MEP-02: The Effect of Ultrasonic Vibration for the Machining with Non-rotating Tool
S. ITO, National Institute of Advanced Industrial Science and Technology, E-mail: Satoshi.ito@nii.aist.go.jp

The machining method using single cutting edge non-rotating tool can finish the work piece without the tool rotational direction scratch. However, the cutting speed is limited within the table feed speed. To increase the cutting speed, ultrasonic vibration was added on the cutting edge and the effect was examined. The ultrasonic vibration equipment was attached in the spindle head of a vertical type machining center. The vibration method was twisted type, vibration frequency was 27 kHz, and amplitude was range of 5 to 30 micrometers. Observations of oscillating state of the cutting edge during the machining showed that the amplitude was decreased sharply. Addition of vibration made the cutting force decreased and a surface roughness improved, especially during dry cutting process. Within moderate amplitude of ultrasonic vibration, the residual stress of the machined surface changed to direction of compression stress with the increase of amplitude. However, unlike cutting force or surface roughness, if the amplitude was too large, the residual stress changed to an opposite direction. For acquiring a good residual state stress, it is effective to use the machining conditions to reduce cutting force rather than adjusts tool vibration amplitude or tool rake angle.

MEP-03: Finite Element Investigation of Multi-Phase Transformation within Carburized Carbon Steel
S.H. KANG, Y.T. IM, Korea Advanced Institute of Science and Technology (KAIST), E-mail: yitim@kaist.ac.kr

Mechanical components for the automobiles, aircrafts and machines are required to have the higher strength, hardness and wear resistance, when these parts are generally subjected to the circumstance of high load and impact. Such mechanical properties can be obtained from the carburization and quenching processes. Thus, in this study, numerical investigation using three-dimensional finite element technique was made to simulate the carburization and multi-phase transformation processes within the carburized carbon steel during the quenching. In order to simulate the carburization process, the second Fick’s equation and carbon diffusion equation were adopted. For numerical simulation of the diffusional phase transformation occurred during the non-isothermal quenching process, subdivision of the cooling curve into various small isothermal steps was introduced with the help of various TTT diagrams of carbon steel. In addition, Shell’s additive rule and JMAK’s equation were also employed. On the other hand, Koistinen and Marburger’s equation was used to model the diffusionless transformation. Through numerical analyses of carburization and quenching processes, the temperature and volume fraction of each phase were predicted for simple cylindrical specimen and complex geometries considering the latent heat generated during phase transformation. The numerical results were compared well with the data available in the literature.

ICS-11: INTERFACES AND CONTACT SURFACE MECHANICS

ICS-07: An Analysis on Singular Fields around an Interface Edge of Ceramic/Metal Joints using Moire Interferometry Technique
L.K. SAMADDER, Y. ARAI, E. TSUCHIDA, Saitama University, E-mail: yara@mech.saitama-u.ac.jp

Characteristics of singular fields around an interface edge between ceramic and soft metallic interlayer were investigated experimentally and
theoretically. Displacement fields around the interface edge were measured by means of high-sensitivity moire interferometry. The slope of the log-log plot between the displacement and the coordinate in ceramic side decreased with decreasing the coordinate. The slope was in between 0.6 and 0.7. This slope is smaller than the predicted value using elastic/plastic materials interface edge theory which is calculated from the elastic modulus of silicon nitride and Cu. Intensification of stress concentration around the interface edge due to the plastic deformation of the interlayer was clearly observed experimentally and illustrated based on the analysis. The stress value near the interface in ceramic under the external stress of 273 MPa was about four times of the stress value at the same location under the external stress of 132 MPa which is only the half value of 273 MPa as an external stress. The reason of the different stress concentration between these external stress of 132 and 273 MPa is considered that the different scale of the plastic deformation around the interface edge gives the elastic singularity and the elastic/plastic singularity for each external stress. The linear hardening interface theory and the power-law hardening/rigid interface theory can predict smaller index of singularity compared with the elastic interface theory. The external stress level at which the elastic/plastic effects emerged in the experimental results coincided with the one at the evolution of the plastic zone in the interlayer especially along the interface. The yielding scale factor is considered to control the evolution of the elastic/plastic singularity around the interface edge through the plastic zone size along the interface.

ICS-08: Finite Element Stress Analysis and Strength Evaluation of Stepped-lap Adhesive Joint under Static Bending Moments
T. SAWA, Hiroshima University; K. ICHIKAWA, Yamanashi University; I. HIGUCHI, Kofu Josai High School, E-mail: sawa@mek.hiroshima-u.ac.jp

Stress distributions in stepped-lap adhesive joints of similar adherends subjected to static bending moments are analyzed using three-dimensional finite-element calculations. The effects of Young's modulus of the adhesive, adhesive thickness and number of steps on the stress distributions at the adhesive interfaces are examined in elastic range. As the results, it is found that the maximum stress occurs at the edge of the interface in the butted adhesive layer. It is observed that the stress component in the peel direction is highest among all the stress components. It is found that the maximum value of the stress decreases as the thickness of butted adhesive layer increases and as Young's modulus of the adhesive decreases. It is also observed the maximum value of stress decreases as the number of steps increases. For verification of the FEM calculations, the experiments were carried out to measure the strains in the joints using strain gauges and the joint strength. Fairly good agreements are observed between the numerical and the measured results.

ICS-09: Axisymmetric Stress Analysis and Strength of Bonded Shrink-fitted Joints of Solid Shafts subjected to Torsional Loads
T. SAWA, Hiroshima University; M. YONENO, Henkel Loclute (Japan) Corp., E-mail: sawa@mek.hiroshima-u.ac.jp

This paper deals with stress analysis and strength evaluation of bonded shrink fitted joints subjected to torsion. The stress distributions in the adhesive layer of bonded shrink fitted joints are analyzed by using the axisymmetric theory of elasticity when an external torsion is applied to the upper end of shaft. The effect of the outer diameter and the stiffness of rings on the interface stress distributions are clarified by the numerical calculations. Using the interface stress distributions, joint strength is predicted. In addition, joint strength was measured experimentally. It is seen that a rupture of adhesive layer is initiated from the upper edge of the interfaces when a torsion is applied to the upper end of shaft. The numerical results are in fairly good agreement with the experimental results. It is found that the joint strength of bonded shrink fitted joints is greater than that of shrink fitted joints.

ICS-10: Study on the Strength of GFRP/Stainless Steel Adhesive Joints Reinforced with Glass Mat
M. IWASA, Hitachi Ltd., E-mail: masaaki.iwasa.mp@hitachi.com

The adhesive strengths of glass fiber reinforced plastics/metal adhesive joints reinforced with glass mat under tensile shear loads and tensile loads were investigated analytically and experimentally. First, the stress singularity parameters of the bonding edges were analyzed by FEM for various types of adhesive joints reinforced with glass mat. The shear stress and normal stress distributions near the bonding edge can be expressed by two stress singularity parameters. Second, tensile shear tests were performed on lap joint and tapered lap joint reinforced with glass mat and tensile tests were performed on T-type adhesive joint and T-type adhesive joint reinforced with glass mat. The relationships between the loads and the crosshead displacements were measured. We concluded that reinforcing adhesive joints has a greater effect on strength under tensile load and under tensile shear load. The adhesive joints strength reinforced with glass mat can be evaluated using by stress singularity parameters.

ICS-11: Identification of Debond Size in Adhesively Bonded Lap Joint by Inverse Method
Y. NAKANO, Sazuka National College of Technology; M. KATSUO, Shonan Institute of Technology, E-mail: yutaka@astl-hyogo.ac.jp

This study deals with a method for identification of size of a debond which may be included in an adhesively bonded lap joint by the inverse analysis. Firstly, the joint which includes a debond is kept under some uniform temperature change and a thermal displacement distribution of an upper surface of the joint is measured simply using an electric micrometer. Secondly, the displacement distribution is obtained numerically from the initial assumptions of size and location of a debond using the two-dimensional thermal stress and distribution analysis. Finally, the size and location of a debond are determined inversely through minimizing the residual between the measured and numerically obtained displacements. By comparing the numerically estimated size and location of a debond with the corresponding measured ones, it is shown that the inverse method proposed in this study has an applicability for identification of a debond in an adhesively bonded lap joint.

ICS-12: Bonding Dissimilar Materials by Exposure to an H2O Ion Beam
Y. SETOMOTO, S. YAMASHITA, University of Hyogo; H. UEDA, K. ITOGAWA, Tokai Rika Co., Ltd.; T. HATTORI, University of Hyogo, E-mail: yutaka@astl-hyogo.ac.jp

The authors studied a bonding technology that uses an H2O ion beam to produce an OH radical on the materials to be bonded. This technology is useful for Microsystems since it does not require the materials to be heated to a high temperature or compressed to a high pressure and hence does not remarkably deteriorate the characteristics of the materials. To evaluate the usefulness of this technology, we prepared a specimen by producing an OH radical on a PTFE sheet and sputtering Cr on the sheet. Using this specimen, we measured the adhesion strength between the PTFE sheet and Cr layer. We also measured the difference in wetness and surface roughness of the PTFE sheet between the area exposed to the H2O ion beam and an unexposed area.

ICS-13: Thermal Stress Analysis of Multi-Layered Electronic Assemblies
M. KATSUO, Shonan Instutute of Technology; Y. NAKANO, Sazuka National College of Technology,