Poroelastic Solutions for Spherical-Tip Indentation (#7870)

A method for addressing current challenges in characterizing poroelastic materials

This method for characterizing poroelastic materials addresses the mathematical difficulties involved with solving the complex system of equations that need to be accounted for, including the compressibility of both solid and liquid. Georgia Tech's approach advances the promise of using poroelastic indentation with rigid tools as a versatile experimental technique for better understanding the properties of such materials. The method enables researchers to interpret experimental data more readily through use of a spherical indentation tool (either permeable or impermeable) aided by force sensors and processors that direct the tool to indent the material to a predetermined depth and record the force data and elapsed time. The improved characterization technique can potentially improve design protocols for a range of applications in Earth resources engineering, including hydraulic fracturing, reservoir production, geothermal recovery, carbon dioxide storage, and more.

Benefits/Advantages

- **Robust**: Provides a rigorous theoretical base that takes into account poroelastic coupling and the effects of Poisson's ratio as well as the compressibility of both fluid and solid phases on force relaxation
- **Intelligent**: Can be used with sensors and processors to automatically direct an indentation tool and record pertinent data
- **Flexible**: Accommodates both permeable and impermeable indentation tools
- **Enabling**: Fulfills the promise of material indentation as a valuable experimental and evaluative technique by addressing current characterization challenges

Potential Commercial Applications

- Hydraulic fracturing for oil and gas recovery
- Geotechnical engineering
- Geothermal recovery
- Carbon dioxide storage

Background/Context for This Invention

The process of indentation using rigid tools has been widely studied for its versatility as an experimental technique to better understand the properties of poroelastic materials. In particular, spherical indentation

has been applied to characterize poroelasticity of fully saturated porous media, such as polymeric gels and hydrated bones, via either displacement- or force-controlled tests. However, challenges with the complexity of the mathematical equations have limited the full realization of these methods. Georgia Tech's method is an improved material characterization technique that takes into account the compressibility of both the fluid and solid phases and extends previous characterization methods to general poroelastic media.

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More Information

International Application Filed - WO 2019/204452 A1

Publications

Poroelastic Response of Spherical-tip Indentation, 52rd U.S. Rock Mechanics/Geomechanics Symposium, 17-20 June 2018

Poroelastic response of spherical indentation into a half space with a drained surface via step displacement, International Journal of Solids and Structures, 15 June 2019

Poroelastic response of spherical indentation – step displacement loading, 53rd U.S. Rock Mechanics/Geomechanics Symposium , 23-26 June 2019

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/poroelastic-solutions-spherical-tip-indentation

Images:

The automated sequential delivery of multiple fluids. A varying number of delay gates imprinted in the branches are shown in the figure.

COVID-19 and flu saliva test on paper: (A) The automatic sequential delivery of multiple reagents required for virus test; (B) Water pouring into the device triggers the virus assay, allowing the presence of SARS-CoV-2 and influenza A & B viruses to be visually identified by the color changes in the corresponding detection spot