Chapter 6
Artificial Neural Network:
A New Tool for the Prediction of Hydrate Formation Conditions

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ABSTRACT

The analysis and collection of data is an integral part of all research fields of the modern world. There is a need to perform forward mathematical modeling to improve the operations and calculations with modern technologies. Artificial neural network signifies the structure of the human brain. They can provide reasonable solutions quickly for the problems that classical programming cannot solve. An in-depth systematic study is presented in this chapter related to artificial neural network applications (ANN) for predicting the equilibrium conditions for gas hydrate formation, which can assist in designing future dissociation technology for gas hydrate so that this white gold can make world energy free for the future generation. This chapter can also help to develop a novel inhibitor for gas hydrate formation and save millions of dollars for the oil and gas industry.

INTRODUCTION

Gas hydrates are solid crystalline compounds formed by the physical interaction between water and gas molecules (Kumari et al., 2020). The gas molecules are entrapped inside the cages formed by the

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hydrogen-bonded water molecules. The gas hydrates can be formed as methane (CH_4), ethane (C_2H_6), propane (C_3H_8), and carbon dioxide (CO_2), as well as nitrogen (N_2), hydrogen sulfide (H_2S), and natural gas (Kumari et al., 2020). At low temperatures and high pressures, the gas molecules, usually methane, react with water molecules and form the gas hydrates. Hydrates can be found within deep-water permafrost and oceanic regions. Each gas hydrate volume can contain 184 volumes of gas at STP; hence, hydrates can be considered a potential unconventional energy source. The volume of gas recovered from hydrate reservoirs is about ten times the volume of all known retrievable gas in the whole world. Hence, this makes gas hydrate reservoirs a future energy source to fulfill the world's future energy requirements. Gas hydrate can be formed at approximately 300-800 m water depth depending upon the local temperature of bottom water (E. Dendy Sloan & Koh, 1998; Max et al., 2005; Kumari et al., 2021). Most of the Gas hydrates are formed with methane gas; hence it is termed methane hydrates. The methane gas present in the onshore and offshore gas hydrate reservoir is 3000 times larger than the methane gas present in the atmosphere. Hence, the rapid release of methane gas from gas hydrate could significantly impact the atmosphere's composition and can affect the global climate. Methane gas could release slowly in the atmosphere to oxidize carbon dioxide by the chemical and microbial processes. The methane gas released in the atmosphere should react with the hydroxyl radicals in ten years approximately. Hence, the role of methane gas hydrate in global climate change depends on the release rate of methane gas from gas hydrates, which is primarily unknown. An example of the slow release of methane gas from oceanic sediments is in the Gulf of Mexico, and the rapid release of methane gas is in the Blake Ridge (Kvenvolden, 1999).

The natural gas hydrate can form three types of structure: cubic structure I and II (sI, sII), and hexagonal structure H (sH). sI structured hydrate is formed with the guest molecules (methane, ethane, carbon dioxide) of diameters between 4.2 and 6 Å. The guest molecules of diameters less than 4.2 Å (nitrogen and hydrogen) and diameters between 6 to 7 Å (Propane or isobutane) can form sII structures. When the guest molecules of larger diameter between 7 to 9 Å (iso-pentane or neohexene) are mixed with methane, hydrogen sulfide, or nitrogen, then they will form sH structures (Koh et al., 2009). Based on the geologic and reservoir conditions, the natural reservoirs of gas hydrates are classified into three classes. Class 1 type contains a hydrate layer followed by a two-phase zone of mobile gas and water. Class 2 type consists of a hydrate layer followed by one phase zone of mobile water. Class 3 type consists of a hydrate layer with the absence of underlying zones of mobile fluids (Moridis et al., 2009; Xu & Li, 2015). Three main methods are available for the dissociation of gas hydrates: thermal stimulation, depressurization and chemical injection. In the depressurization method, hydrate is dissociating after decreasing the pressure and this method needs a mobile or permeable fluid zone to produce the gas from the gas hydrates. In the thermal stimulation method, the additional equipment and costs for the injection of hot water or steam are required for the gas hydrate dissociation. Chemical injection requires the insertion of inhibitors such as salts and alcohols and leads to a rapid rate of dissociation and rupturing of the reservoirs (S. H. Khan et al., 2020). The production efficiency of these dissociation methods is affected because of some drawbacks. The depressurization method is favorable for the widespread gas hydrate deposits in a closure. The efficiency of the thermal stimulation method is low due to the high heat loss and high energy consumption. The chemical injection method is not suitable for the ocean area and it is very expensive and creates environmental pollution. Due to these drawbacks, there is a requirement to develop new dissociation techniques for gas hydrates that will be safe and economical (Amit Arora, 2015; Arora et al., 2015).