Returnable Container Crowning and Sealability Performance

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ABSTRACT

The paper covers our work done on improving and upgrading our filling, crowning and sealability performance on our returnable packaging lines. The discussion includes progress made on the investigation and development of cocked/bullnose crown inspection technology, and correcting and reducing the causes of cocked crowns. The work also includes focus on filling performance and consistency, as well as improving package DO performance.

Keywords: jockey crowns, bullnose caps, cocked crowns

INTRODUCTION

Returnable bottle containers represent a 78% plus package share within our package portfolio and consequently need to be effectively managed to ensure optimal utilisation of this key asset. The drive to achieve consistent and optimum packaged product quality performance has resulted in increased focus being placed on reducing and eliminating crowning and sealability defectives which have arisen through damage to the container finish, inconsistent crowning performance and other factors related to the use of a high trip returnable container.

We have found that a particular make of crowner is far more prone to producing jockey / bullnose caps and these crowners have required specific modifications and revised maintenance practices to prevent and reduce this incidence. The need to consistently detect and monitor this problem on a continuous basis has also necessitated the installation of suitable in-line inspection technology.

In this paper, I will cover some of the progress made and our approach to managing out these types of defects.

The following aspects will be covered:

- SAB returnable pack and background / history
- Detection methods introduced and machine modifications done
- Current methodology and focus areas
- Conclusions and further work required.
THE SAB RETURNABLE PACKAGE AND BACKGROUND

Figure 1 shows the pack and pack share mix portfolio within our South African sphere of operations, and, for the purpose of this paper the 750 ml pack has been selected for discussion.

The ‘sealability’ type complaints, ie, jockey caps, micro leakers and cracked / damaged necks were of particular concern as they were not being adequately detected through our normal routine process control checks during manufacturing.

We also found through our packaged container dating system (we use a Julian date code, and code by brewery, packline and time of packaging) that the problem appeared to be far more prevalent on a particular make of filler / crowner – in terms of magnitude by three times as much as any of our other makes of crowner. This was further exacerbated by the problem appearing to be occurring randomly and not consistently, which indicated that set up and maintenance was a significantly contributing factor.

DETECTION METHODS INTRODUCED AND MACHINE MODIFICATIONS DONE

In order to attempt to specifically quantify the extent of the problem, we introduced a manual inspection procedure on each of our returnable packaging lines where a physical sample of 100,000 containers was inspected at a set frequency. These results were tabulated on all of our returnable packlines and a similar pattern emerged on all lines equipped with this particular make of filler / crowner.

The results of this survey are shown in Figure 3.

These results reflected a significantly higher number of defects than shown in Figure 2 (the trade complaint numbers) which indicated that we were not capturing all possible complaints and that the situation was more serious than first envisaged.
We then selected a particular packline which had shown consistently poor performance results with these types of defects as a pilot for further research and development work. An extended performance capability trial was conducted over a 120 hour continuous period on this filler / crowner. This trial was preceded by a full set up review to restore the machine to manualised standards by the supplier’s service engineers.

Some very marginal improvement was evident, however, certainly not to an acceptable level. In addition, the machine supplier was only prepared to guarantee a total performance capability level of 0.1% or 1000 defects per million, which again, was clearly unacceptable.

We then decided to tackle the problem by, firstly, addressing the root cause, and, secondly, introducing suitable in-line inspection technology to provide the necessary detection capability to reduce the incidence of defects to Six Sigma target levels, and, also provide packline management with suitable proactive process control indicators.

In conjunction with the machine supplier, the following modifications were implemented on this pilot machine in an attempt to improve crowning and crown handling. Five key machine modifications were undertaken—

a) Guides and Starwheels

Spring loaded body and neck bottle infeed guides were fitted to the machine to assist in keeping the bottle aligned and stable at the point of crown application.

Newly designed crowner body and neck starwheels were fitted. The neck starwheel was moved and positioned closer to the bottle neck to ensure better positioning of the bottle in combination with the spring loaded neck guide. Refer Figure 4.

b) Crown Feed Star Mounting

A re-designed crown feed starwheel mounting, capable of rotational, horizontal and vertical adjustment with respect to the outer shroud of the crowner was installed to enable finer alignment to individual crown elements. Refer Figure 5.

c) Crown Feed Chute Modification

The crown feed chute was modified to accommodate replaceable wear strips to ensure optimum crown feed and reduce crown chute maintenance costs. The crown feed stopper piston was moved closer to the crown feed starwheel to reduce crown loss in the event of the no bottle no crown trip being activated and on bottle run out. Refer Figure 6.

d) Re-designed Crown Extractor Plungers

Re-designed crown extractor plungers, with a machined concave face to match the profile of the crown shell, were installed to reduce crown movement / slippage on the extractor plunger face. Refer Figure 7.

e) Extended Crowner Centre Column

The existing hub design did not have sufficient capability to fully accommodate our very tall 750 ml container. The crowner had been generically designed to accommodate a wide range of bottle heights and had not been specifically designed for our container. At optimum height setting very little tolerance existed between the crowner machine centre column and the moveable hub causing excessive hub and keyway wear which resulted in excessive crowner head movement and inconsistent crowned bottle performance. Refer Figure 8.

![FIGURE 4](image_url)

Guides and Starwheels
Figure 1: Mounting before modifications

Figure 2: Adjustable mounting

Figure 3: Crown Star

Figure 4: Crowner shroud cover

Figure 5: Crown Feed Star Mounting

Figure 6: Mounting after modifications

Figure 7: Re-designed Crown Extractor Plungers

Figure 8: Movable Hub Section

Figure 9: Extended stationary centre column

Figure 10: Crown Extractor Plunger

Figure 11: Machined Concave Face

Figure 12: Stopper Piston moved closer to crown star

Figure 13: Replaceable Wear strips

Figure 14: Crown Star

Figure 15: Extended Crowner Centre Column
A post modification 120 hour performance test was conducted and the results achieved are tabled in Figure 9.

![Figure 9](image)

**FIGURE 9**
Post Modification Performance Test

At best the performance capability of this machine was observed to be around 45 defects per million which, again, was clearly not acceptable to us, and, consequently highlighted the need to urgently introduce suitable in-line inspection technology to manage the incidence of these types of defects.

In addition, the need to review our maintenance programme on these machines was a prime requirement as we found that even with having introduced this modification to all of these particular crowning machines (at a cost of around $60,000 per machine) the incidence of defects and particularly cocked crowns / jockey caps increased over time and throughput due to wear and tear and other related factors.

Our maintenance requirements were amended to focus more specifically on the following aspects summarised in Table 1.

### CURRENT METHODOLOGY AND FOCUS AREAS

As I have mentioned earlier, the need to urgently introduce suitable in-line inspection technology was essential to manage the incidence of these types of defects. Our requirements were to source technology suitable to detect and reject both micro leaker defects, as well as cocked crowns / jockey cap defects.

A number of types and makes of system were initially evaluated and we then focussed on joint development of technology with Taptone, a division of Benthos Incorporated, to suit our

### TABLE 1
Revised Maintenance Requirements

<table>
<thead>
<tr>
<th>EVERY WEEK</th>
<th>EVERY MONTH</th>
<th>EVERY 8 WEEKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowner piston lube</td>
<td>Centre column bearing condition</td>
<td>Neck and body starwheel condition</td>
</tr>
<tr>
<td>Bottle platform and transfer plate condition</td>
<td>Centre column key wear and play</td>
<td>and wear</td>
</tr>
<tr>
<td>Crown feed system cleanliness</td>
<td>Crown starwheel, platform and guides condition</td>
<td>Sealing piston springs – hydraulic</td>
</tr>
<tr>
<td>Excess crown removal funnel condition</td>
<td>Compensation movement and crowner head setting</td>
<td>pressure</td>
</tr>
<tr>
<td>Crown throat and extractor plunger cleanliness</td>
<td></td>
<td>Crown extractor magnet strength</td>
</tr>
<tr>
<td>Height setting of crown extractors at crown pick up point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air gap between crown extractor plunger and crown at pick up point (critical)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crown feed starwheel alignment to crown piston</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck and body starwheel condition, wear and alignment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition and position of all bottle handling guides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>crowning throat condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring loaded guide set up and condition (critical)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
requirements and specifications. Table 2 summarises these and the performance capabilities achieved.

As can be seen from Table 2 the inspection capability was adequate in detecting leakers and missing crowns, however, the equipment initially failed quite severely in terms of consistently detecting cocked crowns / jockey caps, at initially a 30% level of performance capability.

Further development work with the supplier ensued; in fact, four generations of inspector were developed and tested before an acceptable solution was found. In essence, this extended period of development was required to develop technology suitable to detect a sealed, non leaking / no pressure loss container with a cocked / jockey cap, which was not acceptable in the finished pack from an appearance point of view, and also had a very high probability to leak later. We also required the technology to be capable of compensating for variations in bottle pressure due to slight CO₂ content variation, crown type variation between crown suppliers and pasteuriser beer out temperature variations.

The final generation machine which met all of our performance requirements was re-designed to incorporate an auto-tracking algorithm which enabled the inspector to consistently detect all types of leakers, and, with the incorporation of an additional inspection system to analyse the crown profile using an analogue proximity sensor and digital signal processing technol-

![Graph showing performance levels of different defects](image)

**FIGURE 10**
Current Performance Levels with Taptone Installed

**TABLE 2**
Sealability Inspection Requirements

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>STANDARD</th>
<th>METHOD OF TEST</th>
<th>CAPABILITIES ACHIEVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection capability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Leaker detection</td>
<td>&gt; 98% of test bottles</td>
<td>Sample bottles</td>
<td>Achieved</td>
</tr>
<tr>
<td>- Bull nose / Jockey crown</td>
<td>&gt; 96% of test bottles</td>
<td>Sample bottles</td>
<td>30%</td>
</tr>
<tr>
<td>detection</td>
<td></td>
<td>Sample bottles</td>
<td></td>
</tr>
<tr>
<td>- No crowns</td>
<td>100% of test bottles</td>
<td>Sample bottles</td>
<td>Achieved</td>
</tr>
<tr>
<td>False reject rate</td>
<td>&lt; 0.01% of throughput</td>
<td>100,000 bottle throughput survey at the rejector</td>
<td>Achieved</td>
</tr>
<tr>
<td>False acceptance rate</td>
<td>&lt; 0.02% of throughput</td>
<td>100,000 bottle throughput survey at the rejector</td>
<td>Not Achieved</td>
</tr>
<tr>
<td>Rejector capability</td>
<td>100% rejection of 20</td>
<td>Sample bottles</td>
<td>Achieved</td>
</tr>
<tr>
<td></td>
<td>consecutive defective bottles at line rated speed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ogy. Consequently, all forms of jockey cap / cocked crown are now being detected.

It must be noted that bottle handling and conveyor set up conditions can adversely influence this capability to detect all leakers. Micro leakers, ie, hairline cracks, that repressurise themselves prior to inspection due to agitation of the container can be missed. Adequate maintenance of conveyor systems to reduce poor bottle handling is essential to reduce this incidence.

Current performance levels are shown in Figure 10.

CONCLUSIONS AND FURTHER WORK REQUIRED

Our performance trends have moved from an alarming high of around 800 defects per million on sealability defects to around 5 to 8 defects per million. Refer Figure 11.

I am quite confident that we now have the appropriate maintenance and management systems and inspection systems / technology to manage and control the incidence of these types of defects.

The focus on machine capabilities has led to a full review of our crowner design specifications and maintenance practices, and, the introduction of this type of inspection technology on all of our returnable packaging lines has certainly identified other areas of opportunity and focus – our glass container and crown supplier specifications have been rigorously reviewed as a consequence.

![Chart showing performance improvements](chart.png)

**FIGURE 11**

Overall Performance Trends - Sealability Defects

**REFERENCES**

Hansberry, J – On line beer bottle / can inspection systems for quality assurance and process control. MBAA Technical Quarterly, Volume 36, Number 1 – 1999.