Characteristics of Vibrations Produced by Egg Sorters Exported for Asian Laying Hen Farming

Dong-Il Chang*1, Jae-Kwang So*2, Seung-Joo Lee*2, Yun-Beom Lee*2, Taek-Jin Yoon*3

Abstract

In this study, mechanical vibration generating cracked-eggs was measured and analyzed using commercial egg sorter. Vibration measurement of egg sorter was carried out by a FFT Analyzer ZonicBook/618E and acceleration sensors on the transfer system and packing system. The vibration measured on the transfer system ranged from 202.03 to 396.87 G (where, G=9.81 m/s²), and the magnitude of the impulse that eggs received from the transfer system was about 20.60~39.24 N in these tests. In the packing system, the vibrations were 7.98~9.05G, and the quantities of impulse imparted on the eggs were about 3.92~4.91N.

[Key Words]: Egg sorter, Vibration, Transfer system, Packing system, Cracked-egg

I Introduction

Recently, as the food consumption pattern of Asian countries has changed, the amount of egg production and consumption has increased as shown in Table 1. This has led to industrialization and large-size layer houses, and the facilities of laying hen house have been automated. Therefore, since collecting and sorting processes are mechanized, the impulse force given eggs by sorters has increased. Consequently, this has led to increased crack production on eggshells. (Wall et. al, 2002; Mertens et. al, 2006). Results of the previous studies showed that ratio of cracked-egg production by egg sorter was more than 70% among the total production of cracked-eggs. In general, it was misunderstood on farms that most cracked-eggs were produced by the impulse exerted by the machine units of the egg sorter for sound eggs instead of cumulative fatigues produced by the egg collecting process. Therefore, a study was needed on the cumulative fatigues produced by the egg collecting process, and on the mechanism of cracked-egg production for an eggshell having cracked by the force exerted by an egg sorter.

The objectives of this study were to position the anticipated machine parts of the sorter producing cracked-eggs, and to analyze the impulse imposed on the eggs by measurement of the vibration of the positioned parts, and to utilize the these results in order to reduce the number of cracked-eggs produced by the industrialized egg sorters, that would be a core technology for sorter development.

Table 1  Production of hen eggs in shell of Asian countries for the past several years  unit : MT

<table>
<thead>
<tr>
<th>Year</th>
<th>China</th>
<th>India</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Korea, Rep</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>6,560,750</td>
<td>1,161,000</td>
<td>364,400</td>
<td>2,419,000</td>
<td>393,320</td>
<td>291,700</td>
<td>319,000</td>
<td>449,100</td>
</tr>
<tr>
<td>1995</td>
<td>13,781,595</td>
<td>1,496,000</td>
<td>582,300</td>
<td>2,548,827</td>
<td>453,884</td>
<td>354,869</td>
<td>453,884</td>
<td>499,000</td>
</tr>
<tr>
<td>2000</td>
<td>18,911,880</td>
<td>2,015,000</td>
<td>642,000</td>
<td>2,535,444</td>
<td>478,800</td>
<td>390,550</td>
<td>445,000</td>
<td>514,563</td>
</tr>
<tr>
<td>2005</td>
<td>21,040,550</td>
<td>2,539,000</td>
<td>886,580</td>
<td>2,482,643</td>
<td>514,862</td>
<td>442,000</td>
<td>522,000</td>
<td>514,563</td>
</tr>
<tr>
<td>2007</td>
<td>21,833,300</td>
<td>2,670,000</td>
<td>2,525,000</td>
<td>1,174,600</td>
<td>545,000</td>
<td>465,000</td>
<td>530,000</td>
<td>469,709</td>
</tr>
</tbody>
</table>

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II Material and Methods

1. Causes of cracked-egg production

The causes of cracked-egg production would be ① age of laying hen, ② breed of laying hen, ③ properties of feed supplied, ④ abnormal hardness of eggshell due to rearing conditions, ⑤ friction produced between eggs during

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collecting and sorting processes, friction produced between eggs and parts of sorter, etc. During the egg collecting process, cracks are developed by the cumulative fatigues on the eggshell, which are produced by the collecting system. The eggs having cracks on their surface are broken by the impulse exerted by the sorter during the sorting process, which is about 9.81~19.61N (Seo et. al., 1997), or finish the sorting process without breakage.

2. Test materials and equipment

In this study, in order to find the anticipated machine parts of the sorter producing cracked-eggs, the operations of the sorter and video of the sorter in action were observed minutely. After positioning the suspected parts, measurement of the mechanical vibration of those parts were taken using an egg sorter for exporting (Model : α-4000; Eggtech Co. Ltd., Korea) as a test sorter.

Eggs collected by a collecting system are handled through a roller-conveyor, an accumulator, a washer, a dryer, an oil-coating machine, and inspection equipment in that order. During the inspection process, eggs having cracks are selected by the inspector first. Then the weight of the egg is measured by a load cell system and the eggs are moved to a basket-conveyor by a transfer system. Eggs were graded by weight and packed by a packing system. The specifications of the egg sorter used in the test are shown in Table 2, and a schematic of the tested egg sorter is shown in Fig. 1.

Table 2 Specifications of the tested egg sorter.

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>α-4000</td>
</tr>
<tr>
<td>Grading capacity</td>
<td>48,000 egg/h</td>
</tr>
<tr>
<td>Weight measuring error</td>
<td>±0.3 gf</td>
</tr>
<tr>
<td>No. of grading class</td>
<td>5 classes</td>
</tr>
<tr>
<td>No. of moving line</td>
<td>2 lines</td>
</tr>
<tr>
<td>No. of standing line</td>
<td>12 lines</td>
</tr>
<tr>
<td>No. of packer</td>
<td>12 set</td>
</tr>
<tr>
<td>Power</td>
<td>Three-phase, AC 220 V, 60 Hz</td>
</tr>
<tr>
<td>Consumption power</td>
<td>5.4 kW</td>
</tr>
<tr>
<td>Total weight</td>
<td>8,000 kgf</td>
</tr>
</tbody>
</table>

In order to find the suspected parts of the sorter producing cracked-eggs, a movie of egg sorting operation was taken with a Digital Camcorder (DCR-SR100, Sony Corp., Japan). By close observations, the machine parts of the sorter imposing impulses on the eggs were found. Then the opinions of the manufacturer of the sorter and farmers using the sorter were collected and the transfer system and the packing system (Fig. 2) were selected as parts of sorter process producing cracked-eggs.
were not sorted were purchased and stored at room temperature. The average weight of the eggs tested was 47.5~56.1g.

3. Methods of measurement and analysis of vibration

In order to measure the vibration produced in the tested sorter by weight of eggs, the transfer system and packing system were chosen as expected parts of the sorter which caused cracks on eggs. Vibration measurement was taken for each part.

The vibration measurement devices used were a FFT Analyzer ZonicBook/618E (Somat Ltd., England, 8 Channel), and an acceleration sensor (8720A500. Kistler Corp., USA) (Fig. 3).

The acceleration sensors used were attached to parts of the transfer system and packing system that imposed direct impulse on eggs as shown in Fig. 4, and real time on-line measurements of vibration imposed on eggs were taken by a control program of the FFT Analyzer ZonicBook/618E as shown in Fig. 5.

![Fig 4. Measurement systems of vibration in tested egg sorter.](image)

III Results and Discussion

1. Vibrations produced by transfer system

Measurement of breakage strength of eggshell was carried out to set up a standard of egg breakage strength in the egg sorter. The results showed that eggshell breakage strength ranged from 11.48 to 48.66N, and the average strength was 36.10N in the sampled eggs.

The vibration measured at transfer which is a suspected part of producing cracked-eggs by the cumulative fatigue during sorting operation, showed characteristics as in Fig. 6. The values of acceleration of vibration measured and analyzed by weight of eggs were 202.03~396.87G (where, G=9.81 m/s²) as shown in Fig. 7. Considering the mass of transfer only without considering the damping coefficient of material of transfer imposing impulse on eggs directly, the quantity of impulse imposed on eggs was about 20.60~39.24N. Because the average breakage strength of eggshell in sampled eggs having cumulative fatigue appeared 36.10N, cracks on eggshell would be expected from the transfer system.

![Fig 6. Test results of vibration levels at transfer.](image)

![Fig 7. The characteristics of acceleration produced by transfer system.](image)

2. Vibrations produced by packing system

The vibration measured at packing system which is a suspected part of producing cracked-eggs by the cumulative fatigue during packing operation, showed characteristics as
The values of the acceleration of vibration measured and analyzed were 7.98–9.05 G as Fig. 9 shows. Considering the mass of the packing system only without considering the damping coefficient of material of packing system imposing impact on eggs directly, the magnitude of impulse imposed on eggs was about 3.92–4.91 N. These were less than the average breakage strength of eggshells in this study, but, it was more than 1.96 N which was the lowest eggshell breakage strength in the previous study (Seo et al., 1997). Therefore, production of cracked-eggs was expected according to position or degree of accumulative fatigue of eggs.

The expected positions where cracked-eggs might be produced could be chosen in the egg sorter by the test results above. Based on this study, it was concluded that design changes are needed for the suppression of the transfer system and packing system to reduce the cracked-eggs rate in egg sorters.

**IV Summary and Conclusions**

In this study, parts of an industrialized sorter were analyzed and parts suspected of generating cracked-eggs were chosen. Measurements of vibrations were taken for those chosen parts. The study results may be summarized as follows:

1. A video of egg sorting operation was taken to find the parts of the sorter which were producing cracked-eggs. The transfer system and the packing system were chosen by analyzing the video.

2. The vibrations measured on the transfer system ranged from 202.03 to 396.87 G (where, G = 9.81 m/s²), and the impulse force that the eggs received by that system was about 20.60–39.24 N in these tests. This result showed that impacted eggs and sound eggs might be cracked by the transfer system.

3. The results of vibrations measured on packing system, were 7.98–9.05 G, and the magnitude of impulse imposed on eggs was about 3.92–4.91 N. These were less than the average breakage strength of eggshell in this study, but, it was more than 1.96 N which was the lowest eggshell breakage strength in the previous study. Therefore, production of cracked-eggs was expected according to position or degree of accumulative fatigue of eggs.

**References**


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