Cost-effective Sieverts-type apparatus for the study of hydrogen storage in materials

In the context of climate change in which the planet finds itself, hydrogen is one of the energy carriers with the greatest potential, and therefore the most studied, to replace hydrocarbons. However, its large-scale implementation has not been possible mainly due to problems in its storage. The most used techniques do not have a large capacity, and involve extreme operating conditions, which makes technologies such as solid-state storage in materials, where higher capacities are achieved at moderate operating conditions, an alternative to consider, and where the most prominent are metal hydrides, borohydrides and alanates, although they can have long kinetic times(Abe et al., 2019; Millet, 2014; Schlapbach & Züttel, 2001; Schneemann et al., 2018; Tarhan & Çil, 2021).

To evaluate the performance of this type of materials there are two techniques, gravimetric and manometric, where, depending on the variable that is recorded, weight and pressure respectively, the amount of hydrogen stored or released at certain conditions of temperature and pressure can be calculated. However, in general, the manometric technique is usually the most widely used, since it is considered sufficiently robust and the necessary equipment, known as Sieverts, is cheaper. However, this equipment is still quite expensive commercially and with generic performance, and that is why many research groups worldwide have developed equipment based on this technique, with better performance and which are usually cheaper(Blach & Gray, 2007; Carrillo et al., 2018; Pyle et al., 2017).

Considering that hydrogen storage is a line of research that is gaining more and more weight in Colombia and Latin America. It is necessary to have this type of equipment to evaluate the materials developed, in such a way that they are accessible to research groups in the region, without this implying a loss of range or accuracy in the measurement. For this reason, this work presents the design (Figure 1) and construction (Figure 2) of an economic, portable and semi-automatic Sieverts type apparatus, with an approximate cost of 8,000 USD, and which, with at least 160 mg of material, is capable of accurately performing the typical tests performed on these materials, PCI curves, kinetic curves and cyclic behavior curves; at temperatures up to 773K and pressures from 0.01 MPa to 10MPa.

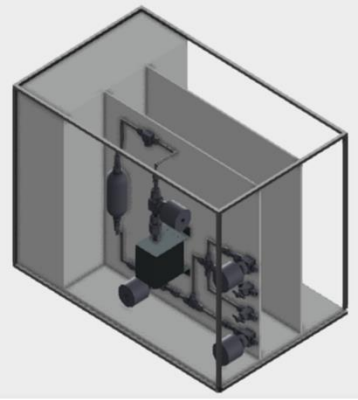

Figure 1. CAD drawings of the Sieverts-type device.

The apparatus has two volume systems, 176 and 14 mL respectively, with independent heating systems with PT100 sensors and thermocouple type K respectively, the pressure is measured with 0.01%F.S. 0-100 bar pressure sensor, pneumatic valves are used to perform the measurements and depressurize the equipment, both systems are controlled via PLC that allows the monitoring and control of the apparatus remotely. The gas input is done manually to have a better control over the apparatus. The data is processed in an Excel template for easy accessibility. The performance of the device has been tested on typical solid state hydrogen storage materials such as magnesium hydride and lithium alanate.

Figure 2. Sieverts type apparatus constructed.

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