3차원 균열의 세라믹 원판에 대한 응력해석
Stress Analysis for Ceramic Disk of 3D Crack

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1. Introduction

Crack resistance is important to the structures can be destroyed under statics and dynamic load as well as to the ceramic products under extreme mechanical load and thermal load. As a ceramic and ceramic composite material of single crystal, poly crystal and glass, etc. with pin hole and pore have high strength, thermal conductivity in contrast to low density, they have been applied for cutting tools, machine parts, structural elements for heat-resistance machine and functionality for electronic component devices, etc. But in addition to the metallic material, ceramic and ceramic composite materials have been pointed out low resistance an brittle issue by against mechanical impact or thermal impact. To work out a solution of this issue for a long time, many experts in a variety of ways have been participating in the development for process technology and composite materials.[1].

To put a ceramics as industrial materials to practical use and material development, accurate analysis ways for the fracture characteristics has not to make in structural and functional but a lot of studies also shall be conducted for the reliable assessment. Therefore, to get high strength material design variables while keeping light weight, this study derives the modulus of elasticity for ceramic disk with elliptical crack pore and performs fracture behaviors assessment appling the modulus of elasticity derived and MSST techniques to compare with test data.

2. Analysis

In case of porous materials like a ceramic, the modulus of elasticity and stress-strain curve change variously by pore coefficient, η(0.1-0.45)[2]. In case of the ceramics, an experimental coefficient b quoted 3.5. At this point, each modulus of elasticity obtained from the test in porous and brittle materials as equation (1). Poisson's ratio applied 0.2 for the brittle materials[3].

$$E_{(\eta=0)}e^{-b\eta} \qquad (1)$$

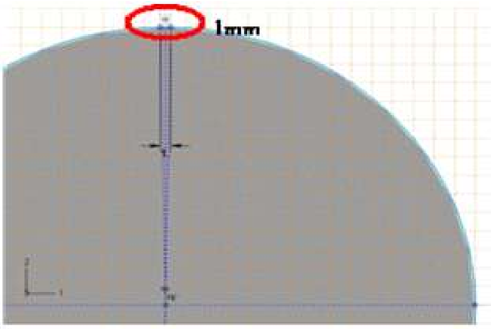

Fig. 1 The disk model with surface (1mm3mm) for FEM

Prior to simulation performing, we made very small area to contact between disc and anvil for the analysis stability as shown Fig. 1. In addition, boundary conditions of contact area between anvil and disc was restricted to one direction behavior based on the structure analysis and static load. We inflicted load of 20kgf, 40kgf on the anvil pressing the disc. The elements for the analysis are 8 nodes brick elements. When the load of 40kgf is inflicted on the disc in a same boundary conditions, Fig. 2, 3 showed the distribution of stress component occurred to the y-axis direction. The compressive stress of 16.6MPa was occurred at half-elliptical crack in the center of disc to y-axis direction and compressive stress of 64.3MPa was concentrated on the contact area between anvil and disc.

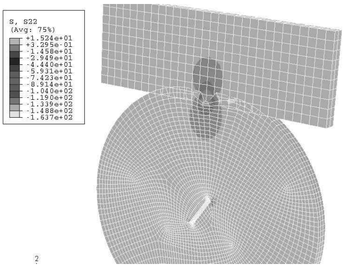

Fig. 2 Distribution of stress components on S22 under 40kgf

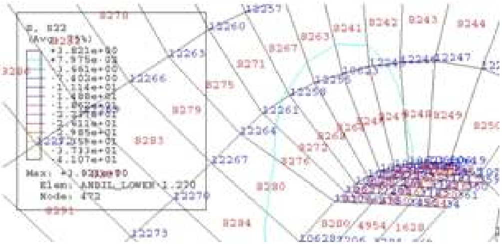

Fig. 3 Nodes and elements of crack on S22 under 40kgf

	Crack area[MPa]	Contact area[MPa]
S11	-1.4	-34.6
S22	-16.6	-64.3
S33	0.1	-8.6
S12	0.01	-3.3
S23	-0.01	1.3
S13	0.6	0.1

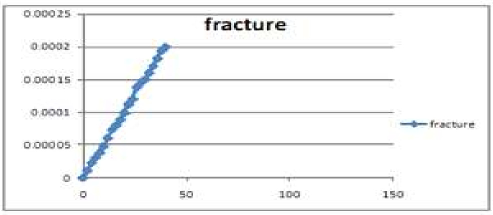

Fig. 4 Fracture curve for test under 40 kgf

3. Assessment Result for the Fracture Behavior

In the analysis result of stress factors, stress values to the S11, S22 direction had the most real impact factor, stress values to others occurred less. Stress factor in the S22 direction has to be large as a matter of course, it was able to ascertain stress state by Mohr Circle created. As we demonstrated, stress was concentrated on the 744(crack area) and 7665(contact area) most significantly and to assess fracture on the maximum stress area, we found out fracture status from MSST (Maximum Shear Stress Theory) fracture[4].

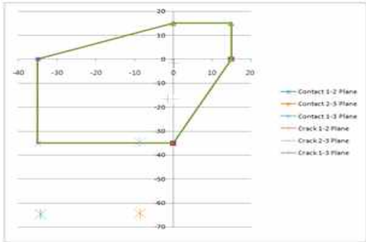

Fig. 5 Maximum principal stresses under 40 kgf by MSST

4. Conclusion

As a result of fracture behavior assessment based on the MSST theory, if stress is greater than fracture strength of material, it showed high probability of occurring of the shear fracture when fracture strength is 35 MPa. And it is capable to calculate its error, 8 %, as experiment and simulation result is compared.

As the above assessment, the material having excessively large porosity is lighter but less strong. To avoid fracture behavior it is important to assess the disk with crack and pore through simulation.

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