

This invention relates to methods and devices for testing the tightness of a hollow body and to utilisation of the methods or devices for flexible hollow bodies such as coffee packages or for at least partially filled hollow bodies.

In the packaging of certain foodstuffs, such as sweeteners, coffee, and also medicines, e.g. in the form of effervescent tablets, it is essential that the packaging containers are tight with respect to the atmosphere in order, e.g. to prevent contamination of the packaged material by atmospheric humidity. Containers such as tins, bags, etc., i.e. generally dimensionally stable or flexible hollow bodies provided with a cover or sealing part are sometimes used to this end, wherein the latter can be opened, but in the sealed state is supposed to tightly seal the interior of the hollow body.

Various processes are used in the manufacture of containers of this kind, e.g. welding processes. The tightness of hollow bodies of this kind, including dimensionally stable containers, especially in the regions of joints, is an essential criterion for their usability.

By virtue of the methods or devices proposed according to the invention, the tightness of hollow bodies can be tested in a simple manner with a high degree of reliability.

The invention takes advantage of the fact that if a hollow body, which may be and preferably is filled, is introduced into a test chamber and is subjected in the test chamber to a positive or negative differential pressure of a test gas, preferably air, with respect to the internal pressure of the hollow body, pressure compensation between the test chamber

pressure and the internal pressure of the hollow body is effected according to the tightness or leakage of the hollow body, the time characteristics thereof being a measure of the magnitude of any leakage that may be present.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a functional block diagram of the basic structure of a device for testing tightness;

Fig. 2a shows the qualitative curves of the internal pressure of the hollow body and the internal pressure of the test chamber over time, with differential pressure between the test chamber and the internal pressure of the hollow body directed towards the interior of the hollow body, with completely rigid and tight hollow body walls, on the one hand, and with hollow body walls that although tight, yield when pressure is applied thereto;

Fig. 2b is a qualitative representation according to Fig. 2a, with different leakages of the hollow body;

Fig. 3 departing from the representation according to Fig. 1, shows a first variant embodiment according to the invention, in which a constant pressure is maintained in the test chamber and the controlled variable is evaluated;

Fig. 4 departing from the representation according to Fig. 1, shows a second variant embodiment according to the

invention of the pressure recording system, measuring the differential pressure, and

Fig. 5 departing from the representation according to Fig. 4, shows a preferred embodiment of the device for applying pressure to the test chamber and with a timing device for timing the individual phases of the method.

Fig. 1 shows by way of a schematic block diagram a basic variant embodiment of a method for testing tightness or a device for carrying out this method. A hollow body 1 is to be tested for tightness or leakage. The hollow body 1 is introduced into a test chamber 3, e.g. through an insertion opening that can be tightly sealed by means of a cover 5. An internal pressure p_{i1} generally corresponding to atmospheric pressure p_u prevails in the interior of the hollow body 1. After hermetic sealing of the test chamber 3, the test chamber 3 is placed under pressure, a pressure medium source 7 being connected to the test chamber 3. A gas, preferably air, is used as the pressure medium. In this manner, a positive or negative differential pressure is produced in the test chamber 3 with respect to the internal pressure p_{i1} within the hollow body 1.

The pressure within the test chamber 3 is designated by p_3 in Fig. 1. Subsequently, the pressure system consisting of test chamber 3 and hollow body 1 to be tested is disconnected from the pressure medium source 7, e.g. by a shut-off valve 9, and is allowed to stand by itself. If the hollow body 1 is tight with respect to the gas used and its walls are so rigid that the forces resulting from the pressure difference between p_3

and p_{i1} do not cause any noticeable deformation of the walls, an output signal $s(p_3)$ as represented qualitatively in Fig. 2a is recorded by means of a pressure sensor, such as the one shown in diagrammatic form in Fig. 1 at 11, e.g. designed as a mechanical/electrical converter, such as a piezoelectric pressure sensor.

Fig. 2 shows the pressure in the test chamber 3 corresponding to the signal $s(p_3)$ and the internal pressure p_{i1} in the hollow body 1 qualitatively over time t . Up to the time t_1 , i.e. until the hollow body 1 is introduced into the test chamber 3 and the latter is tightly sealed by the cover 5, p_3 and p_{i1} are equal to atmospheric pressure p_u . At the time t_1 pressurisation of the test chamber 3 by the source 7 begins, and the pressure in the test chamber 3 increases. In the abovementioned case of rigid and tight hollow body walls, the internal pressure p_{i1} remains uninfluenced by the change in pressure in the test chamber 3. If at the time t_2 the source 7 is disconnected from the test chamber 3, the test chamber pressure p_3 (a) remains at least approximately constant, 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, but deflect towards the interior or the exterior, at least at certain points and according to the extent of the pressure difference Δp applied and its sign, then the qualitative curves p_3 (b) and p_{i1} (b) indicated by the dash-dotted line are produced, with differential pressure directed towards the interior of the hollow body. Analogous conditions are produced with differential pressure directed towards the test chamber 3.

As is clear from these qualitative curves, the two pressures tend asymptotically towards a different constant limit value after a relatively short or a relatively long period of time.

Fig. 2b shows the conditions prevailing in the case of leakages of different magnitudes present on the hollow body 1, in a representation analogous to that of Fig. 2a. In the case of a relatively small leakage, the internal pressure of the hollow body 1 and the pressure between the test chamber 3 and the hollow body 1 become equal relatively slowly according to the qualitative curves p (c), and in the case of relatively large leakages, increasingly rapidly, e.g. as represented by the curves p (d). If a desired curve p_3 , e.g. according to p_3 (b), is generally known for intact, tight hollow bodies 1 and, taking account of a possible change in volume of the hollow body 1 caused by the differential pressure applied, a judgement is made at the output side of the sensor 11, by comparing the actual curve with a desired curve of this kind, on to what extent a tested hollow body is tight or should be deemed a reject.

According to Fig. 1, the pressure p_3 is measured to this end, e.g. with respect to the atmosphere with pressure p_u . As will be described in more detail hereinafter, in one embodiment, differential pressure measurement of the pressure p_3 is effected according to the invention with respect to a predetermined reference pressure. However, a further variant according to the invention is first shown in Fig. 3, in which the pressure in the test chamber 3 is kept constant and to this end the quantity of pressure medium or gas supplied to or removed from the test chamber 3 per unit of time or integrated over a predetermined period of time is taken as a measured

variable.

According to Fig. 3, after the hollow body 1 to be tested has been introduced into the test chamber 3 then tightly sealed, the latter is placed under pressure by means of a medium source 7 such as air or is evacuated once again and the internal pressure of the test chamber 3 is recorded as the controlled variable W by a pressure sensor 11. The controlled variable W is compared at a differential unit 13 with a reference pressure x or a signal corresponding to the reference pressure and the resulting control difference Δ is connected to a control input S_7 of the source 7. With the latter as a controlled variable, the pressure in the test chamber 3 is adjusted to the desired value x or desired value characteristics set at a preselector unit 15. The medium volume per unit of time supplied by the source 7 as a control device for the test chamber 3 is recorded by a flow sensor 17, as a signal s ($\frac{\Delta V}{\Delta t}$) which is integrated for further evaluation, e.g. over a predetermined period of time.

Curves analogous to the curves shown in Fig. 2 are produced for the signal s ($\frac{\Delta V}{\Delta t}$).

Fig. 4 shows a further variant embodiment according to the invention of the pressure measurement according to Fig. 1 at the test chamber 3. During the pressure build-up phase between the times t_1 and t_2 , the test chamber 3 is connected by means of a line 19 to one input E_{19} of a differential pressure sensor 21, such as a piezoelectric sensor. The test chamber 3 is further connected to the second input E_{23} of the differential pressure sensor 21 by means of a second line 23, having a shut-off valve 25. At the time t_R according to Fig. 2, the shut-off

valve 25 is closed, so that the pressure then prevailing in the test chamber 3 remains built up in the section of line 23_a as a reference pressure system between the shut-off valve 25 and the input E₂₃. 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 differential pressure measurement at the differential pressure sensor 21 with respect to the test chamber pressure at the time t_R . As is clear from Fig. 2, the time t_R is adjusted to give optimum measuring results for each specific case, as shown by $t_{R'}$, $t_{R''}$ and the resulting reference pressures $p_{R'}$, $p_{R''}$.

Fig. 5, departing from the representation of Fig. 4, shows a preferred variant embodiment of the application of pressure to the test chamber 3. To this end, a test gas source such as a pump 7_a is connected by means of a further shut-off valve 27 to a reference volume in a reference chamber 29. The latter is connected to the test chamber 3 by means of a further shut-off valve 31. The reference chamber 29 is filled with test gas by the source 7_a, with the valve 27 first opened and the valve 31 closed, and the pressure therein is measured by means of a pressure sensor 33. If the pressure measured by the sensor 33 reaches a reference pressure set at the reference signal source 35, the valve 27 is closed. Then, if the valve 31 is subsequently opened, the chambers 3 and 29 form a communicating system and test gas compensation is established according to the volumes in the chamber 29 and in the chamber 3. After a compensating phase, according to the time t_2 , t_1 of Fig. 2, as described with reference to Fig. 4, the characteristics of the differential pressure are measured by the differential pressure sensor 21, or differences between a desired pressure difference

and an actual pressure difference are recorded at a predetermined measuring time t_m according to Fig. 2b.

As is shown further in Fig. 5, the output of the differential pressure sensor 21 is to this end fed, e.g. to a differential unit 37, to which, at a second input, a standard curve is supplied from a storage and output device such as a computer shown in diagrammatic form at 39, so that at the output of the differential unit 37 the variations in the instantaneous test result are given by a predetermined desired result, and, as a result of these variations, decisions can be made about the intactness or rejection of the tested hollow body 1. Of course, as already mentioned, instead of comparing the time characteristics, it is also possible to compare the actual differential pressure at the output of the differential pressure sensor 21 with desired values stored at the unit 39 quasi-punctually at a predetermined time corresponding to t_m . A timing interval control unit shown in diagrammatic form at 41 is triggered when a predetermined pressure is reached in the reference chamber 29 and subsequently controls the valves 31, 25 and possibly the desired value evaluation at S_{39} according to given periods of time T .

According to these methods and with the devices described, leakages can be detected reliably and rapidly over an extremely wide range.

In one variant embodiment, the pressure in the test chamber is thus preferably kept constant according to predetermined time characteristics and the controlled variable used to this end is evaluated. If a leakage is present in the hollow body to be tested, then in order to maintain a constant pressure in the

test chamber, a specific quantity of pressure medium per unit of time, corresponding to the quantity of pressure medium per unit of time which flows from the chamber into the interior of the hollow body or vice versa, must be supplied to or removed from the test chamber as a controlled variable. This compensated quantity of pressure medium, or, with differential pressure directed towards the exterior from the interior of the hollow body, this quantity of pressure medium leading away from the test chamber per unit of time, is then preferably evaluated as the measured variable.

In order to apply a predetermined pressure value to the test chamber, virtually as an initial value, and then, after isolation of the chamber and the hollow body with respect to pressure, to make a decision on the abovementioned criteria from the pressure characteristics, a further chamber can be boosted to a predetermined pressure and then this further chamber can be connected to the test chamber in order to produce the differential pressure. The pressure in the test chamber is thus produced when the two chambers are connected, on the one hand, by the boost pressure of the further chamber and the volume ratio of the two chambers. It is preferably also proposed, in order to increase the measuring signal, first to preload the test chamber with a positive or negative pressure with respect to atmospheric pressure.

In order furthermore to provide a defined reference pressure for the evaluation of the internal pressure of the test chamber and then to effect evaluation on the basis of a differential pressure measurement, before the evaluation, the chamber is connected according to the invention to a reference pressure system and a reference pressure sensor, then the reference

pressure system is disconnected from the chamber and the pressure thereof is used as a reference pressure for the subsequent evaluation of the chamber pressure.

As a result of the fact that the reference pressure system is first connected to the chamber and the differential pressure sensor, the same pressure is established therein as in the test chamber before the reference pressure system is disconnected from the chamber and the pressure then prevailing in the test chamber remains stored in the reference pressure system and serves in the subsequent evaluation as a reference pressure for a differential pressure measurement.

As a result of the evaluation of the chamber pressure at a predetermined time punctually, extremely simple evaluation is possible. At a predetermined time, it is checked whether the actual chamber pressure corresponds to a desired chamber pressure, e.g. previously recorded for tight hollow bodies. If the actual test chamber pressure is compared at two or more points of time or even over its continuous time curve with desired pressure values at two or more points of time or with desired pressure time characteristics, there is an increase in the evaluation result, especially in the case of very small leakages, e.g. by integration of the comparison result or the difference between the actual and desired values.

Predetermined desired pressure values or desired pressure characteristics are preferably stored and compared with the then recorded actual values in the above testing procedure as a comparison value, in order, e.g. to reject a hollow body on account of excessive leakage.



CLAIMS

1. Method for testing tightness, in which a hollow body (1) is exposed to a pressure difference in a test chamber (3) and is measured and evaluated by means of a differential pressure sensor (21) between a reference pressure system (23a) and the test chamber (3), the reference pressure system (23a) at first being connected to the test chamber (3) and then being disconnected therefrom in order to maintain an instantaneous pressure as the reference pressure, and the two inputs (E_{23} , E_{19}) of the differential pressure sensor (21) being connected to the test chamber (3) by means of lines (19, 23) connected in parallel, one of which leads via the reference pressure system (23a).
2. Method according to claim 1, characterised in that one line (23) extending in front of the sensor input is disconnected from the test chamber and that the reference pressure is maintained as a reference pressure system in the section of line (23a) disconnected from the test chamber.
3. Method according to claim 1 or claim 2, characterised in that the pressure in the test chamber (3) is adjusted according to predetermined time characteristics and a controlled variable $s \left(\frac{\Delta v}{\Delta t} \right)$ set to this end is measured and evaluated.
4. Method according to one of claims 1 to 3, characterised in that the evaluation is effected punctually at a predetermined point of time or at two or more points of time or continuously.



5. Method according to one of claims 1 to 4, characterised in that the measured and evaluated magnitudes are compared with predetermined, preferably stored (39) desired values or desired characteristics and, from the results of the comparison, conclusions are drawn about whether to reject the hollow body.
6. Device for testing the tightness of a hollow body having a test chamber (3) for the hollow body to which pressure can be applied, a reference pressure chamber (23a) and a differential pressure sensor (21), one input (E_{19}) of which is connected to the test chamber (3) and the other input (E_{23}) of which is connected to the reference pressure chamber (23a), the two inputs of the differential pressure sensor (21) being connected via paralleled connections (19, 23) to the test chamber (3) and one (23) of which leads via the reference pressure chamber (23a) and a shut-off device (25).
7. Device according to claim 6, characterised in that the reference pressure chamber is a piece of connecting line (23a) between a sensor input (E_{23}) and the shut-off device (25).
8. Device according to claim 6 or claim 7, characterised in that a control unit (41) is provided which closes the shut-off device (25) once a predetermined pressure has been reached in the test chamber (3) in order to store the then prevailing chamber pressure as the reference pressure in the reference pressure chamber (23a).
9. Device according to one of claims 6 to 8, characterised in



that the sensor (11) is connected as a controlled variable measuring element in a control system for the pressure in the test chamber and the corrective signal $s \left(\frac{\Delta v}{\Delta t} \right)$ of the control system is evaluated.

10. Device according to one of claims 6 to 9, characterised in that pressure means (7a) for the test chamber (3) are connected via at least one shut-off device (27) to a prechamber (29), the latter being connected via a further shut-off device (31) to the test chamber (3).
11. Device according to one of claims 6 to 10, characterised in that storage means (39) for data corresponding to at least one desired value or at least one desired characteristic of the evaluated signal are provided and that the evaluated signal, on the one hand, and the storage means (39), on the other hand, are connected to a comparator device (37).
12. Utilisation of the method according to one of claims 1 to 5 or of the device according to one of claims 6 to 11 for testing the tightness of flexible hollow bodies such as coffee packages.
13. Utilisation of the method according to one of claims 1 to 5 or of the device according to one of claims 6 to 11 for hollow bodies already at least partially filled with their filling material.