DOI: 10.2478/ata-2013-0012

Acta technologica agriculturae 2
Nitra, Slovaca Universitas Agriculturae Nitriae, 2013, p. 47–50

IMPROVEMENT OF MANUFACTURING PROCESS QUALITY ACCORDING TO FINAL INSPECTION RESULTS

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Final inspection represents the last inspection operation of production line before the product reaches a customer. If non-conformities are not detected within the production process, final inspection has to ensure their detection. This contribution focuses on the final inspection results of the manufacturing process of automobile's front seats. The outputs of final inspection are prepared by means of quality management tools (Pareto analysis). Inspection items, their changes, remedies and precautions leading to seat quality improvement are defined. The evaluation of final inspection for the following period confirms the improvement of the manufacturing process or control quality for selected inspection items.

Keywords: quality, final inspection, quality management tools, Pareto, automobile seat

Final inspection is the inspection of attributes of a final product (functional, dimensional), with the number of inspected items being higher than at self-inspection. Each workplace of final inspection has to be approved by a quality manager and substantiated with documents for approving the obligatory items for final inspection. Inspection items are updated according to the number of non-conformities, and work description is defined (what items, how they should be inspected, in what frequency, how to detect non-conformity and how to proceed in such a case). Standardised work at final inspection is tested by audits in selected time intervals. This contribution deals with the data collection of non-conformities at final inspection, data processing and evaluation of the quality of front seats by Pareto analysis. Critical non-conformities are determined and remedies and precautions are proposed to improve the quality for the next period.

Material and methods

More than 1,000 parts enter into the manufacturing process of front seats. The main inputs are foams, metal frames, covers, head rests, back rests and plastic parts (Fig. 1).

One of the basic quality management tools used on the production line is a Poka Yoke system, i.e. a 100 % quality control. For safety regulations, legal requirements or product characteristics that affect assembly, Poka Yoke is defined in FMEA and control plans (Andrássyová, 2011). Other important approach to quality control within the production process is self-inspection done by operators.

Data collection

Data of non-conformities are collected at the end of the production line (Tab. 1), according to records on final inspection and inspected items for six months (from July to December 2011). Remedies and precautions are applied after a half-year evaluation in case of critical non-conformities. Data collection is repeated in the following period of time (from January to June 2012).

Data are analysed by Pareto analysis and graphically depicted in a Pareto chart. Absolute and relative frequencies (depicted in a histogram) as well as cumulative absolute and cumulative relative frequencies (depicted in diagram by the curve of cumulative relative frequency) are calculated.

Results and discussion

Pareto analysis from 2011 (Tab. 2) showed the highest frequencies of non-conformities of front seats from final inspection.

Recorded and calculated frequencies were plotted into the histogram and curve of cumulative relative frequency (Fig. 2). The most critical non-conformity (with the highest frequency) was dirty or oily cover, plastic part, metal, head

Figure 1 Front automobile seat

Table 1 Collected data of final inspection in the second half of year 2011 and in the first half of year 2012

Non-conformity		Frequency in individual months											
		2011						2012					
	July	August	September	October	November	December	January	February	March	April	May	June
Dirty or oily cover, plastic part, metal, head rest	60	104	91	125	70	38	25	56	79	78	65	35
Crimp of rest part	40	87	82	101	73	36	39	61	66	44	30	31
Crimp of upper rest part cover from side	27	48	43	79	60	26	7	31	30	42	61	31
Crimp of rest part cover in front	22	35	35	79	70	13	33	21	21	33	36	27
Opening between drawer and side piece of seat	26	40	21	42	39	21	14	18	34	21	12	12
Fitting of drawer and seat	5	14	8	39	27	5	7	7	8	5	4	4
Damaged cover – rest part, seat, head rest	7	20	10	17	12	3	5	5	0	1	3	5
Function of rest part button	16	27	26	17	4	0	4	0	4	4	3	1
Cover pulled out of drawer	1	7	4	21	13	5	0	0	8	3	4	1
Crimp of head rest with LCD monitor	0	1	0	0	8	0	1	1	0	1	0	0
Head rest does not move into lower position without pressed button	4	1	0	0	0	0	0	0	0	0	0	0
Number of inspected seats	**3,791**	**6,503**	**6,479**	**6,509**	**6,629**	**3,038**	**2,973**	**6,434**	**7,670**	**6,647**	**7,697**	**7,419**

rest (24.93 %), the second one was crimp of a rest part (21.48 %), then crimp of an upper rest part cover from the side (14.49 %), crimp of a rest part cover in the front (13.03 %), and opening between a drawer and side piece of the seat (9.64 %). They generated 83.58 % of the percentage of non-conformities detected in final inspection.

Remedies and precautions were applied to the production line of front seats to reduce or completely eliminate the non-conformities (Tab. 3).

The application of remedies and precautions to the manufacturing process brought new results of non-conformity frequencies from final inspection. The following half-year period of 2012 was evaluated by Pareto analysis (Tab. 4).

The most critical non-conformities of the first half-year of 2012 were dirty or oily cover, plastic part, metal, head rest (28.63 %); crimp of a rest part (23.02 %), crimp of an upper rest part cover from the side (17.07 %), crimp of a rest part cover in the front (14.43 %). Those four non-conformities generated 83.15 % of the total percentage of non-conformities. The non-conformity head rest does not move into a lower position without pressed button was completely eliminated.

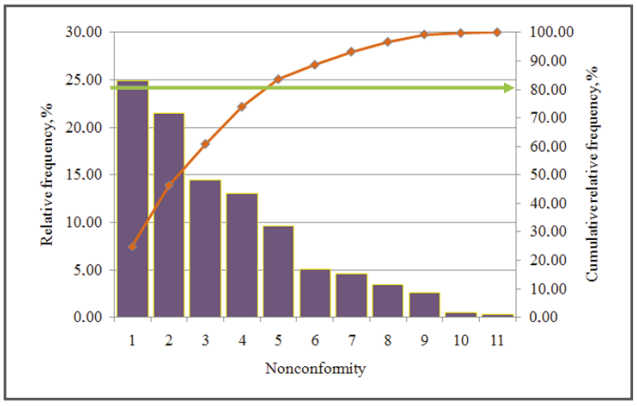

Figure 2 Pareto chart of non-conformities of seats in the second half-year of 2011

The total quotient of non-conformities during the period from July until December 2011 was $p_N = 0.059$, and in the following period from January until June, it was reduced to $p_N = 0.03$. Non-conformities in the first half-year of 2012 were reduced by 49 %.

Defined tools instruct to a double inspection (quality wall) in case of frequent non-conformities in organisation

Table 2 Pareto analysis of non-conformities from the final inspection in the second half-year of 2011

No	Non-conformity	Absolute frequency, n_i	Cumulative absolute frequency, Σn_i	Relative frequency, %	Cumulative relative frequency, Σ%
1	Dirty or oily cover, plastic part, metal, head rest	488	488	24.93	24.93
2	Crimp of rest part	420	907	21.48	46.41
3	Crimp of upper rest part cover from side	283	1,191	14.49	60.90
4	Crimp of rest part cover in front	255	1,446	13.03	73.94
5	Opening between drawer and side piece of seat	189	1,634	9.64	83.58
6	Fitting of drawer and seat	99	1,733	5.05	88.63
7	Function of rest part button	90	1,823	4.59	93.22
8	Damaged cover – rest part, seat, head rest	68	1,890	3.46	96.68
9	Cover pulled out of drawer	51	1,941	2.59	99.27
10	Crimp of head rest with LCD monitor	9	1,950	0.47	99.73
11	Head rest does not move into lower position without pressed button	5	1,955	0.27	100

Table 3 Remedies and precautions used in organisation

Defined non-conformity	Remedies	Precautions
Dirty or oily cover, plastic part, metal, head rest	– definition of part where the non-conformity occurs – definition of non-conformity location on seat – definition of variant (leather, leatherette, fabric, etc.) – definition of dirt type (lubrication, oil, etc.) – modification of usage of working equipment	– modification of usage of working equipment – changes in manipulation with parts – changes in lubrication procedure of parts – changes in packaging of parts
Crimp of cover	– definition of variant (leather, leatherette, fabric, etc.) – definition of non-conformity location on seat – checking the working procedure of ironing	– modification of ironing procedure – change in upholstering procedure – modification of cutting
Opening	– definition of variant (leather, leatherette, fabric, etc.) – definition of non-conformity location on seat and its size	– modification of fixture for fixing the seat – changes in assembly procedure of drawer and seat

Table 4 Pareto analysis of non-conformities from the final inspection of the first half-year of 2012

No	Non-conformity	Absolute frequency, n_i	Cumulative absolute frequency, Σn_i	Relative frequency, %	Cumulative relative frequency, Σ%
1	Dirty or oily cover, plastic part, metal, head rest	338	338	28.63	28.63
2	Crimp of rest part	272	610	23.02	51.65
3	Crimp of upper rest part cover from side	202	811	17.07	68.72
4	Crimp of rest part cover in front	170	982	14.43	83.15
5	Opening between drawer and side piece of seat	111	1,092	9.36	92.51
6	Fitting of drawer and seat	34	1,126	2.86	95.37
7	Damaged cover – rest part, seat, head rest	20	1,145	1.65	97.03
8	Function of rest part button	16	1,161	1.32	98.35
9	Cover pulled out of drawer	16	1,177	1.32	99.7
10	Crimp of head rest with LCD monitor	4	1,180	0.33	100

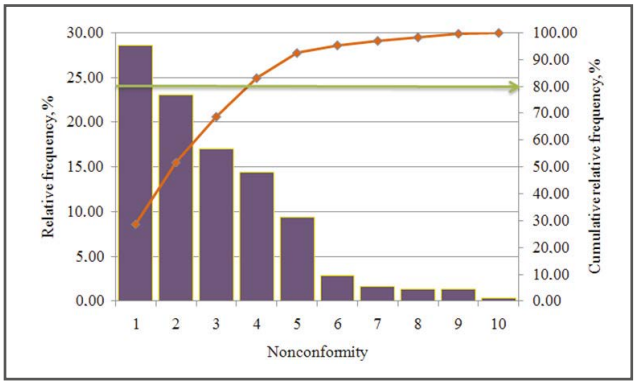

Figure 3 Pareto chart of non-conformities of seats in the first half year of 2012

(Tools, 2011). Responsible operator inspects the defined quality characteristics that are not detectable within self-inspection or final inspection. If the operator detects any non-conformity, there should be an immediate feedback into a responsible workplace of the manufacturing process. Remedies for the prevention of the same non-conformity (description is coincident) are applied immediately.

The Pareto chart is an analytical tool which takes into consideration defined criterions and enables defining the most important problems in such methods as FMEA and FMECA (Bujna, 2012) – those ones that need a lot of attention. The usage of this quality management tool is connected with other tools for determining the causes and effects, i.e. Ishikawa diagram or brainstorming that enables revealing many different ideas of studied issues (Prístavka, 2011) and giving a better view of problems.

Conclusion

Final inspection is one of the most important quality inspections of automobile seats. It is the last workplace where the non-conformity could be detected before it reaches the customer. Therefore, it is important to record, analyse and evaluate the results of final inspection. A decisive standpoint has to be adopted for remedy. Remedies are applied depending on an exact specification of the non-conformity. The most critical non-conformities can be listed by Pareto analysis (according to the rule of 80 % / 20 %). Quality management procedures and tools such as brainstorming, Ishikawa diagram, 5 Whys should be recommended for a more detailed analysis of non-conformities. More complicated problems require tools and procedures such as 8D report, affinity diagram, relative diagram, etc. Each selected tool or procedure has to be effective for analysis.

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