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RISK ANALYSIS OF PRODUCTION PROCESS FOR AUTOMOTIVE AND ELECTRICAL ENGINEERING INDUSTRY USING FMEA

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A failure mode and effects analysis (FMEA) is the most often used (and required by customers) tool for quality planning. The FMEA examines possible errors with their consequences for customers as well as their possible causes. This analysis can be realized on several levels (structure or process), and thus it may become a subject of various teams, from engineers of whole parts to those dealing with individual units, from workers preparing the manufacturing processes as a whole to those who prepare (or control or even perform) individual operations. The aim of this work is the analysis of risks using the FMEA for a selected production process and proposal of measures to eliminate risks.

Keywords: FMEA method, risk, threat

The aim of the FMEA method is to:

- identify the function of the process or requirements for the process;
- identify all the possible errors associated with the process;
- estimate the effects of these errors for the customer;
- identify the possible causes of these errors in the manufacturing process or assembly and to identify the process parameters that should be focused on by the process management to limit errors and increase the probability of their detection;
- rank errors according to their riskiness and based on this, to propose actions for their reduction.

It will be necessary to make a selection of the technological flow of production in a selected company (Služba Nitra, s. r. o.), to identify threats, the nature of risks that give rise to a negative phenomenon resulting in accidents, health risks, machine failures and other, and to implement the FMEA in the manufacturing process for the production of printed circuit boards (PCB).

The re-training of employees is conducted in the field of safety at work to eliminate the risks. In the stage of equipment servicing, the FMEA can evaluate the greatest ergonomic risk factors caused by poor working layout and increased temperature at workplace (Burda et al., 2011).

The purpose of this method is to highlight the importance of compliance with established rules and standards to enhance the needs of continuous improvement in environmental organizations, whatever their sphere of competence (Korenko et al., 2010).

The risk of individual operations is greatly reduced after applying corrective measures. Although the most risky operations will remain where they are, their risk level is reduced and it is the main objective of FMEA (Paulíček et al., 2011).

The FMEA can be part of several methods. It is performed within a safety audit but also with a Poka Yoke method (Andrássyová et al., 2011; Kaplík et al., 2010).

Material and methods

Procedure of FMEA (ten steps):

1. Review the process
 2. Brainstorm potential failure modes
 3. List potential effects of failure
 4. Assign severity rankings
 5. Assign occurrence rankings
 6. Assign detection rankings
 7. Calculate the RPNs (RPN – risk priority number)
 8. Develop the action plan
 9. Take action
 10. Calculate the resulting RPNs.
- Occurrence – probability that a given specific cause/mechanism will occur. To estimate the occurrence, we use a table according to VDA 4.2.
 - Severity – a sign associated with the most critical consequences of a given failure type. It expresses a relative evaluation within the FMEA. Severity is estimated according to VDA 4.2.
 - Detection – a sign assigned to the best measures for detection. To determine its value, the table according to VDA 4.2 is used.

The most important step before launching FMECA method analysis is to choose a team leader who will be responsible for the entire process of analysis and the following tasks:

- to lead the team,
- to choose team members from various departments of the organization,
- to secure the required materials and statements,
- to follow the determined plan,
- to process forms accurately,
- to involve other specialists.

Results and discussion

The manufacturing process of one- and two-sided PCBs was evaluated by a photoresist method, with a possibility of HAL application – for the automotive and electrical engineering industry.

Work operation

Cutting

1. Board type and quality control before cutting according to TPC 006, point 1.
2. Cutting dimension tolerance ± 0.5 mm (unless other value is set in VTD), cut edges without cracks.
3. Work with protecting gloves, not to damage the Cu foil.
4. Do not cut defective boards!!!, wrap it in the original packaging and file a complaint.

Brushing

1. Cu foil must have a coherent shimmer without oxides.
2. Openings cannot have burrs.
3. If conditions 1 and 2 are not met, repeat brushing up to two times.
4. Work with protective gloves.
5. Technical parameters – max. length of the shorter side of blank 600 mm.

Developing

1. Any poorly lit areas of a light-sensitive layer must be removed from the blank.
2. Strip unsatisfactory blanks by oper. 110 and place in the manufacturing process for oper. 040.
3. Technical parameters – max. length of the shorter side of blank 420 mm.

Etching

1. Minimum width of the soldering annulus 0.1 mm.
2. Acceptable errors – small remnants of Cu in isolated gaps max. $5/100 \text{ cm}^2$, cauterizing of conducting joint, max. size of etched surface 50 % longitudinal, 15 % transverse from the width of conducting joint.
3. Unacceptable errors – short circuits and breaks.
4. Technical parameters
 - a) double sided PCB thickness of Cu foil max. $70 \mu\text{m}$,
 - b) max. length of the shorter side of blank 420 mm,
 - c) stated parameters of etching:
 - volume of Cu in etching device $80 \pm 10 \text{ g l}^{-1}$ (to measure 2x per shift),
 - volume of Cu in regenerating tool $50 \pm 5 \text{ g l}^{-1}$ (to measure 2x per shift),
 - volume of ammonium sulphate $210 \div 240 \text{ g l}^{-1}$ (to measure 1x weekly),
 - volume of ammonium chloride $2.5 \div 3.5 \text{ g l}^{-1}$ (to measure 1x monthly),
 - pH 8.3–8.6.

Stripping

1. Complete removal of the light-sensitive layer from the surface of blank.
2. Technical parameters – max. length of the shorter side of blank 600 mm.

After performing the risk analysis by the FMEA on the technological flow of PCB production, we found that

the greatest risk arises when etching and stripping as the resultant indicator of risk priority was higher than 100.

This indicator is slightly significant; therefore, a corrective action is necessary and must be taken as soon as possible, preferably during the shift when the error occurs. Each operator is trained for a specific line, and occurred errors are often the cause of a human factor. No production is error-free and therefore does not produce at 100 %.

Conclusion

The performed risk analysis using the FMEA method revealed errors in the process that were immediately removed after corrective actions.

The advantages of FMEA:

- increasing the safety and reliability of products;
- reducing warranty and service costs;
- shortening the process of development;
- onsets of series with fewer errors;
- improving the compliance with deadlines;
- increasing the economy of production;
- better service and in-plant communication.

The FMEA is a real document and should always reflect the current state of the process, thus the action taken at the stage of batch production, e.g. responses to complaints, the occurrence of errors not considered as errors in the meantime, etc.

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