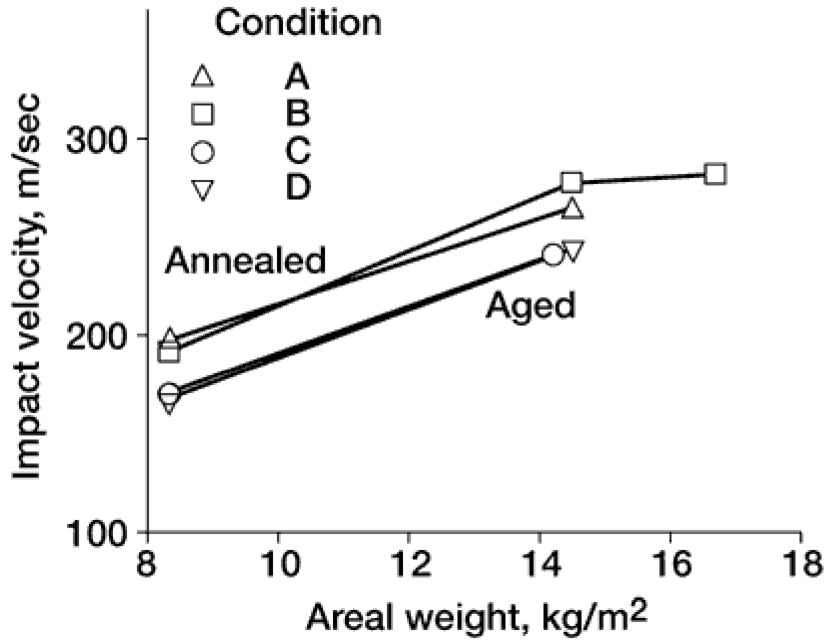
Effects of Various Heat Treatments on the Ballistic Impact Properties of Inconel 718 Investigated

Uncontained failures of aircraft engine fan blades are serious events that can cause equipment damage and loss of life. Federal Aviation Administration (FAA) certification requires that all engines demonstrate the ability to contain a released fan blade with the engine running at full power. However, increased protection generally comes at the expense of weight. Proper choice of materials is therefore imperative to an optimized design. The process of choosing a good casing material is done primarily through trial and error. This costly procedure could be minimized if there was a better understanding of the relationships among static material properties, impact properties, and failure mechanisms. This work is part of a program being conducted at the NASA Glenn Research Center at Lewis Field to study these relationships. Ballistic impact tests were conducted on flat, square sheets of Inconel 718 that had been subjected to different heat treatments. Two heat treatments and the as-received condition were studied. In addition, results were compared with those from an earlier study involving a fourth heat treatment. The heat treatments were selected on the basis of their effects on the static tensile properties of the material.

The impact specimens used in this study were 17.8-cm square panels that were centered and clamped over a 15.2-cm square hole in a 1.27-cm-thick steel plate. Three nominal plate thickness dimensions were studied, 1.0, 1.8, and 2.0 mm. For each thickness, all the specimens were taken from the same sheet of material. The projectile was a Ti-6Al-4V cylinder with a length of 25.4 mm, a diameter of 12.7 mm, and a mass ranging from 14.05 to 14.20 g. The projectiles were accelerated toward the specimens at normal incidence using a gas gun with a 2-m-long, 12.7-mm inner-diameter barrel. The ballistic limit for each heat treatment condition and thickness was determined by conducting a number of impact tests that bracketed as closely as possible the velocity required to penetrate the specimen.

We found that both the static and impact properties as well as the failure mechanisms of Inconel 718 can be changed significantly by varying the heat treatment. Under the conditions used in this study, softer annealed material performed dramatically better in ballistic impact tests than harder annealed and aged material (see the figure). Micrographs indicated highly localized areas of large shear deformation in impacted aged specimens. In the annealed material, the deformation was not as localized. Future studies will attempt to determine what specific material properties have the greatest influence on impact properties.



Ballistic limit of Inconel 718 as a function of areal weight and heat treatment.

Glenn contacts: Dr. J. Michael Pereira, (216) 433–6738, J.M.Pereira@grc.nasa.gov; and Dr. Bradley A. Lerch, (216) 433–5522, Bradley.A.Lerch@grc.nasa.gov

Authors: Dr. J. Michael Pereira and Dr. Bradley A. Lerch

Headquarters program office: OAST

Programs/Projects: HSCT