

The Cleaning Effectiveness in Electronics Assembly Process

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Abstract

This paper deals with research and development of the cleaning process conditions regarding the efficiency of practical cleaning methods in the area of electronics assembly technologies, target the cleaning after lead-free soldering. Increased miniaturization, higher speeds and tighter board space highlights that need, as well as request for higher reliability, especially by some type of applications (automotive, medical, military etc.). Correct adjustment of the cleaning equipment and cleaning process may save as the time as well materials consumption and costs. In this paper are discussed some parameters of cleaning process, especially cleaning medium, including its optimal controlling and setting. The special test pattern on glass substrate were designed and realized to become a “scale” for measuring cleaning efficiency. This pattern was used for optimal arrangement and adjustment new cleaning equipments, which are developing in Pbt Rožnov Company in the Czech Republic [4]. Latest work is focused on cleaning medium controlling in the practical use. In more with introduction of new environmental regulations (WEEE, RoHS) and also eco-design (EuP) rules the cleaning process becomes to be more and more important, not only for lead free soldering as well for various parts of technological processes.

Introduction

Cleaning process efficiency very much depends on physical conditions under which the cleaning runs. To examine cleaning requires the understanding of a procedure which forms a very complex process, comprising a number of different inputs and outputs as was described by Ishikawa diagram in [6]. There are several key factors as type of flux, type of assembly, staff competency, but the most important is the cleaning equipment that is much related to cost. User needs to resolve two important steps, the first which cleaning equipment to use, and the second how to arrange and how to control single cleaning process. For this second are above all:

- the shape of contaminated component,
- the selection of a cleaning agent (with maximum matching between the chemistry of the agent and that of contamination),
- process parameters adjustment.

The base of our work makes analyzing of principal agitation methods during the cleaning process in the electronics assembly production. Several experiments have been done for example to compare efficiency of ultrasonic agitation with other methods, like spraying in air, spraying under immersion etc. There were three different methods for contamination measurement applied, the first with standard contaminometer, and two based on

optical principle. Results and conclusions were derived on the base of statistical valuation [5], [6].

Our new method is based on a specially developed test pattern for this purpose contaminated by flux and submitted to simulated reflow conditions. The basic idea of this method consists of making the residues under components visible. The pattern is designed so that the cleaning task will be extremely difficult. This causes generally cleaning times longer than usually and even fine differences among processes can be evaluated more easily. Visual checking is enabled by the use of glass substrate. Moreover, objective evaluation is possible by testing such substrate under an Automatic optical test system (AOI) originally designed for testing solder print quality. The view from the bottom side detects the gradually cleaned gap between glass substrate and chip. Final evaluation is accomplished through the raster scanning method. The block diagram of this evaluation method is shown in Fig. 1.

Development and testing of test-pattern enables to use that evaluation method like some kind of “external calibration” for cleaning process or in case of need directly for cleaning equipment. In general the cleaning process, being a result of many factors, is very difficult to be described with quantitative expressions. Testing substrates, which

has been designed and tested, enable to compare different cleaning processes and also a real cleaning process with ideally running process in the same equipment.

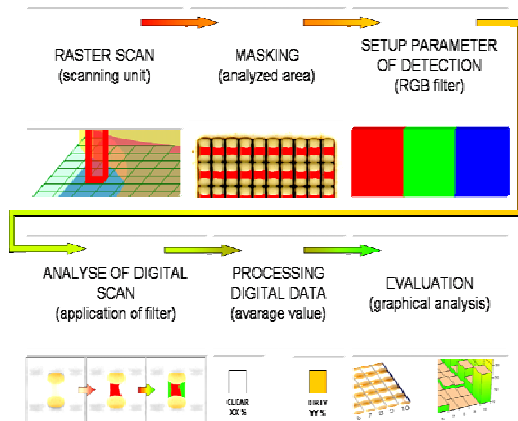


Figure 1: Block diagram of evaluation method

The described measurement method allows us to evaluate test patterns in any stage of the cleaning process. That means the test pattern can be measured before cleaning and then many times during the actual cleaning. This enables us to check the rundown of the cleaning process efficiency during a longer period of time. Above all, this test method can also be used for the following purposes:

- Comparing the cleaning efficiency of different cleaning methods
- Adjusting and optimizing parameters of a single method.

Cleaning Efficiency Measurement

The main hardware component for testing is a test pattern (substrate). It is a structure of ceramic (inert) chip models placed with high precision on the glass substrate on exactly printed glue spots. This enables a direct optical inspection of the space under the components. The core part of the measuring equipment is the scanning unit (AOI) which can digitize the scanned picture in high resolution.

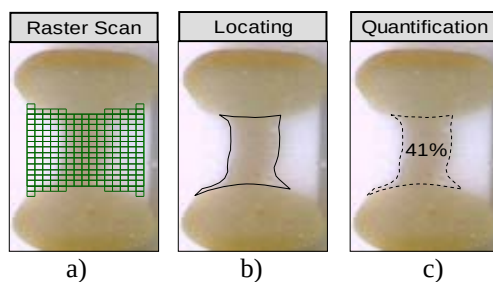


Figure 2: Raster scanning principle

Evaluation is based on the detection of selected component color at each particular point. If the detected value is confirmed, the result goes as “clean”, in the opposite case, if the component color is different, then the result goes as “not clean”.

The picture of the whole sample area is scanned for impurity residues in high resolution. The principle of raster scanning used for cleaning evaluation is shown in Fig. 2. There are three significant stages:

- a) raster scanning
- b) locating
- c) quantification

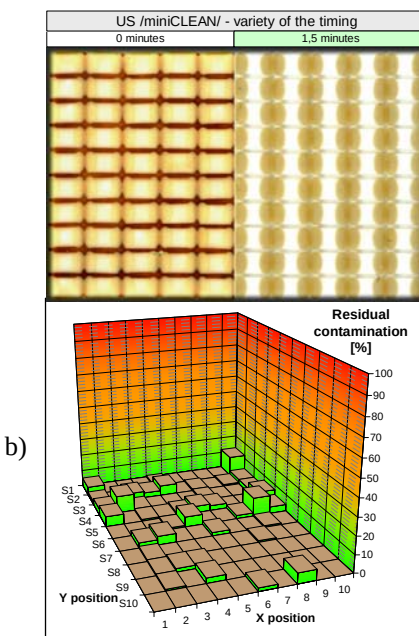
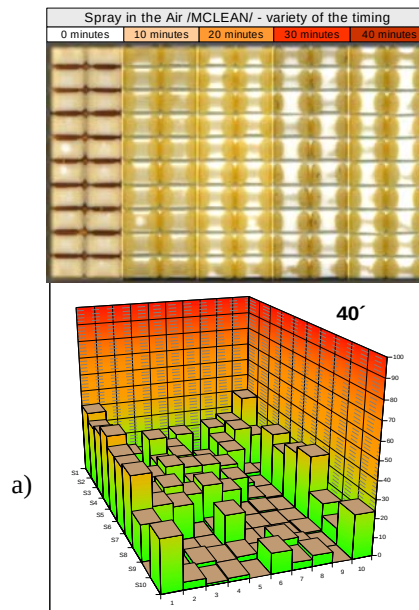


Figure 3: Result of cleaning a) spray in air after 10', 20', 30' and 40'
b) ultrasonic after 1,5'

The main tested place is the gap between the chip and the substrate, whose thickness lies in the interval of 25-40 μm . This parameter is very important concerning the various cleaning processes because it affects the flow of the cleaning medium.

The pattern configuration is a result of a comprehensive optimizing process in the course of which different parameters arrangements were tested, for example glue resistivity against reflow and following cleaning process etc. Moreover, the test pattern has to be acceptable for objective evaluation and comparison of various cleaning systems with different cleaning efficiency. Comparison of cleaning process results for spray in air and for ultrasonic are shown in Fig. 3 [6].

Cycle of Medium in Cleaning Equipment

One very important factor which determines cleaning efficiency is cleaning medium quality, respectively its activity evaluation.

The cleaning medium is retained in decanter of equipments (Figure 4). During cleaning process the cleaning medium is drawn by pump to filter circuit. Important function of filter circuit is monitoring of flow volume (pressure control) and also separation of mechanical impurities (mechanic filter 1, 2). After impurity separation is the cleaning medium ready to start new cleaning cycle from spray shank.

Cleaning medium loses his cleaning capability during cleaning process. This fall is caused as from reason of physical declining as well by gradual diminution of cleaning medium regarding cleaned impurities. Physical impurities are just retained by mechanic filters. That other reason of cleaning medium weakening, weathering is very difficult to indicate. Common measurement methods, as electric conductivity or pH measurement are not too much practical.

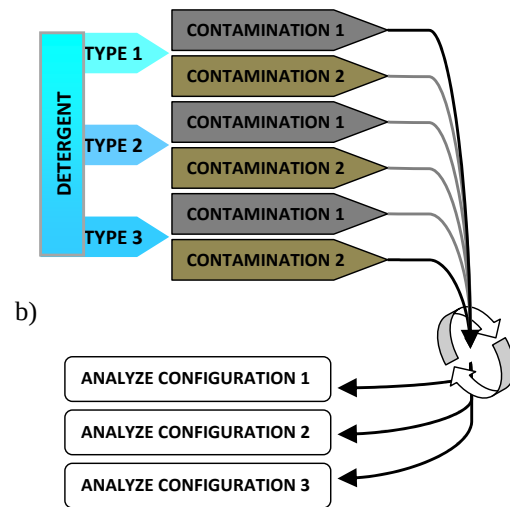
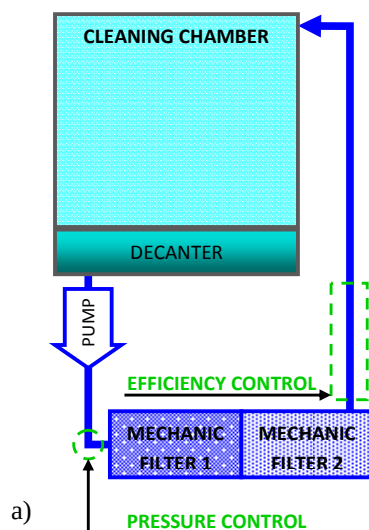


Figure 4: Cleaning medium circuit in cleaning equipment (a) and the configuration for analyze (b)

Evaluation of cleaning medium activity is possible through some electrochemical methods which control the volume of elements in the cleaning solution. We are able on the basis of that measurement to indicate different state of cleaning medium satiety with different time of use. We can clarify by this way the time period, which can assure the necessary efficiency of the cleaning process and when it is necessary to change it.

Medium activity evaluation is depended on cleaning medium type and also on contamination sort. Fortunately there is possible to make calibration of this analytical method for actual cleaning medium. One example is shown on Figure 5. In this VA characteristic is good to see difference between new (clean) medium and medium that was used for 10 working cycles (dirty).

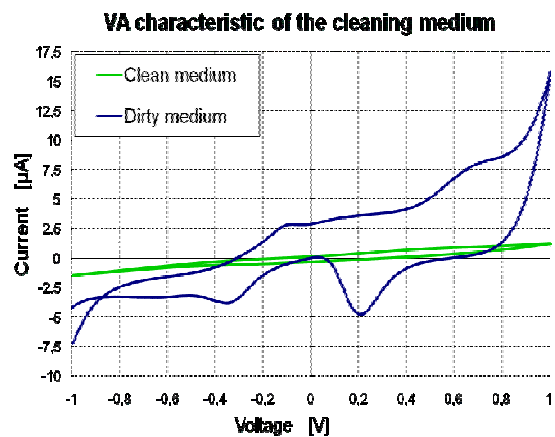


Figure 5: Two VA characteristics for clean and dirty medium

This electrochemical measurement method is good usable for indication of active components in the cleaning medium. Our results have shown that we can evaluate for a certainty impurity saturation value of cleaning medium through VA characteristic measurement. Detected impurity should be these one, which was not separated by mechanic filters and also chemical contamination of solution.

Conclusion

Cleaning process is often discussed area regarding to set together SMT production line. There are two factors that contrapose each other, cost and reliability. But for each process is a key enabler reducing the cost through improvement of efficiency.

Our experience has shown that the cleaning process efficiency depends on more various parameters. That is reason for studying step by step some of them more in detail.

Provided the mechanical parameters (of a particular process) remain constant, the cleaning efficiency measurement can be used to monitor the cleaning agent activity without measuring the partial chemical and physical characteristic values of the cleaning solution (pH, Redox, specific density, light breaking index etc.) That enables the use of such a method like sensing activity aids (concentration) for monitoring, to control automatic dosing of fresh cleaning medium in the cleaning machine eventually.

Our method can also be used in longer intervals as an external calibration aid of the cleaning process. It can easily monitor any alterations in the original stage of the process.



Figure 6: Automatic stencil, misprint + defluxing machine Super SWASH

This method was successfully applied to optimize the design of several cleaning equipments. By using this and other test methods, new generation of machine in design could reduce the cleaning period and consumption by about 50% in comparison with the previous generation (and similar models on the market).

The newly developed cleaning equipment from the design centre of PBT Rožnov p.R., s.r.o. are: Super SWASH – universal stencil, misprint and defluxing cleaning system, meeting the highest requirements of middle-size substrate defluxing and high capacity stencil and misprint cleaning.

The other cleaning system is COMPACLEAN, which uses special nozzle configuration for high capacity defluxing of PCB's.



Figure 7: Automatic PCB defluxing machine COMPACLEAN

The results acquired in our study show that the developed method of evaluating cleaning can be successfully applied in comparison of various cleaning methods as well as in adjusting and optimizing particular equipment and cleaning processes.

Practical experience has showed that every application of the cleaning process is slightly different. That is caused by many factors, e.g. different material of cleaned parts, their different chemistry, different soldering parameters (which cause different grades of polymerization in synthetic resin, containing fluxes), different capacity etc. Therefore the building of a powerful cleaning machine, with perfect cleaning results and lesser process and investment cost cannot be achieved without sophisticated experimenting.

What is more, cleaning is subject to environmental regulations, which play a very important part in today's environmental impact. With the introduction of new environmental regulations (WEEE, RoHS, EuP) cleaning becomes to be more and more important in various parts of technological processes, including lead-free solders. One of the most important aspects, which are always pressing when purchasing cleaning equipment, is to establish objective criteria for selecting the most suitable cleaning equipment. We have to make a compromise between the cleaning efficiency, operating costs and the impact on environment. The physical methods as ultrasonic have to be analyzed deeper because this should be efficient compromise for future.

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