Development of a Print Checker for Bottle Labels

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This paper was originally presented at the MBAA 112th Anniversary Convention, Keystone, Colorado, 1999.

ABSTRACT

We have been using a laser printer to print the “best-before-date” on our bottled products, and the checker attached to the printer was not sensitive enough to detect all the defective prints subject to complaint from consumers. In Japan, incomplete and illegible prints of a date code can lead to consumer complaints. We were thus forced to perform periodic “on the line” visual inspections in addition to the automated checking system. When a defective print was found, we inspected all the products produced between the time of the previous inspection and the time the defective print was found.

This has been a great burden on the brewery, and we therefore started to develop a new checking system. The aims for the development were:

1. a high detection capability, and
2. capability to inspect 100% of the products.

The checker we have developed inspects print not by detecting the amount of laser luminescence, like the existing checker does, but by processing image data, which is to visually check the print itself. This system yielded a high detection rate of defective prints. One of the well-known disadvantages of the image processing system is its slow processing capability, which makes it unsuitable for high-speed lines. In order to compensate for the high-speed, we therefore positioned several checkers on each line and divided the monitoring range of a print so that each checker can monitor its range in shorter time. A trial of the checker on a 600 bpm bottling line proved it to be a checker significantly more accurate than the existing checker and one capable of resolving the problems we have had.

Keywords: checking, print checker, image processing, laser printer

INTRODUCTION

Breweries in Japan are required to label their products with the date of manufacture and the Best Before Date, by the Food and Hygiene Law. However, there is another reason for providing such labeling: Japanese consumers place a high value on freshness. Under such circumstances, we are printing the date of manufacture and Best Before Date using codes. If we ship prod-

SINTÉSIS

Nosotros hemos estado usando una impresora láser para imprimir “mejor antes que esta fecha” en nuestros productos embotellados, y el checador pegado a la impresora no fue lo suficientemente sensitivo para detectar todas las impresiones defectuosas de las que se quejan los consumidores. En Japón, las impresiones incompletas o ilegibles del código de fecha pueden conducir a quejas del consumidor. Fue por eso que nos vimos obligados a ejecutar inspecciones visuales “en línea” periódicas además del sistema de chequeo automático. Cuando se encontró una impresión defectuosa, nosotros inspeccionamos todos los productos producidos desde la fecha de la inspección previa a la fecha en que se encontró la impresión defectuosa.

 Esto ha sido una gran carga en la cervecería y por eso empezamos a desarrollar un sistema nuevo de chequeo. Las metas para el desarrollo fueron:

1. Una alta capacidad de detección y
2. La capacidad de inspeccionar el 100% de los productos.

El checador que nosotros hemos desarrollado no inspecciona las impresiones mediante la detección de la cantidad de luminiscencia del láser, como los otros checadores que existen, sino mediante el proceso de datos de imágenes, que es inspeccionar el impresión misma visualmente. Este sistema ofreció un nivel de detección alta de impresiones defectuosas. Una de las mas conocidas desventajas del sistema de proceso de imágenes es su lenta capacidad de procesamiento, lo que lo hace inadecuado para líneas de alta velocidad. Para compensar la alta velocidad, nosotros colocamos varios checadores en cada línea y dividimos el rango de monitoreo de la impresión de tal manera que cada checador pueda monitorear su rango en un tiempo más corto. Una prueba del checador en una línea embotelladora de 600 bpm comprobó que el checador era mucho más preciso que el existente y era capaz de solucionar los problemas que te estabamos teniendo.

Shojiro Ozaki was born in Funabashi-city, Chiba in 1971. In 1994 he graduated from Chiba University with a BS degree in electronic engineering. That same year Shojiro joined the Engineering Department of Hakata Brewery of Asahi Breweries, Ltd. From 1996-1997 he was in charge of works for building filtration equipment (60kL/h) and 6 fermenters (420kL) at the Hakata Brewery. The next year, 1997-1998, he was in charge of works for building 24 storage tanks (420kL) at the Hakata Brewery. Following that, Shojiro developed a print checker for bottle labels in 1998. Presently he is in charge of works expanding capacities at the Hakata Brewery packaging lines (mainly for two 900kPH kegging lines).

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ucts with defective prints, we both violate the law and fail to meet consumer expectations, which must be prevented at all costs. Therefore, not even one bottle with defective prints should be placed on the market. This is the basis of our business strategies.

We are now using a laser-printing method. Information for labeling is printed on the back label of a bottle; the information includes not only the date of manufacture and Best Before Date, but also the code of the production brewery and the lot number specified for each five-minute production period. In addition, we use machines that inspect the amount of light for printing inspection.

One of the problems in printing is defective prints. Table 1 summarizes the types and causes of defective prints, as well as their frequency over the past year.

**TABLE 1**
Causes and Frequency of Defective Prints.
June '97 - June '98

<table>
<thead>
<tr>
<th>Failure</th>
<th>Cause</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>No print</td>
<td>Two labels picked up</td>
<td>8</td>
</tr>
<tr>
<td>Elongated print</td>
<td>Flagged</td>
<td>16</td>
</tr>
<tr>
<td>Incomplete print</td>
<td>Improper mask rotation</td>
<td>40</td>
</tr>
<tr>
<td>Light print</td>
<td>Burned lens</td>
<td>48</td>
</tr>
</tbody>
</table>

There are four types of defective prints:

1). **No print:** This occurs when two labels overlap during printing.

2). **Elongated letters:** This occurs when the label separates slightly from the pallet. Under such conditions, the letter printed on the separated part elongate.

3). **Incomplete letters:** This occurs when the rotating mask of the coder gets stuck and interferes with the laser beam.

4). **Light letters:** This occurs when the lens of the coder has been burnt, thereby decreasing the laser transmission.

We have taken various countermeasures to eliminate such defective prints, but this cannot be accomplished using the existing technology alone.

Another important element is the inspection machine. As I have already explained, we use a checker to inspect the amount of light. The principle of the checker is to measure the amount of light when the laser evaporates label ink, and to judge whether the print is normal, based on the amount of generated light. However, the amount of generated light varies significantly depending on the letter profile, the thickness of the label-ink, and the output of the laser. To prevent detection errors, therefore, we have to set a low detection level. As a result, the capability of the checker to detect defective prints is also extremely low.

Figure 1 shows samples of print failures. The purpose of printing is to provide information on the product to consumers. Therefore, legibility is the minimum requirement for printing. However, the existing checkers cannot detect all illegible prints, such as incomplete, elongated, or light letters.

The production line is frequently disturbed by such problems. In routine operation, we visually inspect the prints once every five minutes. This requires an enormous workload for operators. When an defective print is detected in the visual inspection, we stop the production line, suspend shipping, and re-inspect all bottles that have passed through the checker since the previous visual inspection. This also requires labor for adjusting the figures for the demand for and supply of products, and may inconvenience customers due to a shortage of products.

As I have explained, enormous manpower is required due to the insufficient capacity of the checker. Therefore, we considered the introduction of a high-performance checker. There are three types of conventional checkers, as shown in Table 2.

**TABLE 2**
Conventional Print Checker

<table>
<thead>
<tr>
<th>Type</th>
<th>Printing Method</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1:</td>
<td>Detection of the</td>
<td>Laser printing</td>
</tr>
<tr>
<td></td>
<td>amount of light</td>
<td>Widely used</td>
</tr>
<tr>
<td>Type 2:</td>
<td>Image-processing</td>
<td>Ink-jet printing</td>
</tr>
<tr>
<td></td>
<td>inspection of the</td>
<td>Laser printing</td>
</tr>
<tr>
<td></td>
<td>area of letters</td>
<td>Used for inspection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of letters on cans</td>
</tr>
<tr>
<td>Type 3:</td>
<td>Image-processing</td>
<td>Ink-jet printing</td>
</tr>
<tr>
<td></td>
<td>pattern matching</td>
<td>Laser printing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used for inspection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of letters on cans</td>
</tr>
</tbody>
</table>

**Disadvantages:**

1. Does not include a space for installing a stroboscope.
2. Precision is low when letters are changed during the inspection.
3. The inspection area cannot be changed.
Type 1) Checker that inspects the amount of light: This is the same type we are using. Its capacity to detect defective prints is extremely low.

Type 2) Checker that inspects the area of letters through the use of an image-processing device. It also judges the integrity of letters based on a physical quantity or the area of letters. Due to variances in the letter profile, high accuracy cannot be expected of such an inspection method.

Type 3) Checker that performs pattern matching with normal letters through the use of an image-processing device. Unlike the two inspection methods I have explained here, it can inspect the letter profile. We are using this method to inspect letters on the bottom of cans. The accuracy of this type is excellent.

When we applied type 3 checker to the inspection of bottle-label printing, however, three problems arose.

1) There is no space for installing a stroboscope for inspecting bottle label prints that is needed to stabilize the accuracy of his machine.
2) The lot number, and other letters are changed during the course of inspection. Pattern matching cannot ensure high accuracy for inspecting the lot number and the other letters that are changed during the course of inspection. Such letters can be inspected only by the type 2 checker, which inspects the area of printed letters.
3) The inspection area cannot be changed.

For these reasons, any conventional checker did not allow us to inspect bottle label printing properly. Therefore, we have developed a new inspection machine.

FEATURES OF THE NEWLY DEVELOPED MACHINE

The newly developed inspection machine uses a new means and method different from those of conventional checkers. Table 3 compares the new machine and an old machine (type 3) that performs pattern matching.

TABLE 3
Features of the Newly Developed Checker

<table>
<thead>
<tr>
<th>Feature</th>
<th>Conventional (Type 3)</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing method device</td>
<td>Image-processing device, binary processing</td>
<td>Image-processing device, gray processing</td>
</tr>
<tr>
<td>Inspection method</td>
<td>Pattern matching (fixed letters) Detection of the area of letters (changed letters)</td>
<td>Pattern matching + Reading of letters (all letters)</td>
</tr>
<tr>
<td>Position correction</td>
<td>Expanded inspection area</td>
<td>Displacement of images by pattern matching</td>
</tr>
</tbody>
</table>

One of the features of the new checker is gray processing of images. A second feature is that the machine identifies letters themselves. A third feature is that the machine corrects the inspection position through pattern matching.

These three features have eliminated all the problems associated with the conventional checkers.

Feature 1

There are two methods of image processing. One is binary processing used by the conventional checkers. The other is gray processing adopted for the new checker. Binary processing classifies the degree of shading at a point into two values, white and black, by comparing it with a reference shading level. This method features high-speed processing, as the volume of data processed is small. However, there is a problem which is its high sensitivity to environmental conditions. If the ambient light gets dark, the composition of white and black changes. Therefore, we needed a stroboscope for conventional checkers. (see figure 2).

On the other hand, the gray processing method processes the shading of an image as it is. In other words, it processes the degree of shading or the waveform of light, which is insensitive to the level of illumination and other environmental conditions. This ensures the accuracy of inspection. Therefore, it is not necessary to use a stroboscope for the new checker. A space for installing it is not necessary, either. However, this method also has disadvantages. As it must process a large volume of data, it throughput is low. To solve this problem, we use three image-processing devices.

Feature 2

The conventional inspection method performs 1:1 (one-to-one) pattern matching by comparing the printed letters with registered normal letters. However, pattern matching cannot be performed for letters such as lot numbers, as their normal letters are changed during the course of inspection. (See figure 3).

Therefore, we have adopted a new concept for the new checker: that is identifying letters for inspection. As shown in figure 3, the machine compares each printed letter with all registered normal letters and selects the one most similar to the printed letter.
The machine then inspects letters through pattern matching between the printed letter and the selected normal letter. This makes it possible to perform pattern matching even for lot numbers, and enables high accuracy inspection. (See figure 3).

**FIGURE 3**
Features of the New Checker (2)

**Feature 3**

As the objects of inspection are moving at a high speed, they are not fixed by the imaging camera. In addition, the position of the label on the bottle often deviates slightly from the standard position, and the line speed also fluctuates.

To solve this problem and ensure high accuracy inspection, the conventional method inspected an area larger than that normally required. However, there are letters and patterns on the label that should not be inspected in the expanded inspection area. When such unnecessary letters and patterns are inspected, an inspection error occurs. (See figure 4).

In contrast, the newly developed machine moves the inspected image to the normal position through pattern matching. This solves the problems inherent with the conventional checkers. (See figure 4).

**COMPOSITION OF THE INSPECTION SYSTEM**

Figure 5 shows the system composition of the newly developed checker. This machine is composed of three image-processing devices, cameras, monitors, and a sequencer. The image-processing device is the Omron type F350.

**FIGURE 5**
Composition of the Inspection System

The monitor of each image-processing device is connected to an image-storing device. This image-storing device automatically stores images in the event of defective printing, or when an NG image is detected. This helps determine the cause of failures in printing. This is also one of the features of the new checker.

**OBJECT AND AREA OF NEWLY DEVELOPED CHECKER**

Figure 6 shows object and area of newly developed checker. We use 39 letters for printing, and print 17 letters in two lines. The capacity of the production line is 600 BPM. To meet the requirements for inspection, this checker divides the area of inspection into three sections and three image-processing devices are used to inspect these three areas.

**FIGURE 6**
Object and Area of Inspection
When the label shows the date of manufacture and the Best Before Date only, just one image-processing device is enough to inspect the prints.

PICTURES OF THE NEWLY DEVELOPED CHECKER

FIGURE 7
Incomplete letter

PICTURE 1
Checker

PICTURE 2
Camera implanted in the labeler

PICTURE 3
NG image-storing device

SAMPLES OF IMAGES INSPECTED BY THE NEWLY DEVELOPED CHECKER

Figures 7, 8 and 9 are images monitored by image-processing device number 1. The area-framed bold line is the inspection area. The letter-framed thin line are judged as normal. In figure 7, the top of the letter 5 is incomplete and it is judged as no good (NG). In figure 8, two of the Chinese characters are elongated and are therefore also judged as NG. In figure 9, all letters are light and are judged as NG.
PERFORMANCE OF THE NEWLY DEVELOPED CHECKER

We have tested the machine on a 600-BPM bottling line. The maximum capacity of the machine is 720 BPM. The minimum requirement for the checker is to detect all illegible letters. The checker we have developed meets this requirement.

This machine has several advantages. First, the inspection mechanism is compact, as it doesn't require a stroboscope. Second, it ensures high-accuracy inspection through pattern matching, even when letters are changed during the course of inspection. Third, it can inspect properly even when the inspection position shifts greatly.

This newly developed checker has great performance which I have explained here, and can solve the present problems.