Numerical Simulation of Fracture Propagation Control in Modern Pipelines for CO₂ Transportation

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ABSTRACT

The purpose of this study is to predict the fracture propagation control in modern pipelines for CO₂ transportation. It is known that gas pipelines rupture with a long and wide and liquid pipelines rupture with short and narrow. Since decompression behavior of liquid and gas pipelines are different, there can be a difference between liquid and gas pipelines in ruptures. The dense phase of CO₂ pipelines are ruptured by rapid decompression and long plateau occurs. It is indefinite that rupture in dense phase CO₂ pipelines will be identified with ruptures in liquid and gas pipelines. In order to predict the fracture dense phase in CO₂ pipelines, Battelle Memorial Institute developed in the early 1970s two curve model (TCM) approach which is predicted the fracture propagation using pipeline geometry, low toughness and depression behavior of fluid. In recently, Pipelines are developed as high strength and toughness more than 100J and requires development of predicting fracture propagation in CO₂ pipelines. In this study, Finite Element Method (FEM) pipe model predicts crack propagation and studies for requirement of pipelines toughness to arrest crack propagation.

KEY WORDS: CCS, XFEM, Crack propagate, CO₂ pipeline

INTRODUCTION

Electricity generation is one of the major sources of carbon dioxide emissions such as fossil fuel power plants cause global warming of the world. Because of global warming, temperature is increased and melts of glaciers at the South and North Pole, and leading to rise in sea levels. These issues are coming very important for the all over the world to prevent from weather accident, so they are trying to capture and storage somewhere on earth. In 2010, Countries got together to declare of global warming to reduce the production of carbon dioxide by 2050 called Tokyo Protocol. CCS (Carbon capture & storage) is becoming the great technologies that the process of capturing carbon dioxide transporting by pipelines, ships and trucks it storage and depositing it will not enter the atmosphere.

In order to develop the thickness, diameter and toughness of CO₂ pipeline, it is important to predict the decompression curve of CO₂ pipelines. The decompression curve is different from liquid and gas pipelines. The liquid pipelines would fracture with short and narrow and gas pipeline with long and wide as shown in Fig. 1. However, CO₂ pipeline of decompression are also different from liquid and gas pipelines, crack initiation and propagation of CO₂ pipelines could show different behavior (Cosham, 2012). It is unclear that cracks with CO₂ pipelines could rupture as a liquid pipeline or gas pipeline.

Fig. 1. (a) Gas and (b) liquid pipelines fracture behavior.