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Editorial

Advances in Modelling of Heat and Mass Transfer in Porous Materials

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Porous materials are used across a huge array of applied sciences and engineering disciplines.

From biology to geoscience, chemistry to materials science and civil engineering to environmental engineering, the research of porous media represents a remarkable issue. The understanding of the relationships between structures and properties symbolise an ultimate step for traditional and advanced applications as in chemical, food, petroleum, gas, and nuclear industries.

Thanks to their significance and prevalence, the investigation of transport phenomena in porous materials has emerged as a distinct field of study. Transport phenomena, comprehended from the microscopic scale upward, encompass the general theories behind flow and transport in porous media and form the basis of deterministic and stochastic models that describe them. Research in the area generally evaluates the role of porous media in single and multiphase fluid flow, solid particle motions, heat conduction and convection, and electrical and acoustical transport along with their biomolecular and chemical composition.

This special issue has been dealt in seven high quality papers that focused on theory and simulation in an endeavour to advance the understanding of heat and mass transfer in porous materials, especially as a function of their structure and properties.

The paper proposed by H. Singh and R. S. Myong, titled "Critical Review of Fluid Flow Physics at Micro- to Nano-Scale Porous Media Applications in the Energy Sector," pronounces the gas and liquid flow at micro- and nano-scale and identified critical gaps to improve fluid flow modelling in four diverse applications related to the energy sector. The review for gas flow is primarily focused on gas flow at rarefied conditions, the velocity slip and temperature jump conditions. The review for liquid flow bestows fundamental flow regimes of liquid flow and liquid slip models as a function of key modelling parameters.

M. O. Dominguez et al., in the paper entitled "Modeling of the Growth Kinetics of Boride Layers in Powder-Pack Borided ASTM A36 Steel Based on Two Different Approaches" made use of two mathematical approaches for determining the value of activation energy in the Fe_2B layers on ASTM A36 steel during the iron powder-pack boriding in the temperature range of 1123–1273 K (treatments times between 2 and 8 h). The first approach was based on the mass balance equation at the interface (Fe_2B/substrate) and the solution of Fick's second law under steady state (devoid of time-dependent). The second approach was based on the same mathematical principles as the first approach for one-dimensional analysis under non–steady state condition. The measurements of the thickness (Fe_2B), for different temperatures of boriding, were used for the calculations. Consequently, the boron activation energy for the ASTM A36 steel was estimated to be 161 $kJ \cdot mol^{-1}$. This value of energy was compared for both models and other literature data. Experimental tests for characterising the Fe_2B layers grown on ASTM A36 are carried out by X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy dispersive X-ray spectroscopy (EDS). Finally, the experimental value of the Fe_2B layer's thickness obtained at 1123 K with exposure times of 2.5 h was compared with the predicted thicknesses by using these two approaches. A good agreement between the experimental data and the simulated results has been noted.

Y. Luo et al., in the work titled "Longitudinal Reservoir Evaluation Technique for Tight Oil Reservoirs," studied pore structure at microscopic scale, fluid occurrence conditions, start-up pressure gradient, and the content of clay minerals in the longitudinal direction of tight reservoirs. Each parameter signified a physical property of the reservoir. These parameters were independent of each other and did not affect each other, so the assessment results obtained in this way were objective. The longitudinal evaluation method for tight reservoirs was proposed, and the optimal development mode was selected in accordance with the reservoir assessment results.

The paper titled "Molding of Polymeric Composite Reinforced with Glass Fiber and Ceramic Inserts: Mathematical Modeling and Simulation" by T. R. N. Porto et al. carried out a numerical study of a polymer composite manufactured by using liquid composite material moulding. Simulation, by using the Ansys FLUENT®, of resin flow into a porous media constituted by fibre perform (reinforcement) inserted in a mould with pre-allocated ceramic inserts has been done. Results of resin volumetric fraction, stream lines, and pressure distribution inside the mould and mass flow rate (inlet and outlet gates) of the resin, as a function of filling time, have been presented and deliberated. Results indicate that the number of inserts affects the filling time, whereas the distance between them has no influence on the process.

X. Zhu et al. proposed a paper titled "Entire Process Simulation of Corrosion due to the Ingress of Chloride Ions and CO_2 in Concrete" and studied a comprehensive mathematical model capable of simulating the entire corrosion process of reinforcement in concrete. The mutual effect of carbonation and chloride ingress has also been deliberated in the mass transport module. Nonuniform corrosion distribution has been employed for studying the mechanical damage in concrete. The association of ABAQUS with MATLAB has been adopted for the numerical implementation of the developed model. The numerical results of an illustrative example designate that the depassivation time of reinforcement, corrosion rate and expansion displacement, and cracking pattern of concrete can be precisely predicted.

The paper entitled "Effect of Seepage Velocity on Formation of Shaft Frozen Wall in Loose Aquifer" by J. Lin et al. addressed the difficult closure of a frozen wall in a coal mine shaft owing to excessive seepage velocity in an aquifer when the aquifer is penetrated via artificial freezing method. Based on hydrothermal coupling theory and bearing in mind the effect of diminished absolute porosity on seepage during the freezing process, a mathematical model of hydrothermal full parameter coupling with a phase change is created. A shaft is used as a prototype and COMSOL multi-physics finite element software is used to perform a numerical simulation of the shaft freezing process at numerous stratum seepage velocities. The numerical simulation results are substantiated via a comparison with field measurement data. Based on the numerical simulation results, the impact of various underground water seepage velocities on the artificial frozen wall formation process with the seepage temperature field coupling effect is investigated. Based on the analysis results, the recommended principles of the optimization design for a freezing plan are described as follows. Firstly, the downstream area is closed to enable the water insulation effect. Secondly, the closure of the upstream area is accelerated to diminish the total closure time of a frozen wall.

B. Wang et al. proposed a work titled "Study on the Formation Law of the Freezing Temperature Field of Freezing Shaft Sinking under the Action of Large-Flow-Rate Groundwater." It testified a numerical model of hydrothermal coupling using laws of conservation of energy and mass. The model is substantiated by the results of large-scale laboratory tests. By applying the numerical calculation model to the formation of artificial shaft freezing temperature fields under the action of large flow groundwater, we conclude that groundwater with flow rates of less than 5 m/d will not have a substantial impact on the artificial freezing temperature field. The maximum flow rates that can be handled by single-row freezing pipes and double-row freezing pipes are 10 m/d and 20 m/d, respectively, during the process of freezing shaft sinking. By analysing the variation of groundwater flow rate during freezing process, we found that the groundwater flow velocity can reach 5–7 times the initial flow velocity near the closure moment of the frozen wall. Finally, in the light of the action characteristics of groundwater on the freezing temperature field, we made recommendations for optimal pipe and row spacing in freezing pipe arrangement.

Conflicts of Interest

The editors declare that there are no conflicts of interest regarding the publication of the special issue.

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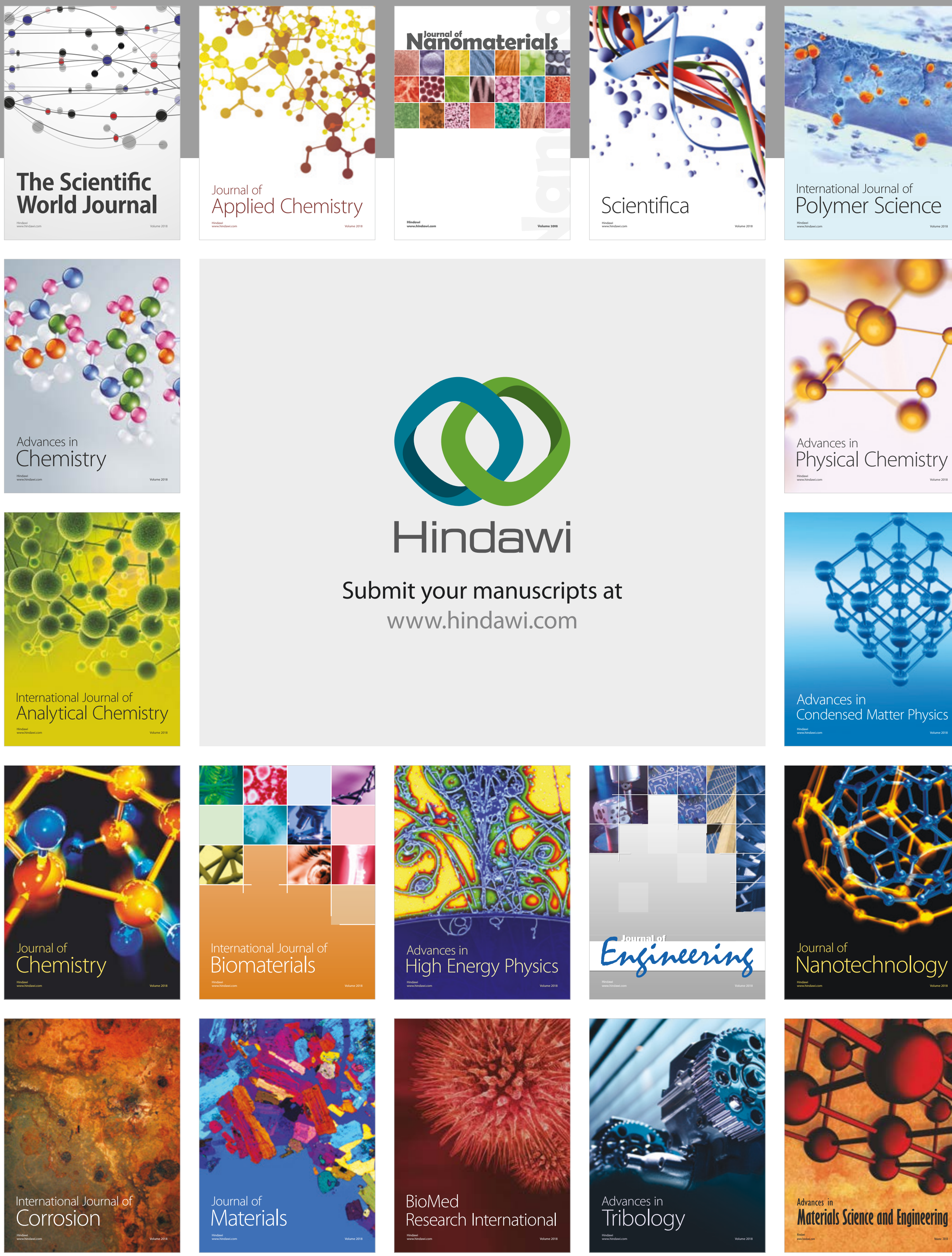
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