The Development of Puguang Sour Gas Field

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Puguang Gas field, located at Xuanhan county, Sichuan province, is the largest sour gas field in China at present.

It was discovered in 2003. The GIIP is more than $300 \times 10^9 m^3$. 
Primary characteristics

◇ carbonate reservoir

◇ giant reservoir thickness, good porosity and permeability but strong heterogeneity.

◇ high content $\text{H}_2\text{S} \ (15.16\%) \& \text{CO}_2 \ (8.64\%)$

◇ formation depth: 5000～5900m

◇ high pressure: 55～60MPa
Productivity of Puguang gas field

Because of large reserve, great thickness, etc, the designed annual productivity is more than $10 \times 10^9$ m$^3$. The beginning of product is at the end of year of 2009.
Main strategies to CDM

- Made more than 50 company criterions on Puguang gas field development;
- Improve gas field development design requirement, preventing corrosion & dangerous gas leakage;
- Strengthen tail gas management, decreasing tail gas emission;
- Synthetically treat industrial rubbish, purify produced water and reinject.
Nowadays, some professional laboratories of sour gas phase behavior, anticorrosive, etc., are established in research institutes, which can satisfy the requirement of sour gas field experiments.

It, however, is still lack of correlative experiment experience.
It conducted experiments on sour gas phase behavior and high-pressure physical property parameters.
Experiment results show

- No dew point with some dry gas samples,
- Liquid drops separate from gas when pressure & temperature decrease with another samples.
- The lower P&T, the faster liquid drops precipitate.
The solubility of sulfur in sour gas greatly affects on elemental sulfur deposition while gas wells produced. When the content of H2S in gas is constant, experiments indicate that:

- the solubility of sulfur in natural gas increases, while the pressure increases,
- the solubility of sulfur in gas raise when temperature increases under the same gas components and pressure.
Although the sour gas PVT experiment equipments have already been established preliminarily, there are some problems as followings:

- Wellhead sampling. Because of the strong corrosion and toxicity, it can't put the sampling devices into well bottom to collect gas sample. The compositions of gas sample getting from wellhead, therefore, many be very different from that in real reservoir condition.

- The theory calculation methods are necessary to be improved. The error from sampling may induce the lack of verification of theory models.
As mentioned, elemental sulfur separates out from saturated sour gas and may deposited in transporting medias when reservoir’s temperature and pressure reduce. It studied on simulation model to calculate sulfur deposition in porous media, fractured well and tubing. Meanwhile, treatments of preventing & removing elemental sulfur were developed.
Sulfur plugging of some wells in Sichuan basin

(H$_2$S 6.87%, CO$_2$ 2.76%)
Gas saturation, power of gas current & size of transporting channel are key factors impacting on elemental sulfur deposition in reservoir. The deposition of sulfur in formation is partitioned as four areas,

- Non-sulfur deposited area;
- Sulfur particles steadily deposited area;
- Sulfur particles hydrodynamic carry area;
- Sulfur particles hydrodynamic erosion area.
On the condition that gas current power is not enough to carry sulfur separated out from saturated sour gas, simulation shows elemental sulfur deposits primarily in the area closed to well bore and the precipitation rate becomes higher and higher while gas well continuously produced.

profile of sulfur concentration around well bore

Sulfur concentration in reservoir
The main influence factors

- Well hole pressure
- Well hole temperature
- Flow rate in tubing
- Roughness of tubing

**Elemental sulfur transport in tubing**
Sulfur deposition analysis and prediction in well hole

- Pressure model
- Temperature model
- Sulfur solubility model
- Separation of elemental sulfur
- Particle transportation model
- Adsorption model
- Deposited Sulfur

Solubility of sulfur in well hole

Current velocity

Critical rate carrying

Identify sulfur precipitation position

Move upward
Sulfur deposition prevention measures

Physical measures:
- heating, scraping

Chemical measures:
- dissolution with solvent

Injecting chemical agents is the measure that takes in Puguang gas field to prevent and remove deposited sulfur.

The injection mode is capillary transportation.
Problems

- Sulfur concentration or saturation in original reservoir condition
- Sulfur deposition identification & monitoring measures
- Cost of treatment

We sincerely hope we can cooperate and communicate with relative companies or CCOP MC.
THANK YOU!