**See also:**
4 Su-Field Analysis and Standard Solutions
5.3 Techniques to resolve Physical Contradictio

# 3 Short Review of Altshuller's Algorithm of Inventive Problem Solving (ARIZ) Illustrated by the Analysis of a Real Problem

This article is aimed at facilitating the understanding of the general principles of ARIZ operation, but not at a detailed assimilation of all the steps of this algorithm. We are only going to discuss the goal of each Step and its role in the entire process of the analysis. We would also like to remind that the ARIZ Author advised to undergo training before applying TRIZ to real problems. There exist numerous nuances important for performing separate steps of ARIZ. It is difficult to illustrate all of them while analyzing one problem only; therefore, it would be better to learn ARIZ under the guidance of an experienced teacher using a large number of training problems as examples.

## 3.0 ARIZ creation and development

In the course of ARIZ evolution, the analysis and contradiction resolution steps were permanently improved, developed, specified and tested on complicated problems collected by the ARIZ author during 40 years, starting from 1946 till 1986. By the mid-80s, Altshuller had collected over 120 problems where previous ARIZ versions where of little help. Those problems were used to test and polish new ARIZ versions, including their use at workshops and by distant students.

ARIZ development is also connected with the development of the technical system evolution laws and the understanding of how these should be applied to the design of new systems or improvement of existing ones. Thus, in the current version of ARIZ and its OTSM supplements, the evolution laws are mostly present in an unobvious form.

Currently, ARIZ is a highly detailed method and may seem complicated. This material is designed to facilitate the understanding of the general logic of Altshuller's last ARIZ version (ARIZ 85-C). Using a real problem as an example, we will try to illustrate the assistance OTSM can render in resolving some difficulties occurring while using ARIZ-85-C.

It should also be mentioned that thorough execution of the steps according to ARIZ-85-C considerably simplifies the analysis compared to the previous ARIZ versions. Thoroughly performing these steps forms certain thinking skills in students, which can be effective while dealing with a problem.

It is also necessary to mention some peculiarities of bringing ARIZ assimilation to the level of automatism in its application to real problems.

First, additional nuances of performing each step depending on a specific situation are learned by repeatedly practicing ARIZ steps on training and real problems. As a result, the performance of the steps becomes automatic and the steps begin to be performed faster and on a subconscious level.

It often happens that students themselves do not realize their achievements at this step. Not infrequent are cases when some of them think that a problem has been solved without using ARIZ and demonstrate quite an acceptable, practically realizable solution. Discussing the situation with such a student proves that he has formulated a contradiction, analyzed the resources available in the given situation and found the way to use those resources for resolving the contradiction, the result being close to IFR (Ideal Final Result) to the extent permitted by the re-



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sources available in this situation. This generally proves that the skills of performing many steps of the first parts of ARIZ have already been formed in the student but the skill of reflection described in its last part has not been developed to a necessary extent. That is, the student has solved a problem but has not analyzed his own thinking process and the way he has traveled to obtain the solution. This usually happens with relatively simple problems and students may get the impression that they have already penetrated into ARIZ. However, they cannot deal effectively with more complicated problems where the reflection skill is particularly important for performing the third part steps. After passing through this ARIZ assimilation stage, students achieve a higher level of command of the tool. They are able not only to suggest a solution to a problem after getting acquainted with the initial description of a situation, but also to show in general how this solution results from the problem description.

And finally, after gaining some experience in the work on real problems, one more skill is formed. The thing is that training problems are usually more or less adapted to specific objectives of the training Steps. Properly speaking, this situation is typical for training in any other subject which forms skills of practical use of obtained knowledge. In reality, an initial description of a non-standard problem is often either rich in unnecessary and unessential particulars, or, on the contrary, lacks some information important for understanding the problem essence. Professional TRIZ experts often suggest some solutions by mentally passing a problem through all ARIZ steps so as to define more exactly the initial description of the problem situation before starting an in-depth analysis. From outside, it may look as an ordinary error-and-trial method, but in reality, it is quite a different technology of dealing with a problem. Mentally analyzing a problem in accordance with ARIZ steps, an expert evaluates the already available information and obtains additional important information about the problem, which is absent in the initial problem description. After the problem situation description has become sufficiently complete, a serious in-depth work using ARIZ or other OTSM-TRIZ tools starts. For example, if a situation includes numerous problems, it would be wise first to formalize its description in the form of the OTSM Network of Problems. While constructing this network, mental analysis of separate sub-problems and their specification are used, as described above.

Thus, ARIZ is not only a tool for solving complex problems, but also, which is most important, a tool for forming a certain thinking style in work with the knowledge about a problem situation. It is just the work with the already available knowledge with the aim of obtaining and creative use of new knowledge that makes ARIZ an important pedagogical tool which can be helpful in the spectrum of educational processes and technologies. For example, it may significantly improve the effectiveness of the so-called problem teaching, where introduction of a new topic is started with offering some typical problem situation to students which they have to deal with to become prepared for assimilating a new material and understanding how the studied material can help them in dealing with similar typical situations. Thinking skills necessary for performing separate steps of ARIZ also prove useful for various pedagogical and educational situations and technologies.

To summarize this part of the introduction to ARIZ, we would like to note that the skills formed while mastering ARIZ help teachers solve their pedagogical problems arising during the educational process (as well as their private problems). As for students, these skills help them assimilate new knowledge in a more effective and systematic manner. These skills may also be formed by means of separate OTSM-TRIZ trainings, such as the training based on the "Yes-No" game. However, in this case, it is also extremely important to integrate all these segmental skills into a system by doing exercises for all ARIZ steps.

### 3.0.1 Solving a problem: a short review of the main stages of ARIZ-based work

With any scientific approach, first of all it is necessary to select and create a problem-describing model. It means that an initial situation description should be turned into a model of this situation formulated in a certain manner according to distinct rules. This results in the appearance of the model of the initial problem situation described through a contradiction to be solved.

Transition from an initial description of a problem situation to a description of a problem model occurs in the same way as in physics or mathematics: it is necessary to try to reformulate the situation in a canonical form which will be then analyzed while constructing a solution. It is very important to note that in the process of ARIZ-based work, just as in the entire Classical TRIZ and in OTSM, the idea of a conceptual solution is not searched for randomly, but is constructed, step by step, in the process of analysis of a problem situation and synthesis of an acceptable solution concept (Satisfactory Conceptual Solution). It is one of the main distinctions of Classical TRIZ and OTSM from many other methods of solving complicated, non-typical creative problems.

Transformation of an initial problem into a model can reduce the problem to a typical, standard one (from the TRIZ viewpoint), the solution to which is already known in a general form. Then, after constructing a model of a problem situation at the end of the first part of ARIZ-85, transition to the system of standard inventive solutions is performed. Currently, this system contains 76 standard problem situations. If the known generalized standard solutions do not suit our specific situation for some reasons, the situation continues to be analyzed according to ARIZ. If further analysis results in a satisfactory solution, the latter should be converted into a typical, standard solution which takes into account the peculiarities of similar specific situations. This is roughly how the collection of Standard Inventive Solutions of Classical TRIZ was created.



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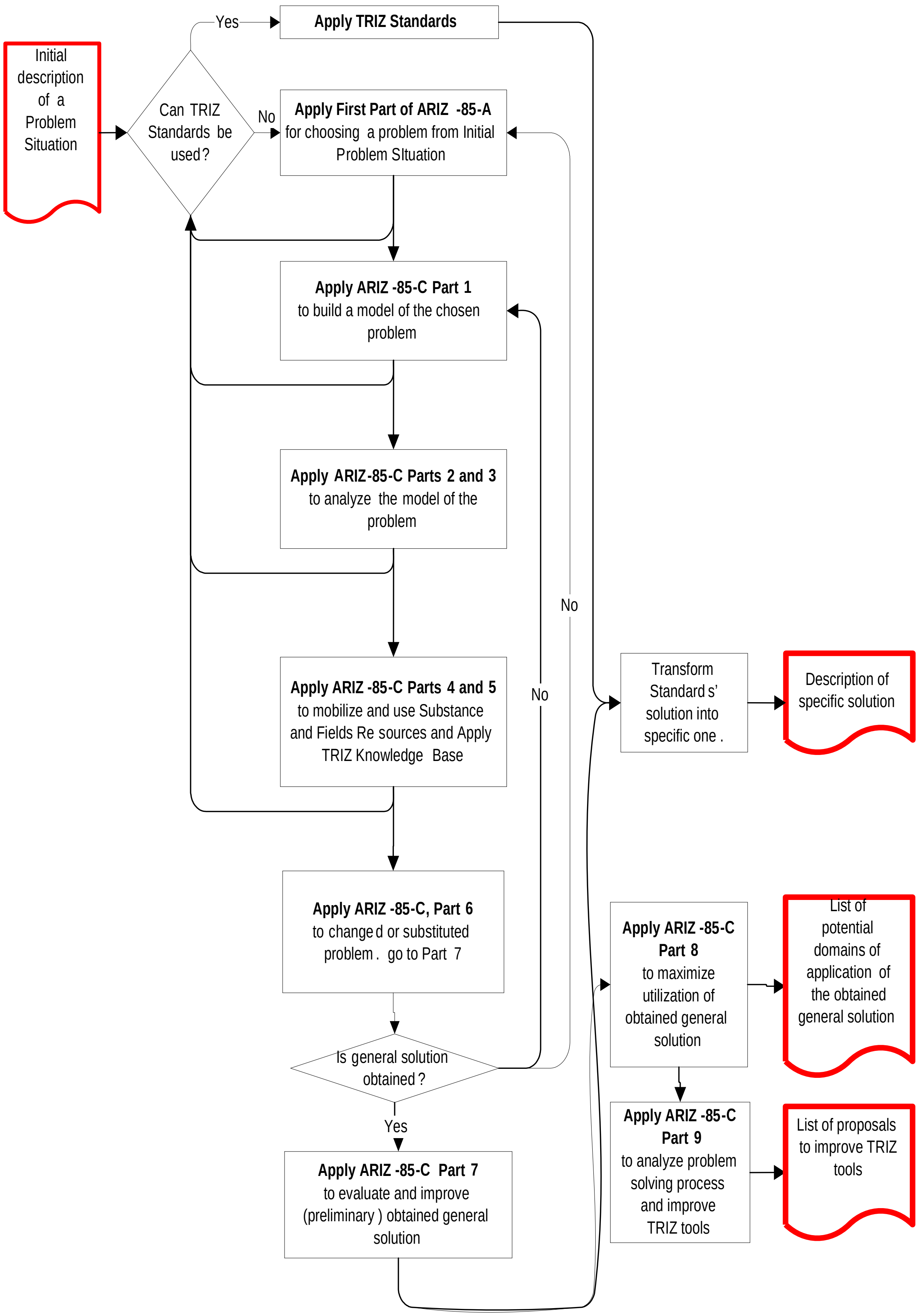

*Fig. 1 The scheme of stages of ARIZ-based problem analysis.*

### 3.1 The first stage. Constructing a problem model and using standard inventive solutions

#### 3.1.1 Inventive solutions

Selecting a problem to be solved from a set of problems contained in an initial problem situation is not among the Classical ARIZ tasks. In the ARIZ-based OTSM technology "Contradiction", the Express Analysis of an initial situation is used for this purpose. It effectively works with comparatively simple problem situations. For more complicated ones, it is expedient to use the tools of the OTSM technology "New Problem".

The aim of the first part of ARIZ is creating a model of a problem to be solved. At the end of the first part, the problem selected from the initial situation is formulated as a technical contradiction – a contradiction that describes a conflict between two parameters used for evaluating the quality of a given system (evaluation parameters). Accordingly, Technical Contradictions in OTSM are called a contradiction of a specific system, which means that a given system confronted a conflict between two important parameters during its evolution.

Example: There is a system "rubber seal of a hole through which a rotating shaft goes". The more tightly the seal is retained against the shaft, the better is the sealing property. However, this leads to an abrupt loss of energy caused by friction between the shaft and the seal. Thus, we have a conflict between two parameters which are important for evaluating the quality of the specific system -"Rotating Shaft Seal".

In OTSM, these contradictions describe conflicts between parameters of non-technical systems (scientific, management, social and business systems, economic systems, etc.).

Example: To effectively solve some problem, a typical solution is attracting a large number of employees possessing knowledge in various fields. These people, however, often do not understand each other's problems because of the lack of knowledge in other subject areas. Meetings become ineffective, the problem remains unsolved.

Here we have to do with the "Working Team" system where a conflict arises between the parameters "Degree of competence in allied sciences" and "Effectiveness of discussing various aspects of a problem situation".

If identifying contradictions for the first stage of ARIZ is difficult in a given situation, using the methods of the OTSM Technology "New Problem" is recommended. In comparatively simple cases, you can also resort to the Express Analysis of the initial problem situation, developed within the OTSM Technology "Contradiction". For more complicated situations, the OTSM "Problem Network" tool may be employed. This tool allows conducting a more detailed analysis of a complicated problem situation and identifying key problems which need to be solved in the first place. It is useful to apply the Express Analysis to such problems to provide a precise formulation of the first step of ARIZ. Applying the OTSM Express Analysis of a problem situation requires additional knowledge about the minimal system notion.

Performing the steps of the first part of ARIZ-85-C on the basis of OTSM comments results in obtaining a problem model which will be further analyzed. But before passing to the second part of the Algorithm, it is necessary to see if the inventive standards of Classical TRIZ may be used.

The thing is that after transforming the description of an initial problem situation into a problem model, only the most important components, responsible for creating the problem situation, remain in the model description. As a result, it becomes easier to give the description of the problem situation a form that allows application of standard inventive solutions accumulated in Classical TRIZ.



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### 3.1.2 The second stage. Analyzing the available resources

The second part of ARIZ is designed for analyzing the obtained problem model and preparing for the identification of in-depth contradictions underlying the problem. To be more exact, this part is designed for analyzing resources that can be potentially used for problem solving, in particular, the resources of place, time, “substances” and “fields”. Partially tested is also the possibility to apply some standard mechanisms of bypassing or fully resolving contradictions. Just like the first part of ARIZ, the second one contains some mechanisms for suppressing psychological inertia.

### 3.1.3 The third stage. Constructing an idea of a satisfactory solution by analyzing IFRs and Physical Contradictions related to specific resources

ARIZ is designed for revealing the in-depth roots of a problem and removing them by means of resources available in a specific problem situation. In the third part of the Algorithm, the description of a desirable result and contradictions hampering the achievement of this result continues to be specified.

The First Objective of the third part of ARIZ is specifying the problem model obtained in the first part. This objective is achieved by using the additional information obtained through the model analysis conducted in the second part of the Algorithm. This new, specified model is constructed according to different rules and differs fundamentally from the model produced in the first part.

In this part, it is necessary to determine which result can be considered as a solution to the problem and to identify numerous contradictions preventing the use of the available resources for obtaining the desirable result.

The second objective of this part is obtaining partial solutions which will be used for assembling a conceptual solution of the entire problem as a whole. The obtained partial solutions are integrated into a single system of solutions providing the maximum approach to the most desirable result. The principles of removing physical contradictions and the system convolution mechanisms are employed for this purpose.

Generally, starting from the third part, the number of obtained partial solutions begins growing and new final solutions are formulated. In such a situation, there is a temptation to terminate the process of search for solutions. Nevertheless, the Algorithm rules recommend passing through all ARIZ stages because these help obtain additional ideas, strengthen a found solution or detect some other problem-solving ways corresponding to more advanced stages of system evolution.

Executing the third part of the Algorithm results in that our idea of the problem situation essentially changes again and is formed at step 3.5 of the Algorithm. As a result, the last step of this stage refers us once more to the system of inventive standard solutions.

### 3.1.4 The fourth stage. Mobilizing the resources

The fourth part of ARIZ is designed for understanding how the available resources can be used to solve the problem as the latter is defined in the third part of the algorithm and to increase the effectiveness of the already found solutions.

The fourth part includes a set of operators aimed at obtaining a version that would be more developed from the system evolution theory view point.

If one of the obtained solutions suits us, we can pass to the seventh part of ARIZ for preliminary evaluation of the solutions in accordance with the ARIZ rules.

If, on the contrary, no satisfactory solution has been found, the analysis continues according to the fifth part of the Algorithm.

### 3.1.5 The Fifth Stage. Using the knowledge collection accumulated in TRIZ

In the Fifth part, a solver is proposed to refer to the collection of various TRIZ tools which describe standard solutions in different forms: the System of Inventive Standards, principles of resolving physical contradictions, effect pointers.
If the use of the data base has not resulted in a satisfactory solution, it is necessary to pass to the **sixth part** of ARIZ.

### 3.1.6 The sixth stage. Changing and/or correcting the initial problem description

The sixth part of the Algorithm offers recommendations regarding the change or correction of a problem definition or problem model before analyzing it again starting from the first part of ARIZ.

### 3.1.7 The Seventh Stage. Evaluating the obtained solutions

The seventh part of ARIZ contains rules of evaluating solutions from the TRIZ viewpoint and strengthening the obtained solution.
It is but a preliminary evaluation. In the course of this evaluation, there may appear new ideas specifying or improving the obtained solution.
This is, however, but a preliminary express evaluation of the solution. Sometimes, solving a problem according to ARIZ helps overcome stereotypes of professionals and brings solvers outside their professional competence, so it is necessary to consult respective specialists for evaluating the obtained solutions.
If a solution has been accepted, it makes sense to discuss with patent engineers a possibility of making an application for a patent.

### 3.1.8 The Eighth Stage. Expanding the application scope and standardizing a creative solution

The eighth part of ARIZ serves to prepare the implementation of a final solution and to check whether this solution can be applied to solving other problems, including those from different subject areas.
This allows giving the solution a more generalized standard form for further practical application. This part is also necessary for providing a better patent protection of your solution (creating a patent umbrella).
In addition, this part helps increase the solution effectiveness and derive an additional profit from its implementation.

### 3.1.9 The ninth Stage. Reflection about the performed work

The ninth stage of ARIZ helps better understand the core of the performed work. The aim of this stage consists in learning as much as possible in the field of problem solving, thereby increasing the creative potential of an individual or a team.
This stage is designed for developing the skills of reflection about the work being performed. In principle, each ARIZ step should be followed by reflection about how that step was made, what difficulties were faced while performing that step, what difficulties were overcome, how accurately the ARIZ recommendations were performed, whether the performed work differs from what is recommended by ARIZ and why such differences occurred.
The answers to these questions develop the reflection skills and facilitate understanding of the ARIZ-based problem solving process at the stage of assimilating the Algorithm on the examples of training problems. At the stage of professional application of ARIZ to real problems, they facilitate further development of ARIZ itself and improvement of its effectiveness in solv-

ing new, increasingly more complicated problems.
It should be noted in conclusion that the reflection skill is one of the most important thinking skills in general and not only with respect to Classical TRIZ and OTSM tools. The ninth part of ARIZ helps us develop this fundamental thinking skill.

## 3.2 The list of ARIZ steps

The previous sections shortly describe the designation of each ARIZ part at each stage of work on a problem.
Below is given a list of Algorithm steps. Further, we will show how these steps were executed while solving a problem.

**Part 1: Analyzing a problem and creating a model.**

Step 1.1. Describing a problem condition.
Step 1.2. Identifying the conflicting elements of a system.
Step 1.3. Creating a graphical scheme of a system of conflicts.
Step 1.4. Selecting a graphical model of a system.
Step 1.5. Aggravating the main conflict.
Step 1.6. Formulating a problem model.
Step 1.7. Searching for a standard solution

**Part 2: Analyzing a problem model.**

Step 2.1. Analyzing the operational zone.
Step 2.2. Analyzing the operational time.
Step 2.3. Analyzing su-field resources.

**Part 3: Defining an ideal final result (IFR) and physical contradictions which prevent the achievement of IFR.**

Step 3.1. Formulating an ideal final result (IFR-1).
Step 3.2. Intensifying the IFR-1 definition.
Step 3.3. A physical contradiction (PhC) on a macrolevel.
Step 3.4. A physical contradiction on a microlevel.
Step 3.5. Formulating an ideal final result (IFR-2) for different resources and specifying the initial problem
Step 3.6. Using the system of standards (76 standard solutions to inventive problems, using a su-field model).

**Part 4: Mobilizing resources**

Step 4.1. Modeling a problem with “little creatures”.
Step 4.2. Using «a step back from IFR” method
Step 4.3. Using a mixture of available resources
Step 4.4. Introducing voids of different types into available resources.
Step 4.5. Using substances derived from available resources
Step 4.6. Checking whether a problem may be solved by replacing some substance with an electric field or interaction between two electric fields.
Step 4.7. Checking whether a problem may be solved by introducing a “field – additive responding to a field” pair.

**Part 7: Checking a method of removing a physical contradiction.**

Step 7.1. Checking an answer.
Step 7.2. Preliminary evaluation of an obtained solution.
Step 7.3. Checking for the absence of the invention in the patent collection.
Step 7.4. Evaluation of subproblems arising during implementation.

**Part 8: Using an obtained solution.**

**Part 9: Analyzing the solving procedure.**



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## Example of solving a problem by using ARIZ

Above we have described the role of each of the nine ARIZ parts. Now, we are starting to describe the objective of each step constituting these parts of the algorithm. To this end, we are going to use one of real problems solved by using TRIZ.

### Initial problem description

To create large-diameter concrete pipes (up to 6 meters in diameter), a concrete mixture is poured into a double steel formwork (see Fig. 1).

To improve the pipe quality, the concrete mixture undergoes vibration treatment by vibrators attached to the formwork. The vibrator's operation principle is very simple: it is an eccentric flywheel slipped over a motor drive shaft. When the motor is running, the eccentric flywheel hits the formwork inducing vibrations which are transmitted from the formwork to the concrete.

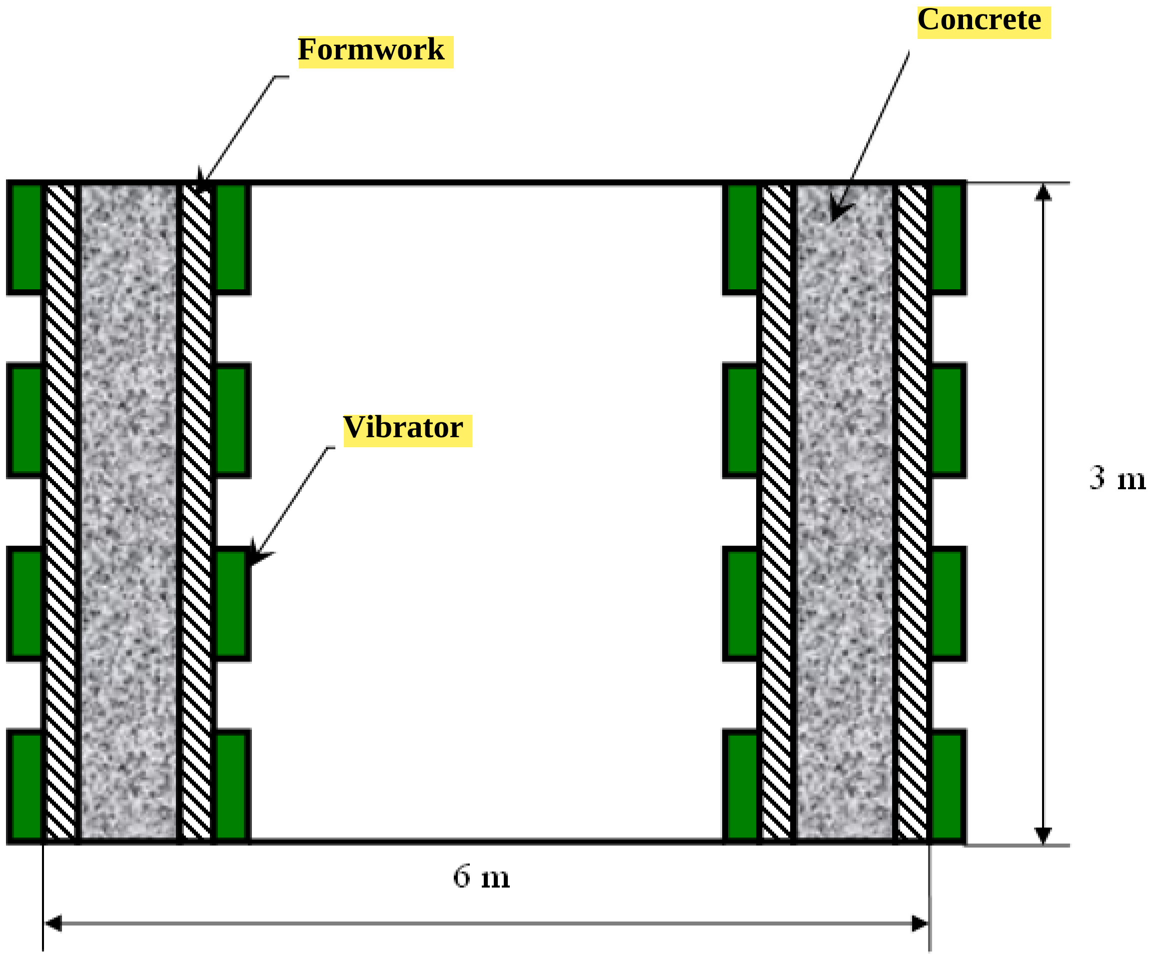


*Fig: 2 Section of a formwork for concrete pipe production, provided with a vibrator to make concrete compact.*

At the level of a production process, the vibrator performs its function well enough. The only disadvantage of this system is a high-level noise. As the strength of the produced sound is concerned, it can compete with a jet engine. How can this disadvantage be eliminated by introducing minimum changes into the existing system and by using minimum external resources and maximum internal resources available within the system or the surrounding environment?

In terms of Classical TRIZ, such a formulation of a problem is called a mini-problem. A mini-problem is characterized by that it contains maximum restrictions concerning the introduction of new components. The general rule of defining a mini-problem is “Everything should remain as it is, but the disadvantage should disappear”.

Inversely, a maxi-problem admits any changes up to a radical change of the system itself or its replacement with a different system which is free of the given undesirable effect.

Thus, solutions can be classified according to the limitations within the frames of which they solve a problem, starting with the maximum limitations of a mini-problem and finishing with the minimum limitations of a maxi-problem.

It is evident that the recent advanced technology of self-compacting concrete does not require use of vibrators and is a problem solution differing from that described in this article. However, solving the problem by means of self-compacting concrete is not a mini-problem solution, because it requires more changes and more advanced research than those necessary for the proposed solution.

The idea of such concrete was produced at the very beginning to the problem solving process. At that time, however, creation of such concrete was a serious research problem and required much time. We should also mention that the problem arose at an operating plant and needed to be solved within a short period of time, with available means and at an acceptable price.

And, finally, we would like to remind our readers that this example was written by a TRIZ specialist who is not an expert in civil construction. It is transparent not only to specialists in the given field, but also to the general public.

### 3.2.1 Part 1: Analyzing a problem and creating a model

**Step 1.1. Describing a problem condition**

#### 1.1.1. A short description of a technical system, its designation and basic components

The given technical system serves to produce concrete pipes. It is composed of a double steel concentric formwork (into which a concrete mixture is poured) and vibrators (which hit the formwork for increasing the concrete density and removing the air voids formed while poring the concrete into the formwork).

#### 1.1.2. A system of contradictions

From the TRIZ viewpoint, any problem is complicated because it contains a hidden or apparent contradiction. To solve a problem, it is necessary to identify a contradiction and to describe the problem in such a manner as to bypass or eliminate the revealed contradiction.

Thus, to begin with, it is necessary to identify a problem-causing contradiction. In TRIZ, correctly describing a problem means finding this contradiction and defining it as clearly as possible according to certain rules. This may be done by using OTSM Express Analysis of a problem situation. In some relatively simple cases, however, ARIZ may be immediately applied to a problem situation. For this purpose, ARIZ includes a system of technical contradictions called TC-1 and TC-2.

A correct description of the system of contradictions allows understanding which parameters used for evaluating the properties of a given system are connected with a contradiction: two parameters of a technical system under consideration (Evaluation Parameter 1 and Evaluation Parameter 2) are interrelated through a third parameter which can be used to change the values of the Evaluation Parameters. This parameter is called the Control Parameter because changing its values allows the Evaluation Parameters to be controlled (Control Parameter).

While formulating TC-1 and TC-2, it is important to identify the element to which the control parameter, connecting two Evaluation Parameters, belongs, the connection being such that improving Evaluation Parameter 1 worsens Evaluation Parameter 2 and vice versa.

We are not going to describe the initial situation process in detail and will directly give a system of contradiction.

TC-1:

If the vibration force (Control Parameter 3) of the vibrators (element E) is large (value of the Control Parameter 3), the concrete density and homogeneity (Evaluation Parameter 2) are high (value of Evaluation Parameter 2, positive), but the noise level (Evaluation Parameter 1) is very high (value of Evaluation Parameter 1, negative).

TC-2:

If the vibration force (Control Parameter 3) of the vibrators (element E) is not large (value opposite to the value of Control Parameter 3 indicated in TC-1), then the noise level (Evaluation Parameter I) can be reduced (value of Evaluation Parameter I, positive), but the concrete density and homogeneity (Evaluation Parameter 2) are reduced (value of Evaluation Parameter 2, negative).

| | |
|---|---|
| Parameter 1 - Evaluation | Noise level |
| Parameter 2 - Evaluation | Density and homogeneity of concrete |
| Parameter 3 - Control | Vibration force |

It should be noted that grouping into control and evaluation parameters is absent in Classical TRIZ. It was introduced within the framework of OTSM for clearly distinguishing the roles of parameters in the course of analysis of complicated problem situations when one and the same parameter plays different roles. In addition, even in the process of ARIZ-based analysis of relatively simple problems, there arises a necessity of introducing new control parameters which can serve as an alternative to the given parameter.

It is important to understand that the Evaluation Parameters selected at step 1.1. remain unchanged during the entire problem analysis. They can only be specified. At the same time, the list of control parameters may be expanded while analyzing the problem in the third part of the Algorithm.

### 1.1.3 The desired result

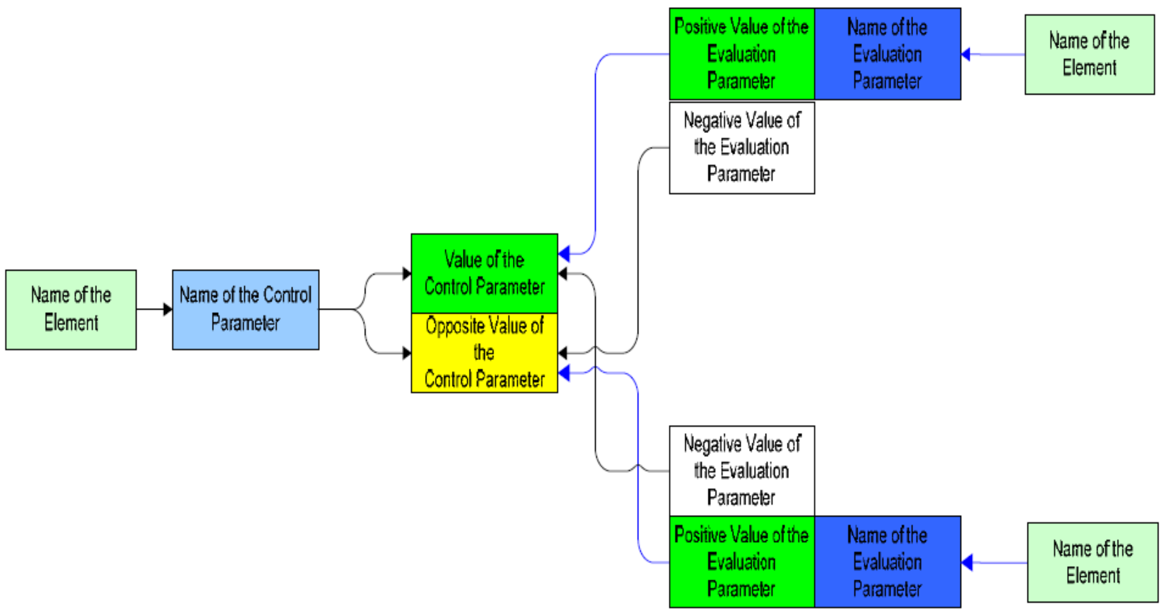


*Fig. 2. The OTSM ENV scheme of the system of contradictions.*

If the system of contradictions is correctly built and if the model is properly defined, it is enough to assemble the positive values of Evaluation Parameters 1 and 2 of the model of the system of contractions as shown in Figure 2.

The desired result definition

To solve the problem, it is necessary to provide a high density and homogeneity of the concrete (the value of Parameter 2, positive) while preserving the low level of noise (the value of Parameter I, positive).

It is essential to comprehend the laws of the subject area (physical or other) which interconnect the key parameters of the system (the above mentioned evaluation parameters 1 and 2).

In terms of Classical TRIZ and OTSM, the law is a steadily recurring relation between parameters, phenomena or events. If one event occurs, then another one naturally follows. If one of the parameters changes its value, then the values of other parameters, connected with this parameter, also change.

If fulfilling the first step of ARIZ causes difficulties in dealing with some problem, it is recommended to use the OTSM Express Analysis for transforming the initial problem situation into an OTSM ENV scheme of the system of contradictions.

### Step 1.2. Identifying the conflicting elements of a system

This step is aimed at identifying the system elements which connect the positive and negative parameters described in step 1.1. through cause-effect relations, laws.

The ARIZ steps are closely interrelated, each following step is always a logical continuation of the previous one. The absence of such interrelation means that some logical mistake has been made and it is necessary to revise the previous steps to find and correct this mistake in the analysis. With a correctly performed analysis, each subsequent step logically results from all previous ones.

If the first step was performed by using the OTSM Express Analysis of the problem situation, then the result f step 1.2 should match with the scheme of the positive system obtained as the result of the express analysis.

The two conflicting elements are the tool and the product.

The product is an element that need to be processed (manufactured, moved, changed, improved, protected from a harmful influence, revealed measured etc.) according to the problem conditions. For problems about detection and measurement some element considered as tool (according its base function), can be considered as product (e.g. a sensor receives a function by the signal source, thus it is a product not a tool).

The tool is an element that directly interacts with the product (e.g., mill rather than a milling machine; fire rather than a burner).In particular, a part of the environment can be considered as a tool. The standard parts from which the product is assembled can be considered as a tool too (e.g., meccano this is tool to create of various "product")

One of the elements in the conflicting pair can be doubled. For instance, two different tools are given, and they have to act on the product simultaneously, where one tool interferes with the other. Or two products are given, and they have to be processed with the same tool, where one product interferes with another.

As to our example, the following participants of the problem situation can be identified as a product and a tool:

*Product: concrete mixture*

We need to produce a denser concrete mixture. That is, the performance of this function must result in an increased concrete density.

*Tool: vibrator and formwork*
The formwork directly interacts with the concrete but the formwork itself cannot cause the concrete vibration; therefore, in accordance with the ARIZ rules, we are considering the double tool “formwork+vibrator”.
The tool vibrates and compacts the concrete mixture, which is its main function. However, a harmful (undesirable) product – sound - occurs during this operation. It should be removed without preventing the performance of the tool’s main function. The appearance of a loud sound is a secondary phenomenon. In this situation, it is again considered undesirable. Therefore, to solve the problem, this phenomenon should be removed.
To complete this step, it is necessary to formulate what the system should do, or, in other words, to formulate its function. To describe the function, OTSM-TRIZ recommends using a group of synonyms. It helps to overcome psychological inertia imposed by the professional terminology. By the way, we deal here with one of the general rules of Classical TRIZ which states that all special terms must be replaced with ordinary words used in the everyday life.
This forces a solver to examine a phenomenon of interest at different angles and to better understand what exactly the analyzed system should do.

An even more effective tool for suppressing the psychological inertial imposed by terms and for determining the function even more precisely is the Three-Step Function-Describing Algorithm built on OTSM models which we are not going to describe in this paper.

In mastering ARIZ, it is important that a teacher pay special attention to teaching students to perform self-verification of the performed steps. It is one of the reflection skills which are so important in dealing with complicated problems. Teaching students to carry out self-verification of the step performance quality is closely connected with different OTSM-TRIZ models, postulates and tools. The wider and the deeper the students’ knowledge of the entire complex of OTSM-TRIZ theoretical basics and practical tools, the easier is controlling the quality of the steps they perform and the higher is the quality of the entire problem-solving process.
For example, when controlling the performance quality of step 1.2., it is useful to compare the obtained result with the system description at step 1.1. If a solver is familiar, for example, with the OTSM Three-Step Function-Describing Algorithm, then it would be helpful to use it for determining a product.
But if the OTSM Express Analysis of a problem situation has been carried out, then it would be useful to make a stop at step 1.2. and to check how step 1.2. of ARIZ is coordinated with the models obtained in the course of the Express Analysis.
The process of verifying the performance logic of ARIZ steps is often akin to the process of verifying computation results in mathematics: it is necessary to perform computation by some other method and to compare the results. This is done by means of the next step too.

**Step 1.3. Creating a graphical scheme of a system of conflicts**
The goal of this stage is analyzing the appropriateness and logical unity of the previously performed steps. To this end, a problem-describing graphical model is created in the course of analysis.
Presenting the text, obtained for describing a conflict at step 1.1., in the form of graphical models (see chapter on Su-Field modeling) is one of the ARIZ inherent mechanisms used to overcome psychological inertia. To perform this operation, other mechanisms of our conscious and unconscious thinking are employed. The thing is that, according to the researchers dealing with the study of the brain activity, different parts of the brain are generally responsible for text and for graphics. Therefore, describing a conflict through graphics and doing that through text are alternative tools which are helpful for self-verification of our work quality.


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Generally, after each two or three ARIZ steps, it is necessary to think over and verify the performed work summarizing the performed steps. If the steps logically follow from each other and do not contradict each other, you may pass to the next step.
But if the logic between the previous steps and the one being performed at a given moment is broken, if formal logic is violated, it is a signal denoting that we need to give more thought to the reason of that breakage.
In our example, it is necessary to compare the graphical models of the conflicts obtained at step 1.3. with the text description and ENV scheme (diagram) of the conflicts at step 1.1. In the graphical schemes just as at step 1.1., the evaluation parameters Noise Intensity Quality (density and homogeneity) of Concrete are in conflict with each other. The name of the evaluation parameter "Density and Homogeneity" of Concrete given in the text changed into the "Quality" parameter in the graphical presentation. The thing is that the notion of "quality" depends on many evaluation parameters and acquires different meanings for one and the same product or service depending on a situation; accordingly, this notion is easy to use by substituting it for more specific criteria and specific evaluation parameters. This, however, often reduces the analysis effectiveness. It is generally advisable to avoid wide terms and to indicate specific evaluation parameters which are used to evaluate the performance quality of a function.
Note that conflict schemes should include both the product and the tool identified at step 1.2. Both the concrete and the vibration formwork are present on the graphical schemes.
In conclusion, it should be said that graphical schemes can be executed in an arbitrary form convenient for a solver. The main condition is the logical correspondence to all previously performed steps: correlation with the text description of the conflicts and the presence of the same Product and Tool in the graphical and text descriptions of the conflicts.

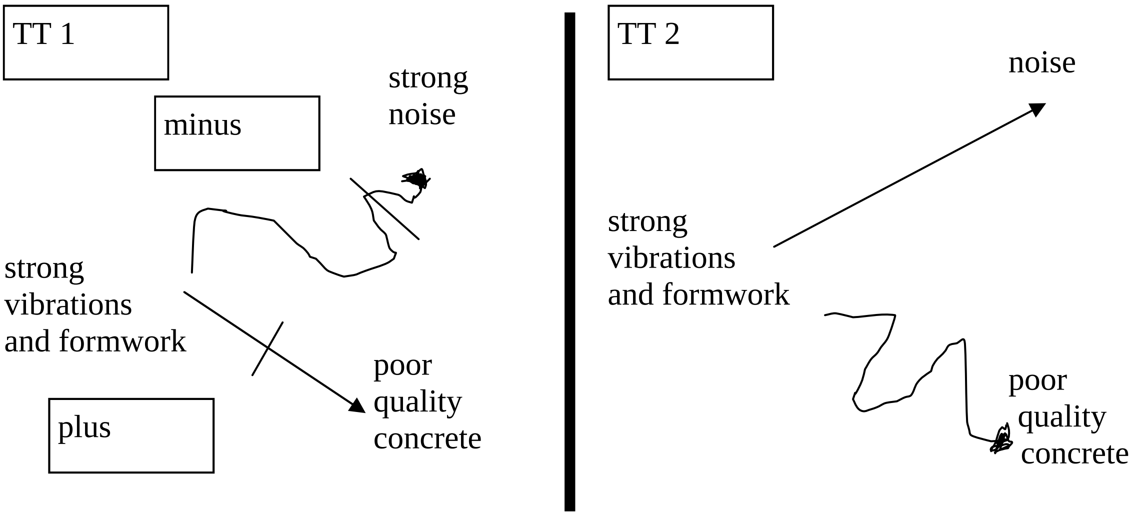


*Fig.3: Graphical models of the problem.*

**Step 1.4. Selecting a graphical model of a system**
To build a problem model, we need to select one of the revealed conflicts.
To make a correct choice, OTSM-TRIZ suggests considering the hierarchy of objectives to the system of which the function of the system under consideration belongs.
Such an approach allows a better understanding of what exactly the main production process is in terms of Classical TRIZ. According to the ARIZ rules, it is proposed to select that of two graphical models which potentially improves the realization of the Main Production Process.



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TRIZ beginners often confuse the main function of a system with the main production process. To avoid this mistake, it makes sense to start this step with building a hierarchy of objectives. It should be noted that the function and the objective are usually considered as synonyms in terms of OTSM-TRIZ. In other words, the system function is considered as the system existence objective. The main production process is the existence objective (function) of some supersystem to which a system of interest belongs as one of its subsystems.

Example. The Main Function and the Main Production Process.
The function of an electric motor of a lathe tool is converting electric energy into the mechanical energy of rotation. Then the mechanical energy is used to rotate a block of material and move a cutter in different directions. As a result, the block of material is shaped into a necessary part such as a cylinder of an internal combustion engine. Thus, the Main Production Process is the production of internal combustion engines. The Main Function of the “electric motor” system is converting electricity into the mechanical energy of rotation.

To determine the Main Production Process, it is necessary to rise at least 3 or 4 levels above the level of the system under analysis.

### 1.4.1 The hierarchy of objectives

We need to reduce the noise level. But noise is produced during the performance of the main function by the vibrators.
The vibrators hit the formwork, thereby causing vibrations in the liquid concrete. The vibrations generated are gradually spread in the entire concrete bulk.
As a result, the concrete moves downwards squeezing out the air which got into it during pouring.
As a result, the quality of the concrete pipes produced by this company improves.
High-quality pipes are used for building pipelines of all kinds.

### 1.4.2. Selecting the graphical model of a problem

According to the analyzed hierarchy of objectives, the building of various transportation systems requires high-quality concrete pipes. Therefore, we are going to use the graphical model which allows producing the best-quality concrete (of high density and homogeneity). In other words, we are going to use the problem model described by contradiction TC-1.

If step 1.1. was performed by using the OTSM Express Analysis of the problem situation, then it would be useful to compare the hierarchy of objectives, obtained at step 1.4., with that obtained through the Express Analysis. If a significant difference is revealed between them, it is necessary to understand its causes and to eliminate them. To this end, we sometimes need to return to the beginning and to check the entire course of the analysis starting with the process of building the hierarchy during the Express Analysis. A solver has to switch attention from problem solving to the reflection about the conducted analysis logic trying to understand where and why the logic was broken causing a significant difference between the hierarchies of objectives and, as a result, a difference in determining the Main Production Process at different analysis stages. In such cases, it often becomes clear that the understanding of the particulars of the problem situation changed in the course of the analysis, but the change remained unnoticed. Hence it is necessary to repeat the entire process of the analysis in accordance with this new understanding of the problem situation.
It should be noted that a problem very often arises through to the absence of a clear understanding of what is happening in a given situation and why some phenomena are considered as

negative. The process of analyzing a problem situation by using the OTSM-TRIZ tool is aimed at better understanding and removing the in-depth causes underlying the occurrence of this problem situation. The problem solving process is organized in such a manner that we can view the identified conflict at different angles just as we do while examining some sculpture.
For better illustration, let us draw an analogy with a video camera. While analyzing a problem, we alternately move away from it to view the situation as a whole and come closer to view some details. Then we move away again and change our position to view the problem at a different angle, verifying the analysis logic and recoding solution ideas arising from subconsciousness. As we do this, our vision and understanding of the problem are being permanently changed and specified.
It is important to mention that in the course of applying the Classical TRIZ and OTSM tools, confirmed was G.S. Altshuller's initial hypothesis that the revealed mechanisms for solving technical problems would also prove useful for solving nontechnical problems. It is only necessary to organize an effective cooperation between TRIZ professionals and experts from narrow subject areas. The OTSM tools moved even farther in this respect. They are practically not connected with any subject area. Whether it be technology or research, business or economics, the OTSM-TRIZ tools allow an effective processing of knowledge in various subject areas. It is knowledge that is needed.
The thing is that analyzing a problem situation in accordance with OTSM-TRIZ often brings narrow specialists to the idea that a problem can be solved by attracting the knowledge from other fields of human activity. Our tools help understanding what kind of knowledge is needed and determining the sphere of activity where this knowledge is used most frequently and effectively. Inviting experts from this area of knowledge may help you find a necessary conceptual solution and bring the general ideas of this solution to a level of detail which enables the implementation of this solution.

Example from my recent practice. One of the students of the innovation design program was developing a project related to the matching of two very small objects for their further assembly. Both he and his colleagues were mechanical engineers. Because most of their knowledge belonged to this area, they were only focusing on finding a mechanical solution to their problem. The problem analysis which they had carried out using OTSM-TRIZ tools brought them to a conclusion that their problem could be solved by supplementing the mechanical part with an optical part. First they were confused because they were not competent enough in the given area of optics. That is why they had never considered and proposed solutions that needed knowledge outside their competence. Nevertheless, ARIZ prompted them to attract specialists from this knowledge area. The company for which the student worked, found respective specialists in optics and, as a result, an application for a patent was filed.

The above example, just as many other examples from our practice, proves that the OTSM-TRIZ tools force a solver to diverge from the beaten track into the area of innovations where very interesting and promising solutions may be found. This peculiar feature of the OTSM-TRIZ tools allows engineers and other users to more effectively create new products and services, to organize business process in organizations in such a manner as to increase the competitiveness of their business under the rapidly changing market of products and services, to make their company capable of steadily producing necessary innovations, doing it effectively and timely. Of course, this requires efforts on the side of the highest level management and respective coordination of efforts between managers and professionals of all levels. But the game is worth the candle. Here is but one example. Samsung Corporation that started introducing TRIZ and the OTSM elements in 1999-2000 came in second in the world with regard to the number of patents registered in the United States, the first place being occupied by IBM. One of my students employed by IBM told me that such a quick growth of Samsung's innovation potential causes a serious concern at his company…

But let us return to our analysis of the concrete pipes problem.

Having made our choice in favor of the process which ensures a high density and homogeneity of concrete, we thereby also select an undesirable effect which we are going to eliminate using all available resources. The preliminary analysis of the undesirable phenomenon as well as the analysis of the resources potentially available in the initial problem situation will be carried out in the second part of ARIZ. Starting with step 1.4, the negative phenomenon and available resources are always analyzed in parallel and simultaneously. After identifying the details of the undesirable phenomenon, we clarify what resources can be used to eliminate this phenomenon (the second part of ARIZ). Then we see what prevents using the available resources for removing the undesirable phenomenon (the third part of ARIZ). Parts 2 and 3 of ARIZ systematically stimulate the work of subconscious creative mechanisms. The individual nuances of the undesirable phenomenon are being integrated into a more complete and more detailed picture of the occurrence and evolution of the undesirable effect selected at step 1.4. Partial conceptual solutions are arising in parallel. They are tying into a more complete and detailed picture of the future solution to the problem. In this case, to synthesize solutions, solvers may use various tools which are not directly mentioned in the canonical ARIZ text. The ARIZ text is a kind of strategy of using individual tools and theoretical statements of the permanently developing OTSM-TRIZ. Individual ARIZ steps are tactical ploys needed for realizing the strategy. Depending on the development level of the new tools and theoretical basics of OTSM-TRIZ as well as on the awareness of these novelties, the solver performs respective ARIZ steps leading him to a Satisfactory Conceptual Solution.

But before passing to the second part of ARIZ, we have to complete the process of building the problem situation model. Step 1.5. makes OTSM-TRIZ similar to karate. G.S. Altshuller even called Classical TRIZ an intellectual karate. Why? We will answer this question at the next step.

**Step 1.5. Intensifying a conflict**

Classical TRIZ and OTSM points out, with a high degree of precision, the direction to a solution. However, to move through the labyrinth of the problem, knowing the direction is not enough. It is also necessary to have a "means of transportation" that allows moving in the indicated direction. Such means is often the knowledge in some scientific area. One of the advantages of the Classical TRIZ tools is that they not only point out the direction, but also help to choose a "means of transportation".

In other words, they allow selecting the knowledge which is really indispensable for solving the problem, from a great amount of specialized knowledge. If the necessary knowledge already exists and is available, it brings us closer to the problem solution. If not, the TRIZ tools allow us to clearly understand what knowledge is needed to solve the formulated problem or to find a way to avoid this problem. That is, to change the situation in such a manner as to make problem solving unnecessary.

Example of bypassing a problem.

Many years ago, using a public phone, people had to pay a call by throwing a coin into a narrow slot and there was a special service responsible for regularly collecting these coins. Robbers attracted by this money often broke telephone apparatuses. There occurred a problem of creating an absolutely reliable public telephone sets securely protected against vandalism and robbery.

Many engineers were engaged in the solving of this problem, creating new and new models of

telephone apparatuses. They, however, failed to succeed in this competition with robbers.
What was to be done?
As all of us know today, the problem was solved by entirely changing the approach to paying telephone calls. There was organized a system of selling telephone cards or a direct use of bank cards. Money disappeared from telephone apparatuses and these ceased to attract robbers.

An important step toward solving a problem is step 1.5, intensifying a conflict.
For beginners, it is often difficult to appreciate the creative contribution of this step to problem solving. They unconsciously try to avoid it or perform it formally (just to show that they have performed it). ARIZ is an analysis tool but it cannot replace the analysis itself. Passing formally through all ARIZ stages very often results in a failure to solve a problem. That is why TRIZ-based computer programs do not always lead to a successful solution even if a solver has formally passed through all the stages. These programs help to move in a necessary direction but they are not designed for replacing a thinking person. To understand the recommendations given by ARIZ or TRIZ-based programs, it is necessary to have a good knowledge of TRIZ and to clearly understand how the tools of this theory work.
Let us expand on how step 1.5. works and on the many-sided role is plays, which is actually true with respect to any other step of G.S. Altshuller's Algorithm.
Those familiar with karate or other oriental fighting systems know that the latter includes not only physical motions of a body but also very sophisticated motions of the brain which allow a fighter to perform a necessary motion in the most effective manner.
Once I used one of these thinking mechanisms in wood chopping. But let us start from the beginning.
In karate, there is a general principle of aiming before striking a blow at a respective point of the contestant's body. One needs to mentally focus not on a strike point but on a point that is much farther than the aiming point. In this case, the delivered blow is much stronger, the consumed force being the same.
This principle works very well in wood chopping. You can check it yourself. One should aim not at the top of a log and not even at the surface of the chopping block on which the log stands, but at a much lower point. Then your axe will pass through the log almost without your effort… Why?
One can but admire the fact that the karate inventors found solutions combining psychological, physiological and physical mechanisms.
It turns out that when we are aiming at some point, our subconscious mind gives an order to the physiological mechanisms of our organism, the self-preservation order. As our hand is approaching a blow point, we instinctively, on a subconscious level, begin to slow down its motion for preventing damage of our own body. In this case, first we spend energy on speeding-up and, while approaching the impact point, we spend it on deceleration. As a result, the energy consumption increases and the impact force reduces.
Something like that occurs while working on a problem. A solver is instinctively trying to smooth a conflict underlying the problem and to compromise instead of solving it.
As we know from the theoretical foundations of Classical TRIZ, the tools of this applied theory are aimed at the greatest possible reduction of the number of empty trials and errors under given conditions. Step 1.5 is one of the tools which allow us to reject a great number of compromise, unsatisfactory ideas without generating them. At the start, it looks strange for beginners, but with the assimilation of the entire body of knowledge of OTSM-TRIZ, there comes understanding of how and why it is possible.
The previous steps helped us formalize the problem description and give a more detailed description of the essence of the problem. At step 1.4., we have selected a solving direction, the



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point of intellectual blow, on which we are going to focus, not once, our attention at the following steps of the Algorithm.
From the karate terminology, we have selected the aiming point on which we must focus our efforts. Now it only remains to mentally move this aiming point as far away as possible. Then our intellectual efforts will turn out to be more productive in terms of removing the problem and the barriers which hamper its solving.
Let us go back to the pay telephone example. There was a telephone robbery problem. Let us increase the requirements imposed on the solution. When will the robbery of pay telephones become impossible? The answer is quite obvious: when there is no money in them and there is nothing to steal. This general solving direction leads us to an obvious solution: it is necessary to make such a telephone apparatus in which money could never appear. Correspondingly we come to the idea that calls should be paid elsewhere, where money safety is already guaranteed. Thus, instead of the problem of preventing the robbery of public telephones we solve the phone call payment problem.

Let us consider the concrete pipe example. The undesirable effect – strong noise – occurs because it is necessary to compact concrete. There will be no noise if we do not hit the formwork, but then concrete will not be compacted. One of possible formulations of the new problem will sound like follows: there must be no hits on the formwork but concrete must compact itself. This leads to an idea of creating a new kind of concrete. Today, such concrete does exist. However, at the time when this problem was urgent, no such concrete existed. There was also one more important detail. As we have already mentioned, the problem arose at a plant which had no research department capable of creating such concrete. As a result, they had to focus on a mini problem: the concrete pipe production technology must not undergo significant changes but noise must be eliminated or considerably reduced.
The conflict intensification is one of the stages which can be passed purely formally. But his operation will not be able to lead us to a solution until a person who is studying ARIZ has mastered the mechanisms of this stage. The better his knowledge of this ARIZ stage, the higher is his professional level. To properly perform through this step, it is necessary to overcome psychological inertia which prevents finding a solution. Those who are able to do this significantly increase their problem solving abilities. One of the Classical TRIZ tools which can help perform this step in the best possible way is the STC (Size-Time-Cost) operator. We will, however, omit the step performance description and will only give its performance results.

**Initial conflict**:
The vibrators hit strongly the formwork in order to compact concrete but this causes a strong noise which is considered as a disadvantage under the given conditions.

Because we have selected the mini-problem for solving, we must formulate the intensified conflict as applied exactly to the existing technology:
**Intensified conflict:**
The vibrators hit the formwork with such a force that the produced noise is insupportable even at a distance of hundreds of kilometers from the pipe production place. This operation induces vibrations which are not dampened (their amplitude is the same in the entire bulk of concrete), thereby proving the best compaction quality.

It should be noted that intensifying a conflict according to the OTSM-TRIZ rules allows passing through stage 1.5. not just formally, but penetrating deep enough into the problem. As we see, to improve the concrete quality we need to provide a necessary vibration amplitude in the entire bulk of concrete. The undesirable effect arouse just because it is necessary to provide a required vibration amplitude of concrete particles in the center of the concrete mass between

two formwork sides. However, due to the concrete properties, vibrations attenuate rapidly while propagating from the wall toward the center of the concrete mass.
One of the rules applied in the above examples points out that the conflict intensification should not be only confined to intensifying the undesirable effect (the strong noise becomes even stronger), but should also forecast the intensification of the positive (desired) effect which we could use (uniform and continuous vibration in the entire concrete mixture).
Step 1.5. proves once again that both the desired and undesirable effects are logically connected with each other. At step 1.5., it sometimes becomes clear that this connection is absent. This means that we have to define the problem in a different manner and it will probably be solved by some typical method.
Thus, step 1.5. also performs the verifying function. It checks whether there exists a cause-effect connection between two evaluation parameters through a control parameter.
After performing the conflict intensification step, an experienced OTSM-TRIZ user already roughly knows where the solution "hides" itself. Nevertheless, even without any special skills in using TRIZ, this stage helps to notice something which slipped attention of specialists who previously worked on this problem, specifically, that to produce a necessary result, it is enough to know how to induce sustained vibrations in the concrete body or how to create vibrations of the concrete itself using resources.

For example, while solving this problem in a classroom, some of the students often come to an idea of producing vibrations by using the reinforcement placed inside the concrete mass.
It is one of the most frequent partial solutions obtained at this step. There are also other solutions, because psychological inertia is beginning to break down and the problem is becoming more and more comprehensible even to specialists who have been dealing with it for a long time.
It is practically impossible to show a beginner all the nuances of work on real problems, only using one problem as an example. The real life will always be much richer than training examples. Therefore, while seriously studying ARIZ, students must solve their own practical problem taken from their professional or private life.
Many ARIZ steps may be used both as self-sufficient, independent tools and in combination with other OTSM-TRIZ tools. However, using them as part of the Algorithm produces better results.

## Step 1.6. Formulating a problem model

Step 1.6. summarizes the work done in accordance with the first part of ARIZ. At this step, we play the role of an outside observer and integrate all the results, attained at individual steps, into an organic whole so as to clearly describe the new understanding of the problem situation – the problem model.

**1.6.1. Specifying the description of conflicting elements**

Now, based on the work dedicated to selecting one of the conflict schemes and on the intensified formulation of the selected conflict, we can again determine the conflicting elements (a tool and a product) and compare them to those identified at step 1.2.:

**Tool:**
a high-power vibrator which hits very strongly a formwork (vibrator + formwork). It hits the formwork so strongly that sustained vibrations are induced in the entire bulk of concrete.

**Product:**
a mixture of concrete and air (contained in the concrete)

The product has remained unchanged but the state of the tool has been significantly corrected.



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### 1.6.2. Formulating the intensified conflict

The high-power vibrator hits the formwork so strongly that the "stirring" (motion, fluctuation, vibration) amplitude of the concrete mixture is virtually not dampened and remains the same in the entire concrete bulk. But the produced noise becomes unbearable.

If step 1.5. has been thoroughly performed, it may seem that its formulation can just be copied. However, it is not worth doing. It would be better to give another thought to how to intensify the conflict still more and to focus on the conclusions that may be derived from the intensified conflict. In the instant case, while intensifying the conflict, we have revealed the best concrete compaction conditions: an equally strong vibration amplitude of the concrete mass over the entire distance between the formwork walls. Now we can correct the desired result description.

### 1.6.3. Reformulating the desired result

It is necessary to introduce an unknown element or make necessary changes which will be further referred to as an X-element which, on one hand, will provide a necessary force and amplitude of stirring (motion, fluctuation, vibration) in the concrete bulk and, on the other hand, will provide an absolutely noiseless operation of the vibrators.

Note that an X-element is not necessarily a physical object; it may as well be a structural change in the already available elements of an initial system. This is just what we are aiming at: to introduce minimum changes but to eliminate a negative effect preserving and enhancing a positive effect.

Thus, we have analyzed and summarized all the work done in accordance with the first part of ARIZ. In this part, we have obtained a clear formulation of the problem model which we are going to use for analyzing resources available in the system up to the beginning of the third part of the Algorithm. Moreover, as we have already mentioned, due to the conflict intensification, this formulation calls our attention to the recommendation regarding problem solving.

Before finally completing step 1.6, let us use the OTSM rule and separately write out the description of the Positive phenomenon to be preserved and enhanced, giving also a clear description of the negative phenomenon to be eliminated.

**The positive effect we want to obtain and preserve by solving the problem:**

Obtaining a necessary force and amplitude of "stirring" (motion, fluctuation, vibration) in the concrete bulk.

**Undesirable effect to be eliminated:**

Noise occurring during concrete compaction. Making possible a noiseless concrete compaction.

As seen, the problem description has been considerably simplified. Now it has fewer details, the essence of the problem being preserved. We do not need to think about different solutions which do not work with this model. Nevertheless, such ideas may occur. They, just like all other ideas, should be recorded separately from the text of the Algorithm steps being performed so as to increase the effectiveness of OTSM-TRIZ-based work on these ideas in due time and not to search for them in the entire text of the ARIZ-based problem analysis.

### Step 1.7. Searching for a standard solution

Looking more attentively at the problem model description, one can notice that although the system element "vibrators" is preserved in the problem model description but it paled into insignificance only leaving the function he had to perform: to induce sufficiently strong vibrations of a specific amplitude in the concrete bulk.

Therefore, within the Su-Field problem model, it is worth starting with a su-field model, where we only have one substance and to select a corresponding standard solution or a group of such solutions.



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Here is one of the standard solutions recommended by the system of standards for a case that is analogous to ours: only one substance, adding one more substance or field to a system, organizing the interaction of both substances and the field in such a manner that the undesirable effect disappears while the positive effect remains or even improves.
At the given analysis stage, this recommendation seems very vague. However, the subsequent course of analysis will allow us to better understand what substance and field should be introduced into the system so that it can be solved.
The existing version of the System of Inventive Standards proposed by G.S. Altshuller allows the problem to be solved already at this step. But the goal of this material is not demonstrating how the System of Inventive Standards works but describing the work of ARIZ steps if standard inventive solutions do not bring us to a satisfactory solution. Therefore, we omit the detailed description of this step and transition to Altshuller's System of Inventive Standards.

### 3.2.2 Part 2: Analyzing a problem model

The second part of the Algorithm is designed for revealing and carrying out a preliminary analysis of available resources for resolving the conflict described in the problem model. In this part, we analyze space and time, substance and field resources available in the initial problem situation.
If the problem under consideration is not of a technical character, it will be necessary to analyze other kinds of resources specific for systems which need improvement or which need to be created within the framework of problem solving.
All this is the preparation for the solving process culmination which occurs in the third and fourth parts of the Algorithm.
In the second part of ARIZ, the number of arising ideas usually begins to grow. These ideas often seem ridiculous, unrealistic or just having serious disadvantages. The solvers' typical error is rejecting these ideas without having sufficiently analyzed them, while the reason of rejecting and underestimating them lies in psychological inertia.
All, even the most unrealistic and ridiculous ideas should be registered in a separate protocol, a bank of ideas. This is the general rule of OTSM-TRIZ analysis of problem situations irrespective of whether a Classical TRIZ or OTSM tool is used in the work on a problem.

#### Step 2.1. Analyzing the operational zone

The goal of this step is focusing, according to certain rules, our brainwork only on the analysis of space where a contradiction arises and checking a possibility of resolving the contradiction in space.
An operational zone is the part of space where a problem arises. It can be identified as the region where the Tool and the Product, identified at step 1.2, have an undesired or unsatisfactory interaction.

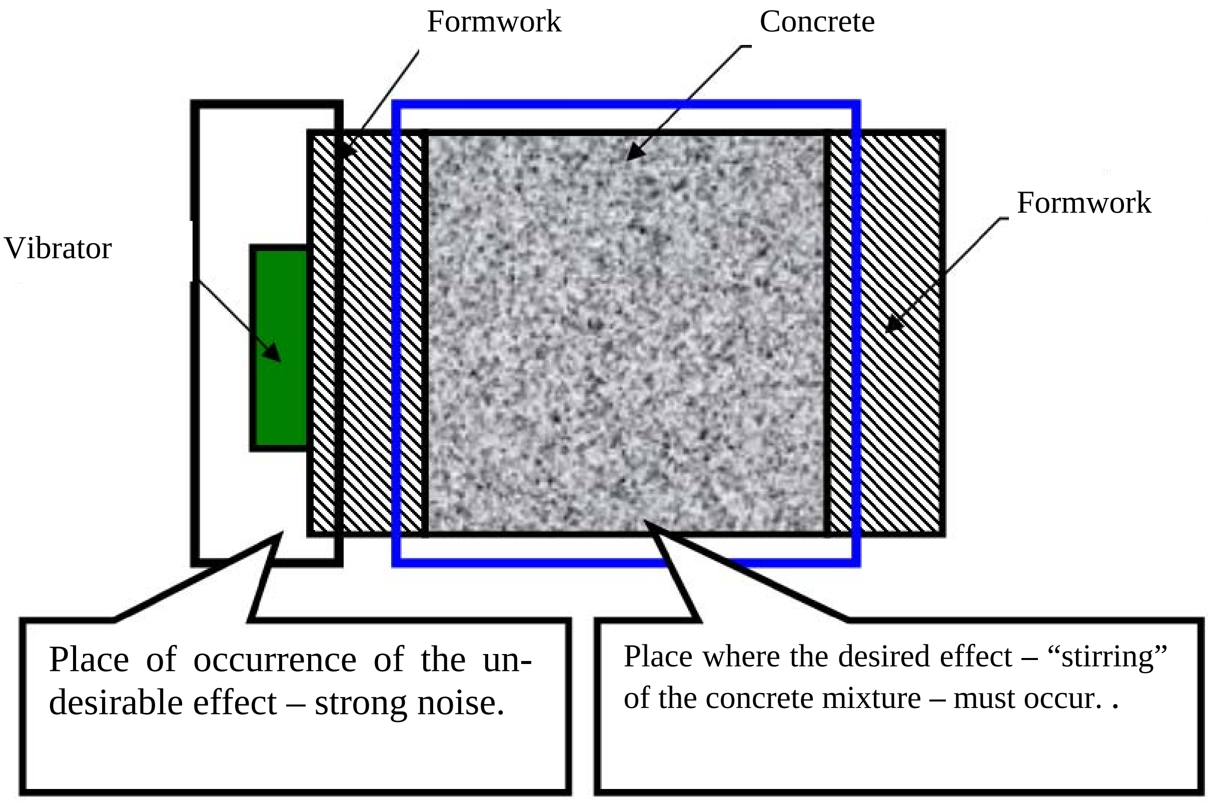


*Fig 5: Space zones where desired and undesirable effects arise.*

This figure shows that concrete stirring and noise generation occur in different regions of the space.
Analyzing the operational zone figure shows that the zone where the desired effect (stirring of concrete) must arise and the zone where the undesirable effect (air vibration) arises do not overlap in space. This proves the idea that the problem may be solved by separation in space. It is one of the most generalized conflict solutions used within Classical TRIZ. Thus, it is necessary to reflect upon what can be done to induce vibrations in the inner part of the formwork only or even in the concrete only so that there are no vibrations at all in the external part of the formwork or in the entire formwork as a whole. This solution is usually rejected and forgotten by TRIZ beginners, which, however, is a great error. This idea, along with other arising ideas, should be put into the bank of ideas to be used to gradually build the features of the future solution.
This is a kind of prompt to be taken into account and analyzed together with other solution ideas and available resources.
Also note that while describing the desired and undesirable effects, we used a term and gave a short explanation to it. The thing is that according to Classical TRIZ, all professional terminology used in the solving process should be replaced with simple, sometimes even strongly simplified terms which only stress that functionality which is important in a given case. That is why we replaced the term “vibration” with the term “stirring” with regard to the desired effect. For the same reason, the term “noise” is replaced with the term “air vibrations”.
A joint analysis of the term replacement and the operative zone allows us to give some preliminary description of the solution, which will be subsequently specified and supplemented with details. We will describe this prototype of the solution here and now. But we would like to re-

mind our readers that all ideas and combinations of ideas obtained in the process of work on the problem should be registered for their subsequent analysis using OTSM-TRIZ rules and tools.

Thus, let us carry out reflection (summarizing) on the step 2.1. performance analysis.

The problem can be solved by providing concrete stirring only within the formwork, so that the outer part of the formwork does not vibrate and does not induce air vibrations. Then absolutely no noise will occur during the concrete stirring and compaction.

This generalized description may seem too fuzzy, lacking concreteness and unrealistic. Nevertheless, let us register it and continue our analysis. Those more experienced in TRIZ may notice in this description the indication of at least two directions of search for interesting solutions. If psychological inertia still paralyzes the reader’s mind, let us go on. If you have arrived at some more or less realizable ideas, you should still continue the ARIZ-based analysis until you reach the fourth part. This will help you to “polish” the obtained ideas and to significantly improve them. In some cases, we can even arrive at absolutely different ideas which will grow out of the above described generalized, fuzzy conceptual solution or out of other ideas obtained in the course of further analysis.

The truth is that summarizing (reflection) should be carried out after each step and the ideas that arise during reflection should be registered in the bank of ideas for further analysis. We, however, do not do this here not to overload the text with superfluous comments and explanations. We are trying to show in a general form the process of analyzing a problem situation and synthesizing a solution.

### Step 2.2. Analyzing the operational time

The purpose of this step is focusing, using certain rules, our brainwork only on the analysis of the time intervals during which a contradiction occurs and checking whether the contradiction can be resolved in time.

To this end, we must, just as in case of space analysis, separately analyze the time intervals during which desirable and undesirable phenomena start and finish to occur. Indeed, the operational time is identified as the interval within the Tool and the Product, identified at step 1.2, have an undesired or unsatisfactory interaction.

In our specific case, both the undesirable and desired effects occur at the moment of starting the vibrator and continue till the moment of its de-energizing.

Thus, the time intervals during which the desired effect (stirring of the concrete mixture) and undesirable effect (strong air vibrations) occur are identical.

It is unlikely that we will manage to resolve the contradiction using the time resource, though in some cases it will be possible to change the speed of the concrete stirring process, thereby eliminating the occurrence of sound. For example, if the speed of occurrence of the formwork pressure on the concrete and the speed of eliminating this pressure are low enough, then the formwork vibrations will not generate such a strong noise.

Changing the speeds of the processes is also one of the methods for solving this problem in time.

In order to properly understand the separation in time opportunities it is suggested to become familiar with the System Operator

**Comments on the System Operator, ARIZ and TRIZ teaching purpose**

Those of the readers who are familiar with the System Operator of Classical TRIZ can notice that, while performing steps 2.1 and 2.2., we analyze a situation along two of the three axes of the System Operator: the time axis and the hierarchy axis.

The TRIZ author, G.S. Altshuller, considered ARIZ as a detailed analysis of a problem situation according to the System Operator presented in the form of a linear process. By its nature, the System Operator describes nonlinear thinking. As we have already mentioned, the main function of ARIZ is solving a specific nonstandard problem. But the Main Production Process in which ARIZ participates is developing in a solver of the skills of creative thinking built on the System Operator.

The term “System Operator” arose in the environment of TRIZ specialists as a synonym of the fuller name proposed by G.S. Altshuller – “Multi-Screen Diagram of Powerful Thinking. G.S. Altshuller considered the TRIZ training process as a process of development of powerful thinking skills realized in accordance with this multi-screen diagram. ARIZ is one of the most important tools of Classical TRIZ used for forming such skills. A student acquires a complex of these skills with the accumulation of experience in applying ARIZ to various training and real-life problems.

Let us look back and evaluate the performed work from the System Operator application viewpoint.

During our work according to the first part, we initially observed the general picture of the problem situation at the first step. It was a general survey of some fragment of the problem situation according to the System Operator. We considered the system designation (inducing vibrations in concrete for removing air cavities and increasing the concrete density) and its components (subsystems). We also identified the supersystem and the main production process (pipe production) presented in the initial description of the problem.

We also briefly considered the problem situation along the time axis (first concrete is poured into an empty formwork; then vibrators are started and concrete is compacted).

The axis of antisystems was presented in more detail in the form of two problem-solving versions, neither of which is satisfactory (TC-1 and TC-2). The system of contradictions shows us the relations between the System and Antisystem.

We also decided what the supersystem should look like in the future from our point of view (the final part of step 1.1.).

Then we zoomed in on only two system components: the product and the tool. At step 1.3 we again turned attention to the interrelation between the system and antisystems. But this time we presented the conflicts in a graphical form.

At step 1.4., we zoomed out, thereby widening the System Operator zone, and selected the conflict that occurs at the level of the selected system and provides a potentially best performance quality of a sufficiently higher function (Main Production Process). At step 1.5., we focused again on the selected conflict and intensified it mentally.

This fourth axis – the axis of mental transformations – is absent in the classical System Operator. G.S. Altshuller wanted to introduce this axis into the System Operator as early as the 70s, before the publication of the book “Creativity as an Exact Science”. He said that he had rejected the axis of mental changes because he had not managed to find a simple and comprehensible picture for a 4D system operator. It should be noted that the graphical scheme of the operator was 3D in the manuscript of this book but it was replaced with a 2D scheme by mistake during publication. The 2D scheme only has 9 screens whereas the original G.S. Altshuller’s drawing in the manuscript included 18 screens. The axis of antisystems is mentioned in the text of the book but absent in the drawing. During the OTSM development, there appeared an advanced System Operator containing this axis – the axis of mental experiments – as well as some other axes, which were considered equally important by G.S. Altshuller.

At step 1.6., we zoomed out, thereby widening the field of our mental consideration of the situation and described the problem situation model.

In the second part, we are focusing on various resources available in the system, its subsystems and supersystem (Zoom Out). It is just what we are going to do while performing step 2.3.



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### Step 2.3. Analyzing su-field resources

The goal of this step is focusing our brainwork only on the analysis of substances and fields (material objects) which are available both within the frame of the problem model and within the frame of the entire problem situation. If a problem is related to non-technical systems, subject to analysis are resources on which the given type of system is built: financial resources for business systems; psychology for an individual, social psychology for management and educational systems, etc.

We would like to remind you that step 2.3. only deals with a preliminary analysis of the material substances of the initial situation. Their more detailed, complex analysis will be carried out within the limits of the operational zone within the operational time intervals in the third part of the Algorithm.

#### 2.3.1 Intrasystem resources

**The su-field resources of the tool:** metal box of the vibrator, electric motor, electric energy, eccentric flywheel, acoustic waves generated by the vibrator and formwork, cables.

**The su-field resources of the product:** cement, water, gravel, mechanical waves occurring in the concrete bulk.

Intrasystem resources are resources located in the Operational Zone, specified at step 2.1., within the Operational Time, specified at step 2.2.

#### 2.3.2. Outside the system.

The su-field resources of the environment which are characteristic of this problem:

The peculiarity of this process versus the general process which employs this concrete-mixing principle consists in that the formwork is located in a cylindrical recess made in the ground. But locating a sound-insulating cover plate over this recess is undesirable.

The su-field resources of the environment which are common for all problems: gravitation which permits concrete compaction by means of vibration.

#### 2.3.3. In the supersystem

The waste (inexpensive resources) of an external system (if such a system is accessible within the frame of a problem). Really, different plants of a region produce different kinds of waste. In our specific case, we do not know as yet what characteristics the waste we need should possess. It will be possible to obtain answers to these questions while summarizing the results of the 3rd and 4th parts of ARIZ (reflection). The thing is that at the end of the 3rd part and, the more so, after the 4th part, the image of a future solution generally becomes clearer and we can again consider a possibility of using this type of resources.

"Cheap" resources are: external elements the price of which may be almost neglected, such as water and air.

**Summarizing the second part:**

The analysis of the su-field resources of the system (tool-product) makes one think about the method of generating mechanical waves in the entire concrete bulk without generating acoustic waves in the environment. Such space separation would for certain be helpful in solving the problem.

The analysis of the internal and external resources of the system did not give any clear answer. It, however, pointed out the resources which may be used for solving the problem after we have clearly defined characteristics necessary for performing the useful function. With the accumulation of experience in ARIZ application and liberation of thought, various ideas of using

different kinds of resources are beginning to arise. As mentioned, these ideas sometimes look ridiculous and unrealistic. Nevertheless, they should be preserved in the bank of ideas for subsequent analysis in accordance with OTSM-TRIZ in order to synthesize them into a single operable system of ideas.
At step 1.7., we obtained a prompt from the System of Inventive Standards that in addition to the concrete mixture, there should appear some second substance and field in the operational zone. We have a very dim idea of them as yet. It is only clear that they must ensure concrete stirring within the formwork in the entire bulk, with a necessary sustained amplitude, without generating strong air vibrations beyond the formwork.
Readers who are more experienced in TRIZ and ARIZ could probably add that all this must cause minimum changes in the system, that is, must use the initial system resources available at the plant – vibrators.
When we develop a new system and our system only exists in our mind at first, we have much more possibilities to select resources than when we deal with an already existing system. The second case is generally typical for production companies where some equipment has already been used but this equipment does not satisfies all the requirements made of the technological process. TRIZ beginners often face difficulties while analyzing already existing systems and their components. These difficulties are due to psychological inertia inherent in anyone. We wish to find a ready solution to a nonstandard problem, just as is the case with standard problems. If there is some standard problem corresponding to some typical problem description, then, to solve this problem, we need to use a corresponding standard solution.
When, on the contrary, we are dealing with non-standard problems, this approach is impossible and much effort is required to cope with our own psychological inertia in order to destroy thinking stereotypes affecting our thinking process and search for creative solutions. We should be ready to decompose the existing systems into independent components, consider these components as absolutely independent resources and try to understand how one or another component can help us solve our problem…
It is necessary to mention one very important moment for problem solvers, especially for managers.
The thing is that using OTSM-TRIZ tools in our work, we overcome, step by step, our psychological inertia. As a result, an obtained creative solution is so different from known standard solutions that it is usually immediately rejected by the people who have not participated in the solving process and, therefore, are unable to immediately accept the obtained solution; they are often not even ready to discuss such an extraordinary solution. This situation usually occurs when obtained ideas are too prematurely presented to managers. Being unprepared by the solvers, managers generally reject unusual ideas, because they are still influenced by psychological inertia unlike the solvers who have managed to overcome it in the course of work on the problem.
In 2000, we worked for one of the well-know European companies trying, together with the specialists of that company, to solve some problems. The obtained solution was unusual: the problem could be solved by replacing a monolithic piece of metal with a metal brush. It was something unprecedented in this industry. When that solution was submitted for approval to the manager, the latter just threw the sheets of paper where the ideas were described into a waste-basket without giving the specialists two or three days more for modeling the ideas on a computer.

The company invited OTSM-TRIZ specialists because the problem was complicated. We worked on it all together using OTSM-TRIZ tools. Step by step, we were producing new ideas, overcoming psychological inertial and generating new, creative ideas, trying to integrate them into a system of solutions and to build a solution which would be acceptable to the company. Much money and the specialists' working time had been spent. It seemed that allocating other two or three working days of one specialist for simulating and testing the solution were not a problem and were worth the candle. The developers went to the manager for solving a seemingly simple question of allocating the time of one person for performing computer modeling of the obtained solution but ran against a volitional, ill-founded emotional decision to fully stop the work…

All of us were very disappointed.

It is not an extraordinary example. There were also situations in our practice when solutions rejected by managers were found and introduced by competitors after a time.

This is the price paid for the premature presentation to managers of obtained nonstandard, creative solutions to persistent world-level problems.

Managers are usually very busy and overloaded. Permanent work under stress, lack of time and the necessity to coordinate complicated processes sometimes prevent them from making well-founded decisions. Before submitting new, nonstandard ideas for their consideration, it necessary to think twice how to help them overcome psychological inertia within several minutes (specialists themselves usually spend several weeks or months doing this).

Unfortunately, managers themselves are generally unaware of ineffectiveness and irrationality of some of their decisions. In this connection, it would be interesting to remind about the research results given in the IBM's report dedicated to innovations in the companies worldwide. The report states that 85% of managers think they are able to make right decisions. At the same time, the results of another research prove that 65% of decisions made by managers are cancelled or undergo significant correction because of their inefficiency…

Altshuller's study of numerous situations related to the introduction of new ideas demonstrated that the higher the idea's novelty level, the stronger is the resistance this idea encounters on its way to implementation…

The paragraph, describing the relationship between managers and problem solvers, seems to be in no way related to the problem under consideration and TRIZ. But the thing is that the tools created within the framework of Classical TRIZ and OTSM development often allow finding nonstandard technical solutions containing a high innovation potential. Companies often reject such solutions on that ground that nobody does in this way and, thereby, lose patent priority, which, in its turn, leads to lost profit. Later, they bethink, come to TRIZ experts, express regret and ask for help in circumventing the competitor's patent…

Unfortunately, such situations are not infrequent in our practice. Ideas are often rejected not only by managers but even by the working group members. The combination of psychological inertia, when people do not want to accept partial solutions because those seem empty and unnecessary, with certain personality features of a specific man sometimes stops any work that does not lead to known standard solutions. Complicated nonstandard problems cannot be solved by applying standard solutions known to professionals. That is why they are difficult to solve. Solving such problems requires stepping over the bounds of traditional thinking. Violating the canons seems inadmissible to such people and they do their best to block the work of the working group which uses OTSM-TRIZ for solving the problem, and try to bring the work back to familiar solutions which do not work in a given case. This causes a considerable damage to the company's interests.

Looking ahead, we must say that the solution to the described problem also met with a strong resistance at first. Yet the solver was given a chance to prove the realizability of the obtained ideas.

The reverse is also possible. An obtained solution is so simple and easy to implement that managers think that it was quite obvious and there was no need to invite TRIZ experts. At the same time they often forget that the company's best intellects have grappled with the problem for months and years without finding a satisfactory solution version. Nevertheless, the OTSM-TRIZ tools helped the specialists to overcome thinking inertia and to choose quite an unexpected solving direction where a simple and seemingly simple solution was found. All the above proves that the Classical TRIZ and OTSM tools are helpful in effectively overcoming psychological thinking inertia. Thus, one should understand that the first attempts to present an obtained solution will run against psychological inertia and cause incredulity of colleagues or rejection.

The psychological inertia of both specialists and managers often cause a huge damage to their own interests as well as to the interests of their companies.

We have touched upon a very serious problem related to innovation projects. It turns out that having effective tools for producing innovations is not enough to succeed in applying innovations. Serious changes in the corporate culture and structure of a company are also required…

In this area, innovation ideas of overcoming management's psychological inertia are needed.

### 3.2.3 Part 3: Determining the ideal final result (IFR) and physical contradictions which prevent obtaining IFR.

The third part of ARIZ differs markedly from the previous ones in structure and performance of the algorithm steps.

In this part, actions leading to a problem solution change their direction. In the previous parts, we primarily dealt with analysis (parts 1 and 2) while in the third part of ARIZ we pass to the activity which is first aimed at synthesizing Partial Solutions and then at synthesizing Satisfactory Conceptual Solutions (parts 3, 4 and 5). The third part is a kind of problem analysis culmination and transition to the synthesis of a Satisfactory Conceptual Solution.

We would like to remind that TRIZ tools are designed not for search for a solution, but for a planned, stage-by-stage creation of a solution image that would be sufficiently detailed to ensure transfer to the development of a prototype or a computer model for testing the obtained conceptual solution.

The image of a future solution is built step by step and is becoming increasingly clear. The image is created through the accumulation of conceptual solutions which partially correspond to technical requirements. We call these solutions "partial" because they only solve a problem partially. Partial solutions serve as a raw material for creating a Satisfactory Conceptual Solution. A satisfactory solution is obtained on the basis of partial solutions by using various Classical TRIZ and OTSM tools.

Those elements of partial solutions which prevent them from being full solutions can be presented in the form of requirements that should be met by any satisfactory solution. It is a kind of additional technical specification. Applying OTSM-TRIZ tools to this technical specification, we build additional partial solutions which are then integrated into a single system of solutions – Satisfactory Conceptual Solution.

This is the advantage of using the "partial solution" notion: revealing the reasons for which a partial solution cannot be considered as a satisfactory solution allows us to specify technical requirements and to better identify the restrictions to be observed while creating a Satisfactory Conceptual Solution. The Satisfactory Conceptual Solution makes it possible to create a technical solution: drawings, computations, etc. The technical solution will allow us to create a prototype which, when tested, will lead us to an improved solution version.

Thus, proceeding to the third part of ARIZ, we should aim at the solution synthesis but, at the same time, perform a needed analysis. In this situation, ARIZ can be compared with the blood-vascular system of a human body. The first and second parts of ARIZ correspond to arteries carrying information about a problem. The third part of the algorithm is similar to a capillary network where the collected information is changed and gradually turned into a solution. Partial solutions together with critical comments form brooks of ideas feeding an emerging image of a satisfactory solution. This part also threads all subsequent parts of ARIZ just like the blood flowing in veins. Now let us look at how the problem analysis gradually changes into the solution synthesis in the course of ARIZ implementation. This transition occurs simultaneously in several parallel branches merging at the end of the third part of ARIZ.

**Step 3.1. Formulating the ideal final result (IFR)**

The goal of step 3.1. is reformulating a problem once again so as to start gradually synthesizing a solution. This stage is dedicated to determining the problem description for further use and requirements to be satisfied while solving the problem. Subsequently, we will use the problem description obtained at step 3.1. instead of the problem model produced at step 1.6., because in the second part of ARIZ we specified the details of the place and time of the problem occurrence. In addition, we made a preliminary list of resources that can be used for solving the problem. All this will lead to a transformation of the problem model at 3.1.

It is often said that a well defined problem is at least half of a solution. That’s why the idea of specifying a problem and requirements imposed on a solution runs through the entire ARIZ.

IFR-1:

X-element, without complicating the system and without causing any harmful phenomena, eliminates the undesirable effect – “strong noise” during the <Operational Time> inside the <Operational Zone>.

In other words, the undesirable effect must not occur in the environment surrounding the vibrators (outside the formwork) when the vibrators work and hit strongly the formwork for compacting the concrete mixture.

At the same time, the vibrators must preserve their force and amplitude required for compacting the concrete mixture throughout the entire formwork volume.

Already at this problem specification stage, some new ideas may come into readers’ heads or some old, long-forgotten ones may come back. Because of psychological inertia, those known solutions were not previously connected with the given problem in our consciousness.

As seen, performing the ARIZ steps results in planned specification of the problem causes and the requirements imposed on a future solution. At the same time, some new solving ideas are beginning to appear. Even if these ideas seem quite realizable and ready for implementation, it is worth proceeding with the problem analysis until the forth part is reached. This is an obligatory ARIZ rule. The thing is that all ARIZ steps are lined up in accordance with the system evolution laws. Performing these steps, we essentially follow the system evolution laws. And an obtained solution may be developed and improved by performing subsequent steps of the algorithm.

We can write down in the **bank of ideas** (a special notepad where we collect partial solutions) that one of possible conceptual solutions consists in placing vibrators within the concrete mixture. Then the noise level will be considerably reduced. However, formwork users are against this solution.

As we have already explained, to help in creating a problem solution description, objections to proposed solutions and critical comments should be turned into requirements.

In our case, the idea of placing the vibrators within the concrete mixture looks very attractive because concrete itself can play the sound insulating role and reduce the noise level around the installation. However, the external requirements imposed on the production process do not allow placing the vibrators within the concrete mixture. Thus, we can formulate a new requirement for the solution: it is necessary to provide vibration inside the concrete mass without introducing any mechanisms which would be impossible to remove after concrete hardening… How can this be achieved? It is not easy to say but this idea should also be recorded in the **bank of ideas**, no matter how ridiculous it looks.

Step 3.1. is preparation for executing step 3.2. All other ARIZ steps work in exactly the same manner – executing one step prepares our thought for performing operations of next steps.

**Step 3.2. Intensifying the IFR-1 formulation**

At step 3.2., the analysis is beginning to turn into the first steps of solution synthesis. The thing is that IFR formulated at step 3.1. should be replaced with one of the resources described at step 2.3. Now one of the mechanisms for overcoming psychological inertia comes into play. To master this mechanism, one should have some experience and be familiar with other TRIZ tools. The key idea of the third part is studying the causes which prevent obtaining solutions, satisfying the requirements described at 3.1., by using one of the available resources. The analysis mechanism proposed by Altshuller stimulates subconscious creative processes which sometimes result in jokey and sometime in very serious partial and even satisfactory solutions. The appearance of jokey solutions is a good mark. It shows that we are gradually destroying psychological inertia and are beginning to think more openly, as they say in the United States, “to think out of the box” which hinders imagination and thinking and wherein we were held by our professional education which developed in us professional thinking inertia within the limits of standard solutions to standard problems.

Standard solutions constitute professional wealth and skills in any line of profession. They help professionals solve problems quickly and effectively, until they face a non-standard problem that cannot be solved by means of professional standard solutions. In many cases, systemic use of OTSM-TRIZ tools results in that an initial problem which originally looked non-standard acquires the form of a standard problem, not only from the OTSM-TRIZ viewpoint, but also from the viewpoint of narrow specialists. This often happens at the end of the first part of ARIZ. But even in such cases, it is useful to proceed to the end of the fourth step of ARIZ. The experience of TRIZ specialists proves that solutions obtained in the first part may be considerably improved and an entire range of satisfactory solutions may be obtained and used for creating a range of products.

The ideas collected in the bank of ideas during the performance of the ARIZ steps or application of any other OTSM-TRIZ tools can be divided into three groups. The first group includes ideas that can be implemented quickly enough. The second group consists of ideas which require some time for additional research and development, purchase of equipment, etc. The third group is composed of ideas which are left for the future, the ideas about the system development direction and about new products, services and technologies which can be created with the time.

Unfortunately, OTSM-TRIZ is often considered as a tool for removing emergency situations, when a solution needs to be obtained and implemented now and here. This is generally the competence of lower management at the point where an emergency situation arises. They have to eliminate the problem at any cost. Banks of ideas are not their competence. It is the competence of higher level managers, sometimes even of the highest level such as heads of organizations or companies. Managers of this level are generally unaware of the OTSM-TRIZ existence and the opportunities it offers to upper management. The second and third groups of solutions are but a relish of what could be used by upper management in their difficult work. OTSM-TRIZ can also offer assistance to heads of subdivisions engaged in the development of the strategy and evolution of a company and business. In this case, however, ARIZ is included as an element of more complicated OTSM tools.

For brevity sake, we are only dealing here with three parallel ways of using three resources: the vibrator, formwork, and concrete mixture.

TRIZ beginners are usually bewildered by phrases built according to TRIZ rules. Indeed, from the linguists’ point of view, these phrases are not quite correct. The advantage of these phrases consists in that OTSM-TRIZ can play the role of interdisciplinary language in work on compli-

cated and/or interdisciplinary problems. This language is designed for work on problems which usually become more complicated due to the use of the ordinary language because the latter causes psychological inertia. In addition, the ordinary language is well-adapted for use as the means of communication but does not always allow us to effectively solve problems. Sometimes, a good literary language even hampers problem solving. At the same time, a good figurative language is often a helping hand to OTSM-TRIZ in dealing with a problem. OTSM-TRIZ tools create image features – partial solutions.
The figurative language allows these separate features to be synthesized into a single image. That is why Tatyana Sidorchuk has developed a special pedagogical technology for teaching children to find metaphors and compose metaphorical figurative statements. This method is currently used by adults in advertising for creating figurative texts and video clips. The standard language, everyday phrases and expressions are often carriers of psychological inertial. This inertia can become an insurmountable obstacle to finding a problem solution. It means that one should boldly build phrases according to the OTSM-TRIZ rules even if these are not always beautiful and often do not originally have any literary value …

**Intensified IFR-1, using the "Vibrator" resource.**

The vibrator itself, without complicating the system and without creating undesirable phenomena, eliminates the undesirable effect: "strong noise" in the space surrounding the system of vibrators (i.e. outside the formwork) when the vibrators work and hit the formwork very strongly for compacting the concrete.
At the same time, the vibrators provide the vibration force and amplitude required for compacting the concrete mixture in the entire volume confined by the formwork.
After writing down the formulation of step 3.2 for the "Vibrator" resource, it is necessary to identify those Control Parameters of this resource which determine the "Noise Level" and "Concrete Density" Evaluation Parameters.
In our case, both the parameters depend on the Control Parameters:

- Vibrator hit force
- Formwork vibration amplitude created by the Vibrator.

Can you say which other parameters influence both the Evaluation Parameters simultaneously?
Dear Reader, try to perform the subsequent steps of ARIZ with the parameters you yourself proposed.

**Intensified IFR-1, using the "Concrete Mixture" resource.**

The Concrete Mixture itself, without complicating the system and without creating harmful effects, eliminates the undesirable effect: "strong noise" in the space surrounding the system of vibrators (i.e. outside the formwork) when the vibrators work and hit the formwork very strongly for compacting the concrete.
At the same time, the Concrete Mixture does not prevent the vibrators from providing the vibration force and amplitude required for compacting the concrete mixture in the entire volume confined by the formwork.
After writing down the formulation of step 3.2. for the "Concrete Mixture" resource, it is necessary to identify those Control Parameters of this resource which determine the "Noise Level" and "Concrete Density" Evaluation Parameters.
Dear Reader, try to find those parameters of the "Concrete Mixture" Resource which affect the Concrete Density. Make a list of those parameters.
The next step is writing a list of the "Concrete Mixture" Resource parameters which influence the "Noise Level" Evaluation Parameter of our system".
Compare the two lists and make a separate list of parameters which influence both the Evaluation Parameters simultaneously.

The following algorithm may be helpful while performing step 3.2.

- Replace "X-Element" with "[Resource] ITSELF". The word [Resource] should be replaced with the name of a corresponding resource.
- Identify in the Intensified IFR Formulation the names of two Evaluation Parameters the values of which should be provided at a necessary level.
- Using your knowledge and/or the knowledge of experts, identify a list of Control Parameters for the first Evaluation Parameter. Changing the values of Control Parameters can change the values of Evaluation Parameters.
- In the same way, create a list of Control Parameters which will allow you to change the values of the second Evaluation Parameter.
- Compare the two lists of Control Parameters and identify those of them which allow changing both the Evaluation Parameters. They will be later used for performing steps 3.3. and 3.4. of ARIZ
- The absence of common members in the lists of parameters is one of the signs that the problem can be solved by changing corresponding parameters of that Evaluation Parameter which needs to be improved for providing the best possible performance of the Main Production Process (the Main Objective for which the given problem is being solved).

It should be stressed that the Main Production Process (the Ultimate Goal of solving the given problem) is the function of one of the super-systems located in the System Operator 3-4 levels above the system level where the given problem is being solved.
While describing an initial problem situation and selecting a Product and a Tool at step 1.2., one should not confuse the Main Production Process (MPP) and the Main Function of a system indicated at step 1.1.

Similarly to other additional recommendations regarding the performance of ARIZ steps, this algorithm was proposed in the course of research into the transformation of Classical TRIZ and its tools into OTMS and its tools.
OTSM has developed similar detailed procedures for each ARIZ step. Their detailed description is beyond the scope of this paper. Mastering these procedures constitutes the main production process of ARIZ assimilation. This review is part of the system of in-depth training in professional ARIZ secrets, just like concrete vibration is part of production of large-diameter concrete pipes which are then used to build pipelines. Laying a pipeline is the Main Production Process (MPP) for the sake of which vibrators compact concrete.
Making, together with specialists, a list of parameters which may be used for changing concrete density, we can find such of them which can increase concrete density without producing noise. This leads us to the idea of creating the currently well-known self-compacting concrete. But the problem arose many years ago when this type of concrete did not exist. Creating such concrete required research-and-development activities. The problem was that the production plant where this problem occurred did not have any R&D departments. In addition, the situation was urgent and a solution which would entail minimum changes of the production process had to be found as soon as possible.
As is seen, ARIZ brings us to interesting ideas. Sometimes, some of these ideas seem unrealizable under conditions existing at the moment of their occurrence. TRIZ and OTSM history knows many examples when ideas of this type were rejected at the moment of occurrence but were later implemented.



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It should be noted that ARIZ application often results in a number of ideas that can be and must be classified into three groups.
**The first group** includes ideas which are immediately accepted for implementation.
**The second group** consists of ideas which require some minor research or acquisitions. Or it is just necessary to wait for some propitious moment in the company’s life, for example, change of production equipment or manufacture of new moulds for the production of plastic articles.
**The third group** is formed by ideas which require considerable time and investments. Some of these ideas may look fantastic or even unrealistic. Nevertheless, even such ideas should be put into a special bank of ideas. After a time, these ideas will be analyzed using Classical TRIZ and OTSM methods designed for transforming the unreal into what can be implemented under certain conditions.
Fantastic and unrealistic ideas should be accumulated and discussed, if only because they shatter and defeat psychological inertia and help to create an image of the Most Desirable Result (MDR) we are trying to approach. How this occurs, what tools are used is beyond the scope of this review and is the subject of more intensive courses in Classical TRIZ and OTMS.

**Intensified IFR-1, using the “Formwork” resource**

The Formwork itself, without complicating the system and without creating any harmful effects, eliminates the undesirable effect: “strong noise in the space surrounding the system of vibrators (i.e. outside the formwork), when the vibrators work and hit the formwork very strongly for compacting the concrete.
At the same time, the Formwork does not prevent the vibrators from providing the vibration force and amplitude required for compacting the concrete mixture in the entire volume confined by the formwork.

At the first glance, such a formulation seems to offer nothing beyond what we already know. This, however, is a superficial glance, because ARIZ is a tool for thinking but not instead of thinking…
Let us give this formulation, produced in a formal manner, a step-by-step consideration. One of ARIZ remarkable features is that one can formally perform all its steps without actually making a single step toward a solution. Thus, after performing each step, it is necessary to look at it as if from the outside and to think what new strokes may be added to the solution image, what new understanding of the situation can be derived from the diagram or formulation obtained by performing the given step.
Let us do this work together:
**The question the Solver asks to himself or to experts:**
When won’t the formwork produce noise?
**The Solver’s answer to himself** (based on his own knowledge or the knowledge he acquires from experts who are able to answer this question:
The formwork will not produce noise if it is not subjected to deformation and does not work as a membrane producing air vibrations in the formwork-surrounding space.
**The question the Solver asks to himself or to experts:**
When won’t the formwork prevent the “vibrators” from transmitting energy, required for producing concrete vibration of a necessary amplitude and force, to the concrete?
**The answer:**
The Formwork will not prevent energy transmission from the vibrators to the concrete if it is absent in the energy flow way.

**Considering the answers to the questions:**
In the initial system, the formwork performs the role of transmission by transmitting energy from the vibrators to the concrete. That is why it moves forward and backward due to the action of the vibrator’s impacts and elastic stresses produced by these impacts. These movements (vibration) of the formwork cause vibration of both the concrete in the formwork and the air around the formwork.
We do not need air vibration around the formwork but we need concrete vibration within the formwork.
The formwork will not vibrate if the vibrators do not hit it. But the vibrators must hit it to impart energy to the concrete.

**Conclusion:**
If the formwork is not subjected to vibrator hits, there will be no noise, but it will be necessary to provide energy transmission through the formwork - from the vibrators to the concrete.
In other words, energy should be transmitted through the formwork without producing vibration in it.
It is very important to note that reformulating a thought several times using different words is one of the mechanisms for reconsidering already available ideas (models) regarding an initial situation. It is also a mechanism for stimulating subconscious creative processes by means of the solver’s own conscious. In addition, rewording (different verbalization) and use of imagination or drawings (visualization) for presenting an initial problem situation and a situation to be formed by solving a problem are mechanisms for overcoming psychological inertia and breaking thinking stereotypes which are an obstacle to problem solving.
To fight against psychological inertia, it is necessary to replace professional terms with simple, functional terms. This should be done starting with the first ARIZ steps during the entire analysis. Our stereotypes insist on using professional terms. But professional terminology is a good tool for work with standard professional problems. In work with non-standard problems, however, this terminology turns into one of the strongest obstacles to finding a solution. Professional terms produce musty images whereas solving a problem requires use of flexible, dynamic, functionality-reflecting images.
In our case, it is useful to replace the term “vibrator” with the term “vibration energy generator”. The term “formwork” can be replaced, for example, with the term “concrete molder”.

Continuation of the Conclusion (Partial Solution):
Thus, the vibrators and formwork must change in such a manner as to be able on the one hand to perform all their functions and on the other hand to remove negative phenomena without causing new undesirable effects. Both the formwork and the vibrators must change without changing, i.e. they must change not to produce harmful phenomena and must not change to be able to perform their functions.
The “formwork” Parameters (Characteristics, Properties) which affect both the noise around the formwork and the concrete quality:

- Formwork flexibility
- Susceptibility to mechanical energy
- Stiffness, hardness, the ability to serve as a damper.

ARIZ steps and rules effectively direct our thinking; therefore, teaching TRIZ is reduced to teaching students to understand (to feel, according to some professionals) how, where and when ARIZ directs our subconscious creative thinking. As a result, regular use of ARIZ causes development of parallel thinking along the axes (subspaces of parameters) of the System Operator: Hierarchy of system levels (Subspaces of the system level parameters); time-dependent Characteristics of different-level systems – the Time axis (Subspace of parameters); the Anti-

System axis (Subspace of systems which challenge our system, hamper its operation and stimulate its development).

It should be noted that the System Operator is a much deeper content of the model which, with a sketchy knowledge, is a ”Nine-Screen Scheme”. According to G.S. Altushuller’s concept, ARIZ is not so much a problem-solving tool as a tool for developing System Thinking based on the Classical TRIZ System Operator. Developing in ourselves the ability to use these thinking tools we also develop in ourselves complex problem solving skills. It is very important for mastering ARIZ. One can remember all ARIZ rules, comments as well as all classical examples of ARIZ application by heart, but be unable to use ARIZ in practice.

ARIZ-based thinking or thinking based on the Classical TRIZ System Operator can only be developed through practically solving training and real-life problems. Merely understanding the ARIZ operation logic is not enough. ARIZ is a tool which helps a solver activate, feed and direct his own subconscious creative processes. ARIZ also offers rules for work with knowledge from various areas and for integrating this knowledge with the method. This allows a specific problem to be solved in a specific context but on the basis of a common universal procedure.

Adults only achieve in-depth understanding and assimilation of ARIZ through practically dealing with problems, the teacher’s role being very much like that of a pilot’s instructor. First a future pilot studies separate aircraft fly rules on training simulators. Then he gets on a plane and puts his hand on a control lever. He does not fly the plane but feels all the instructor’s actions through the control lever. Then the instructor allows the beginner to fly the plane but is ready to control the plane by himself if necessary. As the plane control skills are formed in the beginner pilot, the instructor interference in the flight control process becomes increasingly rare. Finally, the beginner pilot is allowed to fly a plane all by himself without the instructor’s supervision. Further development of skills occurs independently through permanently practicing in the air and on the ground. The same occurs while teaching ARIZ.

A professional TRIZ specialist conducts a beginner through ARIZ step by step. As good ARIZ application skills starts forming in the beginner, the latter performs more and more ARIZ steps by himself. The ARIZ mastering process has several stages: acquaintance with ARIZ rules and steps; ARIZ application to training problems and gradual formation of skills of performing separate steps up to the level of full assimilation of ARIZ. The second stage has two substages: first, the student starts using ARIZ rules and steps at a subconscious level without being aware of it. The second substage is transition to consciously performing ARIZ steps at a subconscious level. As a result, the student learns to deliberately use the ARIZ thinking style in his everyday professional and private life. It happens in much the same manner as with a foreign language as a second spoken language when we use it outside our native country.

We have shown how an initial problem is being broken into subproblems at step 2.3, each subproblem illustrating a possibility of solving the initial problem by using one or another resource.

It can be said that training in ARIZ is reduced to the development of the ability to see, understand and accept gradual modifications of a problem situation as well as seemingly unrealistic problem formulations and partial solutions. Sometimes, these formulations seem stupid, unfeasible, inaccessible and impossible to beginners. Accumulating the ARIZ and TRIZ application experience as a hole, they start understanding that solving a non-standard problem requires that we outstep the boundaries of the notions of what is possible and what is impossible.

These new problems and partial solutions should be thoroughly considered for overcoming psychological inertia.

To deal with these new, seemingly unsolvable problems and with seemingly unrealistic or inapplicable solutions, it would be useful to use the OTSM Axiom of the Impossible and corresponding tools for practical application of this theoretical Axiom.

These tools help overcome our prejudices concerning the possible and the impossible in real life. These tools allow us to turn the “impossible” into the “possible”. More detailed description of these tools is beyond the scope of our short introduction to ARIZ.
Special stress should be laid on the fact that a non-standard problem appears just because standard, real, tried solutions do not suit us in the context of a specific situation. To find a solution, we need to outstep the boundaries of stereotypes of the possible and the impossible. For this reason we should not reject unusual ideas just because they initially seem impossible. During the execution of one of the projects, each meeting of the company’s specialists with TRIZ specialists started and finished in the same manner. First, the TRIZ specialists presented to the audience the outcome of the problem situation analysis and some ideas obtained as the result of that analysis. And each time the first words of the company’s specialists were that the ideas were of no worth, unrealizable and that nobody ever did like that.
Each time, after a half-hour analysis of the reasons for which a partial solution could not be implemented, it became clear that something could be done in that direction and the solution could be somehow put into practice. The project was not unique from this point of view. This situation is not infrequent. Really unique was that the company’s specialists answered all questions practically immediately, carried out necessary mental experiments and were eager to discuss seemingly very strange solutions. The thing was that they had worked on the problem for over six years and had carried out many experiments, gained rich experience regarding the problem essence and components. Unfortunately, this situation is not common.
The second reason why the project can be considered unique is that a new unexpected solution was obtained and accepted by the specialists. Much more time was spent to convince the company’s managers. As a result, the managers came to a conclusion that the solution was very interesting and useful and had to be patented. While patenting, it became clear that on those very days when the question of accepting the solution was being discussed, an application for a similar patent was filed by one of the competing companies. An important conclusion is that a successful innovation work of a company requires a corporate innovation culture. Having effective problem-solving methods is not enough. Effective use of produced innovative ideas in companies requires creation of a special system of work with innovations. Innovation activity differs strongly from the company’s everyday activity. The experience of my colleagues – TRIZ specialists – proves that companies are not ready today for work under the market-dictated conditions of permanent innovations.
Transition from dealing with separate innovation problems to systematic control of flows of such problems may prove to be a significant competitive advantage of a company. Such work requires a corporate innovation culture which, in turn, differs strongly from the principles underlying currently existing corporate cultures. Companies which will be first to resolve the problem between the existing culture and a corporate innovation culture will gain significant advantages over their competitors.
The third peculiarity of that project was that the discussion about these accidental coincidences with my old colleagues, TRIZ professionals, revealed a tendency for more frequent occurrence of such coincidences. What could not be noticed by one TRIZ specialist became evident to a group of professionals each of whom had over 25 years of TRIZ work experience… The impression is that companies are starting to use TRIZ elements in their work more and more often, which allows them to find effective solutions to problems. Solutions patented by these companies are increasingly difficult to circumvent even using TRIZ tools. This results in one more competitive advantage. Among other things, systematic use of TRIZ elements along with a corporate innovation culture will allow such companies to organize a permanent flow of innovations of products and services as well as of the company itself and the company’s business. Under the modern conditions of keen competition all over the world and a rapidly chang-



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ing market, business cannot be random. Random trials and errors are costly for companies and investors. The problem of the quickness and successfulness of innovations is becoming urgent. This seems not to be related to the topic of the material – short introduction to ARIZ. However, as we have already mentioned above, working according to ARIZ rules brings us to a number of strong, effective and advanced solutions. These solutions can be split into three groups: solutions to be implemented "today", "tomorrow" and "in the foreseeable future". This a kind of company's product evolution forecast. This, however, occurs today at the level of subdivisions and managers who, due to their position, are only interested in implementing obtained solutions "right now", without thinking about the future of the company and its business. Results which are important for strategic planning are just thrown away. It is collecting, organizing and analyzing this kind of information that require a new corporate culture that would encompass all company's levels. Future leaders of successful innovation companies are starting their work today. They are rethinking the existing corporate culture and scheduling its gradual but effective transformation into a corporate innovation culture. ARIZ, Classical TRIZ and OTSM can make a significant contribution to solving this difficult management problem. Creating highly effective innovation companies equipped with a corresponding corporate culture is a serious challenge to the management of the beginning of the 21st century.

It is a very interesting topic where ARIZ-type thinking can offer new ideas and trends. So let us go back to ARIZ



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