining
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The accuracy and efficiency of 3-axis computer numerically controlled (CNC) machining using the inverse offset method (IOM) is dependent on the grid sizes, called the step-forward and step-interval distances respectively in the forward and transverse cutting directions. The step-forward distance produces local gouging in the forward direction whereas the step-interval distance produces cusps in the transverse direction. In this paper, an error analysis is carried out with consideration to the slopes and curvatures in the forward and transverse directions and the machined surface error is estimated as a combination of the chordal deviation and cusp height. In contrast with the uniform grid approach, an adaptive grid generation method is proposed, in which different step-forward and step-interval distances are used in different regions in order to limit the machined surface error within a specified tolerance. A machining example is presented to demonstrate the effectiveness of the algorithm.

MEP-08: Dissolution wear: Decomposition of Tool Material, and Concentration Profile into Chip
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The dissolution hypothesis of tool wear is re-phrased as a boundary condition for the transfer of tool components to the chip's bulk via diffusion. In this setting, dissolution wear is defined as the combined events of tool decomposition at the interface and the subsequent mass transfer of decomposed elements into the chip region. Chemical equilibrium is invoked for the distribution of tool species at the tool-chip interface. The Frank-Turnbull mechanism (interaction between interstitial impurities and vacancies to form substitutional impurities) is used as a hypothesis to explain the humped concentration profile of tool constituents into the chip. The humped concentration profile has been found experimentally by Subramanian et al. [4]. The chosen method is semi-empirical in that the interstitial-impurity distribution is solved from a set of coupled, advection-diffusion-reaction equations, whereas the vacancy distribution is constructed so that the final substitutional-impurity distribution agrees with observed data. The present interpretation of the Frank-Turnbull mechanism is illustrated by finite-element simulations.

MEP-09: Effect of Cutting Tip Thickness and Friction Coefficient on Load Characteristic of Trapezoidal Edge Indentation to Aluminum Sheet
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This paper describes a fundamental relationship among a punching resistance, thickness of a cutting tip, and a friction coefficient, for indentation of a damaged edge into an aluminum sheet on a flat rigid plate. It was found that the second inflection point in the resistance curve is a critical depth of the wedged sheet. In the subsequent indentation, an assumption of the semi-infinite object cannot be applied due to the relationship between the projected width in contact with the cutting tip and the sheet thickness. A prediction formula depending on the deformation resistance of sheet and on the geometrical conditions was investigated by using the updated, large strain, elasto-plastic finite element analysis. The increase of resistance of the trapezoidal model was approximately same as a sharp wedge model in a certain range of friction coefficient, during the pushed stage.

MEP-10: Critical Depth of Cut and Specific Cutting Energy of a Micro-Scribing Process for Hard and Brittle Materials
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This paper investigated the scribing process characteristics of the hard and brittle materials including single crystal silicon, STV-Glass and sapphire substrate. Under various cutting angles, major process characteristics are examined including 1. the groove geometry, 2. the specific cutting energies and 3. the critical depth of cut at the onset of ductile-to-brittle cutting transition. As the cutting depth increases, groove geometry clearly reveals the ductile-to-brittle transition from the plastic deformation to a brittle fracture state. The material size effect in the ductile region as well as the state transition in scribing behavior are well reflected in the specific cutting energy. The change of specific energy as a function of the cutting depth serves as a criterion for estimating the critical depth of cut. The critical depths of cut for these hard materials are found to be between 0.1μm and 0.5μm depending on the material and cutting angles. Based on the experimental results, a model is set up and calibrated for the given scribing diamond cutter to predict the critical depth of cut for a material with known mechanical properties.

MEP-11: Evaluation of Surface Defects of Railway Wheel using Induced Current Focusing Potential Drop
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The majority of catastrophic wheel failures are caused by surface opening fatigue cracks either in the wheel tread or wheel flange areas. Since failure in railway wheels can cause a disaster, regular inspection of defects in wheels is mandatory. Railway wheels in service are regularly checked by ultrasonic testing, acoustic emission and eddy current testing methods and so on. However, it is difficult to use this method because of its high viscosity and because its sensitivity is affected by temperature. Also, due to noise echoes it is difficult to detect defects initiation clearly with ultrasonic testing. It is necessary to develop a non-destructive technique that is superior to conventional NDT techniques in order to ensure the safety of the railway wheelset. The induced current focusing potential drop (ICFDP) technique is a new non-destructive testing technique that can detect defects in railway wheels by applying on electromagnetic field and potential drops variation. In the present paper, the ICFDP technique is applied to the detection of surface defects for railway wheels. To detect the defects for railway wheels, the sensor for ICFPD is optimized and the tests are carried out with respect to 4 surface defects each other. The defect detections in railway wheels by using ICFPD was carried out in the azimuthally direction. The result show that the surface crack depth of 1.0 mm and in wheel tread could be detected by using this method. The ICFPD method is useful to detect the defect that initiated in the tread of railway wheels.

MEP-12: Development of New Piercing System for Small Holes by Continuous Striking of a Punch Using Ultrasonic Vibration
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In this study, a simple and effective piercing system using ultrasonic vibration was newly developed to produce small holes and micro holes with fine sheared surface. This system consists of two independent units. One is the vibration unit and the other is the piercing unit. A coil spring is placed between the punch and the guide-bush to support the punch in the floating state. When the ultrasonic vibration is transferred to the punch by the UV-horn, it extends out and hits the material, and then
rebounds to collide the UV-horn again. This back-and-forth shuttleing motion of the punch is repeated until a hole is opened. Three kinds of piercing modes are employed: Mode-I is the conventional piercing process. In Mode-II called the shuttle piercing, the UV-horn is fixed at a vertical position and the punch is struck intermittently. In Mode-III called the press shuttle piercing, the UV-horn is indented at a constant speed, striking the punch repetitively. In the piercing experiments of small holes on stainless steel sheets, few benefits in shuttle piercing of Mode-II were found. On the other hand, the press shuttle piercing of Mode-III achieved results without causing secondary sheared zone and eliminated the fractured zone. In the piercing experiments of micro holes on stainless steel foils, the process optimizations in press shuttle piercing of Mode-III were conducted. When the initial gap was secured enough, we can obtain the fine quality of sheared surface which contains only a very small fractured zone, irrespective of the foil thickness.

**APP-03: The Effect of in-situ Formation of Al2O3 or Fe2AIC on the Structural and Mechanical Properties of FeAl Intermetallic Alloys**

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The effect of in-situ formation of reinforcing phase on the structural and mechanical properties of FeAl (Fe-40mol%Al) intermetallic alloy was studied. The in-situ FeAl composites containing Al2O3 or Fe2AIC were fabricated by mechanical alloying of elemental powders (Fe, Al, C for FeAl+Fe2AIC system) or elemental powders and mill scale powder (for FeAl+Al2O3 system) followed by vacuum hot pressing. The starting materials were mixed in the appropriate ratio to synthesize 10vol% of the reinforcing phase and Fe-40mol%Al matrix. The microstructure of the composites consisted of very fine matrix about 50nm measured by X-ray diffraction, Al2O3 (about 10-20nm) and Fe2AIC (0.55μm, 8.9vol%). FeAl+Al2O3 and FeAl+Fe2AIC alloys showed high hardness value of HV813 and HV524, respectively. The effect of testing temperature on the 0.2% proof stress was measured at the temperature range from room to 1273K under compression. FeAl+Al2O3 and FeAl+Fe2AIC alloy showed proof stress of 2240MPa and 1380MPa at room temperature, respectively. At higher temperatures above 773K the proof stress decreased rapidly. FeAl base in-situ composites including Fe2AIC or Al2O3 showed the high stress exponent and activation energy in the temperatures range of 1073-1273K in comparison with the reported values of Fe-40mol%Al alloy having large grain size.

**APP-04: Consolidation at Low Heat in Mechanically Alloyed Ti-Al Powders**

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Studies on mechanochemical reaction have found combustion onset at lower temperatures. In this study, mechanical alloying (MA) of Ti-48mol%Al powder mixtures was performed at relatively short milling times (10.8-86.4ks) by planetary ball mill, and the MA powders were hot-pressed at relatively low temperatures (673-873K) and pressures (200-600MPa). The influence of hot press temperature and pressure on consolidation (densification, reactive synthesis, etc.) was investigated for the MA powders. In this experiment, some non-reactive Ti powders remained in the consolidated materials, but the optimum hot press conditions for consolidation by reactive sintering were determined by the MA conditions (milling duration, etc.). Subsequently, the hot-pressed specimens were used for hot-working as in compressive creep testing at 1273K and initial pressure of 50MPa. The high workability was excellent and the deformation was superplasticity-like. The densification and alloying proceeded while maintaining ultra-fine grain size. The greatest change in density for the consolidated materials was seen in the longest milled powders within the limits of this experiment.

**APP-05: The Selective Laser Sintering Method using Titanium Powder Sheet Toward Fabrication of Porous Bone Substitutes**

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The present paper investigates a process of laser sintering of titanium sheets toward the fabrication of porous artificial bones. The novelty lies in the use of titanium powder sheet mixed with an organic binder and the application of selective laser sintering to the fabrication of a laminated porous structure. An alternate irradiation of Nd:YAG pulse with short scanning paths results in the suppression of distortion of the sintered part as well as increases in mechanical properties. Under the...