Indoor Evaluation of the Defoaming Effect of Polyether-modified Organosilicon Defoamer on Fracturing Fluid

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Abstract: Polyether-type defoamer has good defoaming effect on the fracturing fluid prepared by fast hydration and modified guanidinium gum first grade, but the defoaming effect is not ideal for the modified guanidinium gum second grade and the addition of surfactants and other fracturing fluid foams. This paper evaluates the antifoaming performance of the polyether-modified organosilicon by the foam height, defoaming rate and defoaming time. The experiments showed that the defoamer guanidine gum secondary product formulated fracturing fluid defoaming rate of 95%, defoaming time of 51 s, compared with the polyether defoamer defoaming rate of 70%, defoaming time of 90 s, has a stronger defoaming ability. In addition, it has better foam effect on betaine and alkyl polyglycoside surfactants.

Keywords: fracturing fluid, modified guanidine gum, defoaming rate, defoaming performance.

1. Introduction

The formulation of fracturing fluids and the addition of certain additives can generate large numbers of air bubbles that can affect fluid flow and reduce pressure transfer efficiency. In order to reduce the presence of air bubbles, defoamers are usually added to the fracturing fluid. Polyether modified organosilicon type defoamer has the advantages of good dispersion, strong foam inhibition ability, low surface tension, chemical stability, high safety, strong defoaming effect, etc., which can meet the requirements of different industries.

2. Defoaming Mechanism

Defoaming can be categorized into physical defoaming and chemical defoaming. Physical defoaming is mainly through mechanical and thermodynamic interactions on the destruction and dilution of bubbles, can be used to stir, vibration and other means of accelerating the crushing and elimination of bubbles. Physical defoaming methods, common including heating, ultrasonic, mechanical device interference.

Chemical defoaming is to add defoamer to achieve defoaming and foam inhibition. The new polyether modified organosilicon defoamer has antifoaming and foam inhibition properties. Antifoaming mechanism is (1) to reduce the local surface tension of the foam film; antifoaming agent droplets of surface tension is lower than the surface tension of the foam film, when the antifoaming agent is added to the foam system, the antifoaming agent will be rapidly dispersed and unfolded to form droplets in contact with the foam film. These droplets will reduce the surface tension of the foam film locally, thus generating tensile and ductile forces in all directions, which ultimately leads to foam rupture and dissipation. (2) Destruction of membrane elasticity; in the foam system, the introduction of antifoam agent with extremely low surface tension, tiny particles of antifoam agent will quickly destroy the elastic bubble membrane wall, thus preventing the further formation of foam. Due to the low surface tension of the defoamer, it will push the liquid with higher surface tension to flow to the area with lower surface tension, in order to maintain the surface tension balance of the whole system. The defoamer in the membrane wall will always be affected by the surface tension, causing the membrane wall to become thinner and thinner. Eventually, due to the traction of other high surface tension membrane layers and the imbalance of internal forces, the membrane wall becomes thinner and thinner and cannot withstand other high surface tension membrane layers and internal forces, and the membrane wall of the bubbles will rupture. (3) Shorten the life of the bubble by reducing the liquid film viscosity. Liquid film viscosity refers to the degree of viscosity between molecules within the liquid film, the higher the viscosity, the better the stability of the liquid film, the longer the life of the bubble. After the formation of bubbles, the introduction of defoamer reduces the viscosity of the liquid film, the degree of viscosity between molecules within the liquid film decreases, and the liquid film becomes unstable and prone to fracture.

3. Defoamer Component Analysis

According to its main components, defoamer can be mainly divided into non-silicone type polyether type, organosilicone type and polyether modified organosilicone type, etc. [1]. Polyether-type defoamers are primarily divided into two categories: (1) Linear polyethers, including polyoxyethylene and polyoxybutylene. (2) End group defoamers made from polyether derivatives by alcohol, ammonia (amine) or esterification. The only disadvantage of end-based defoamers is the relatively low foam-breaking rate, and when a large number of foams are present, end-based defoamers may be less effective in treating them [2].
Polyether-modified silicone refers to a silicone-ether copolymer obtained through graft modification, where the modifying unit can be either a polyether segment or a polysiloxane segment. This product is primarily synthesized from sulfur-containing silicone oil via chain-breaking transfer polymerization, ultimately forming a polyether-modified silicone defoamer-methyl-terminated allyl polyoxypropylene ether [3]. Polyether-modified silicone antifoam agents generally contain silicone and polyether groups, so that the antifoam agent has the characteristics of both silicone and polyether. The hydrophobicity of the silicone group enables the antifoam agent to form a film on the surface of the liquid, preventing the generation and development of bubbles; at the same time, the hydrophilicity of the polyether group enhances the compatibility between the antifoam agent and the liquid, resulting in a better antifoaming effect [4]. When the formulated fracturing fluid system generates foam, the surfactant in it will form foam. In this case, the antifoam agent quickly destroys the elastic bubble film walls, thus preventing further foam formation. If foam is already present in the fracturing fluid system, the antifoam agent interacts with the water-repellent groups on the bubble film walls to form a thin film layer. Defoamers can achieve defoaming by changing the surface tension of the foam [5-7]. The defoamer has very active hydrophilic groups, so that the macromolecules enriched on the surface of the fracturing fluid are quickly dispersed, so that the surface viscosity and the viscosity of the fracturing fluid remain basically uniform, and the overflowing bubbles break up rapidly on the horizontal plane, so that there will not be any new bubbles formed [8-10].

4. Properties of Polyether-modified Organosilicon Type Defoamer

4.1 Evaluation of compatibility with fracturing fluids

The compounding performance of the polyether modified organosilicon type defoamer was tested indoors (as shown in Table 1). Measure 500 mL of water, weigh 1.75 g of the twice-modified guanidine glue and stir for 3 minutes. Then add an appropriate amount of pH regulator and continue to stir for 2 minutes. Finally, add 0.3 mL of defoamer and observe whether there is any turbidity or precipitation. Add an appropriate amount of crosslinking agent and shear for 90 minutes at 90°C and 100 s^{-1}. The results are shown in the Figure 1.

Table 1 Basic performance

Item	Test results
Compatibility	No turbidity or precipitation with fracturing fluid additives
Freeze gel shear resistance, mPa.s (90°C, 100s^{-1}, 90min)	222

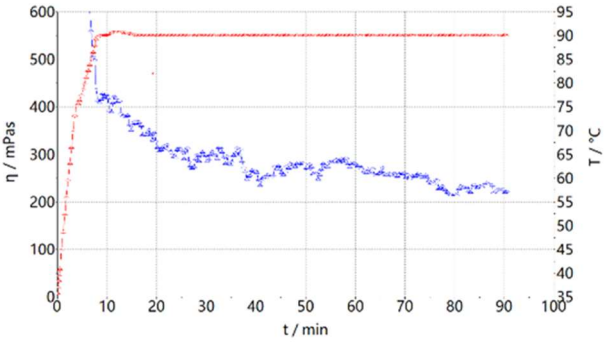

Fig. 1 Temperature and shear resistance of fracturing fluid after adding defoamer

4.2 Defoaming Height, Defoaming Time and Defoaming Rate

4.2.1 Materials and methods

Raw materials: modified guanidine gum secondary product, PH regulator, betaine epimer, epimer, defoamer. Instruments: five-axis stirrer, stirring cup, 1000 ml measuring cylinder, analytical balance, pipette gun, stopwatch and so on.

4.2.2 Experimental program

Take 500 ml of laboratory water in a mixing cup, add guanidine gum powder and PH adjuster in the five-axis stirrer according to the proportion, pour it into a 1000 ml cylinder, which is a blank sample, measure the height of the foam h and record it as h_0. Similarly, formulate two blank samples, respectively add the amount of additives to the cylinder to add the appropriate amount of betaine epimers and alkyl polyglycosides epimers and record the height of the foam as h1 and h2, respectively. The height of the foam was recorded as h_1 and h_2, and the defoaming rate was calculated as $e1=(h_0 -h_1)/h_0$.

4.2.3 Experimental results

Table 2 Comparison of defoaming performance between polyether modified organosilicones and polyether defoamers

Item	blank sample	Blank sample + defoaming		Betaine epimerization + defoaming		Alkyl polyglucoside epimerization + defoaming	
		Polyether modified silicone	Polyether type	Polyether modified silicone	Polyether type	Polyether modified silicone	Polyether type
Foam height	100mL	5mL	30mL	15mL	80mL	20mL	50mL
Defoaming time	20min	51s	90s	64s	105s	56s	95s
Defoaming rate	80%	95%	70%	85%	20%	80%	50%

Fig. 2 Defoaming of secondary modified guanidine gum fracturing fluid by polyether-modified organosilicones and polyether defoamers

Fig.3 Defoaming of fracking fluid with betaine surface activator by polyether-modified organosilicone and polyether defoamer

Fig. 4 Defoaming of fracturing fluid with alkyl polyglycosides by polyether-modified organosilicones and polyether antifoam agents

5. Conclusion

polyether modified organosilicon antifoam agent has an antifoam rate of 95% and an antifoam time of 51s for guanidine gum secondary product formulated fracking fluid, which has a stronger antifoam ability compared with that of polyether antifoam agent with an antifoam rate of 70% and an antifoam time of 90s. In addition, it has a better antifoam effect on betaine and alkyl polyglycoside surfactants, which is over 80%. In addition, the antifoaming rate of betaine and alkyl polyglycoside surfactants reached more than 80%, with better antifoaming effect, providing new products for oilfield fracturing antifoaming.

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