direction is the most typical and serious of all dimensional inaccuracies in the product. It is found that twist in the curved portion of either kind is larger respectively than that in product that has only a curved portion. In the consideration that residual moment plays an important role in the twist, a slit is made on the flange and wall of the product to release residual moment. Before and after making slit on the wall of the product, the difference in the phenomenon is investigated. It is confirmed that twist in the longitudinal direction is mainly caused by spring back on the punch shoulder. Compared with 2D type, 3D type shows specifically that the shrink side mainly influences twist.

PLF-09: Effect of Force Correction Algorithm Arising from Change of Tool Normal on Sheet Metal Forming Simulation
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In sheet metal forming simulations by a finite element method in which tools are assumed to be rigid, generally a tool normal at a tool node is calculated by averaging the normals defined on all adjacent elements. Moreover, a tool normal at an arbitrary point is defined by interpolations, thus achieving the continuity of the normals. In static explicit codes which do not apply iterative schemes, it is important to introduce an algorithm which can explicitly follow the change of the tool normals. This paper describes a new algorithm for the discretization of the tool normal based on the "averaged" tool normal. This algorithm finally becomes a very simple form so that it is easy to implement into the finite element method code. In this study, the developed code is implemented into STAMP3D, which is a static explicit program dedicated to sheet metal forming simulations. Hat bending simulation is performed and the norm of the non-equilibrated forces due to the change of the tool normals is compared between the results by the conventional algorithm and those by the proposed one. It is found that the norm of the non-equilibrated forces is largely reduced when applying the proposed algorithm. This result shows the improvement of the accuracy of the simulation and the validity of the proposed algorithm.

PLF-10: Grain-Refining Process of Magnesium Alloy Powder by Hot Roll Compaction
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Roller compacting (RCP) process has been developed as an advanced grain-refining process to output coarse magnesium alloy powder with 0.5~4 mm in length. Dynamic recrystallization during severe plastic working on raw Mg chips by RCP causes the refinement of grains, uniform distribution of intermetallics, and the increase of the strength and matrix hardness. For examples, the grain-refined AM60 magnesium alloy consolidated by hot extrusion shows 1~3 μm in grain size after 30~50 cycles in RCP. It is much finer than that of raw chips with a grain size of 60~200 μm. The hardening effect is observed in the roll-compacted Mg powder, e.g. the matrix micro-hardness of 75HV is remarkably high compared to the raw materials with 50HV. This process has been applied to the medium-scale equipment to produce superior coarse Mg powder of 40~50 kg per hour. The effects of the RCP parameters on the characteristics of grain-refined Mg powder will be discussed in detail.

PLF-11: Plastic Deformation Behaviors of Magnesium Alloy AZ31 in Plane Strain Compression
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Most of magnesium alloy products are manufactured by die casting or thixo-molding processes, however, there is extremely little use of the products by metal forming due to high resisting plastic deformation in normal temperature and their expensive cost. In this study, to make clear the plastic deformability, stress and strain behaviors of Mg alloy AZ31 hot rolled sheet in plane strain compression in the temperature from 20°C to 250°C have been discussed. Tension test and plane strain compression test have been performed to obtain the equivalent stress and equivalent plastic strain relations. The plane strain compression tests with some lubrications have been performed, and the effects of friction between die and deforming material on plastic deformation behaviors are investigated by the elastic-plastic finite element analysis. Optical microstructures of deformed materials are also observed.

PLF-12: Tensile Straightening of Superfine Wire and Residual Stress Measurement Using Focused Ion Beam
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The general method of reducing curving or bending for midsize wires or sheets is straightening using rollers and/or levelers. For superfine wires, similarly, high straightness is needed. However, it is very difficult to deal with superfine wires due to their fineness and low tensile strength. In our study, warm tensile straightening processes for superfine gold wire, which is widely used as bonding material between leads and IC chips in semiconductors, were examined. Furthermore, finite element analyses of drawing and tensile straightening of superfine wires were carried out. The correlation between straightness and axial residual stress, which was calculated using the curve width when half of the wire was removed by sputtering with a focused ion beam (FIB), was studied. As a result of our studies, the improvement of straightness by tensile straightening of superfine gold wire was demonstrated, and the relationship between axial residual stress and straightness of wires was clarified.

CSW-01: On Wear and Tool Life of Tungsten Carbide, PCBN and PCD Cutting Tools
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This paper uses the experimental tool life, temperature, and Taylor tool life exponent results available to investigate the dominant wear mechanisms of cutting tools. Attention is limited to three widely used yet considerably different tool/work materials, i.e., tungsten-carbide/steel, PCBN/hardened-steel and PCD/MMC. Based on the results presented, it was concluded that the most likely dominant wear mechanism for tungsten carbide tools is diffusion and that for PCBN tools is chemical wear. However, for PCD/MMC, sufficient experimental results are not available to determine the dominant wear mechanism.

CSW-02: Material Surface Treatment Process Using High Pressure and High Sonic Wave by Cloud-Cavitation Phenomenon
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Ferrous and Non-ferrous material surface hardening process has been accomplished by cloud-cavitations mechanism. High-pressure region (over than 2-300Mpa) is created between the high frequency vibration
probes and the treated material under the water-immersed environment. By keeping narrow gap between two substances, and by vibrating high frequency (2-30kHz) for one side of substance, the innumerable cloud-cavities has been generated and dissipated. The confined cloud-cavities interferes each other and create high pressure and high sonic wave region, which beat the treated material surface. Ferrous, stainless steel and aluminum material had been treated in this process. Material hardness is increased 30-50% compared to the virgin material. And the depth of hardness is over 100 micron. This process is extremely competitive to conventional shot blasting methods, which are dusty, and energy consumed process. Application of this process is useful for machinery parts (gear, cam shaft, sleeves valves and etc.). This process is also effective to the stress relief for welded part.

CSW-03: Improvement of Surface Layer Characteristics by Shot Linin g
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The metal lining is available to improve surface properties of the products. For example, the lining of metal surface with dissimilar material such as stainless steel is useful in heightening the wear and corrosion properties. Although the sprayed metal coating is employed for the metal lining, bond strength is not high. On the other hand, clad metals are produced by rolling and extrusion. However, the cladding is not easy in the case of a large difference between flow stresses of the bonded metals. In the present study, lining of the metal substrate with thin foils using shot peening was investigated to improve the surface layer characteristics. In the shot peening experiment, the metal foils set on the metal substrate are peeled with hard particles traveling at a high velocity. The foils are bonded to the surface of the substrate due to plastic deformation induced by the collision of the particles. The foils and the substrate are heated to heighten the bondability because of the reduction of flow stress. Lining the substrate with the hard powder sandwiched between two aluminum foil sheets was also attempted. In this experiment, a centrifugal shot peening machine with an electrical heater was employed. The substrates are commercially aluminum alloys, magnesium alloys and titanium alloy, and the foils are commercially aluminum, titanium, nickel and copper. The effects of shot speed and the heating temperature on the bondability were examined. The wear resistance was also evaluated by grinding. The foils were successfully bonded to the metal surface. It was found that the present method was effective in improving of surface layer characteristics.

CSW-04: Surface Texturing of CoCr by Nd:YAG Laser
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Laser surface texturing (LST) is a common surface engineering approach used to improve tribological performance. LST has been used to provide engineered surfaces for a number of machine element applications such as bearings and seals, and for manufacturing processes such as drawing, forging and sheet metal forming. All of these applications are similar in that fairly constant forces and velocities are usually encountered. A more demanding problem, and one where engineered surfaces have not been as widely applied, is one where the force and/or the sliding velocity are not constant, such as in cylinder liners, cams, and articulating surfaces. For these conditions, it is desirable to produce dimples from laser texturing that are not in the usual hemispherical shape. This paper describes experiments and theoretical modeling for producing textures intended to be useful for both steady and unsteady machine design and manufacturing applications. The use of a Nd: YAG laser can produce either symmetric or asymmetric dimples on the surface, which were measured and correlated to process parameters. Based on model for symmetric dimples, dimple dimensions and profiles can be controlled by the laser operator. More work will be done to finish the model for asymmetric dimples.

CSW-05: Evaluation of Mechanical Properties and Microstructure in Ion-Irradiated Surface Layer
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Target vessel materials used in spallation neutron source will be exposed to proton and neutron irradiation and mercury immersion environments. In order to evaluate the surface degradation of the vessel candidate materials due to such environment, the triple-ion beam irradiation taking the spallation reaction into account and mercury immersion tests were carried out. Mechanical properties of the gradient surface layer were evaluated by the inverse analysis with multi-layer model that considers distribution of surface characteristic was applied to the load and depth curves measured by using the instrumented indentation machine. Transmission electron microscopic observations were performed to evaluate the changes of microstructure in irradiated surface layer using focused ion-beam cut micro-specimen. The mechanical properties distributions in the surface layer were evaluated quantitatively and the changes in microstructures were correspondent to the property distribution. It was confirmed that the ductility loss is enhanced by the irradiation and mercury immersion, and simulated stress and strain curves of the ion-irradiated surface layer were adequately in good agreement with the curves of experimental equivalent neutron-irradiated material.

8:30 a.m. - 10:00 a.m.
Room D

CMC-II: CERAMICS AND CERAMIC MATRIX COMPOSITES

CMC-09: Hybrid Bonding between C/C Composites Using Si Infiltration
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In real hot structures, formation of complicated shapes is often required; However it is in general not easy for C/Cs to form various shapes. In the present paper, a newly devised hybrid bonding method was proposed as a suitable bonding technique for C/Cs to fabricate such structures. This bonding is composed of carbon bonding infiltrated with Si melt into the bonding layer. The principal features of this bonding are to be formed without pressuration and to yield high strength. Optimum process conditions of the hybrid bonding were first explored. Then using the optimized bonding, the strength of the hybrid bonding using 20-C/Cs as substrates was evaluated up to temperatures of 2000 K. The strength of the hybrid bonding inCREASEd with rise in test temperature. This bonding strength enhancement at elevated temperatures was shown to be caused by crack-arresting effect by the presence of SiC within bonding layer and by the release of thermal mismatch stress between the bonding layer and substrate C/Cs.

CMC-10: Rotational Strength of C/SiC Composite Blisk Model
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The ceramic matrix composites (CMCs) are very hopeful for turbine materials of aircraft engines owing to both their high strength and high-