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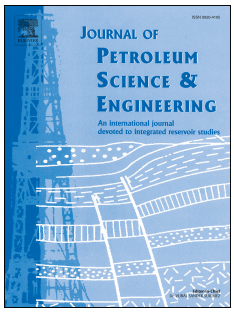

Characteristic study on supercritical carbon dioxide impinging jet: Calculation and stagnation properties analysis

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Characteristic study on supercritical carbon dioxide impinging jet: calculation and stagnation properties analysis

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Abstract: Supercritical carbon dioxide jet is an emerging technology for drilling. Proper understanding of supercritical carbon dioxide impinging jet is the basis for researching and developing this new technology. However, supercritical carbon dioxide has different compressibility and thermal properties from water and ideal gas, which bring difficulties to flow field analysis. The analytical methods reported are limited to experiment and numerical simulation now. In this paper, the flow characteristics of supercritical carbon dioxide jet under different conditions are analyzed. Based on jet dynamics theory and carbon dioxide property equations, we established mathematical model for supercritical carbon dioxide impinging jet and gave a solution algorithm. Use this method, the stagnation properties are discussed. Under the calculation condition, as inject pressure increases from 20 MPa to 50 MPa, stagnation pressure increases by 144.6%, while ambient temperature decreases by 4.14%. With inject temperature rising from 310 K to 340 K, the stagnation pressure changes little and ambient temperature increases by 4.85%. On the condition of same jet pressure difference, improving ambient pressure from 8 MPa to 20 MPa, the stagnation pressure and ambient temperature increases by 46.52%, 2.55%, respectively. The stagnation temperature is mainly controlled by inject temperature, while inject pressure and ambient pressure do not affect it seriously. The method proposed and findings would provide theoretical guidance for field applications.

Key words: supercritical carbon dioxide; impinging jet; submerged jet; calculation method

1 Introduction

Supercritical carbon dioxide is an emerging non-aqueous working fluid which causes heightened concerns of drilling and fracturing researchers (Shen et al., 2010; Middleton et al., 2014). Supercritical carbon dioxide is a fluid state of carbon dioxide where it is held at or above its critical temperature (304.13K) and critical pressure (7.38MPa). Because of its unique advantages such as low rock breaking threshold pressure and high rock breaking efficiency, supercritical carbon dioxide jet assist drilling technology was proposed in recent years (Wang et al., 2011). Kolle first proposed this technology in 2000 and found that supercritical carbon dioxide jet could cut shale and granite at lower threshold pressure than water (Kolle., 2000). Afterwards, many researchers did experimental investigations on rock-breaking performance of