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Waves on a Hele-Shaw Cell: Simulations of Acoustic Emissions During Aerofracture

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In this work, we develop a numerical model to explain the lab scale experimental setup [1] modeling the aerofractures in a porous medium. The mentioned experimental setup consists in a rectangular Hele-Shaw cell with three closed boundaries and one semi-permeable boundary which enables the flow of the fluid but not the solid particles. During the experiments, the fluid (pressurized air) is injected into the system with a constant injection pressure from the point opposite to the semi-permeable boundary. At the large enough injection pressures, the fluid also displaces grains (80 μm grain size) and creates channels and fractures towards the semi-permeable boundary. This analogue model is developed in a linear geometry, with confinement and at a lower porosity to study the instabilities developing during the fast motion of a fluid in dense porous materials: fracturing, fingering, and channeling.

Different sources of the signal (air vibration in the carved area, changes in the effective stress due to fluid-solid interactions [2]) are separately analyzed and are investigated further using a far field approximation of Lamb waves presented by Goyder & White [3]. In the analysis phase, power spectrum of different timewindows (5 ms) obtained from the recorded signal are computed. Then, the evolution of this power spectrum is compared with the experimental findings. In the power spectrum, it is possible to see some characteristic structure like peaks in specific frequency ranges. These “peaks” are strongly influenced by the size and branching of the channels, compaction of the medium, vibration of air in the pores and the fundamental frequency of the plate. We found that, in the synthetic dataset, the peaks in the low frequency range ($f < 20$ kHz) diminishes while the medium fractures as suggested in experimental work.

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