

The invention relates to a method and a use of an arrangement for detecting the volumetric behaviour of a hollow body as a result of a pressure load being applied to its walls.

Various methods such as, for example, welding methods, are used to produce containers for food. Apart from the tightness of hollow bodies of this type, the rigidity of their walls, in particular in the area of joins, is an essential criterion of their utility. This also applies to non-deformable containers. Parts which are too rigid or too weak, for example weld seams, may result in cracks when the containers are used, for example in areas in which parts of differing rigidity are joined.

The invention is based on the object of providing a test method for hollow bodies of this type and using an arrangement with which these hollow bodies can be tested in a simple and highly reliable manner.

Using a method of the type initially mentioned, the invention proposes proceeding according to the wording of claim 1 in order to solve this object.

The procedure according to claim 2 takes advantage of the fact that when a hollow body of this kind is introduced into a test chamber and a differential pressure of a test gas, preferably air, which is positive or negative with respect to the internal pressure of the hollow body, is applied in the test chamber, this results on the one hand in - according to the tightness of or leakage at the hollow body - a pressure equalisation between the test chamber pressure and the internal pressure of the hollow body, the variation with time of which is a measure of the magnitude of any leakage occurring.

On the other hand, there is an increase or a decrease in the volume of the hollow body - an increase in the case of a differential pressure acting outwards from the hollow body

interior and a decrease in the case of a differential pressure acting towards the hollow body interior from the test chamber - which is a measure of the elasticity of the hollow body wall.

In order to subject a test chamber of a volume which is dependent upon the volume of the hollow body to a predetermined pressure value, practically as an initial value, and then, following the isolation in terms of pressure of the chamber and the hollow body, to deduce the above-mentioned criteria from the pressure variation, a chamber of a predetermined volume is pressurised to a predetermined value and this chamber is then connected to the test chamber. When the two chambers are connected, the pressure in the test chamber is the result of the intake pressure of the chamber and the volumetric relationship of the two chambers with the hollow body. In order to increase the measuring signal in this case, the test chamber can be pre-pressurised positively or negatively with respect to atmospheric pressure beforehand.

In order also to create a defined reference pressure for the evaluation of the internal pressure of the test chamber and then be able to carry out the evaluation on the basis of a differential pressure measurement, it is also proposed that the test chamber be firstly connected to a reference pressure system before evaluation is carried out, that the reference pressure system then be separated from the chamber and its pressure used as a reference pressure for the subsequent evaluation of the chamber pressure.

Since the reference pressure system is firstly connected to the chamber, the same pressure is produced here as in the test chamber. If the reference pressure system is then separated from the chamber, the pressure value prevailing in the test chamber at that moment is stored in the reference pressure system and used as reference pressure for a differential pressure measurement upon subsequent evaluation.

Since, moreover, the evaluation as to the chamber pressure is carried out punctually at a predetermined instant, this becomes extremely simple. A test is carried out at a predetermined instant to establish whether the ACTUAL chamber pressure corresponds to a DESIRED chamber pressure determined beforehand. If the ACTUAL test chamber pressure is compared at two or more instants or even continuously as it varies with time with DESIRED pressure values at two or more instants or with a DESIRED pressure variation with time, there will be an increase in the evaluation resolution, e.g. through integrating the comparison result or difference between the DESIRED and ACTUAL values.

Predetermined DESIRED pressure values or DESIRED pressure variations are preferably also stored and during the above-mentioned test in each case compared as a comparative value with the ACTUAL values then recorded in order, for example, to draw conclusions concerning hollow body rejects due to wall parts being either too rigid or too elastic.

A method and a device for testing the tightness of electrical components are known from EP-A-0060548. The component which is to be tested is placed in a test chamber which is pressurised. The test chamber is pressurised via a chamber of a given volume which is pressurised to a predetermined pressure value and conclusions regarding the tightness of the component drawn from the variation of the pressure in the differential volume between the test chamber volume and the component volume.

This arrangement, which is known per se, is extremely suitable according to the wording of claim 9 for the testing, on which the invention is based, of hollow bodies as to their volumetric behaviour.

The invention is explained in the following by way of example on the basis of figures, in which:

Figure 1 shows the basic structure of an arrangement according to the invention, which operates in accordance with the method according to the invention, on the basis of a functional block diagram,

Figure 2a shows the qualitative variation with time of the internal pressure of the hollow body and of that of the test chamber when the differential pressure between the test chamber and the internal pressure of the hollow body is acting towards the hollow body interior, in the case of completely rigid and tight hollow body walls on one hand and in the case of hollow body walls which, although tight, yield under a pressure load,

Figure 2b is a qualitative representation according to Figure 2a with different hollow body leakages,

Figure 3 shows a first variant which is based on the representation according to Figure 1 and in which the test chamber pressure is regulated to a constant value and the correcting variable is evaluated,

Figure 4 is a preferred variant, which is based on the representation according to Figure 1, of the pressure recording as a differential pressure measurement,

Figure 5 is a preferred embodiment, which is based on the representation according to Figure 1 or Figure 4, of the pressurising arrangement for the test chamber and with a timing arrangement for timing the individual method phases.

Figure 1 shows on the basis of a schematic block diagram a first variant of the method according to the invention and an arrangement for carrying it out. A hollow body 1 is to be tested as to how its volume changes due to a pressure load and elastic deformation of its walls. The hollow body 1 is introduced into a test chamber 3, for example through a feed opening which can be hermetically closed by a cover 5. Inside the hollow body 1 there is an internal pressure p_{i1} ,

which usually corresponds to the ambient pressure p_u . After the test chamber 3 has been hermetically closed, it is pressurised by turning on a pressure medium source 7 for the test chamber 3. A gas, preferably air, is used as the pressure medium. A differential pressure which is positive or negative with respect to the internal pressure p_{i1} inside the hollow body 1 is thus produced in the test chamber 3.

The pressure inside the test chamber 3 is designated by p_3 in Figure 1. The pressure system consisting of the test chamber 3 and the hollow body 1 which is to be tested is then separated from the pressure medium source 7, for example by a shut-off valve 9, and left alone. If the hollow body 1 is tight with respect to the gas which is used and its walls are rigid such that the forces on the walls resulting from the pressure difference between p_3 and p_{i1} do not cause any noticeable deformation, an output signal $s(p_3)$, as shown qualitatively in Figure 2a, is recorded by a pressure sensor which is represented diagrammatically at 11 in Figure 1 and is formed, for example, as an electromechanical transducer, such as a piezoelectric pressure sensor.

In Figure 2 the pressure in the test chamber 3 according to the signal $s(p_3)$ and the internal pressure p_{i1} in the hollow body 1 are plotted qualitatively against the time t . p_3 and p_{i1} are the same as the ambient pressure p_u until the instant t_1 , when the hollow body 1 is introduced into the test chamber 3 and the latter is hermetically closed by the cover 5. At the instant t_1 the process of pressurising the test chamber 3 by means of the source 7 commences and the pressure in the test chamber 3 rises. The internal pressure p_{i1} remains unaffected by the change in pressure in the test chamber 3 in the above-mentioned case in which the hollow body walls are rigid and tight. At the instant t_2 the source 7 is separated from the test chamber 3, with the test chamber pressure $p_3(a)$ remaining at least almost constant in the present case, as does the internal pressure $p_{i1}(a)$ in the hollow body 1.

If the walls of the hollow body 1 are not absolutely rigid in the above sense, instead bending at least at certain places and inwards or outwards according to the pressure difference Δp which is applied and its sign, the qualitative variations $p_3(b)$ and $p_{i1}(b)$, which are plotted as dot-dash lines, will result when the differential pressure is acting towards the hollow body interior. Similar conditions are produced when the differential pressure is acting towards the pressure chamber 3.

As shown by these qualitative variations, both pressures tend asymptotically towards a different, constant limit value after a shorter or longer time.

Figure 2b is a similar representation to Figure 2a showing the conditions when the hollow body 1 is subject to leakages of different magnitudes. When the leakage is relatively small the internal pressure of the hollow body 1 and the pressure between the test chamber 3 and the hollow body 1 are equalised relatively slowly according to the qualitative variations $p(c)$, while this process becomes increasingly faster when the leakages are greater, as represented, for example, by the variations $p(d)$. If a DESIRED variation p_3 , e.g. according to $p_3(b)$, is generally known for intact tight hollow bodies 1 and taking account of any change in volume of the hollow body 1 due to the differential pressure load, an evaluation is made on the output side of the sensor 11, by comparing the ACTUAL variation with a DESIRED variation of this kind, as to the extent to which a tested hollow body is tight or not and whether or not it is to be classified as a reject.

For this purpose the pressure p_3 is measured according to Figure 1, for example with respect to the ambient atmosphere with a pressure p_u , with a differential pressure measurement of the pressure p_3 with respect to a predetermined reference pressure advantageously being carried out, as will be described in the following. Firstly, however, Figure 3 shows

another variant, in which the pressure in the test chamber 3 is regulated to a constant level and the quantity of pressure medium or gas which is for this purpose delivered to or removed from the test chamber 3 per unit of time or integrated over a predetermined period of time is determined as measurable variable.

According to Figure 3, after the hollow body 1 which is to be tested has been introduced into the test chamber 3, which is then hermetically closed, the latter is pressurised by means of a medium source 7, such as air, or evacuated again, and the internal pressure of the test chamber 3 is determined as controlled variable W by a pressure sensor 11. The controlled variable W is compared with a reference pressure X or a signal which corresponds to a reference pressure at a differential unit 13, and the resulting control difference is superimposed upon a control input S₇ of the source 7. With the latter as control element, the pressure in the test chamber 3 is brought to the DESIRED value X which is set at a presetting unit 15. The medium volume to be delivered per unit of time to the test chamber 3 by means of the source 7 as control element is determined at a flow sensor 17 as a signal $s(\frac{\Delta V}{\Delta t})$ which is integrated for subsequent evaluation, for example over a predetermined period of time.

Variations of the signal $s(\frac{\Delta V}{\Delta t})$ which are similar to those shown in Figure 2 are produced.

Figure 4 shows a preferred variant of the pressure measurement according to Figure 1 at the test chamber 3. During the pressure build-up phase between the instants t₁ and t₂ the test chamber 3 is connected to one input E₁₉ of a differential pressure sensor 21, such as a piezoelectric sensor, via a line 19. The test chamber 3 is also connected to the second input E₂₃ of the differential pressure sensor 21 via a second line 23 with a shut-off valve 25. The shut-off valve 25 is closed at the instant t_R according to Figure 2, so that the pressure then prevailing in the test chamber

3 remains built-up in the line section 23_a , as reference pressure system, between the shut-off valve 25 and the input E_{23} . This pressure in the connection 23_a acts as a reference pressure on the differential pressure sensor 21 and, as the line 19 remains open in the subsequent measuring phase for $t > t_2$, there is a differential pressure measurement at the differential pressure sensor 21 with respect to the test chamber pressure at the instant t_R . As shown by Figure 2, the instant t_R is specifically set for the case in question for optimum measurement resolution, as represented by $t_{R'}$, $t_{R''}$ and the resulting reference pressures p_R , $p_{R'}$, $p_{R''}$.

Taking as a basis the representation according to Figure 4, Figure 5 shows a preferred variant for pressurising the test chamber 3. For this purpose a test gas source, such as a pump 7_a , is connected via a shut-off valve 27 to a reference volume in a reference chamber 29. The latter is connected via a further shut-off valve 31 to the test chamber 3. With the valve 27 firstly open and the valve 31 firstly closed, the reference chamber 29 is filled with test gas by the source 7_a and the pressure in this chamber is measured by means of a pressure sensor 33. If the pressure which is measured by the sensor 33 reaches a reference pressure which is set at a reference signal source 35, the valve 27 is closed. The valve 31 is then opened, so that the chambers 3 and 29 form a communicating system and a test gas equalisation takes place according to the volumes in the chambers 29 and 3. As has been described with reference to Figure 4, following an equalisation phase corresponding to the period t_2 , t_1 of Figure 2, the pressure sensor 21 measures the variation of the differential pressure or records differences between a DESIRED pressure difference and an ACTUAL pressure difference at a predetermined measuring instant t_m according to Figure 2b.

As is also shown in Figure 5, the output of the differential pressure sensor 21 is for this purpose delivered, for example, to a differential unit 37, to which a standard curve, which is fed into a storage and output device, such

as a computer, which is represented diagrammatically at 39, is delivered at a second input, so that the deviations of the instantaneous test result from a predetermined DESIRED result are delivered at the output of the differential unit 37 and a decision regarding the intactness or rejection of the tested hollow body 1 can be made on the basis of these deviations. As already mentioned, it is of course possible to compare the ACTUAL differential pressure at the output of the pressure difference sensor 21 with DESIRED values stored at the unit 39 at a predetermined instant corresponding to t_m in a quasi-punctual manner instead of comparing the variations with time. A timing control unit diagrammatically represented at 41 is in this case triggered upon a predetermined pressure being reached in the reference chamber 29 and then, according to input periods of time T, actuates the valves 31, 25 and possibly also the DESIRED value superimposition at S₃₉.

As explained with reference to Figure 2a, using this method and the described arrangement, it is possible to detect deformation behaviour of the hollow bodies which differs from that which is expected, such as, for example, occurs in the case of unacceptably rigid or unacceptably elastic wall parts.

Claims:



1. Method for testing at least one hollow body (1), in which a given volume (29) is pressurised to a predetermined (35) value and the predetermined pressure is discharged into a volume (3) which is dependent upon the volume of the hollow body (1), characterised in that the pressure ($p_3(a)$, $p_3(b)$) produced following discharge in the volume (3) which is dependent upon the volume of the hollow body is evaluated as a magnitude ($s(p_3)$) which indicates the change in volume or the volume of the hollow body (1) when it is pressurised.

2. Method according to claim 1, characterised in that the hollow body (1) is subjected in a test chamber (3) to a pressure difference between the internal pressure (p_{i1}) of the hollow body and the external pressure (p_3) on the hollow body, and the pressure in the test chamber is measured by means of a pressure sensor (21).

3. Method according to claim 2, characterised in that a reference pressure system is connected to the test chamber (3) and then, in order to record an instantaneous pressure in the test chamber (3) as reference pressure in the system, separated from it.

4. Method according to claim 3, characterised in that the two inputs of a differential pressure sensor are connected to the test chamber (3) via parallel-connected lines, one of which passes via the reference pressure system (23a), the reference pressure system (23a) is then separated from the test chamber and the pressure then prevailing in the test chamber is recorded as reference pressure.

5. Method according to claim 4, characterised in that one line (23), which is disposed directly before the sensor input, is separated from the test chamber and the reference pressure is recorded in the line section (23a), as reference pressure system, which is separated from the test chamber.



6. Method according to one of claims 1 to 5, characterised in that a pressure in a test chamber of a volume which is dependent upon the volume of the hollow body (1) is evaluated as a magnitude which indicates the volumetric behaviour of the hollow body.
7. Method according to one of claims 2 to 6, characterised in that the sensor output signal is evaluated punctually at a predetermined instant or at two or more instants or continuously.
8. Method according to one of claims 1 to 7, characterised in that the evaluated pressure magnitude is compared with predetermined, preferably stored (39) DESIRED pressure values or DESIRED pressure variations and conclusions concerning hollow body rejects are drawn from the comparison result.
9. Use of an arrangement with a hollow body (1), the volume (3) of which arrangement is dependent upon that of the hollow body, with a given volume (29) which can be connected to this volume (3) via a shut-off member (31), with a device (7a) for subjecting the given volume (29) to a predetermined pressure and with a measuring device (21) for the pressure in the dependent volume (3) for detecting the change in volume or the volume of the hollow body (1).
10. Use of the method according to one of claims 1 to 8 for testing flexible hollow bodies, such as coffee packages.