Comparative Study of the $C_{7+}$ Characterization Methods: An Object-Oriented Approach

Abstract When using equations of state (EOS) to predict the phase behavior of hydrocarbon mixtures, problems occur with the $C_{7+}$ fraction that exists in such mixtures. Minimizing such problems requires either fine-tuning the EOS and/or characterizing the $C_{7+}$ fraction. $C_{7+}$ characterization is the most important, yet most difficult step associated with the description of reservoir fluids. Several methods have been proposed for characterizing the $C_{7+}$ fraction. Collectively, these methods are grouped into two main categories: correlation and splitting and lumping. This paper revisits the most common characterization methods presented in the literature, which have received wide acceptance. In addition, a worthwhile contribution of this paper is the proposed improvement to the Katz constant-parameter splitting method. A further contribution is that the resulting program is coded in an object-oriented manner, which offers flexibility in programming and allows the different parts of the code to be described easily and in a natural manner as if they were real world objects.

Keywords $C_{7+}$ Splitting · Hydrocarbon plus fractions · Phase behavior · Equations of state · OOP application
1 Introduction

In compositional reservoir simulation, equations of state (EOS) are extensively used for pressure–volume–temperature (PVT) predictions and phase behavior calculations of hydrocarbon mixtures. Problems, however, arise when dealing with the C7+ fraction that exists in the hydrocarbon mixtures. To minimize these problems, numerous methods for fine-tuning the EOS and/or characterizing the C7+ fraction have been proposed. C7+ characterization is the most important, yet most difficult step associated with the description of reservoir fluids. Several methods have been proposed for characterizing the C7+ fraction. Collectively, these methods are grouped into two main categories: correlation and splitting and lumping.

It is a simple fact that, in most PVT studies, only specific gravity and molecular weight of the C7+ fraction are reported. Correlation refers to the prediction of C7+ properties solely from its specific gravity and molecular weight. Splitting refers to the process of breaking down the C7+ fraction into a number of pseudo-components with a single carbon number, C7, C8, C9, ..., Cn. The pseudo-components are described by the same physical properties used for pure components, which are well defined. However, after splitting is done, it is unpractical to list all the components contained in the C7+ fraction, because the cost required for compositional reservoir simulation increases substantially with the number of components. Thus, lumping, which refers to the process of regrouping the components resulting from the splitting process into a lesser number of pseudo-components, say three or four components that are considered to describe the C7+ fraction, is coupled all the way with splitting.

Several splitting methods have been proposed by different authors. The exponential molar distribution is the simplest method for splitting the C7+ fraction, with the Katz method a special case thereof. This method uses constant parameters; i.e., it only requires the C7+ mole fraction and the carbon number of the component whose mole fraction is to be calculated. However, the method performs poorly in some cases relative to other splitting methods, because it does not take into account the specific gravity and molecular weight of the C7+ fraction. In this paper, the constant parameters of the Katz method are replaced with variable parameters that take into account the molecular weight and specific gravity of the C7+ fraction. This modification proves to be simple and practical and compares well with other splitting schemes.

Another important aspect of the paper is that the program presented herein is developed using the object-oriented C# programming language, which provides substantial computing and programming advantages and allows the most difficult coding tasks to become truly feasible. To the best of my knowledge, no discussion on the C# implementation of phase behavior applications is available. So far, most phase behavior programs have been developed using the traditional FORTRAN language, which is a natural choice from the viewpoint of continuity in downstream data processing. Such a natural choice, however, may not necessarily be the optimal choice. In fact, the use of an object-oriented language is more desirable for future reservoir simulators. The paradigm of object-oriented programming allows the different parts constituting the process of petroleum reservoir simulation to be described easily and in a natural manner as if they were real world objects.