MONDAY, June 20

Coffee Break

Opening Address

8:30 a.m. - 9:15 a.m.
OTANI MEMORIAL LECTURE

Macroscopic and Microscopic Scale Effects in Mechanical Behavior of Materials

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Various simulation techniques are employed with using different scale models in practical engineering fields, including mechanical, thermal, electrical and other problems. The simulations can be analytical, numerical or experimental. It sometimes rises questions whether the simulation using different scale truly represent the actual engineering phenomenon. In some cases, the inconsistency arises due to the mechanical field change with changing scales, however, in some other cases, the simulation may not be valid even without changing the mechanical fields. There are also other problems that can be interpreted only by considering microscopic mechanism. In this paper, problems of scale effects are analyzed with the concept of macroscopic aspects and microscopic aspects in mechanics. Scale effects in various fields are studied, including deformation and fracture of materials and material processing. The mechanism of scale effects is analyzed and explained in each case. Non-dimensional method is introduced to meet the scale effect in actual problems.

9:15 a.m. - 10:00 a.m.
PLENARY LECTURE I

Composite Materials for the 787

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The 787 Program is defining the future of commercial transport aviation through its recent selection of advanced composite materials for the airframe structure. Although all composite airframe designs have been demonstrated on regional jets, many technical challenges are now being solved for the application of these materials more broadly to commercial transport class aircraft. The composite experience gained on the 777 empennage and previous airplane models has positioned Boeing to deliberately pursue composites more extensively on the 787 Program. Composite use on 787 primary structures includes the fuselage monocoque, outboard and center wing box, trailing edge structures and the empennage. The improved fatigue properties and corrosion resistance of composite materials enables Boeing to deliver an airplane with enhanced passenger experience such as a 6000ft cabin altitude and larger windows.

The 787 Program has set extremely aggressive cost and weight targets that dictate the need for innovation design and manufacturing solutions. Boeing is pursuing joint airframe and technology development activities with international partners capturing the experience and capabilities of a global supplier base. This presentation will discuss the design and manufacturing technologies that will enable Boeing to develop the 787 family of aircraft providing a new standard for airplane operational efficiency and market effectiveness.

10:30 a.m. - 12:00 noon

Room A

PMC-I: POLYMERS AND POLYMER MATRIX COMPOSITES

PMC-01: Making a Complex Three-dimensional Shape from Bamboo

O. YAMASHITA, H. YOKOCHI, Nagoya University; H. IMANISHI, K. KANAYAMA, National Institute of Advanced Industrial Science and Technology,

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The flow properties of air-dried and oven-dried bamboo powder were investigated by a capillary rheometer. Air-dried bamboo powder started to flow immediately after applying pressure in the range of 180-220°C while oven-dried bamboo powder required a certain amount of time to start flowing under the same condition. Heat pretreatment of oven-dried bamboo powder in open system decreased the fluidity. It suggests that oven-dried bamboo powder attributes its flow to its thermal decomposition product. Injection molding of bamboo powder was performed. A complex three-dimensional shape with smooth surface was obtained.

PMC-02: Evaluation of Interfacial Strength using Model Composites

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The validity of usage of a cruciform specimen as an evaluation method of interfacial strength is discussed. To avoid the stress singularity at the free edge, an experimental method which is similar to the cruciform specimen method is considered. Both experimental approach which uses a model composite and analytical approach which uses finite element analysis are employed to discuss the validity of the method.

PMC-03: On Statistical Strength Characterizations of Kenaf Bast Fibers with Variable Cross-Sectional Geometries and Mesoscopic Internal Structures (A Preliminary Numerical Investigation from 2-D FEM Approach)

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Recently kenaf (*Hibiscus cannabinus* L.) bast fibers (KBFs) have been using for one of the promising reinforcing agents of environmentally-friendly polymer composites. However, these kind of natural plant fibers usually exhibit large scatters in terms of their geometries and mechanical properties, and hence a margin of safety for products including such natural plant fibers will become unnecessarily large. In this study, in order to investigate factors affecting the fiber strength variation, a statistical finite element modeling framework by combining beam and solid elements was proposed for KBFs with variable cross-sectional geometries and so-called mesoscopic internal structures, and applied to the tensile stress analysis and statistical strength simulations for KBF monofilaments under tension. From the numerical results for stress distributions obtained by using a preliminary two-dimensional finite element method (2-D FEM) model, the mesoscopic internal structures in KBFs, which consist of elementary fibrous cells (EFC) and inter-cell material (ICM), were found to give rise to axial stress concentrations in EFCs and so-called free-edge shear stresses in ICM, both of which could initiate the fiber fracture. Furthermore, by applying two-parameter Weibull analysis to the numerical simulation data, the dependency of fiber strength and its initiating failure modes

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upon gauge length was also shown. From the present preliminary 2-D FEM numerical investigation, the mesoscopic internal structures of natural plant fibers were found to possibly affect the fiber strength statistical distributions as well as along- and among-fiber cross-sectional area variations, which implies a well-described distribution model for KBF tensile strength should take both of the geometrical variation and the mesoscopic internal structures into account.

PMC-04: Plastic Deformation Ability of High Strength Natural Fiber Green Composites

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It is expected that environment-friendly biodegradable composites reinforced by high strength natural fibers are widely used for industrial applications, preferably in place of glass fiber reinforced plastics (GFRP). However, since natural fiber strength is less than glass fiber strength, the purpose of this study is to create a new class of green composites, which cannot be exhibited by GFRP, especially in terms of toughness improvement. Ramie, one of the strongest fibers in cellulose-based natural fibers, was alkali-treated with and without load application to improve its brittleness. Biodegradable resin matrix composites reinforced by untreated and alkali-treated fibers, called natural fiber green composites, were fabricated using a press forming method. The result of tensile test of the composites showed that the alkali-treated fiber green composite increased its fracture strain twice to three times higher than the untreated fiber green composite. Especially, the alkali-treated fibers with load application changed the composite into high toughness property without loss of strength.

PMC-05: Development and Evaluation of Ramie/Starch FW Composites

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Although FRP are widely used due to the high mechanical properties and the environmental stability, traditional FRP cause environmental problem. In the present paper, biodegradable FW pipes were manufactured by using ramie fibers and starch resin. In order to evaluate mechanical properties of the FW pipes, tensile tests of single fibers, fiber strands, resin, unidirectional laminates and FW pipes were conducted. From the experimental results, it was found that the elastic properties of the FW pipes were almost same as the angle-ply laminates. Therefore our molding method of the pipes was appropriate to ramie/starch FW composites. From the circumferential tensile tests, it appeared that the tensile strength of 160 MPa was achieved for the parallel wound FW pipes.

PMC-06: Improvement of Interfacial Adhesion in Bamboo Polymer Composite Enhanced with Micro-Fibrillated Cellulose

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Current study presents one of effective techniques to improve mechanical properties of PLA (Poly-Lactic Acid)-based bamboo fiber composite. Commercially available Micro-Fibrillated Cellulose (MFC) obtained from wood pulp was applied as an enhancer to the composite. The bamboo fibers were extracted by steam explosion method and they were also rubbed in water to remove xylem (soft-wall cells). The liquid-based MFC, PLA and the bamboo fiber were mixed in water for several minutes and they were filtrated under vacuum pressure. To fabricate the composite, remained sheets were then hot pressed after dry. Three-point bending strength and Mode I fracture toughness of the composite were significantly improved, even when 10% of the MFC was added into the PLA/BF composite in weight. If small amount of MFC added into the bamboo fiber composite, tangled MFC fibers prevented the growth of micro crack

along the interface between bamboo fiber and matrix.

10:30 a.m. - 12:00 noon

Room B

CAS-I: ADVANCED CASTING

CAS-01: Semi-Solid Processing of A201 Aluminum Alloy

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Although thixoforming complex near net shaped products in aluminum alloys is now an established technology in many automotive applications, current developments are taking place in three fronts: in dynamic applications for load bearing components; in alloy development (expanding the existing portfolio of thixoformable alloys) and in materials recycling. Thixoforming has seen commercialization around existing alloy compositions based on the aluminum-silicon casting 356 and 357 alloys. A number of players (both commercial and academic/research) are undertaking research in order to expand the portfolio of existing commercial alloys. This work reflects on both traditional casting A356 and high strength A201 casting aluminum alloys.

CAS-03: High Speed Twin Roll Caster for Aluminum Alloy Thin Strip

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A high-speed twin-roll caster for aluminum alloy is presented. The roll-caster is configured vertically with a number of improvements that increase the casting speed, including a cooling slope for low-superheat casting, copper rollers without lubricant for more rapid cooling, and a nozzle in contact with the rollers to improve casting stability. The new caster is demonstrated to achieve continuous casting of thin (<3 mm) strips at speeds of 60 m/min using 6063 and A356 aluminum alloys with up to 5 wt% Fe as an impurity phase simulating recycled aluminum alloy. The cast strip has improved microstructural properties, reducing the deterioration of material properties due to the presence of impurities.

CAS-04: Analysis of Semi-solid Diecasting Runner-gate System as a Function of Solid Fraction

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The injection of alloys in the semisolid state, is highly effective in reducing casting porosity, particularly the one due to turbulences during die filling. On the other hand, the use of semisolid billet poses additional difficulties about either proper alloy re-heating and die design, especially runner and gate system. Obviously gates must be thicker than in traditional diecasting, because of the higher alloy viscosity, however no standards for a good die design are today available in the literature and each manufacturer refers to his own experience and know-how. The aim of this work is to evaluate the effect of the various runner and gate geometrical parameters on the filling pattern, taking also into account the influence of different solid fractions, not only those related to not properly controlled re-heating temperature, but also those typical of rheocasting technology. The study was carried out by means of a numerical simulation commercial software (Procast), considering a typical aluminum-silicon alloy (A356), whose thermo-fluid dynamics properties needed for simulation are mostly available. The results obtained will be subsequently used for the fabrication of an experimental die, for the production of dumb bell and toughness