Technical Note
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What is Relative Virtual Weight by X-ray Inspection Systems?

Have you heard of the relative virtual measurement by x-ray inspection systems? Many of you may wonder why x-ray systems can measure the weight. Relative mass is the value which the difference of density between x-ray images of the reference master product and the inspected product is converted into the mass. This paper explains the principles of the relative virtual weight measurement, usage and cautions.

【1】The Principle of Virtual Relative Weight Measurement

X-ray inspection systems perceive x-rays transmitted through the product from a sensor and generate the x-ray image wherein the amount of x-ray transmission is shown by gradations of grey color in the shade.

For instance, when x-rays are applied to the product with a thickness of 50 mm, shade density of the x-ray image of the product is specified as 1. Then, when x-rays are applied to the product with a thickness of 45 mm, shade density of its x-ray image will be 10% lighter than the product with a thickness of 50 mm (45 mm divided by 50 mm = 0.9) if the density of these two products are the same.

Namely, it could be determined that if shade density is 10% lighter, the thickness of the product would be 10% lighter. In principle, it can be called virtual thickness; however, we call it virtual weight since the mass is widely used as a standard of measurement for food products.

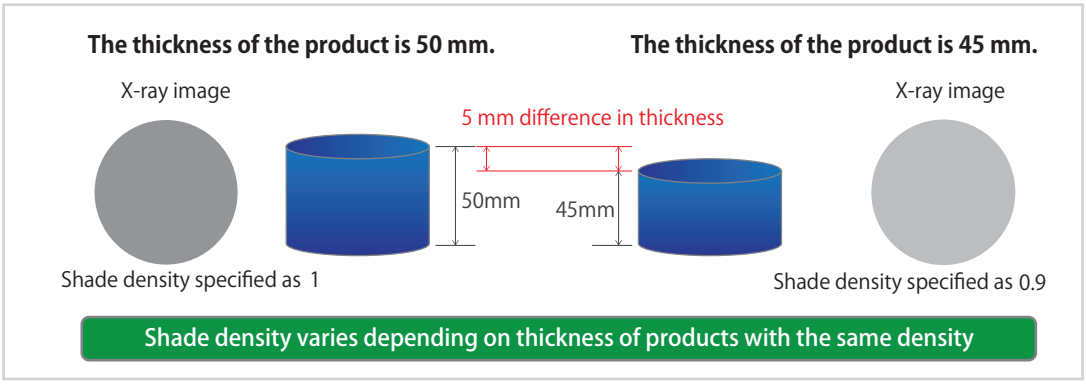

Fig.1-1 : Mechanism of Virtual Weight

【2】Application Examples for Virtual Weight Measurement

① Frozen Scallop Grading

In the production line where frozen scallops are classified into specified mass at high speed, a checkweigher is used to classify the product by weighing the products. Frozen scallops stored in a container are individually separated to weigh on the weigh table. However, the product can roll on the conveyor which leads a checkweigher to have a double product error (two items are on the weigh table at the same time that results in unmeasurable evaluation).

Our latest x-ray inspection system can process x-ray images of multiple products simultaneously and measure the virtual weight of each product for accurate classification. X-ray inspection system offers a high yield compared to the automatic checkweigher.

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The product is separated individually on an inclined conveyor

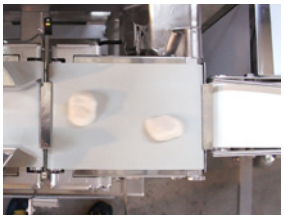

Two items on scale

Fig. 2-1:
Inspection by a Checkweigher

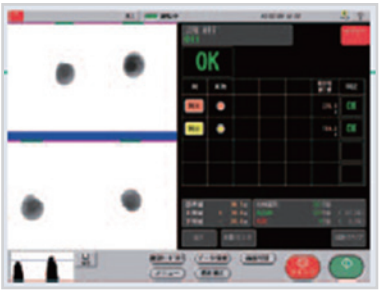


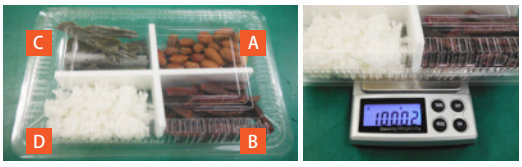
Fig. 2-2:
Screen Image of X-ray Inspection

② Excess and Deficiency Inspection of Specified Contents of Product

There are two bento boxes that contain four kinds of dishes divided by partitions. The image on the left shows the standard portion in each dish. Both bento boxes 1 and 2 in the below images weigh the same by an electronic scale.

Now, let's take a look at the x-ray images of these two boxes. The x-ray system can measure the relative virtual weight of each area in the box. As shown in the x-ray image, the dish in the area B in the bento box 2 has the same weight as the bento box 1, the reference master product. But the dishes in the areas A and C in the bento box 2 are overweight while the area D is insufficient in quantity. The x-ray system using the relative virtual weight measurement prevents a bento box in which any of the dishes is insufficient or excess in quantity from being sold in stores.

Bento box 1
the reference master product

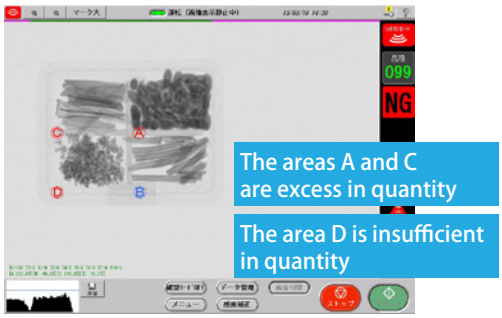


Mass value

X-ray image

Bento box 2
The total weight is the same but the weight of each area from A to D differs from Bento box 1.

Mass value



X-ray image

Fig. 2-3 : Excess and Deficiency Inspection of Contents of Product

【3】Is Checkweigher No Longer needed?

X-ray inspection system not only can detect contaminant but also can detect the difference in the weight from the x-ray image.

Does this mean the inspection by an automatic checkweigher is no longer needed? We compare the measurement result between an x-ray system and an electronic scale using 200 grams of butter and margarine.

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First, the weight of butter and margarine are measured individually by an electronic scale. The total weight including the wrapping is 215 grams for butter and 216.2 grams for margarine.

Now, the relative virtual weight of butter and margarine are measured by the x-ray system. The relative virtual weight of butter and margarine are measured using an x-ray image of butter as a reference.

When butter used for a reference was fed one more time, the same x-ray image was generated so that the relative virtual weight value of 215.2 grams that is almost the same as the actual weight is obtained. The relative virtual weight for margarine, on the other hand, was 211.6 grams which was 4.6 grams lighter than the value measured by a scale. When comparing x-ray images of butter and margarine, we can see the gray scale image of margarine appears slightly lighter than that of butter. The composition difference between margarine and butter would make the x-ray image to appear differently in the density of shade. When the relative virtual weight is measured using a different product as a reference, it is possible that the result is considerably different from the actual weight obtained. Even with the same products, the size of particles and leveling method for filling in the container could vary depending on the production lot. The gradation of shade on x-ray image is directly linked to a measurement error; therefore, it would be better not to use the relative virtual measurement in x-ray system for checking the weight accurately.

The actual weight of butter

The actual weight of margarine

The relative weight of butter

The relative weight of margarine

The actual weight by electronic scale		The relative weight by x-ray system
215.0 g	≒	215.2 g

The actual weight by electronic scale		The relative weight by x-ray system
216.2 g	>	211.6 g

Fig. 3-1 : Difference between the relative virtual weight and the actual weight

[4] Conclusion

Making the size of products such as fruits, vegetables, and marine products uniform when they are packed in a box will enhance the added value of products. In future, the virtual weight inspection by the x-ray system may provide more solutions. However, it is necessary to check if the variation in the virtual weight significantly differs from the variation in the actual weight by using an electronic scale and ascertain its practical use while comparing these two systems.