Study of a Crude Oil Desalting Plant of the National Iranian South Oil Company in Gachsaran by Using Artificial Neural Networks

H. Kiani, S. Moradi, B. Soltani Soulganl, S. Mousavian

Abstract—Desalting/dehydration plants (DDP) are often installed in crude oil production units in order to remove water-soluble salts from an oil stream. In order to optimize this process, desalting unit should be modeled. In this research, artificial neural network is used to model efficiency of desalting unit as a function of input parameter. The result of this research shows that the mentioned model has good agreement with experimental data.

Keywords—Desalting unit, Crude oil, Neural Networks, Simulation, Recovery, Separation.

I. INTRODUCTION

CRUDE oil contains varying amounts of inorganic salts (NaCl, CaCl2, MgCl2, and so on). The presence of such salts presents difficulties during crude oil processing such as corrosion, plugging and fouling of equipment, and poisoning the catalysts in processing units. In order to mitigate the effects resulting from the presence of salts, it is advantageous to reduce the salt concentration to the range of 3–5mg/L.

At most of the world’s oil fields there is considerable water and brine in the extracted oil, with Iran’s field being no exception. Desalting of crude oil is necessary due to the relationship between the price of exported crude oil and its quality. An increase of one part per million (ppm) of water and brine reduces the cost of crude oil by approximately 0.85–1.3$ per barrel. Currently, there are several available methods, such as chemical demulsification, gravity or centrifugal settling, pH adjustment, filtration, heat treatment, membrane separation and electrostatic demulsification. Each of these methods has advantages and disadvantages. For example, pH adjustment may be utilized to separate oil–water emulsions, but it is not usually effective in breaking water–oil emulsions. Centrifugation, an effective method for some emulsions, has a high operating cost. This method is used in laboratory and isn’t suitable for industrial scale. Heat treatment can reduce the viscosity of the oil, thus allowing any water droplets to fall more rapidly through the oil phase, helping the separation of any trapped gas in the crude oil. This method can reduce API of crude oil in high temperature because of evaporating light hydrocarbon of crude oil in addition it has a high operating cost. However, the heat and chemical treatments are expensive and have a tendency to result in high fuel consumption [1].

Over the past 50 years, many studies have been conducted in emulsions with an aim to understand these complex systems. However, many unresolved questions still remain. Oil–water emulsions contain complex mixtures of organic and inorganic materials, all of which affect their behavior. These mixtures contain surface active materials which are responsible for the stability and integrity of the emulsion. They include asphaltene (bituminous materials), resins, phenols, organic acids, metal salts, mud, clay and wax. The petroleum industry faces the challenge of resolving several types of complex emulsions on a daily basis. Production techniques result in stable crude oil–water emulsions which require aggressive treatment methods. The stability of the emulsion depends on a variety of factors introduced by the production process such as thermal and pressure cycles and energy input [1], [2].

Desalting/dehydration facilities are often installed in crude oil production in order to minimize the occurrence of water in oil emulsions. A typical desalting unit is shown in Fig. 1. The main objectives of installing desalting plants are maintaining production rate in a field, decreasing the flow of salt content to refinery distillation feed-stocks, reducing corrosion caused by inorganic salts and minimizing energy required for pumping and transportation [3], [4].

The desalting process involves six major steps: separation by gravity settling, chemical injection, heating, addition of less salty water (dilution), mixing and electrical coalescing. Gravity separation refers to the primary free settling of water and is related to the residence time that takes place in both settling tanks and desalting vessels. The gravitational residence time is governed by the Stokes’ law:

\[ v = \frac{2\pi r^2 \Delta \rho g}{9\mu} \]  

(1)

From (1) it is clear that gravitational separation can be intensified by maximizing size of a drop (chemical injection, electrical coalescing), maximizing density difference between two phases and minimizing viscosity of oil phase (heating, dilution). Several studies have been done to analyze and study the affecting parameters on SRE and WRE [5]-[9].

The aim of this study is simulating complicated desalting unit by use of neural networks.
II. NEURAL NETWORKS

Application of an ANN is new and has proven successful in solving problems in a variety of areas. The network consists of at least three layers, namely, the input, hidden, and output. The input layer consists of nodes accepting the input information specified by the user or the plant data. Each of these nodes trigger signals to the nodes of the hidden layer, which may be single or multilayered, consisting of nodes like the neurons of nervous system of human being communicating with the brain. Output signals from each of these nodes are triggered by the signals emanating from the input nodes which can be modeled as a sigmoid relation:

\[ f_i(a_i) = (1 + e^{-a_i}) \]  
(2)

where \( f_i \) is the output signal from the \( i \)th node and \( a_i \) is the activity of the \( i \)th node. The activity of \( i \)th node is obtained as the sum of the signals received from the preceding nodes and defined as:

\[ a_i = \sum w_{ij}x_j \]  
(3)

where \( w_{ij} \) are the weights connecting input node “i” to hidden node “j”, \( x_i \) is the input value (normalized to unity) to input node “i.” Signals from the hidden nodes then propagate to the output layer and generate output signal similarly as input did.

Output from the net is the output signal of the controller. During training of the net, back propagation was used for updating the weights. The number of iterations governing the accuracy depends on the number of hidden nodes between the input and output layers. Details of the ANN algorithm are available in literature [10]-[12].

III. EXPERIMENTAL DATA

Experimental data of a desalting plant of the National Iranian South oil company in Gachsaran is given in Table I.
<table>
<thead>
<tr>
<th>Voltage (°C)</th>
<th>Oil Temperature (°C)</th>
<th>Water injection (%)</th>
<th>Chemical injection</th>
<th>Input Oil Flow</th>
<th>Salt in oil (%)</th>
<th>Output Oil Flow</th>
<th>Water in oil (%)</th>
<th>Output water (%)</th>
<th>Salt in output oil (%)</th>
<th>Recovery</th>
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</table>

Input oil flow and output oil flow are expressed in bbl/day
Salt in oil is expressed in terms gr/m³
Water injected is a percent of input oil flow
The recovery calculated in Table I are calculated by the following equation:

$$\text{Recovery} = \frac{\text{Output oil flow} - \text{Input oil flow}}{\text{Input oil flow}} \times 100$$
Recovery = \frac{(\text{Input oil flow} \times \text{Salt in input oil}) - (\text{Output oil flow} \times \text{Salt in Output oil})}{(\text{Input oil flow} \times \text{Salt in input oil})}

(4)

IV. RESULTS AND DISCUSSION

Artificial neural networks model (ANNM) with different layer and different neurons in each layer was examined. ANNM with 38 neurons in one layer has the best fit. Fig. 2 shows accuracy the mentioned model.

Fig. 2 shows that one layer neural network model with 38 neurons has good agreement with experimental data especially in upper efficiency. This model can be used to optimization crude oil desalting process.

REFERENCES


