Hygiene Control of Soymilk Production Lines by ATP Swab Tests

Use of ATP method to set CIP and COP conditions and to check cleanliness after cleaning

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This article is a summary of the lecture given by Yuka Yanuma of Kikkoman Soyfoods Company at the 91st Lumitester* Seminar held at Tsukisima Social Education Centre in Chuo-ku Tokyo Japan on 16 April 2014.

* Lumitester is a trade name for ATP detectors manufactured and sold by Kikkoman Biochemifa Company.

Company Profile

Kikkoman Soyfoods Company (HQ locates in Irifune Chuo-ku, Tokyo) was established as Kamogawa Chemical Industry Co., Ltd. in 1962. The company has started manufacturing soymilk since it acquired Gifu Plant from Kibun Health Foods Co., Ltd. as well as changing the company's name to Kibun Food Chemifa Co., Ltd. in 1983. It became a wholly owned subsidiary of Kikkoman Corporation in 2008. The company's name was changed to Food Chemifa Co., Ltd. in 2009 and Kikkoman Soyfoods Company in 2011. In the same year, chemical product division was fractionalized and integrated to Kikkoman Biochemifa Company and it continues till today.

Currently, our beverage factories include Gifu Plant (Hoe Mizuho-shi Gifu-ken, started production in 1983), Saitama Plant (Shinsayama Sayama-shi Saitama-ken, started production in 2005 and added cup lines in 2011) and Ibaraki Plant (Goka-machi Sashima-gun Ibaraki-ken, started production in 2013, **Photo 1**). Gifu and Saitama factories obtained FSSC 22000 certification in 2013 regarding international standards for food safety.

This article mainly introduces successful application of ATP swab test (ATP test) in Ibaraki Plant.

The idea of "production cycle"

Figure 1 shows an outline of the soymilk production process. As we produce long self-life products, the process includes

Photo 1: Ibaraki Plant of Kikkoman Soyfoods Company (Its site area is approx. 38,000 m^2; the gross floor area is approx. 19,000 m^2; the production capacity is approx. 90,000 packages/day and the number of employees is approx. 60 as of March 2014.)

"Ultra High Temperature (UHT) sterilization" (the sterilization process with ultra high temperature for a few seconds).

Especially, the "sterilization process" and "filling process" (enclosed by dotted line in **Fig.1**) require high levels of hygiene control.

Soymilk beverage has neutral pH which easily allows bacteria to grow and proliferate and vegetable proteins which are difficult to remove by cleaning. However, cleanliness control (protein removal) of facilities and equipments is extremely important. Therefore, we have adopted the idea called "production cycle" as shown in **Figure 2**. Facilities used in production are "sterilized" following "cleaning". ATP tests (**Photo 2**) are performed at the points marked with ★ in **Fig.1** between cleaning and sterilization. Sterilization is performed only after an adequate cleanliness (no residue of protein) is confirmed by ATP test (the detail is mentioned below).

Generally, two different cleaning methods are used in beverage factories - COP (Cleaning Out of Place) and CIP (Cleaning In Place). CIP is mainly used in soymilk production lines. CIP is a term used for the method in which production units are cleaned by supplying and circulating detergent without being dismantled.

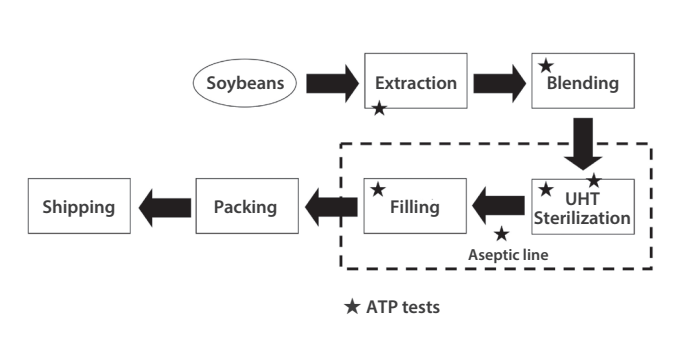

Figure 1: Soymilk production process and the points where ATP tests are performed. (ATP tests were also performed at the installment of this process in Ibaraki Plant.)

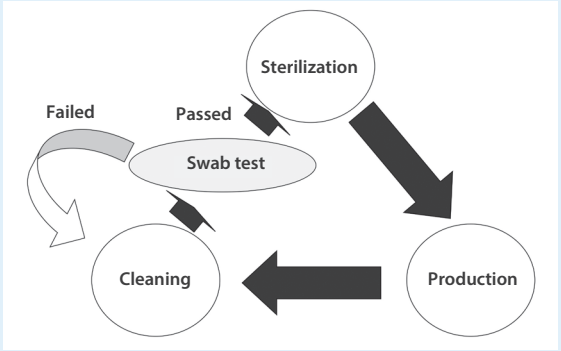

Figure 2: Production cycle of soymilk. Production starts after cleaning and sterilization. ATP test is used for the cleanliness check after cleaning.

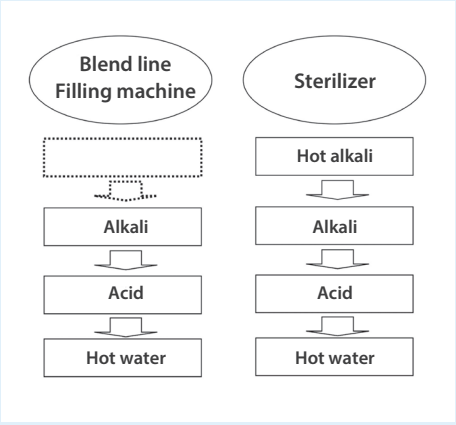

Figure 3: CIP flows in the "blend line and filling machine" and "sterilizer".

However, COP is also used for units which can be partially dismantled.

Using ATP test for COP

COP is performed at the soybean curd residue separator in the extract process, filters in the blending process, the lower filling pipe and floats in the filling process, and nozzle filters in the cup filling process. ATP tests are performed to check the cleanliness following COP.

ATP test is also used to set conditions of the standard COP methods. For example, soaking duration of the blending process filters into a detergent (alkaline fluid) was determined according to result of ATP test. Ultrasonic cleaning durations of the lower filling pipe and floats in filling process and nozzle filters in the cup filling process were also determined using the result of ATP tests.

Using ATP test for CIP

Figure 3 shows the outline of CIP for the "blend line", "filling machine" and "sterilizer". Only the sterilizer includes the heating process among them. In the sterilizer (right hand side on **Fig.3**), proteins contained in products may be fixed as dirt when they are denatured by heat. Alkaline treatment is used as a cleaning method to remove such dirt. Specifically, the dirt is treated with alkali at approximately 150 ℃ so that its heat denaturation is further proceeded and the dirt is removed from pipes as it is partially broken down (To maximize the cleaning effect, chlorine- or oxygen-based surfactant may be also added).

In CIP, factors such as "temperature", "duration", "flow rate" and "concentration" are said to be important. ATP test is also used for setting our CIP conditions.

Photo 2: ATP test instrument "Lumitester PD-30" (right) and its reagent "LuciPac Pen"(left) manufactured by Kikkoman Biochemifa Company.

History of Introducing ATP test

Why cleaning is required before sterilization as shown in **Fig. 2** in aseptic beverage production factories? The reason is shown in **Figure 4**. If any residue (dirt) remains, steam and hydrogen peroxide water used for sterilization in our factories cannot penetrate its interior (only the surface will be sterilized but not inside). If this unsterilized residue fallls away form the surface during production, bacteria within the residue may contaminate the products. It may cause intermittent defective production as shown in **Figure 5**. To prevent such incidents, "cleanliness check" following the cleaning is essential.

Cleanliness level used to be checked only "visually". However, it is impossible to detect "invisible dirt" in this way. The decision criterion was also unclear due to individual differences or illuminant differences in the facilities. Therefore, we have adopted ATP test which can detect invisible dirt since 1999. It gives a clear decision criteria based on numerical results if the reference values are preset regardless of a person who performs the test. Currently, ATP tests are performed at the exit of blend tank in the blending process, the holding tube in the sterilization process and the upper filling pipe and valves in the filling process in Ibaraki Plant. The swabbing parts are selected from "the parts where the dirt easily accumulate on and which can be opened easily". The control standard value is set "within 50 RLU*".

*RLU (Relative Light Unit) is a unit used for ATP test.

How to set the control standard value (50RLU)

Figure 6 shows the correlation between concentration of processed soymilk and RLU value. As a result of RLU measurements in a serial dilution of processed soymilk, visual detection of residues on the pipe surface was difficult roughly after 100 time dilution (approx. 1,000 RLU). It means that ATP test can detect the residue which is difficult to detect visually. Residues in tap water is said to be 0-30 RLU, which is equivalent to 10,000 time dilution (50 RLU) of processed soymilk. Therefore, our control standard value was set to 50 RLU to achieve this cleanliness level.

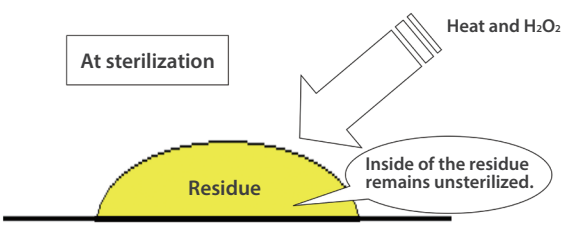

Figure 4: Inside of the residue (dirt) remains unsterilized when it is not removed from the equipments.

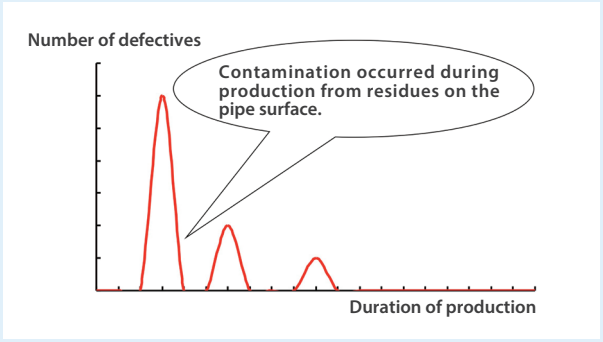

Figure 5: If unsterilized residues remain on the pipe surface, they may cause intermittent microbial contamination.

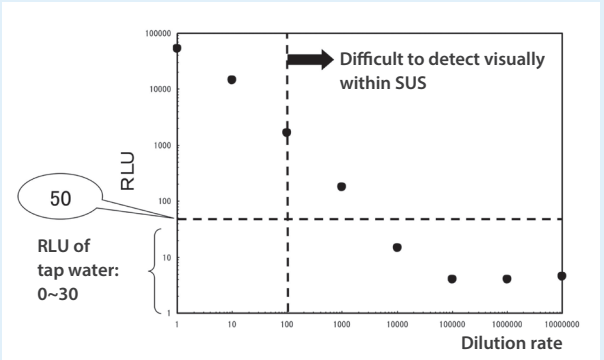

Figure 6: The correlation between concentration of processed soy milk and RLU value.

The correlation between concentration of molt coffee soymilk beverage and RLU value was similar. Therefore, we set the same control standard value, 50 RLU, for all kinds of soymilk beverages.

When the result of ATP test is fail, the examiner reports it to the line manager. Then, the line manager arranges re-cleaning. Re-cleaning will be repeated until it passes ATP test. If required, equipment inspection will be performed.

Use of ATP test in each process

Blending process

Figure 7 shows the outline of the blending process. The fluid blended in the blending tank is sent to the sterilizer for the next process. ATP test in this process is performed at the "sampling cock" in the blending tank (marked with ★ in **Fig.7**.)

To select swabbing parts, ATP tests were performed at various parts and equipments in the tank.

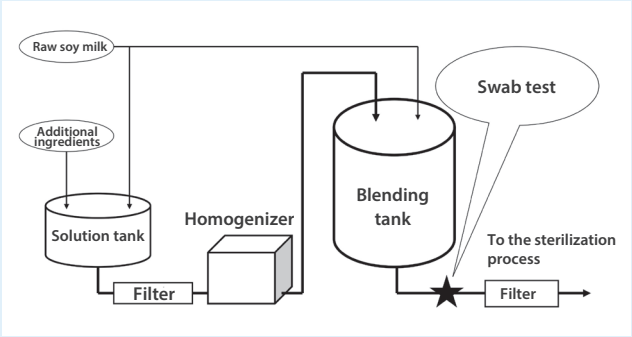

Figure 7: Outline of the blending process

The sampling cock has the least flow of detergent at CIP. If its cleanliness level is appropriate, cleanliness of other parts (which have more flow of detergent) should be fine. Therefore, swabbing is performed at the sampling cock twice along with its inner perimeter following CIP (**Photo 3**).

Sterilization process

Figure 8 shows the outline of the sterilization process. The blended fluid passes through the preheating tube, the steam injector for final heating and the holding tube and is sent to the "vacuum vessel". Then, it passes through the cooling tube and the homogenizer and is sent to the aseptic tank for the next process.

Burnt dirt may be fixed on the inner surface of the steam injector by its high temperature treatment. Therefore, ATP tests for this process are performed at the steam injector and the holding tube near the exit (marked with ★ in **Fig.8**) by swabbing twice along with the inner perimeters (**Photo 4**).

Filling process

Figure 9 shows the overview of filling process. The fluid from the aseptic tank is filled into cylindrically formed paper packages in the filling machine. ATP tests for this process are performed at the "valve" (**Photo 5**) and the "upper filling pipe" (**Photo 6**) (both marked with ★ in **Fig.9**.)

As shown in **Photo 5**, the valve has a complex structure in order to switch between the vertical and horizontal pipe networks. As it is difficult to clean this part, it was selected for the swabbing part of ATP test. The upper filling pipe was also selected for the test as it is the last point of CIP (ATP test for the lower filling pipe is performed following COP). Swabbing for the valve is twice along with the inner perimeter and three times for the upper filling pipe because its diameter is smaller.

Cup filling machine

Saitama Plant has the cup filling machine to produce soymilk beverages and soup beverages. **Figure 10** shows the overview of the cup filling process.

The nozzle shape of the cup filling machine is different from those of conventional filling machines. Therefore, a new CIP standard had to be set when the machine was introduced to the factory. To examine the CIP conditions, approximately 30 parts were selected from various parts of the equipment, dirt model (actual product) was added, then CIP was performed and visual detection and ATP test were performed following CIP.

Currently, ATP tests are performed at the interior of the chamber, the valve cluster, the upper filling pipe and filling nozzles (marked with ★ on **Fig.10**). Regarding the filling nozzles, all filters (10 filters × 2 sets) are removed before ATP test. Nozzle

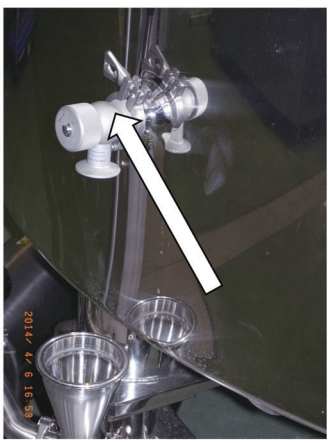

Photo 3: In blending tank, the inner surface of the sampling cock is swabbed twice along the inner perimeter.

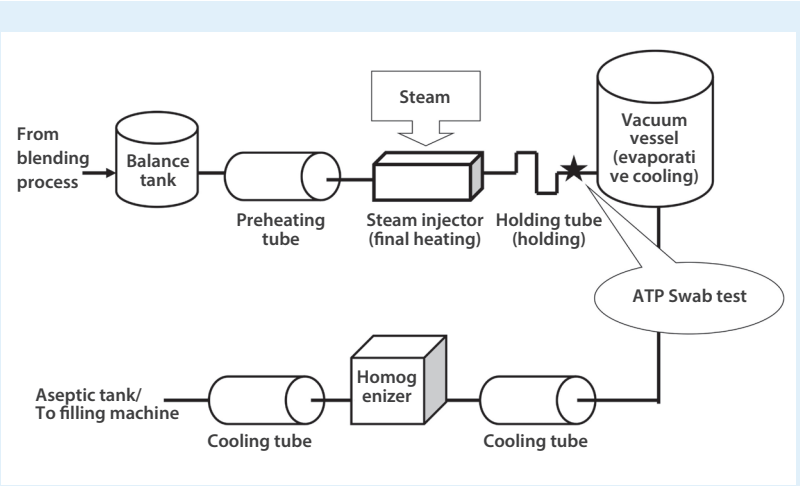

Figure 8: Outline of the sterilization process.

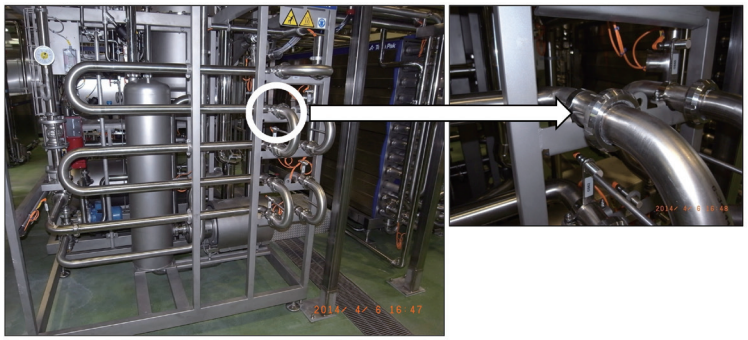

Photo 4: Holding tube of the sterilizer is swabbed twice along with the inner perimeter.

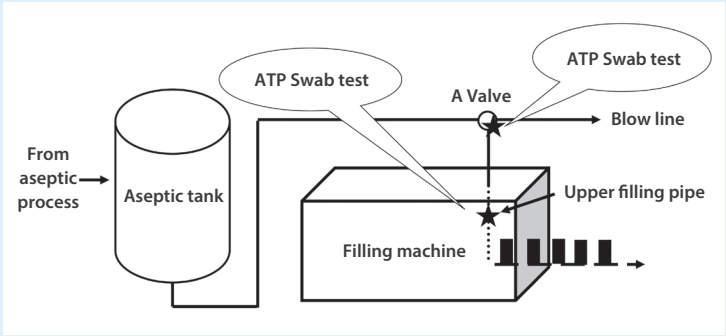

Figure 9: Overview of the filling process

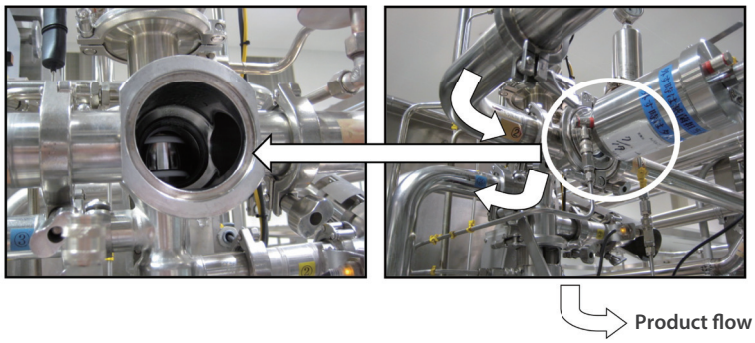

Photo 5: Valve of the filling machine is swabbed twice along with the inner perimeter.

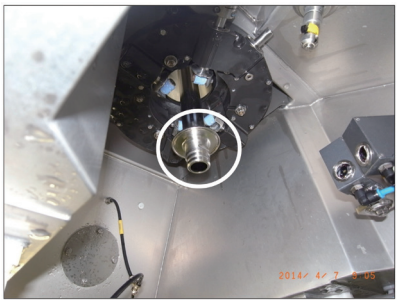

Photo 6:

Upper filling pipe of the filling machine is swabbed three times along with the inner perimeter.

filters is covered with a mesh sheet in order to avoid dripping liquid. The mesh sheet is difficult to clean by CIP. Therefore, it is removed to be cleaned by ultrasonic cleaning. Its ATP test is performed after cleaning. It is time consuming to remove filters from all nozzles and perform ATP tests for each of them but we believe they are crucial for aseptic control as a part of thorough cleanliness control.

BIB filling process

We also produce BIB (Bag In Box) filled products for various sizes from 10 kg to 1 ton (**Photo 7**). ATP test for the BIB filling machine is performed by swabbing the filling faucet once along with the inner perimeter (**Photo 8**).

Other examples

ATP portable test instrument is easy to carry and anyone can perform the test. Its numerical result is also easy to share. Because of these characteristics, ATP tests are also performed by factories of other companies. The following is an example among them.

Cleanliness check at contract production factories

Outsourcing companies have different facilities and different ideas and conditions of cleaning. However, ATP test is performed in their environments and we can confirm that "they have same hygiene control level as our company" by setting control standard value at 50 RLU.

Cleanliness check on the transporter lorries of raw soymilk

When we outsource soymilk production, we produce raw soymilk and ship it to an outsourcing company by its dedicated lorries. To prevent contamination or proliferation of microbes during transport, ATP tests are performed at the receiving ports of tank lorries.

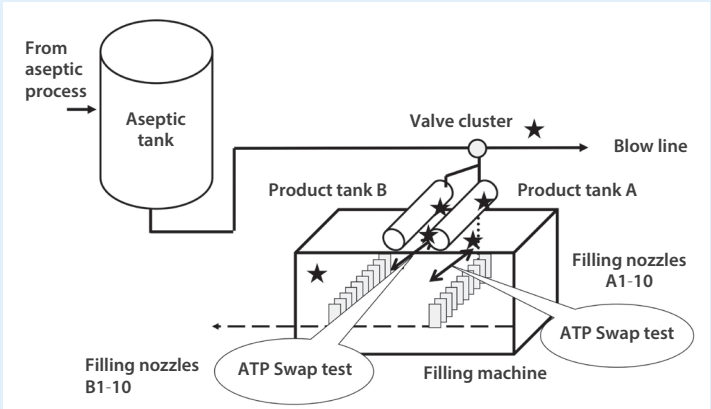

Figure 10: Outline of the cup filling process

Photo 7:
BIB filled products

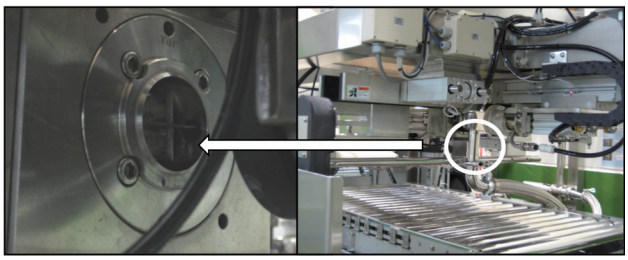

Photo 8: BIB filling machine is swabbed at the filling faucet once along with the inner perimeter.

Photo 9: Microbial test kit "CheckLite AT100*" manufactured by Kikkoman Biochemifa Company, which applies ATP measurement. *AT: Aseptic Test.

Considering the use of ATP measurement for shipping decision test

Currently, shipping decision of products is based on microbial test with incubation. However, it takes 6 days to get the result, examiners should be trained with expertise in aseptic manipulation, and up to nearly 1,000 samples/day are handled.

Therefore, we are currently considering the use of a microbial test kit which applies ATP measurement for the shipping decision test (**Photo 9**).

If the microbial test kit is used as the shipping decision test, decision making will be faster and it may lead to various benefits.

Further study will be required to measure ATP values of each product and contaminated products and to examine the correlation between the official method of microbial test and ATP values.

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