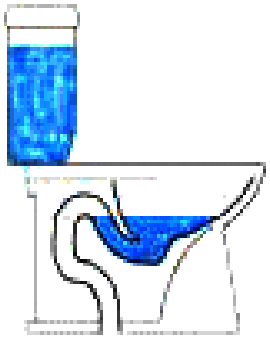
USIT Case Study 3. Saving Water for a Toilet System



References:

[1] Source: 'Practical Case Study of Resolving the Physical Contradiction in TRIZ; Super Water-Saving Toilet System Using Flexible Tube', Hong Suk Lee and Kyeong-Won Lee (Korea Polytechnic Univ., Korea), TRIZ Journal, Nov. 2003

[2] Japanese translation: '"Practical Case Study of Resolving the Physical Contradiction in TRIZ; Super Water-Saving Toilet System Using Flexible Tube', Japanese translation by Eiji Fukuzawa and Toru Nakagawa, "TRIZ Home Page in Japan", posted on Jan. 8, 2004

[3] Introduction: "A New Generation of TRIZ" , Toru Nakagawa, 1st TRIZ symposium in Japan, Sept. 1-3, 2005, at Shuzenji; "TRIZ Home Page in Japan", Sept. 20, 2005 (in Japanese and in English)

[4] Description of this case study: "USIT Case Study (3)", by Toru Nakagawa (OGU), May 13, 2015 (in Japanese), Jun. 4, 2015 (in English)

USIT Case Study 3. Saving Water for a Toilet System

Introduction: Outline and Significance of this Case Study

The present case was developed by Prof. Kyeong Won Lee and his group in Korea and was published in the (online) TRIZ Journal in Nov. 2003.

The flush lavatory system was patented in 1874 and has been used over 140 years all over the world.

Saving the water for flushing the stool is much desirable in many areas where water supply is limited; it has been a problem that everybody knew in the world but it has not been solved well.

The problem is caused by the S-shape pipe behind the basin; the S-shape pipe is necessary but makes a barrier for flushing the water. -- Everybody knows.

The authors recognized this problem in terms of the 'Physical Contradiction' in TRIZ and solved it by use of Altshuller's Separation Principle.

Their logic is simple and clear, and their thinking process is applicable widely.
This case study is an excellent material for studying the Physical Contradiction in TRIZ and Separation Principle for solving it.

The present documents of 'USIT Case Studies' intends to illustrate examples of creative problem solving in general with the paradigm of 'Six-Box Scheme', and hence adopted the present case study as the 3rd in the collection.

It is remarkable that the original authors described their trials for making their solutions into commercial products.

A familiar and important problem was solved nicely with the concept of Physical Contradiction in TRIZ.

USIT Case Study 3. Saving Water for a Toilet System

Table of Contents

[Case 3. Toilet] Step 1. Define the Problem (1) Preparation: Development Project

In the Real World, raise an issue and prepare for a Project of problem solving

(1) Preparation: Start a Project for Developing the Water-Saving technology of Toilet

On the basis of the original paper and the talk with Prof. Lee,
this page was described by Nakagawa.

Situation: The large amount of water necessary for flushing lavatory is a serious social problem in the world. So we wish to develop a technology for solving the problem and to make a business by licensing patents. .

Target: To develop a technology of water-saving toilet system by use of TRIZ we already mastered. To make a patent of the technology and license it to some manufacturers and get the profit.

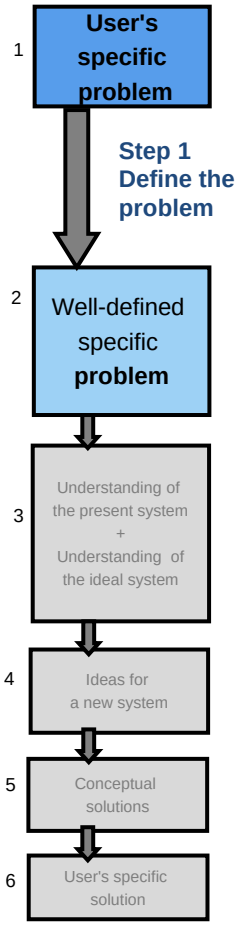
Project: A development project in a start-up company (Korea Item Development, Inc.) which was recently founded by Prof. K.W.. Lee.

Activities: Not disclosed. A technology development project with a very few member.

Team: Not disclosed. Supposedly: Main engineer: Hong Suk Lee, Manager: Prof. Kyeong Won Lee

Theme: Sanitary equipment necessary for everyday life

[Case 3. Toilet] Step 1. Define the Problem (2) Clarify the problem situations



Define the Problem

According to the original paper:

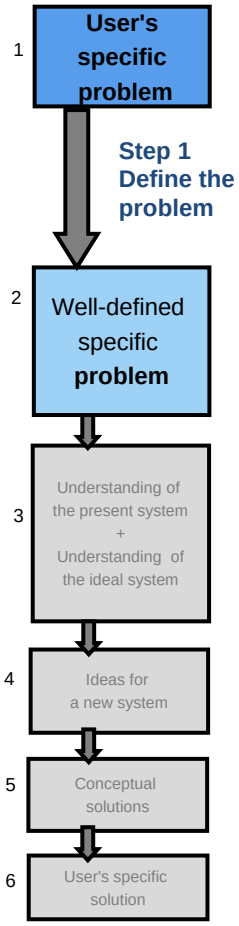
- South Korea is a country suffering from the shortage of water; an important social issue.
- For overcoming the shortage of water, saving water of the flush lavatory is important.
- The amount of water consumed for flushing lavatory is estimated about 27% of the water consumed at home and over 50% of the water used in commercial complexes.
- In conventional toilet system, about 13 liters of water is used at a time. (6 liters even for a water-saving type system)

The authors used QFD for understanding the users' needs and for focusing the problem:

Customer needs		**Design parameter**	
	....	S-shape pipe structure	....
1. Removing stool		NO S-shape pipe is better	
2. Washing/cleaning the basin		NO S-shape pipe is better	
3. Preventing bad odor from the sewerage		Necessity	
4. Saving water for washing		NO S-shape pipe is better	
5. Reducing noise during the flushing		NO S-shape pipe is better	

Actually, the problem is directly understood as contradictions without use of QFD, according to Prof. Lee.

[Case 3. Toilet] Step 1. Define the Problem (2) Clarify the problem situations



Define the Problem (using the standard template in the USIT Manual)

Hong Suk Lee & Kyeong-Won Lee (Korea) TRIZ Journal (Nov., 2003)
'TRIZ homepage' (Jan., 2004)

Step 1. Define the Problem

USIT Standard format of is used here.

(a) An unwanted effect:

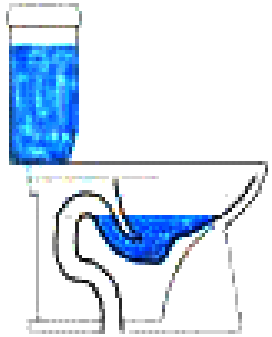
Flushing lavatory is clean and comfortable, but it waste much water when it flushes water for sending away stool. About 6 to 13 liters at a time, This is a serious problem for the countries and seasons of shortage of water.

(b) Task statement:

Drastically reduce the amount of water necessary for flushing stool at a flushing lavatory.

(c) Simple sketch of the problem situation:

For flushing the stool, water is flushed suddenly in a much amount.



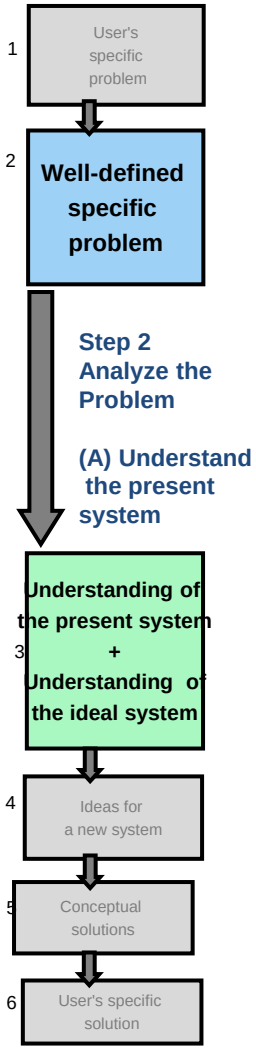
(d) Plausible root causes:

Behind the basin, the pipe is lifted in an S-shape. A large amount of water is necessary for overcoming this barrier for flushing.

(e) A minimum set of relevant objects:

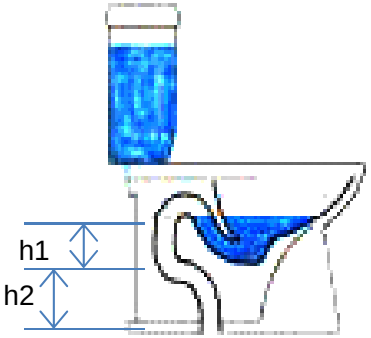
Basin, Stool, Water (water in the basin, additional flushing water) , S-shape pipe, sewerage, water tank

[Case 3. Toilet] Step 2: Analyze the Problem (A) Understand the present system



(A1) Understand the Space Characteristics

The pipe behind the basin is made in the form of S-shape:
For keeping water in the basin at ordinary period, especially during the usage of toilet, we need the height h1 about 15 cm.
For using the siphon effect at the time of flushing away the stool, the lowest part of the pipe should locate below the basin bottom by h2, about 15-20 cm.



(A2) Understand the Time Characteristics

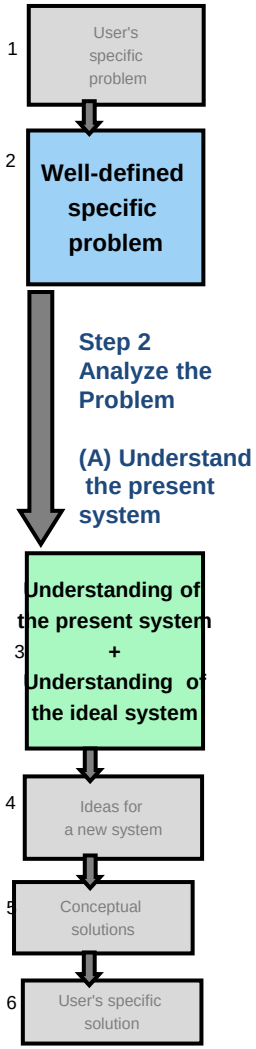
The temporal cycles of usage are as follows:

Ordinary (non-usage) period: Keep the water in the basin, for the purpose of preventing bad smell from coming out through the pipe, and keeping the basin wall wet and clean.

During usage: The stool is kept in the water of the basin, without sticking to the basin wall.

At the end of usage: The user turns a knob (or a switch) to put additional water in the basin.
The water goes beyond the top part of the S-shape pipe and the stool and water flow down through the pipe.
By the siphon effect, all the water in the basin flows down till the basin becomes empty.
Some more water is put in the basin, and return to the ordinary state.

[Case 3. Toilet] Step 2: Analyze the Problem (A) Understand the present system



(A3) Understand the Attributes (properties)

This page is inserted by Nakagawa

Object	Attributes which increase the water requirement	Attributes which decrease the water requirement	Attributes irrelevant to the water requirement
Stool	Hardness, amount		
Water	Volume of additional water		Quality of water
Basin	Capacity of the lower part (= volume of water kept at the ordinary period)	Smoothness of wall, design of good water flow in the basin	Shape and height of the upper part, material, color
S-shape pipe	Height (h1) of the top position, diameter	Position (h2) of the bottom part	Material, color

(A4) Understand the Functional Relationships

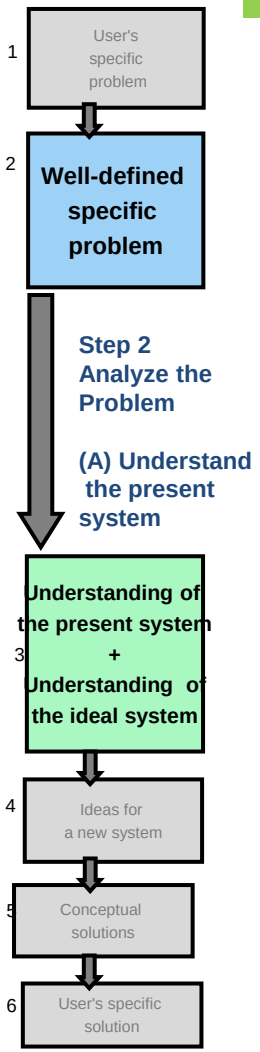
The purposes (or function) of having the S-shape pipe behind the basin are:

During the ordinary (non-use) period and the usage period, keep the water in the basin,
(in order to avoid the bad smell from coming out,
and to keep the stool in the water soft and without sticking to the wall),

At the time of flushing the stool with water, all the water goes down until the basin becomes empty .

However, the S-shape pipe is harmful because it request a large amount of water for flushing.

[Case 3. Toilet] Step 2: Analyze the Problem (A) Understand the present system



(A5) Understand the essence of the problem in terms of Contradiction

What is the essence of this problem (essence of the difficulty) ?

==> The S-shape pipe is useful, but it is harmful because it forms the barrier of flushing.

State about it more clearly.

==> The S-shape pipe is necessary AND YET better not have it (<= an obstacle)

Recognize the situation as a contradiction:

==> Request the existence of the S-shape pipe AND request Non-existence of it.

==> This is a case of Physical Contradiction in TRIZ

requesting the Existence / Non-existence of the S-shape pipe.

Can we separate the opposing requirements in terms of Space, Time, Conditions, etc.?

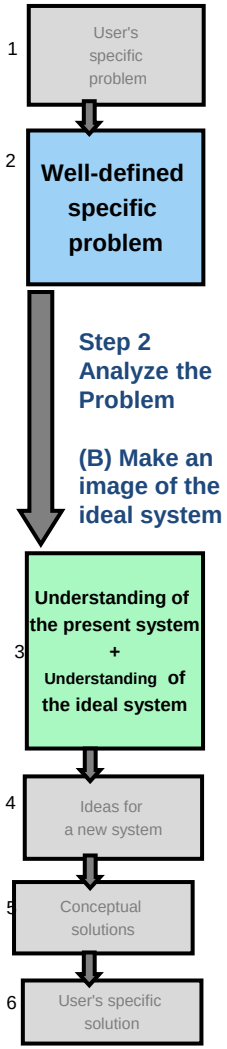
==> They are separable in terms of time (and condition)

Ordinary period: Request the existence of the S-shape pipe.

During flushing: Request 'No existence of the S-shape pipe .

This page is the essence of the problem-solving method of TRIZ.

[Case 3. Toilet] Step 2: Analyze the Problem (B) Make an image of the ideal system



(B1) Consider with Separation Principle (Altshuller's method)

Separate the requirements in time (or in condition) and generate the ideas to fulfill each requirement fully:

==> ordinary period: Existence of the S-shape pipe (the same as the present state)
flushing period: No existence of the S-shape pipe.
(The pipe can be straight down behind the basin.)

The ideal situation (which eliminates the contradiction) is the solution satisfying the two solutions at the same time:

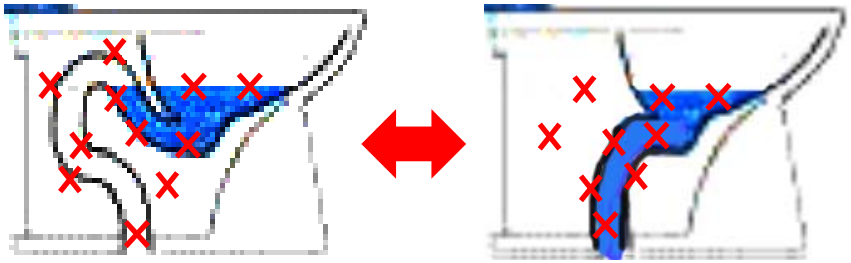
==> S-shape pipe EXISTS during the ordinary period AND
DOES NOT EXIST at the time of flushing.

To achieve the ideal situation, we go ahead to Step 3; Generate ideas.

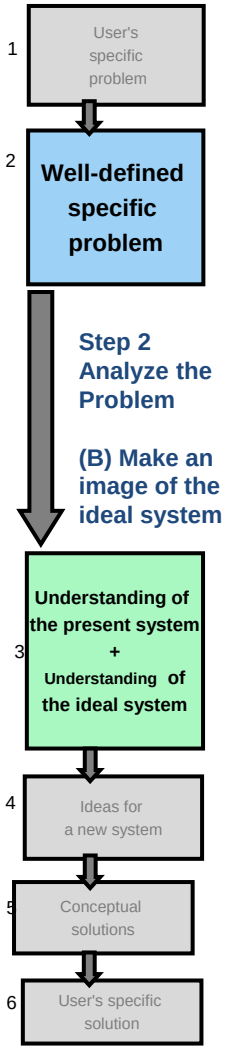
(B2) Consider with Particles method (Sickafus' method)

Sketch of the Ideal system:

This sketch is based on the understanding of the ideal situation, obtained in the above (B1)



[Case 3. Toilet] Step 2: Analyze the Problem (B) Make an image of the ideal system



(B2) Consider with Particles method (continued)

This page is inserted by Nakagawa

(d) Desirable behaviors (to be performed by the magical Particles)

To reduce the amount of water necessary for flushing at the toilet

The S-shape pipe exists during the ordinary period and does not exist while flushing

The piping in the back changes its shape, and while flushing no S-shape (no lifting in the middle)

The change occurs in parallel to the flushing operation

Piping in the back is made flexible (in structure or material, partly or entirely)

A part of piping in the back is movable up & down

The flushing moves the pipe up & down by itself

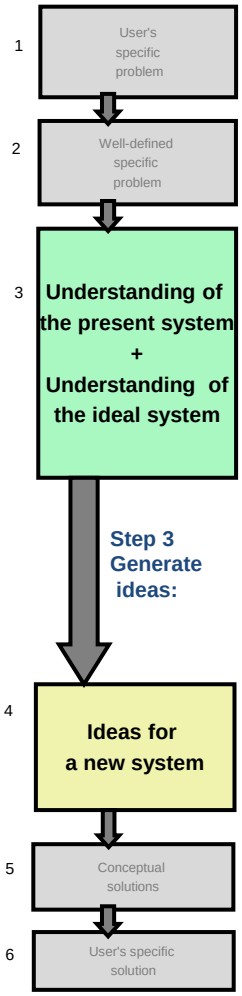
(e) Desirable properties

- Made of flexible plastic, entirely.
- Made of flexible plastic, partly
- Bellows structure
- Extend/shrink
- Passible to bend
- Switching between two different piping systems

- Pull it up
- Support with a bar
- Slam it down
- Using a chain

- Mechanical synchronization
- Connect with a chain
- Electrical synchronization
- Turn on a motor
- Operate with pulley and chain
- The weight of water in the pipe

[Case 3. Toilet] Step 3: Generate Ideas



(1) Generate ideas with the Separation Principle of Physical Contradiction

Requirement: S-shape pipe EXISTS during the ordinary period AND DOES NOT EXIST at the time of flushing

==> The S-shape pipe does not necessarily mean the **present metal pipe**;
it is called because of its shape, where the middle of the pipe is lifted.

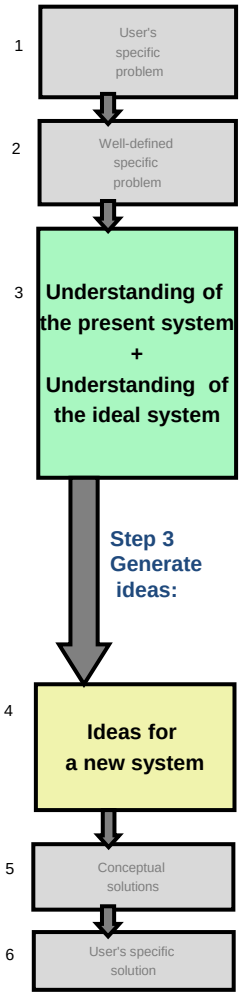
==> The pipe behind the basin is of **S-shaped (lifted at the middle)** in the ordinary period,
while it is not of S-shaped (not lifted in the middle) during flushing.

==> The pipe should **change its shape** in such a manner depending on the time.

==> For such a purpose, the pipe may be **made of some flexible tube** of plastics.

It is important to be able **to change the viewpoints** as written above.
By learning various examples, we may have such a capability.
This way of thinking may be more widely applicable and effective than simply trying to search for some suitable inventive principles.

[Case 3. Toilet] Step 3: Generate Ideas



(2) Basic ideas integrating various ideas stimulated by the problem analysis

- The pipe behind the basin is lifted in the middle (in an S-shape) during ordinary period, while is not lifted during the time of flushing.

- For this purpose, the pipe is **made of flexible tube**, either entirely or in two end places.

- The pipe (in the middle) is lifted and lowered smoothly by use of the flexible bending at some proper parts.

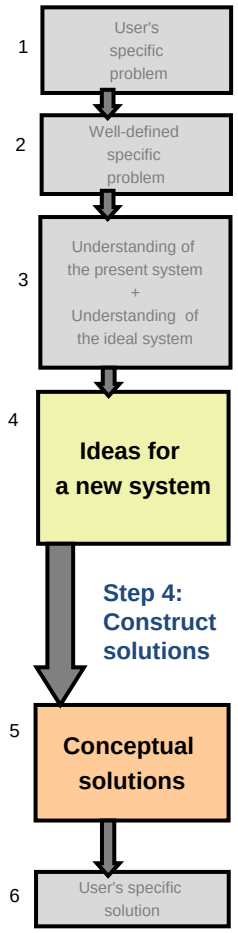
- When lowered, the **pipe may be slammed down**.

- The motion of up and down should be synchronized with the flushing operation. Mechanical links and electrical switching/motors may be used.

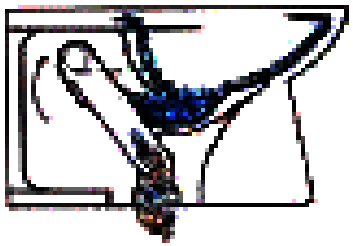
.

- It is a good idea of moving the pipe **up and down by itself** with the weight of water in the pipe by use of a pulley and a balance weight mechanism

[Case 3. Toilet] Step 4: Construct Solutions (2) Construct the conceptual solutions



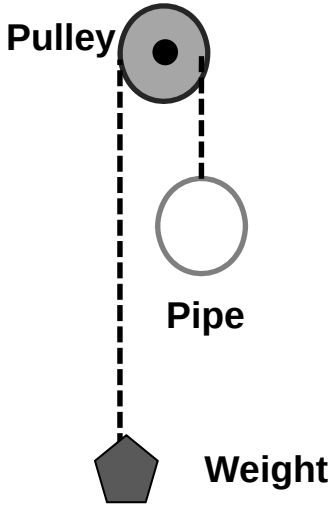
On the basis of the basic ideas in the previous step, the conceptual solution is constructed:



(3) at the end of flushing

(1) Ordinary period

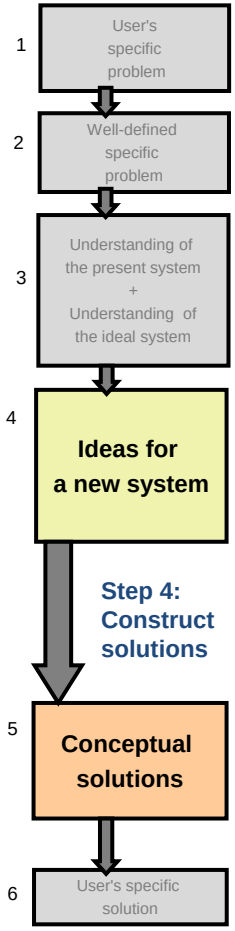
(2) during flushing



When the water is flushed for removing the stool, the pipe filled with water becomes heavier than the balance weight and slam down to the floor. At the end of flushing, the pipe becomes empty and comes up **by itself**. .

'By itself' is a form of an ideal in the sense of TRIZ.

[Case 3. Toilet] Step 4: Construct Solutions (3) Report the results



(3) Report the results as a development project

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Because this project was carried out in a small start-up company, the usual process for a problem solving team to report the results to its parent project in the company seems to be skipped.

The results were evaluated highly and the next process of 'Implement the Solution' was started quickly.

The results of the problem solving (USIT) project may be summarized as follows:

(1) A good conceptual solution was obtained for reducing much the required amount of water for flushing at a toilet. It can be an important technology which can contribute to solve the problem of shortage in water supply.

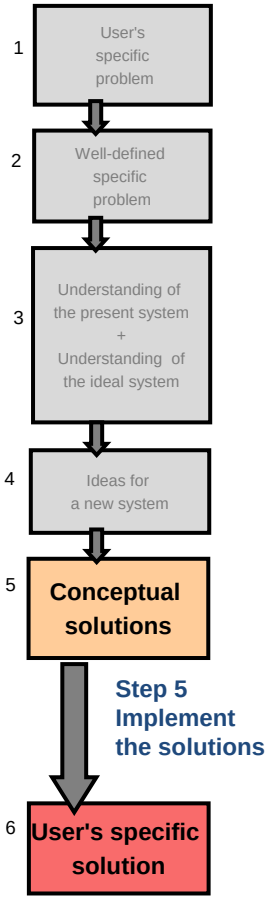
(2) The familiar problem that the S-shape pipe of the toilet is an obstacle for flushing and causing much water has been recognized as a case of the Physical Contradiction in TRIZ and has been solved completely by the introduction of a flexible tube in place of the metallic S-shape pipe.

(3) The amount of required water has been reduced from conventional 13 liters (or 6 liters for some cases) to only 3 liters.

(4) We should now go ahead to make a prototype of the solution, examine the effectiveness, clear the possible secondary problems of the clogging of the sewerage lines, file the patent, license the patent, and make it commercialize.

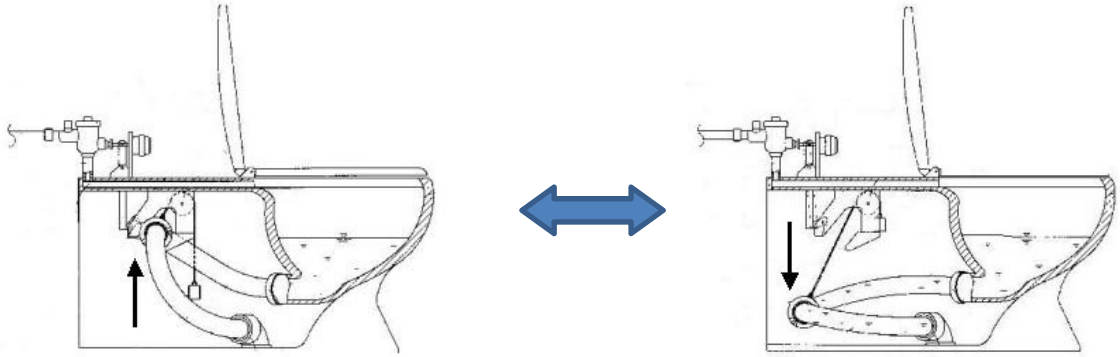
(5) We should also report the project as a TRIZ case study in a journal.

[Case 3. Toilet] Step 5: Implement the Solutions : (Real activities in the 'Real World')



Make a prototype of the solution

A rough design of a prototype:



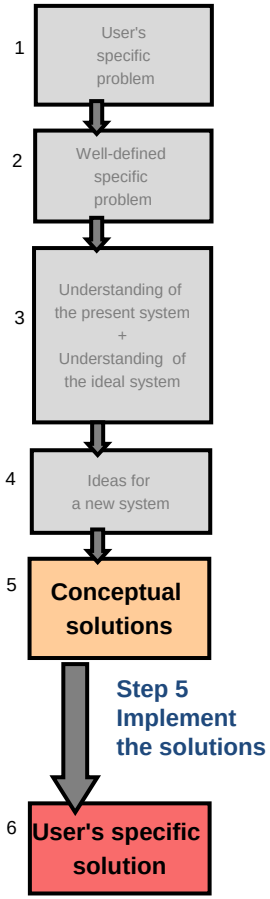
a design for commercial facilities: a flushing valve is used, no water tank

A design for home: with a water tank of 3 liters

The pipe behind the basin is made of a flexible plastic tube, which is strong for warm /cold, persistent against acids, and of antibacterial property.

The flushvalve (self-closing faucet) was taken from the ordinary one for flushing urine.

[Case 3. Toilet] Step 5: Implement the Solutions : (Real activities in the 'Real World')



Performance test and reliability test

This is a summary of the description of original paper.

(1) Following the criteria defined by the Korean Standards L1551, the performance test of cleaning the basin was carried out by use of rumpled paper and aniline dye.
Required amount of water has been evaluated as 3 (±0.5) liters.

(2) Using a test equipment for pushing the flushing valve 4 times per minute, the persistence of the prototype was tested with success for 165,000 times of flushing (equivalent to 20 years of usage).

(3) The resistance test against chloric acid and bleaching agents is also OK.

(4) The sewerage pipe below the basin is usually made of polyvinyl chloride or iron, having 100 mm in diameter, and is set with the slope of 1/50.
The test of usage of the present water saving toilet was successful without clogging the pipe.
A prototype of the present solution was actually installed in a public restroom in a metro station, and the inner wall of the sewerage pipe at 30 m down-stream was examined with an industrial inner scope and found no problem.

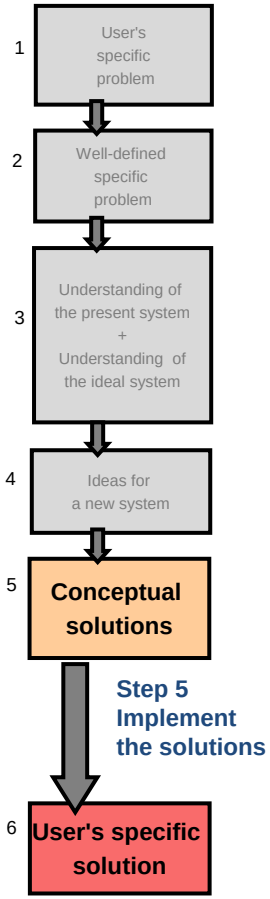
(5) The noise of flushing water of toilet sometimes causes troubles in apartment buildings at night.
By the actual measurement of the noise, the present prototype resulted 60 db in contrast to 70 db for ordinary ones; thus reducing the noise by 10db.

In conclusion, a prototype of water-saving toilet system with only 3 liters of water requirement is now developed successfully with assured reliability.

[Case 3. Toilet] Step 5: Implement the Solutions : (Real activities in the 'Real World')

This page is a summary of the description of original paper. plus comments

Filing a patent and trials of commercialization



(1) The original authors published their paper in the TRIZ Journal in Nov. 2003.

(2) The authors filed their patent in Korea, Singapore, and USA. And at the time of their paper publication, a patent in USA was already granted, they say.

(3) Eiji Fukuzawa (TOTO Ltd.) and Toru Nakagawa translated the original paper into Japanese and posted it in 'TRIZ Home Page in Japan' on Jan. 8, 2004.

(4) Fukuzawa wrote a Postscript Note (dated Nov. 11, 2003) to discuss on this solution as follows:

(a) TOTO developed a water-saving toilet system with a fixed S-trap and sell it in USA. Because of the necessity to flush the stool down to the sewage main pipe, the toilet uses 6 liters of water.

(b) About 20 years ago, TOTO introduced to sell a US technology which uses pressurized air to transport the stool to the sewage main pipe with 2 liters of water; But Japanese municipal sewage offices in cities did not give permission of the system, probably in the risk of clogging of the sewage pipe.

(c) A toilet system using vacuum for flushing was permitted by the government and in the market.

(d) In Japan Matsushita Electric Works sells a 'turn-trap' toilet system (where the S-shape pipe changes its shape).

(5) At the time of 2004, neither TOTO nor Matsushita claimed against the patent of the present work and show any interest in the license of the present patent

I do not know the current situations about the patents, licenses, commercial products, markets, etc. in relation to the present case study.

USIT Case Study 3 [Toilet] (overview). Saving Water for a Toilet System

A familiar, important problem was solved nicely with the concept of Physical Contradiction in TRIZ.

H.S.Lee and K.W. Lee (Korea) (2003)