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PRIORITIZATION OF PRODUCT REQUIREMENTS TO DESIGN FOR A POKA-YOKE ASSEMBLY-DFPYA

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ABSTRACT

During design process, in the clarification of the task stage, designers elaborate the product requirements list to establish the specification that product being developed must to comply with; even the ideal condition is to satisfy all requirements it is not always possible. The systematic design process approach by Pahl and Beitz recommend a qualitative method to classify design requirements in demands and wishes in order to define a priority; demands have more priority than wishes then designers know that product must to comply at less with demands and if it is possible they will try to satisfy wishes. DFPYA approach is a guide that propose a seventeen poka-yoke design requirements that must be considered by designers since clarification of the task stage, in this work is proposed a quantitative method to define the priority of the poka-yoke assembly design requirements-Rx, this method consists in calculate a weight to each Rx based on these criteria i) severity and frequency of assembly issues associated to Rx and ii) impact of Ax in the system phase where issue can occur. A case study is presented using the Access 2002 software to program the DFPYA approach.

Keywords: design for X, poka-yoke, assembly, design process, design requirements list

1 INTRODUCTION

In previous works was proposed a new DFX approach titled Design For Poka-Yoke Assembly-DFPYA [1], [2], [3]; this approach is based on the poka-yoke or error proofing technique developed by Shigueo Shingo that has been successfully used to reach zero defects on many companies [4], this technique help to prevent the occurrence or detect on time defective parts during manufacturing or assembly processes; these improvements are possible by means of product or process design changes [5].

Even poka-yoke redesigns can be considered as efficient way to eliminate quality defects it can be more efficient if instead of redesign product, after experience product rejections or customer complaints, it is evaluated since early design stages the potential defects, failure, rejections, complaints etc., that can occur in the product been developed in order to aid designers to anticipate to these issues and make appropriate poka-yoke decisions oriented to prevent them; the purpose of DFPYA approach is to prevent quality assembly issues referenced as A_x since early design stages.

In recent work about DFPYA [3] was proposed an approach to identify since clarification of the task stage the poka-yoke assembly design requirements that have to be used to prevent the quality assembly issues-A_x; these DFPYA requirements complement the product design specifications list that is commonly elaborated by designers during clarification of the task phase. See figure 1.

The purpose of this work is to define a method to calculate the priority of poka-yoke assembly design requirements referenced as R_x to help designers to decide which R_x has more impact in the product in order to justify spending more resources in develop a product oriented to comply with a specific requirement. A case study is presented in section 4 to show how this method can be used.

2 DESIGN FOR POKA-YOKE ASSEMBLY

Design For Poka-Yoke Assembly-DFPYA proposes an approach to identify potential quality assembly issues-A_x since clarifying the task stage and also it establishes poka-yoke assembly design requirements-R_x that guide designers to think in poka-yoke solutions to orient product design to prevent specific potential quality assembly issues that can be experienced in the overall life phases of a system [1], [2].

DFPYA approach consists in guide designers to identify the potential quality assembly issues-A_x that can occur during the life phases of a system-S_x, then for each assembly issue identified as potential it is proposed a poka-yoke assembly design requirement from a list of seventeen-R_x that indicates how a specific type of design decision-T_x during process design stages-D_x can be oriented to prevent the potential A_x by complying with the proposed R_x. See figure 1.

Description of poke-yoke assembly design requirements-R_x cluster	
PRODUCT ARCHITECTURE DEFINITION *Define modular product oriented to be safety and easy assemble and disassemble product to:* **R1.** Inspect and test product during assembly operations. **R2.** Change product configuration and give maintenance to product. **R3.** Remove modules for recycling or further use.	**TYPE OF MATERIAL SELECTION** *Select parts material properties oriented to:* **R4.** Resistance to assembly devices. **R5.** Be flexible to easily insert parts by hand.
PART FEATURES DESIGN *Design features in parts oriented to:* **R7.** Just correct assembly is possible due to matting faces design. **R8.** Be used by poka-yoke detection devices. **R10.** Do not look symmetrical when they are not. **R11.** Bring stability to part face in contact with assembly device. **R17.** Integrate alignment specification into dimensions of parts.	**FASTENING METHOD SELECTION** *Design parts oriented to:* Comply with: R1, R2 and R3. **R6.** Integrate small parts in bigger parts to reduce quantity. **R9.** Use appropriate fastening methods to reduce effort for manual assembly.
TOLERANCE ALLOCATION *Allocate tolerance in parts considering the following:* **R14.** Not excessive effort to manual parts insertion. **R15.** Comply to alignment specifications. **R16.** Variations of materials during life cycle stages.	**ASSEMBLY SEQUENCE** *Design assembly sequence in order to:* **R12.** Assemble small parts after free access are enclosed. **R13.** Assemble a part after assure that other assemble operations will not damage it.

Ax	Quality assembly Issues description: Ax cluster
A1	Product damaged
A2	Difficult to alignment parts
A3	Instability in dynamic parts
A4	Incorrect position of parts
A5	Wrong part assembled
A6	Omission of parts during assembly
A7	Parts trapped inside product
A8	Ergonomic issues to assemble parts
A9	Improper fasten of parts
A10	Difficult inspection and test activities
A11	Wrong installation of parts
A12	Damages of part during installation
A13	Operation assembly failures
A14	Difficult assembly for maintenance
A15	Assembly configuration issues
A16	Difficult disassemble for recycling-further use

Tx	Type of design decisions-Tx cluster
T1	Product architecture
T2	Type of material selection
T3	Part features design
T4	Fastening method selection
T5	Tolerance allocation
T6	Assembly sequence definition

Sx	System phases-Sx cluster
S1	System production
S2	System installation
S3	System operation
S4	System replacement

Dx	Design phases-Dx cluster
D1	Conceptual Design
D2	Embodiment Design
D3	Details Design

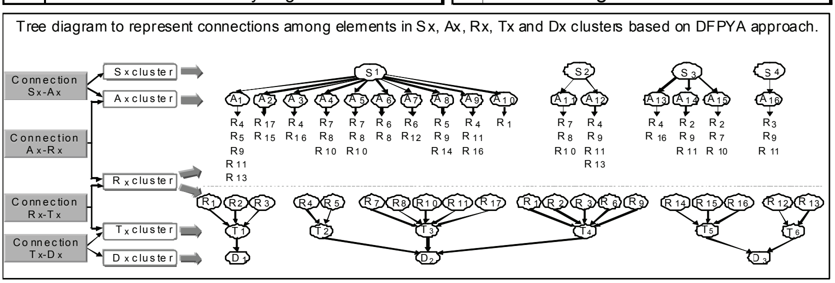


Figure 1. Summarize of connections among DFPYA clusters R_x, A_x, T_x, S_x and D_X. Source [3]

The DFPYA approach establishes a guide matrix that summarizes all connections among elements of S_x, A_x, R_x, T_x and D_x clusters [3]. The description of elements for each cluster is defined in figure 1. Based on [3] the general steps that have to execute designers to apply this approach are:

i) Identification of potential assembly issues since clarification of the task stage; these issues are the elements of cluster A_x and designers identify these issues by asking seven questions such as: Q_1: Is the product planned to have parts to be assembled manually? or Q_6: Is the product planned to have parts or modules to change configuration? Then if answer is yes specific quality assembly issues and poka-yoke assembly design requirements are linked to each question. (see figures 5 and 6).

ii) Review the DFPYA guide matrix of clusters and cancel the columns of poka-yoke assembly design requirements that are not applicable to product being developed.

iii) Designers use during design process the guide matrix (see figure 2 and 7), in order to keep the poka-yoke assembly design requirements that have to comply with during each stage of design process; for example in the matrix from figure 2 the D_x-T_x section indicates that D_1 is connected to T_1 because there is a "1" in that cell, it means the during conceptual design stage (D_1) designers used to make the decision about product architecture definition (T_1); in the R_x-T_x section there is a connection among R_1 and T_1 it means that designers must pay attention when deciding the product architecture of the product to comply with the requirement R_1 that state: define modular product oriented to be safety and easy assemble and disassemble product in order to inspect and test product during assembly operations. In section R_x-A_x indicates which Rx apply to prevent a specific Ax based on predetermined connections developed in Estrada et al., 2009. In S_x-A_x section of the DFPYA guide matrix (figure 2 and 7) it is described the system phase where is potential to occur the quality assembly issue; for example A_{10} is potential to occur during system production phase S_1.

D_1	D_2	D_3	Dx \ Rx / Tx	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}	R_{16}	R_{17}
1	0	0	T_1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	T_2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	T_3	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	1
0	1	0	T_4	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
0	0	1	T_5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
0	0	1	T_6	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

S_1	S_2	S_3	S_4	Sx \ Rx / Ax	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}	R_{16}	R_{17}
1	1	1	1	A_1	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0
1	0	0	0	A_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1	1	1	1	A_3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
1	1	1	1	A_4	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
1	1	1	1	A_5	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
1	1	1	1	A_6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
1	1	1	1	A_7	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
1	0	0	0	A_8	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0
1	1	1	1	A_9	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0
1	0	0	0	A_{10}	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	A_{11}	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
0	1	1	1	A_{12}	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0
0	0	1	1	A_{13}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
0	0	1	1	A_{14}	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0	0	1	1	A_{15}	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
0	0	0	1	A_{16}	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Figure 2. DFPYA guide matrix to represent connections among elements in R_x, A_x, S_x and T_x clusters

The purpose of this work is to add in the DFPYA guide matrix, specific weights for each R_x based on the weight of connected A_x in order to help designers to decide which poka-yoke assembly design requirements are more important; it is not always possible for designers to comply with all requirements for this reason Pahl and Beitz [6] propose a qualitative way to separate requirements in demands and wishes to give priority to comply with demands and if after comply with demands designers have opportunity and resources they must comply with wishes. The prioritization of product requirements approach is a quantitative method that calculates the A_x weights (see section 3.1.1) and based on these weights is calculated the R_x weights (see 3.1.2 section) these weights help designers to decide which requirements are more important to comply with; some times results impossible to comply with all requirements and designers must decide to solve issues linked to requirements with low priorities in later stages probably by implementing an action in the assembly process; for example if designers are developing a refrigerator design it can be found that there is a customer expectation in the system replacement phase by asking Q_7: is the product planned to have modules or components that have to be disassembled for disposal? If answer is yes then designers must orient product to eliminate the A_{16} issue and there are three requirements that are oriented to eliminate that issue R_3, R_9 and R_{11}; if designers observe that A_{16} and R_3, R_9 and R_{11} have low weights and designers does not have time to comply with these requirements in the product they can decide to implement a different strategy not associated with product features probably by adding a tool or clarifying in the user instructive a detailed method to disassemble the modules in a easy and safety way.
DFPYA approach tries to prevent the quality assembly issues in a way that is considered the most efficient method to prevent them because product is designed with poka-yoke or error-proofing features, but when designers consider that there is not time or there is a conflict with the compliance of two or more requirements they can decide to prevent those issues also in a poka-yoke way but not in the product design, they can do it when designing the assembly process; the prioritization method proposed in this work indicates which requirements have more priority to be complied when designing the product.

3 APPROACH

The purpose of this work is to develop a systematic approach to determine which poka-yoke assembly design requirements are more important from the list of seventeen R_x, this evaluation is based on how critical are the quality assembly issues A_x that are connected to R_x. In section 3.1.1 is described the method to calculate the weights of each A_x and based on these results is calculated the R_x weights, see section 3.1.2.

3.1 Method to calculate R_x priorities

The purpose of this model is to establish the priorities of poka-yoke assembly design requirements based on how critical are the potential assembly issues connected to a specific R_x. These priorities will be expressed by giving a specific weight to each A_x and then by adding the weight of each A_x connected to a specific R_x.

3.1.1 Evaluation of weight for quality assembly issues-A_x

The total weight of quality assembly issues will consider three factors i) frequency of quality assembly issues, ii) severity of quality assembly issues, iii) and severity of system phase where it is potential to occur the issue. Then to calculate a specific A_i weight the formula will be:

$$A_{i\text{-}weight} = (A_{i\_frequency}) * (A_{i\_severity}) * (S_{i\_severity}) \quad (1)$$

$A_{i\_frequency}$: the frequency of quality assembly issues is obtained from historical data recorded from products that have similar characteristics, mechanisms or devices than product been developed.
$A_{i\_severity}$: the severity of quality assembly issues is needed to make a difference about the consequences for each quality assembly issue; for example is more critical to experience the A_6: omission of parts during assembly than A_2: difficult to align parts; the A_6 will definitely represent a defective product because it means that product is incomplete due to a component was not assembled on it and A_2 represents an issue to the operator who assemble the product and it is potential to become

in a quality issue if parts sometimes are not correctly aligned due to the activity is difficult to perform for this reason A_6 will have a highest severity value than A_2.
The following criteria is proposed to assign the severity weight to each A_x; similar than method used in FMEA [8] a 1 to 10 is used to evaluate severity; where 10 represent the most critical consequences and 1 means consequences are low and represent just a minor issue for professional or customers expectations of the product. The criteria can be described as follows: i) for those issues that represent a defective product because an assembly is not according to drawing specifications and they will cause a functional issue they are evaluated from 8 to 10 for example A_4, A_5, A_6, A_9, A_{11}, A_{13} and ii) if it is out of specification but it can affects just product appearance or a defect that does not represent a functional issue then can be evaluated from 5 to 7 such as A_1, A_7, A_{12}; iii) for those issues that does not represent a direct defect on the product just difficulties to assemble, disassemble or give maintenance to product can be evaluates from 1 to 4 such as A_2, A_3, A_8, A_{10}, A_{14}, A_{15}, A_{16}.
$S_{i\_severity}$: the third factor to calculate the total weight of A_x is the severity of each system phase, it is important to consider this factor because depending of the system phase where the issue can be experienced it can represent a biggest issue. For example it is more critical to experience the A_{12}: damages of parts during installation in S_2 (system installation phase) than A_1: product damaged in S_1 (system production phase) because issues that happen during system production phase occurs inside the company and they can be controlled better than issues that can be experienced by customers and also it is worst to receive claims from customers due to assembly issues found in the final product than defective parts found during assembly process inside the company.
To obtain the S_{x_sev} matrix, it was established a criteria to assign a different weight to each system phase, it is proposed to assign values from 1 to 4 that represent the four system phases and the highest number will be assigned to the most critical system phase and 1 to the less critical phase. To assign the severity numbers was separated the phases that occur inside the company (S_1) and the phases that occur outside (S_2, S_3, S_4); the highest values were reserved for phases that occur outside the company and the lowest value to S_1 that is the only phase that is experienced inside the company. Then to decide the values from 2 to 4 it was asked three questions i) what is the most important phase where is more critical to experience quality issues? ii) what is the main function and expectations of the product and iii) what is the system phase where quality issues can occur that affect the main function of product?. Responding these questions was assigned severity of 4 to S_3 (system operation phase) because is the most important phase where the customer evaluate the product performance, then the number 3 is assigned to S_2 (system installation phase) because if quality issues occur in this phase it can affect the function of the product due to some component was incorrectly assembled or damaged during installation activities. And the last value 2 is assigned to system replacement phase.

3.1.2 Evaluation of total weight of Rx to establish priority

The last step is to evaluate weights of elements in R_x cluster, the matrix of connection among clusters R_x and A_x is multiplied by $A_{x\_Totalweight}$.
Then to calculate Rx total weight is used the following formula:

$$R_{x\_Twgt}=[A_{x\_Total\ weight}]*[R_{x}\_A_{x}]=[R_{1\_Twgt\ 11}\quad R_{2\_Twgt\ 12}\quad R_{2\_Twgt\ 1n}] \qquad (2)$$

Calculation of R_4_weight based on example presented in figures 3 and 4.

R_4_weight = (1,54)(1)+(0,7)(0)+(0,4)(1)+(3,78)(0)+(1,98)(0)+(0,06)(0)
R_4_weight = 1,58

Ax	Ax total weights	Rx							
		R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_i
A_1	1,54	0	0	0	1	1	0	0	…
A_2	0,7	0	0	0	0	0	0	0	…
A_3	0,4	0	0	0	1	0	0	0	…
A_4	3,78	0	0	0	0	0	0	1	…
A_5	3,24	0	0	0	0	0	0	1	…
A_6	1,98	0	0	0	0	0	1	0	…
A_7	0,06	0	0	0	0	0	1	0	…
A_i	……	…	…	…	…	…	…	…	…

Figure 3. Example of connections among elements of Ax and Rx clusters and Ax total weights

$$
\text{Rx\_total weight} = \overset{\begin{matrix}\text{A1\_Twgt} & \text{A2\_Twgt} & \text{A3\_Twgt} & \text{A4\_Twgt} & \text{A5\_Twgt} & \text{A6\_Twgt} & \text{A7\_Twgt} & \text{Ai}\end{matrix}}{\begin{bmatrix}1{,}54 & 0{,}7 & 0{,}4 & 3{,}78 & 3{,}24 & 1{,}98 & 0{,}06 & \ldots\end{bmatrix}} * \begin{matrix} R1 & R2 & R3 & R4 & R5 & R6 & R7 & Ri \\ \end{matrix}
\begin{pmatrix}
0 & 0 & 0 & 1 & 1 & 0 & 0 & \ldots \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \ldots \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & \ldots \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & \ldots \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & \ldots \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & \ldots \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & \ldots \\
\ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots
\end{pmatrix}
\begin{matrix} A1 \\ A2 \\ A3 \\ A4 \\ A5 \\ A6 \\ A7 \\ Ai \end{matrix}
$$

Figure 4. Example to represent how is multiplied the matrixes [$A_{x\_Total\ weight}$] and [R_x_A_x]

3.1.3 DFPYA program

In order to facilitate the use of DFPYA it was programmed in Access software [9] the methodology to execute the steps to implement DFPYA in a new product development project; this program start asking the seven questions oriented to identify potential assembly issues in product being developed, these question are described in Estrada et al., 2009 and are showed also in figure 6 and 7.

Based on answer of these questions and predetermined connections among elements from DFPYA clusters a qualitative DFPYA guide matrix is generated in this program. These connections are described in Estrada et al., 2009.

The next step is to calculate the total weights of Ax based on formula described in equation (1). After calculate Ax total weights the Rx weights can be calculated based in the formula described in equation (2).

In next section is showed a case study using the DFPYA program. The case study showed in section 4 is based on example described in Estrada et al., 2009.

4 CASE STUDY

This case study is based on the example of an oven rack slide project that was presented in Estrada et al., 2009; this example was used in [3] to apply the approach to generate the qualitative DFPYA guide matrix. This matrix is generated by asking seven "yes or not" questions since planning and clarifying the task stage depending of answers and based on DFPYA approach there are assembly issues-A_x that are linked to a specific question when answer is yes; there are also specific poka-yoke assembly design requirements-R_x linked to the resulting A_x after respond "Yes" to a specific question. The steps 1 and 2 showed in figure 5 are to generate this matrix.

This paper is a continuation of the approach presented in [3] and the purpose of the present paper is to propose an evaluation method to calculate weights for A_x and R_x in order to define the priorities to help designers in decide which requirements must be attended as more important.

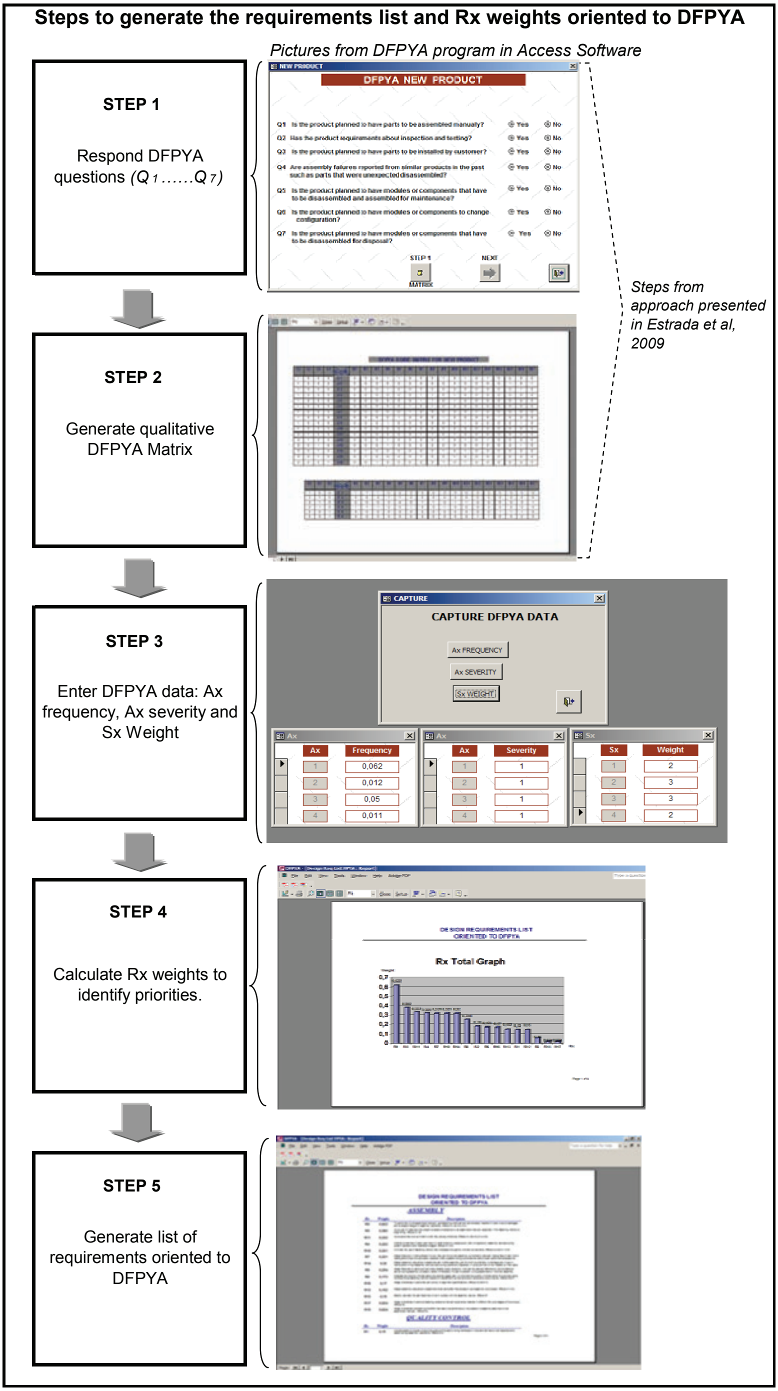


Figure 5. Steps to generate product design requirements and R_x oriented to DFPYA; using Microsoft ® Access 2002 software [9].

Check List to elaborate a requirements list for new product development

Precision Slides Company	Requirement List for: Oven Slide-Rack Project	Date: 02/05/08
Requirements		Responsable: H. Castro

A. Application
Slide rack in stove

B. Size of drawers-slides
16" model

C. Maximum load
40 lbs

D. Materials

	Material				
	CRS	HRS	SS	Plastic	Other:___
IM	X				
INT	X				
OM	X				

Lubricant for slide
- [ ] Food grease
- [ ] Standard grease
- [x] Special grease: Resistance high temperatures

Finish
- [ ] Black
- [ ] White
- [x] Nickel Chrome
- [ ] Zinc Plating
- [ ] Stainless
- [ ] Other:___________

E. Open / Close Mechanisms
[ ] Touch Release [ ] Self Close [ ] Easy close [X] Standard open/close mechanism

F. Assembly:
[X Yes] [No] Q1: Is the product planned to have parts to be assembled manually?

G. Quality Control:
[X Yes] [No] Q2: Has the product requirements about inspection and testing?

H. Installation:
[Yes] [X No] Q3: Is the product planned to have parts to be installed by customer?

I. Product operation and maintenance:
[X Yes] [No] Q4: Are assembly failures reported from similar products in the past such as parts that were unexpected disassembled?
[Yes] [X No] Q5: Is the product planned to have modules or components that have to be disassembled and assembled for maintenace?
[Yes] [X No] Q6: Is the product planned to have parts or modules to change configuration?

J. Environment during application
Components of slides have to resist:
High temperature: 600°F
Low temperature:
Humidity:
Special chemicals:________________________*(cleaners, lubricants etc.)*

K. Recycling:
[Yes] [X No] Q7: Is the product planned to have modules or components that have to be disassembled for special disposal? Verify if governmental requirements apply.

L. Specifications for durability tests
Cycle test: Pass at less 100,000 cycles Salt spray: Pass at less 12 hours

M. To be manufactured in series:
[ ] Series A [X] Series D [ ] Series G
[ ] Series B [ ] Series E [ ] Series H
[ ] Series C [ ] Series F [ ] Series I

Responsible Team							
Project leader	Design	Manufacturing	Quality	Tooling	Maintenance	Production	Purchasing
H. Castro	S. Lopez	M. Perez	C. Martinez	S. Vargas	J. Gomez	A. Vela	E. Villa

Figure 6. DFPYA Check list to elaborate a requirement list for new product development. Source [3]

4.1 Process to apply DFPYA program in the oven rack slide project

In this section is showed the five steps followed in the DFPYA program to generate the poka-yoke assembly design requirements to the oven rack slide project.

4.1.1 Step 1. Respond DFPYA questions

In this step (see figure 7) was introduced in the DFPYA program the answers of questions showed in figure 6, DFPYA check list. This step is part of the approach presented in [3].

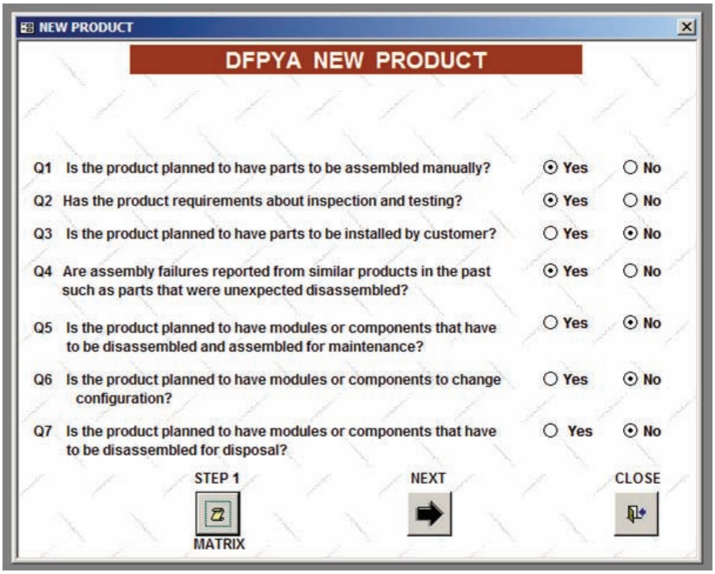


Figure 7. Screen of step 1 to introduce answers of seven questions in DFPYA program.

4.1.2 Step 2. Generate qualitative DFPYA matrix

After introduce answers in step 1 the DFPYA program generates the DFPYA guide matrix presented in figure 8. In figure 7 there is a icon that indicates "STEP 1 MATRIX" by making a click the program automatically generates this matrix. See figure 8. This step is part of the approach presented in [3].

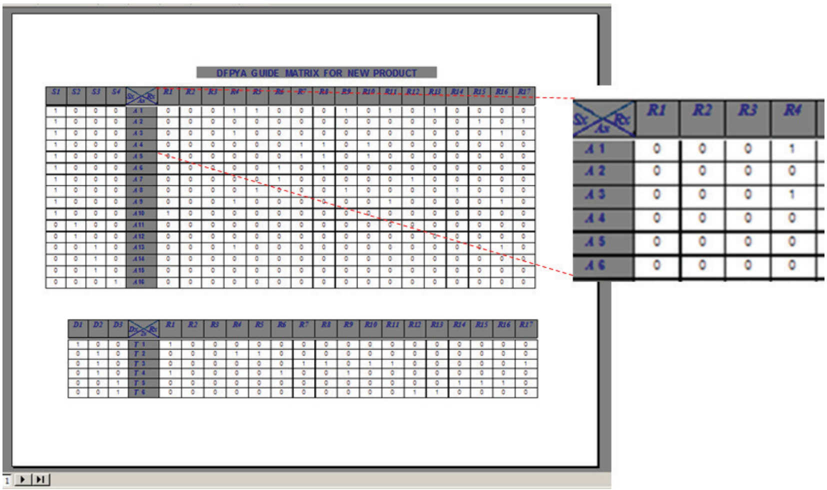


Figure 8. Screen of step 2, DFPYA guide matrix generated after respond the seven questions of step 1.

4.1.3 Step 3. Enter DFPYA data

In this step begins the calculations proposed in this paper to determine the priority for poka-yoke assembly design requirements. As stated in section 3.1.1 Ax Frequency is entered based on historical data recorded from products that have similar characteristics than product in development. In the slides company was investigated this data and it was entered in the corresponding field in DFPYA program, see figure 9. Data for Ax severity was introduced in the DFPYA program option "Ax severity"; these values are to represent the severity of quality assembly issues-Ax; the purpose of this matrix is to assign a weight of each A_x based on the severity of consequences that represent each quality assembly issue. And the third factor system severity is also introduced in the option of the DFPYA program "Sx weight". See figure 9.

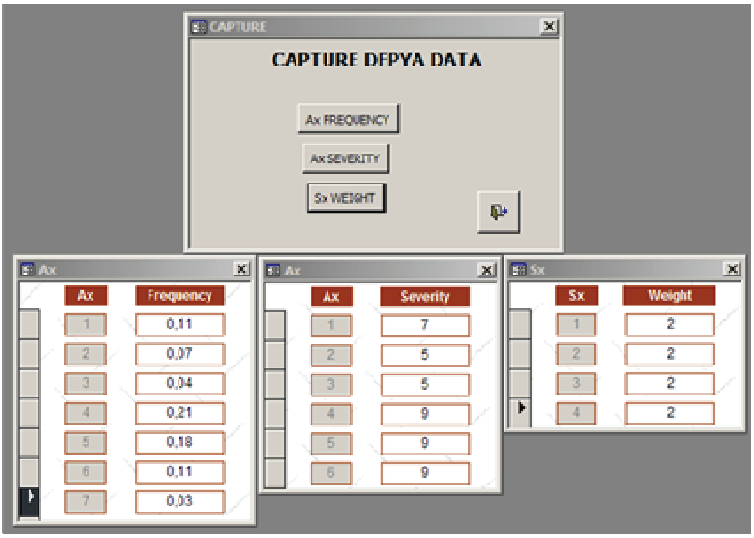


Figure 9. Screen of step 3 to enter DFPYA data: Ax frequency, Ax severity and Severity of Sx.

4.1.4 Step 4. Calculate Rx weights to identify priorities

Based on method described in section 3.1.2 the DFPYA program calculates automatically the weights for each poka-yoke assembly design requirement-Rx and also a chart is generated to visualize better the R_x with highest priority. See figure 10.

4.1.5 Step 5. Generate list of product design requirements oriented to DFPYA

In this step is automatically generated a document that complement the list of product requirements that is commonly elaborated during planning and task clarification stage; this document indicates to designers the poka-yoke assembly design requirements that apply to product being developed and the weight of each R_x to determine the priority; this program sort by priority and classify the requirements based on the main heading of check list proposed by Pahl and Beitz to elaborate the requirements list, these are: material, ergonomics, production, quality control, assembly, transport, operation, maintenance, recycling etc [6]. Additional to requirement list designers will use this DFPYA requirements document (see figure 11) to design products for poka-yoke assembly in order to prevent quality assembly issues.

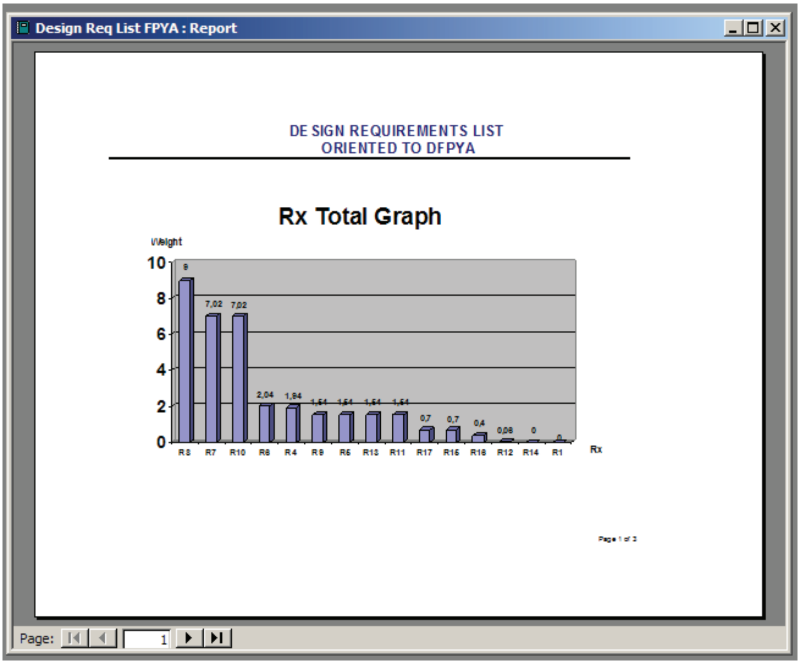
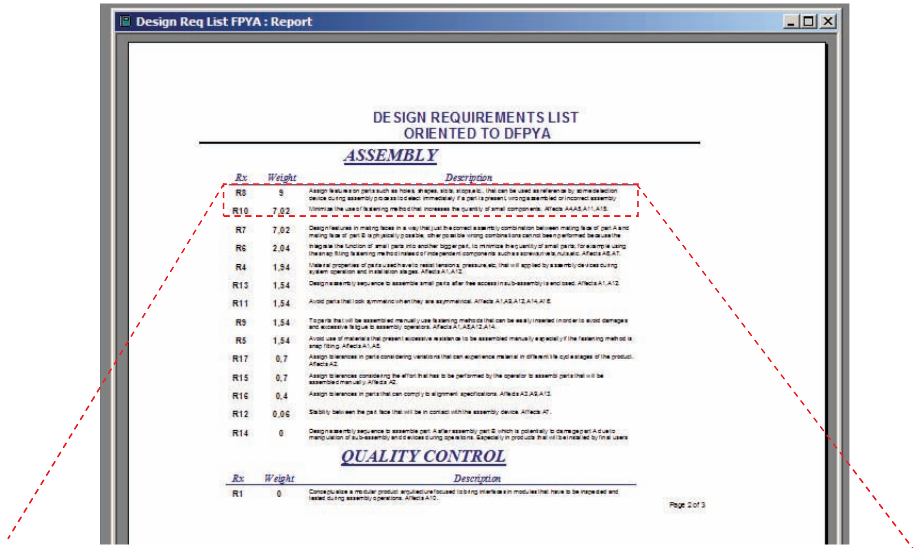


Figure 10. Screen of step 4,calculate Rx weights to identify priorities



Rx	*Weight*	*Description*
R8	**9**	Assign features on parts such as holes, shapes, slots, stops,etc., that can be used as reference by some detection device during assembly process to detect immediately if a part is present, wrong assembled or incorrect assembly
R10	**7,02**	Minimize the use of fastening method that increases the quantity of small components. Affects A4,A5,A11,A15.

Figure 11. Screen of step 5, generate list of design product requirements oriented to DFPYA

5 CONCLUSIONS AND FUTURE WORK

The requirement list is an essential document for designers to state the design specifications of the product and it is important to define in this document the poka-yoke assembly design requirements-Rx that are able to prevent potential assembly failures-Ax. The systematic design process approach by Pahl and Beitz recommend to classify design requirements in demands and wishes in order to define a priority; demands have more priority than wishes then designers know that product must to comply at less with demands and if it is possible they will try to satisfy wishes. The method to prioritize the poka-yoke assembly design requirements-R_x proposed in this work has the same purpose that Pahl and Beitz propose by separating requirements in demand and wishes the difference is that Pahl and Beitz is a qualitative method and DFPYA approach defines criteria to evaluate in a quantitative way which quality assembly issues-A_x are more critical by considering the severity and frequency of assembly issues and the impact of A_x in the system phase where these issues can occur; based on A_x weight and previous connections matrixes R_x-A_x it was possible to calculate the total weight of R_x based quality assembly issues connected to each poka-yoke assembly design requirement. This method was programmed in Access [9] and a case study was performed in section 4 using this program.

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