IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 8, Issue 11 Ver. I (Nov. 2015), PP 49-50
www.iosrjournals.org

Experimental Determination of Compressibility Factors of Gases

N.Sesha
Asst. Professor Dept. Of Chemical Engineering Bms College Of Engineering Bangalore 560019

I. Introduction

The compressibility factor Z also known as the compression factor is the ratio of the molar volume of a gas to the molar volume of an ideal gas at the same temperature and pressure. It is a useful thermodynamic property accounting for real gas behavior. In general, deviation from ideal behavior becomes more significant at lower temperatures and higher pressures. For gas mixtures, a gas composition must be specified while calculating the compressibility factor.

II. Overview

Two main types of apparatuses have been used time and again to determine the compressibility factor of gases and mixtures of gases; they are the Burnett and the Bean apparatus. The Bean apparatus(1) is an adaptation of the classic laboratory procedure of expanding an unknown quantity of gas in successive increments from a high pressure bomb of known volume into a calibrated burette at essentially atmospheric pressure and computing the total volume from a summation of these increments at atmospheric pressure. The compressibility factor at test conditions is then calculated from a knowledge of these volumetric measurements.

Developed by E.S. Burnett of the Bureau of Mines, the Burnett apparatus(2) essentially consists of two high pressure chambers of known volume ratio separated by an expansion valve. In the conventional or "true" Burnett apparatus, the test gas is expanded from the first chamber into the second chamber. The pressure of the gas is measured before and after an expansion. The compressibility factor is then calculated from a knowledge of these pressures and the volume ratio. The second chamber is then evacuated and the procedure is repeated by making successive expansions. A significant feature of the Burnett method is that only the temperature and pressure of the gas need to be measured to determine its compressibility factor.

The Burnett apparatus is most often housed in a thermostatic bath whose temperature can be controlled. Belzille et.al. measured temperature using a platinum resistance thermometer and a Meuller bridge , controlling temperatures with a precision better than 0.005K. Dillard and workers used a thermostatic liquid bath wherein ethanol or ethylene glycol was used as a bath fluid. The bath temperature was controlled by a three mode PID controller with a precision of 0.002K. Hall and coworkers used helium as the bath fluid resulting in precision of 0.01K and control of 0.002K.

III. Experimental Setup

In this experimental work a compressibility cell (referred henceforth as the Z meter) was used to measure compressibility factors. The Z meter is a modified type of Burnett apparatus. It differs from its true counterpart in that, the second chamber is not evacuated after an expansion; instead the pressure in the first chamber can be brought back to its original value or adjusted to a new value before a run is made.

The pressure in the first chamber is measured using a dead-weight gauge prior to an expansion. However the pressure in both chambers following an expansion is measured using a Rosemount pressure transducer. The Z meter is housed in an isothermal bath whose temperature is controlled using a modern HP data acquisition and control unit.

It is housed in a inner wooden cabinet surrounded by a large outer wooden cabinet. The walls of both cabinets are lined with three inches of Styrofoam. The Z meter is connected to the test gas cylinder and the dead weight tester by stainless steel tubing. A refrigeration unit circulates a solution of ethylene glycol through a finned type heat exchanger passing through the inner cabinet. A fan and two blowers circulate air through the inner cabinet to minimize temperature fluctuations.

The dead weight tester and the automation unit are mounted in a rack beside the outer cabinet. The dead weight tester is a DH model 5200 type pneumatically operated instrument with a maximum operating pressure of 4000psig. A model 3456A digital voltmeter, model 3497A data acquisition and control unit and personal computer (HP-85 series) form the essential components of the automation unit. The automation unit performs two main functions:

It maintains the temperature of the Z meter to within 0.0023K of the desired temperature permitting near isothermal operation.

It increases the rate of data acquisition by permitting unattended operation.

Thus, the Z meter and measuring accessories were assembled. The refrigeration unit was operated and the computer used to control the temperature. The initial pressure was set, the valve between two chambers was opened and the final pressure noted by measuring voltages from the transducer.

Computer programming was done to automatically record compressibility factor values some of which are presented in Table 1. and Table 2.

Table 1 Compressibility Factors For Pure Methane
Pressure 900psig
Temperature: 288.71k

RUN NUMBER	COMPRESSIBILITY FACTOR
1	0.88364
2	0.88379
3	0.88376
4	0.88361
5	0.88363
6	0.88375
7	0.88383
8	0.88393
9	0.88367
10	0.88377

Table 2 Compressibility Factors For Methane-Propane Mixture
Composition: 85.4206 Mol% Methane And 14.5794 Mol % Propane
Temperature: 278.15k
Multiple Runs At Three Different Pressures Reported

TEMPERATURE	PRESSURE	COMPRESSIBILITY FACTOR
278.15	813.411	0.78156
278.15	813.400	0.78157
278.15	813.398	0.78154
278.15	713.491	0.80924
278.15	713.496	0.80946
278.15	713.493	0.80931
278.15	613.502	0.83731
278.15	613.493	0.83714
278.15	613.490	0.83724

IV. Conclusion

An experimental method to measure high accuracy compressibility factors is described in this paper. Repeated experimentation at same conditions have produced values differing not more than 0.05%.

The automation of the equipment renders fast data acquisition with accurate temperature control and the values obtained at various conditions of temperature and pressure can be used for developing highly accurate equations of state.

Acknowledgements

The author acknowledges of his thesis advisor Professor Rex T. Ellington (University of Oklahoma, Norman, OK, USA) for all his advice, support and help in conducting this research.

References

[1] Sesha Narayanan, M.S.Thesis, University of Oklahoma, 1985.
[2] Mark J. Hill, M.S. Thesis, University of Oklahoma, 1985.