Contribution ID: **497** Type: **Oral Presentation**

Physical models for fracture flow tests by 3D-scanning and -printing

Tuesday, 23 May 2023 14:15 (15 minutes)

Visual observation of flow and transport processes in fractures require transparent replicas. Quite easily realized are parallel plate models which pose only a quite rough approximation and require certain geometric conditions /TSA 87/. A better representation can be gained by impressions from real fractures, either by forming the free space, a common technique (e.g. /PER 95/) but rather effortful, or by epoxi imprints of the fracture surfaces (e.g. /WIN 20/). Accurate surface measurements and determination of contact pressures indicate, though, that several imprints of the same locations may show significant differences /STI 20/.
A rather new class of transparent physical models has been made possible with the introduction of reasonably accurate 3D-printers. Hydraulic tests with principle models of single fractures as well as DFNs have been established quite early (e.g. /ISH 19/, /SUZ 17/). Realistic single fracture replicas still pose a problem, though.
Three steps are required for the production of a fracture replica by this method:
1. 3D-scanning of the fracture surfaces
2. Preparation of a printable digital model of the fracture
3. Printing out the digital model
This procedure has a lot of appeal as it rather elegantly avoids the problem of air enclosure and bubble evolution between resin and fracture surface. Moreover, it is possible to add features to the digital model that facilitate hydraulic tests such as connectors to inflow and outflow tubes. The method allows even for repeating destructive tests. Since it was intended to cover the whole production process of this method, a 3D-scanner as well as a 3D-printer have been acquired accordingly.
However, new challenges appear also at all three stages of production. One obvious point is the accuracy. The coordinates of a fracture surface can of course only be sampled at a limited number of scanning points. On the same scale, also the dimensional accuracy of the 3D-Printer is restricted. Less evident is the problem of alignment of the two fracture surfaces. Snapping points at a distance of less than one millimetre have been found in a printed fracture of a 7 x 10 cm size, suggesting a possibly serious impact on the aperture distribution by misalignment. Another point concerns the general ability of plastics to take up water. This phenomenon affects printed resin material to a considerable extent in that weight and size change with time. Details and solutions to these problems are addressed in the present paper.
In closing, the repeatability of an actual tracer test in a printed fracture replica is investigated. The experimental setup consists of an upper and a lower part. Transport of a colored solution in the fully water-filled replica has then been observed with an industrial camera and repeated three times. Grayscale images were acquired every 10s. The post-processing includes a segmentation of each image and a statistic evaluation for all pixels. This statistic provides information for each pixel stating with which probability there was tracer measured at this spot or not.

Participation

In-Person

References

/ISH 19/ Ishutov, S., Hasiuk, F. (eds.): Special Issue on 3D Printing.Transport in Porous Media, Volume 129, Issue 2, Springer, 2019
/PER 95/ Persoff, P. and Pruess, K.: Two-Phase Flow Visualization and Relative Permeability Measurement in Natural Rough-Walled Rock Fractures. Subsurface Hydrology, vol. 31, issue 5, pp. 1175-1186, 1995. DOI: https://doi.org/10.1029/95WR00171
/STI 20/ Stigson, M.: POST II. Presentation on the 38th Meeting of the Task Force on Groundwater Flow and Transport of Solutes, Berlin, 2020.
/SUZ 17/ Suzuki, A., Watanabe, N., Li, K., Horne, R. N.: Fracture network created by 3-D printer and its validation using CT images, Water Resour. Res., 53, 6330–6339, 2017. doi:10.1002/2017WR021032
/TSA 87/ Tsang, Y.W. und Tsang, C.-F.: Channel Model of Flow Through Fractured Media. Water Resources Research, Vol. 23, No. 3, pp. 467-479, 1987.
/WIN 20/ Winberg-Wang, H.: Water density impact on water flow and mass transport in rock fractures. Doctoral Thesis, KTH Royal Institute of Technology, School of Engineering Sciences in Chenistry, Biotechnology and Health, Department on Chemical Engineering, Stockholm, 2020.

MDPI Energies Student Poster Award

No, do not submit my presenation for the student posters award.

Country

Germany

Acceptance of the Terms & Conditions

Click here to agree

Energy Transition Focused Abstracts

Primary authors: KRÖHN, Michael (GRS gGmbH); KRÖHN, Klaus-Peter (GRS gGmbH)

Presenter: KRÖHN, Michael (GRS gGmbH)

Session Classification: MS03

Track Classification: (MS03) Flow, transport and mechanics in fractured porous media