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TRIMMING & DFA, Finding Synergies

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Abstract

This paper refers to the development of an innovative approach to match two methods: Functional Trimming and Design For Manufacturing and Assembly, where the methodologies have the potential to help in the cost analysis and reduction. The proposal is preceded by an extensive review of the methodologies; and then followed by a set of findings to use them in a synergetic way. The review included literature, patents, and market information; as well as interviews to fully understand the methods and its current state. The expectations, standard requirements, patented ideas, and options available on the literature were identified and taken in consideration during the development of the proposed approach. Some experimental work was conducted on proving the feasibility of the synergy to perform its function.

The development of the proposed approach was supported by specific methodologies to assure meeting all objectives. Consequently, an effective analysis is presented as a realistic alternative for the development of innovations.

Keywords: design methodologies, product development, trimming, DFM&A, TRIZ.

1. Introduction

The Primary TRIZ Postulate states that Engineering (technological) systems evolve not randomly, but according to objective patterns developed by Genrich Altshuller [1, 2, 3]. These patterns can be identified from the patent archives and decisively used for systems development, product design or evolution without numerous blind trials. The Evolution of System's Performance goes for the next Stages Of Evolution: When a new product (system) starts, its performance is increased at the expense of simplicity, adding supplementary sub-systems [4] . This is the expansion period of the technical system.

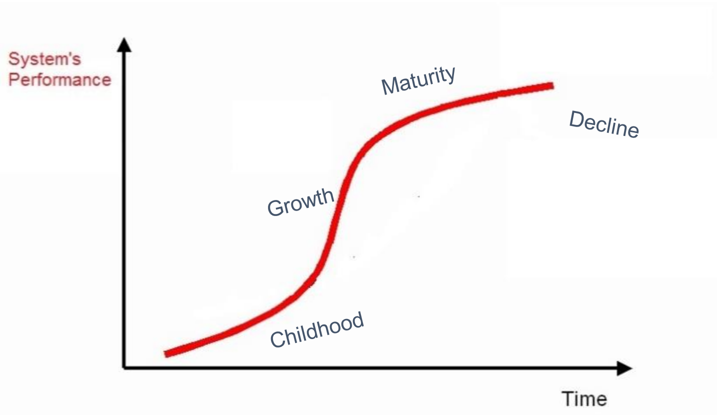

Fig.1 S-Curve of System's Performance

System's performance on one axis (y axis) and Time shown on other axis (x axis) results in the classical "S" curve. (See Figure 1) Going through: Childhood, Growth, Maturity and decline areas. Later evolution is confronted with objective constraints on physical, dated, economical, ecological complications. A simplification of the technical system is then required. Two techniques are known that help in simplifying: DFA & Trimming. Following is a comparison of both techniques, presented looking for possible synergies.[5, 6, 7]

2. Methodology

2.1. Definitions: Trimming & Design for Assembly

Trimming is removing elements or replacing parts, features, or the components functions with other constituents. DFA [8] is related to trimming in that most times you need to remove parts to make product easier to assemble, easier to repair and more competitive. The main function of Design for Assembly is helping in identifying the ways for simplifying the structure of the systems by minimizing the number of parts and to streamline the assembly, design and or manufacturing processes.

The Minimum Part Criteria for DFA (Fig. 2), states that, for reducing components in an assembly, four questions need to be addressed:

1. Is it the base part, or must the part be separate from other parts for purposes of assembly or disassembly?
2. Does the part move relative to other parts already assembled?
3. Must the part be of a different material or be isolated from the other parts already assembled?
4. Can parts or operations be eliminated & their functions be incorporated in other parts?

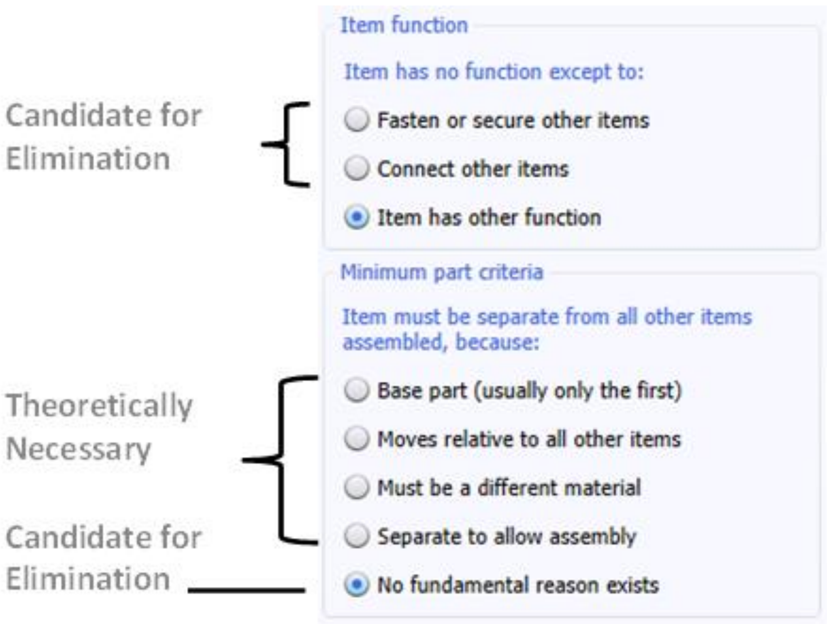

Fig. 2 Minimum Part Criteria

Candidate for Elimination are items that have no other function except to fasten or secure other items, connect other items, or some item that has no function.

Minimum Part Criteria for Theoretically Necessary items states that all items must be separate from all other items assembled because it is a base part (usually only the first), moves relative to all other items, must be of different material, or separate to allow assembly.

Candidate for Elimination are items that have no fundamental reason to exist.

TRIZ Trimming

The TRIZ trimming concept means that a component of a system or a process is eliminated and its useful functions transferred to other components. [9, 10]

Function model definition.

A function model describes the relationships between system elements in terms of the tasks that they perform. When a function model represents a device, it captures what each component of the device does, as well as how well it does it, to promote the overall goal of the device. Furthermore, the function model captures the unnecessary and harmful functions that are also performed, or the poorly executed required functions.

Note: The function model is not a flowchart, although it might look like one. The function model does not capture WHEN the various interactions occur in time. Instead, it emphasizes all the states or relationships of the system throughout its operation cycle.

What component to trim? The trimming decision may be made based on the three inputs:

1. Functional significance,
2. Cost and
3. The “headache index”, which is an integral measure of complications related to operation and maintenance of the component.

Functional Significance states that the target of a device is the primary reason why the device was designed. The main function of a device is performed on the target. The target is an element that exists outside the device that you are analyzing. Use the following guideline to identify the device target: The target is the recipient, or the object, of the main function of an engineering system.

The Function Rank is an indicator of the relative importance of the functions that are performed by the device components. The components that function on the target most directly are considered to be more valuable in the device, and have the highest Functional Rank.

What component to trim? One of the trimming rules can be formulated as follows: If functional significance of a component is low, and its cost is medium, and its trouble index is medium, then it is a likely candidate for trimming. This is usually done by ranking components on a scale from 0 to 1 (or, 0 to 100), with the first candidate to be trimmed having the highest rank (the largest number).

If a component is "functionally distant" from the target (that is, it acts on the target through many other model elements), it is considered less important to the device and is therefore assigned a higher priority for being simplified (or trimmed) from the design.

3. Product development

3.1 Case studies

After reviewing the literature it was found that the approaches for both methodologies have a lot of similarities, and these can be seen by presenting some examples. In this paper are reported the findings after making comparisons between different approaches. The products shown as examples made it possible to notice that, during the use of the methods, innovative results can be developed in many situations. Finally, the examples pointed out that the results are very promising.

Develop a concept

Function Example: Toothbrush

•What is the main function of a toothbrush system?

•Contrary to everyday thinking, it is not to brush teeth. If you consider teeth carefully, no parameters of the teeth are modified by the toothbrush.

•In fact, the toothbrush is designed to act on the plaque which coats the teeth.

•Plaque is the element on which the toothbrush acts directly.

•Therefore the main function of the toothbrush system is to remove plaque.

•The parameter of the plaque that is affected by its removal is the amount of plaque.

•Since plaque is the object of the main function, it is the target of this system.

•A system can have several main functions, and therefore it can have multiple targets.

•For example, a toothbrush can also be designed to massage gums.

Trimming Example 1 Syringe (See Figure 3)

The Fingers, Thumb (Finger), Tissue, Medicine, Container, Piston, and Needle are a few of the components of a function model of a typical function model of a common hypodermic syringe.

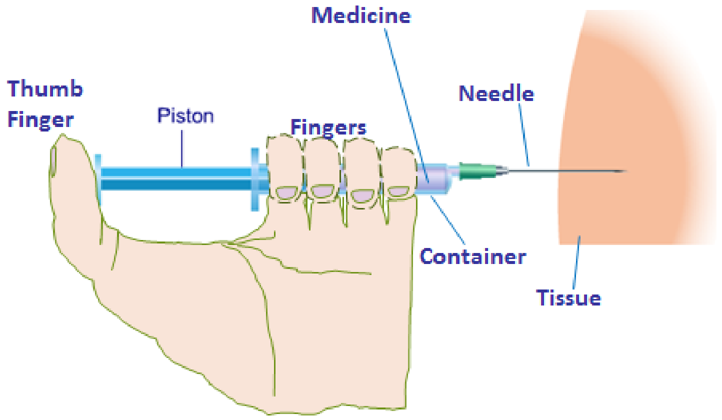

Fig. 3 Example Syringe

Device model definition

•A device model is an abstract representation of a device in terms of its components and its environmental elements (or elements of the super system), as well as the functions that are performed by these elements.

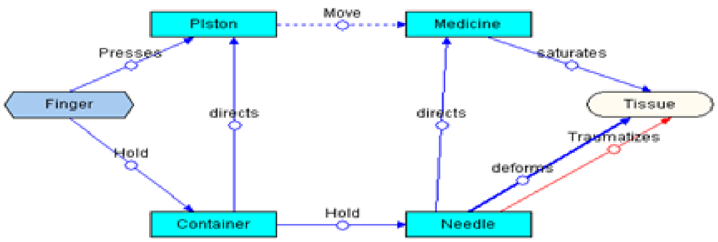

Fig .4 Device model Syringe

Link Analysis

Problem name: Improvement of "deforms" (Needle - Tissue) Problem description:

Problem name: Improvement of "Move" (Piston - Medicine)

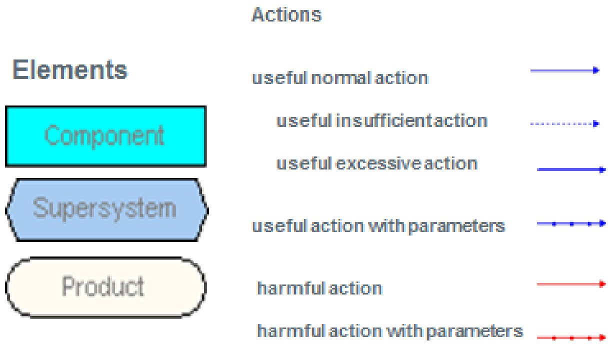

Fig. 5 Diagram Symbols

Trimming Criteria

Maximum Value

•V = F*F/(P+C). The most valuable components have the highest Function Rank and the lowest Problem Rank and Cost. To use this formula, you must enter the approximate values or actual values of the Cost parameter for each component.

Minimum Cost

•V = 1/C. The highest-rated components have the lowest Cost. To use this formula, you must enter the values of the Cost parameter for each component.

Minimum Problems

•V = 1/P. The highest-rated components have the lowest Problem Rank. Since the Problem Rank is calculated automatically by the Goldfire Innovator software, you do not need to enter any values manually.

Interaction matrix	Finger	Needle	Tissue
Finger			
Needle			EH
Tissue		EH	
Medicine		U	U
PIston	U		
Container	U	U	

Legend
U useful interaction
I useful insufficient interaction
E useful excessive interaction
H harmful interaction

Table 1: Table of Interactions

Element	Action	Target Node	Rank	Performance
Finger	Hold	Container		adequate
	Presses	PIston		adequate
Needle	deforms	Tissue	B	n/adequate
	directs	Medicine	A1	adequate
	Traumatizes	Tissue	H	
Medicine	saturates	Tissue	B	adequate
PIston	Move	Medicine	A1	n/adequate
Container	directs	PIston	A2	adequate
	Hold	Needle	A1	adequate

Legend
B - basic function
An - auxiliary function of rank **"n"**
H - harmful function

Table 2: Link Analysis Matrix

Device analysis steps

•In this step you do the following:

–Define the parts of the device and their interactions

– (Optional) Define any custom diagnostic parameters for the model components and enter their values (most likely you'll find the predefined parameters are sufficient).

–Select or define the formula that will be used to calculate the relative value of the components in your model.

Solve in Solution Manager of Goldfire Innovator Software.

•In this step you solve problems, validate concepts, and rank solutions either by hand or using software.

•This example was run using Solution Manager in Goldfire Innovator Software from IHS.

Functional Model: Syringe

Problem name: Elimination of "Traumatizes" (Needle - Tissue)

Problem description: How to eliminate function Traumatizes Tissue?

Nr	Name	Group
3.1	Improvement of "deforms" (Needle - Tissue)	Efficiency increase
3.2	Improvement of "Move" (PIston - Medicine)	Efficiency increase
4.1	Elimination of "Traumatizes" (Needle - Tissue)	Quality increase

Table 3: Problem List Table

Function Rank

	Value
Container	5.00
Medicine	10.00
Needle	6.50
PIston	3.33

Problem Rank

	Value
Container	0.00
Medicine	0.00
Needle	10.00
PIston	5.19

Cost Rank

	Value
Container	0.09
Medicine	0.05
Needle	0.06
Piston	0.12

Table 4: Functional parameters of components

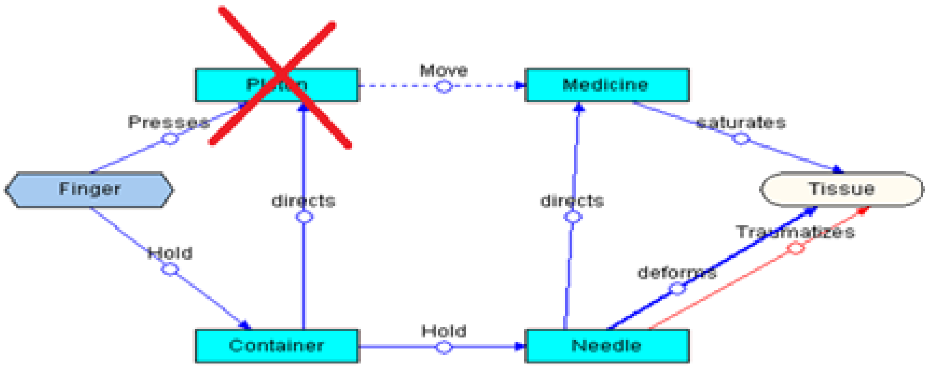

Fig. 6. Trimming of syringe's piston

Fig. 7 Piston-less syringe

KEY TAKE AWAY- Function Models got you to this point. The Needle actually traumatizes the tissue. This is a Problem Statement. That is something your TEAM can find solutions for instead of just making smaller and sharper needles!

Trimming Example 2: Ionic Toothbrush (*)

(*) With permission from TRIZ for Patent Strategies from Sergei Ikovenko, TRIZ Master ,Dr-Eng, PhD, professor (adjuncts), MIT

A toothbrush described in a patent, consists of a head containing bristles, and a handle that holds the head.

- The handle and head also hold an electrode that is powered by a battery inside the handle.
- The electrode ionizes air and aids in easy plaque removal

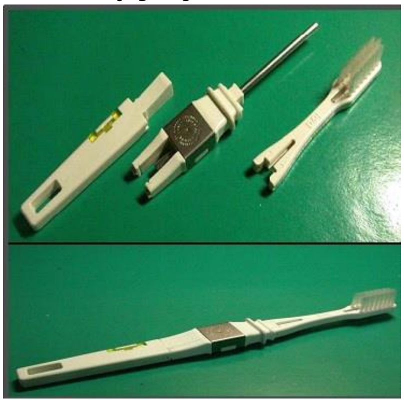

Fig. 8 Ionic Toothbrush components

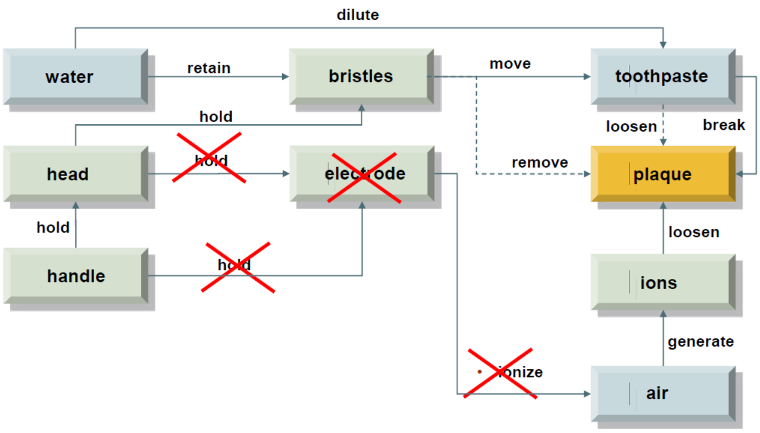

Fig. 9 Ionic Toothbrush: Function Model and Trimming

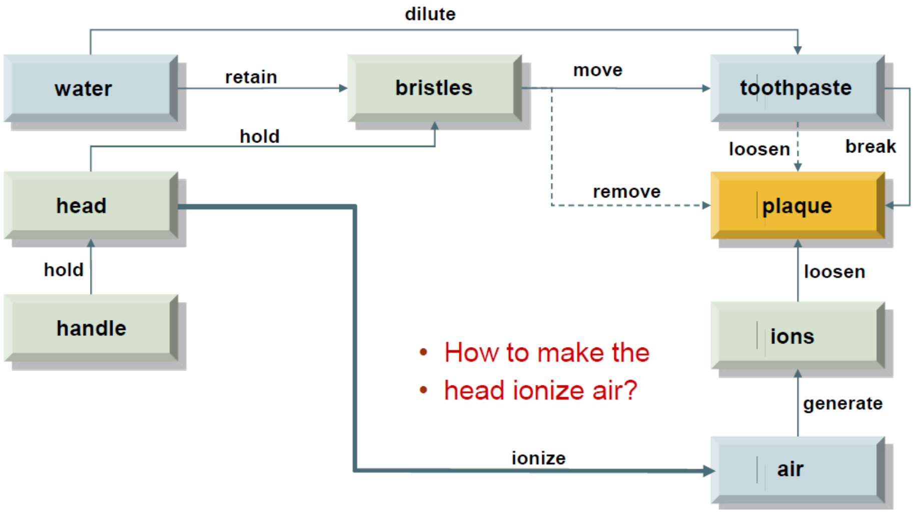

Fig. 10 How to make the head ionize air

Solution: The toothbrush head surface is covered with an alloy that, when in contact with toothpaste and water, works as an active couple and generates voltage. As a result, the head itself ionizes the air near the plaque.

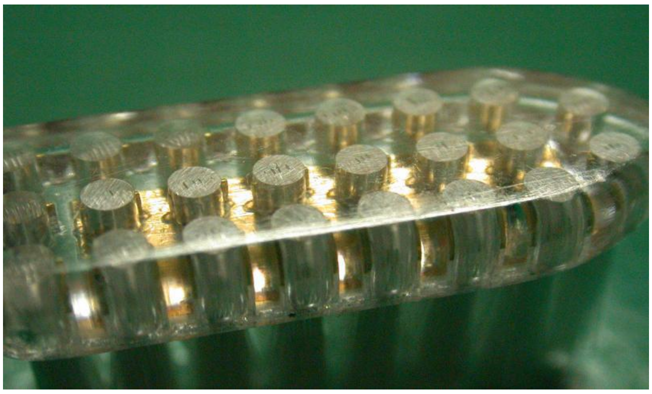

Fig. 11 Toothbrush head surface as an active couple and generates voltage.

DFA Example Labels

Problem: Labels fall off power tools over time they don't stick well to plastic housings.

DFA-Mold or cast the label information in the plastic housings, no need to assemble label, because the label is part of the housing now produced at injection molding process level and now permanently marked, no need for label, no label storage, no concern about loss, and no mis-labeled products.

DFA Example: Metal Frame of solar panel

Problem: Metal Frames of solar panels are difficult to assemble, screwed together, glued or taped to glass panel and must be grounded to metal frame (rack) on roof.

DFA-What if glass was formed in Pyrex TM cake pan shape? Now glass could act as the frame as well. No need to ground (since no metal frame), no glue or tape, no screws, and no frame assembly. Huge cost savings.

4. Discussion and Conclusions

Implementation of DFA and TRIZ Trimming can be performed in many ways, for example:

- Lunch-n-Learns with diverse teams, breakdown problems and the company's walls.
- Find and use problem solving Champions & successes to spread the word within your company. Break problems down to functions (nouns) and list relationships between components into Useful, Harmful, Necessary, Adequate, Inadequate actions (verbs).
- Conduct more internal specific DFMA, Trimming, and TRIZ related training and use it when problem solving.
- Identify Action Words used in your industry: heat, vibrate, excite, support, burn, insulate, corrode, dissolve, align, isolate, penetrate, detonate, wear, hold, reflect, contain, protect.
- Identify Functions that are reoccurring issues, then start with your of components around that problem component or area.
- Create Function Models for your problem areas, your most challenging processes, the habitual RCAs, the company's or vendor's most costly parts or assemblies.

DFA, TRIMMING, and TRIZ along with other simple methods of problem solving and function modeling can help you and your company produce better products in less time, that cost less to produce, manufacture and assemble. Better, Cheaper, Faster and more Robust- If you are not doing it for your industry's products, your competitors probably are.

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