Experimentální Analýza Napětí 2011
Experimental Stress Analysis

Measuring and quality evaluation of Printed circuit board development

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Abstract: The paper deals with methodology for testing and evaluation of possible failure of printed circuit boards (PCBs) during its production process. The methodology is based on demand of automotive manufacturer to increase quality, reliability and safety of car components. The methodology is based on test guideline IPC/JEDEC-9704. The paper shows practical experience with testing and result evaluation.

Keywords: Strain, Printed circuit boards, IPC/JEDEC-9704

1. Introduction

The quality of production process is the most important thing for each company on the market, especially in area of automotive industry. Suppliers of car manufactures are required to declare the highest level of products quality.

Nowadays modern cars are equipped with many electronics systems which are responsible for controlling important car functions. Those functions can be critical (for example locking of steering wheel). Damaged or failure of electronic parts during driving can cause serious car accidents. Therefore faultless production is very important for car developer and also for the suppliers.

The manufacturing process is monitored by PCB developers directly on production line. Each developed board is inspected for their functionality and also on board components are visually inspected for their possible damaged. Unfortunately, the manufacturing process can cause hidden defect or residual stresses of PCBs which may not be detected by board testing and inspection but which can cause PCB failure during operation in car. Therefore there is a need to proof that the manufacturing process satisfied requirements of some standard.

2. Measuring and test result evaluation

The methodology of testing is based on strain measurement of PCBs in location of excessive strain possibility. Measuring points on PCBs should be selected carefully close to on board components of great importance. In some cases on board components can be removed from PCB. On the other hand, removing of on board components can cause change in board stiffness with production of conservative testing results.

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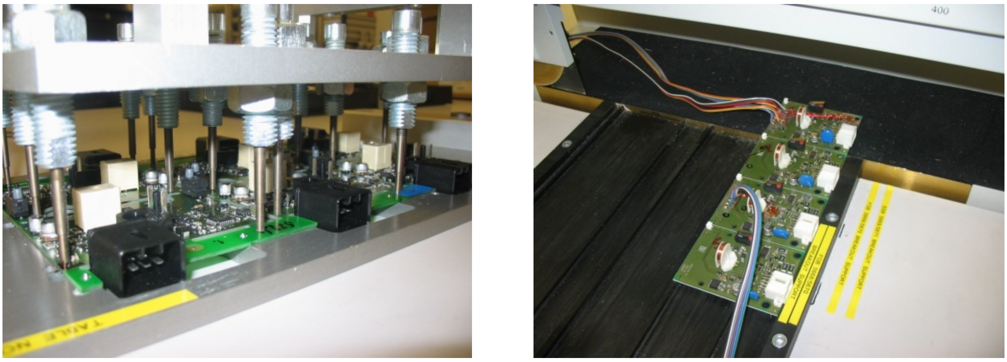

Fig. 1. Examples of PCBs with strain gauges during productions proceses

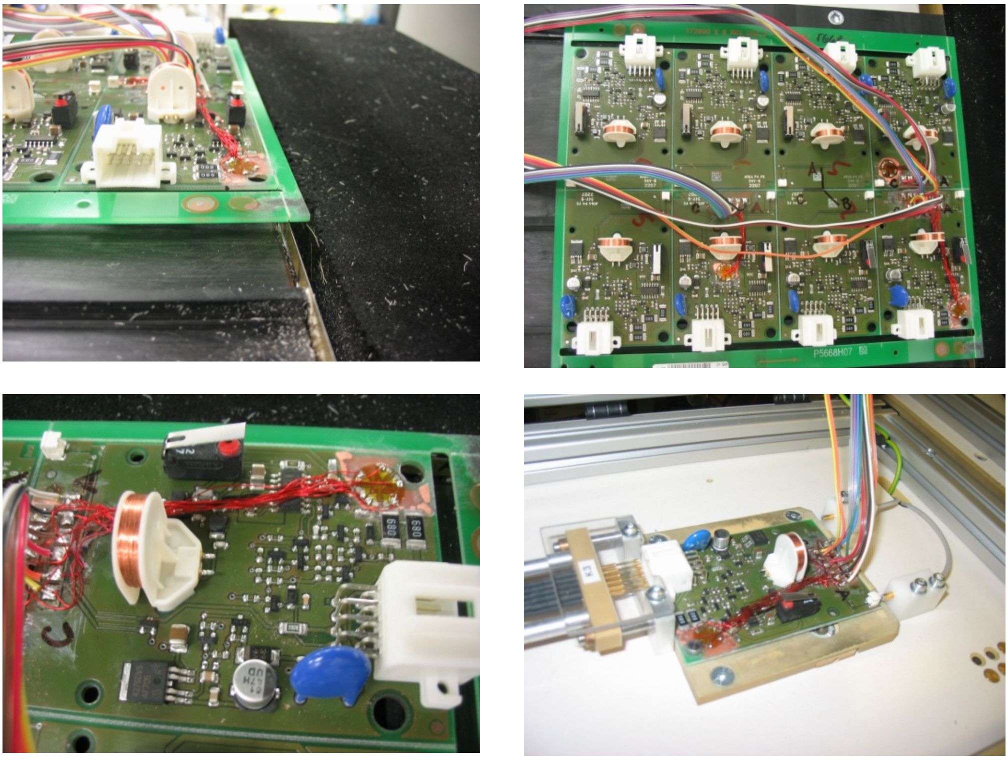

Fig. 2. PCBs with instaled strain gauges

The strain of PCBs is measured by strain gauges. When the direction of maximal strain in measuring point is known uni-axial strain gauge can be used. In other cases the strain gauge rosette should be used for maximal strain determination. The strain gauge rosettes measure strains in three directions. Individual windings are marked (a), (b) and (c) and are located in the rosette anticlockwise, with 0°, 45° and 90° angles of rotation. The rosette with 0°/60°/120° angle of measuring grid rotation can be also used.

Strains measured on individual measuring windings - $\varepsilon_a, \varepsilon_b, \varepsilon_c$ – are used to calculate principal strain as per the following relation:

$$\varepsilon_{1,2} = \frac{\varepsilon_a + \varepsilon_c}{2} \pm \frac{1}{\sqrt{2}}\sqrt{(\varepsilon_a - \varepsilon_b)^2 + (\varepsilon_b - \varepsilon_c)^2}$$

$\varepsilon_1, \varepsilon_2$ represents first and seconds principle strains and can be interpreted as maximal strains in area of rosette installation.

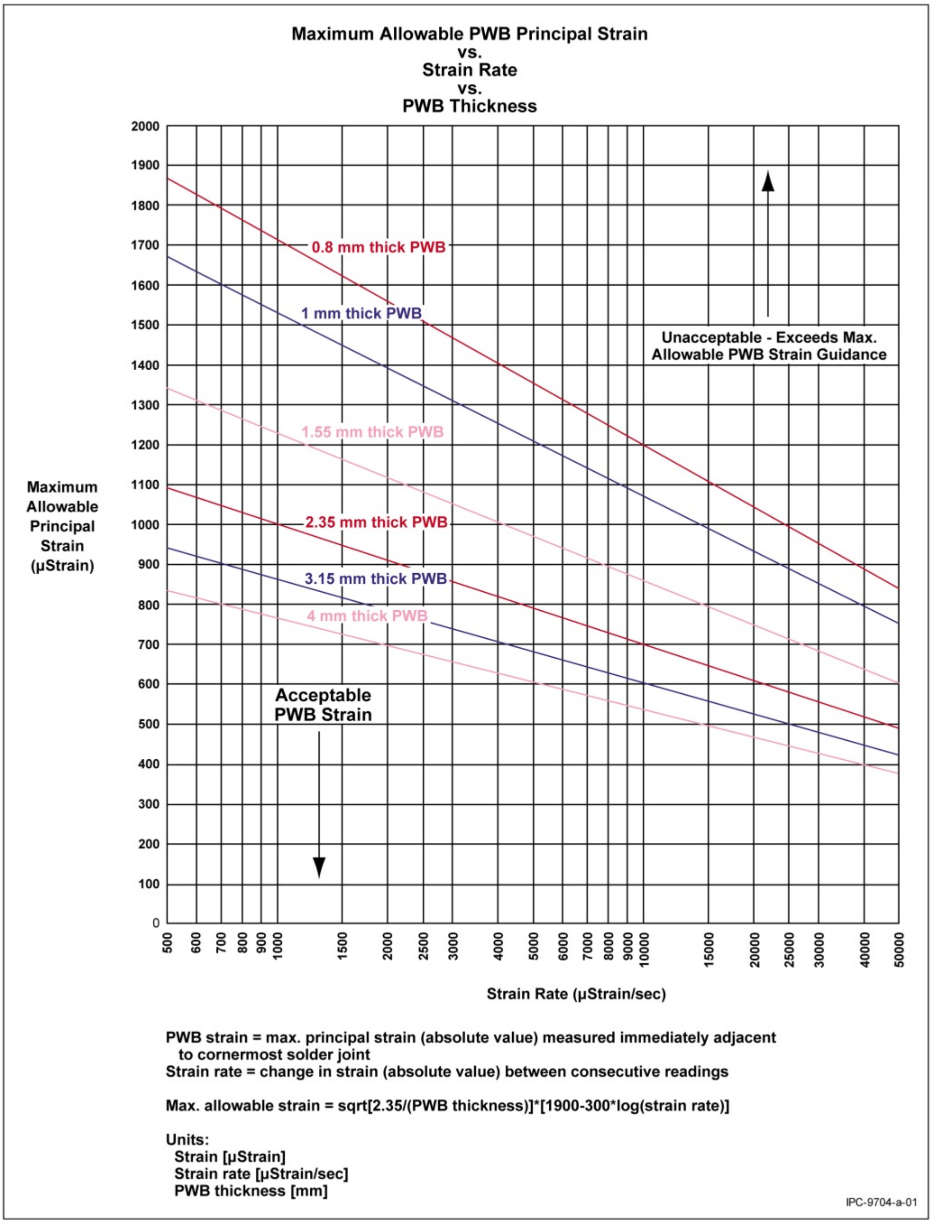

Fig. 3. Limit values in strain vs. Strain rate plot

The PCB board with strain gauges is than subjected to few tests during production process (for example pick&place operation, printing of soldering paste, depaneling, ICT testing, function tests, assembly and etc.). During those tests strain of PCB is measured. Test guideline prescribes 100 Hz of sampling frequency for strain gauge signal acquisition. This frequency is too low in comparison to speed of some production processes and can cause omission of significant high strains with effect of test failure. Experience from the practical measurement shows the necessity to use higher sampling frequency.

The evaluation of test results is performed by strain vs. strain rate plot. For measured strains or for principle strains retrieved from strain gauge rosette the strain rate $\dot{\varepsilon}$ should be calculated based on the time record according to the relation:

$$\dot{\varepsilon} = \frac{\varepsilon_{(i+1)} - \varepsilon_{(i)}}{\Delta t}$$

where $\varepsilon_{(i+1)}$, $\varepsilon_{(i)}$ are two consecutive values of strain and

Δt is a time step of the measurement

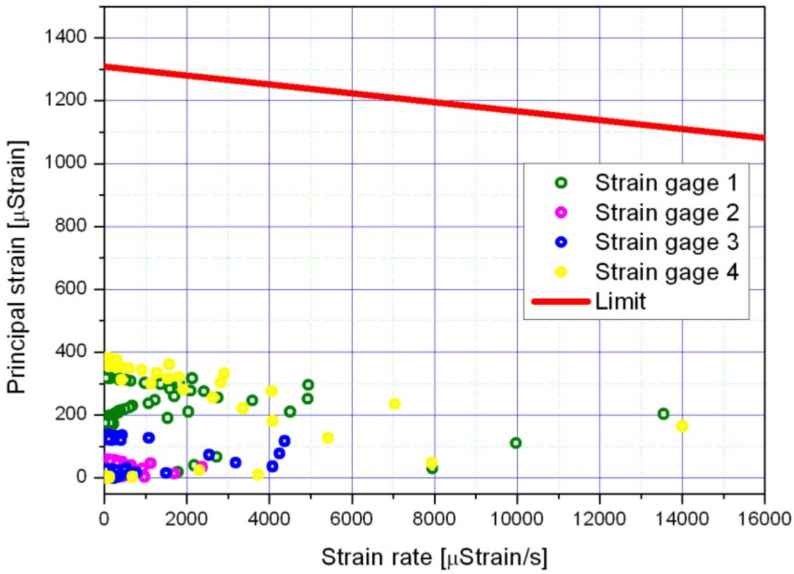

Fig. 4. Result of PCB measurement which succeeds to test

The obtained quantities will be displayed in correlation, where strain rate is an independent quantity (x axis) and calculated principal strain is a dependent quantity (y axis). The test guideline also specifies a limit value that can be reached by this dependence. The limit value is given by the relation (see reference [1] and Fig. 3 for more details):

$$\varepsilon_{aMAX} = \sqrt{\frac{2.35}{th} \cdot [1900 - 300 \cdot \log(\dot{\varepsilon})]}$$

where ε_{aMAX} is maximal allowable strain

th is a PCB thickness (1.6 mm for many cases)

$\dot{\varepsilon}$ is strain rate

Values exceeding the limit value are inadmissible and can cause damage to the board or on-board components. In such cases the production process of PCB has to be modified.

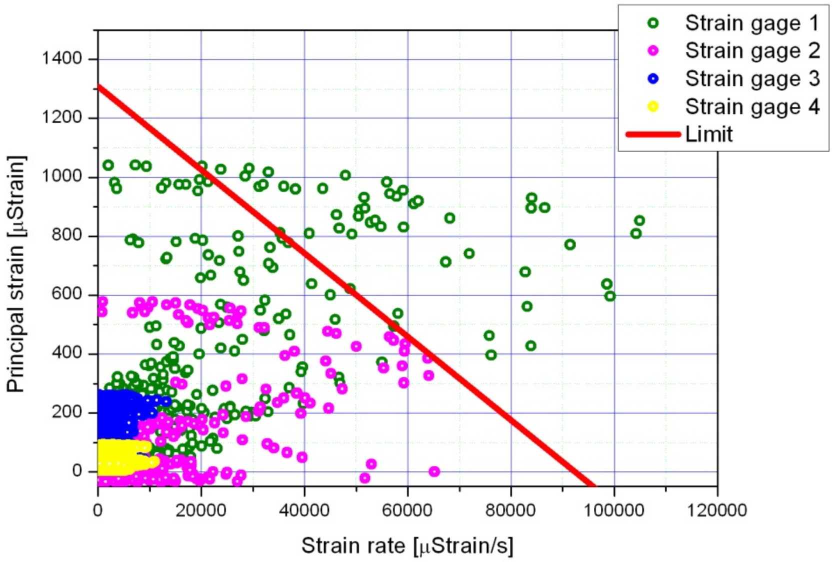

Fig. 5. Result of PCB measurement failed test

3. Conclusion

The paper showed the methodology for testing and evaluation of possible failure of printed circuit boards (PCBs) during its production process. The methodology of PCB evaluation is based on test guideline IPC/JEDEC-9704. This guideline is accepted standard for car component developer and also for car producers. The guideline defines procedures of testing and result evaluations which helps to prove quality of PCB developing process.

Authors of the paper used the methodology for many measurement for Czech and also for foreigners PCBs producers for many technological operations as depaneling, pick&place operations, ICT testing etc. The methodology is not complicated and can be easily used in practice.

Acknowledgement

The present work has been supported by European Regional Development Fund in the framework of the research project NETME Centre under the Operational Programme Research and Development for Innovation. Reg. Nr. CZ.1.05/2.1.00/01.0002, id code: ED0002/01/01, project name: NETME Centre –New Technologies for Mechanical Engineering).

References

[1] IPC/JEDEC-9704 - Printed Wiring Board Strain Gage Test Guideline