SIMULATION OF FRACTURE SURFACES BY POWER SPECTRUM FRACTAL MODEL

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Abstract:

Evaluation of hydraulic properties of subsurface fractures is very important in various engineering application such as the underground disposal of high level radioactive wastes, the geothermal energy extraction and the development of underground fluids like hydrocarbon and groundwater. Borehole Radar is an electromagnetic tool that can determine subsurface fracture location and orientation depending on the change of electrical conductivity and dielectric permittivity of the subsurface fracture properties. But, it has some limitation for measuring deeper objects due to high attenuation of electromagnetic waves. To overcome this problem, we developed a new full electromagnetic polarimetry subsurface system for this purpose.

To analyze the full polarimetry data and results we have to understand some behaviors of electromagnetic scattering due to fracture characteristics. So, we created fracture surface using power spectral method as simulated surface with determined surface roughness and highest and lowest spatial frequency of this surface.

$$h(k_x, k_y) = C / \left(\sqrt{k_x^2 + k_y^2}\right)^{(\beta+1)} e^{j2\pi\phi}$$

$$h(x, y) = F^{-1}[h(k_x, k_y)]$$

C : proportional constant.
β : the fractal dimension.
k_x, k_y : spatial frequencies.
$h(k_x, k_y)$: power spectral density.
ϕ : random phase number [0 1]
F^{-1} : 2D inverse Fourier transform
$h(x, y)$: 2D fracture surface height.

from the previous first equation we can derive the fracture aperture surface after taking the inverse 2 D Fourier transform $h(x, y)$ for the power spectral density $h(k_x, k_y)$.

FDTD simulation for the created fracture aperture surface will be used then for understanding the exact behavior of electromagnetic wave scattering due to different fracture surface characteristics.

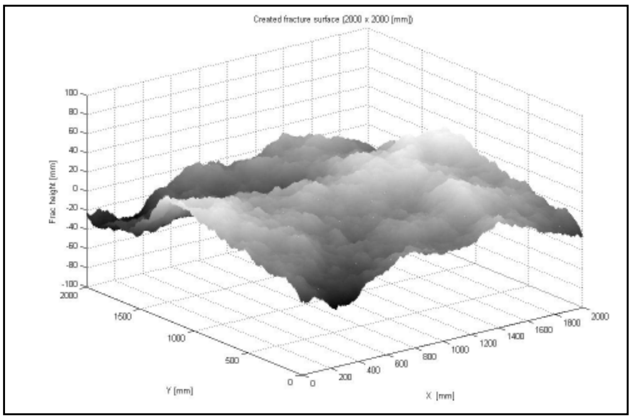

Figure1.Created fracture surface with size 2000 x 2000 mm (dx=4 mm).

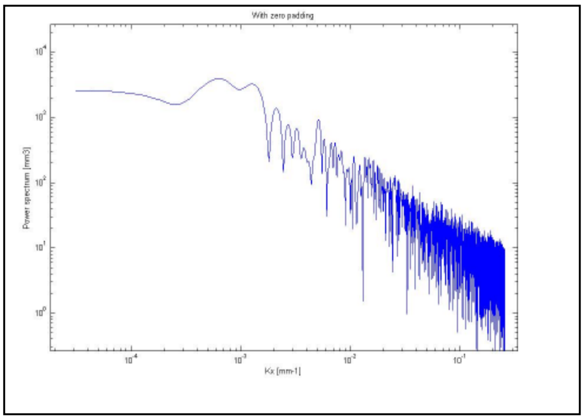

Figure2.Power spectrum density profile of a selected 1D surface topography.