Upscaling Surface Roughness In Porous Media: From Pore To Core And Beyond

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Abstract

Objectives/Scope: Modeling of surface roughness effect on NMR T2 relaxation is a challenging issue. Previous works successfully modeled the surface roughness of disconnected pore structures with an arbitrary shape and moderate complexity, yet rarely consider the surface roughness over the entire core plug model. This work proposes a practical way to upscale surface roughness from the pore scale to the core scale.

Methods, Procedures, Process: This work aims to populate pore-scale surface roughness to the entire core sample. The proposed workflow includes three steps. First, a two-level pore separation algorithm is used to create disconnected pore structures, reducing the complexity of the shape description problem. We then leverage spherical harmonics to model pore-scale surface roughness and parameterize it as a dimensionless number. We will sample the representative surface roughness in terms of the distribution of shape factor and populate an average value for each type of pores.

Results, Observations, Conclusions: The accuracy of the proposed upscaling scheme is validated by comparing the NMR T2 relaxation time obtained from numerical simulation and laboratory experiments. The surface roughness effect is not generally considered in the NMR T2 relaxation simulation, thereby leading to a faster relaxation behavior. It is also worth noting that the pore separation algorithm plays a critical role in the proposed method, as it is very challenging to directly model the surface roughness of the interconnected pore space. However, even with a proper division, the pore separation step inevitably creates some artificial cross-section(s), resulting in an overestimation of surface roughness. Therefore, it is important to identify the location of artificial roughness and remove it from the subsequent calculation. In the end, sampling representative surface roughness in terms of the shape factor will better estimate the overall roughness.

Novel/Additive Information: We developed an innovative approach to upscale pore-scale surface roughness to the entire core sample. The proposed method extracts representative roughness textures, eliminates the contribution of artificial cross-sections, and populates averaged roughness to the corresponding pore category. This provides a technologically feasible way to simulate the variation of surface roughness effect in space on NMR T2 relaxation with good accuracy.