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The Development of A Device to Measure the Ripeness and Internal Quality of Watermelons

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ABSTRACT

Recently, it has been popular for family use to sell a watermelon by the piece such as a half or a quarter. Therefore, it has been necessary to detect and sort out hollow or overripened watermelons before they are shipped. Previously, inspection and rejection of hollow or overripened watermelons were carried out by skilled inspectors with their experience and intuition based on the traditional slapping method. In recent years many inspectors have became older and are going to retire. Thus automatic quality measuring devices have to be developed.

There are many reports on the measurement of internal quality for watermelons with non-destructive methods. However, there is no online device to detect and measure both hollow and ripeness of watermelons until now.

We have developed the model MWA-9002 online device to detect hollow and measuring the ripeness of watermelons by acoustic impulse. The developed of this devices has enabled accurate distinction and rejection at the same level of the skilled inspectors, and also has saved labor. Nowadays nine automatic watermelon sorting and packing facilities applied this device have installed in Japan.

Key Words : FFT, FFT analysis, Internal Quality, Watermelon, Online device

INTRODUCTION

Recently, in Japan, watermelons are generally sold in supermarkets and retail stores in cut sections. For this reason, the detection and removal of hollow and overripened watermelons has become a major focus of attention at the producing area in setting new product shipping standards.

Usually, watermelons have been tested for ripeness by experienced inspector in the detection of hollow and overripened watermelons. These inspector would slap on the surface of the melon and judge the degree of ripeness aurally, relying on factors such as the pitch and tone of the resulting sound. With this method, however, many years of experience are required before any degree of precision can be expected in classification of watermelons. With the number of experienced inspector decreasing due to aging, there has been a strong call for the development of automatic recognition and sorting machines.

Research aimed non–destructive measuring the internal quality of watermelons has been carried out by various researcher (Chuma 1977, Yamamoto 1984, Sasao 1985, Kawamura 1988), and research reports have been published concerning various testing methods. However, there are no practically applicable online measurement and sorting devices which can detect the degree of ripening and the same time determine whether or not a watermelon is hollow.

We studied a method of classifying ripeness and identifying hollow watermelons using an acoustic technique, and this research led to the development of the MWA–9002, a system designed to sort watermelons.

The other hand, operations such as the lifting inspecting and packing of watermelons, with their substantial weight, is hard enough even for young worker, let alone aged workers. This has led to strong demand for the mechanization of sorting operations. In response to this demand, we have conducted research on a sorting and packaging system designed to allow the MWA–9002 to be operated online, as well as to reduce the labor involved in packing processes. Our research led to the development of automatic watermelon sorting and packaging equipment which is designed to work in conjunction with a classification system which discriminates between hollow, ripe, and overripened watermelons.

COMPONENTS AND PRINCIPLE

Determination Ripeness and Detecting Hollow of Watermelons Using the Acoustic Technique

This device, which measure ripeness and detects hollow of watermelons, consists of a mechanical supply section,where watermelons are set on a "free tray" (described later), a height measurement section, an acoustic sound measurement section, and a rating display section where the results of the acoustic analysis are output; and a wave analyzing device which analyzes input acoustic signals (see Fig.1). With the acoustic technique, the watermelon is tapped with a small hammer, and the degree of ripeness and presence of hollow watermelons are detected based on changes in the sound waves transmitted from the interior of the watermelon.

A watermelon which has been set on a free tray in the supply section at first, and it goes to the height measurement section, where its height is measured and the height up to the equatorial line is calculated. This is so that always the hammer and the acoustic sensor which measures the acoustic sound can be positioned automatically at the equatorial line, regardless of the size of the fruit. Once the acoustic sensor has been set at the equatorial position, the watermelon is tapped lightly with the hammer. The resulting acoustic sound is picked up by three sensors (condenser–type microphones) positioned around the watermelon, and the sound is amplified and noise eliminated. Following this, the sound is input to the wave analyzing device, and the measured value is output. The degree of ripeness, and whether or not the watermelon is hollow, are determined by comparing the measured values with judgment values established beforhand. The result of the judgment is then recorded by grade display switch on the free tray.

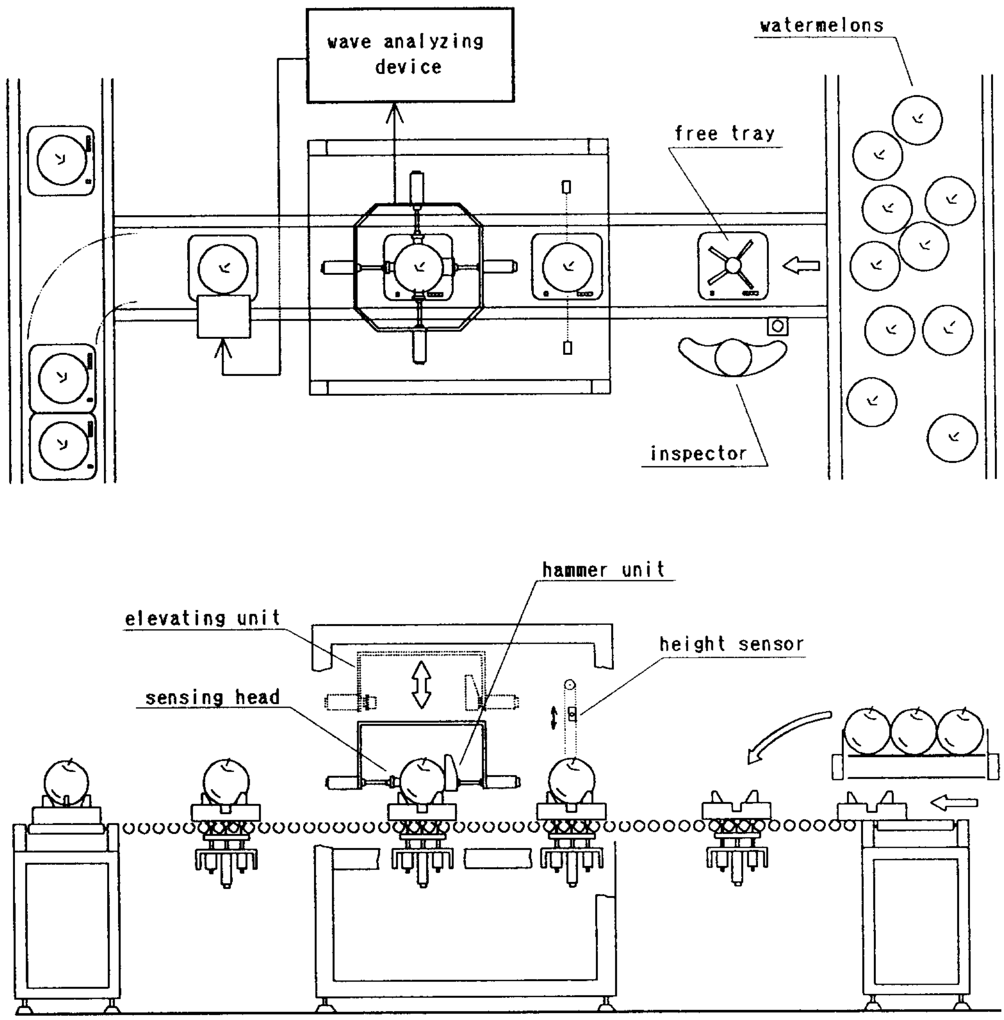

Fig.1 Ripeness and hollow detecting apparatus for watermelon. (MWA−9002)

Measurement of the ripeness and hollowness of the watermelon is carried out on the acoustic sound using a Fast Fourier Transform analyzer to analyze the waveshape. The results of a normal watermelon and a hollow watermelon using this device are shown in Figs.2 and 3 respectively. The graphs show (a)the original wave(signal), (b)the power spectrum, and (c)the auto correlation coefficient wave (spectrum).

Looking at a comparison of the original wave and the auto correlation coefficient wave from a normal watermelon with those from a hollow watermelon, a normal watermelon produces a clean damped waveshape, while a hollow watermelon produces disorder of waveshape. Thus, to determine whether a watermelon is hollow,the sum of the peak waveshape values for a given cycle is determined, and the result is compared with a judgment value established beforhand. If the watermelon is watermelon is hollow, there will be more than one peak, with the second peak tending normal, the

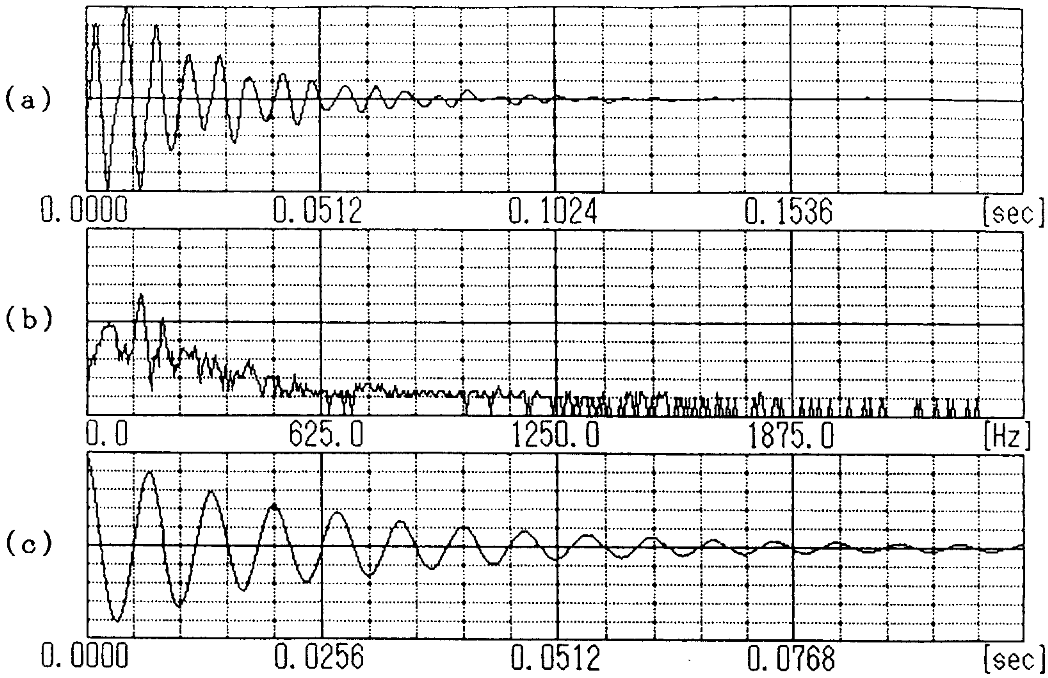

Fig.2 Result of waveshape analysis for normal fruit. The graphs show (a)the original wave, (b)the power spectrum, and (c)the auto correlation coefficient wave.

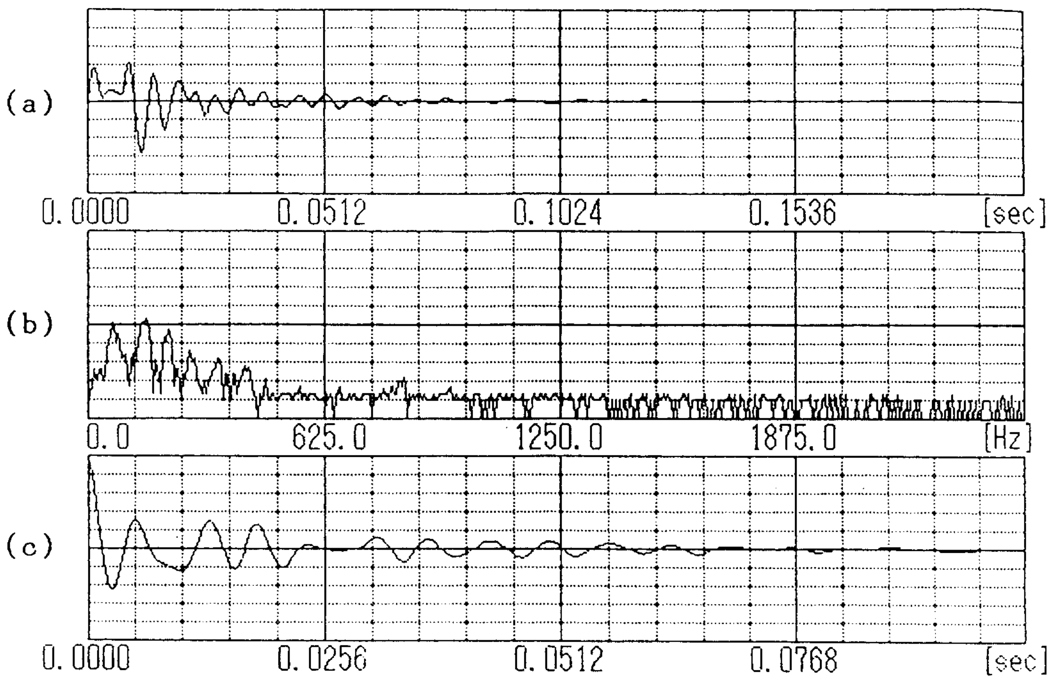

Fig.3 Result of waveshape analysis for hollow fruit. The graphs show (a)the original wave, (b)the power spectrum, and (c)the auto correlation coefficient wave.

peak frequency of the power spectrum is clearly discernible, but if the to have a lower frequency than the first peak. The quality of the watermelon can be determined by comparing the difference between the peak frequencies with the judgment value. Hollow spots and cracks, however, appear not in one isolated spot, but in a variety of locations.

Consequently, there are cases in which these flaws cannot be detected using a single sensor. We realized, as a result of our research, that a minimum of three sensors is necessary for accurate measurement, and we have thus used a method in which the auto correlation coefficient waves from the three sensors are compared in order to find defective watermelons.

There is a significant correlation between the ripeness of a watermelon and the hardness of its fruit. In an unripe watermelon,the fruit is harder, and gradually softens as the watermelon ripens.It has been reported that, as this happens, the peak frequencies gradually shift from higher frequencies to lower. The speed at which this transition occurs, however, varies considerably depending on the size of the watermelon. Therefore, we have found that it is not possible to measure ripeness accurately simply by determining the peak frequency. Fig.4 shows the results of tests carried out on 300 watermelons, in which the relationship between the peak frequencies was studied in terms of watermelon size and changes in ripeness. Namely, we found, when measuring ripeness, that it was necessary to correct for the diameter of the watermelon when measuring the peak frequency of the power spectrum determined through wave analysis.

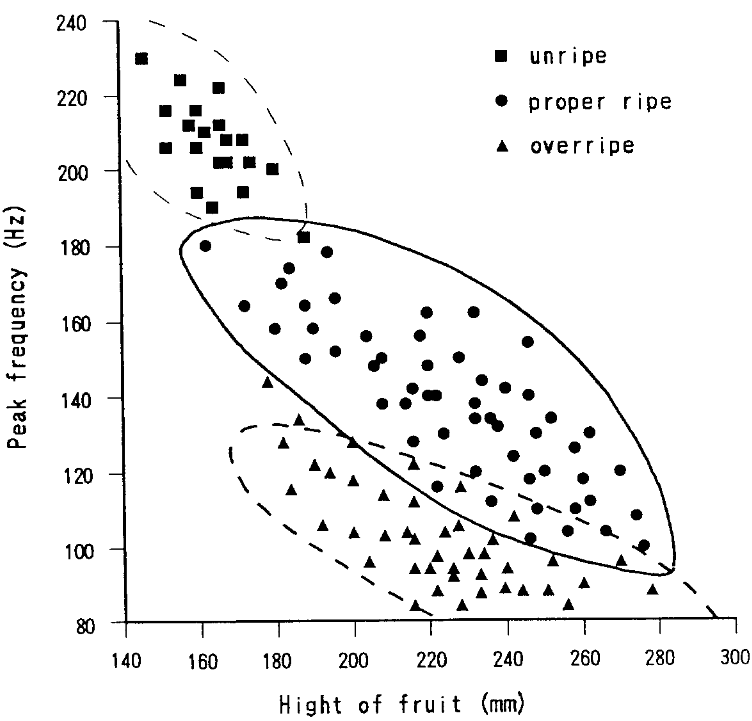

Fig.4 Relationships between the peak frequency and changes in the height of watermelon accompanied with progress of ripeness.

Specifications of the Automatic Watermelon Sorting and Packaging System and its Features

Prior to the development of the automatic watermelon sorting and packaging system, grading and sorting machines were used which classified watermelons by size and weight. However, watermelons had to be sorted and packed by hand. This new equipment is designed to automate all sorting processes to the fullest possible extent, thus reduction the workload and the labor required.

With this newly developed equipment, all of work processes, from the receiving process in which watermelons loaded on a truck by the producer are unloaded onto a conveyor, to the final process in which the watermelons are stored by grade and then are loaded on trucks, have been automated (except for one part of the visual inspection process), and operations in all of the processes are controlled by computer (see Fig.5). The primary feature of this system is the conception and actualization of the "free tray" system enables the fruit to progress smoothly from one process to the next with no damage from dropping or impact.

The free tray system is a transport system employing free trays which are recirculated. These free trays are 340 mm × 340 mm square trays made of plastic, each of which has four projections on it which keep the watermelons in place (see Fig.6). These four projections ensure that the watermelon does not roll off the tray because of oscillation or vibration during transport, and are covered with rubber caps to keep them from scratching the fruit. When the acoustic sounds are measured, it is necessary to suppress any effects caused by mechanical vibration, so the trays have been designed with contact between the watermelon and the projections at certain points, enabling precise sound measurements.

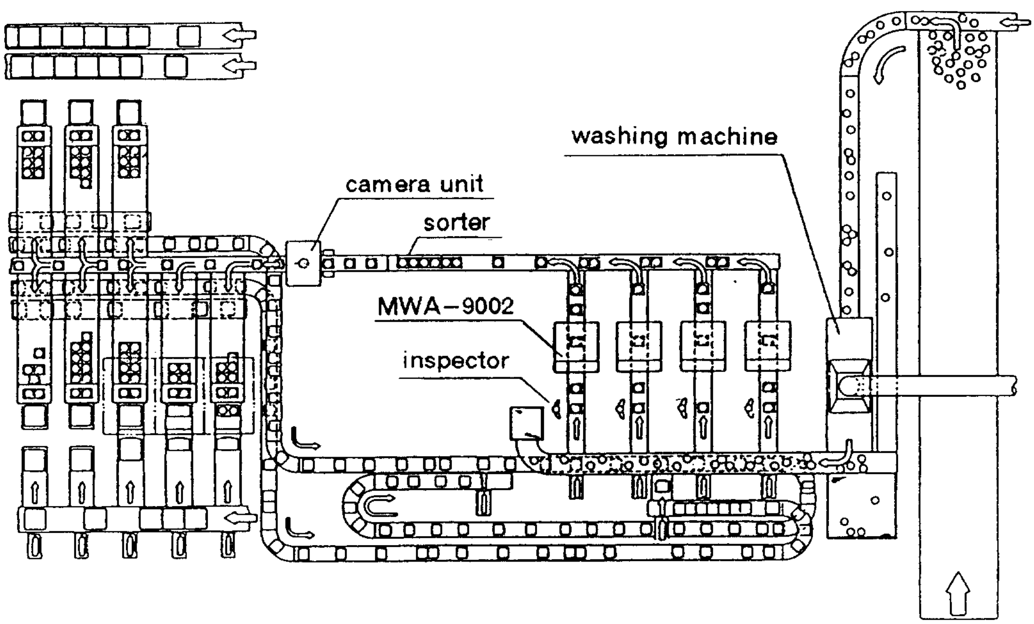

Fig.5 Sorting and packing equipment for watermelons.

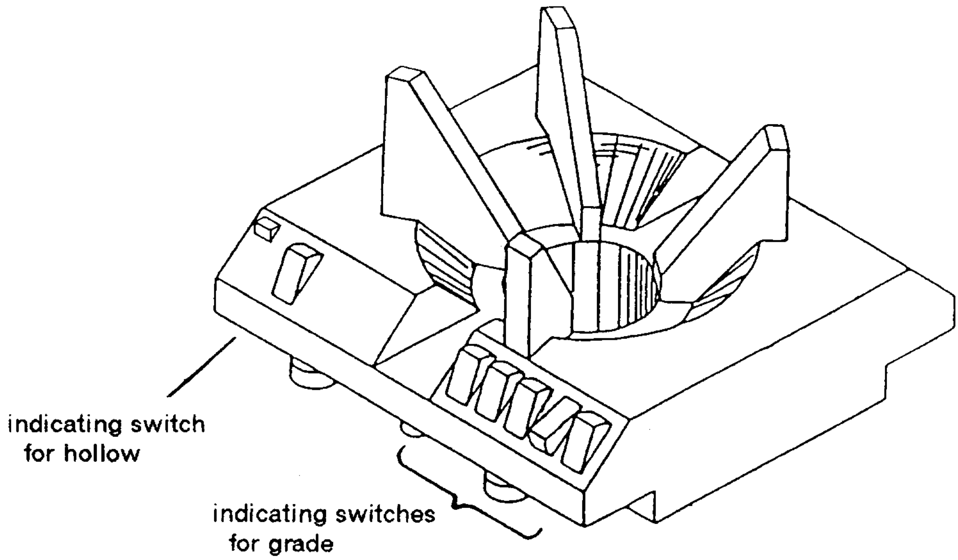

Fig.6 Free tray for watermelon.

This equipment is capable of processing 3,600 watermelons per hour. The flow of the sorting process is as follows: watermelons supplied to the sequencing line by mean of an intake conveyor go first to a washing machine, where any surface dirt is removed. An inspector then examines them visually for a number of factors(signs of damage or disease, stripe patterns, stylar scarring stem condition, degree of deformation, etc.) and sets them on a grade inspection conveyor to wait for a free tray. When the watermelon has been placed on a free tray, the Start button for the inspection process is pressed, and the watermelon is transported on its free tray through the various process, including measurements of the degree of ripeness and testing for hollow watermelons, a grade measurement process, labelling, and a process where it is classified by grade and size, after which it arrives at the packing process. The free trays carrying the watermelons are lined up on the packing pool conveyor to match the packing pattern (2, 4, or 5 watermelons to a box), and each watermelon is picked up from its free tray by an automatic packing robot which sets the watermelon in its box. The empty free tray is then sent to the retrieval line to be returned to the first process again.

The boxes containing the packed watermelons are automatically stamped on their side surfaces with the grade and size of the watermelons, and are sent to a product separation unit. This unit reads the grade and size from the stamped lettering and the product volume is recorded in a computer. From here, the box is sent to a storage unit where product are stored by grade and size. This same unit can also be used to send products automatically to trucks, using commands output by the computer.

CONCLUSION

In order to test watermelons for ripeness and hollowness, we have developed a system using an acoustic technique which is both safe and inexpensive, and makes watermelons easier to handle, and which allows online testing of watermelons.

In order to incorporate this device into the workplace and to reduce the workload and labor required in fruit sorting and selection, we also developed an automatic sorting and packing system.

The results of this development are summarized below.

(a) Using the acoustic technique, watermelons can now be tested online for ripeness and hollowness. As a result, sorting work which has previously depended on the intuition or "sixth sense" of the inspector can be carried out based on consistent judgment criteria, enabling product quality to be assured.
(b) A "free tray" system eliminates the previous problem of watermelons rolling off the conveyors and being damaged by impact during the sorting processes. In addition, packing is now handled by robots, thus reducing the workload and requiring less labor than before. As a result, the work involved in sorting and packing has been reduced by more than 50% in comparison with previous methods.
(c) Currently, this system has been installed in nine locations throughout Japan where watermelons are being sorted and packed automatically.

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