

True Density Measurement of Solid Matter by Constant Volume Gas Pycnometer-A Review

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Abstract— Gas pycnometry is based on Boyle’s law, there are three kinds of gas Pycnometer are constant volume, variable volume and comparative volume. Gas Pycnometer are being used to obtain the material true density/volume, apparent density/volume and porosities of the particles, drugs, pigments, and ceramics Measurement. Measuring the volume/density of Irregular shape, Porous and non-porous material. It is also control the temperature for the reference and sample chamber, and pressure transducers, valve is also inside a special chamber with a same temperature distribution. Here, it is said helium Pycnometer because the helium gas used for a pressurized gas because its atoms are too small so that easily passed in all pores of the material and define its porosity from its density. We can measure the density with porosity of any types of solid material and other material with high moisture content.

Keywords: Helium/Nitrogen Gas, Pycnometer, density, volume, porosity, solid particle

I. INTRODUCTION

Helium Pycnometer [1 2]run based on a Boyle’s law Determine the true density or real density and volume of substance. Helium which can enter the voids of pores in a material and with known weight and unknown the volume or density of material and give the final density and volume of material[2].The density define the how much the material should be porous. Porosity defined the total and apparent volume this difference called particle volume.

Here, the helium is an inert gas so they do not harm and not make the atomic reaction to any material and its small atoms passed.

Through the each and every Area of the material. There are three kinds of Pycnometer reported in a literature review: constant volume[1], variable volume[1] and comparative gas Pycnometer[1] used to determine density and volume of granular, porous and soluble compounds, solid particles, coal, ceramic salts and pigments. For one thing, the volume of substances that react chemically or physicochemical with water can be determined. Further, the problem of air entrapment, which is common in liquid Pycnometer (e.g., [3]), does not exist.

II. BASICS OF PYCNOMETER

A. Constant Volume Gas Pycnometer:

In a constant volume gas Pycnometer have two different chambers reference chamber and sample chamber, here the volume of the reference chamber should be defined by the fixed volume (via.calibration) [4]or internal volume and sample chamber volume depend on his sample size and mass

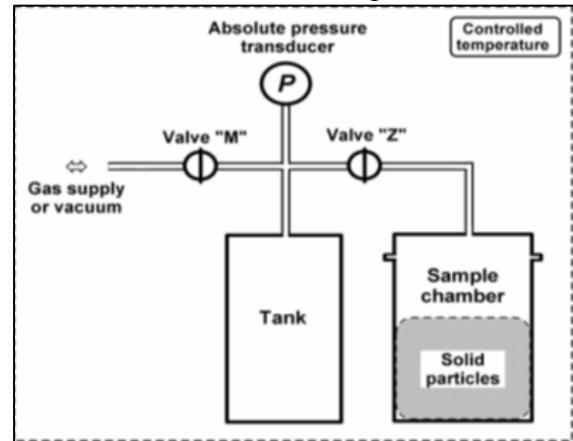


Fig. 1: Diagram of a constant-volume Pycnometer

B. Variable Volume Gas Pycnometer:

Variable volume Pycnometer consist of either single or two variable volume chamber and the volume of the chamber varied by a simple mechanical piston or fixed travel or gradually by a graduated piston, pressure can be read by a transducers or nullified by adjustment of a third ancillary[5],graduated variable-volume chamber. It’s only for the standard test method for open cell content rigid cellular plastics air Pycnometer.

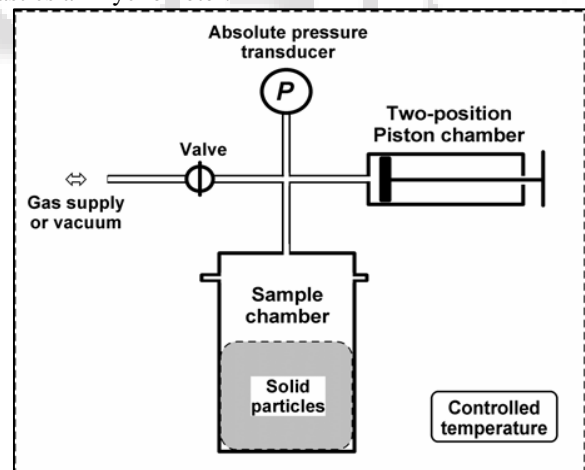


Fig. 2: Diagram of a variable-volume Pycnometer.

C. Comparative Volume Gas Pycnometer:

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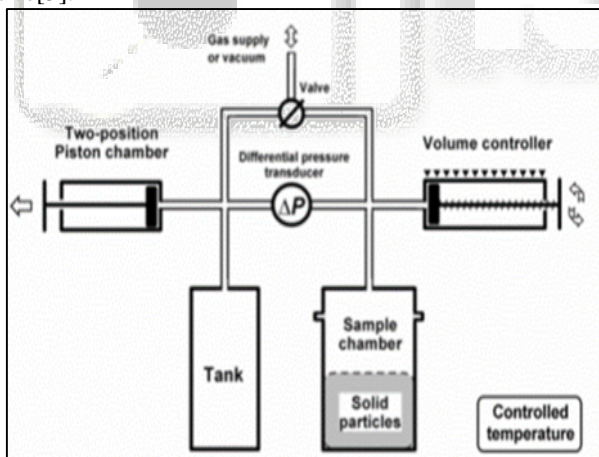


Fig. 3: Comparative Pycnometer

Now, we will study on a Constant volume gas Pycnometer

IV. CONSTANT VOLUME GAS PYCNOMETER WORKING METHOD

Helium Pycnometer measure the volume (density) using the gas displacement by employing the Boyle's law $pV=nRT$, this process explain by the following diagram.

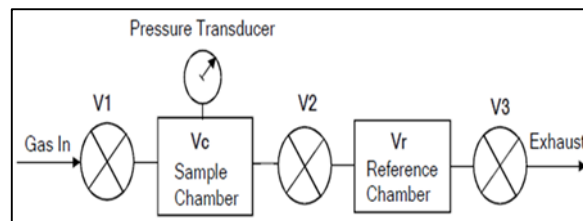


Fig. 4: Flow diagram of gas Pycnometer design.

The constant volume gas Pycnometer basically working on a three cycles[6]

- 1) Cycle1: V1 valve is closed and V2 and V3 valve are open so, the gas exhausted from chamber, it is called P_a Ambient pressure.

$$(P_a V_r)/RT \dots (1)$$

- 2) Cycle2: V1 valve is open and V2 and V3 valve are opened to required pressure level, now V1 valve is closed and stabilized the pressure P_p is read.

$$(P_p(V_c - V_{obj}))/RT \dots (2)$$

- 3) Cycle3: Finally, the V2 valves is opened and depressurized the cell, final pressure established in both chamber.

$$(P_d(V_c + V_r - V_{obj}))/RT \dots (3)$$

It's defining the complete process of measuring the volume/density. The mass balance is given by the above three equations:

$$(P_a V_r)/RT + (P_p(V_c - V_{obj}))/RT = (P_d(V_c + V_r - V_{obj}))/RT$$

Where, V_r =reference volume

V_c =chamber volume

V_{obj} =object volume

In a above equation have the temperature constancy present so, they calculate the object volume V_{obj} by using the V_r and V_c .

And then knowing the object (m) mass, (V_{obj}) object volume which is defined it's density (d).

V. OBJECTIVE

- 1) To study about the design objectives was to combine manually operated Pycnometer (especially for foams density determinations) and automatically operated ones into a single design.
- 2) To Measure the largest range of sample volume determinations.
- 3) Analysis about the sample porosity and density by Constant volume Pycnometer.

VI. SCOPE

- 1) Pycnometer defines its density and porosity of powdered and solid material of regular or irregular shape.
- 2) Determination of specific gravity and water content in a soil solid by Pycnometer.
- 3) The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

VII. LITERATURE REVIEW

- 1) Alberto M. Sereno, et al, [1]: One of the most important parameters of the macroscopic structure of porous media is porosity, generally defined as the ratio of pore or void volume to the apparent volume of the porous sample. It is common to add an "adjective" to define porosity more

precisely, such as effective interparticle, particle and powder. In many aspects, the quality of porous products is dependent on their porosity. The porosity behavior during the processing of such products is a true concern when researching foods, inorganic catalysts, as well as powder processing in general. Porosity determination requires the knowledge of the total or apparent volume, and the void volume included in the material matrix. Their difference is also known as the particle volume. Measurement of the apparent or total volume is a relatively easy task and has been performed by means of different experimental procedures.

- 2) ASTM, D5550-00, at el, [2]: This test method covers the determination of the specific gravity of soil solids by means of a gas Pycnometer. Particle size is limited by the dimensions of the specimen container of the particular Pycnometer being used.
- 3) R.S. Ruoff [3]: A great many methods have been developed for determining porosity, mainly of consolidated rocks having inter granular porosity (encountered in oil reservoir). Most of the methods developed have been designed for small samples. From the definition of porosity it is obvious that common to all methods is the need to determine two of three volumes. Total or bulk volume of the sample, its pore volume, and/or the volume of its solid matrix. The various methods based on such volume determination, called "direct methods", differ from each other in the way these volumes are determined. Other methods are available, called "indirect methods" based on the measurement of some properties of the void space. Examples of such properties are the electrical conductivity of electrically conducting fluid filling the void space of the sample, or the absorption of radioactive particles by a fluid filling the void space of the sample.
- 4) M.A.Rao, at el, [4]
Porosity is a fundamental physical property of meteorites. As such, it provides insight on the behavior of meteorites material subjected to a range of physical processes, such as shock and weathering. Grain volume measurements were made using an unusually large He gas Pycnometer. A given volume of He (helium) at a known temperature and pressure is introduced into a chamber of known volume containing the meteorite. The He diffuses rapidly along micro fractures and grain boundaries but is excluded from crystal lattice structures. The final volume of the He in this chamber can be determined from its pressure and temperature and, hence, the grain volume of the meteorite can be determined.
- 5) S. Tamari and R.I. López-Hernández, at el, [5]
Known about the optimum design of gas pycnometers, so that they can determine the volume of solid particles with the greatest accuracy. The purpose of this study was to investigate the optimum design of the "comparative" gas Pycnometer. An error analysis was performed to derive a theoretical formula that relates the pycnometer's accuracy to the main sources of random error (sample-chamber, piston-chamber, and volume-controller volumes). The consequences of this formula in terms of optimizing the geometry and working conditions of the Pycnometer are discussed.

VIII. CONCLUSION

From Various Literature survey found out the Helium gas Pycnometer mainly focus on a density and volume measurement and works on necessary pressure which is given by us, set the Reference volume by the calibration. I work on Constant volume gas Pycnometer system and identified and defined Different parameters.

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