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Sulfur Glomeration Mechanism and Critical Velocity Calculation in Sour Gas Well Bore

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Abstract

with the decreasing of temperature and pressure, elemental sulfur may precipitate in wellbore. The diameter of some parts of the wellbore becomes smaller when there are plenty of precipitated sulfurs on the inner side of the wall. The mechanism of sulfuric glomeration and adsorption were investigated and the tendency of sulfuric distribution was analyzed in wellbore, critical gas velocity and sulfur particle mechanical models were established. The results indicate that liquid bridge force, which is produced by the effects of water film between sulfur particles, is the main cause of sulfur glomeration. At the beginning of sour gas reservoir development, when borehole pressure is lower than saturation pressure, the distribution of precipitated sulfur and critical velocity of carrying sulfur are increasing from bottom hole to well head. Sulfur particles are difficultly carried when liquid bridge force is formed. Critical velocity goes up with precipitated sulfur diameter increasing.

Keywords: Well bore; mechanical model; Critical velocity; Glomeration; Mathematic simulation

1. Introduction

There are three ways of elemental sulfur movement in well bore [1]. ①combined with H_2S and formed polysulfide ;②dissolved in high polymer parrffin hydrocarbons;③ moved with gas as the form of particles (lower than sulfur melting point) or liquid droplet(higher than sulfur melting point). Elemental sulfur is deemed to be carried and deposited by hydrogen polysulfide. Because hydrogen polysulfide is extremely unstable, with temperature and pressure decreasing, hydrogen polysulfide equilibrium

($H_2S+S_x \Leftrightarrow H_2S_{x+1}$) may drift left and resolve, elemental sulfur may precipitate from saturated gas. Most researches are mainly concentrated on reservoir damage and there are few papers published on well

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bore sulfur deposition. Single sulfur particles mechanical models were given in well bore, but sulfur glomeration mechanism and carried sulfur calculation were not demonstrated [2].

Therefore, it is important to establish a comprehensive sulfur deposition model in wellbore.

2. Elemental sulfur glomeration mechanisms

Generally speaking, particles are all likely to agglomerate in the air and the origin of agglomeration is attraction. Van Der Waals force always exists between particles, but the effective distance is so small that are proportional to the inverse 6th power of the distances. With the increasing of distance, the declining rate of Van Der Waals force is slow and the effective distance can reach 50nm. What's more, electrostatic attraction always exists because particles are charged in the air. In addition, liquid bridge force, magnetic interaction energy, and solid bridging force may all exist between particles. However, Van Der Waals force, electrostatic force and liquid bridge force are the most important forces to particles agglomeration in the air. Electrostatic force is smaller than the other two forces. Liquid bridge force is essential to particle agglomeration in the air and Van Der Waals force is the best important in dry condition.

Van Der Waals force, electrostatic force and liquid bridge force are increasing with particles diameter, electrostatic force is smaller than Van Der Waals force and liquid bridge force. In the dry condition, sulfur glomeration is dependent on Van Der Waals force. In the wet condition, the main factor is liquid bridge force. Gas-liquid-solid three-phase all exist and the main factor is liquid bridge force in bore well [3].

Sulfur particles glomeration may occur when they are collided each other and increase from single particles to particles glomeration (Fig.1). Under the combination between collision force and liquid bridge force, single particles may cement each other and form different particle chain. Particle chains may cement each other and form branched glomeration, then the diameter of branched glomeration is increasing and some sulfur particles, which are on the surface of nodular particles, may fall off and adhere, at last up to a dynamic equilibrium and the diameter keeps constant[4].

Single particle Single chain Branched Double branched Developing glomeration Balanced glomeration

Figure 1 The process from single particle to glomeration

With temperature and pressure decreasing from bottom hole to well head, water vapor may become liquid and condensate on the inside wall. Due to the condensation of liquid water on the internal wall, precipitated sulfur cements each other by liquid bridge force. The thickness of deposited sulfur will increase from bottom hole to well head (Fig 2).

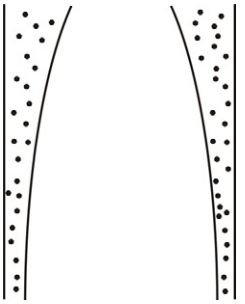

Figure 2 precipitated sulfur distributions in well bore