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DESCRIPTION

INSPECTION OF CONTAINER FINISHES

The present invention is directed to inspection of containers, and more particularly to methods and apparatus for inspecting the finish of containers for finish defects.

In the art of container manufacture, the term "container finish" generally refers to that portion of the container which defines the container mouth. In a bottle, for example, the finish includes that portion of the container neck having threads and/or shoulders for receiving the container cap, as well as the upper surface of the neck surrounding the container mouth against which the cap seats. It is important that the container finish be properly manufactured and without defects so that a cap may be affixed thereto to seal the container cavity against leakage and escape of carbonation, and the like during handling and storage.

Conventional technology for mass production of glass or plastics containers involves forming the containers in a multiplicity of blow-moulds. Various types of defects may occur. It has heretofore been proposed to employ optical scanning techniques for inspecting such containers for defects which affect optical transmission characteristics of the container side wall. In United States Patent Specifications Nos. 4,378,493, 4,378,494 and 4,378,495, there is disclosed a method and apparatus in which glass

containers are conveyed through a plurality of positions or stations where they are physically and optically inspected. At one optical inspection station, a glass container is held in vertical orientation and rotated about its vertical central axis. An illumination source directs diffused light energy through the container side wall. A camera, which includes a plurality of light sensitive elements, i.e., pixels, oriented in a linear array parallel to the vertical axis of container rotation, is positioned to view light transmitted through a vertical strip of the container side wall. The output of each pixel is sampled at increments of container rotation, and event signals are generated when the magnitude of adjacent pixel signals differ by more than a predetermined threshold level. An appropriate reject signal is thus produced and the defective container is sorted from the conveyor line.

It is a general object of the present invention to provide an apparatus for inspecting the finish of a container as a function of the optical characteristics thereof, and for indicating that the container under inspection should be rejected when such optical characacteristics do not meet a predetermined standard.

A more particular object of the invention is to provide a container finish inspection apparatus of the described character wherein optical transmission characteristics of a test container are obtained and

compared with corresponding characteristics of a standard acceptable container, and wherein a reject signal is provided where such comparison indicates that the test container is unacceptable.

Copending Patent Application No. 88 00235 discloses a method of inspecting the finish of containers, having an open mouth and a central aixs, which comprises the steps of (a) selecting a standard container having an acceptable finish, (b) directing diffused light energy onto the finish of said standard container while rotating said standard container about its central axis, (c) scanning the finish of said standard container as it rotates and storing in a memory information indicative of optical characteristics of said standard container as a function of increments of container rotation, (d) selecting a test container having unknown finish characteristics, (e) directing diffused light energy onto the finish of said test container while rotating said test container about its central axis, (f) scanning the finish of said test container as it rotates to develop information indicative of optical characteristics of said test container as a function of increments of container rotation, (g) comparing said information developed in step (f) with said information stored in the memory in step (c), and (h) providing a signal when said information developed in step (f) differs from said

information stored in step (c) by more than a predetermined threshold.

According to the present invention however, apparatus for inspecting the finish of a container having a central axis and an open mouth surrounded by a finish wall having internal and external wall finishes, comprises means for holding and rotating a container about its central axis whilst otherwise held stationary, a light source positioned to direct diffused light energy onto the finish of a container in said holding and rotating means in a direction transverse to said axis, a camera positioned at an angle with respect to said axis to view into the mouth of a container in said holding and rotating means, the camera having a field of view which includes portions of said internal and external finish wall surfaces, means responsive to said holding and rotation means for providing signals at increments of container rotation, and means responsive to the camera and to said signal providing means for obtaining information regarding a function of optical characteristics of said finish as a function of container rotation.

In a preferred embodiment of the invention, the camera and light source are positioned on opposite sides of the container axis. Light energy "seen" by the camera is thus a complex function which depends upon the refractive characteristics of the container under test.

It will be appreciated, however, that such characteristics will be generally similar for a given container configuration, with some differences associated with manufacturing tolerances, differing forming moulds and differing glass runs. It is contemplated that the threshold difference between the test and standard information arrays which results in a reject signal is to be empirically determined by the operator.

Accordingly, the present invention provides apparatus for inspecting the finish of a container having a central axis and an open mouth surrounded by a finish wall having internal and external wall surfaces, the apparatus comprising means for holding and rotating a container about its central axis whilst otherwise holding it stationary, means for indicating increments of container rotation, a light source positioned to direct light energy onto the finish of a container in the holding and rotating means from a direction transverse to said axis, a camera positioned on a side of the axis opposite to the light source, the camera comprising a plurality of light responsive elements disposed in a linear array coplanar with the axis and at an angle thereto such that the camera has a linear field of view which includes portions of said internal and external finish wall surfaces, means responsive to the indicating means for scanning the camera elements at increments of container rotation, and first memory means responsive to the scanning means for storing scan information as a combined function of camera element and scan increment.

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

Fig.1 is a schematic diagram of apparatus for inspecting the finish of containers in accordance with a presently preferred embodiment of the invention;

Fig.2 is a schematic illustration of the container finish as viewed by the camera, with camera field of view superimposed therein; and

Fig. 3 is a flow chart which illustrates operation of the invention for inspection of container finish.

Referring to Fig. 1, a conveyor 20, typically including a rotatable starwheel (not shown) and a slide plate 21, is so disposed and connected to a source of moulded containers as to bring successive containers 22 into position at a finish inspection station 24. Conveyor 20 may be of any suitable type, such as those shown in U.S. Patent Specifications Nos. 4,230,219 and 4,378,493, and would typically include the rotatable starwheel for bringing successive containers into position and holding them in fixed position during the scanning operation. A bottle rotating device 26 such as a drive roller is positioned to engage container 22 at station 24 and to rotate the container about its vertical axis 23. An encoder 28 is coupled to the container rotation mechanism to provide signals indicative of increments of container rotation. A detector 30, such as a limit switch, is positioned to provide a signal indicative of presence of container 22 at station 24.

In the preferred implementation of the invention herein discussed, container 22 is illustrated as a moulded glass bottle having a container body 32 and a generally cylindrical neck 34 which projects upwardly from the body shoulder 37. The portion of the container finish inspected in accordance with the present invention

includes the upper portion of the neck 34 which terminates in a cap sealing surface 36. A helical thread 38 is integrally moulded onto the outer surface of the finish wall which surrounds the container mouth, and a lip or shoulder 40 is likewise formed on the finish wall outer surface over which a cap skirt may be crimped in the usual manner for affixing the cap to the container, In general, the present invention is adapted to inspect that portion of the container finish to which the cap is to be affixed.

A light source 42 is positioned to direct diffused light energy onto the container finish from a direction generally normal to container axis 23. Light source 42 includes one or more lamps 44 and a diffuser plate 46. A camera 48 is positioned on the side of axis 23 opposite to light source 42. Camera 48 includes a plurality of light sensitive elements or pixels 52 (Fig. 2) disposed in a linear array 50 coplanar with axis 23 and directed downwardly toward the container mouth at an angle 54 with respect to the container axis. A lens 56 focuses the field of view of camera linear array 50 in the manner illustrated in Fig. 2 so as to view diametrically opposite portions of the coaxial cylindrical container finish external and internal wall surfaces 58, 60, internal wall surface 60 being viewed at angle 54 through the open container mouth. (It will be appreciated that the effective image 48' of camera 48 is illustrated in Fig. 2). In a preferred embodiment of the

invention, element array 50 includes two hundred and fifty-six elements 52 having a composite linear field of view which extends at least from the opposite edge of sealing surface 36 to the adjacent lower edge of shoulder 40. (It will be appreciated, of course, that the invention is in no way limited to the particular finish configuration shown for illustration purposes in the drawings.)

An information processor 62 receives a signal from detector 30 indicative of the presence of a container 22 at inspection station 24, and signals from encoder 28 indicative of increments of container rotation. Light sensitive elements 52 of camera array 50 are likewise individually coupled to information processor 62 for providing thereto respective signals indicative of the intensity of light incident on each element. Information processor 62 is connected to an object array memory 64 and to a standard array memory 66, and has an output for providing a reject signal to container sorting apparatus (not shown). Each array memory 64, 66 is an N x M array memory, where N is equal to or greater than the number of elements or pixels 52 in camera array 50, and M is equal to or greater than the number of scan increments for one complete rotation of container 22. In the preferred embodiment of the invention, two hundred and fifty-six elements or pixels 52 are provided in array 50, and two

hundred and fifty-six increments per container rotation are employed, each memory 64, 66 thus containing an array of at least 256 x 256 memory word locations.

Fig. 3 is a flow chart which illustrates operation of information processor 62 for inspecting the finish of container 22. When a container 22 is detected at inspection station 24, information processor 62 scans each element 52 of camera array 50 at each increment of container rotation and stores information in object array memory 66 as a function of corresponding light intensity at each array element. During an initial or learning phase, container 22 is selected to possess a known acceptable container finish, and the information obtained in each scan is averaged over several scans and then stored in standard array memory 66. Standard array memory 66 thus contains a complete array of average intensities, by camera element and scan increment, for a container having an acceptable finish. During inspection of test containers, i.e. when station 24 is not in such learning phase, the object or test array in memory 64 is compared, following completion of container rotation and scan, with the corresponding standard information stored in memory 66.

It will be appreciated, of course, that although memories 64, 66 contain corresponding arrays for comparison purposes, such arrays need not necessarily register with each other since container finish scans do

not begin and end at a predetermined fixed position circumferentially of the container axis. Stated differently, each container scan begins at a random angular location circumferentially of the container axis. However, for a given container design configuration, the array patterns will remain substantially identical. It is therefore only necessary to translate or shift data stored in object array memory 64 until the pattern of data stored therein generally registers or corresponds with that stored in standard array memory 66, so that the data may then be compared to determine if individual or groups of data stored in object memory 64 indicate a defective container. Such comparison preferably includes a first comparison of data at individual array locations to determine if test and standard data differ from each other by an operator adjustable threshold difference. A second comparison is then implemented to determine if the average or weighted intensity of the entire data pattern differs from the standard pattern by more than an operator adjustable difference. If either or both of such comparisons indicate an excessive difference, the reject signal is set, and processor operation recycles to await receipt of a subsequent container at the inspection station.

Camera 48 and lens 56 (Fig. 1) are preferably mounted for adjustment of angle 54 with respect to container axis 23. Angle 54 is adjusted during a set-up

operation as a function of container geometry, so that camera 48 will be able to view both the internal and external finish wall surfaces as described. Specifically, the viewing angle is determined by the height of the threads and the size of the mouth opening such that the thread area on the far side of the container is visible through the mouth and finish wall. As presently envisioned, angle 54 is preferably adjustable between at least 45° and 75°.

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CLAIMS.

1. Apparatus for inspecting the finish of a container having a central axis and an open mouth surrounded by a finish wall having internal and external wall finishes, comprising means for holding and rotating a container about its central axis whilst otherwise held stationary, a light source positioned to direct diffused light energy onto the finish of a container in said holding and rotating means in a direction transverse to said axis, a camera positioned at an angle with respect to said axis to view into the mouth of a container in said holding and rotating means, the camera having a field of view which includes portions of said internal and external finish wall surfaces, means responsive to said holding and rotation means for providing signals at increments of container rotation, and means responsive to the camera and to said signal providing means for obtaining information regarding a function of optical characteristics of said finish as a function of container rotation.

2. Apparatus as claimed in claim 1, in which the camera comprises a plurality of light responsive elements disposed in a linear array.

3. Apparatus as claimed in claim 2, in which the camera is positioned so that the linear array of light responsive elements is coplanar with the axis of a container in the holding and rotating means.

4. Apparatus as claimed in claim 1, 2 or 3, in which the camera is positioned on a side of said axis opposite to the light source.

5. Apparatus as claimed in any of claims 1 to 4, in which the camera has a line of view which is at an angle of 45° to 75° to said axis.

6. Apparatus as claimed in claim 2, or in any claim appendant thereto, in which the information-obtaining means comprises means for scanning the camera array at increments of container rotation, and a first array memory for storing scan information as a function of camera element and scan increment.

7. Apparatus as claimed in claim 6, in which the information-obtaining means further comprises a second array memory for storing information indicative of an acceptable container, means responsive to completion of a container scan for comparing information stored in said first and second memories, and means for providing a container reject signal as a function of a difference between the information stored in said first and second memories.

8. Apparatus as claimed in claim 7, in which the reject signal providing means includes means for providing the reject signal when said difference exceeds a preselected threshold.

9. Apparatus as claimed in claim 8, further comprising means for selectively varying the preselected

threshold.

10. Apparatus as claimed in claim 7, 8 or 9, in which the information-obtaining means further comprises means selectively responsive to the scanning means and to said camera array for storing scan information in the second memory as a function of camera element and scan increment.

11. Apparatus for inspecting the finish of a container having a central axis and an open mouth surrounded by a finish wall having internal and external wall surfaces, the apparatus comprising means for holding and rotating a container about its central axis whilst otherwise holding it stationary, means for indicating increments of container rotation, a light source positioned to direct light energy onto the finish of a container in the holding and rotating means from a direction transverse to said axis, a camera positioned on a side of the axis opposite to the light source, the camera comprising a plurality of light responsive elements disposed in a linear array coplanar with the axis and at an angle thereto such that the camera has a linear field of view which includes portions of said internal and external finish wall surfaces, means responsive to the indicating means for scanning the camera elements at increments of container rotation, and first memory means responsive to the scanning means for storing scan information ...

as a combined function of camera element and scan increment.

12. Apparatus as claimed in claim 11, further comprising second memory means for storing information indicative of an acceptable container finish as a combined function of camera element and scan increment, and means for comparing information stored in the first and second memory means.

13. Apparatus for inspecting the finish of a container, constructed and arranged and adapted to operate substantially as hereinbefore particularly described with reference to and as illustrated in the accompanying drawings.