CHAPTER II
BACKGROUND AND LITERATURE SURVEY

2.1 Background

In the countries that utilize the natural gas, the demand of natural gas is not constant. In the cold weather countries, the demand of natural gas is high in winter, but it is low in summer. It is opposite from hot weather countries. The problem of natural gas is the problem of unstable demand. Natural gas storage is the good way to solve the problem by injecting the natural gas in low demand period and supplying in the high demand period than the problem can be solved.

In natural gas storage, the main equations are mass balance dacay law and gas law. The combination of the main equations becomes the governing equation which is related in form of partial differential equation (PDE).

$$\frac{\partial}{\partial x}\left(\frac{P}{zT}\frac{h\kappa}{\mu}\right)\frac{\partial P}{\partial x}+\frac{\partial}{\partial y}\left(\frac{P}{zT}\frac{h\kappa}{\mu}\right)\frac{\partial P}{\partial y}-\frac{MhR}{M_W}=\varepsilon h\frac{\partial\left(P/zT\right)}{\partial t} \tag{2.1}$$

The gas potential (Φ) is defined as shown below

$$\Phi=\int^{p}\frac{pdp}{z\mu} \tag{2.2}$$

Equation 2.1 is rearranged as shown in Equation 2.3

$$\frac{\partial}{\partial x}hk\frac{\partial\Phi}{\partial x}+\frac{\partial}{\partial y}hk\frac{\partial\Phi}{\partial y}-\frac{q_s Tp_s}{T_s}=\varepsilon h\gamma\frac{\partial\Phi}{\partial t} \tag{2.3}$$

The simulation program can be used to solve Φ of this problem. It is convenient to solve simultaneous problem. The program can predict the amount of withdrawn gas by using the numerical method, which is called Implicit Alternating-Direction Method (IAD) having general equation as shown in Eq2.4. (Wilkes, 1999)

$$-\lambda_{x_{i,j}}\Phi^{*}_{i-1,j}+(1+2\lambda_{x_{i,j}})\Phi^{*}_{i,j}-\lambda_{x_{i,j}}\Phi^{*}_{i+1,j}=\lambda_{y_{i,j}}\Phi^{n}_{i,j-1}+(1-2\lambda_{y_{i,j}})\Phi^{n}_{i,j}+\lambda_{y_{i,j}}\Phi^{n}_{i,j+1}-\delta_{i,j} \quad (2.4)$$

2.2 Literature Survey

Park *et al.* (2002) studied on natural gas storage based on the continuum dual-porosity concept by using numerical simulation. The model was assumed that the fractures form very regular patterns, different from field observations. In this problem, a method is proposed to consider the characteristics of the real fracture system and develop a two-phase transient finite element method (FEM) (TENFEM) model able to implement an effective permeability tensor. A steady-state FEM (EPC) model also coded in this work. The developed models were applied to reservoir of a multiwell experiment (MWX) site to demonstrate validity and applicability of the models. The estimated average permeability in the MWX is almost identical compared to the results of the well test analysis. Then the numerical simulation with the TENFEM model was performed by using the transient pressure recorded from a gas well test on the MWX #1. From the results, it was noted that the model with effective permeabilities generated almost identical results against the DFN model in the aspects of the behavior and the direction of fluid propagation with pressure decline, and therefore the proposed model is considered to be more efficient in terms of the computation time as well as the required storage capacity.

Tan *et al.* (2001) studied on an optimization running analysis of bottom water drive underground natural gas storage in seasonal peak shaying. The change in seasonal city natural gas consumption decides the injection-production performance process of underground natural gas storage. Owing to the heterogeneity of geological structure used as underground natural gas storage and different capacities of storing and transmitting fluid in reservoir. According to the injection-production performance mathematical model of underground natural gas storage of bottom water drive depletion type gas reservoir. In the running of gas storage, the minimum power consumed at compressor station and the maximum peak-shaving gas production supplied to city are taken as the objective functions in summer and winter respectively. Then in light of each restrict conditions, the optimum running modes in summer and winter are set up by use of composite optimum-regulating method. So providing a theoretical fundamental concept for optimizing running mode of practical underground natural gas storage in seasonal peak shaving.

Kilincer *et al.* (2000) studied on cushion gas to makes the largest part of the investment in underground gas storage. The suggested method of reducing this cost is the replacement of some parts of the cushion gas with less expensive inert gas. In the replacement, there might be some problems due to mixing between natural gas and inert gas. There are no underground storage units, but they have two gas reservoirs. From this point of view, the gas-mixing problem is investigated for a typical gas reservoir by coupled use of a gas reservoir simulator and a transport model. The model uses single-phase numerical in two-dimensional (2-D) to simulate the gas reservoir. The simulator is developed to obtain the pressure distribution during production and injection cycles. The transport model is used to calculate nitrogen concentrations around the injection wells. Both models are used effectively for controlling the mixing problem in an underground gas storage reservoir.

Misra *et al.* (1999) studied on the use of inert gas to substitute all or part of the base gas requirements in underground natural gas storage fields is a promising technology that has been successful. A storage field in the U.S. has been selected to illustrate detailed data collection and analysis that will lead to formulation of a plan to inject inert gas and predict long term field performance using reservoir models. The reservoir modeling are favorable features that would make a field an attractive candidate for inert gas use. The storage field operations can be predicted with the help of reservoir simulators now available.

Tan *et al.* (1999) studied on Optimization of underground natural gas storage reservoir in summer. When gas is injected, the mathematical model of injection production performance of water-driving underground gas reservoir, the dynamic characteristics of pressure and saturation in reservoir are set up. The minimum power consumed in summer and the total amount of natural gas in a given period are optimum operation in summer by use of composite optimum-regulating method.

Sonier *et al.* (1993) studied on Full-field gas storage simulation using a control-volume finite-element model. Simulations and history-matches have been performed initially with a finite-difference model using a cartesian local grid refinement technique. Following this, a general-purpose model including a control-volume finite-element (CVFE) method has been used. The simulator use 3-dimensional full-field multi-phase reservoirs. The ability of simulation confirms by to real reservoir studies.

Bittkow *et al.* (1991) studied on Simulation of conversion of Lobodice underground gas storage facility from town gas to natural gas. The reservoir engineering project of conversion has been developed by a 2D simulation model of gas mixing in an aquifer gas storage. Besides the mixing problem the maintenance of the aquifer pressure balance during conversion had to be considered, to prevent a reservoir blocking by water inflow. From the simulation results a base load performance is proposed for the first conversion cycles with a limited active gas volume. The technology of flooding gas by gas is suitable on gas quality, but needs additional equipment effort. The load performance of the storage the residual town gas concentration in the produced natural gas increases.