Analysis of production incompatibilities and risk level in series production of assembly elements for the automotive industry

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Abstract. The paper presents issues connected to risk analysis of production incompatibilities occurrence. Low-pressure cords thermoforming process analysis was presented, as well as analysis of types of incompatibilities during the phase of marking product (pad printing). The risk analysis is based on three factors: occurrence, detection, and severity of a specific incompatibility. 6 incompatibility types were defined and their various causes were determined. One critical incompatibility was determined, as well as 4 severe production problems. Presented analysis is an element of implementation of project of new products into the existing thermoforming processes.

1 Introduction

An important element of quality management and assessment is involving the management in the area of actions connected to detected production incompatibilities. An element of process supervision system is management involvement both during the phase of new production implementation and realisation maintenance and supervision. One of component of production preparation and supervision is production incompatibilities occurrence risk analysis. The analysis regards at first production planning, and then it is continued as supervision over production tasks fulfilment and achieved results monitoring. Utilising FMEA analyses is a system activity, the purpose of which is to ensure correct level of sureness that the product will meet assumed quality requirements [1].

One of the most important quality processes in the w automotive field companies is PPAP - Production Part Approval Process. By obtaining PPAP confirmation, the company simultaneously receives from the customer approval of competence of assembly elements provider. Processes connected to obtaining PPAP are focused on process approach, the basic element of which is focus on the customer and his expectations. PPAP requirements include the following documents: project provisions, materials composition, engineering changes documentation authorised by the customer, project FMEA, process flow chart, process FMEA, analysis of measurement systems defined by the control plan, measurement

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report, statistics control records, test results, appearance compatibility report, part samples, model sample [2, 3].

Assembly elements producer is obliged to present full PPAP documentation only if:

- a new part or product appears, which the customer has not been previously supplied with,
- inaccuracies in comparison to the previous PPAP need to be rectified,
- changes regarding materials or technical specification occurred in the area of provided product,
- changes in the product production process itself occurred – using new or modified tool or form,
- occurs a change of: supplier, control methods, production technology.

Presented actions are connected to the quality management in low-pressure cords production processes. The necessity of providing full PPAP documentation was connected to structural changes in a new model of the product. Research entity prepared full documentation and assessed risk connected to the planned production processes quality. PPAP processes are realised according to the internal guidelines of the company, ant the responsibility for specific implementation phases of PPAP requirements lies within responsibilities of the Head of the Process Engineering Department.

2 FMEA analysis – main assumptions

Presented FMEA analysis is an element of set of documentation prepared as preparation of new production on low-pressure cords production lines. According to the requirements, a basis for beginning a cooperation with a customer (automotive corporation) is ensuring proper supervision of production processes (PPAP). An important element of the documentation is risk analysis of potential production incompatibilities, which is conducted in both FMEA process analysis and FMEA product analysis.

The presented analysis of planned production processes uses basic risk factors based on severity, occurrence, and detection values. The values were evaluated on scale 1-10, according to the guidelines of an external customer [4-8]. Risk priority number in the FMEA analysis was assessed on the basis of the formula:

$$RPN = SEV \; x \; DET \; x \; OCC \tag{1}$$

where: RPN – risk priority number, SEV – severity, DET – detection, OCC – occurent.

For the needs of PPAP production parts approval process, quality tests were conducted mainly on characteristics regarded as important by the customer. Serial production implementation process analysis was conducted on the basis of low-pressure cord production. Design team is decomposing the system and preparing comparisons related to new production implementation: amounts of necessary materials, their quality, machine requirements (production devices and their wiring).

The analysis itself describes and classifies potential faults and their severity. The next phase is determining probability of fault occurrence and determining its severity for functioning of the product. the next phase is providing proper guidelines in order to decrease faults occurrence risk. Table 1 presents detailed FMEA analysis of product marking process. FMEA analyses results become a basis of creation of standard operating procedures for processes operators at specific work stations after undercure process.

Table 1. FMEA method in process of tampoprin-marking.

Requirement	Failure Mode	Failure Effect	SEV.	Potential Failure Cause	Preventive Action	OCC.	Detection Action	Control mean	DET.	RPN
Orientation of marking according to drawing tolerances	Incorrect orientation of marking	Risk of contact with adjacent elements	6	Use wrong tool (gabarit)- operator mistake	SW includes number of gabarit	*2*	Error or cause detected by the operator at the station by a visual/tactile	Visual / operator	7	84
			6	Mistake an operator (incorrect placing the part in the gabarit)	Workplace training. The construction of gabarit hindering the incorrect putting of detail visualization method of putting part in gabarit is include in SW	2	Error or cause detected by the operator after operation using attribute gauge	CSE Gauge / yhe operator of next operation	7	84
			6	Improper mounting tool (gabarit) in machine	Comparing axis marking with the index nominal on gabarit (gabarit must include an index of nominal)	3	Error or cause detected by the operator on station using attribute gauge	Assembly gabarit / operator	6	108
Positon of according to draw ng tolerances	Incorrect position of tampo (for the hose ends - the distance from the start of hose)	Leakage in the car or in the engine	8	Use wrong tool (gabarit) - operator mistake	S W includes number of gabarit	2	Error or causa detected by the operator on the position by measuring variables	Ruler / operator	5	80
			8	Incorrect setting of the trolley with the part	Adjusting the trolley with part to the correct position marking the beginning of production	2	Error or cause detected by the operator on the position by measuring variables	Rules / operator	5	80
			8	Mistake an operator (incorrect placing the part in the gabarit)	Workplace training. The construction of gabarit hindering the incorrect putting of detail. visualization method of putting part in gabarit is	2	Error or cause detected by the operator after operation using attribute gauge	CSE gauge ruler / the operator of next operation	7	112
Positon of according to *drawi*ng tolerances	Incorrect position of tampo (for marking on middle of hose)	Risk of contact with adjacent elements	6	Use wrong tool (gabarit)- operator mistake	SW includes number of gabarit	2	Error or cause detected by the operator at the station by a visual *i* tactile	Visual / operator	7	84
			6	Mistake an operator (incorrect placing the part in the gabarit)	Workplace training. The construction of gabarit hindering the incorrect putting of detail. visualization method of putting part in gabarit is	2	Error or cause detected by the operator after operation using attribute gauge	CSE gauge, ruler / the operator of next operation	7	84
Readability marking	Unreadable, incomplete marking (for standard marking)	Product incomplete	6	Badly prepared paint - the wrong proportions	Instructions for preparing the paint (the mixing operation is not less than 20 sec) The paint is prepared in a graduated burette.	3	Error or cause detected by the operator on the position by measuring variables.	Laboratory buret / warehouse operator	5	90
			5	Badly prepared paint - improperly mixed	Instructions for preparing the- paint (the mixing operation is not less than 20 sec). The paint is mixed by paint mixer.	3	Error or cause detected by the operator at the station by a visual/tactile	Visual / operator	7	105
			6	Expired paint delivered from the warehouse to the production line	Compliance with dates FIFO by a system during download component for the production, Cabinet for chemicals (access only by the leaders of change)	3	Cause detected by the automatic control of the position - nonconforming product will not be made	AS400 / automatic control	2	36
			6	The use of expired ink located in the area of the production line	All cans are labeled with an expiration date of paint	3	Error or cause detected by the operator at the station by a visual ' tactile	Visual / warehouse operator	7	126
			6	Wet/oily/dirty detail	Trolley between operation are cohered, visualization included in KWD	3	Error or cause detected by the operator at the station by a visual "tactile	Visual/ operator	7	121
			6	Improper lighting or position does not allow the operator to accurately assess the marking	Lack	5	Error or cause detected by the operator at the station by a visual/tactile	Visual/ operator	7	210

			6	The operator left paint uncovered for a long time and later used it (bad viscosity ink density)	Prohibition of the use beakers of paint	3	Error or cause detected by the operator at the station by a visual/tactile	Visual/ operator	7	126
Incorrect hose used in process	Incorrect hose used	mounting impossible	8	The operator did not check the number hose before starting work	SW includes number of detail and a photo, Additionally the operator based on a shaped part gage	2	Error or cause detected by the operator at the station by a visual/tactile	Visual/ operator	7	112
			8	Operator used wrong hose	SW includes number of detail and a photo, Additionally, the Operator based on a shaped part gage	2	Error or cause detected by the operator at the station by a visual/tactile	Visual/ operator	7	112
Marking dimension according with drawing	Wrong dimension of marking	Risk of contact with adjacent elements	6	Operator used incorrect cliche	Number cliche in specification SW /Photos or drawing printing in the specification SW / dimension marking specified in KZD	2	Error or cause detected by the operator on the position by measuring variables	Ruler/ operator	5	60

3 Conclusion

Marking process analysis determined production of the workplace. Their analysis was a basis of developing standard operating procedure of the process and guidelines of visual control conducted by the operator. The most important incompatibility type is illegibility of the printing pad, which results from few possible errors. Analysis of causes determined as many as 6 sources, half of which surpassed RPN value over 100 pts. A vital issue in this area is employee training on proper workplace preparation and following standard operating procedure.

The problem is illegible printing pad, which causes the product to be incomplete. There may be the following causes: incorrectly prepared ink, expired ink, damaged detail, incorrect lighting, using ink without cover, using incompatible cord, using incorrect film. In all of these cases apart from the incorrect film usage, RPN is higher than 100, which proves these are actual problems that can occur during production.

Described 6 production incompatibilities of marking process have been included in the Standard Operating Procedure (SW) and guidelines of workplace control.

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