MANAGEMENT OF NONCONFORMITIES IN THE INDUSTRIAL FIELD

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REZUMAT: The work is based on a study that quantifies the costs of a production batch of a gas safety valve product. It will be studied if it is worth putting a quality loop in order to make the product. The control of non-conforming safety valve products is an important process to ensure the reliable and normal operation of safety valves. Safety valves are used to protect systems and equipment from overpressure or other hazardous conditions, so it is important to ensure that they are operating properly within specifications. The main non-conformities are analyzed with the help of a quality inspection method, which appear after the FMEA in order to establish improvement methods for them. The marketing part of the product will also be created to emphasize the important features of the safety valve.

KEYWORDS: nonconformity, AMDEC, crack, improvement, inspection

1. Introduction

The paper focuses on the management of nonconformities in industrial engineering. Using the AMDEC method, the main benchmark with the highest score that could cause the failure of the Gas safety valve product is studied. The costs will be established if a 100% compliant inspection process is carried out on the landmark and if a non-compliance is determined, and the costs of repairs. The SR ISO/TR 10014:2015 Guidelines for the management of the economic aspects of quality will be used for the evaluation. Improvement methods will be established on the benchmark to prevent future non-conformities.

2. Case Study

The gas safety valve is a product that is designed to automatically open and release gas in a controlled manner if the pressure in the gas system exceeds a certain limit. The landmarks that make up the overall assembly are made of different steels. As the main part that makes up the general assembly Body gas safety valve is made of brass, it may be subject to non-conformities that would make it difficult for the product to function in the operating environment. The objectives of the work are to establish a global cost of evaluating a quality block (a quality control on the flow) and if a nonconformity occurs, the repair cost for it.

3. AMDEC analysis

Failure Modes and Effects Analysis (AMDF or FMEA) is a systematic method of analyzing the ways in which a product or system can fail, identifying their causes and effects. This method is mainly applied in industrial and manufacturing fields, but can be used in a variety of other fields.

AMDEC analysis is an inductive method that allows a qualitative analysis of the reliability or operational safety of a system, from a lower functional level to the highest level of the system.

In order to analyze AMDEC, the product "Gas safety valve" presented in figure 1 will be considered.

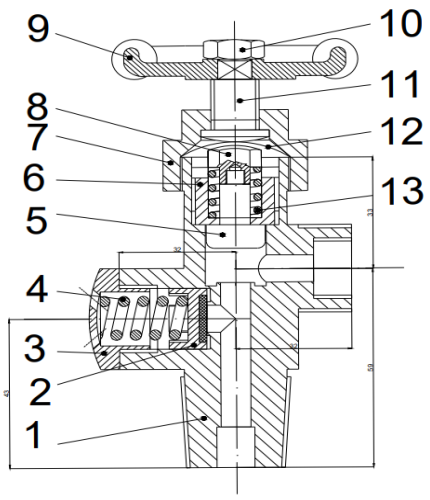

Fig. 1. Gas Safety Valve product for AMDEC analysis

The improvement of the product's performance is based on a detailed design analysis, which aims to identify all non-conformities and take improvement measures, where the situation requires it. In order to improve the product, a research topic will be drawn up.

In what follows, I will analyze from the point of view of failure modes using the AMDEC method, the criticality of each milestone to determine which of them affect the functionality of the product. I use this method to prevent and fix future non-conformances that may occur in the benchmark with the highest score.

Following the AMDEC analysis studied in the table below, we can see that the highest value of the risk coefficient is represented by the gas safety valve body and cover 1. These are the main points that can cause the malfunction of the general gas safety valve assembly.

In the following, the main non-conformities that may appear in the main points of the general assembly and may cause its non-functionality are presented.

The landmark "Gas safety valve body" is a part obtained by the technological casting process. The finished semi-finished part is obtained through mechanical processing: milling, turning, drilling and reaming.

The following table shows the main types of non-conformities according to the technology of obtaining the finished semi-finished product.

To control nonconforming products, organizations must develop and evaluate nonconforming products - after nonconforming products have been identified, organizations must evaluate them to determine the degree of nonconformity and the impact on implement quality control procedures that include the following steps :

- Identification of non-conforming products - it is important that organizations can quickly and accurately identify products or services that do not meet quality standards or specific customer requirements.

- Taking corrective action - organizations must take corrective action to remedy the non-conformity and prevent similar issues from occurring in the future. These measures may include repairs, replacement of non-conforming products or services, or modification of production processes to avoid future errors.

- Verifying the effectiveness of corrective actions - after corrective actions have been taken, organizations must verify that they have been effective in eliminating the problem and preventing its recurrence.

Table 1. Nonconformities according to the technology of obtaining the semi-finished product

Process name	Name non-conformity	Cause of non-conformity
Casting	Cracks	The melting temperature of the material
	Goals	Insufficient amount of material
	Sulfide	The presence of air or gases in the cast material
	Incomplete form filling	The melting temperature of the material Mold design
Mechanical processing	Dimensional and shape deviations	Non-compliance with work technology
	Surface appearance	Incomplete documentation
	Material scratch	Wrong part grip

Table 2. Selective AMDEC analysis

ANALYSIS OF FAILURE MODES FOR THE "SAFETY VALVE" PRODUCT							
Landmark name	Function accomplished	Failure mode	The causes of the defect	The probability of failure	The criticality of the defect	The difficulty of detecting the defect	Risk coefficient
				A	B	C	R=A·B·C
Safety valve body	Role of protection and assembly of landmarks as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	5	5	100
Chair	Spring support roll Ø12;	Deformation;	Wrong assembly as a whole;	2	3	2	12
Threaded Cap 1	Assembly role of milestones as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	4	5	80
Helical Spring Ø12	Damping of shocks and vibrations;	Deformation;	Strong vibrations; Strong shocks;	2	2	2	8
Pushing	Fixing role of landmarks 6 and 8;	Deformation;	Wrong assembly as a whole;	2	3	4	24
Threaded bushing	Assembly role of milestones as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	3	3	36
Threaded Cap 2	Assembly role of milestones as a whole;	Deformation; Threaded area wear;	Casting technology; Wrong assembly as a whole;	4	5	3	60

4. Quantifying the costs of quality assessment

To quantify the quality costs, three scenarios will be evaluated for which it will be determined whether introducing a quality loop would optimize the quality costs or not. This loop has a cost to the product but can determine and prevent non-conformities that can be repaired. The non-conformity is considered to be cracks detected by the non-destructive inspection method with penetrant liquids, which can be repaired. These products will have different labels printed on them to identify whether or not the product has been inspected.

In the following, the aspects of calculating quality costs are presented.

The following table shows the variables for the quality loop calculation process represented by quality control.

Table 3. Process variables (estimated values)

Process variables (estimated values)	100% inspection and repair scenario			Scenario without quality cost		
	1	2	3	1	2	3
N_p	2400	2500	2500	2400	2500	2500
P_d	2%	2%	1%	2%	2%	1%
C_i	0,1	0,2	0,2	0	0	0
C_e	-	-	-	960	1000	500
C_r	2	2	2	-	-	-
C_o	15	15	15	-	-	-
R	80%	80%	80%	-	-	-
C_s	-2	-2	-2	-	-	-

Where,

C_e= represents the cost of failure

N_p= number of units manufactured in the process

C_n=unit cost of moving defective units to the next process

P_d=proportion of defective units after the process

C_i = cost of inspection and control

C_r=unit cost of repair

C_o=unit cost of not delivering units

R=proportion of repairable defective units

C_s=unit cost of waste

In order to achieve the quality costs with 100% inspection and repair, the following calculation formulas present in the following table will be used.

Table 4. Calculation formulas for establishing quality costs

Nr. Crt	Name cost	Calculation formula
1	The cost of inspecting the number of units manufactured in the process C_{np}	$C_{np} = N_p \cdot C_i$ (1)
2	Number of defective units (after manufacture) N_{df}	$N_{df} = N_d \cdot P_d$ (2)
3	Number of repairable units (defects) N_r	$N_r = N_{df} \cdot R$ (3)
4	Repair cost (of repairable defective units) C_{re}	$C_{re} = N_r \cdot C_r$ (4)
5	The number of unrepairable units N_n	$N_n = N_{df} \cdot (1 - R)$ (5)
6	Cost of delivery of defective units C_{nu}	$C_{nu} = N_n \cdot C_o$ (6)
8	Waste cost for unrepairable units C_{dn}	$C_{dn} = N_n \cdot C_s$ (7)
9	Internal failure E_i	$E_i = C_{re} + C_{nu} + C_{dn}$ (8)

The results of the calculations are presented in the following table where the quality costs are determined.

Table 4. Quality costs

Costs	100% inspection and repair scenario			Scenario without quality cost		
	1	2	3	1	2	3
The cost of inspecting the number of units manufactured in the process C_{np}	240	500	500	-	-	-
Prevention costs	-	-	-	0	0	250
Number of defective units (after manufacture) N_{df}	48	50	25	-	-	-
Number of repairable units (defects) N_r	38	40	20	-	-	-
Repair cost (of repairable defective units) C_{re}	76.8	80.0	40.0	-	-	-

The number of unrepairable units N_n	10	10	5	-	-	-
Cost of delivery of defective units C_{nu}	144	150	75	-	-	-
Waste cost for unrepairable units C_{dn}	-19	-20	-10	-	-	-
Cost of delivery of defective units C_{nu}	240	500	500	-	-	-
Internal failure E_i	202	210	105	0	0	0
External failure E_e	0	0	0	960	1000	500
Total cost of quality	**442**	**710**	**605**	**960**	**1000**	**750**
Total quality/unit cost	0.18	0.28	0.24	0,4	0,4	0,3
Proportion of defective units (after quality control) sent to waste	0.4%	0.4%	0.2%	2%	1%	1%

After the analysis carried out in the three scenarios for the two situations, the following important aspects on the cost of quality were concluded:

1. If there is no quality control loop on the manufacturing flow to detect possible non-conformities in the product, it is considered that it is sent to the customer without the product undergoing changes to the quality cost. Two scenarios can be determined in this situation.

i. a first scenario is when the product is sent to the customer and it performs its functional role in the operating environment without the appearance of a non-conformity in the product. In this case it is considered that no quality control loop is performed, the quality cost being very low and the profit per product being maximum.

ii. a second scenario is when the manufacturer cannot do anything to improve the situation and the customer reacts against the manufacturer.

2. If a quality control loop appears on the product manufacturing flow to detect nonconformities that could disrupt functionality in its operating environment, the cost of quality would increase and the rate of occurrence of nonconformities would decrease. In this scenario, it is considered that the product sent to the customer is according to the specifications and it performs its functional role. It can be considered that the product has a non-conformity (the rate of non-conformities in this situation being very low) that would negatively influence the functional role of the product, the customer returns to the manufacturer and the cost of the repair varies depending on the non-conformity. The total cost of quality increases and the profit per product would decrease drastically.

5. Conclusions

Following the analysis for whether or not to introduce a quality loop on the manufacturing flow, some important aspects are concluded.

1. We have managed to establish any occurrence on the manufacturing flow of the product that appears in the quality loop. We optimized the quality calculation and reduced the number of non-conformities that can appear in the benchmark.

2. The AMDEC analysis carried out for the Gas Safety Valve product prevents future scenarios in which various non-conformities may appear in the benchmark with the highest criticality according to table 2, but not only that, it also establishes the main non-conformities that appear as a result of the way the product was obtained.

3. A product that has an inspection during the manufacturing flow may be cheaper than a product that does not benefit from such an inspection. This is because inspection during manufacturing helps to identify problems and errors earlier in the production process. By identifying and correcting problems in the early stages, the high costs of recalls or subsequent repairs are avoided.

4. By improving manufacturing processes through periodic inspections, the number of defects can also be reduced, which can reduce overall production costs.

5. Inspection during the manufacturing flow can help improve product quality and reduce overall manufacturing costs, although specific costs may vary depending on the manufacturing process and final product.

6. Bibliography

[1]. SR EN ISO 9001:2015 Quality management system. Requirements.

[2]. SR ISO/TR 10014:2015 Guidelines for the management of economic aspects of quality