Scuffing

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ABSTRACT

Scuffing is the appearance of white wear marks on bottles which are less attractive for consumers and unacceptable for quality products.

Full scale trials showed that a scuffing reduction of 100% can be obtained by applying a post-end coating which lowers the mechanical impact on bottles, thereby doubling the lifetime of bottles. An additional 20-50% scuffing reduction can be obtained by optimization of the chemical conditions in a bottle washer.

Several coatings and application techniques to mask scuffing were evaluated on laboratory scale, positive results were found. Depending on the scuffing level of a bottle stock either reducing or masking scuffing is most cost beneficial.

In addition to this work an extremely accurate scuffing analyzer was developed which has been installed successfully on a bottling line.


INTRODUCTION

In most countries in Europe, beer is packaged in glass bottles of which a high percentage is packed in returnable bottles. These bottles are put on the market several times and, in between, are returned to the brewery for cleaning and filling. By increasing the lifetime of these bottles, so-called scuffing develops on the bottle surface. Scuffing is the white/gray wear marks on glass bottles resulting in an unattractive visual appearance of the product and is unacceptable for quality products. The generation of scuffing is caused by bottle handling on the bottle filling lines. The mechanical impact of bottles during transport causes microcracks in the glass surface. A subsequent chemical attack of caustic soda in industrial bottle washers etches the microcracks and gives them a more pronounced white/grey appearance.

At the moment there are basically two options to obtain a better quality of a bottle stock as far as scuffing is concerned. These options are prevention by reducing the chemical attack and/or mechanical impact on bottles or by masking the scuffing rings of bottles.

The effect on scuffing resulting from the presence of some components in a bottle washer was examined on laboratory scale and implemented in practice, the results of this were also evaluated. To analyze the results of these various options, a scuffing analyzer was developed to measure the generation of scuffing by increasing the lifetime of a bottle. This analyzer was also installed on a bottling line to measure scuffing of a bottle stock and to reject severely scuffed bottles.

The reduction in scuffing, which can be obtained by using a polyethylene post-end coating by lowering the friction forces between bottles during transport on the bottling lines, was also examined. This coating is a relatively new formulation, giving better results than an already existing polyethylene product which is normally applied by sponges directly after the bottle washers.

Several already commercially available masking (or camouflage) coatings and some coatings which are still under development were evaluated on laboratory scale. A manual application method was developed, which is preferably used in production practice.
EXPERIMENTAL AND METHODS

Scuffing experiments

Scuffing experiments were carried out on laboratory scale, simulating the actual bottle handling processes on the bottle filling lines. The mechanical impact is simulated with an AGR line simulator. This apparatus has been designed to provide an accelerated, reproducible and standardized laboratory abuse treatment between bottles which simulates the abrasion characteristics of normal filling lines. The subsequent chemical attack is carried out using hot water and hot caustic soda baths to simulate the industrial bottle washers. One trip on a bottle filling line can accurately be simulated by a cycle as follows: 1.5 min. AGR line simulation at 50% slip velocity followed by 5 minutes pre-rinsing in hot water $T = 50^\circ C$, followed by 15 minutes soaking in caustic soda at $T = 80^\circ C$, followed by 5 minutes cooling at $T = 50^\circ C$ in post-rinsing water at $T = 50^\circ C$ and 5 minutes at $T = 20^\circ C$.

Such a simulation will save a lot of time compared with a full-scale trial and gives very accurate results which can be directly interpreted for production usage. This test equipment has been of special interest to us in our investigations of the chemical influence on scuffing. The effect of temperature and additives in the caustic soda baths can easily be analyzed with the above-mentioned simulation.

Scuffing analysis

To avoid poor reproducibility of scuffing analysis by visual observation, a scuffing analyzer has been developed. Two systems were tested on laboratory scale and evaluated. The systems evaluated were a Line Scan Camera and a CCD camera. The scuffing was only measured at the top and bottom scuffing rings and not over the whole circumference of the bottle. It was found that the use of a front light source on the bottles gave a better result than a background light source for a CCD camera. For the line scan camera only a background light source was tested. Both systems proved to be able to give an accurate and reproducible scuffing analysis of bottles with different scuffing classes.

Masking experiments

To evaluate the possibilities of masking coatings, an application method was simulated comparable to the application to be used in production. In this method sponges are used at the outgoing starwheel of the labeler. No additional equipment up- or downstream the labeler is needed with this application.

Important parameters had to be measured by the human sensors: the visual effect and the bottle surface ‘feeling’ after treatment with a coating. The effect of the removal of the applied coating once the bottles are washed was simulated by the four-stage washing procedure. No production scale experiments were carried out.

RESULTS

Scuffing prevention

Reduction of chemical attack

By optimal selection of additives and by avoiding certain components and process conditions of a bottle washer, scuffing caused by chemical attack can be reduced in the range of 20 - 50%. This scuffing reduction depends on the conditions typically existing in the bottle washer. This result was found after analysis on laboratory scale of some bottle washer conditions and some of the results were verified in production. It was found that the reduction in scuffing can be obtained by avoiding or minimizing certain components such as carbonates, phosphates or calcium in the caustic soda solution or by lowering the temperature. We also found that several anti-foam agents and additives increased scuffing without knowing exactly which components are accelerating the chemical attack. It would, therefore, be recommendable to analyze the existing additives used in a brewery on the effect on scuffing, and to replace scuffing-accelerating components by scuffing neutral components. The results obtained, operating the bottle washer with a low carbonate level, are given in this paper.

Low soda content

In a particular brewery the water consumption of a bottle washer was reduced by lowering the water use in the post-rinsing zone. This resulted in a relatively high pH of this post-rinsing zone, owing to carry-over of caustic soda, which causes scaling on the bottles. This scaling can be avoided by dosing CO$_2$ in the post-rinsing zone to reduce the pH. This CO$_2$ dosing resulted in a high CO$_2$ atmosphere above the caustic soda baths. The CO$_2$ is then absorbed and reacts with OH$^-$, producing CO$_3^{2-}$. As was found from laboratory-scale experiments a high carbonate concentration increases the rate of chemical attack. In figure 2 the result is illustrated of a full-scale trial, in which the effect of a high carbonate concentration is tested against the lifetime of a bottle.

Reduction of mechanical impact

At the moment several breweries in Europe already apply post-end coating (polyethylene based). This coating lowers the friction forces between bottles and thereby prevents the generation of microcracks. So far these coatings gave a scuffing prevention of approx. 30%. A new type of coating has been tested on one of the existing installations; results were very positive: a scuffing prevention of 80-100% was obtained. Such a post-end coating is preferably applied by sponges directly after the bottle
washer. In this set-up the maximum amount of prevention can be obtained when the bottles pass all the way through the lines. The reason why this coating performs better than the previous ones is that the coating is not washed off during pasteurization. Therefore, it will also prevent a bottle from scuffing ex-pasteurization and pre-bottle washer and, up to a certain amount, in the bottle washer from chemical attack, although the coating is completely washed off in a bottle washer and degraded by caustic soda. This effect of a bottle with polyethylene coating which is not washed off during pasteurization was identified by using alumina pulver. A bottle without a polyethylene coating does not retain the alumina pulver, contrary to a bottle with a polyethylene coating.

The result of the use of this post-end coating is shown in figure 3.

**Visual Classification of Masking**

<table>
<thead>
<tr>
<th>Brown Bottles</th>
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<tbody>
<tr>
<td>Number of Bottle Trips</td>
</tr>
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<td>5</td>
</tr>
<tr>
<td>10</td>
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<td>45</td>
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<td>50</td>
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**FIGURE 4:** The relation between the visual scuffing classification and the lifetime of a bottle for non-treated and masked samples.

**Masking of scuffing**

The visual appearance is, of course, the first factor of interest when evaluating different masking coatings. This, however, is not a discriminating aspect; all tested coatings performed comparably. However, a different performance results from different colors of bottles. In general, it can be stated that the darker the bottle, the better the reduction, e.g. a brown bottle gives a better result than a green one.

The application method that was aimed for is integrated in the exit starwheel of the labeling machine. This is more critical than the equipment used nowadays, mainly in Japan, which is an additional linear type application. An advantage of the method used is the ability to apply the coating only on the scuffed areas of the bottles, usually the bottom and shoulder areas. This offers a reduction as much as 50% in coating use. The effect of masking is illustrated in figure 4.

The surface feeling was changed by all coatings used (wax, silicone-based, etc.) in such a way that this will be an important factor when approving their use. Curing coatings (like some silicone-based products) gave a 'routher' surface. Drying coatings (like some wax-based products) resulted in a more slippery feeling. The acceptance level is to be determined with the help of the consumer.

**On-line Scuffing analysis**

The line-scan scuffing analyzer which was developed for laboratory-scale use was also installed on a bottling line to reject scuffed bottles. The basic principle of this analyzer is illustrated by the pictures below:

**FIGURE 5:**

Schematic overview of the bottle transport and Inspection area.

Of each bottle passing the line scan camera, at least 200 vertical line scans of a top or bottom scuffing area are taken. The measurement of a line scan is based on the amount of light passing through the scuffed area. When a bottle contains a large amount of scuffing, the majority of the light is scattered and, therefore, the amount of light measured by the line scan camera is less than for a new bottle. Every individual line-scan is evaluated and after statistical analysis of all line scans, one scuffing value is given to a bottle. Due to this statistical analysis and by using a color reference point of a bottle, the measurements are not influenced by wall thickness and color variation of the individual bottles.

In this particular brewery where the line-scan camera is installed, it has a rejection function as well as a monitoring function of the scuffing level of a bottle stock. The results of this analyzer were compared with an existing empty bottle inspector which used the side wall inspection for scuffing detection and rejection of severely scuffed bottles. It was found that the line scan camera does not produce any false rejects of acceptable bottles which show scuffing, contrary to an existing side wall inspection, which rejects 5% of acceptable bottles among all the bottles.
rejected bottles. Bottles which pass on to the filler contain 5% of very severely scuffed bottles when the line scan camera is used, and more than 10% when a standard side wall inspection is used.

**CONCLUSIONS**

Based on existing theory and practice the options mentioned were evaluated and tested on laboratory scale and in practice.

Prevention of scuffing is of special interest to breweries with a rather new bottle stock. The options to be used are prevention by a post-end coating and reduction of chemical attack by caustic soda, resulting in a scuffing prevention of more than 100%.

Masking of scuffed bottles is of particular interest when an old and severe scuffed bottle stock is concerned. In this case the masking option is generally a more cost-effective solution to upgrade a scuffed bottle stock in comparison with replacement of heavily scuffed bottles by new bottles.

When it is considered to upgrade a bottle stock by rejecting severely scuffed bottles a line-scan camera is preferably used. Currently, this is a good measuring technique, which does not cause many false rejects. This applies especially to bottle stocks with a large variation in wall thicknesses, bottom push-up and color deviation.