# ENGENHARIAS:

## BENEFÍCIOS PARA A INDÚSTRIA E PARA A SOCIEDADE


Amanda Fernandes Pereira da Silva
(Organizadora)



Atena Editora
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# Engenharias: benefícios para a indústria e para a sociedade


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# APRESENTAÇÃO

Um paradigma que expande seu domínio de conceitos teóricos para aplicações no mundo real, é o campo das Engenharias. É capaz de incorporar muitos conceitos tecnológicos em diferentes setores. Juntamente com a pesquisa e a busca por inovações frente ao serviço da indústria, possibilita a existência de uma transição de serviços que contemplem uma indústria mais sustentável, centrado na sociedade e resiliência.

Nesse contexto, o intuito da obra "Engenharias: Benefícios para a indústria e para a sociedade" foi de colaborar com pesquisas que abordem a inovação aprimorada para a indústria e o ser humano afim de impulsionar e corroborar ideias de pesquisa que se utilizem da sustentabilidade como estratégia principal. Em todos os trabalhos fornecidos compreende-se a busca por alternativas viáveis e sustentáveis com relação à medicamentos, energias alternativas e menos poluentes, otimização no uso de máquinas e consumos de energia, reutilização de resíduos e áreas correlacionadas.

A necessidade de mudanças tem sido reconhecida pela indústria há bastante tempo e é motivada devido aos potenciais impactos ambientais, altos investimentos nas tecnologias de fabricação de materiais e, consequentemente, agravamento de desigualdades de impacto social. Desta maneira, é importante a disseminação de pesquisas que englobem aspectos ecológicos e sociais, que tenham como foco a economia atrelada aos benefícios e oportunidades sociais que resultem em sustentabilidade.

Em face ao exposto, esta obra abrange estudos práticos da área de engenharia realizados por pesquisadores do país que enfatizam essencialmente indústria-engenharia de sucesso para construir um meio mais sustentável adeque ao contexto real.

Amanda Fernandes Pereira da Silva

## SUMÁRIO

SUMÁRIO

# CAPÍTULO 1

# APPLICATION OF THE SIX SIGMA METHODOLOGY FOR THE LONGEVITY OF BON TOOLS IN TAB BOND MACHINES

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**ABSTRACT:** The research was increase longevity of the bond tools on the other hand it serves to ensure adherence in the terminal with the pad (area of soldering in the integrated circuit) when the Tab Bond machines apply ultrasound solder through the tip or bond tool. It has variability in used each machine and shift of the analyzed history. Application of the Six Sigma methodology, the results after several design of experiments, it was obtained that the variables with the most influence were temperature and force that affect tip wear, the temperature was controlled on the pedestal with a thermometer to 175°C (degrees Celsius) and with a control graph, the force range was increased from 90 to 170 grams force, on the other hand, the pull test in the terminal was improved obtaining cp and cpk (process capability) greater than 1, in the 22 terminals; therefore lengthening the change time at the bond tools to maintain good adhesion not less than 30 pound force. The consumable was reduced by 10%, increasing the number of bonds greater than 1,000,000 per tip, concluding a savings of $ 18,000.

**KEYWORDS**: Six Sigma, ultrasound solder, design of experiments, pull test, and bond tool.

## 1 I INTRODUCTION

Any process that generates defects incurs unnecessary costs that companies sometimes cover by increasing their sales prices and causing customers to look for other price options more suited to their needs. Managers have realized that this is not the best solution to their problems and have looked for another way to combat them. From the above, the Six Sigma (6s) philosophy was born, created in 1980 by the Motorola organization, a discipline for the reduction of defects in manufacturing processes, applied to service organizations (Harry, 2000). This methodology is focused on customer satisfaction throughout the development of the product until the final delivery. Its processes and methodology allow to eliminate the variability in the processes and reach a level of defects less than or equal to 3.4 defects per million (Valles, 2002). This project focuses on the application of the Six Sigma methodology for the longevity of bond tools in Tab Bond machines.

## 2 I MATERIALS AND METHOD

The Six Sigma methodology is made up

of 5 stages that are described below.

## 2.1 Define

The output characteristics are the specifications or requirements of the clients which are called Critical for Satisfaction (CTS) and have control support in the waste reports and in the history of the use of the tips (maintenance), and it is divided into:

Critical to Quality (CTQ). - For the Production Department it is necessary to maintain the current quality level or increase it.

Delivery Critical (CTD).- This study does not have this critic for either of the two clients, since the operation is relatively fast, however, the possibility that this critic may arise during some step is not ruled out. In the development of the project.

Critical to Cost (CTC). - The need of the Warehouse Department is to decrease the number of tips and, therefore, the cost incurred by the lack of control in said use.

Critical to the Environment, Safety (CTX). - This type of critic is also absent for both clients, however, it may be possible that it appears when deepening the knowledge of the process.

## 2.2 Measure

During this measurement phase, the current situation was analyzed, beginning by defining what is important for the client, the lack of control of the use of bond tools using a (cause-effect diagram) figure 1 to recognize the situations that cause process failures.

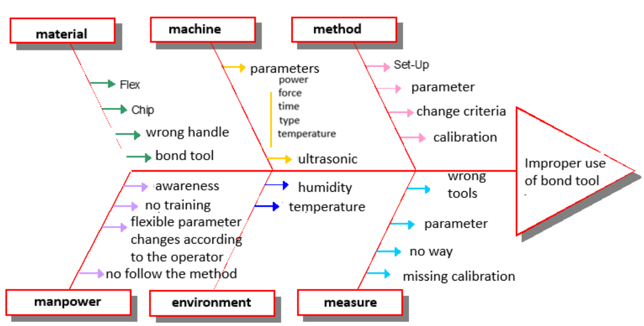


Figure 1 Cause-Effect Diagram

With the information it was already possible to determine which machines spend the most bond tools and start with their analysis and corrective actions. The cause-effect matrix allowed us to relate what is most important to customers and how current process data influences them, so it is possible to start by improving what is predominant in said relationship. By qualification obtained, the three main factors that have the greatest influence on welding within ranges, the useful life of the bond tool and the frequency of stops due to its change were:

1st calibration and the different set up both with 207 points

2nd mishandling of material with 177 points

3rd the force-power with 167 points

The change of the bond tools was analyzed, since it is done without first verifying that the rejection of the sample by weak soldier is due to other parameters, that is, it may be that the tip and the height between the bond tool and the bonding area or adherence is not adequate, among others. Adjustments are made to the machine during calibration but do not ensure that the parameters are appropriate and are limited to changing the bond tool. To collect the information on the machines it was necessary to resort to the maintenance history about the use of bond tools, with this, study data was obtained, in which the date and number of bond tools that were taken from the inventory, the machines in which they were recorded. They placed the product they make and the cell to which they belong. The time is established in the original inventory database and this determines the shift during which shift. This was carried out for the period during the months of July and August.

When obtaining the inventory history and looking at the variation between the machines, it was necessary to compare against the number of bond tools that each should consume in a month, although currently there is no data on the number of them that a machine should use, but it is found approximately between 4 to 5 of them per month. The difference in use is found not only between the machines but also between the shifts, this adds one more variable to the study, it is unknown why one shift spends more than the other.

Figure 2 shows a bar graph that compares the use of bond tools between the shifts of the 36 machines, obtaining that shift A consumes 77, B = 122, C = 78 and D = 34 during July-August. Due to the fact that the product with the highest consumption is the model call Yellow Stone Mono manufactured with four machines, the decision was made to study the TB 101 and TB 144 machines. The inspection tests are carried out by the “pull test” machines. When a pull test detects that the terminal of the integrated circuit is poorly soldered (weak), it is attributed to the wear of the bond tool, thus increasing the parameter force and power or change it.

The independent variables and constant parameters are shown in table 1. There is a 100% reliability in the welding machines that come from a certain manufacturer, which are calibrated by maintenance personnel every 3 months, by ruling out this possible source of variation or error, we have to accept that it comes from the machine operator, since it can change the operating parameters of the machine according to your convenience.

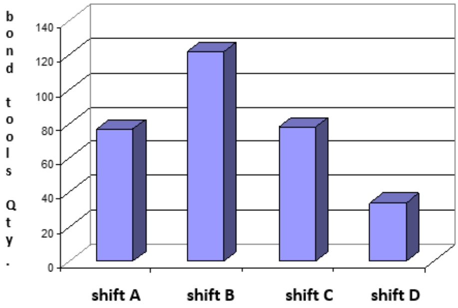


Figure 2 Graph of consumption of bond tools per shift period July to August

The criterion of the operator is involved when there is a need to change a bond tool according to the information that the pull test, however, to know how the machine is working, samples have been taken from those that have resulted with the highest use of this; two samples of size n = 22 were taken for the TB 144 and TB 101 machines. The data was verified to be normal.

| VARIABLE | CONSTANTS |
|---|---|
| **Flatness of the die and flexible roll** | Strength from 120 to 170 (grams strength) |
| **Height 3680 +/- 50** | Power from 110 to 160 or up to 215 maximum micro inch width. |
| **Perpendicularity** | Bond Time. |
| | Type of Power (Ramp, squad and explosion). |
| | Notepad temperature (200 to 300 degrees centigrade). |

Table 1. Tab bond Operation Parameters

The specification that the client requires on 60 lbF (pound force) mean, the minimum of 30lbF and the upper limit of 90lbF.

Objective 1. - Control a Cp and Cpk (process capability) between 1 to 1.33 and not have a Cpk greater than 2 or 3, because this makes the bond tool wear more.

Objective 2. - That the test has consistency of adherence of the terminals with the soldering area on the integrated circuit (pad), on both sides of the integrated circuit (chip).

Objective 3. - Reduce the consumable by 10%, looking for the root cause of why some machines have a lot of variation.

Objective 4. - Reduce the variation between machines number of bonding > 1, 000,000.

Objective 5. - Develop an experiment design to optimize the use of the bond tools.

Objective 6. - Train personnel to manage parameters and raise awareness to reduce wear.

## 2.3 Identify and Analyze

A Multivariable analysis was performed, a graphical tool that evaluates how an x affects a Y, and also evaluates the combination of several x's affecting a Y, to relate the behavior of the machines with the highest consumption of points in each of the shifts of the business. Figure 3 shows the consumption of tips relating the shift and the machines. Figure 4 shows in detail the variation in the four machines and the inconsistency of consumption between the four shifts.

Figure 5 shows that shifts A and C consume a similar amount of tips, while shift B is the one that consumes more and D is the least expensive, this raises the following questions: What does shift D consume the least number of tips than the rest of the turns? And what does turn B do to spend more tips than the rest of the turns? What makes the TB 144 machine consume more tips than other machines?

Figure 6 shows the consumption separately for each of the shifts, where the variation in consumption between the machines for each of them is reaffirmed, as previously analyzed in figure 4, here it is also easy to see that in general the highest consumption is concentrated in turbo B and the minor on turn D. From all of the above, as a conclusion of the Multi-Vari analysis, we have that: there are differences in criteria between operators of the same shift (between machines) and between the criteria of operators between shifts.

As an action plan, it was necessary to carry out an R&R analysis to see if there are differences in the method of increasing strength, power and the decision to change the tip by the operator and to unify the criteria. The Gage R & R method tells us that there is a respectability of 92.31% between operators, consistency and it maintains its criteria the same among the tests that the same operator does.

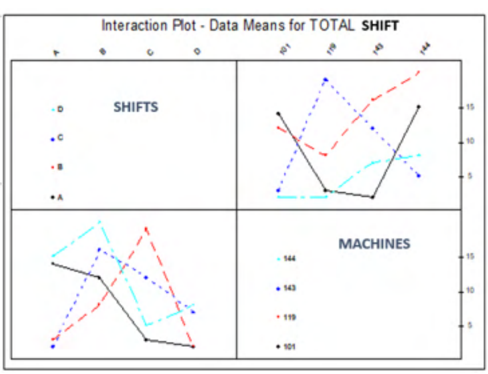


Figure 3 Multi-Vari analysis of shifts and machines

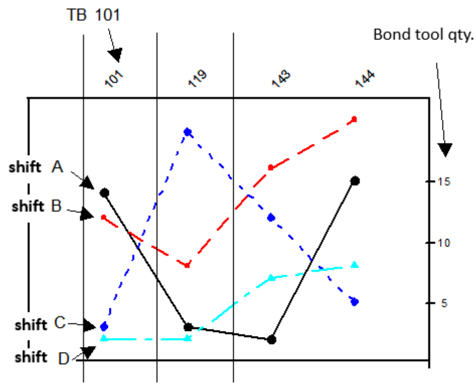

Figure 4 Multi-Vari (second quadrant detail)

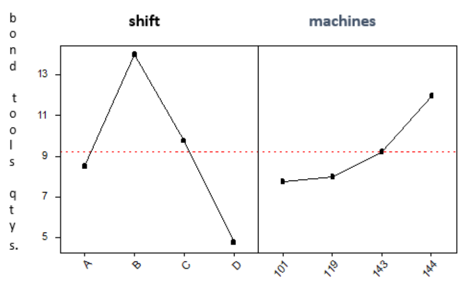

Figure 5 Main effect graphics

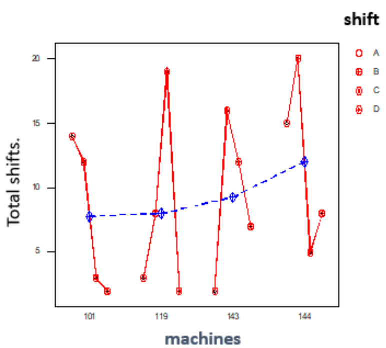

Figure 6 Multi-Vari general shift-machine relationship

To know the variables that have the most impact for better adherence, the factors used are: power, force, Time BT (Bond Time milliseconds), and Type & Temperature with two levels. Where Y = Reduce the wear of the bond tool, representing all the X variables. Table 2 shows factors and levels used for the design of experiments to start playing with the levels and ranges to analyze.

| | Factors | Nivel 1 | Nivel 2 |
|---|---|---|---|
| Y = tip wear | Micro inch power | 70 | 190 |
| | Force (grams force) | 80 | 190 |
| | Time milli seconds | 15 | 25 |
| | Type | Square | Burst |
| | Temperature degrees centigrade | 140 | 250 |

Table 2 Factors and levels used for the design of experiments.

Procedure recommended by Montgomery (1991). Using the Minitab as a statistical tool, the corresponding run was made with the variables described above with a run of 24 combinations and 1 replicate. It can be seen that the two factors with the greatest influence on the Minitab results are:

a) Power: A T of 19.5 and a P of 0.000

b)Temperature: A T of 7.57 and a P of 0.000

Figure 7 below shows the variables that are significant, all the variables that the red line touches are significant. Showing that the first is force, the second is temperature, which are the variables that will continue to be used in the following experiments. Figure 8 shows the slopes of the variables which means that the more slope the more influence it has with respect to the adherence of the terminal with the pad or soldering area. The equation to optimize the parameters is as follows:

Y = -52.3692 + 0.0456319(X1) + 0.348766(X2) + 1.45876(X3) - 1.55042(X4) + 0.0449614(X5) - 0.00474697(X2) (X3) + 0.000904270(X2) (X5)

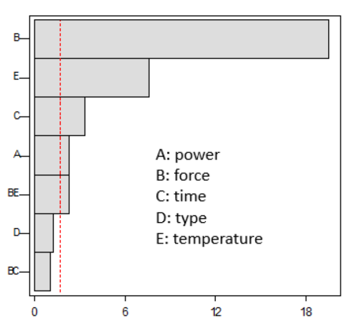


Figure 7 Most significant variables of the experiment.

Once the most relevant factors were obtained, that is, force and temperature, a second design of experiments was carried out for both. Obtaining the data shown in Table

3 with force values at 140 and temperature at 240ºC, an average of 82.71 adherence was obtained in the pull test, an acceptable value. The question arose whether there was any restriction on the temperature to which the chip is subjected in the semiconductor process, so a third experiment was carried out, obtaining results that represented in Figure 9 indicate that the higher the temperature and the greater the adhesion.

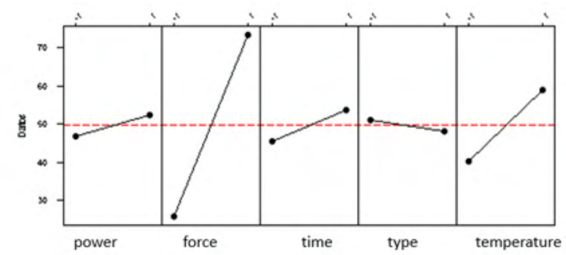


Figure 8 Slope of the variables

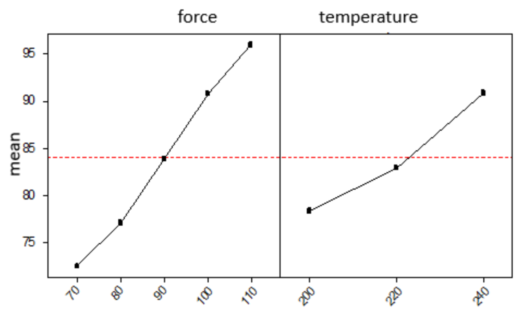


Figure 9 Force and temperature with respect to the mean lbF

Figure 10 shows the behavior of the mean with the variables force and temperature. Once the parameters that allow obtaining quality welds and at the same time maximizing the useful life of the tip were determined, tolerance ranges were established in which said parameters can vary without affecting the life of the tip and quality.

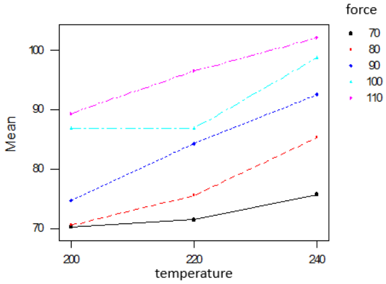


Figure 10 the mean lbF with temperature and force.

### 2.4 Define controls

According to the DOE carried out, Force and Power should start in measure 90, with a temperature of 175ºC (degrees Celsius) constant on the calibrated pedestal, the compensation in the temperature control, both parameters (force and Power) will be increased from 5 to 5 starting at 90 until reaching 170 (grams force), when the pull test fails with these last parameters then the bond tool is changed, not before. The cp and cpk (process capability) obtained is 1.08 for TB 101 and the cpk is 1.28 obtained for TB 144. Table 3 shows the improvement after controlling the pedestal temperature and power and force in TB 101 and 144.

### 2.5 Implement Controls

Meanwhile temperature control at 175ºC is performed by the equipment maintenance personnel as part of the machine setup. Next stage it is necessary to control the process with a control chart. Therefore to keep the average of mean close to 60 lbF in the pull test. Afterwards to realize that for this stage there need to train the personnel, as a series of resistance to carry out the control graph as not to raise the parameters of force and power until necessary. It is make a plan and design a control system that includes:

i Training and raising awareness among staff on the uncontrolled use of the bond tools of force and power parameters (method on the criteria to change it).

ii Changes the process of making two samples when the first has been rejected, increase power and force of 5 on 5 how to the process diagram shows.

| | TB 101 | | TB 144 | |
|---|---|---|---|---|
| | before | after | before | after |
| LSL ( lower limit) | 50 | 90 | 50 | 90 |
| USL (upper limit) | 110 | 150 | 110 | 150 |
| Cp (Process Capability) | 1.000 | 1.13 | 0.890 | 1.580 |
| Cpk (Process Capability Index) | 0.990 | 1.08 | 0.490 | 1.260 |
| Mean | 80.233 | 121.160 | 93.566 | 114.360 |
| Standard deviation | 10.040 | 8.800 | 11.200 | 6.330 |

Table 3 before and after controlling the pedestal temperature and power and force for TB 101 & 144

## 3 I RESULTS

After the implementation of the temperature control on the TB 101, showing the difference after the improvement that a single tip lasted more than 15 days. Saving bond tools from 3 to 1. The same saving behavior before and after the improvement in the pedestal temperature control in TB 144 of (5 to 1). 5 in 15 days before improvement and 1 for 15 days after as well as increased range of force and power (90 to 170 grams force) and increased from 5 to 5: The explanation that is given for this project is the improvement in the control of force and power parameters that was necessary to carry out from September mentioned in the control stage. Savings of $ 18,000 for the first year.

## 4 I CONCLUSIONS

Cp and Cpk were obtained between 1.00 and 1.26, causing the tip to have less wear. The consumable was reduced by 10%, on the other hand it was found two variables such as temperature and force for find the root cause of why some machines had so much variation. The Tab Bond machine increased the number of bonds greater than 1,000,000 per tip. It was checked with the design of experiments to optimize the use of it. With the Gage R & R study it was found that the personnel are trained, for future works the only thing that is lacking is the awareness of the personnel to manage parameters to reduce wear. It has been reduced that the technician has inventory having bond tools in the briefcases.

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