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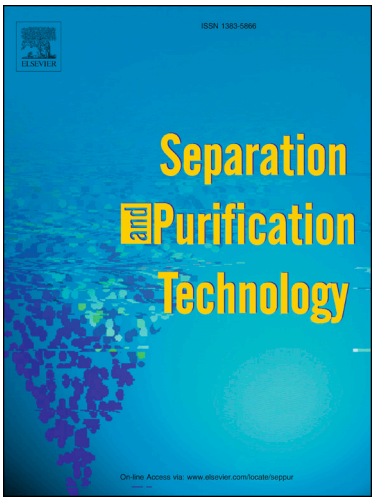

Deep eutectic solvents used as adjuvants for improving the salting-out extraction of ursolic acid from *Cynomorium songaricum* Rupr. in aqueous two-phase system

Changyong Cai, Shuanggen Wu, Chaoyun Wang, Yuanru Yang, Danyu Sun, Fenfang Li, Zhijian Tan

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An analytical model to evaluate the heating conditions for drilling in hard rock using an innovative hydrothermal spallation method

Xiaodong Hu, Xianzhi Song*, Gensheng Li, Zhonghou Shen, Zehao Lyu, Yu Shi, Rui Zheng

China University of Petroleum, Beijing, China

Corresponding author: Xianzhi Song

Email: songxianzhi@aliyun.com

Abstract

Hydrothermal jet spallation drilling (HJSD) is a new drilling method suitable for drilling deep wells in hard rock formations. The characteristics of HJSD are that the rock surface is impinged by a high-velocity hydrothermal jet, causing rock breaking into small spalls. In this study, we develop an analytical model to evaluate the heating conditions (surface temperature and surface heat flux) in HJSD, in which the effect of jet impact on the heating conditions is first considered. Meanwhile, we conduct thermal spallation experiment using sandstone and granite samples. After that, the effects of jet impact on the heating conditions are investigated. Furthermore, the impacts of all physical parameters on the heating conditions are compared to clarify the key factors. Additionally, we compare the rate of penetration and heating conditions between sandstone and granite, which can provide direct understanding about the suitability of HJSD for sandstone and granite. Our study provides a further understanding of critical physic affecting the rate of penetration and heating conditions in HJSD.

Keywords: Thermal engineering； Drilling engineering; Thermal spallation; Temperature difference; Heat flux