Inventive problem solving using the OTSM-TRIZ "TONGS" model

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Abstract

One of the simplest tools in OTSM-TRIZ is the "TONGS" model. Despite being simple, the "TONGS" model provides a versatile way to frame and study an inventive technological problem. For TRIZ novices, the "TONGS" model can be trained and applied very rapidly. For more advanced TRIZ users, the "TONGS" model can set discrete TRIZ tools in context or can direct each process step in ARIZ (Algorithm for Inventive Problem Solving) and PFN (OTSM based Problem Flow Networks approach). In this paper we describe the "TONGS" model and apply it to an inventive problem situation, highlighting the benefits of this model. Finally, we describe some key applications for the "TONGS" model in education, problem solving and in the development of new OTSM-TRIZ tools.

Keywords

OTSM-TRIZ, TONGS model, Problem Solving

1. INTRODUCTION AND SHORT HISTORY OF THE TONGS PROBLEM SOLVING MODEL:

The "TONGS" model is the simplest and most accessible model from Classical TRIZ and it has the advantage that it can be learned quickly and used by people who are entirely new to TRIZ, without any deep learning of the theory and its tools. At the same time this model was historically the first one that appeared in the course of Classical TRIZ evolution, starting from the very simple methodology that was used in the 1940-50s. We believe it can be useful to introduce this old model to students with modern remarks and comments and that is why we mention in the paper some of the theoretical background and tools of Classical TRIZ and OTSM, linking this oldest model with Classical TRIZ and OTSM and the more recent problem solving process models and tools based on TRIZ and OTSM. What is surprising is that this model appears perfectly ready for practical applications of all three postulates of Classical TRIZ that were formulated later to provide a part of the theoretical background of Classical TRIZ.

The name of the model first appeared in the course of OTSM evolution; this was done for educational purposes to help our students communicate efficiently about the various problem solving process models which are used in Classical TRIZ and OTSM.

After the "TONGS" problem solving process model first appeared in TRIZ in the 1940-s [1, 2], it evolved through the introduction of additional rules and procedures but was not fundamentally changed until after the mid 1970s when new problem solving process model was implemented for the first time in ARIZ 77. We named it the "HILL" model [3]. This model has a very different structure from the "TONGS" model but included it as a component. The next problem solving process model appeared in the middle of 1980-s. We named it as "Problem Flow model". It was implemented in ARIZ-85-C. Both previous models became components of the new model. In the course of the transition from Classical TRIZ to OTSM, the "PROBLEM FLOW" model appeared that included the 3 previous models as components. Finally the "PROBLEM FLOW" model appeared as a component of the more advanced and universal OTSM Fractal Model of a problem solving process [4, 5]. This new model is now being used to create the third generation of the OTSM toolbox, including all previous models as components. We should mention here just namely one more model that we call the "FUNNEL" model. This problem solving process model of Classical TRIZ is used for integration of all others into a unified system. It illustrates the process of narrowing the area of research we should conduct in order to develop a satisfactory solution.

We have provided this short history of the evolution of the TRIZ and OTSM problem solving process models to show why we propose to start the TRIZ educational process with the "TONGS" model. First of all it is still an active tool that is a component of the more powerful models and tools. It is simple to learn and can be developed further to prepare student for deep learning of Altshuller's ARIZ. Step by step the students can learn all of the TRIZ and OTSM models and how to implement them in particular situations. The "TONGS" model is also helpful in developing the many skills that are necessary for them to have in order to understand and learn the modern tools of Classical TRIZ and OTSM. The "TONGS" model can be viewed also as a "frame" for learning every single tool, its components and steps deeply. This model is not only a problem solving tool in itself but also a tool for learning many other problem solving concepts starting right away from the deeply philosophical but still practical background of classical TRIZ.

2. HOW TO APPLY THE TONGS MODEL

According the OTSM Axiom of a root of problems fundamentally, any problem situation can be described as a conflict between human desire and objective factors or natural laws. The TONGS model can be used to spell out the conflicting elements of any problem situation, drill down into the objective factors preventing us from solving the problem and steer us towards a strong solution. Although the TONGS model is simple to apply and use, there are some key steps which should be followed to get the most from the approach. The sequence of application is not critical but it is important to be consistent and logical when using the model and to work systematically towards uncovering the core of the problem. One last point about the TONGS model is that it is intended to support an iterative process, where we use partial solutions to help us to explore the barriers which prevent us from completing our problem solving journey from our "departure point" to our "final destination". The more competence users have in Classical TRIZ, OTSM and their related problem solving toolboxes, the less iteration they will need.

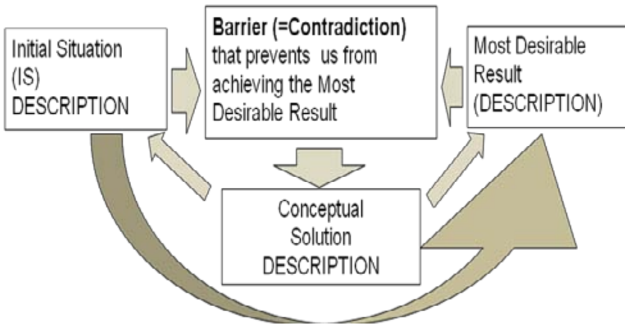

Figure 1: General schema of The Tongs model of a problem solving process.

The key steps in the TONGS model are:

2.1 State the Initial Situation (IS):

This should be a description in simple language (i.e. without professional jargon and terminology) of the initial problem situation. The statement should highlight the main **Negative Effect** of the problem situation - in other words it should describe what it is that seems at the beginning the most unsatisfactory aspect of the current situation. As a trivial example, we could consider the subject of cleaning dishes after a meal, in which case the main Negative Effect we might state is "it takes a lot of time to clean the dishes after a family meal".

2.2 State the Most Desirable Result (MDR):

This should be a description of the best outcome to the problem situation or an ideal solution. The stronger and more provocative we can make the MDR statement, the more useful it will be in guiding the subsequent problem solving stages. To generate a really stretching statement of the Most Desirable Result, we can imagine that we have in our hand a magic wand which can be waved over the problem situation to achieve a result that would usually seem totally impossible to achieve. Another way to think of the MDR is to state the positive result that is needed which also eliminates the negative effect. To steer the analysis away from more complex solutions, it also helps to write the MDR statement in such a way that the system with the problem stays the same (or possibly becomes simpler) while the problem is solved completely. It is a good idea to use here the rules of DTC operator to exaggerate the situation. Do not forget – we have a magic wand! Everything is possible on this stage of a problem analysis (according to the OTSM Axiom of Impossibility)! For the example of cleaning dishes, after exaggeration a bold statement of the MDR might be "the dishes clean themselves" (or "the dirt disappears by itself" - OTSM-TRIZ has rules to make a choice among set of alternative MDRs. Those rules can be learned later or right away, depending on the duration of the course).

2.3 a). State the Barrier:

During this stage, we describe what seems most impossible about our statement of the MDR within the context of the Initial Situation. The purpose of stating the Barrier in this way is to expose what it is that is stopping us from achieving the MDR. At this stage it can be useful to think about the OTSM axiom of impossibility or in other words, if something "impossible" happens, how might it practically happen? If the duration of the training course allows, to answer the question, we can teach students how they can use the "Gold Fish" method proposed by G. Altshuller or Sword Fish method (to assume something that that cannot be assumed) developed by V. Gerasimov [6].

In the example of cleaning dishes, we might say that the main Barrier is that we have no means to make the dishes clean themselves. One question we can now start to ask is if we did have self cleaning dishes, how might they clean themselves?

b). Reframe the Barrier as a contradiction:

Now we drill down into the problem to discover the objective (natural) factor which is behind the problem we stated in the Initial Situation. This also helps us to re-state the problem as a new Initial Situation with a new Negative Effect. To do this we can ask ourselves the question "what is the new Negative Effect we now have or the new Initial Situation we have to improve?" In the case of the example of cleaning dishes, the objective factor we need to address is that without any cleaning action, the food residue will stay stuck on the dishes. In other words, the Negative Effect we now need to deal with is the food residue sticking to the dish surface.

2.4 a). Identify "Common Sense" Solutions:

Confronted with the new Negative Effect, we now need to ask ourselves "what common sense or professional solutions might solve or partially solve this re-stated problem". At this stage we don't need to identify a complete solution, we simply want to attempt to move closer to the MDR. In the case of preventing food residue from sticking to the dish surface, we might suggest a low-friction coating on the surface of the dish. This new "common sense" solution may well have further drawbacks, when tested against the MDR, which can be used as the basis for a new Initial Situation description which allows us to iterate through another cycle of the TONGS model.

b). Identify OTSM-TRIZ based solutions using OTSM-TRIZ principles of contradiction resolution or Classical TRIZ system of Standard Inventive Solution or any other OTSM-TRIZ based method that the user might know:

If we have more knowledge of TRIZ, we can apply a number of TRIZ tools at this stage, for example we can answer the following questions:

"What principles of technical contradiction resolution could be useful to resolve the technical contradiction in this problem?"

"What principles of OTSM-TRIZ could be used to satisfy both opposite demands for the same parameter?"

"What is the Substance-Field model for this problem situation and which of the 76 Standard Inventive solutions can be used?"

Once again we can test solutions generated during this step against the MDR and if necessary, use the most appropriate solution for a further cycle through the TONGS model.

3. AN EXAMPLE OF THE TONGS MODEL APPLIED TO A REAL PROBLEM:

The problem being solved appeared as a Request for Proposal (RFP) document on the Nine Sigma website (http://www.ninesigma.com) in July 2008.

THE PROBLEM

Against the background of a need for more fuel efficient vehicles, auto manufacturers are urgently looking for ways to reduce vehicle weight. One area which is under active investigation is the use of aluminium body panels to replace steel. Indeed, some car manufacturers such as Audi and Jaguar are already using the technique on their more expensive models. In order to form a body panel, flat sheets of metal are fed from a stack of sheets into a press (figure 2).

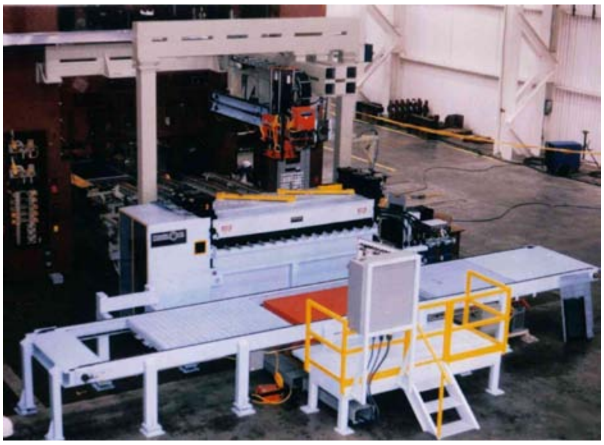

Figure 2: De-stack sheet feeder system.

Steel sheets can be fed very quickly by this method – as fast as one every two seconds, but aluminium sheets can only be fed at a rate of 8 per minute. There are tried and tested methods to separate steel sheets using magnets but these don't work for aluminium because it is non-magnetic. Also, the aluminium sheets are coated with a sticky oil film, which is needed for a previous process step and cannot be easily removed. The Nine Sigma RFP requested solutions which would allow a doubling of feed rate for aluminium sheets. Figure 3 shows the arrangement of the aluminium sheet feeding system.

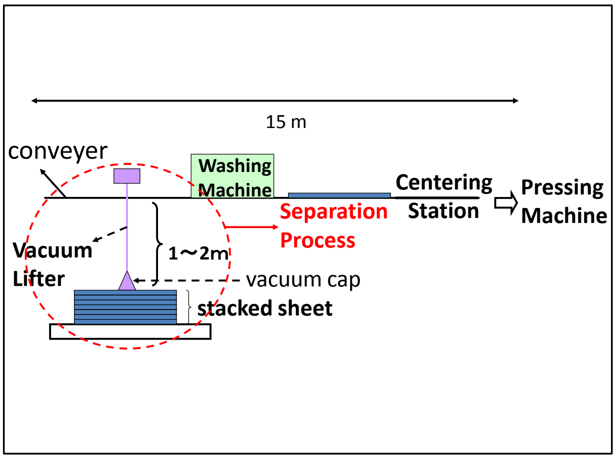

Figure 3: Aluminium sheet feeder layout.

Application of the TONGS model to this problem:

3.1 State the Initial Situation (IS-0):

In this problem, the Initial Situation is one where the main Negative Effect is *"if the sheets are fed too quickly, the second sheet sticks to the first sheet and stops the press feeder"*.

3.2 State the Most Desirable Result (MDR-0):

For the sheet feeding problem, an MDR we might wish for is that *"as the vacuum suckers arrive above the top sheet, the top sheet immediately separates itself from the second sheet and moves towards the suckers".*

3.3 a). State the Barrier:

In this problem, the key barrier seems to be that *"the sheets can't separate themselves because air doesn't have enough time to get between the top sheet and second sheet and atmospheric pressure is holding the two sheets together"*

b). Reframe the Barrier as a contradiction between Human desire and Natural Laws or other objective factor (OTSM axiom of a root of problems):

In this problem, the objective factor which is at the root of the problem is that *"it takes a certain amount of time for the air to pass between the two sheets but we need this to happen faster".*

3.4 a). Identify "Common Sense" Solutions:

What common sense or professional solutions might solve or partially solve this re-stated problem?

A possible partial solution to get air to move more quickly between the two top sheets is to set up a pressurised air feed to blow air into the gap between the two sheets.

If we benchmark this solution against the MDR, we can see that while it does provide a more positive separation of the two top sheets, it also complicates the system. To continue the analysis, we will now iterate through the TONGS model using this partial solution.

Iteration 1:

3.5 State the Initial Situation (IS-1):

In this problem, the Initial Situation is one where the main Negative Effect is *"the air blast system complicates the sheet feeder"*.

3.6 State the Most Desirable Result (MDR-1):

For the sheet feeding problem, an MDR we might wish for is that *"as the vacuum suckers arrive above the top sheet, the top sheet immediately separates itself from the second sheet and moves towards the suckers <u>without</u> complicating the system".*

3.7 a). State the Barrier:

In this problem, the key barrier seems to be that *"I need something to force air past the oil and between the two top sheets"*

b). Reframe the Barrier as a contradiction:

What is the objective (natural) factor which is behind the problem we stated in the Initial Situation? Re-state the problem as a new Initial Situation with a new Negative Effect.

In this problem, the objective factor which is at the root of the problem is that *"the oil is stopping the air from moving between the two top sheets".*

3.8 a). Identify "Common Sense" Solutions:

A possible partial solution to prevent the oil stopping the air is to get rid of the oil completely.

If we benchmark this solution against the MDR, we now have a much simpler solution but we have lost an important function, that is, to protect the aluminium sheets. We will now iterate another time through the TONGS model using this new partial solution.

Iteration 2:

3.9 State the Initial Situation (IS-2):

In this problem, the Initial Situation is one where the main **Negative Effect** is *"without an oil coating, the aluminium sheets are not properly protected"*.

3.10 State the Most Desirable Result (MDR-2):

For the sheet feeding problem, an **MDR** we might wish for is that *"as the vacuum suckers arrive above the top sheet, the top sheet immediately separates itself from the second sheet and moves towards the suckers <u>without</u> complicating the system and the aluminium sheets are fully protected".*

As we can see each of the iterations gives us new knowledge on the context of the particular situation. So Tongs model appears to be a tool to apply the Third postulate of classical TRIZ concerning the context of a specific situation [4, 7, 8].

3.11 a). State the Barrier:

In this problem, the key barrier seems to be that *"I need something to protect the aluminium sheets but I can't use oil"*

b). Reframe the Barrier as a contradiction:

In this problem, the objective factor which is at the root of the problem is that *"the oil should stop the air to protect the sheet surface but shouldn't stop the air from moving between the two top sheets".*

3.12 a). Identify "Common Sense" Solutions:

A solution direction suggested here is that something needs to happen to the oil but what could it be?

We will now move onto stage 4 b) to complete the analysis:

b). Identify OTSM-TRIZ solutions using OTSM-TRIZ principles of technical or physical contradiction resolution or Classical TRIZ system of Standard Inventive Solution:

"What principles of technical contradiction resolution could be useful to resolve the technical contradiction in this problem?"

Possible conflicts we have are between ***Speed*** and ***Loss of Substance***, ***Speed*** and ***Harmful Effects Acting on System*** and ***Productivity*** and ***Loss of Substance***. A principle which seems to recur is number 35, parameter change.

"What principles of OTSM-TRIZ could be used to satisfy both opposite demands for the same parameter?"

To indentify a physical contradiction for the oil we can state the useful action as "protects aluminium sheet" and the harmful action as "stops air moving between first and second sheets".

In order to maintain the useful action the oil must be able to flow -> liquid

In order to prevent the harmful action, to oil must be not able to flow -> solid

We can separate in time and use"low melting point oil" which can flow over the sheets to protect them and then solidify before the sheets are put into a stack so that air can move freely between the sheets. In other words, the sheets should be coated in wax.

If we benchmark this solution against the MDR, we now have a relatively simple solution and we can still fully protect the aluminium sheets. For the purpose of this example, we can now decide to stop the analysis.

4. SOME OTHER APPLICATIONS OF THE TONGS PROBLEM SOLVING PROCESS MODEL

4.1 Applications for OTSM-TRIZ Education

There are at least two key points to mention about the application of the "TONGS" model for the OTSM-TRIZ educational process.

First of all, as we discussed at the beginning of the paper, the "TONGS" model is one of the main sub-component of the other problem solving process models which were developed in the course of Classical TRIZ and OTSM evolution. This means that learning the "TONGS" model can be a key first step towards developing a deep understanding of many other notions, theory and practical tools which should be known by TRIZ and OTSM practitioners, professionals and developers. The model helps us to understand how the theoretical background can work for practice; how TRIZ based tools can reduce the amount of trial and error without losing out on quality of the solution for non typical problematic situation. The "TONGS" model also serves to help us better understand how Altshuller's three postulates work as practical tools, helping us to narrow our research to discover the deep root of a problematic situation and develop an image of a satisfactory solution. Each iteration of the "tongs" model adds at least one more detail to the image of Most Desirable Result as well as understanding and clarification the Initial Situation.

The more students learn about practical application of the three postulates, the better they can apply many other tools of Classical TRIZ and OTSM. Depending of the aim of students and teachers we can provide a deep understanding on how Classical TRIZ works as a theory for creating new tools for solving various kinds of non typical problems.

The second point is about the structure of the model. Understanding of the "TONGS" model structure can be used later to study any other OTSM-TRIZ based tools as well as many other methods. For example, each tool or method has an Initial Situation to which it must be applied. Also every single step of ARIZ or other similar method should start with an Initial Situation. Similarly, the MDR is a statement of the best possible output that should be delivered from that step or method. Finally, the core of the step is the mechanism to overcome the barrier that prevents us from obtaining result of the step or method from our Initial Situation. This allowed student to understand better what kind of difficulties (barriers) they face and how they can overcame those barriers as soon as they try to apply particular step of ARIZ or any other methodology.

In other words The "TONGS" model can be viewed not only as a problem solving tool but as a tool for education and self education.

4.2 Applications for OTSM-TRIZ Users

The more deeply the users study how to apply the different TRIZ and OTSM techniques and methods for effective application of the "Tongs" model, the better they can use it for many other OTSM-TRIZ based tools.

For instance: the First part of Altshuller's ARIZ (ARIZ-85-C) is based on the "HILL" model and the Third part of the ARIZ is based on "PROBLEM FLOW" model; steps 1.1 and 1.6 is a direct application of the ``TONGS`` model; steps 1.2 – 1.5 dedicated to improve and verify the ``TONGS`` model that was created on the step 1.1. When students clearly understand the meaning and practical application of the ``TONGS`` model for study various tools they can better understand various applications of those tools and how the tools are integrated into while system. As a result, they can develop their own combination of the tools for certain particular needs. In turn this lead to more flexible use of various tools (not only OTSM and TRIZ based tools) to operate them for complex interdisciplinary problematic situations according to the OTSM ``FRACTAL MODEL`` of a problem solving process. For instance ``TONGS`` model was used for developing OTSM interpretation of Altshuller`s Law of Completeness of a Technical System. In turn this interpretation was used to create OTSM Negative system technique, OTSM express analysis of an initial situation, OTSM Network of Problems/Solutions etc.).

As we saw in the earlier example, the “TONGS” model can be used to clarify both the deep root of an Initial Situation and the more detailed image of a satisfactory solution as close to MDR as possible. One of the most important applications of the ”TONGS model is the description of a sub problems that can be used for creating an OTSM Network of Problems that can then be used to discover the bottleneck of a problematic situation and for the evaluation of obtained solutions [9,10].

The “TONGS” model is also important as a tool to split initial problems into several subproblems to be solved to obtain an appropriate satisfactory solution [11]. In this application the “TONGS” model can be used for clarification of the OTSM network of Problems and Solutions as well as an independent tool to clarify an initial situation during problem solving process.

4.3 Applications for OTSM-TRIZ developers and new tools creating.

When TRIZ and OTSM professionals start using TRIZ and OTSM as a theoretical basis on which to create new problem solving tools they can apply the ”TONGS” model to identify barriers that the particular new tools should be able to overcome in the course of a problem solving process in general. Then we can set out to answer the problem by creating new problem solving tools, methods or techniques or just by clarifying a particular step of an existing method and tool.

5. CONCLUSIONS

More than 60 years of using the “TONGS” model in practice for TRIZ based problem solving makes this model very useful for study by beginners, professionals and developers of tools for problem solving. It is a versatile, domain-free tool that can be used right away for many areas of human activity.

In turn this gives much more freedom to beginners than the study other simple empiric tools of classical TRIZ like the matrix and 40 principles that appeared before TRIZ were formed as a mature theory. With the “TONGS” model, many simplified tools can be used more effective because it helps us to pose the problem correctly before starting to solve it right away. As we know most beginners try to solve problems right away as soon as they hear the initial problem description. With the “TONGS” model they learn the importance of the MDR as a guide to a satisfactory solution which helps decrease the amount of useless trials and errors. Each iteration with the “TONGS” model leads us to a better description of the MDR and we can pose the problem correctly and apply appropriate tools. Looked at in this way, it is difficult to overestimate the value of the “TONGS” model for the TRIZ and OTSM educational process.

Understanding the “TONGS” model allows professionals to use existing tools more effectively and to be more fluent in the application of various tools from the OTSM-TRIZ toolboxes.

For developers of new problems solving tools,”the “TONGS” model provides a framework for specifying requirements for new tools, methods or new steps in existing tools. In turn this allows us to pose the problem about the importance of a new tool and/or process step in a clear form. When we obtain a proposal to improve existing tools or create new ones we can use this form for preliminary evaluation of the proposals we have developed. Of course the “TONGS” model cannot replace real life evaluation but preliminary evaluation of the tools can bring some more improvement before testing it to solve real problems. Preliminary evaluation is also helpful in developing several options of the tool with final selection of the best one through practical application.

Last but not least, we should stress that the “TONGS” model is a powerful domain-free educational tool for OTSM-TRIZ teachers that allows them to reduce the overall time needed to educate students to a good professional level. The “TONGS” model builds the ability of students to solve problems based on Classical TRIZ ideology from the very first steps of their education. Continued use of the model provides a framework for students to learn about more advanced models and tools for problem solving in terms of both the problem context and evaluation of very strong solutions.

6. SUMMARY

This paper describes the “TONGS” model, one of the very first TRIZ tools, and discussed how the tool is still very relevant today, being useful for both TRIZ novices and established TRIZ users. The “TONGS” model provides an important “frame” for the problem solving process, or sub-steps within a more complex process, and gives a simple objective means to determine if the problem solving process is progressing in the right direction.

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