TRIZ: Design Problem Solving with Systematic Innovation

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Additional information is available at the end of the chapter

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1. Introduction

Systematic innovation is crucial for increasing design effectiveness, enhancing competitiveness and profitability. Enterprises need to invest in systematic innovation if they want to win or survive. Innovation can no longer be seen as the product of occasional inspiration. Innovation has to be learned and managed. Innovation has to be transformed into a capacity, not a gift.

Unexpected occurrences, inconsistencies, process requirements, changes in the market and industry, demographic change, changes in perception or new knowledge can give rise to innovation opportunities.

Systematic innovation can be understood as a concept that includes the inventive instruments necessary to invent the right things that need to be invented, and incorporate them into new products and processes. Design activity needs innovation with the right dose and in the nick of time.

The Theory of Inventive Problem Solving (TRIZ), Brainstorming, Collateral Thinking, Mind Maps and other methodologies can stimulate individual and collective creativity.

2. Theory of Inventive Problem Solving (TRIZ)

The Theory of Inventive Problem Solving, better known by its acronym TRIZ was developed by Genrich Altshuller, from 1946 [1]. TRIZ is a theory that can help any engineer invent.

The TRIZ methodology can be seen and used on several levels. The highest level, the TRIZ can be seen as a science, as a philosophy or a way to be in life (a creative mode and a permanent search of continuous improvement). The more practical level, the TRIZ can be seen as a set of analytical tools that assist in the detection of contradictions on systems, in formulating and solving of design problems through the elimination or mitigation of contradictions [2].

The TRIZ methodology is based on the following grounds:

- Technical systems.
- Levels of innovation.
- Law of ideality.
- Contradictions.

Every system that performs a technical function is a technical system. Any technical system can contain one or more subsystems. The hierarchy of technical systems can be complex with many interactions. When a technical system produces harmful or inadequate effects, the system needs to be improved. Technical systems emerge; ripen to maturity, and die (they are replaced with new technical systems).

Altshuller's analysis of a large number of patents reveals that inventive value of different inventions is not equal. Altshuller systematized the solutions described in patent applications dividing them into five levels [3]:

- Level 1: routine solutions using methods well known in their area of specialty. The Level 1 is not really innovative. This category is about 30% of the total.
- Level 2: small corrections in existing systems using methods known in the industry. About 45% of the total.
- Level 3: major improvements that solve contradictions in typical systems of a particular branch of industry. About 20% of the total. This is where creative design solutions appear.
- Level 4: solutions based on application of new scientific principles. It solves the problem by replacing the original technology with a new technology. About 4% of the total.
- Level 5: innovative solutions based on scientific discoveries not previously explored. Less than 1% of the total.

The TRIZ aims to assist the development of design tasks at levels 3 and 4 (about a quarter of the total), where the simple application of traditional engineering techniques does not produce notable results.

The Law of Ideality states that any technical system tends to reduce costs, to reduce energy wastes, to reduce space and dimensional requirements, to become more effective, more reliable, and simpler. Any technical system, during its lifetime, tends to become more ideal.

We can evaluate an inventive level of a technical system by its degree of Ideality.

There are several ways to increase an ideality of a technical system.

The TRIZ axiom of evolution reveals that, during the evolution of a technical system, improvement of any part of that system can lead to conflict with another part.

A system conflict or contradiction occurs when the improvement of certain attributes results in the deterioration of others. The typical conflicts are: reliability/complexity; productivity/precision; strength/ductility, etc.

Traditional engineering and design practices can become insufficient and inefficient for the implementation of new scientific principles or for radical improvements of existing systems. Traditional way of technical and design contradictions' solving is through search of possible compromise between contradicting factors, whereas the Theory of Inventive Problem Solving (TRIZ) aims to remove contradictions and to remove compromises.

The inconsistencies are eliminated by modification of the entire system or by modification of one or more subsystems. TRIZ systematizes solutions that can be used for different technical fields and activities.

In TRIZ, the problems are divided into local and global problems [1]. The problem is considered as local when it can be mitigated or eliminated by modifying of a subsystem, keeping the remaining unchanged. The problem is classified as global when it can be solved only by the development of a new system based on a different principle of operation.

Over the past decades, TRIZ has developed into a set of different practical tools that can be used together or apart for technical problem solving and design failure analysis.

Generally, the TRIZ's problem solving process is to define a specific problem, formalize it, identify the contradictions, find examples of how others have solved the contradiction or utilized the principles, and finally, apply those general solutions to the particular problem.

Figure 1 shows the steps of the TRIZ's problem solving.

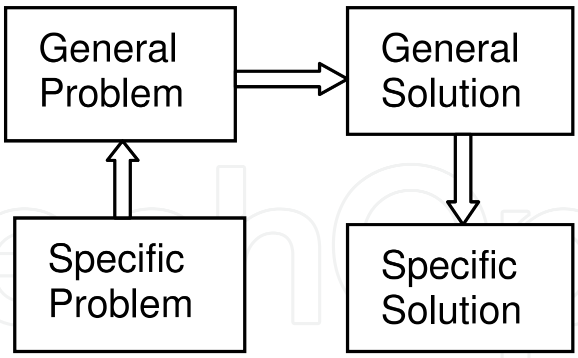

Figure 1. Steps of the TRIZ's algorithm for problem solving [4]

It is important to identify and to understand the contradiction that is causing the problem as soon as possible. TRIZ can help to identify contradictions and to formalize problems to be solved. The identification and the formalizing of problems is one of the most important and difficult tasks, with numerous impediments. The situation is often obscured.

The problem can be generalized by selecting one of the TRIZ problem solving tools. The generic solutions available within TRIZ can be of great benefit at choosing of corrective actions.

The integral development of TRIZ consists of a set of concepts [5]:

- Problem formulation system.
- Physical and technical contradictions solving.
- Concept of the ideal state of a design.
- Analysis "Substance-Field".
- Algorithm of Inventive Problem Solving (ARIZ).

Altshuller found that, despite the great technological diversity, there is only 1250 typical system conflicts. He also identified 39 engineering parameters or product attributes that engineers usually try to improve.

Table 1 presents the list of these parameters.

1. Weight of moving object	21. Power
2. Weight of nonmoving object	22. Waste of energy
3. Length of moving object	23. Waste of substance
4. Length of nonmoving object	24. Loss of information
5. Area of moving object	25. Waste of time
6. Area of nonmoving object	26. Amount of substance
7. Volume of moving object	27. Reliability
8. Volume of nonmoving object	28. Accuracy of measurement
9. Speed	29. Accuracy of manufacturing
10. Force	30. Harmful factors acting on object
11. Tension, pressure	31. Harmful side effects
12. Shape	32. Manufacturability
13. Stability of object	33. Convenience of use
14. Strength	34. Repairability
15. Durability of moving object	35. Adaptability
16. Durability of nonmoving object	36. Complexity of device
17. Temperature	37. Complexity of control
18. Brightness	38. Level of automation
19. Energy spent by moving object	39. Productivity
20. Energy spent by nonmoving object	

Table 1. Engineering parameters according to TRIZ [3]

All of these 1250 conflicts can be solved through the application of only 40 principles of invention [3], often called Techniques for Overcoming System Conflicts, which represent the Table 2.

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1. Segmentation	21. Rushing through
2. Extraction	22. Convert harm into benefit
3. Local quality	23. Feedback
4. Asymmetry	24. Mediator
5. Combining	25. Self-service
6. Universality	26. Copying
7. Nesting	27. Inexpensive, short-lived object for expensive, durable one
8. Counterweight	28. Replacement of a mechanical system
9. Prior counter-action	29. Pneumatic or hydraulic construction
10. Prior action	30. Flexible membranes or thin film
11. Cushion in advance	31. Use of porous material
12. Equipotentiality	32. Changing the color
13. Inversion	33. Homogeneity
14. Spheroidality	34. Rejecting and regenerating parts
15. Dynamicity	35. Transformation of the physical and chemical states of an object
16. Partial or overdone action	36. Phase transformation
17. Moving to a new dimension	37. Thermal expansion
18. Mechanical vibration	38. Use strong oxidizers
19. Periodic action	39. Inert environment
20. Continuity of a useful action	40.Composite materials

Table 2. Invention principles of TRIZ

However, most of the principles of invention of Table 2 have a specific technical meaning introduced by Altshuller. For example, the principle of Local Quality [6]:

- Transition from a homogeneous structure of an object or outside environment/action to a heterogeneous structure.
- Have different parts of the object carry out different functions.
- Place each part of the object under conditions most favourable for its operation.

Altshuller built a contradictions matrix, classifying them as follows [1]:

- Physical Contradiction - occurs when two mutually incompatible requirements refer to the same element of the system.
- Technical Contradiction - occurs when the improvement of a particular attribute or characteristic of the system causes the deterioration of another attribute.

The first step in the conflict solving process is drawing up a statement of the problem in order to reveal the contradictions contained in the system. Then, the parameters that affect and improve system performance are identified.

The rows of the table of contradictions are then populated with parameters whose adjustment improves the behavior of the system, and these intersect the columns with parameters whose adjustment produces unwanted results. At the intersection are the numbers of invention principles that are suggested as being capable of solving the contradiction (Table 3).

In the Table 3, the rows and columns refer to the Table 1. The numbers in cells refer to the Table 2.

		Characteristics	Characteristic that is getting worse												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Characteristic to be improved	1	Weight of a mobile object		-	15, 8 29, 34	-	29, 17 38, 34	-	29, 2 40, 28	-	2, 8 15, 38	8, 10 18, 37	10, 36 37, 40	10, 14 35, 40	1, 35 19, 39
	2	Weight of a stationary object	-		-	10, 1 29, 35	-	35, 30 13, 2	-	5, 35 14, 2	-	8, 10 19, 35	13, 29 10, 18	13, 10 29, 14	26, 39 1, 40
	3	Length of a mobile object	8, 15 29, 34	-		-	15, 17 4	-	7, 17 4, 35	-	13, 4 8	17, 10 4	1, 8 35	1, 8 10, 29	1, 8 15, 34
	4	Length of a stationary object	-	35, 28 40, 29	-		-	17, 7 10, 40	-	35, 8 2, 14	-	28, 10	1, 14 35	13, 14 15, 7	39, 37 35
	5	Area of a mobile object	2, 17 29, 4	-	14, 15 18, 4	-		-	7, 14 17, 4	-	29, 30 4, 34	19, 30 35, 2	10, 15 36, 28	5, 34 29, 4	11, 2 13, 39
	6	Area of a stationary object	-	30, 2 14, 18	-	26, 7 9, 39	-		-	-	-	1, 18 35, 36	10, 15 36, 37	-	2, 38
	7	Volume of a mobile object	2, 26 29, 40	-	1, 7 4, 35	-	1, 7 4, 17	-		-	29, 4 38, 34	15, 35 36, 37	6, 35 36, 37	1, 15 29, 4	28, 10 1, 39
	8	Volume of a stationary object	-	35, 10 19, 14	19, 14	35, 8 2, 14	-	-	-		-	2, 18 37	24, 35	7, 2 35	34, 28 35, 40
	9	Speed	2, 28 13, 38	-	13, 14 8	-	29, 30 34	-	7, 29 34	-		13, 28 15, 19	6, 18 38, 40	35, 15 18, 34	28, 33 1, 18
	10	Force	8, 1 37, 18	18, 13 1, 28	17, 19 9, 36	28, 10	19, 10 15	1, 18 36, 37	15, 9 12, 37	2, 36 18, 37	13, 28 15, 12		18, 21 11	10, 35 40, 34	35, 10 21
	11	Tension/Pressure	10, 36 37, 40	13, 29 10, 18	35, 10 36	35, 1 14, 16	10, 15 36, 28	10, 15 36, 37	6, 35 10	35, 24	6, 35 36	36, 35 21		35, 4 15, 10	35, 33 2, 40
	12	Shape	8, 10 29, 40	15, 10 26, 3	29, 34 5, 4	13, 14 10, 7	5, 34 4, 10	-	14, 4 15, 22	7, 2 35	35, 15 34, 18	35, 10 37, 40	34, 15 10, 14		33, 1 18, 4
	13	Stability of composition	21, 35 2, 39	26, 39 1, 40	13, 15 1, 28	37	2, 11 13	39	28, 10 19, 39	34, 28 35, 40	33, 15 28, 18	10, 35 21, 16	2, 35 40	22, 1 18, 4	
	14	Strength	1, 8, 40 15	40, 26 27, 1	1, 15 8, 35	15, 14 28, 26	3, 34 40, 29	9, 40 28	10, 15 14, 7	9, 14 17, 15	8, 13 26, 14	10, 18 3, 14	10, 3 18, 40	10, 30 35, 40	13, 17 35
	15	Time of action of a moving object	19, 5 34, 31	-	2, 19 9	-	3, 17 19	-	10, 2 19, 30	-	3, 35 5	19, 2 16	19, 3 27	14, 26 28, 25	13, 3 35
	16	Time of action of a stationary object	-	6, 27 19, 16	-	1, 40 35	-	-	-	35, 34 38	-	-	-	-	39, 3 35, 23
	17	Temperature	36, 22 6, 38	22, 35 32	15, 19 9	15, 19 9	3, 35 39, 18	35, 38	34, 39 40, 18	35, 6 4	2, 28 36, 30	35, 10 3, 21	35, 39 19, 2	14, 22 19, 32	1, 35 32
	18	Brightness	19, 1 32	2, 35 32	19, 32 16	-	19, 32 26	-	2, 13 10	-	10, 13 19	26, 19 6	-	32, 30	32, 3 27
	19	Energy spent by a moving object	12, 18 28, 31	-	12, 28	-	15, 19 25	-	35, 13 18	-	8, 35	16, 26 21, 2	23, 14 25	12, 2 29	19, 13 17, 24
	20	Energy spent by a stationary object	-	19, 9 6, 27	-	-	-	-	-	-	-	36, 37	-	-	27, 4 29, 18

Table 3-a: Altshuller's Table of Contradictions (Features to Improve 1-20 vs. Undesired Result 1-13)

http://dx.doi.org/10.5772/55979

		Characteristics	Characteristic that is getting worse												
			14	15	16	17	18	19	20	21	22	23	24	25	26
Characteristic to be improved	1	Weight of a mobile object	28, 27 18, 40	5, 34 31, 35	-	6, 29 4, 38	19, 1 32	35, 12 34, 31	-	12, 36 18, 31	6, 2 34, 19	5, 35 3, 31	10, 24 35	10, 35 20, 28	3, 26 18, 31
	2	Weight of a stationary object	28, 2 10, 27	-	2, 27 19, 6	28, 19 32, 22	19, 32 35	-	18, 19 28, 1	15, 19 18, 22	18, 19 28, 15	5, 8 13, 30	10, 15 35	10, 20 35, 26	19, 6 18, 26
	3	Length of a mobile object	8, 35 29, 34	19	-	10, 15 19	32	8, 35 24	-	1, 35	7, 2 35, 39	4, 29 23, 10	1, 24	15, 2 29	29, 35
	4	Length of a stationary object	15, 14 28, 26	-	1, 40 35	3, 35 38, 18	3, 25	-	-	12, 8	6, 28	10, 28 24, 35	24, 26	30, 29 14	-
	5	Area of a mobile object	3, 15 40, 14	6, 3	-	2, 15 16	15, 32 19, 13	19, 32	-	19, 10 32, 18	15, 17 30, 26	10, 35 2, 39	30, 26	26, 4	29, 30 6, 13
	6	Area of a stationary object	40	-	2, 10 19, 30	35, 39 38	-	-	-	17, 32	17, 7 30	10, 14 18, 39	30, 16	10, 35 4, 18	2, 18 40, 4
	7	Volume of a mobile object	9, 14 15, 7	6, 35 4	-	34, 39 10, 18	2, 13 10	35	-	35, 6 13, 18	7, 15 13, 16	36, 39 34, 10	2, 22	2, 6 34, 10	29, 30 7
	8	Volume of a stationary object	9, 14 17, 15	-	35, 34 38	35, 6 4	-	-	-	30, 6	-	10, 39 35, 34	-	35, 16 32, 18	35, 3
	9	Speed	8, 3 26, 14	3, 19 35, 5	-	28, 30 36, 2	10, 13 19	8, 15 35, 38	-	19, 35 38, 2	14, 20 19, 35	10, 13 28, 38	13, 26	-	10, 19 29, 38
	10	Force	35, 10 14, 27	19, 2	-	35, 10 21	-	19, 17 10	1, 16 36, 37	19, 35 18, 37	14, 15	8, 35 40, 5	-	10, 37 36	14, 29 18, 36
	11	Tension/Pressure	9, 18 3, 40	19, 3 27	-	35, 39 19, 2	-	14, 24 10, 37	-	10, 35 14	2, 36 25	10, 36 3, 37	-	37, 36 4	10, 14 36
	12	Shape	30, 14 10, 40	14, 26 9, 25	-	22, 14 19, 32	13, 15 32	2, 6 34, 14	-	4, 6 2	14	35, 29 3, 5	-	14, 10 34, 17	36, 22
	13	Stability of composition	17, 9 15	13, 27 10, 35	39, 3 35, 23	35, 1 32	32, 3 27, 15	13, 19	27, 4 29, 18	32, 35 27, 31	14, 2 39, 6	2, 14 30, 40	-	35, 27	15, 32 35
	14	Strength		27, 3 26	-	30, 10 40	35, 19	19, 35 10	35	10, 26 35, 28	35	35, 28 31, 40	-	29, 3 28, 10	29, 10 27
	15	Time of action of a moving object	27, 3 10		-	19, 35 39	2, 19 4, 35	28, 6 35, 18	-	19, 10 35, 38	-	28, 27 3, 18	10	20, 10 28, 18	3, 35 10, 40
	16	Time of action of a stationary object	-	-		19, 18 36, 40	-	-	-	16	-	27, 16 18, 38	10	28, 20 10, 16	3, 35 31
	17	Temperature	10, 30 22, 40	19, 13 39	19, 18 36, 40		32, 30 21, 16	19, 15 3, 17	-	2, 14 17, 25	21, 17 35, 38	21, 36 29, 31	-	35, 28 21, 18	3, 17 30, 39
	18	Brightness	35, 19	2, 19 6	-	32, 35 19		32, 1 19	32, 35 1, 15	32	13, 16 1, 6	13, 1	1, 6	19, 1 26, 17	1, 19
	19	Energy spent by a moving object	5, 19 9, 35	28, 35 6, 18	-	19, 24 3, 14	2, 15 19		-	6, 19 37, 18	12, 22 15, 24	35, 24 18, 5	-	35, 38 19, 18	34, 23 16, 18
	20	Energy spent by a stationary object	35	-	-	-	19, 2 35, 32	-		-	-	28, 27 18, 31	-	-	3, 35 31

Table 3-b: Altshuller's Table of Contradictions (cont.) (Features to Improve 1-20 vs. Undesired Result 14-26)

Characteristic to be improved	Characteristics	27	28	29	30	31	32	33	34	35	36	37	38	39
		Characteristic that is getting worse												
1	Weight of a mobile object	3, 11 1, 27	28, 27 35, 26	28, 35 26, 18	22, 21 18, 27	22, 35 31, 39	27, 28 1, 36	35, 3 2, 24	2, 27 28, 11	29, 5 15, 8	26, 30 36, 34	28, 29 26, 32	26, 35 18, 19	35, 3 24, 37
2	Weight of a stationary object	10, 28 8, 3	18, 26 28	10,1 35, 17	2, 19 22, 37	35, 22 1, 39	28, 1 9	6, 13 1, 32	2, 27 28, 11	19, 15 29	1, 10 26, 39	25, 28 17, 15	2, 26 35	1, 28 15, 35
3	Length of a mobile object	10, 14 29, 40	28, 32 4	10, 28 29, 37	1, 15 17, 24	17, 15	1, 29 17	15, 29 35, 4, 7	1, 28 10	14, 15 1, 16	1, 19 26, 24	35, 1 26, 24	17, 24 26, 16	14,4 28, 29
4	Length of a stationary object	15, 29 28	32, 28 3	2, 32 10	1, 18	-	15, 17 27	2, 25	3	1, 35	1, 26	26	-	30, 14 7, 26
5	Area of a mobile object	29, 9	26, 28 32, 3	2, 32	22, 33 28, 1	17, 2 18, 39	13, 1 26, 24	15, 17 13, 16	15, 13 10, 1	15, 30	14, 1 13	2, 36 26, 18	14, 30 28, 23	10, 26 34, 2
6	Area of a stationary object	32, 35 40, 4	26, 28 32, 3	2, 29 18, 36	27, 2 39, 35	22, 1 40	40, 16	16, 4	16	15, 16	1, 18 36	2, 35 30, 18	23	10, 15 17, 7
7	Volume of a mobile object	14, 1 40, 11	26, 28	25, 28 2, 16	22, 21 27, 35	17, 2 40, 1	29, 1 40	15, 13 30, 12	10	15, 29	26, 1	29, 26 4	35, 34 16, 24	10, 6 2, 34
8	Volume of a stationary object	2, 35 16	-	35, 10 25	34, 39 19, 27	30, 18 35, 4	35	-	1	-	1, 31	2, 17 26	-	35, 37 10, 2
9	Speed	11, 35 27, 28	28, 32 1, 24	10, 28 32, 35	1, 28 35, 23	2, 24 35, 21	35, 13 8, 1	32, 28 13, 12	34, 2 28, 27	15, 10 26	10, 28 4, 34	3, 34 27, 16	10, 18	-
10	Force	3, 35 13, 21	35, 10 23, 24	28, 29 37, 36	1, 35 40, 18	13, 3 36, 24	15, 37 18, 1	1, 28 3, 25	15, 1 11	15, 17 18, 20	26, 35 10, 18	36, 37 10, 19	2, 35	3, 28 35, 37
11	Tension/Pressure	10, 13 19, 35	6, 28 25	3, 35	22, 2 37	2, 33 27, 18	1, 35 16	11	2	35	19, 1 35	2, 36 37	35, 24	10, 14 35, 37
12	Shape	10, 40 16	28, 32 1	32, 30 40	22, 1 2, 35	35, 1	1, 32 17, 28	32, 15 26	2, 13 1	1, 15 29	16, 29 1, 28	15, 13 39	15, 1 32	17, 26 34, 10
13	Stability of composition	-	13	18	35, 24 30, 18	35, 40 27, 39	35, 19	32, 35 30	2, 35 10, 16	35, 30 34, 2	2, 35 22, 26	35, 22 39, 23	1, 8 35	23, 35 40, 3
14	Strength	11, 3	3, 27 16	3, 27	18, 35 37, 1	15, 35 22, 2	11,3 10, 32	32, 40 28, 2	27, 11 3	15, 3 32	2, 13 25, 28	27, 3 15, 40	15	29, 35 10, 14
15	Time of action of a moving object	11, 2 13	3	3, 27 16, 40	22, 15 33, 28	21, 39 16, 22	27, 1 4	12, 27	29, 10 27	1, 35 13	10, 4 29, 15	19, 29 39, 35	6, 10	35, 17 14, 19
16	Time of action of a stationary object	34, 27 6, 40	10, 26 24	-	17, 1 40, 33	22	35, 10	1	1	2	-	25, 34 6, 35	1	20, 10 16, 38
17	Temperature	19, 35 3, 10	32, 19 24	24	22, 33 35, 2	22, 35 2, 24	26, 27	26, 27	4, 10 16	2, 18 27	2, 17 16	3, 27 35, 31	26, 2 19, 16	15, 28 35
18	Brightness	-	11, 15 32	3, 32	15, 19	35, 19 32, 39	19, 35 28, 26	28, 26 19	15, 17 13, 16	15, 1 19	6, 32 13	32, 15	2, 26 10	2, 25 16
19	Energy spent by a moving object	19, 21 11, 27	3, 1 32	-	1, 35 6, 27	2, 35 6	28, 26 30	19, 35	1, 15 17, 28	15, 17 13, 16	2, 29 27, 28	35, 36	32, 2	12, 28 35
20	Energy spent by a stationary object	10, 36 23	-	-	10, 2 22, 37	19, 22 18	1, 4	-	-	-	-	19, 35 16, 25	-	1, 6

Table 3-c: Altshuller's Table of Contradictions (cont.) (Features to Improve 1-20 vs. Undesired Result 27-39)

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Characteristics			Characteristic that is getting worse												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Characteristic to be improved	21	Power	8, 36 38, 31	19, 26 17, 27	1, 10 35, 37	-	19, 38	17, 32 13, 38	35, 6 38	30, 6 25	15, 35 2	26, 2 36, 35	22, 10 35	29, 14 2, 40	35, 32 15, 31
	22	Waste of energy	15, 6 19, 28	19, 6 18, 9	7, 2 6, 13	6, 38 7	15, 26 17, 30	17, 7 30, 18	7, 18 23	7	16, 35 38	36, 38	-	-	14, 2 39, 6
	23	Waste of substance	35, 6 23, 40	35, 6 22, 32	14, 29 10, 39	10, 28 24	35, 2 10, 31	10, 18 39, 31	1, 29 30, 36	3, 39 18, 31	10, 13 28, 38	14, 15 18, 40	3, 36 37, 10	29, 35 3, 5	2, 14 30, 40
	24	Loss of information	10, 24 35	10, 35 5	1, 26	26	30, 26	30, 16	-	2, 22	26, 32	-	-	-	-
	25	Waste of time	10, 20 37, 35	10, 20 26, 5	15, 2 29	30, 24 14, 5	26, 4 5, 16	10, 35 17, 4	2, 5 34, 10	35, 16 32, 18	-	10, 37 36, 5	37, 36 4	4, 10 34, 17	35, 3 22, 5
	26	Amount of substance	35, 6 18, 31	27, 26 18, 35	29, 14 35, 18	-	15, 14 29	2, 18 40, 4	15, 20 29	-	35, 29 34, 28	35, 14 3	10, 36 14, 3	35, 14	15, 2 17, 40
	27	Reliability	3, 8 10, 40	3, 10 8, 28	15, 9 14, 4	15, 29 28, 11	17, 10 14, 16	32, 35 40, 4	3, 10 14, 24	2, 35 24	21, 35 11, 28	8, 28 10, 3	10, 24 35, 19	35, 1 16, 11	-
	28	Accuracy of measurement	32, 35 26, 28	28, 35 25, 26	28, 26 5, 16	32, 28 3, 16	26, 28 32, 3	26, 28 32, 3	32, 13 6	-	28, 13 32, 24	32, 2	6, 28 32	6, 28 32	32, 35 13
	29	Accuracy of manufacturing	28, 32 13, 18	28, 35 27, 9	10, 28 29, 37	2, 32 10	28, 33 29, 32	2, 29 18, 36	32, 28 2	25, 10 35	10, 28 32	28, 19 34, 36	3, 35	32, 30 40	30, 18
	30	Harmful factors acting on object	22, 21 27, 39	2, 22 13, 24	17, 1 39, 4	1, 18	22, 1 33, 28	27, 2 39, 35	22, 23 37, 35	34, 39 19, 27	21, 22 35, 28	13, 35 39, 18	22, 2 37	22, 1 3, 35	35, 24 30, 18
	31	Harmful side effects	19, 22 15, 39	35, 22 1, 39	17, 15 16, 22	-	17, 2 18, 39	22, 1 40	17, 2 40	30, 18 35, 4	35, 28 3, 23	35, 28 1, 40	2, 33 27, 18	35, 1	35, 40 27, 39
	32	Manufacturability	28, 29 15, 16	1, 27 36, 13	1, 29 13, 17	15, 17 27	13, 1 26, 12	16, 40	13, 29 1, 40	35	35, 13 8, 1	35, 12	35, 19 1, 37	1, 28 13, 27	11, 13 1
	33	Convenience of use	25, 2 13, 15	6, 13 1, 25	1, 17 13, 12	-	1, 17 13, 16	18, 16 15, 39	1, 16 35, 15	4, 18 39, 31	18, 13 34	28, 13 35	2, 32 12	15, 34 29, 28	32, 35 30
	34	Repairability	2, 27 35, 11	2, 27 35, 11	1, 28 10, 25	3, 18 31	15, 13 32	16, 25	25, 2 35, 11	1	34, 9	1, 11 10	13	1, 13 2, 4	2, 35
	35	Adaptability	1, 6 15, 8	19, 15 29, 16	35, 1 29, 2	1, 35 16	35, 30 29, 7	15, 16	15, 35 29	-	35, 10 14	15, 17 20	35, 16	15, 37 1, 8	35, 30 14
	36	Complexity of device	26, 30 34, 36	2, 26 35, 39	1, 19 26, 24	26	14, 1 13, 16	6, 36	34, 26 6	1, 16	34, 10 28	26, 16	19, 1 35	29, 13 28, 15	2, 22 17, 19
	37	Complexity of control	27, 26 28, 13	6, 13 28, 1	16, 17 26, 24	26	2, 13 18, 17	2, 39 30, 16	29, 1 4, 16	2, 18 26, 31	3, 4 16, 35	36, 28 40, 19	35, 36 37, 32	27, 13 1, 39	11, 22 39, 30
	38	Level of automation	28, 26 18, 35	28, 26 35, 10	14, 13 17, 28	23	17, 14 13	-	35, 13 16	-	28, 10	2, 35	13, 35	15, 32 11, 13	18, 1
	39	Productivity	35, 26 24, 37	28, 27 15, 3	18, 4 28, 38	30, 7 14, 26	10, 26 34, 31	10, 35 17, 7	2, 6 34, 10	35, 37 10, 2	-	28, 15 10, 36	10, 37 14	14, 10 34, 40	35, 3 22, 39

Table 3-d: Altshuller's Table of Contradictions (cont.) (Features to Improve 21-39 vs. Undesired Result 1-13)

Characteristics			Characteristic that is getting worse												
			14	15	16	17	18	19	20	21	22	23	24	25	26
Characteristic to be improved	21	Power	26, 10 28	19, 35 10, 38	16	2, 14 17, 25	16, 6 19	16, 6 19, 37	-		10, 35 38	28, 27 18, 38	10, 19	35, 20 10, 6	4, 34 19
	22	Waste of energy	26	-	-	19, 38 7	1, 13 32, 15	-	-	3, 38		35, 27 2, 37	19, 10	10, 18 32, 7	7, 18 25
	23	Waste of substance	35, 28 31, 40	28, 27 3, 18	27, 16 18, 38	21, 36 39, 31	1, 6 13	35, 18 24, 5	28, 27 12, 31	28, 27 18, 38	35, 27 2, 31		-	15, 18 35, 10	6, 3 10, 24
	24	Loss of information	-	10	10	-	19	-	-	10, 19	19, 10	-		24, 26 28, 32	24, 28 35
	25	Waste of time	29, 3 28, 18	20, 10 28, 18	28, 20 10, 16	35, 29 21, 18	1, 19 26, 17	35, 38 19, 18	1	35, 20 10, 6	10, 5 18, 32	35, 18 10, 39	24, 26 28, 32		35, 38 18, 16
	26	Amount of substance	14, 35 34, 10	3, 35 10, 40	3, 35 31	3, 17 39	-	34, 29 16, 18	3, 35 31	35	7, 18 25	6, 3 10, 24	24, 28 35	35, 38 18, 16	
	27	Reliability	11, 28	2, 35 3, 25	34, 27 6, 40	3, 35 10	11, 32 13	21, 11 27, 19	36, 23	21, 11 26, 31	10, 11 35	10, 35 29, 39	10, 28	10, 30 4	21, 28 40, 3
	28	Accuracy of measurement	28, 6 32	28, 6 32	10, 26 24	6, 19 28, 24	6, 1 32	3, 6 32	-	3, 6 32	26, 32 27	10, 16 31, 28	-	24, 34 28, 32	2, 6 32
	29	Accuracy of manufacturing	3, 27	3, 27 40	-	19, 26	3, 32	32, 2	-	32, 2	13, 32 2	35, 31 10, 24	-	32, 26 28, 18	32, 30
	30	Harmful factors acting on object	18, 35 37, 1	22, 15 33, 28	17, 1 40, 33	22, 33 35, 2	1, 19 32, 13	1, 24 6, 27	10, 2 22, 37	19, 22 31, 2	21, 22 35, 2	33, 22 19, 40	22, 10 2	35, 18 34	35, 33 29, 31
	31	Harmful side effects	15, 35 22, 2	15, 22 33, 31	21, 39 16, 22	22, 35 2, 24	19, 24 39, 32	2, 35 6	19, 22 18	2, 35 18	21, 35 2, 22	10, 1 34	10, 21 29	1, 22	3, 24 39, 1
	32	Manufacturability	1, 3 10, 32	27, 1 4	35, 16	27, 26 18	28, 24 27, 1	28, 26 27, 1	1, 4	27, 1 12, 24	19, 35	15, 34 33	32, 24 18, 16	35, 28 34, 4	35, 23 1, 24
	33	Convenience of use	32, 40 3, 28	29, 3 8, 25	1, 16 25	26, 27 13	13, 17 1, 24	1, 13 24	-	35, 34 2, 10	2, 19 13	28, 32 2, 24	4, 10 27, 22	4, 28 10, 34	12, 35
	34	Repairability	11, 1 2, 9	11, 29 28, 27	1	4, 10	15, 1 13	15, 1 28, 16	-	15, 10 32, 2	15, 1 32, 19	2, 35 34, 27	-	32, 1 10, 25	2, 28 10, 25
	35	Adaptability	35, 3 32, 6	13, 1 35	2, 16	27, 2 3, 35	6, 22 26, 1	19, 35 29, 13	-	19, 1 29	18, 15 1	15, 10 2, 13	-	35, 28	3, 35 15
	36	Complexity of device	2, 13 28	10, 4 28, 15	-	2, 17 13	24, 17 13	27, 2 29, 28	-	20, 19 30, 34	10, 35 13, 2	35, 10 28, 29	-	6, 29	13, 3 27, 10
	37	Complexity of control	27, 3 15, 28	19, 29 39, 25	25, 34 6, 35	3, 27 35, 16	2, 24 26	35, 38	19, 35 16	19, 1 16, 10	35, 3 15, 19	1, 18 10, 24	35, 33 27, 22	18, 28 32, 9	3, 27 29, 18
	38	Level of automation	25, 13	6, 9	-	26, 2 19	8, 32 19	2, 32 13	-	28, 2 27	23, 28	35, 10 18, 5	35, 33	24, 28 35, 30	35, 13
	39	Productivity	29, 28 10, 18	35, 10 2, 18	20, 10 16, 38	35, 21 28, 10	26, 17 19, 1	35, 10 38, 19	1	35, 20 10	28, 10 29, 35	28, 10 35, 23	13, 15 23	-	35, 38

Table 3-e: Altshuller's Table of Contradictions (cont.) (Features to Improve 21-39 vs. Undesired Result 14-26)

http://dx.doi.org/10.5772/55979

Characteristic to be improved	Characteristics		Characteristic that is getting worse												
			27	28	29	30	31	32	33	34	35	36	37	38	39
	21	Power	19, 24 26, 31	32, 15 2	32, 2	19, 22 31, 2	2, 35 18	26, 10 34	26, 35 10	35, 2 10, 34	19, 17 34	20, 19 30, 34	19, 35 16	28, 2 17	28, 35 34
	22	Waste of energy	11, 10 35	32	-	21, 22 35, 2	21, 35 2, 22	-	35, 32 1	2, 19	-	7, 33	35, 3 15, 23	2	28, 10 29, 35
	23	Waste of substance	10, 29 39, 35	16, 34 31, 18	35, 10 24, 31	33, 22 30, 40	10, 1 34, 29	15, 34 33	32, 28 2, 24	2, 35 34, 27	15, 10 2	35, 10 28, 24	35, 18 10, 13	35, 10 18	28, 35 10, 23
	24	Loss of information	10, 28 23	-	-	22, 10 1	10, 21 22	32	27, 22	-	-	-	35, 33	35	13, 23 15
	25	Waste of time	10, 30 4	24, 34 28, 32	24, 26 28, 18	35, 18 34	35, 22 18, 39	35, 28 34, 4	4, 28 10, 34	32, 1 10	35, 28	6, 29	18, 28 32, 10	24, 28 35, 30	-
	26	Amount of substance	18, 3 28, 40	13, 2 28	33, 30	35, 33 29, 31	3, 35 40, 39	29, 1 35, 27	35, 29 25, 10	2, 32 10, 25	15, 3 29	3, 13 27, 10	3, 27 29, 18	8, 35	13, 29 3, 27
	27	Reliability		32, 3 11, 23	11, 32 1	27, 35 2, 40	35, 2 40, 26	-	27, 17 40	1, 11	13, 35 8, 24	13, 35 1	27, 40 28	11, 13 27	1, 35 29, 38
	28	Accuracy of measurement	5, 11 1, 23		-	28, 24 22, 26	3, 33 39, 10	6, 35 25, 18	1, 13 17, 34	1, 32 13, 11	13, 35 2	27, 35 10, 34	26, 24 32, 28	28, 2 10, 34	10, 34 28, 32
	29	Accuracy of manufacturing	11, 32 1	-		26, 28 10, 36	4, 17 34, 26	-	1, 32 35, 23	25, 10	-	26, 2 18	-	26, 28 18, 23	10, 18 32, 39
	30	Harmful factors acting on object	27, 24 2, 40	28, 33 23, 26	26, 28 10, 18		-	24, 35 2	2, 25 28, 39	35, 10 2	35, 11 22, 31	22, 19 29, 40	22, 19 29, 40	33, 3 34	22, 35 13, 24
	31	Harmful side effects	24, 2 40, 39	3, 33 26	4, 17 34, 26	-		-	-	-	-	19, 1 31	2, 21 27, 1	2	22, 35 18, 39
	32	Manufacturability	-	1, 35 12, 18	-	24, 2	-		2, 5 13, 16	35, 1, 25 11, 9	2, 13 15	27, 26 1	6, 28 11, 1	8, 28 1	35, 1 10, 28
	33	Convenience of use	17, 27 8, 40	25, 13 2, 34	1, 32 35, 23	2, 25 28, 39	-	2, 5 12		12, 26 1, 32	15, 34 1, 16	32, 26 12, 17	-	1, 34 12, 3	15, 1 28
	34	Repairability	11, 10 1, 16	10, 2 13	25, 10	35, 10 2, 16	-	1, 35 11, 10	1, 12 26, 15		7, 1 4, 16	35, 1, 25 13, 11	-	34, 35 7, 13	1, 32 10
	35	Adaptability	35, 13 8, 24	35, 5 1, 10	-	35, 11 32, 31	-	1, 13 31	15, 34 1, 16, 7	1, 16 7, 4		15, 29 37, 28	1	27, 34 35	35, 28 6, 37
	36	Complexity of device	13, 35 1	2, 26 10, 34	26, 24 32	22, 19 29, 40	19, 1	27, 26 1, 13	27, 9 26, 24	1, 13	29, 15 28, 37		15, 10 37, 28	15, 1 24	12, 17 28
	37	Complexity of control	27, 40 28, 8	26, 24 32, 28	-	22, 19 29, 28	2, 21	5, 28 11, 29	2, 5	12, 26	1, 15	15, 10 37, 28		34, 21	35, 18
	38	Level of automation	11, 27 32	28, 26 10, 34	28, 26 18, 23	2, 33	2	1, 26 13	1, 12 34, 3	1, 35 13	27, 4 1, 35	15, 24 10	34, 27 25		5, 12 35, 26
	39	Productivity	1, 35 10, 38	1, 10 34, 28	18, 10 32, 1	22, 35 13, 24	35, 22 18, 39	35, 28 2, 24	1, 28 7, 19	1, 32 10, 25	1, 35 28, 37	12, 17 28, 24	35, 18 27, 2	5, 12 35, 26	

Table 3-f: Altshuller's Table of Contradictions (cont.) (Features to Improve 21-39 vs. Undesired Result 27-39)

Substance-Field Analysis is one of TRIZ analytical tools. It can be used in the solution of problems related to technical or design activities through functional models building [1].

Substance-Field Analysis is a useful tool for identifying problems in a technical system and finding innovative solutions to these identified problems. Recognized as one of the most valuable contributions of TRIZ, Substance-Field Analysis is able to model a system in a simple graphical approach, to identify problems and also to offer standard solutions for system improvement [7].

The process of functional models construction comprehends the following stages [8]:

1. Survey of available information.
2. Construction of Substance-Field diagram.
3. Identification of problematic situation.
4. Choice of a generic solution (standard solution).
5. Development of a specific solution for the problem.

There are mainly five types of relationships among the substances: useful impact, harmful impact, excessive impact, insufficient impact and transformation [8].

Substance-Field Analysis has 76 standard solutions categorized into five classes [9]:

- Class 1: Construct or destroy a substance-field (13 standard solutions)
- Class 2: Develop a substance-field (23 standard solutions)
- Class 3: Transition from a base system to a super-system or to a subsystem (6 standard solutions)
- Class 4: Measure or detect anything within a technical system (17 standard solutions)
- Class 5: Introduce substances or fields into a technical system (17 standard solutions)

These 76 solutions can be condensed and generalized into seven standard solutions.

3. Practical cases of SF model application

An operation batch contains some pieces with characteristics out of specifications.

Figure 2 shows the problem (Problematic Situation 1 - Incomplete Model) [8].

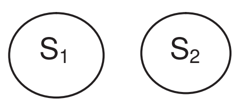

Figure 2. Problematic Situation 1 - incomplete model

The Substance-Field Model is incomplete, a field is missing. The problem corresponds to Problematic Situation 1 and can be solved resorting to General Solution 1.

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Figure 3 shows the solution.

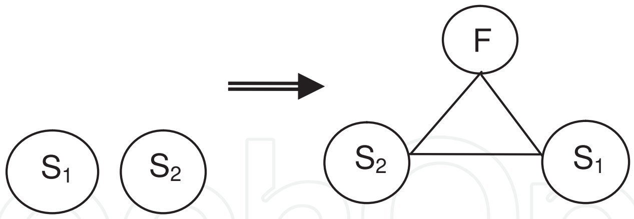

Figure 3. General Solution 1 for Problematic Situation 1

The possible specific solution is to inspect pieces before the operation, putting aside faulty components from acceptable ones. Then the model becomes complete.

A machine-tool fixture used for certain fabrication operation is damaging the lateral surfaces of the workpiece.

Figure 4 shows the problem (Problematic Situation 2 - Harmful Interactions between the Substances).

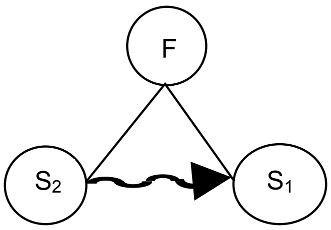

Figure 4. Problematic Situation 2 - harmful interactions between the substances

The Substance-Field Model is complete however the interaction between the substances is harmful. The problem corresponds to Problematic Situation 2 and can be solved resorting to General Solution 2.

Figure 5 shows the general solution.

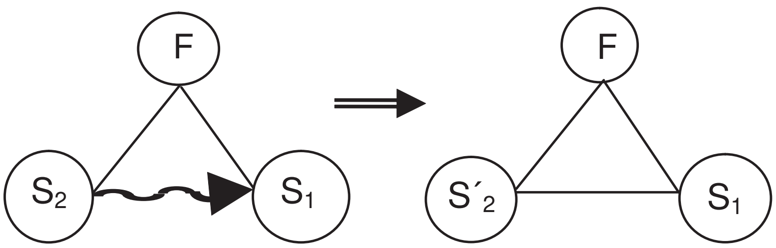

Figure 5. General Solution 2 for Problematic Situation 2

The possible specific solution is to use another machine-tool fixture system or to modify the actual fixture in order to eliminate or reduce damages at the lateral surfaces of the workpiece. Then the harmful interaction is reduced or eliminated.

General Solution 3: Modify S1 to be Insensitive or Less Sensitive to Harmful Impact

The problematic situation is the same (see Figure 4).

General Solution 3 is similar to General Solution 2, but instead of substance S2 modification, the substance S1 is modified. The characteristics (physical, chemical and/or other) of substance S1 are changed in order to become it less sensitive or insensitive to a harmful impact. The changes can be internal and/or external, can be temporary or permanent.

The physical and/or chemical characteristics of substance S1 may be altered internally or externally, so that it becomes less sensitive or insensitive to a harmful impact, as seen in Figure 4. The modification may be either temporary or permanent. Additives may be needed in the modification.

Figure 6 shows the general solution.

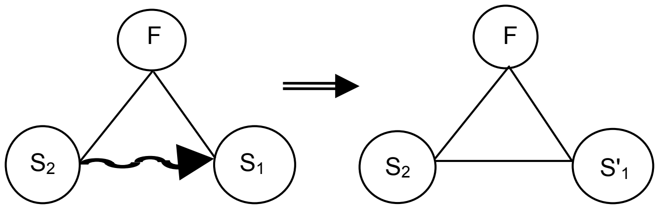

Figure 6. General Solution 3 for Problematic Situation 2

The possible specific solution is to create protection for the lateral surfaces of the workpiece. Then the harmful interaction is reduced or eliminated.

General Solution 4: Change Existing Field to Reduce or Eliminate Harmful Impact

The problematic situation is the same (see Figure 4).

General Solution 4 is similar to General Solutions 2 and 3, but instead of substances modification, the field F is modified.

Changing the existing field while keeping the same substances may be a choice to reduce or removing the harmful impact. The existing field can be increased, decreasing, or completely removed and replaced by another one.

Figure 7 shows the general solution.

The possible specific solution is to change the technological process and its operations keeping the same substances in order to reduce or eliminate the harmful interactions.

General Solution 5: Eliminate, Neutralize or Isolate Harmful Impact Using Another Counteractive Field F_x

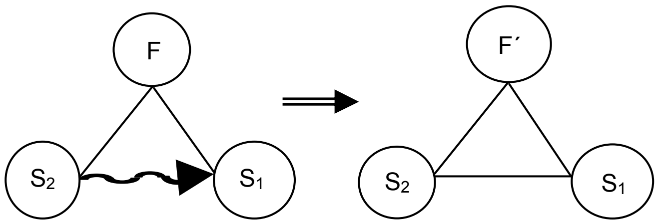

Figure 7. General Solution 4 for Problematic Situation 2

The problematic situation is the same (see Figure 4).

General Solution 5 presupposes introduction of a counteractive field F_X in order to remove, neutralize or isolate the harmful impact. The substances S_2 and S_1 and the field F will not change its characteristics in this solution.

Figure 8 shows the general solution.

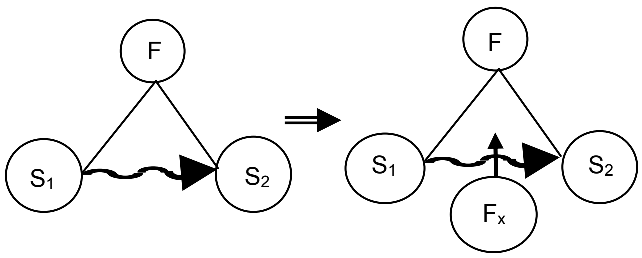

Figure 8. General Solution 5 for Problematic Situation 2

For example, a technological operation is creating significant superficial tensions in workpieces. The possible specific solution is to introduce a tempering operation (heat treatment) in order to reduce the superficial tensions.

General Solution 6: Introduce a Positive Field

The problematic situation is the same (see Figure 4).

General Solution 6 is very similar to General Solution 5.

Another field is added to work with the current field in order to increase the useful effect and reduce the negative effect of the existing system keeping all elements without change.

Figure 9 shows the general solution.

For example, Lean Philosophy is a systematized approach for continual improvement. The possible specific solution is to introduce another positive field, TRIZ techniques, so the useful effect of Lean is increases and negative effects in existing system are reduced.

General Solution 7: Expand Existing Substance-Field Model to a Chain

The problematic situation is the same (see Figure 4).

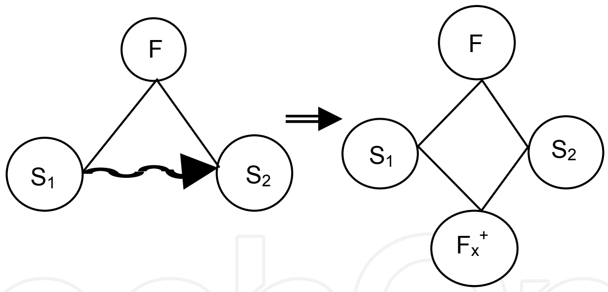

Figure 9. General Solution 6 for Problematic Situation 2

The existing Substance-Field Model can be expanded to a chain by introducing a new substance S3 to the system. Instead of directly acting upon S1, S2 will interact indirectly with S1 via another medium, substance S3.

Figure 10 shows the general solution.

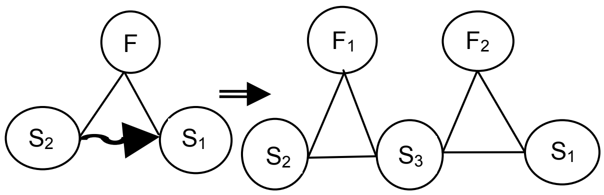

Figure 10. General Solution 7 for Problematic Situation 2

For example, it is difficult for a design team to obtain direct customer feedback about new product. The possible specific solution is to obtain customer feedback through the marketing and sales staff.

Beyond the Problematic Situation 1 (incomplete model) and the Problematic Situation 2 (harmful or undesirable interactions between the substances), also the Problematic Situation 3 (insufficient or inefficient impact) can occur.

Figure 11 shows the Problematic Situation 3.

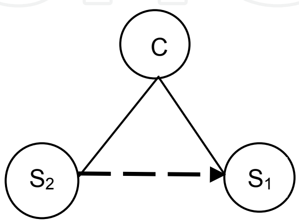

Figure 11. Problematic Situation 3 - insufficient or inefficient impact between the substances

The general solutions used for the Problematic Situation 2 can be used for the Problematic Situation 3. Figures 12-17 show the general solutions.

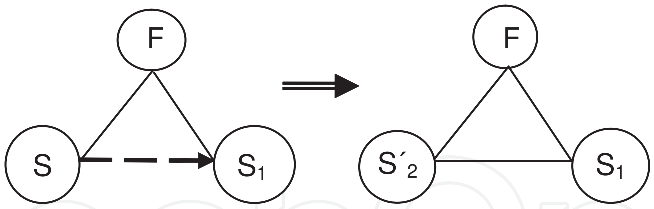

Figure 12. General Solution 2 for Problematic Situation 3

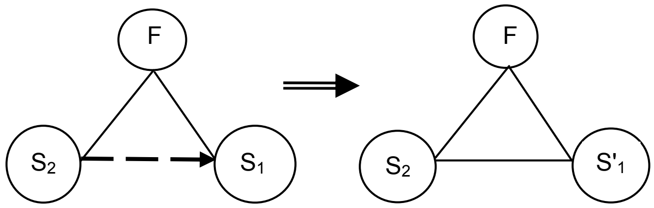

Figure 13. General Solution 3 for Problematic Situation 3

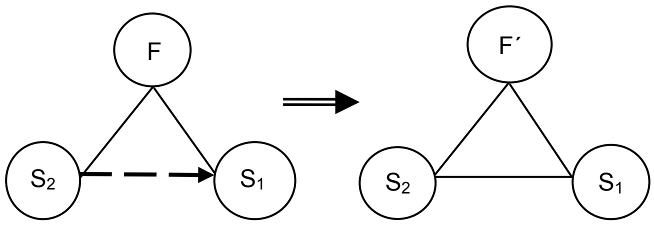

Figure 14. General Solution 4 for Problematic Situation 3

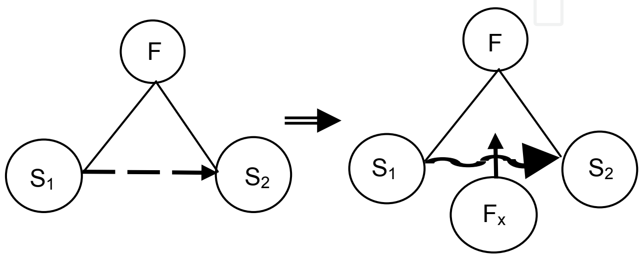

Figure 15. General Solution 5 for Problematic Situation 3

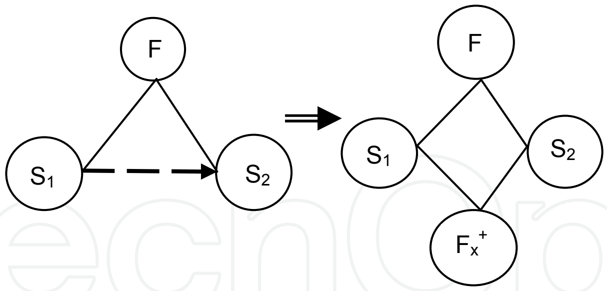

Figure 16. General Solution 6 for Problematic Situation 3

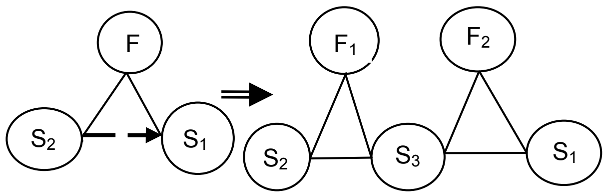

Figure 17. General Solution 7 for Problematic Situation 3

4. Ideality and application of ideality matrix to a camping stove case study

Consider the case of a camping stove design.

Customer requirements were collected, pooled and prepared by an affinity diagram, yielding the following list:

- Volume;
- Weight;
- Firing time;
- Noise level;
- Time required to boil water;
- Tank capacity;
- Burning time at maximum flame;
- Boiled water per unit of gas.

Table4 contains the Matrix of Ideality built for the camping stove.

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Parameter	1.	2.	3.	4.	5.	6.	7.	8.
1. Volume		+			-	-	-	
2. Weight	+				-	-	-	
3. Firing time					+			
4. Noise level								
5. Time required to boil water	-	-	+				-	+
6. Tank capacity	-	-	+		+		+	+
7. Burning time at maximum flame	-	-			-	-		-
8. Boiled water per unit of gas	-	-			+	+	-	

- Harmful iteration

+ Useful iteration

Table 4. Ideality Matrix

The Ideality Matrix helps identify the interactions between the technical requirements and distinguish the positive and negative effects of iterations. For example, weight reduction can lead to reduction in volume, but may lead to reduction of the tank capacity.

Based on the Ideality Matrix, the level of ideality can be calculated as follows [10]:

$$\text{Ideality} = \text{Number of Useful Functions} / \text{Number of Harmful Functions} \tag{1}$$

In this case, the level of ideality is:

$I = 11 / 30 \approx 0{,}367$

To increase the level of ideality it is necessary to move to the next phase, phase of solution of contradictions.

5. Application of ARIZ to a sterilizer case study

The AJC company runs its activity, since 1953, based on manufacturing medical and hospital material, being the main activity the conception, manufacture and assemblage of washer disinfectors of bed-pan and stainless steel utensils, vertical and horizontal steam sterilizers and steam generators.

The sterilization services implement in hospitals new philosophy which encompasses the traceability of equipment to use in the sterilization station, sterilized material, sterilization processes and handling operations with sterilized material and with material to be sterilized. The new sterilization philosophy leads to improvement of sterilizer capacity and sterilizer features. Actually hospitals need centralized management software for all sterilization equipment (including washing and disinfection machines, sterilizers, medical sealers), as well as materials to be sterilized (surgical, orthopaedic, textile and another utensils) and the sequence of operations (separation of material, washing and disinfecting, sorting and packing, sealing, sterilization, distribution and collection of material to be sterilized in the hospital).

The extant manufactured sterilizers are analyzed concerning its adaptation to the new tendencies of sterilization. ARIZ flowchart can be applied (Figure 18) [8].

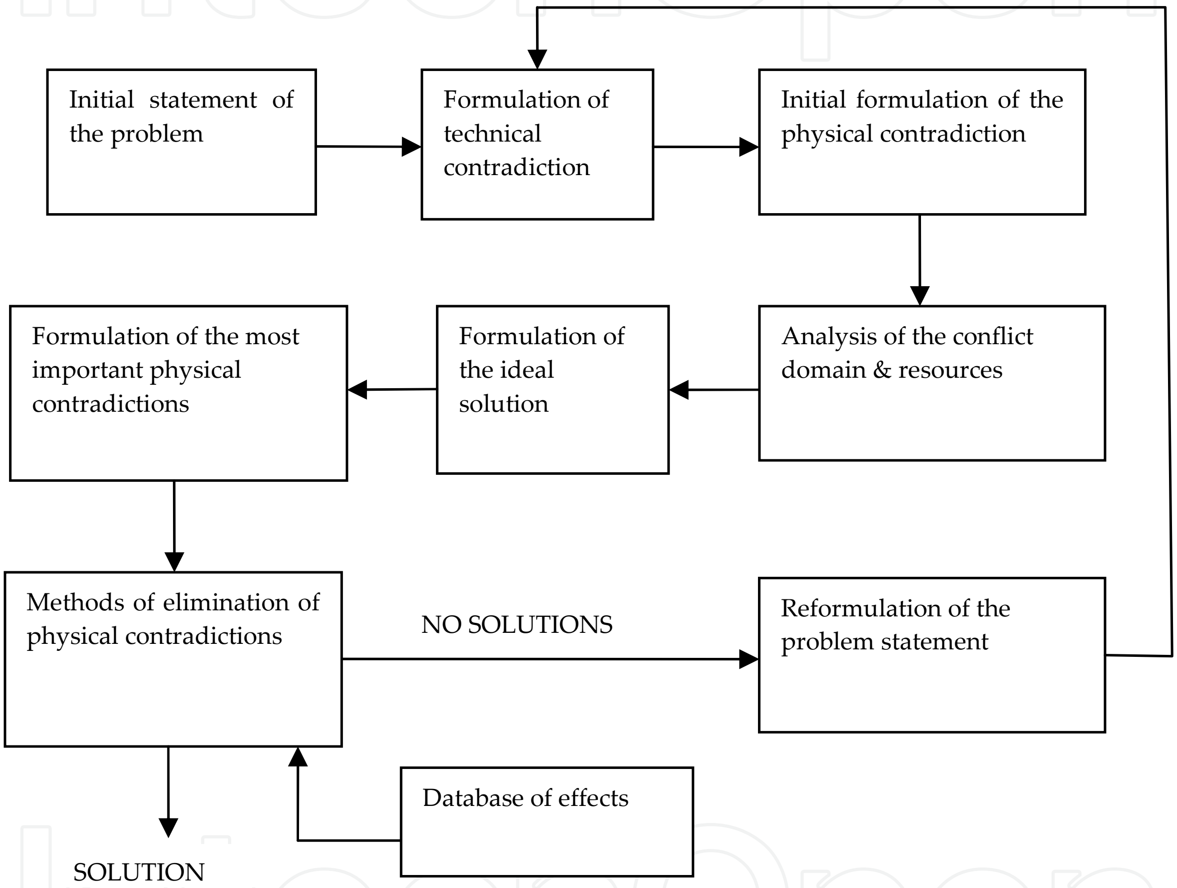

Figure 18. Simplified ARIZ flowchart

Several contradictions can be identified. It became clear that new sterilizers to be introduced on the market will have to undergo significant changes.

Beyond another features, the sterilizer must undergo changes at the level of pressure vessel where the sterilization of materials is performed.

The pressure vessel is constituted by the chamber, jacket, doors and other components welded to the pressure vessel.

The dimensions of the sterilization chamber can be modified. Former dimensions were: 70 centimeters of wide, 70 centimeters in height, 150 centimeters of depth with 735 liters of

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capacity. The new dimensions are: 70 centimeters in wide, 112 centimeters tall, 110 centimeters of depth with 862 liters of capacity.

The sterilizer door performance can be questioned too. The two doors working vertically can be replaced by two doors working horizontally.

The guide system for the door movement can be changed too. The doors can be sliding.

They detected a problem with difficult access to some mechanical and electrical components. The problem can be solved by modification of the component layout. The new sterilizers can have modular approach of the component layout; some mechanical and electrical components can be transferred to the lateral side of the sterilizer. Therefore, the maintenance operations will be easier.

They carried out the study of component layout (including electric framework, power framework, vacuum pump, water pump, condensate pan, valves, filters, etc.) to make assembly, maintenance intervention or replacement of the components easier.

As a result of all these changes, the structure that supports the sterilizer and its components can be reformed and redesigned too.

The sterilizer loading system can be undergone with important changes. The former loading system had an outside loading car that guided to the baskets load platform where the material to be sterilizes can be placed into the chamber. A similar outside loading car can be allowed to withdraw the load platform, baskets and utensils of the chamber in the clean area after sterilization (Figure 19a).

The loading system of the new sterilizer will be consists of a load car placed inside the chamber with the material to sterilize. There is a second outside loading car that transports the loading car from the sterilizer to the transportation board and vice-versa. The transportation board allows transport the sterilized material to outside and the material to be sterilized to the sterilization station (Figure 19b).

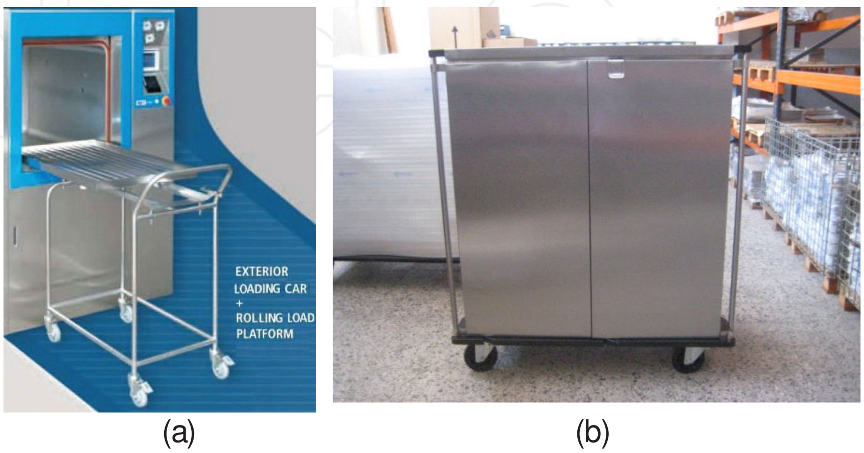

Figure 19. a) Former loading system; (b) New loading system

The Figure 20 shows two sterilizers:

- Sterilizer with sliding door vertically – before the application of TRIZ methodology (Fig. 20a).
- Sterilizer with sliding door horizontally – after the application of TRIZ methodology (Fig. 20b).

(a) (b)

Figure 20. a) Former sterilizer AMARO 5000 with the door vertically; (b) New sterilizer AMARO 5000 with the sliding door horizontally

This project aims to achieve significant improvements in the quality of the sterilization process, simplifying the maintenance of the equipment, the traceability of the processes and equipment, the quality of work of the operators of sterilization station, making easier the sterilizer manufacture and assembly processes, the improvement and introduction of a new concept of charging system of the sterilizer. The developments described will allow company to submit an innovative concept that will be introduced in hospitals of medium and large dimensions.

6. Conclusions

The constant need for change, results in a current trend in industrial design activities. The industrial projects must achieve its objectives. Design teams need powerful and highly efficient analytical tools. One of the most important factors for the success of a project is the generation of ideas and innovation. The lack of creativity can lead to the failure of a project. Borderless communication, information and innovation are crucial for design competitiveness.

The TRIZ methodology, with its strong theme of innovation, can contribute to accelerating the resolution of problems in the industrial design activities [11]. The TRIZ analytical tools would be very useful for schematization of project tasks, structural analysis, identification and formalization of contradictions and problematical situations and its solving.

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