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Self-healing of machined cracks by wheel grinding and resultant high-temperature mechanical properties in Si_3N_4/ SiC composite ceramic

Young-Soon Jung[1], Wataru Nakao[2], Koji Takahashi[2]
Kotoji Ando[2] and Shinji Saito[3]

Summary

Silicon nitride based ceramics and composites have many industrial applications because of its excellent mechanical properties; such as thermal, wear, corrosion resistance and high-temperature strength. However, structural ceramics are brittle and sensitive to flaws. The machining process pays attention not to introduce large machining cracks. As a result, machining costs become expensive. To overcome the disadvantage, crack-healing could be the attractive method. Many structural ceramics have self-crack-healing ability, e.g., Si_3N_4/ SiC, Al_2O_3/ SiC, SiC, and Mullite/ SiC composite ceramics. They can completely heal median cracks introduced by the Vickers indentation. In this study, crack-healing behavior of the randomly introduced machining cracks by a heavy machining was investigated for Si_3N_4/ SiC composite.

The samples were prepared by hot-pressing a mixture of Si_3N_4 powder with 20 wt.% SiC powder and 5 wt.% Y_2O_3 +Al_2O_3 as an additive powder. The hot-pressed plates were cut into 3 mm $\times$ 4 mm $\times$ 22 mm rectangular bar specimens. A semi-circular groove was made at the center of the specimens using the #230 diamond-coated wheel grinding. The machining cracks were introduced at the bottom of the groove during machining. The as-machined specimens were healed at 1473- 1673 K for 1 or 10 h in air, systematically. The bending strengths of specimen were measured by the three-point bending system with a span of 16 mm and a crosshead speed of 0.5 mm/min. The high-temperature strengths and fatigue strengths of machined specimen healed were measured at temperatures range from 873 K to 1573 K in air.

From the strength recovery behavior as a function of crack-healing temperature and crack-healing time, the optimized crack-healing condition of the machined specimen was determined to be 1573 K and 1 h. The average bending strength of the smooth specimens healed at 1573 K for 1 h was 1050 MPa, and the average bending strength of as-machined specimens was 460 MPa. By heat-treatment at 1573 K for 1 h in air, the average bending strength of the machined specimens

[1]Graduate Student, Yokohama National University, e-mail: d06sa691@ynu.ac.jp
[2]Yokohama National University, Department of Energy and Safety Engineering, 79-5, Tokiwadai, Hodogaya, Yokohama, Japan
[3]NHK Spring Co., Ltd.,Research and Development Division, 3-10, Fuhuura, Kanazawa, Yokohama, Japan

was significantly increased up to 1030 MPa, corresponding to 98 % strength of the smooth specimen healed. Moreover, the bending strengths and fatigue strengths of the machined specimen healed at optimized condition shown the same high-temperature behavior to that of the base-material from room temperature to 1573 K. These results demonstrated that the crack-healing was very useful method to reduce machining costs and to increase reliability of the Si_3N_4/ SiC composite ceramic.