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論 文 要 旨 （博士）

論文題目	Dimple fracture under short pulse impulsive loading （短パルス衝撃荷重下におけるディンプル破壊）

The technology needed for aerospace, other high-speed transportation, nuclear power plant and other huge structures have increased importance in study and investigation on the dynamic behavior of materials used for those structures. This work discusses, phenomenological by void nucleation and growth ahead of leading the crack dimple fracture in association with inclusion or second-phase particles based on microscopic observation. The main objective of this work is to investigate the effect of short pulse duration on dimple fracture. The experiments were carried out for 2017-T3, 6061-T651 and 7075-T651 aluminum alloys. The finite element analysis was also carried out to investigate the stress state ahead of the crack tip.

One-point bend method was employed to measure dynamic fracture toughness. It produced smoothly varying stress intensity histories with controlled amplitude and duration. A single edge-cracked specimen was loaded in bending without any support at the specimen ends, and an air gun impact apparatus was used to introduce the impulsive stress intensity in the specimen. When the specimen is subjected to an impulsive load at its midsection, the specimen is bent by its inertial effect. The stress intensity history was measured by a strain gage mounted near the crack tip and showed an approximate sinusoidal time dependence. The measured results in well agreed with the numerical analysis results by FEM to indicate the validity of the strain gage method for the measurement of dynamic stress intensity

The dependence of stress intensity amplitude and duration on the impact velocity, specimens, material and dimensions have been determined both analytically and experimentally. Twelve kinds of specimens having different configurations were loaded by one-point bending to generate the different durations of impulsive stress intensity pulses changing with the specimen length if specimen width was kept constant. Finally, the dimple fracture mechanisms have been discussed for the three kinds of aluminum alloys used in this work. Optical and scanning electron microscopic observations were used to study the dimple fracture. Void grow and coalescence can be easily identified as the fracture processes. The results are summarized as follows:

1) For 7075 aluminum alloy, the critical stress intensity for crack initiation increases gradually with an increase in loading rate from quasi-static loading to 40 μsec and a tremendous rise is observed when stress intensity pulse duration decrease to 20 μsec. Whereas, for 2017 aluminum alloy when the loading rate increase from quasi-static loading to 100 μsec stress pulse duration the critical stress intensity decreases remarkably. However, for both 6061 and 7075 aluminum alloys, the critical stress intensity under 100 and 80 μsec, were close to the quasi-static value.
2) Microscopic observations of the fracture surface by SEM indicated the existence of a dominant void ahead of the crack tip. Measured results of dominant void distance from the crack tip for 2017 aluminum alloy under 25 μsec stress intensity pulse duration is more close to the crack tip than the 50 and 100 μsec pulse durations. It is due to the closely plane stress condition in 25 μsec and plane strain condition in 50 and 100 μsec cases. It means dominant void coalescence depend upon the inclusion site as is the case for 6061 and 7075 aluminum alloys.
3) Measured results of the dominant void size depend upon stress pulse duration. This is especially valid for 2017 and 6061 aluminum alloy at stress intensity of 25 μsec.
4) The hydrostatic stress ahead of the crack tip and the inclusion's average spacing can provide an exact anticipation of a dominant void position.
5) Void nucleation, growth and coalesce take place in different modes depending on local condition. Second-phase particles or inclusions in the materials determine the local conditions.