flexural fatigue strength of CFRP quasi-isotropic laminates using PAN-based carbon fiber and epoxy resin is evaluated over a wide range of temperature and loading rate, and the applicability of time-temperature superposition principle for flexural fatigue strength of this CFRP laminates is discussed by comparing with the progress of deformation and damage of this CFRP laminates during fatigue tests under various loading rates and temperatures.

**P31: Effect of Production Conditions of Wood Powder on Bending Property of Wood Powder Molding Material Without Adhesive**

H. IMANISHI, N. SOMA, National Institute of Advanced Industrial Science and Technology (AIST); O. YAMASHITA, Nagoya University; T. MIKI, Kyoto Institute of Technology; K. KANAYAMA, National Institute of Advanced Industrial Science and Technology (AIST),

E-mail: h.imanishi@aist.go.jp

In order to consider the effect of production conditions of wood powder on the bending properties of wood powder molding material, wood was ground to powder under the conditions of different temperatures (25°C or 100°C) and moisture contents (0%MC or about 30%MC), then stick specimens were produced by injection molding method. The specimens were produced only from wood powder in the steam atmosphere of high temperature, high pressure (175°C, 900 kPa) using self-bonding ability of the wood powder. Adhesives, such as a synthetic resin, were not used. To evaluate the bending properties of the specimens, the modulus of elasticity and the bending strength were examined by static three-point bending test. In case of wood particle by grind under the condition of high temperature and high moisture content (100°C, about 30%MC), tendencies for intercellular layer to be exposed on surface of a particle and for aspect ratio of particles to be large were confirmed. And in that case, the specimen showed the highest value in modulus of elasticity and bending strength. It is highly probable that the improvement of the self-bonding ability of the wood powder and the increase of the aspect ratio take part in the improvement of the strength properties.

**P32: Relation between Impact Damage and Post Impact Fatigue Behavior of Quasi-isotropic CFRP Laminates**

T. KIMURA, H. TAKEUCHI, H. SAITO, I. KIMPARA, Kanazawa Institute of Technology,

E-mail: a6401311@venus.kanazawa-it.ac.jp

The durability of quasi-isotropic CFRP laminates of T800S/3900-2B under tension-compression cyclic loading is very important since it is assumed to be a wing structural materials. The effects of impact damage on fatigue characteristics were discussed based on observation of fatigue damage progress of impact-damaged coupon specimens in this study. It was observed that local buckling was caused at the edge of delamination by compression loading. It is important to notice that such out of plane deformation behavior leads to the reduction of fatigue life, because delamination growth and microbuckling caused by out of plane deformation often causes fiber breakage. On the other hand fatigue damage progression appeared to be classified into several types, and their fatigue lives were apparently different each other. Then from these difference in damage progress patterns, it was thought that damage progression behavior was affected greatly by initial damage caused by impact. Therefore the distribution of initial delamination was observed precisely by ultrasonic B-scope as well as C-scope in this study. It was shown that delamination in back side of specimens was larger than that of impact side and that back side delamination progressed due to fatigue loading.

**P33: Some Important Features of Inelastic Deformation Behavior of Solid Polymers and the Modeling Using Modified Overstress Approach**

Y. NAKAO, Kyushu Inoac Co., Ltd.; T. HIROE, S. MATSUMOTO, K. FUJWARA, H. HATA, Kumamoto University

E-mail: yuji.nakao@inoac.co.jp

Monotonic compressive loading and relaxation tests under constant and time-varying strain rate conditions of 1.1x10^-5 ~ 10^-2 and 10 ~ 40°C and cyclic loading tests basically under completely reversed strain controlled conditions were conducted for four kinds of semi-crystalline and amorphous solid polymers, polyethylene (PE), polypropylene (PP), polycarbonate (PC) and polyphenyl-ether (PPE). The observed stress-strain responses for monotonic loading were similar to those of metallic materials used at elevated temperature showing notable effects of the strain rates and temperature, but the results of such polymers revealed that the strain rate effects are correspond with the temperature effects based on the concept of time-temperature equivalence, and in the strain-rate change tests of amorphous polymers, PPE and PC appeared predominant overshoot phenomena during the stress transfer processes. The viscoplastic constitutive model based on overstress (VBO) applied to PPE successfully reproduced the observed stress-strain responses including the overshoot phenomena using a newly proposed additional function which control the viscosity in the model. The cyclic loading test results show that stress-strain hysteresis loops of solid polymers have a different shape than those of metallic materials. PE, PP and PC have a small acute angle between the tangents to the loading and unloading branches and PPE has a boomerang-like shape. This paper suggests a modification method, which enable the modeling of hysteresis loops with a cusp applying to simulate the cyclic motion behavior of PE in extensive experiments within the framework of the VBO model.

**P34: Compression Characteristics of Flexible Polyurethane Foam and Cell Structure**

H. TOKUHIRA, K. ISHIKAWA, Y. KOBAYASHI, Toyo University,

E-mail: michael.hastuki@hotmail.com

Flexible polyurethane foam with open-cell structure is an interesting material for the characteristics of compression behavior. The experiments were carried out on the several kinds of the foams to understand the relationship between the mechanical response and the structures. The compression behavior depended on the experimental conditions. The compression flow was proportional to the loading rate. The curve was parabolic at the initial stage, followed by the linear increase of the flow stress. Finally, the rapid increase of the flow stress was observed for the whole materials. The compression behavior resulted from the buckling of the cell wall. The rate dependence of the flow stress was explained by the viscoelastic properties of the foam. The cell structure was observed by SEM to evaluate the cell size and thickness. The decrease of the cell size brought the strong dependence of the loading rate on the flow stress. Furthermore, the unloading test was conducted to study the irreversible behavior of the foam. The hysteresis loop also depended on the experimental conditions. We will try to discuss the effect of those mechanical responses on the human sensitivity.

**P35: Development of Newly Designed Ultra-Light Core Structures**

T. NOJIMA, K. SAITO, Kyoto University,

E-mail: kazuya.saito@kxue.kyoto-u.ac.jp

Origami structures consisting of zigzagged faces have consolidation character as well as foldability/deployability function. We proposed 'Origami Kougaku (engineering)’ and envisaged the formation of a new origami technology discipline, proposing several new types of foldable/deployable structures. In this report, some strong and functional ultra-lightweight cores are proposed by origami technique; a thin flat sheet with periodically introduced slits or rectangular punched out portions is bent in a zigzag way into three dimensional structures. Core structures have often been used not only for the strong members but impact-resistant structures. In addition, these structures are able to act as good acoustic absorbers, noise insulators and heat retainers. They are aesthetically pleasing both architecturally and geometrically, displaying changeable shadow patterns created by the interplay of light with the...