Experimental Study on Natural Gas Hydrate Induction Time in the High-Pressure Flow Loop

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ABSTRACT

In order to master the formation law of natural gas hydrate, a series of experiments were carried out by using a high-pressure hydrate flow loop. The influences of macroscopic flow parameters such as outside temperature control, flow rate, initial pressure, water cut and inhibitor dosage on the induction time of natural gas hydrate were investigated respectively. The results of experiments show that: (1) the hydrate induction time decreases when the outside temperature control decreases; (2) the hydrate induction time decreases first and then increases with the increasing flow rate; (3) the initial pressure has an unordered effect on the hydrate induction time; (4) as the water cut increases, the hydrate induction time shows a trend of decreasing first and then increasing; (5) the hydrate induction time is significantly prolonged with the increase of inhibitor dosage when using the mixed inhibitor of emulsifier-Span 20.

KEY WORDS: Natural gas hydrate; induction time; high-pressure flow loop.

INTRODUCTION

Under the external conditions of low temperature and high pressure, natural gas molecules and water molecules will form cage crystal compounds in a certain proportion, which are natural gas hydrate. Natural gas hydrate which is commonly known as combustible ice is similar to ice crystals in appearance, but its crystal structure is different from ice. Its simple chemical formula can be expressed as nGas·mH2O. Natural gas hydrate is a double-edged sword. On one hand, natural gas hydrate is widely used in natural gas storage and transportation, carbon dioxide deep sea storage and other industries because of its unique physical and chemical properties. On the other hand, the formation of hydrate can easily lead to pipeline blockage in the process of oil and gas transportation, posing a threat to the normal exploitation and safe transportation of oil and gas. Therefore, mastering the macroscopic formation rules of natural gas hydrates can not only provide a good theoretical research basis for the development of effective kinetic mechanisms to control the formation rate of natural gas hydrates, but also is of great importance to establish a hydrate microscopic growth model.

The formation process of the natural gas hydrate mainly includes the hydrate nucleation stage and the hydrate growth stage. There exists quite a period of time, before the burst and the rapid growth of the hydrate nuclei, during which the macroscopic characteristics of the system will not change significantly. This period is defined as the hydrate induction phenomenon, which can be described by the hydrate induction time. The formation process of natural gas hydrate is usually characterized by induction time which can not only be used as an important basis to judge whether there is hydrate formation in pipelines, but also can be used to measure the ability of a supersaturated system to maintain in the state of meta-stability. However, many scholars still have not reached a consensus on the definition of the hydrate induction time and there are mainly microscopic definition methods and macroscopic definition methods. The microscopic method is to define the induction time according to the critical crystal nucleus; the period from the equilibrium state of the system to the appearance of the first crystal nucleus with critical size and stable property is defined as the induction time. The macroscopic method is to define the induction time according to the visible crystal nucleus; the period from the equilibrium state of the system to the first appearance of plenty of visible crystals

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