TOP-TRIZ, Method for Innovation, Applications, Implementation

Abstract

TOP-TRIZ is a result of three decades of development of TRIZ by Zinovy Royzen, a TRIZ Master. The objectives of TOP-TRIZ development are the increasing the effectiveness and completeness of both problem formulation and problem solving while making the method more user friendlier, easier to learn and apply. Another objective is to maximize utilization of the recourses in order to develop the most ideal solutions. TOP-TRIZ includes further development of problem formulation and problem modeling, development of Standard Solutions into Standard Techniques, further development of ARIZ and Technology Forecasting. TOP-TRIZ has integrated its methods into a universal and user friendly system for innovation. The power of TOP-TRIZ has been proven by solving many difficult problems. A set of courses provides the learners of TOP-TRIZ with different level of practical experience sufficient to achieve outstanding results.

Classical TRIZ

Genrich S. Altshuller, the creator of the Theory of Inventive Problem Solving, stopped development of TRIZ Methods to solve technical problems in 1985. His last version of TRIZ known as Classical TRIZ. It includes the following methods.

- Substance-Field Analysis
- 76 Standard Solutions
- Algorithm for Inventive Problem Solving (ARIZ)
- Laws of Evolution of Technical Systems

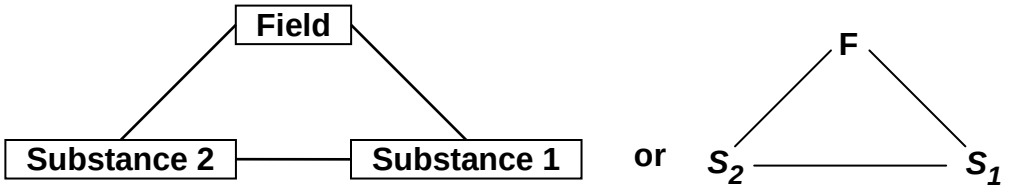
Some people include also 40 Inventive Principles and Contradiction Matrix, the earliest version of TRIZ, even though Altshuller did not mention Inventive Principles in his last technical book titled *To Catch an Idea*.

The most typical question the users, especially beginners, have is what is the problem and how to identify the right TRIZ method to solve it.

Classical Substance-Field Models

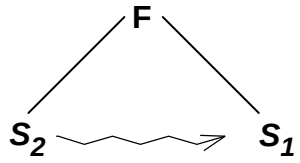
Altshuller's Substance-Field model of the simplest system is composed of three elements — the two substances and a field between them.

Substance-Field Models of the Simplest Useful System



S_1	The object.
S_2	The tool.
F (Field)	Energy or force.

Substance-Field Model of the Simplest System Having a Harmful Action



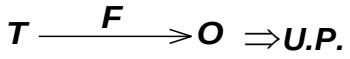
S_1	The object.
S_2	The tool.
F (Field)	Harmful energy or force.

Substance-Field Models describe models of the systems rather than functions. When used for Function Modeling, the Substance-Field models do not provide products or results of the functions.

Tool-Object-Product (TOP) Function Modeling

According to Tool-Object-Product (TOP) Modeling, the complete model of a function has four elements. It has the tool of the function (or the function provider), the object of the function (or recipient of the action of the tool), the action of the tool at the object, and one more component — the product of the function. The action is described by one arrow, which simplifies the model.

TOP Model of a Useful Function



O	The object of the useful action
T	The tool of the useful action
F (Field)	Energy or force, or description of the useful action
U.P.	A useful product.

- An adequate useful action. ⟶
  The value of the useful product meets its requirements.

- An insufficient action. - - - - ⟶
  The value of the useful product is below of its requirements.

TOP Model of an Absent Useful Function

There is an object. It is desired to obtain a useful product, however, there is neither the tool nor the useful action.

O ⇒ ***U.P.***

O	The object of an absent useful function.
U.P.	The desired useful product.

TOP Model of an Absent Useful Function

There is an object and the tool. It is desired to obtain a useful product, however, the action is absent or insufficient.

T - - -> ***O*** ⇒ ***U.P.***

O	The object of an absent or insufficient useful function.
T	The tool of an absent or insufficient useful function.
U.P.	The desired useful product.

TOP Model of a Harmful Function

H.P.	A harmful (unwanted) product or products.
O	The object the harmful action.
F (Field)	Energy or force, or description of the harmful action.
T	The tool or immediate source of the harmful action.

A harmful action is decreased or eliminated.

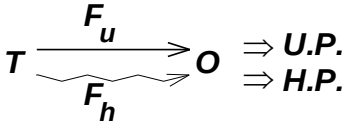
TOP Model of an Unknown Harmful Function

O	The object of the harmful action.
H.P.	A harmful (unwanted) product or products.

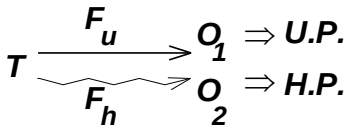
TOP Model of a Conflict

Very often a useful action also causes an unwanted effect, or an attempt to improve a function leads to deterioration in another function of the system. Conflicts are the most difficult type of problem in innovation. TOP-TRIZ offers models to describe any type of conflict.

Conflicting Actions of the Tool on the Same Object



Conflicting Actions of the Tool on Different Objects



Modeling a function by describing all four components — the tool, the object, the action, and the product — improves understanding of both the function and the best ways for its improvement.

Advantages of TOP Function Modeling:

- **Universal Model of a Function**
  Neither the tool of the function nor the object of the function has to be a substance as it is required in Substance-Field Model. In TOP-TRIZ Model, an object is anything we want to modify. It can be a field. TOP Function Modeling allows you to model any function in any system. It is a more generic way to model a function than Substance-Field Modeling.

- **Complete Description of a Function**
  Desired and unwanted products of the functions of a modeled system improve understanding of the system and simplify analysis of the system resources.

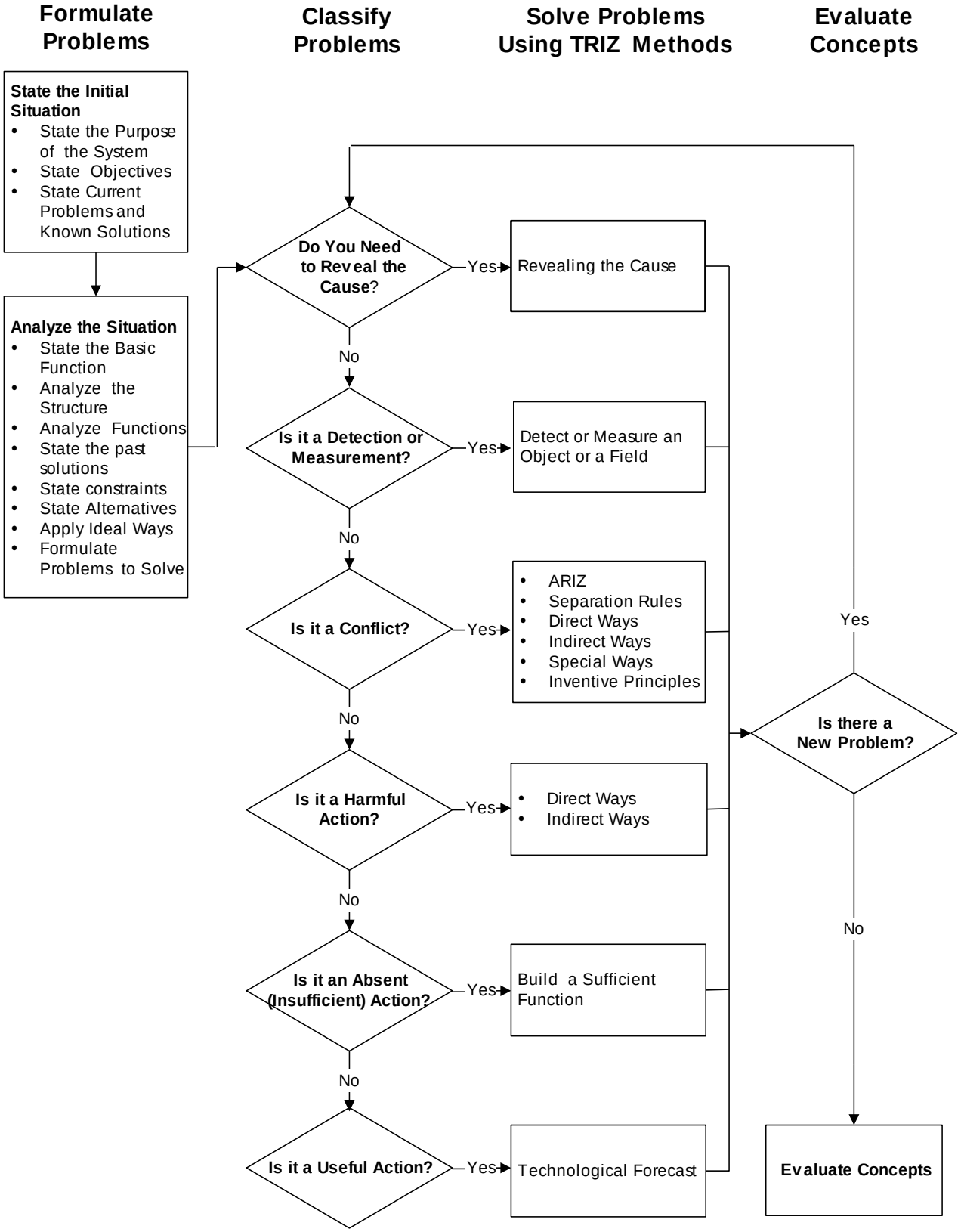
- **Link Between Functions**
  Introducing the product of a function into its model provides a very convenient and understandable link between functions. For example, a product of the first function can be a tool or an object of a subsequent function.

  The link between functions is important in understanding not only a desired performance of a product, but also the chain of unwanted functions. Links between functions simplify cause-effect analysis and improve the process of revealing the cause of a current or potential failure of a product.

- **Increasing Effectiveness of Function Analysis**
  TOP-Function Modeling is supported by templates to guide you in modeling any type of functions and in describing the performance of your system, its interaction with its supersystem and environment by a number of functions.

- **Problem Classification**
  Any single function or a conflict can be considered separately and classified according to TOP-TRIZ Flow Chart. Function modeling helps you to understand the system's performance, state the set of problems to consider, classify the problems, and determine the TRIZ Methods to be applied according to the TOP-TRIZ Flow Chart.

TOP-TRIZ Flow Chart



TOP-TRIZ Problem Formulation

TOP-TRIZ Problem Formulation is a universal approach to analyze any situation needing an improvement. It includes TOP-TRIZ Function Analysis of the current problems of the project, known solutions to these problems and their disadvantages, analysis of the history of the problem and constraints. It includes analysis of the alternatives of the system and Ideal Ways.

Ideal Ways is an analytical method made up of the ideal directions for improving the situation. For example, if a component of the system is involved in a disadvantage, Ideal Way 1 suggests two ways to get rid of the component by eliminating its function. Ideal Way 2 suggests two ways to get rid of the component by its substitution. Ideal Way 3 guides you to make the component itself eliminate its disadvantage.

TOP-TRIZ problem formulation guides you to develop an exhaustive set of problems associated with your system and its need for an innovative solution.

TOP-TRIZ Problem Solving

TOP-TRIZ Flow Chart classifies problems into six classes and offers corresponding problem solving methods for each class of problems. The methods include Standard Techniques and Conflict Solving algorithm (TOP-ARIZ). TOP-TRIZ problem solving methods guides you to develop an exhaustive set of innovative solutions. It also aims to maximize utilization of the resources of the system, its supersystem and environment to make the best solutions inexpensive.

Standard Techniques

TRIZ Standard Techniques is a further improvement of Altshuller's Standard Solutions. Some Rules were reformulated, some new rule were added. Some Standards were integrated, so the total number of the Standards was reduced.

Reclassification of the Standards helps to develop the most simple and user friendly Flow Chart.

Standard Techniques are step-by-step guides for applying generic solutions to your problem and developing specific solutions by utilizing the resources.

A Standard Solution comprises a rule and an example. Each Standard Technique includes also a step-by-step approach to apply the rule to your problem. For example, Standard to eliminate a harmful action by introduction of a substance-insulator became more than a page-long guide how to do it and where to look for this substance-insulator.

As a result of such development, Standard Techniques became both more effective and easier to apply methods than Standard Techniques. In addition, general problem solving

techniques like Standard Techniques to Build a Sufficient Function and for Harmful Function elimination are used also for revealing the causes of the failure, reducing the number of methods to learn and shortening the time of training.

Conflict Solving Algorithm (TOP- ARIZ)

TOP-ARIZ is further development of Altshuller's ARIZ. Integration of TRIZ Methods allowed reducing the number of steps in ARIZ and improving its effectiveness. The steps were redesigned and each step received a template.

Initial function analysis of a system has improved identification of the right conflicts. TOP function modeling improves understanding of the conflict, its opposite versions, the function of X-resource and its product. One of the most difficult steps in ARIZ – formulation of the physical contradiction — is simplified significantly. Techniques for Physical Contradiction Separation are reformulated, supplied with templates and an additional technique was added.

As a result, most difficult problems with contradictions involved can be routinely solved while minimizing product changes and costs.

The Process of TOP-TRIZ Problem Solving

TOP-TRIZ Flow Chart guides you from the very beginning of the process. In general, problem formulation results in an exhaustive set of problems. Selecting one problem at a time, the user classifies the problem according the TOP-TRIZ Flow Chart and identifies the methods to apply. Each method could help to develop a number of concepts. However, it very seldom, any of the concepts could be implemented right away. In most cases, any concept could bring at least one or two new or subsequent problems.

Subsequent Problems

No matter what class of the original problem is, the most common subsequent problems are the following.

- A concept while solving the first problem causes deterioration of a feature or a function. So, it is a conflict.
- A concept requires to modify a resource or to derive what is needed to solve the first problem out of an available resource. This class of problems is an absent action.
- A new action has to be performed in a certain time. This class of problems is detection or measurement.

In the worst situation, a concept might cause all three new problems together.

A subsequent problem is not the reason to reject a concept. TOP-TRIZ Flow Chart guides you to classify a new problem and apply the corresponding methods. And again, a number of concepts could be developed to solve this new problem. And again, the best

concept might bring their own new problems. And again, new problems have to be classified according to TOP-TRIZ Flow Chart. And so on, until there are no more new problems needing innovative solutions.

In addition, there is one more type of subsequent problems which is ignored in many cases by not TOP-TRIZ users. The fact is that no matter how your new concept is good, there are always next steps according to technology forecasting. These steps could be to be discovered by a problem solver right away. However, many users consider technology forecasting as a tool for rood mapping of innovation and, therefore, do not apply while working on a single problem loosing an opportunity to enhance the best concepts.

TOP-TRIZ methodology guides you in your project to formulate an exhaustive set of problems associated with your system, the current problem and your objectives.
Then, TOP-TRIZ guides you to develop an exhaustive set of the best solutions.
This approach helps you not only select the most ideal solution for implementing. Having the exhaustive set of the commercially applicable solutions is the basis for a reliable patent protection of your business.

TOP-TRIZ methodology provides advantages in systematic innovation in order to develop better products and processes at a lower cost and in less time while being user friendly.

- Helps develop breakthrough concepts and ideas
- Helps to solve six classis of problems including contradictions
- Leads to maximize the resources in order to develop better products at a lower cost
- less number of people involved and less time needed to develop an innovative solution to a problem
- Estimation of time for each step and the whole process
- Increases efficiency and effectiveness of creative work
- Develops the winning concepts faster
- Helps pursue competitive advantage

Elegant and valuable solutions to your most difficult design and manufacturing problems can be obtained much faster. The right solution at right time can potentially save hundreds of man-hours, millions of dollars, and accelerate a project by days, months, even years.

Teaching TOP-TRIZ

The complete program includes three 40-hour courses.

1. Designing and Manufacturing Better Products faster Using TRIZ. It is my basic course. It is a 40-hour course and can be conducted as five-day course.
2. Advanced Practice TRIZ Course. It is an entirely practice course (21 cases) and can be conducted as a five-day course or remotely via WebEx, 2 hours a week.

3. TRIZ Practitioner Course. It is also an entirely practice course (21 cases) and can be conducted as a five-day course or remotely via WebEx, 2 hours a week.

The Program of Designing and Manufacturing Better Products Faster Using TRIZ

- Basic concepts of TRIZ
- Analysis of a system and problem formulation
- Solving a class of problems called *Insufficient Function*
- Solving a class of problems called *Conflict*
  - Algorithm for Conflict Solving
  - Five techniques for Physical Contradiction Separation
  - Special Ways to introduce new resources without causing subsequent problems
  - 40 Inventive Principles and Contradiction Matrix
- Solving a class of problems called *Harmful or Unwanted Function*
- Solving a class of problems called *Measurement*
- Solving a class of problems called *Revealing the Cause of a Failure*
- Technology Forecasting
- Concept evaluation
- Combined application of TRIZ Methods
- Solving problems brought by participants.

Advanced Courses

The objective of the advanced courses is to help TRIZ users in gaining advanced level experience in applying TRIZ and confidence in working on their real-life problems and facilitation of TRIZ facilitation of teams.

The TOP-TRIZ courses provide the learners with practical experience sufficient to achieve outstanding results. For example, Peter R. Menge, Ph. D., Senior Scientist at Saint-Gobain Crystals wrote me the following.

"I have taken many professional development training courses over my career in science and engineering. I found the Basic TRIZ and Advanced Practice TRIZ courses to be the most useful, the most stimulating, and the most satisfying of these trainings. Although I have only been applying the techniques and algorithms for a few months, I have been able to find new solutions to chronic manufacturing problems in our plant. The process can be used on low tech and high tech levels. I have used the method from simply helping to take cost out of a manufacturing process to developing intellectual property based on new solid state physics. Two features of TRIZ that I really find to be especially valuable are:

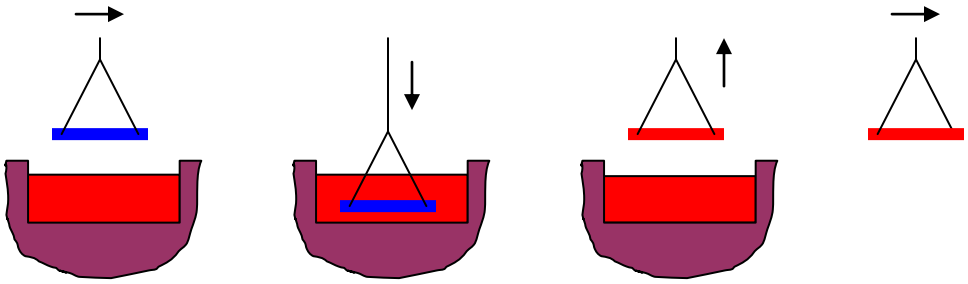
1) The functional analysis process forces you understand what the problem really is on a fundamental level.

2) The TOP-TRIZ algorithm is complete. You can't miss what the general solutions are. You can be confident that if a solution to your challenge exists, you will find it."

TOP-TRIZ Applications

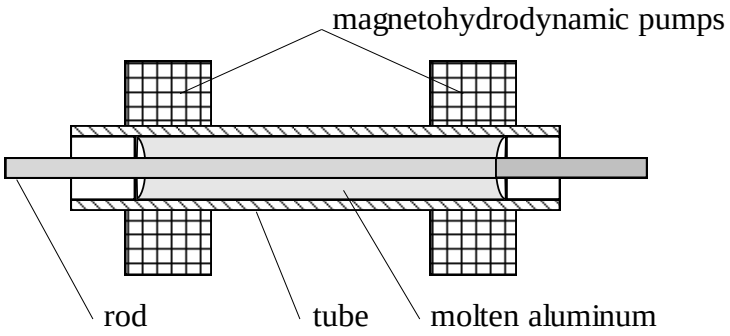
Case 1. Plating Steel Rods and Pipes with Aluminum

Background of the problem
An old system for plating steel rods and pipes with aluminum included a well in the ground of a shop filled with molten aluminum at 700-740° C and a conveyer moving steel pipes and rods. Preheated pipes and rods were submersed into molten aluminum for a short period of time and then removed with a coat of aluminum which protects steel pipes and rods against corrosion.



Old process of plating steel rods and pipes with aluminum

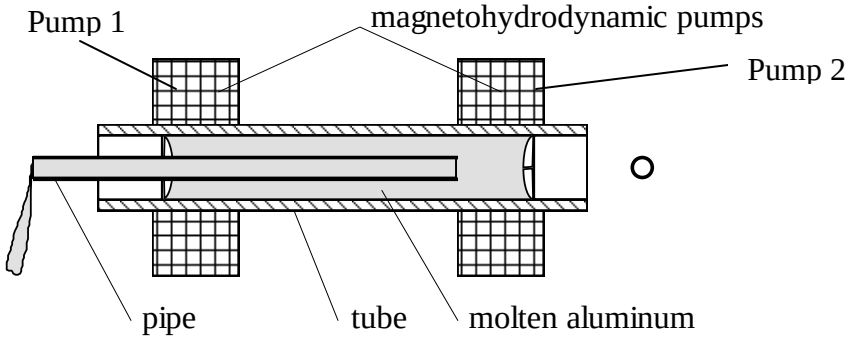
A new system for plating steel rods and pipe with aluminum was developed in order to increase the rate of production. The new system includes a tube and two pumps utilizing the magnetohydrodynamic (MHD) phenomenon. When a magnetic field and an electric current intersect in a liquid, their repulsive interaction propels the liquid in a direction perpendicular to both the field and the current. The pumps keep molten aluminum in the tube, and a rod passing through the tube is plated with aluminum.



Plating steel rods

The test of the new system was a success for plating rods. Strait line motion of the rods increased productivity of the process. In addition, the new system removed excess of aluminum, decreased loss of aluminum due to oxidation, decreased energy loss and improved the shop environment. However, there was a problem with plating pipes. High temperature (700-740° C) molten aluminum was pumped out of the tube through the pipe inserted in the tube.

The cause of the failure was understood. A steel (ferromagnetic) pipe does not allow a magnetic field to pass through it, thus there are no forces to keep molten aluminum inside.



Plating steel pipes

The pipes have to be plated outside and inside. After working on the problem for a half a year without a result, the team requested help.

Initial Situation

1. The purpose of the system is *to plate steel pipes with aluminum.*
2. The objective of the project *is to eliminate leakage of aluminum from pipes.*
3. Current problem. *Aluminum leaks from a pipe going through the tube*
4. State known solutions. State advantages and disadvantages of known solutions.

   A. Collecting aluminum escaping from the pipe and returning it back to the system. This solution complicates the system.

   B. Sealing the pipes for plating the outside surface and different methods of plating the inside of the pipes.
   This solution requires another piece of equipment to plate pipes inside.

Analyze the Situation

1. The basic function of the system is to plate steel pipes with aluminum.
2. Describe the structure:

The system includes:

MHD Pump 1
MHD Pump 2
Tube
Molten Aluminum
Heater
Feeding mechanism
Steel pipe

The Supersystem

Laboratory (Shop)

The Environment

Air

3. Analyze functions and formulate problems.

TOP Function Modeling

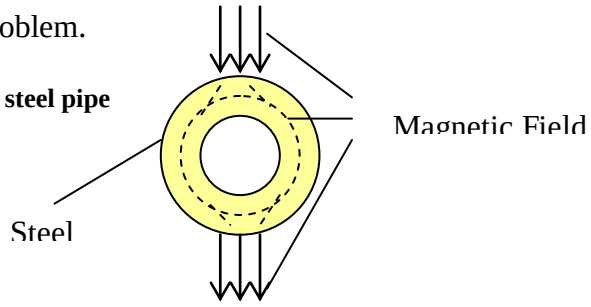
Pump 2 pumps molten aluminum out from the pipe.

The harmful function is caused by disabling the pump 1 to hold aluminum.

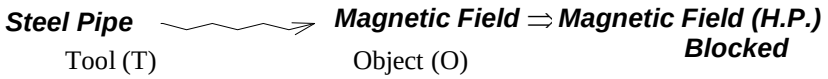
Pump 1 is unable to hold aluminum because a steel pipe blocks magnetic field.

This is the root cause of the problem.

There is no magnetic field inside a steel pipe



It is a harmful function and according to TOP-TRIZ Flow Chart we need to Standard Techniques for Harmful Action Elimination comprising Direct Ways and Indirect Ways.



Direct Ways

Problem ➡ Solution There is a harmful action on an object O T —F→ O Eliminate the harmful action	Description
T —F→ O, F blocked by S_x; S_x =?	Insulate O from the harmful action by a substance-insulator S_x.
T —F→ O, F_x =?	Counteract the harmful action with the opposing field F_x.
T, F, O, S_x =?	Protect O from the harmful action by a safety substance S_x which attracts the harmful action on itself.
T_m —F→ O, T_m=?	Modify the tool (source) of the harmful action T to turn off the harmful action.
T —F→ O_m, O_m=?	Modify O to be non sensitive to the harmful action.
T —F→ O	Alter the amount of the zone of the harmful action, its duration or both to decrease the harmful action or eliminate it completely.

Concept
There is a need to modify the Pipe (Tool) to make it stop blocking the magnetic field.

New Problem

Steel Pipe ⇒ ***Steel Pipe***

It is an absent action and according to TOP-TRIZ Flow Chart we need Build a Sufficient Function.

Problem: ⇨ **Solution according to Rule 1:**

Steel Pipe ⇒ ***Steel Pipe***

Tx $\xrightarrow{Fx}$ ***Steel Pipe*** ⇒ ***Steel Pipe Modified***

F_X =?

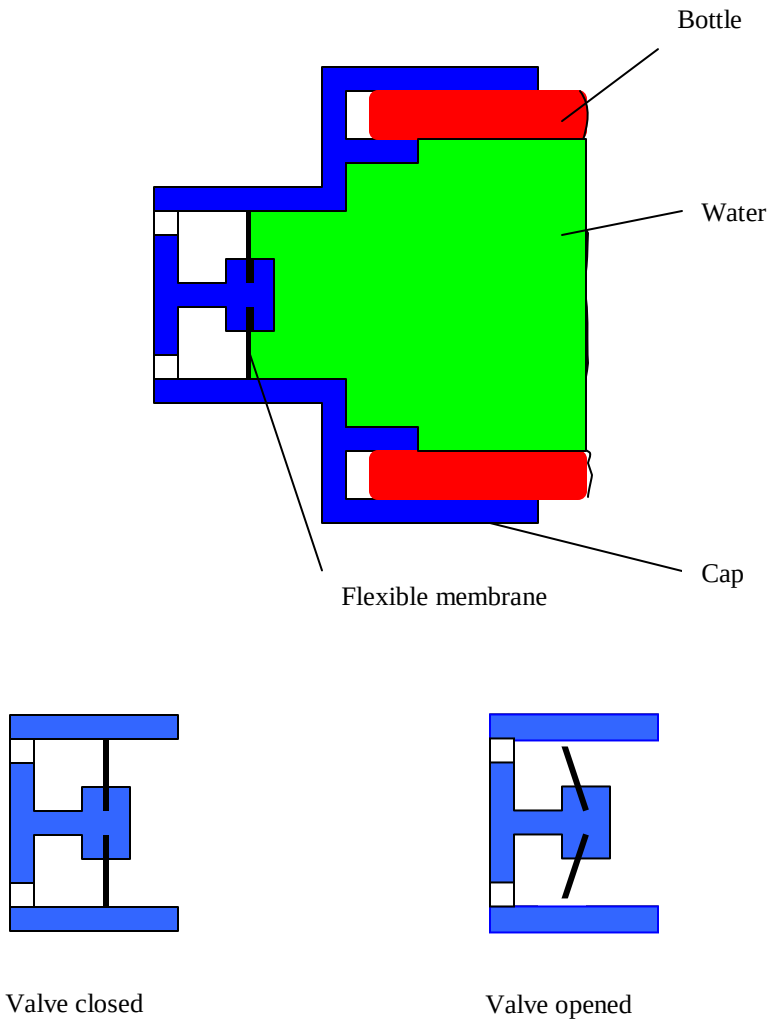
Identify the field F_X. It may be:

- Mechanical fields
- Thermal fields.
- Chemical reaction.
- Electric current.
- Magnetic field.
- Electromagnetic fields.

It was recommended to heat pipes over Curie point of steel which is 770° C.

Case 2. Water Bottle Cap Problem

A water bottle cap which avoid the need for manual positioning of the valve and which permits dispensing water by application of suction, should open easily at suction pressures less than -0.38 psi. The problem is that under normal use, sometimes internal container water pressure can be greater than 0.38 psi, and thus the valve can leak water. Also, water has to be released by squeezing the bottle with pressure applied to the valve not less than, for example, 1 psi. After working on the problem for a year without a result, the team turned to TOP-TRIZ.



Water bottle cap with a flexible membrane

Initial Situation

1. The purpose of the system is to seal water in the bottle and release water by sucking.

2. The objective of the project is to design a closure that meets the following requirements.
   - One hand bottle use
   - Opening the valve by sucking with ΔP not more than 0.38 psi
   - Dispensing water by squeezing the bottle.
   - No leakage

3. Current problem. Valve designed for easy opening by sucking leaks under normal conditions of use.

4. State known solutions. State advantages and disadvantages of known solutions.
   - Push to open valve. Eliminates leakage. It takes two hands to operate.
   - Twist to open valve. Eliminates leakage. It takes two hands to operate.
   - "Stiff " Valve. Eliminates leakage. It does not open by sucking.

Analyze the Situation

1. **The basic function of the system is to seal and dispense water.**

2. **Describe the system, supersystem and environment.**

   The system:

   Cap
   - Case
   - Stem
   - Valve

   Water Bottle

   Water

   Air in the bottle

   The supersystem:

   Customer

   The environment:

   Air

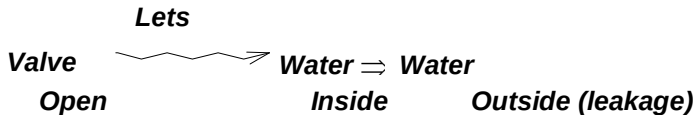
   Outside Forces

3. Analyze functions and formulate problems.

The Current Problem (Problem 1)

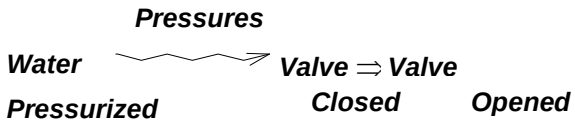
Water leaks through the cap under normal conditions of use because ΔP applied across the valve could be more than 0.38 psi.

Model of the harmful function.



Problem 2.

The Problem 1 is caused because the Valve is opened.
Model of the harmful function.

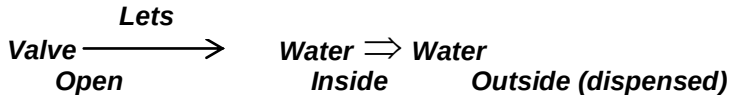


The harmful function is caused because water in the bottle is pressurized by an outside force. However, the valve was designed to be opened when 0.38 psi applied across it.
The open valve causes leakage of water.

The useful functions of the valve are to open and to seal water.

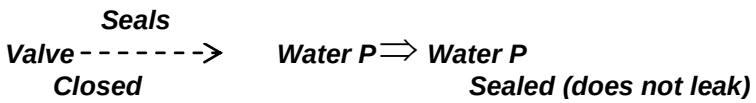
1. The function of the valve is to open water.

Model of the function.



In order to perform the function there is a need to apply suction with *ΔP=0.38 psi*.

2. The function of the valve is to seal water.
Model of the function.

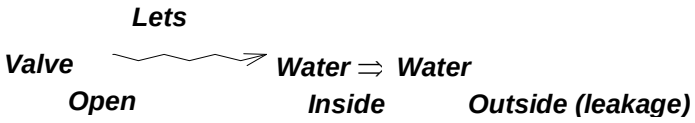


It is also possible to say that the function of the valve is to press the wall in order to seal water.

The function is insufficient. The valve is flexible in order to open it easily. A known solution is to make it "stiffer."

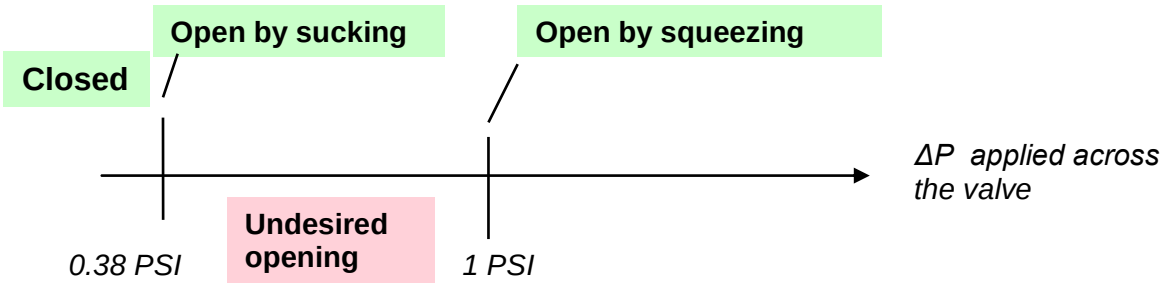
List of Problems

Problem 1.



Problem 2.

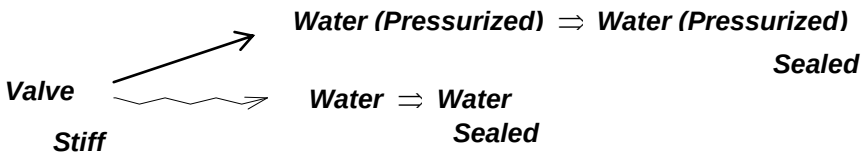
Problem 2 is the preferred problem to start.



Known Solution

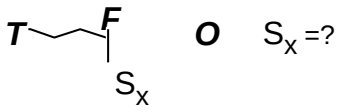
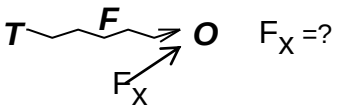
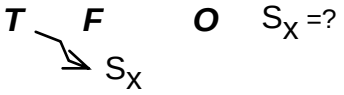
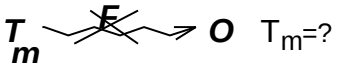
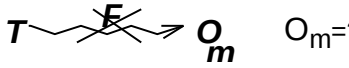
A "stiff" valve eliminates leakage by sealing water; however, water will be sealed even when suction is applied.

Problem 3. Conflict



Problem 2

Direct Ways

Problem ➡ Solution There is a harmful action on an object O T F O Eliminate the harmful action	Description
	Insulate O from the harmful action by a substance-insulator S_x.
	Counteract the harmful action with the opposing field F_x.
	Protect O from the harmful action by a safety substance S_x which attracts the harmful action on itself.
	Modify the tool (source) of the harmful action T to turn off the harmful action.
	Modify O to be non sensitive to the harmful action. *A stiff valve.* *Problem 3.* *A stiff valve will not be opened by sucking.*
	Alter the amount of the zone of the harmful action, its duration or both to decrease the harmful action or eliminate it completely. *In order to reduce total amount of the harmful action we need to decrease the area of the valve exposed to water.* *Problem 4. A smaller area of the valve exposed to water will not be sufficient to open the valve by sucking.*

According to Direct Ways, there are two solutions to Problem 2.

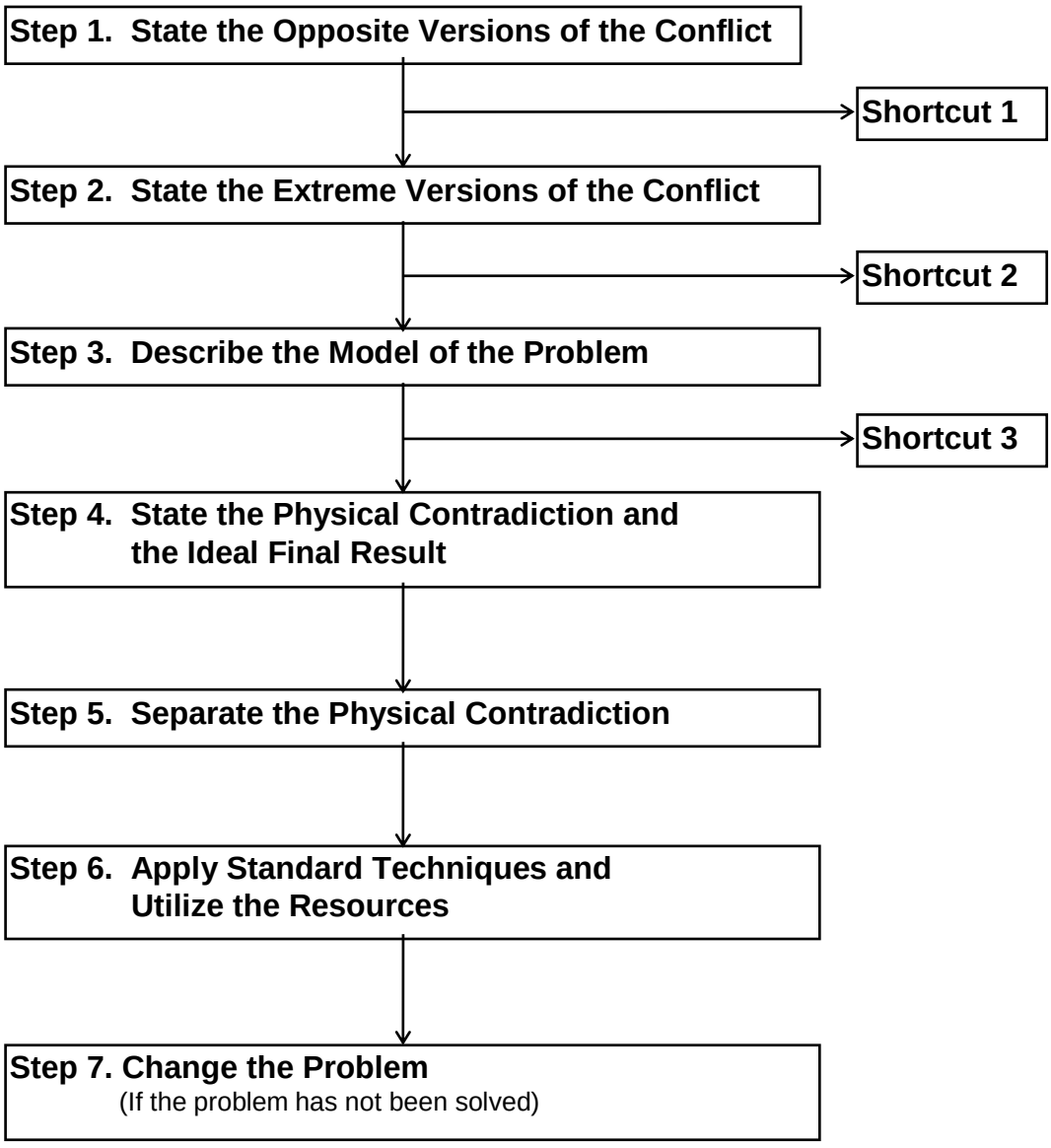
A. A stiff valve. This solution causes a new problem. A stiff valve will not be opened by sucking.

B. A smaller area of the valve is exposed to water. This solution causes a new problem. The valve will not be opened by sucking.

An attempt to solve this problem improves understanding of the physics involved.

Problem 3. Conflict

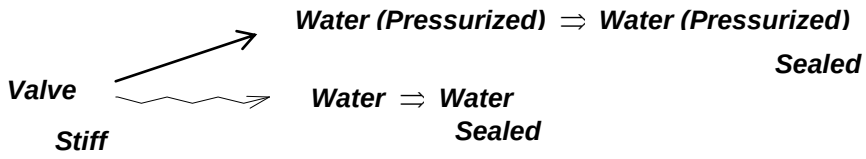
TOP-ARIZ Flow Chart



Algorithm for Inventive Problem Solving

Step 1. State the Opposite Versions of the Conflict

- The system for sealing and dispensing water includes a ~~valve~~ ***Membrane***, water and pressurized water.
  Model of the conflict.



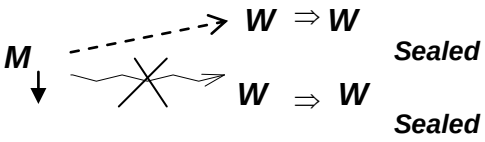
- **State the Opposite Versions of the Conflict**

Conflict 1.

In order to dispense water by sucking

the membrane has to be flexible

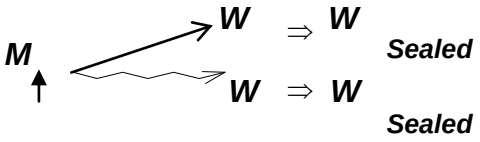
but it does not seal pressurized water.



Conflict 2.

In order to seal pressurized water

the membrane has to be stiff
but it will not dispense water by sucking.



- A minimum alteration of the system has to provide dispensing water by sucking and sealing pressurized water without any complication or deterioration of the system or anything else.

- Shortcut 1. Separate Preliminary Physical Contradiction 1.
  The membrane has to be flexible and stiff.

  1. Separation in Space
  2. Separation in Time
  3. Separation Between the Components
  4. Separation Between the Components and the Set of the Components
  5. Separation Between Parameters

Separate the Physical Contradiction

The valve has to be flexible to be opened by sucking and has to be stiff in order to prevent its opening by pressurized water.

Separation in Space

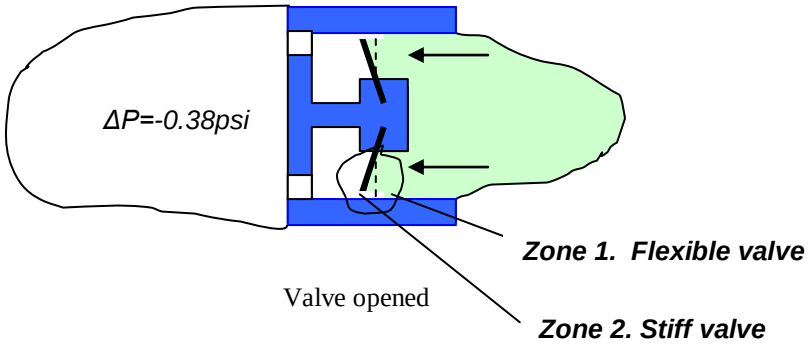
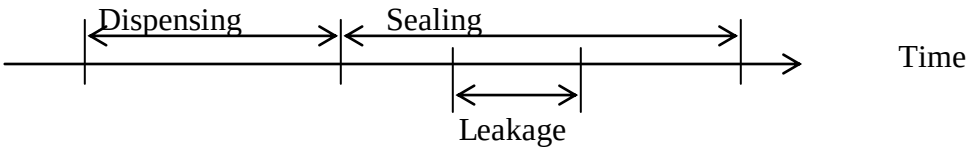


Figure 11: Water bottle cap

Separation in Time



Separation Between the Components

Two valves. Existing valve has to be flexible. A new valve has to be stiff.

Separation Between the Components and the Set of the Components

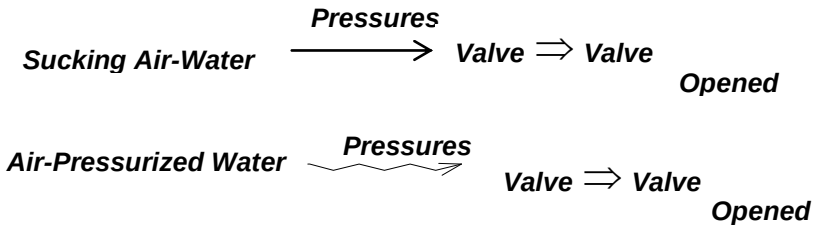
Both valves are flexible. The system of the flexible valves is stiff.

Separation Between Parameters

Opening of the valve depends on the force applied to the valve.

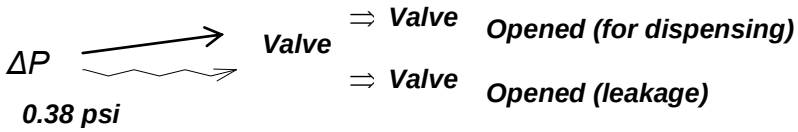
$F = \Delta P \times Area$

Another way to analyze the situation is the following.



The valve is opened when ΔP =0.38 psi applied across it. Even though the tools of the functions are different, the ΔP is the same.

From this point of view the following conflict can be stated.

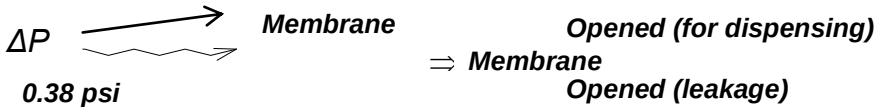


TOP-ARIZ

Step 1. State the Opposite Versions of the Conflict

- The system for sealing and dispensing water includes a ~~valve~~ Membrane and the pressure across the valve.

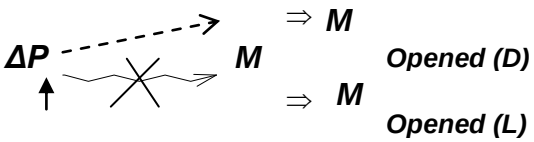
- Model of the conflict.



- **State the Opposite Versions of the Conflict**

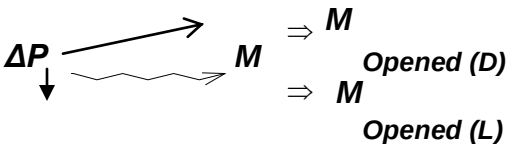
Conflict 1.

In order to eliminate opening of the membrane (leakage) the ΔP across the membrane has to be increased, but the membrane will not be opened by sucking.



Conflict 2.

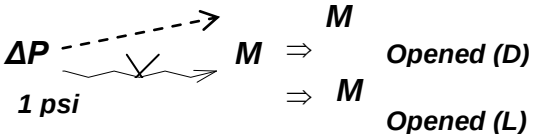
In order to open the membrane by sucking the ΔP across the membrane has to be decreased, but the membrane will be opened by pressurized water (leakage).



Step 2. State the Extreme Versions of the Conflict

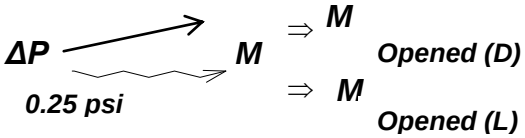
Extreme Conflict 1.

If the ΔP across the membrane is 1 psi in order to eliminate opening of the membrane (leakage) completely, the membrane will not be opened by sucking.



Extreme Conflict 2.

If the ΔP across the membrane is less 0.25 psi in order to open the membrane by sucking easily, the membrane will be opened by pressurized water (leakage).

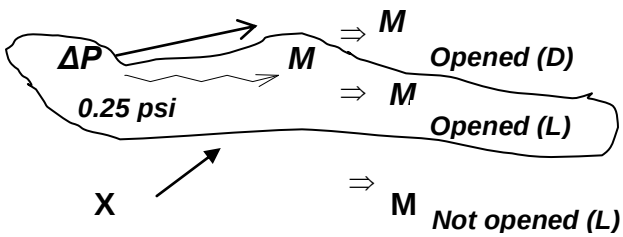


Step 3. Describe the Model of the Problem

- Conflict 2 is better for the basic function of the system.
- It is necessary to identify an *X*-resource:

X-resource has to eliminate opening of the membrane by pressurized water (leakage).

X-resource must not deteriorate easiness of opening the membrane by sucking.



Step 4. State the Physical Contradiction and the Ideal Final Result

- **Define Macro Level Physical Contradiction.**

  In order to eliminate opening of the membrane by pressurized water (leakage), the membrane has to have no opening force **and** the membrane has to have an opening force in order to be opened by sucking.

  .

- **State the Ideal Final Result**

  During the operating time, the zone of the conflict itself has to provide *membrane with an opening force and no opening force.*

Step 5. Separate the Physical Contradiction

Separation in Space

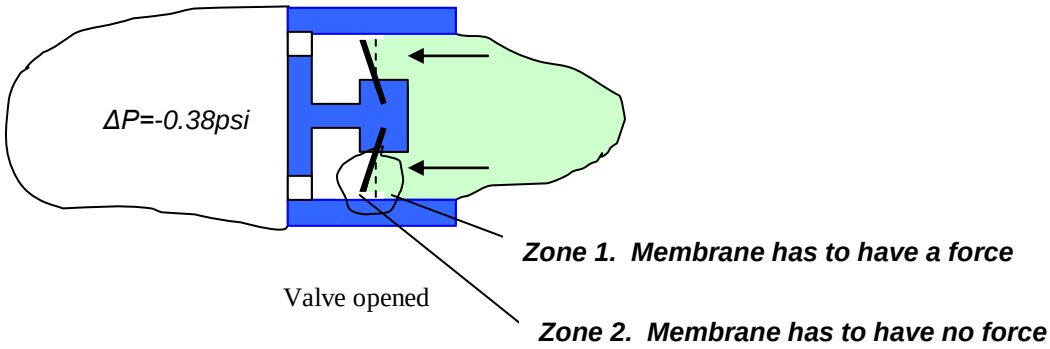
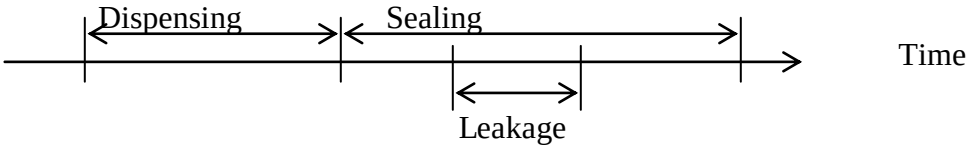


Figure 12: Water bottle cap

Separation in Time



Separation Between Parameters

Opening of the membrane depends on the force applied to the valve.

$$F = \Delta P \times Area$$

In order to have opening force and no opening force having the same ΔP across the valve when sucking and when water pressurized, area of the valve exposed to pressurized water has to be smaller than the area of the valve exposed to suction.
"It is clear that through the application of TRIZ we were able to generate more concepts in two days than the contracted inventors were able to accomplish in over a year. Also

the concepts and approaches we developed with your help are founded in sound engineering principles."
Larry Smeyak

US006832706B2

(12) **United States Patent**
Hearld et al.

(10) **Patent No.: US 6,832,706 B2**
(45) **Date of Patent: Dec. 21, 2004**

(54) **DISPENSING CLOSURE**

(75) Inventors: **Coy Hearld**, Crawfordsville, IN (US); **Lawrence Smeyak**, Crawfordsville, IN (US); **Hassan Najdawi**, Crawfordsville, IN (US); **David Babcock**, Crawfordsville, IN (US); **Ramesh Kamath**, Crawfordsville, IN (US); **Mark Powell**, Crawfordsville, IN (US); **Zinovy Royzen**, Seattle, WA (US)

(73) Assignee: **Alcoa Closure Systems International**, Crawfordsville, IN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 46 days.

(21) Appl. No.: **10/340,319**

(22) Filed: **Jan. 10, 2003**

(65) **Prior Publication Data**

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(51) **Int. Cl.**[7] **B65D 25/40**
(52) **U.S. Cl.** **222/494**; 222/482
(58) **Field of Search** 222/212, 481.5, 222/482, 494, 153.14, 556, 545; 137/852, 854

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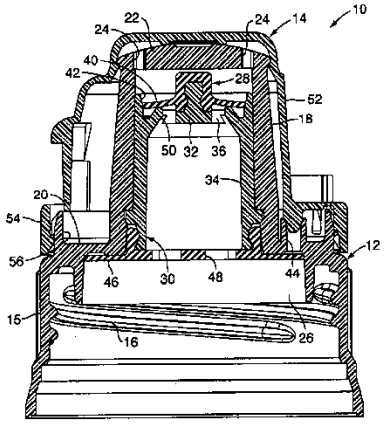
Primary Examiner—Gene Mancene
Assistant Examiner—Patrick Buechner
(74) *Attorney, Agent, or Firm*—Stephen D. Geimer

(57) **ABSTRACT**

A dispensing closure assembly includes an outer closure body having an upper tubular portion which can function as a mouthpiece for users. The closure assembly includes a flexible valve member mounted within the tubular portion of the closure body for dispensing of liquids or like contents by either the application of suction by a consumer, or by squeezing the associated container. By the provision of a liquid seal lip which coacts with an inside surface of the flexible valve member, the closure assembly can be configured to facilitate convenient use by consumers, while avoiding undesirable leakage attendant to normal handling during use.

16 Claims, 11 Drawing Sheets



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