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Reducing Defective Indexes in the Printing Process of the Computer Plates with the Application of the Welding Paste

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Abstract*— *The process of automatic assembly of the smaller components in the plate making industries represents an important manufacturing activity that influences all stages of production. Thus, it is necessary that from the beginning of this process there is a technical follow-up regarding the development of the assembly of the computer boards. The most important process in the manufacture of these plates is the welding process, where 70% of the defects occur, are found from the application of weld. In order to minimize the defects that occurred in the process phase called SMT (Surface Mount Technology) a study was made on the most frequent defects within this process with the use of 5W2H tools and the Ishikawa Diagram. Thus, the project aims to reduce defect rates in order to extend product life and continuous improvement in the automatic assembly process of smaller components.

Keywords*— *Welding Process; Surface Mount Technology; Solder Paste.

I. INTRODUCTION

The present study was developed in a national company of manufacturing of computer boards of Polo Industrial of Manaus, supplier of service of electronic manufacture. One of its main macro processes is the SMT (Surface Mount Technology) where the automatic assembly process of the smaller components is done, its main phase is called "Solder Paste Printing".

The printer equipment is responsible for printing the solder paste on the PCB (printed circuit board) using the process tools called Stencil and Squeegee, which are the main tools for solder paste printing. Stencil, which is a perforated metal mask according to the PCB layout, and Squeegee is a squeegee blade that rolls the solder paste through the stencil hole, this process occurs only after the plate enters the Printer machine by the conveyor and is read from the fiducial, after confirmation, the clamp attaches and raises the plate through a base or backuppin to the stencil, completing the printing process the PCB is ejected.

Companies certified in ISO 9001, seek the continuous improvement of their processes and manufacturing systems. The project aims to reduce the rate of defects from this phase.

The research project brings continuous improvement in the SMT process by working on the high defect index, such as: Solder Paste Failure, Solder Short, Solderbooll, Displaced, Tombtorning, among others. Knowledge in the automatic assembly process increases productivity by directly associating the efficiency of a production process to the generation of a product with a certain degree of reliability, bringing satisfaction to customers with the quality of their product obtained in the process, and increasing the profitability of enterprises.

The question to be answered in the light of this study is: What improvements are needed in the plate printing process that reduce defect rates?

Thus, at the end of this study, it is intended to optimize the automatic assembly process by making an analysis to identify the possible defects given in the printing of the solder paste so that a plan of action is planned and to implant the continuous improvement within the process.

II. THEORETICAL FOUNDATION

In the studies carried out, the SMT process is present, which explains the process steps that are divided between printing, inspection, injection of components and re-fusing. The process of preparing the solder paste which is addressed on: the pulp used in the process and the procedures performed in the preparation of the solder

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paste. Welding process that refers to the application of the paste and to the time of refolding.

2.1 Detail of the SMT Process

The development of technology in recent years has enabled the use of equipment, techniques and compact products, which only existed theoretically, in the same it was possible to believe that they could exist in the insertion of physically ultraminiaturized components and even pop technology the assembly process SMT as a consequence of the advanced technology, had to be improved in the changes of the processes industries, such as equipment renovation, retrofit, programming techniques and optimization in a production line to meet the market demand of plates (Cellular, Tablet, Ultra book, HD, SSD, PDA).

It is presented by [1] an automatic optical inspection system based on neural network for the diagnosis of defects of solder joints in printed circuit boards assembled in surface mount technology. In his book [2] he discusses the theories and application of SMT and states that this is a technology of the day-day and not of the future. Optical surface assembly technology (O-SMT) was introduced, which was proposed by [3] to provide a possible solution to serious growing problems in the manufacturing process of optoelectronic products. After discussing the basic idea of O-SMT, the experimental results are also described to show its viability.

According to [4], Machine through a wave of liquid solder that runs through the lower surface of the printed circuit. In SMT technology, component insertion machines, chip placer and large placer are commonly used throughout the production process, from the application of the solder paste to the assembly of the components and the reflow of the solder paste, since the components in general are very small, sensitive and require great assembly precision, requiring very strict control of the process parameters.

This SMT technology is what makes use of SMD components (Surface Mounting Device), which was created to provide the assembly of electronic circuitry using automatic machines or fully automated assembly lines. In the SMT process where the printing process is done, inspection, automatic assembly of the electronic components and reflow. According to [5], the SMT process begins by the step of printing the solder paste, which is one of the phases corresponding to 70% of most defects becoming the most critical process.

The printer equipment is responsible for printing the solder paste on the PCB using the process tools called Stencil and Squeegee, which are the main tools for solder paste printing. Stencil, which is a perforated metal mask according to the PCB layout, and Squeegee is a squeegee blade that rolls the solder paste through the stencil hole, this process occurs only after the plate enters the Printer machine by the conveyor and is read from the fiducial, after confirmation, the clamp attaches and raises the plate through a base or backuppin to the stencil, completing the printing process the PCB is ejected for the automatic insertion process .

According to [5], inspection equipment and reflow ovens are subject to maintenance actions given their importance to the process. However, pick-and-place machines are the most complex and have the greatest potential at the same time to introduce and suffer process failures. The automatic insertion process, where the SMD components are placed on the surface of the PCBs extremely fast and with impressive precision and that give us the guarantee that the components are glued in a form centralized, with minimal losses and a good productivity. This process corresponds to 20% of the defects that occur within the assembly sector, since the risk that the automatic insertion machine corresponds to the removal of the components of their cocoons (a coil, tray, blister) and to position on the surface of the PCB.

The reflow process is what corresponds to 10% defects in the SMT process, where the welding of the terminals of the components with the PADs occurs. However, when it comes out of the automatic insertion the component terminals are only leaning against the solder paste, because the melting furnace is what guarantees the weldability and has the capacity to reach the temperature capable of melting the solder paste properly and making the connection between the pcb and the components.

2.2 Solder Paste Used in the Process

In the process of manufacturing computer boards, lead-free solder paste is used to avoid contamination in the environment, according to [5], previously used soldering (tin-lead alloys or Sn-Pb alloys) provided auto alignment and corrected minor component positioning errors during re-melt, a property that lead-free solder does not have, but lead-free solder paste is known for the effect of not causing health damage and to the environment.

According to [6], welded joints can be as strong as the base materials if an addition metal has higher strength properties than these materials and if welding techniques are used appropriately. In a welding process, if the material to be used is of good quality, resistance can be adequately formed.

This process is quite complex since the beginning it is essential that since the project planning, you have to think about what type of solder paste should be used in the

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SMT process, as this can directly affect the productivity and the quality of the product.

According to [7], in a welding project the most basic orientation is that the product needs to be designed from the outset as a welded joint, not as a cast or forged or otherwise shaped joint. In this way the most appropriate process to be worked is welding.

2.3 Welding Paste Preparation Process - SMT

According to [8], welding procedure qualifications and welder (or operator) are part of the quality assurance system in welding. The preparation of the solder paste is a necessary procedure for the production process. Solder paste pots are stored in freezers at a temperature of 0 ° C to 10 ° C. For the use of the solder paste in production, some MIX (OKTEK G-5000A) MIX process and rest procedures must be followed. soldering.

After removing the solder paste from the freezer it is necessary to place it in the cabinet for the rest of the solder paste in the period of two hours. After removing the solder paste from the cabinet it is necessary for the operator to tap using the MIX equipment (OKTEK G-5000A), which makes the rotary movement for one minute to activate the flow containing the solder paste making it more homogeneous.

To perform the resting process in order to comply with the technical specifications of the solder paste. Production can only use the solder paste if it is rested for 2 hours at room temperature.

III. MATERIALS AND METHODS

The studies conducted within the SMT sector, with the divisions of each process, were effective as they helped to understand the capacity of each machine and which materials were suitable for the in-process use. Thus, it became easier to analyze the machines and materials, thus bringing the evidence of where the high defect rates occurred and implementing possible solutions within the process.

3.1 SMT Process Analysis

In the process of printing the solder paste the sample of the high defect index inside the process was carried out as in figure 1 below.

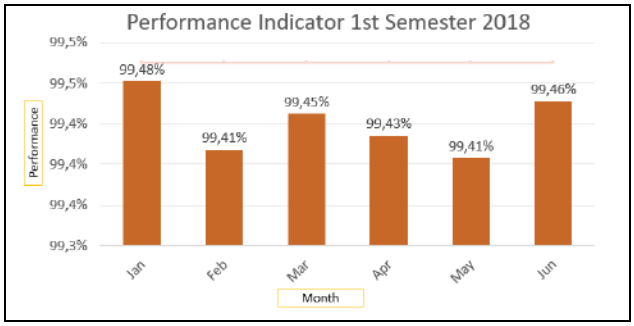

Fig. 1: Performance Indicator 1st Semester 2018

The performance of the process in January was 99.48% the highest index, in February there was a drop to 99.41%, in March it was 99.45%, in April it dropped to 99.43%, March it dropped more to 99 , 41% in June there was improvement to 99.46%.

Figure 2 shows the behavior of the process performance through Pareto Diagram.

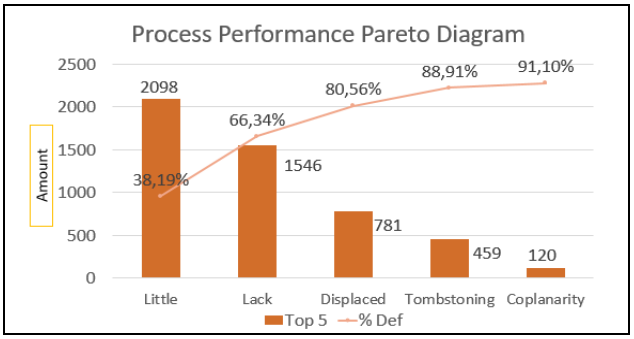

Fig. 2: Process Performance Pareto Diagram

In the process of the SMT, the problem in the weldability of the board was found, in which they reflected as: insufficiency of the solder paste, short of solder, soderbool, displaced, tombstoning and among others, in Figure 3, the Ishikawa Diagram was performed to analyze the cause of the problem in the printing process of the solder paste.

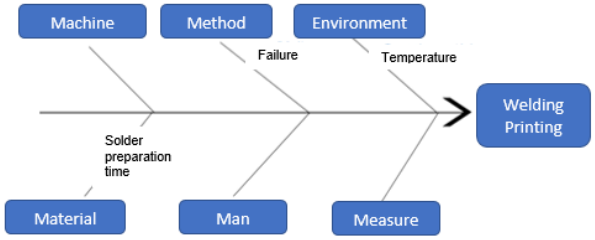

Fig. 3: Analyse Process Ishikawa Diagram

For the better elaboration and understanding of the failure scenarios, there are several analysis tools available, one of which, the cause-consequence diagram, according [9]. This diagram is a graphical analysis that lists the sequence, from a known initial event, that leads to a set of consequences, through a specific syntax, according [5].

The diagram shows that the root cause of the problem is directed to the process of preparing the solder paste, from the beginning of the phases to the last phase of the SMT process.

3.2 Problem Encountered in the Process

In the SMT process, the problem in the weldability of the board was found, in which they reflected as:

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insufficiency of the solder paste, short of solder, soderbool, displaced, tombstoning and among others, which refers to the process of preparation of the solder paste. Before the process of resting the solder paste was controlled by labels that were adhered in the pot of solder paste where the date and time that was withdrawn from the freezer was placed, since they were stored in a plastic container with three drawers where stored separately each model of solder paste.

The problem found in this container is that there was no control that ensured that the solder paste was rested for a time determined by the technician. For the operator of the printer machine had the freedom to withdraw the solder paste at the moment when it found necessary to be beaten in the equipment OKTEK G-5000A for five minutes because it was out of technical specifications, rest time of the solder paste, causing the defect index to be higher than the average.

3.3 Materials Used in the Project

To start with the project it was necessary to divide it into four parts that were identified as follows: 1st Structure construction, 2nd Mechanics, 3rd Electrical, 4th Sonoff device configuration. Both were essential and representative parts within the project, so that it was accomplished obtained the need for the following materials:

1. Power supply 60w, 100-240vac, 24vdc, 2.5a;
2. Timer in solid state;
3. Din rail socket p / my2, c / prot.p / finger, black;
4. Solenoid directional valve - sy5240-3dz series;
5. Manifold sub-base;
6. 1/8 silencer;
7. Straight brass instant connection;
8. Compact-series pneumatic actuator cq2;
9. Aux valve. Of flow control - as series;
10. Magnetic sensor;
11. Regulator filter - aw-b series;
12. Straight brass instant connection;
13. Polyurethane tube;

IV. IMPLEMENTATION OF PROCESS IMPROVEMENT

According to the studies carried out in the process were identified the most frequent defects within the SMT sector, in which it leads the index of defects much higher than expected, for which it was diagnosed in the prince of pcb that were studied, and identified that the problem was not in the printer and on the plate, new studies were carried out, to which the solder paste was involved, that the most frequent defects were identified.

The process of preparation of the solder paste was found problem in which all phases of the SMT influence, causing the defect index to be high, for this a corrective action plan was carried out using the 5W2H quality tool in the table 1.

Table.1: 5w2h Action Plan

Why Hould we Follow the Technical Specifications of the Supplier?			
WHAT	**HOW**	**WHO**	**WHERE**
Reduce defects in the SMT process caused by the printing of the solder paste;	Elaborating an automatic cabinet for the correct rest of the solder paste;	Technical and engineering;	Process for preparing the solder paste;
WHEN	**HOW MUCH**	**Status**	
8 Mounth	$ 1.430,20	Project is under test	

In order for the soldering process to be corrected, a corrective action plan was implemented in which it corresponds to the design of an automatic cabinet that monitors the rest time of the solder paste. The steps in the implementation of the automatic closet design were as follows:

1º Construction of the structure:

A - Assembly of the cabinet structure with profiles and aluminum plates;

B - Mounting in the structure of the angle and partition in MDF;

C - Assembly of the walls of the cabinet structure, sides and bottom in acrylic;

D - Mounting the doors in acrylic.

2 °Mechanics:

A- Installation of the mini electric locks 12V solenoid in the aluminum frame.

3 ° Electrical:

A- Connection of Sonoffs, transformers and electrical locks.

4 ° Sonoff device configuration:

A - Creation of activation and deactivation schedules.

4.1 System Automation

The device control system will be managed through a main HMI, 4.3 "(inches), where it will be possible to lock the selected drawer. After the drawer is locked, in normal process, the opening will only be released again after the 2 (two) hours, pre-established, has been completed.

In case of unforeseen circumstances, the drawer can be unlocked by the HMI through a password and login, provided to system administrators. Another possibility would be if there were any emergency situation and it was necessary to unlock all the drawers immediately, just press the emergency button found on the front of the device. However, in this situation, it is only possible to restart the process with the administrator release through the HMI. The information shown on the HMI will be:

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• Status of each drawer (indicating whether the drawer is locked or not);
• Indication of elapsed time of rest per drawer;
• Process start and stop button;
• Display with fault indication and events;
• Access control for system administrators;
• Stand-by time setup screen per drawer.

4.2 Mechanical Construction of the Device

The coating of the device will be 2 (two) materials, polycarbonate and MDF, both with thickness of 12mm. Drawer latches will be performed by pneumatic actuators that are installed in the back of each drawer. The drawers have on the front of the polycarbonate material, so you can see the internal contents of the cabinet when closed. The rails of the drawers will be of the telescopic type. Each drawer will have a subdivision of 4 (four) compartments.

4.3 Installation in Process

The device will be taken to the previously tested installation location. However, the final test will not be discarded against the customer who took the service. The contractor must provide at the place of installation an electrical supply point 220Vac 1F + N + PE or 127Vac 1F + N + PE together with pneumatic power point for the cylinders of the device.

In order for the assembly procedures of the automatic cabinet to be carried out correctly, it was necessary to make available to the technical workforce for the construction of the device: a Technician in Industrial Automation, a Technician in Industrial Mechanics and a Mechanical Assistant. Each technician has the specialty in the area that will work so that the project does not establish errors in the execution.

Thus, this project reflects on a schedule to open only in a given time by the technician that was long enough for the folder can rest and be directed to the process. The corrective action was taken based on the schedule that corresponds to the project developed and implemented internally in the manufacturing area of the Industry.

V. DATA ANALYSIS

Based on the demonstrated studies, the defect index found within the process was well above the expected, but were found defects in the weldability of the plate, such as: insufficiency of the solder paste, short Solder, Solderbooll, Displaced, Tombtorning, among others . According to figure 4, it was possible to analyze the percentage of defects within the process of weldability of the plate to each month, considering the relation between minimum, maximum, the target and the reality of the quality standard in the process.

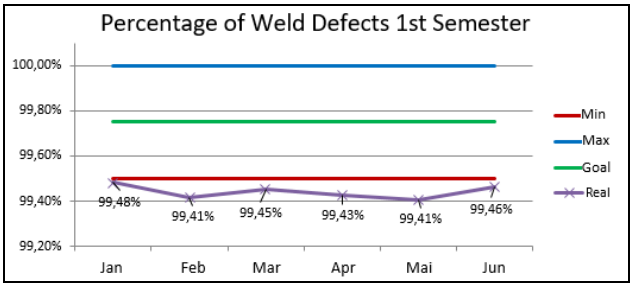

Fig. 4: Percentage of Weld Defects 1st Semester

Based on the analysis carried out between January and June, the company's quality standards targets were highlighted, which were below the minimum level, which however is detrimental to the process and to the clients, although it has studied the process and has diagnosed the root cause of the defects were deployed in the process improvements at low costs.

After having done the process defects analysis, and have found the possible solutions for continuous improvement. Adjustments were made within the process and the actual level of the quality standard was diagnosed, which were positive results for the company. In the month of July to December, shown in figure 4, the level of quality standard were highlighted from 99.43% to 99.85%, since the target of 99.75% were successfully achieved. In addition to the target reached obtained a cost reduction of R $ 37,458.00 which is of great importance to the company.

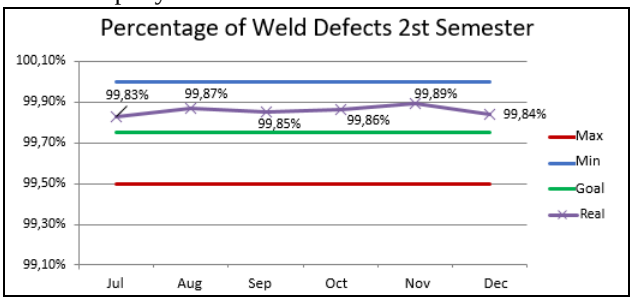

Fig. 5: Percentage of Weld Defects 1st Semester

The process improvements were effective for the company as it obtained results such as cost reduction and the percentage of defects well below those of the previous six months. Because the adjustments within the process were made through the company's technicians without the precision of outsourced companies.

VI. CONCLUSION

When investigating the causes of major defects in the printing process of the computer board it was identified that the resting process of the solder paste was controlled

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through the labels that were adhered to the solder paste jar where the date and time that was placed removed from the freezer because they were stored in a plastic container with three drawers where each model of solder paste was stored separately.

The problem encountered in this vessel through the analyzes performed within the process of preparing the solder paste was that there was no control which ensured that the solder paste was rested for a time determined by the technician. For the operator of the printer machine had the freedom to withdraw the solder paste at the moment when it found necessary to be beaten in the equipment OKTEK G-5000A for five minutes because it was out of technical specifications, rest time of the solder paste, causing the defect index to be higher than the average.

Based on the analysis performed, a corrective action plan was proposed and planned, which consisted in the idea of the realization of an automatic cabinet with locks and timer, in which the guarantee is made that the solder paste will be adequately rested. Based on the studies, the project was implemented and analyzed.

With this design of the Automatic Closet had the reduction of number of defects well above expected because the application of the correct procedures before the solder paste go to the process, influence on the index of defects, because the solder paste being rested for a while determined at room temperature and then tapped into the OKTEK G-5000A equipment following the technical specifications, this activates the flow containing the solder paste, leaving it more homogeneous and ensuring that it will not cause future problems inside the production, as this will reach the quality within the process.

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