BETTER HYGIENE IN FOOD-PACKAGING BOARD AT REDUCED RISK OF REJECTED TONNAGE AND MACHINE CORROSION

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INTRODUCTION

Recent advances have taken some of the mystery out of bacteria problems. Many mills that have been close to the allowed hygiene limits can now run with less worry about specs and potential costs.

Board grades which are used for packaging of dry or fresh food, milk or other liquids for human consumption have strict requirements regarding the hygienic quality of the packaging board. If they are not tightly controlled, minute microorganisms present in hygienic grades like liquid packaging board (LPB) or food-grade folding box-board can be extremely costly.

For example, if some part of a shipment of these grades is out of spec for hygiene, the converter may reject the whole lot. A two-day outbreak of bacterial spores on a board making machine can lead to the loss of thousands of tons of finished LPB, at a cost approaching millions of Euros. This is clearly a much bigger financial loss compared to, for example, a non-food grade machine where slime growth on machine surfaces means smaller losses in terms of money, tonnage and downtime.

To ensure that the hygienic quality of the final board meets the required specifications, manufacturers need to apply high-performance microbe control programs on their board machines. Over the past decade, Kemira has emerged as one of the leading global suppliers of microbe control solutions to the hygienic board industry.

Based on numerous R&D programs and mill trials, we now have a better understanding of how to control process conditions and avoid process situations that cause sporulation. Recent results with new applications in mills show that we are clearly on the right track in taking some of the mystery out of these frustrating and costly disturbances. This report summarizes some of the things we have learned which can help you keep your board within the hygiene specifications. Beside the scientific facts which we have discovered, we also have concluded that high hygiene can only be achieved through very close cooperation between the biocide supplier and the mill’s production personnel.

HYGIENE CONTROL IS ALL ABOUT SPORE CONTROL

Depending on end-uses, board machines have various hygiene targets for food packaging. Many specifications are based on a maximum acceptable level of aerobic bacteria in the final dry board. For example, LPB for milk products normally must contain less than 250 CFU of living aerobic bacteria per gram in dry board.

In reality, however, we have found the quantity of aerobic bacteria in the final dry board depends on bacterial spores only. These spores are thermo-tolerant forms of bacteria (“sleeping” cells) and when they are mature they can survive heat of dryer section, whereas vegetative (“growing”) bacteria cells and incomplete spores are destroyed by heat. Therefore, spores are the real “bad guys” regarding food board hygiene. Figure 1 gives additional examples of this.
In our work with hygiene in mills, we have observed several food-packaging board machines that were running significant amounts of biocides but still having difficulties in meeting strict end-product hygienic specifications. So, despite intense use of biocides, these machines were still periodically suffering from bursts of elevated levels of bacterial spores, thus endangering the hygiene of the food-packaging board. Adding to the mystery, some machines can run every day with high amounts of vegetative bacteria in process water and still not experience hygiene issues in their board.

In deeper studies on one board machine, for example, we observed an interesting phenomenon. In one process tank, the total quantity of vegetative bacterial cells remained at essentially the exact same level for three consecutive days. However, on day 1 the amount of spores was below detection limits, on day 2 they jumped to very high levels, and then on day 3 they were again below detection limits. So the vegetative cells were at stable levels but the spores were fluctuating from day to day.

**Figure 1.** Microscope pictures of paper machine bacteria: Cells of Deinococcus geothermalis growing on steel surface (1a) and cells of Rubellimicrobium bacteria growing in process water (1b). These non-spore formers do not endanger hygiene of board as they are all killed by heat of dryer section. Fig 1c. A mature spore just being released from a Bacillus cell. If present in wet paper web these spores will survive alive into the dry finished board.

- Bacillus, Brevibacillus and Paenibacillus – Among all aerobic bacteria that are capable of growing in the process of a board machines, only these three genera are aerobic spore-formers
- A spore is inactive resting, thermotolerant form of bacteria that resists the dryer heat
- Similar to other bacteria these bacteria prefer to grow (multiply) by simple cell division – They make spores only if needed
- One cell produces only one spore
- Spore formation is an efficient way for the cell to protect itself in case of a threat to survival
- Killing of a mature spore requires a huge amount of biocide = Not economically affordable
- The best approach is to prevent bacteria from making a spore
Our R&D programs aimed at reducing contamination in food-board mills has given us unique insight into the mechanism of sporulation, what triggers it and what controls it in the board making process. This learning and new understanding, in turn, has supported successful application of biocide solutions on hygienic board machines. One of our key findings is that the total quantity of vegetative cells and spore counts do not directly correlate. Some process tanks can contain higher bacterial counts but not spores, whereas another tank that may look fine based on low total bacteria count is really surprisingly high in spore content.

**RUNNING CLOSE TO THE EDGE**

Based on the experience and knowledge gained through both R&D studies and numerous mill trials, we are now confident that we have good programs and concepts to control these hygiene issues. We have worked in many mills which were experiencing hygiene troubles before we got involved, and had tried and failed with other biocide solutions. When we came in and worked closely with the mill team, we were able to get them comfortably and consistently in specifications. Figure 2 below gives a typical before and after picture regarding spores.

We have also observed many machines that run just barely within specifications, meaning very “close to the edge” with respect to going out of specification. This leads to a fairly nervous situation for the mill management, operations and sales teams.

Achieving superior hygiene on a board machine requires close and complete cooperation between the mill and the partner taking care of dosing and monitoring of microbe control products, so that we are anticipating problems rather than only reacting to them. Success also requires careful monitoring of all raw materials coming into the process including pulp and all chemicals. It may initially seem like a large effort to make, but the payback to the mill in terms of reduced lost tonnage is very significant. In addition, the mysterious and frustrating outbreaks of spores are reduced, leading to improved peace of mind for the mill management.

*Figure 2. Development of bacterial spore content in finished board during a period of correcting the hygiene situation (green line) by applying a new control philosophy*
Another issue that, unfortunately, does not receive much attention until it is sometimes too late is corrosion of machinery and components. We have information on over 30 paper and board machines that have experienced dangerous and costly corrosion issues due to intense use of biocides. Machine corrosion due to biocides is a very real risk especially in food packaging board machines which are often using biocide-intensive control strategies due to the hygiene requirements. Thus, especially when applying an intensive biocide program, it is extremely important to understand and mitigate any potential corrosion risks.

We have conducted basic research on vapor phase corrosion mechanisms in paper machines to improve both understanding and control. Like hygiene, corrosion on paper machines is very complex. In all our laboratory studies, steel plates were located above containers of flowing white water in a manner that only vapor phase contact occurred. Then different oxidizing biocides were dosed at equal total active chlorine concentration and the subsequent corrosion of the steel coupons was measured. There were two key findings. Firstly, at equal dosage level in terms of active chlorine content the different species of stabilized chlorine compounds demonstrate corrosion rates of widely different magnitudes. Secondly, laboratory experiments can never fully demonstrate the true corrosion potential in vapor phase in an individual paper machine due to machine specific moisture conditions and in-situ reactions of chemicals in white water. Therefore we developed an on-line probe for measuring changes in vapor-phase corrosion rate. This probe is sensitized so that it corrodes all the time and responds to chemical changes in vapor phase thereby giving a possibility to observe changes and react before corrosion actualizes in the machine. Example data is shown in Figure 3.

**Figure 3.** Kemira CorrStrix™ on-line data from a folding boxboard machine. A new biocide program was started after shutdown with no other changes done in the wet-end of this board machine. As a response the average rate of vapor-phase corrosion at dryer section reduced over 75 % compared to previous biocide program.
As a result of studies both in the laboratory and mills, we have created a complete package to reduce corrosion risks to machines, while at the same time ensuring hygiene in the board products.

Safely achieving hygienic conditions on a food packaging board machine is not simple. The mechanisms of contamination and corrosion are both complex and difficult to control. We have clearly shown that there is no direct correlation between the level of aerobic bacteria and the level of spores, which are the true bad actors because they can survive the heat of the dryer and contaminate your finished product at a high cost.

Kemira has gained significant market share within hygienic board by successfully controlling spore formation mechanisms. Close co-operation among our Sales, Applications and R&D groups with the board mills has provided customers with clear competitive advantages in their board mills: Stable production combined with continuous improvement in hygienic quality. Long-term control of bacterial spores on a board machine requires special competence to select the best control strategy for each individual machine. There is no universal spore control philosophy that best fits all machines in the world. We have seen numerous machines where this ‘one-size-fits-all’ strategy has failed and, when subsequently called in to help, we have been able to correct the situation by applying a different philosophy and understanding to control spore formation. Kemira’s toolbox to combat spores in food-packaging board is unique and the most comprehensive on the market. It includes patented products and treatment concepts such as FennoClean D, patented diagnostics such as qSPORE, and patented on-line monitoring tools such as Kemira FennOx and CorrStrix. When applied correctly, these can help you take the mystery, frustration and costs of contamination out of your food packaging board machine.

**THE COMPLETE PACKAGE FOR HYGIENE CONTROL – KEMIRA FENNOCLEAN**

- Corrosion-safe biocide products for controlling biofilm formation in the machine
- On-line monitoring tools for monitoring of efficacy and safety of biocides such as CorrStrix™
- Know-how and products for controlling spore formation
- Centralized data management and analysis tools KemConnect for follow-up
- Systematic co-operation with customers, enabling continuous improvement in hygienic quality of the finished board
CONCLUSION

Global annual production of hygienic board is approximately 14 million tons, of which liquid packaging board (LPB) makes up about 5.5 million tons. Depending on end-uses of the board grades, these machines have different hygiene specs and targets. Machines with the strictest targets follow the “Dairyman standard” with aerobic bacteria content of max. 250 CFU/g of dry board. This is also the maximum accepted level according to FDA legislation for milk packages in the US market. The most common target setting in foodpackaging grades is aerobic bacteria content of max. 1000 CFU/g of dry board.

Uncontrolled growth of bacteria in wet-end can cause significant build-up of biofilm on machine surfaces. (a) Slime on frames (b) Slime clogging nozzles increasing risk for web breaks and defects in finished product. Biocides are frequently added for controlling biofilms and providing clean machine surfaces (c) Clean headbox, however, if unaware of potential corrosion risks the intense biocide usage can create costly corrosion issues (d) Corrosion damages. More information about corrosion safe use of biocides in the article.

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