Scientific Journals
of the Maritime University of Szczecin

Zeszyty Naukowe
Akademii Morskiej w Szczecinie

2017, 51 (123), 28–34
ISSN 1733-8670 (Printed)
ISSN 2392-0378 (Online)
DOI: 10.17402/227

Received: 28.08.2017
Accepted: 28.08.2017
Published: 15.09.2017

The usage of the Miniature Dwarfs method in the improvement of passenger ship construction

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Key words: Miniature Dwarfs, Method of Little Men, MLM, TRIZ, mental inertia, abstraction, modelling, marine propulsion system, passenger vessel

Abstract

The Miniature Dwarfs method is one of the tools used by the Theory of Inventive Problem Solving (TRIZ) used in the process of modelling and seeking solutions to conflicting situations. This article describes the origin of the Miniature Dwarfs method. The process flow of the usage of the Miniature Dwarfs method was presented both in its original version, suggested by Altshuller, as well as in its recently modified version. The usage of the Miniature Dwarfs method was presented here to minimize the marine hull resistance of a passenger ship in the conflicting situation, where there is a simultaneous necessity to provide both large ship capacity as well as high speed. The issue and the conflicting situation were both presented and modelled. The Operational zone and Operational time were described and modelled with the use of the Miniature Dwarfs method before and during the Conflict, and the desired situation. The search of the potential solutions was carried out with the use of miniature dwarfs; the findings were interpreted with respect to the system under analysis and the stated technical issues. Imagined situations described in individual diagrams are included in the issue under investigation. Selected solutions to the problem were presented. The advantages of the method were indicated and presented as an addition to other methods used in the process of designing new engineering solutions.

Introduction

The Theory of Inventive Problem Solving (TRIZ) is a method designed by Genrich Altshuller (Figure 1) and his co-workers that uses several tools (Chybowski & Idziaszczyk, 2014; Derlukiewicz, Ptak & Koziołek, 2016). One of these tools, which deals with the modelling of contradictions and seeking solutions to the problems, is the Miniature Dwarfs method, also referred to as the Method of (Smart) Little Men (MLM), Smart Little People Modelling (SLPM) or Method of Small Creatures.

The purpose of the MLM is to minimize the phenomenon of psychological inertia that is linked with the habits and resulting from the limitations in the perception of the potential solutions to problems by the analyst (Souchkov, 2009). Altshuller's description of the method is the following: "The indivisibility of the human organism prevents one from successfully employing empathy in solving many problems" (Altshuller, 1979). The use of little people instead of balls or microorganisms, for example, is justified in the following manner: "For modelling, it is important that the small particles should see, understand and be capable of performing actions. These demands are almost naturally associated with man. He has eyes, a brain and hands. By using MLM the inventor uses empathy at the micro level. The powerful aspect of empathy is preserved, without the shortcomings inherent in it" (Altschuller, 1979). Going one step further, and calling these little people miniature dwarfs seems reasonable, as the miniature dwarfs can perform tasks like those of people, animals, plants, inanimate matter, as well as fairy creatures such as dwarfs, gnomes or goblins of supernatural abilities known for centuries. Dwarfs can fly, run, swim, jump, fight, but also appear and disappear, change size, etc. All these features make the search of solutions easier for the analyst who, during the phase of diagram building, answers the question "what to do?" to avoid conflicting situation rather than "how to do it?". The answer to the "how to do it?" question, is sought in the second stage of the MLM process.

Figure 1. Genrich Altshuller presenting the use of MLM in solving invention tasks (Central Screen Film Production, 1974)

The MLM is used as a tool in seeking solutions during the Algorithm of Inventive Problems Solving (ARIZ), but it can also be used independently. Similar concepts that relied on the use of living creatures to describe dead matter, also mentioned by Altshuller himself, were used before the ARIZ method was created, for example by (Altshuller, 1979):

- A German chemist Friedrich August Kekulé von Stradonitz (1829–1896) used apes to illustrate atomic connections, including the description of the structure of Benzene (Figure 2). This description was not met with approval and was later parodied at work (Findig, 1886);

Figure 2. Apes illustrating molecular structure of C_6H_6 according to Kekulé's proposal [Findig, 1886]

- A Scottish physicist and mathematician James Clerk Maxwell (1831–1879), who to illustrate the meaning of the 2nd rule of Thermodynamics proposed a hypothetical being that controls the flow of molecules (Maxwell, 1871) that was later called after his name Maxwell's Demon.

The MLM is often referenced in the literature (Hipple, 2012; Vaneker, 2013), however, it is still rarely recognized outside of the circle of active users of inventive methods. For example, according to Jan Koch only 14% of managers are familiar with some technique that improves creativity, while only 3% use any (Koch, 2008). This paper describes the essence of the MLM followed by a real-life example from the area of maritime technology.

Methodology

The MLM is based on modelling of a system with the use of miniature dwarfs (little smart people) which describe the conflicting situation under analysis. The composition of the diagrams of solutions is based purely on miniature dwarfs, which are elements of the system under analysis. If necessary, the analyst may introduce new types of dwarfs (with different properties and skills). Moreover, if necessary the dwarfs can be equipped with various tools (hammers, torches, lighters, balloons, etc.) and they can be affected by the outside creations that influence their position or features. The use of the MLM allows for the analyst to forget about real objects (substances and fields) connected with the situation under analysis.

Miniature dwarfs impersonate the elements that are part of the resources of the subsystem or system. They can be introduced into the system as additional elements normally unavailable in the system under analysis. Such approach allows for the analyst to break from their habits, connections, stereotypes and routine in favour of undisturbed inquisitive look into the essence of the problem. Miniature dwarfs are used to represent mainly the following:

- granules, solid particles, fragments of the element;
- molecules, ions, atoms;
- fields, electric charges, magnetic domains;
- elementary particles, etc.

In the originally proposed by Altshuller version, the MLM consisted of the following steps (Altshuller, 1979):

1. Separation of the part of the object that does not meet the requirements and representation of this part with the use of little people.

2. Division of the little people into acting groups (moving groups) according to the conditions of the task.
3. Analysis of the model and its adjustment until the conflicting tasks can be done.

The Miniature Dwarfs Method allows to illustrate the Conflict that exists in the problematic situation under analysis (before and after the problem is eliminated), presentation of an ideal final state (the desired/expected situation) and abstract base solutions whose implementation in the form of an actual solution is obtained with the use of the catalogue of physical, chemical and geometrical (AULIVE, 2017; Oxford Creativity, 2017), as well as biological, mathematical and psychological effects (Boratyńska-Sala, 2016). This method has had various modifications. One of the latest versions uses the following steps (Souchkov, 2016):

1. Definition of initial data for the analysis, including the description of the problem in the form of the description of the conflicting situation, the condition of its origin and the definition of the Ideal Final State.
2. Composition of the conflict diagrams that include the use of miniature dwarfs to introduce the situation "before the Conflict" as well as "during the Conflict".
3. Composition of the diagram describing the "desired situation" obtained by modifying the conflicting situation with the use of miniature dwarfs.
4. Composition of the diagrams describing examples of abstract solutions of the problem (7 to 20 examples of solutions). The diagrams represent alternative ways of transforming the situation "before the Conflict" to "desired situation" without the conflicting situation taking place.
5. Interpretation of each proposed solution with respect to the system under analysis and the technical problem. The translation of each abstract situation into the analysed problem with the use of the knowledge of the analyst, the adviser and the available database of effects/phenomenon.

Problem statement

Due to the increases of prices in fuel and tightening of environmental protection standards the producers of sea ships to seek more effective ways to reduce the use of fuel by their drive system while maintaining satisfactory levels of speed. During this analysis, big as well as fast waterborne passenger ships were considered. The problem statement was generalized to reduce mental inertia (the use of abstraction). Abstraction was used in the initial stage of the analysis by replacing the word "water" with "liquid", and replacing "ship's hull" with "the box". Two conflicting technical contradictions (TC) were defined during the search for the solution to the technical system for transporting passengers on the liquid surface including metal, coating and water (Figure 3):

- TC#1: If the box size is big, it is possible to transfer many passengers, but it takes time due to high drag (friction forces).
- TC#2: If the box size is small, it is possible to transfer only a few passengers but transport is quick.

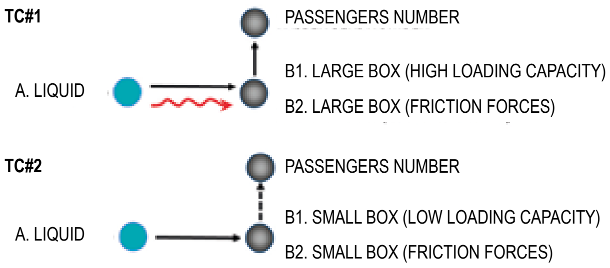

Figure 3. Graphical Representation of Conflicts; solid line – useful effect, dotted line – missing effect, red line – negative effect

The problem under analysis took the following form: "It is necessary to transport many passengers

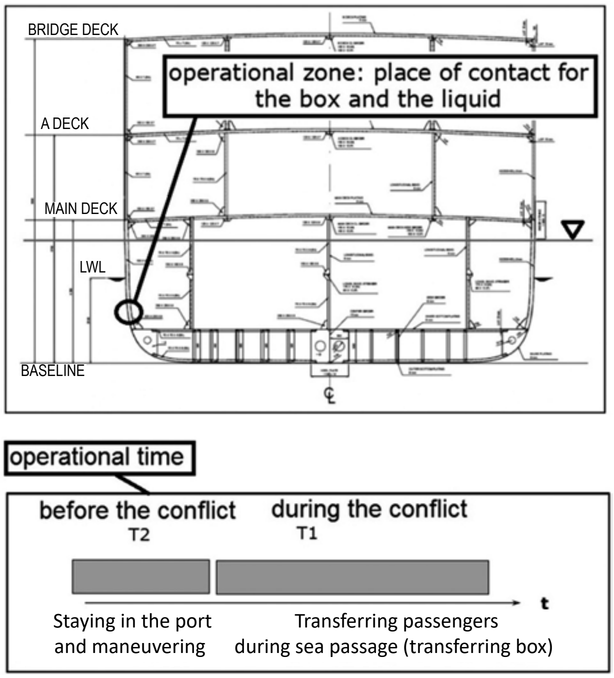

Figure 4. Operational zone (at the hull cross-section) and operational time for the problem

through the liquid surface in the box in a short time by introducing minimal changes in the system". Operational zone and Operational time for the problem are presented in Figure 4. The shape add the size of the hull is not analysed in this study. The use of the algorithm ARIZ-85C allowed for the construction of the right Substance-field (Su-field) model and the solutions to the problem with the use of the inventive rules of TRIZ were proposed. Those solutions are not part of this paper due to its limited size. The use of the ARIZ-85C algorithm allowed a physical contradiction to be obtained at the micro level in the form of the following stipulation: "The particles of the box must contact the liquid to provide buoyancy and should not contact the liquid in order to reduce friction."

The corresponding micro level Ideal Final State was defined with the following statement: "The box must provide contact with the liquid and should provide isolation from the liquid all by itself when the box is in motion".

Modelling of the situation with the use of MLM

The problem under analysis is described as follows: "How to provide isolation between the box and the liquid during transferring the box only in the place of contact while the loading capacity of the box remains high?". This conflicting situation and final desired situation were modelled with the use of MLM in the form of the diagrams shown in Figure 5. The build-up of liquid (water) pressure, which is the result of the box (ship's hull) moving, is represented by an increase in the density of "liquid" dwarfs in front of "the box" dwarfs.

In line with the previously described steps of the method, ten solutions were proposed (Figure 6). These solutions used actions that would prevent the conflicting situation taking place.

The proposed solutions are as follows:

1. An external layer of box dwarfs has shields which prevent liquid dwarfs from over-accumulating.
2. An external layer of box dwarfs transmits a thermal field which keeps liquid dwarfs away. Liquid dwarfs are afraid of heat.
3. An additional layer of new dwarfs generates the barrier against liquid dwarfs who over-accumulate.
4. New dwarfs, which attract liquid dwarfs and prevent them from over-accumulating around the box dwarfs.
5. An external layer of box dwarfs that have sharp sticks which hit liquid dwarfs and prevent them from over-accumulating.
6. An external layer of box dwarfs that scream very loudly in the direction of liquid dwarfs and prevent them from over-accumulating.
7. Box dwarfs on the external layer are excited and "Kung-fu" fight the liquid dwarfs away.
8. Box dwarfs have void spaces which liquid dwarfs can easily pass through to avoid the over-accumulation of liquid dwarfs.
9. Box dwarfs have void spaces which new dwarfs go through to the liquid dwarfs, which prevents over-accumulation of liquid dwarfs.
10. Box dwarfs have an electrical shield which is continuously changing its electrical polarisation. Electrically sensitive liquid dwarfs follow the electrical signal which prevents over-accumulation of liquid dwarfs.

Problem solutions

The individual abstract proposed solutions modelled in Figure 6 have detailed descriptions based on the available resources of systems and effect databases including effects presented in (Pajor, Marchelek & Powalka, 1999, Bejger & Gawdzińska, 2011; Dziczkowski & Żółkiewski, 2014; Bejger

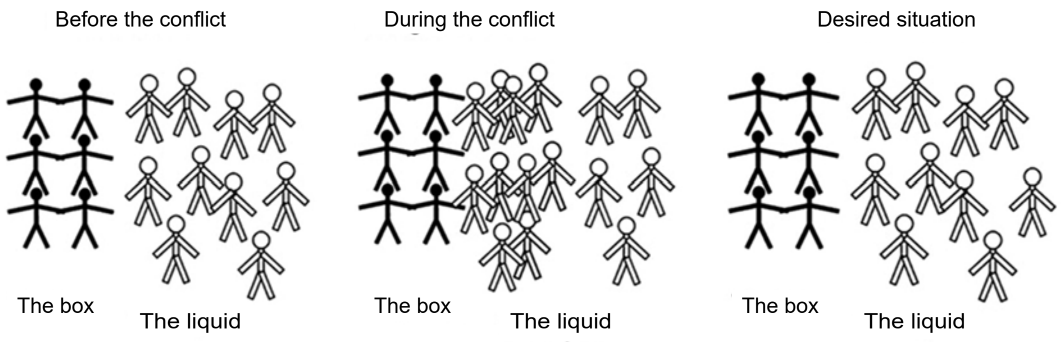

Figure 5. Conflict diagrams and desired situation for the problem under analysis

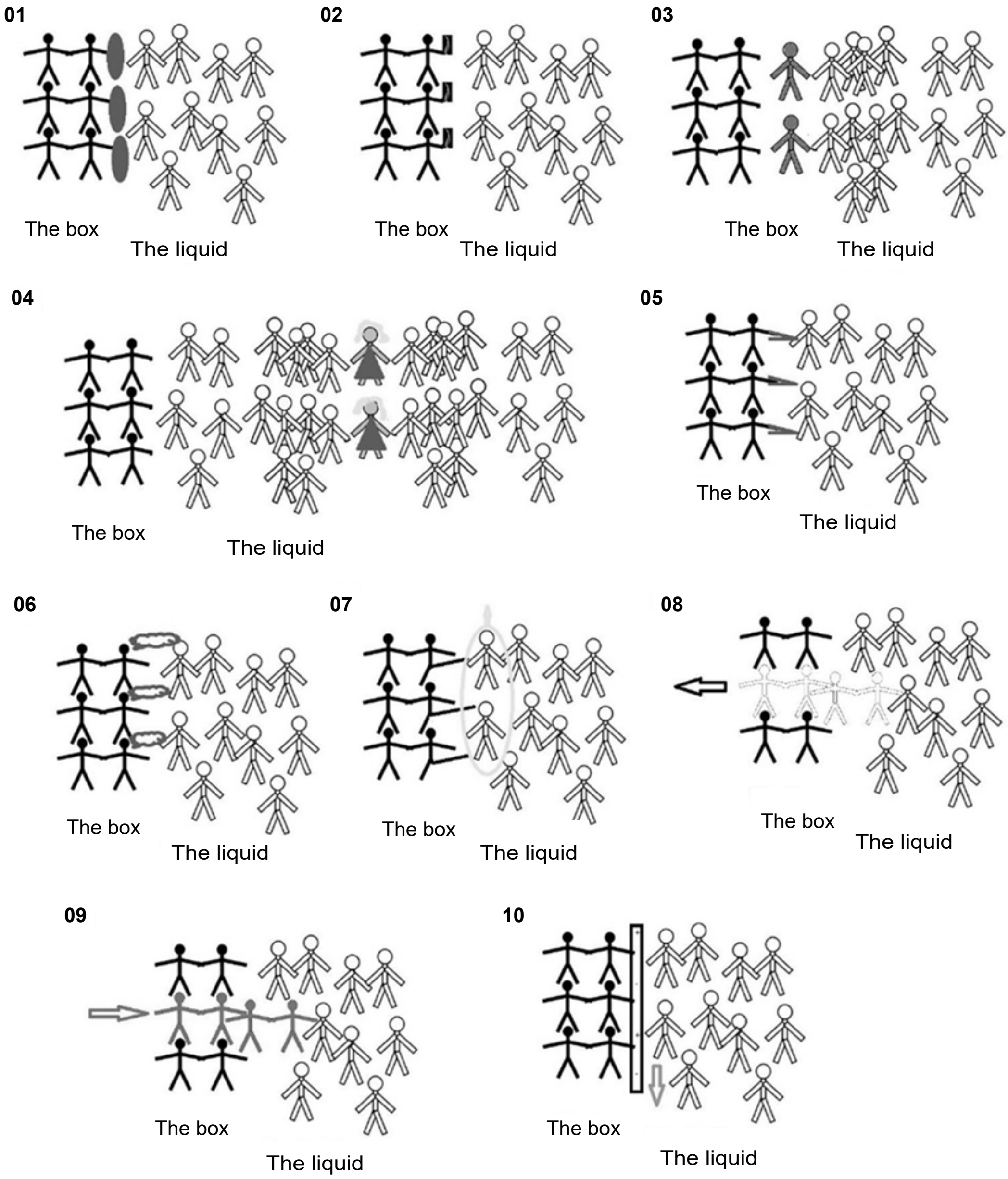

Figure 6. Scenarios of solutions with the use of miniature dwarfs

& Gawdzińska 2015; Chybowski & Kuźniewski, 2016; Gawdzińska, Chybowski & Przetakiewicz, 2016; Zaplata & Pajor, 2016; Alves de Sousa, Ptak & Fernandes, 2017). A summary of selected descriptions of the solutions is presented in Table 1.

This paper does not describe the details of the solutions described above due to its limited size. There are some completely new solutions e.g. 2.1, 3.1, 4.1, 4.2. However, it is worth mentioning that some of these solutions were derived with the use of other methods. For example, the solution no. 09.01, which uses the so called "air bubble lubrication system" method developed in more the recent years (Figure 7), which may be used in passenger ships.

This solution guarantees the Ideal Final State indicated in the beginning of the process of seeking the solution, i.e. "the solution introduces an X-component, without complicating the system and without causing harmful side effects to reduce friction in the contact area between the box and the liquid during motion of the box, but preserves the ability of the box to have a high load capacity". The solution eliminated the physical contradiction: "the particles of the box must contact the liquid to provide buoyancy but should not contact the liquid in order to reduce friction".

The new solution includes air inlet lines with control valves, which are well-controllable parts. They can be controlled by changing the open position.

Additionally, based on the number and location of air inlet lines as well as the control algorithm, it is possible to use the obtained solution for different hull shapes operated in real conditions over many cycles.

Table 1. Summary of proposed solutions

Solution	Ideas
1.1	Application of a special extremely smooth cover (fish-skin / ichthyosis, glass, Teflon) / coating (polymers, carbon) / paint (new generation anti-fouling chlorinated rubber) / oil-based gels with hydrophobic properties.
2.1	Application of an energetic field + cavitation protection.
3.1	Application of an isolating layer in the water generated by means of electrical, electromagnetic or ultrasonic field.
4.1	Special hydrophilic additives to the liquid applied from an external source connected to the box. Additives will change liquid properties by colloidation, coagulation, ionization etc.
4.2	Application of an external electrical field (external electrode at a given distance from the box) which will excite the flow of electrolyte liquid.
5.1	Application of a special hydrophobic coating with "micro-structure" based on bionic examples (e.g. air-keeping the lives of Sylvania plant, dolphin skin)
6.1	Application of a sound barrier, including the use of ultrasonic or infrasonic.
7.1	The use of vibration (vibrating rods) of the box for moving the liquid around.
7.2	Application of movable external parts on the box surface (e.g. using centrifugal forces) for moving the liquid around.
8.1	Application of special channels (voids) in the box for modification of hydrodynamic characteristics to reduce external dynamic water pressure.
9.1	Use of gas bubbles (air from the atmosphere or steam from surrounding liquid) to build an isolation layer between the box and the liquid.
10.1	Application of many electrodes installed on the surface of the box, which can generate a time-variable electric field which induces liquid electrolyte flow over the box.

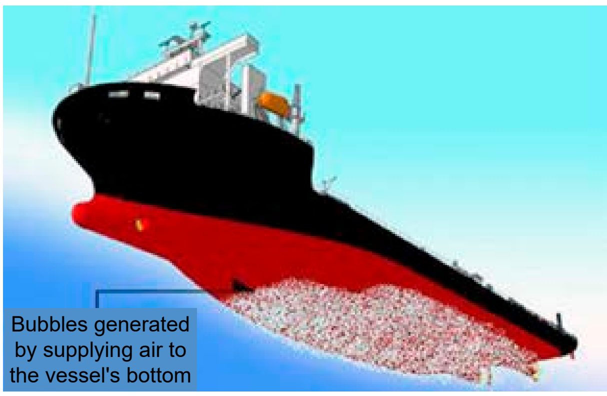

Figure 7. Air lubrication system for ships (Raunek, 2017)

Final conclusions

The effectiveness of the MLM results from knowledge, imagination and space for finding solutions which elements are basic for every analyst. It might limit the method though. The problem could be solved using the method by multidisciplinary teams of analysts and making use of other inventive tools which might not bring satisfactory results but might generate very valuable solutions difficult to be achieved by means of classical (analytic) methods (Souchkov, 2009; Proctor, 2014; Chybowski & Idziaszczyk, 2014; 2015). In Raunek (Raunek, 2017) it is stated that: "according to classification society Det Norske Veritas (DNV), one of the world's leading classification societies, Air Bubble Lubrication System is one of the promising technologies which will help ships to improve their efficiency and reduce energy losses". According to this statement, the MLM shows significant potential to derive innovative solutions with the use of other methods (such as the system presented here to minimize drag on the hull). The MLM might be successfully used in addition to other analytical and invention methods e.g. (Wolniak, 2010; Dziemba & Senczyna, 2012; Żółkiewski, 2013; Biały, 2014; Mayer, 2017) that may limit the influence of psychological inertia in the process of creation, e.g. morphological box, lotus flower or multi-screen diagram (Koziołek, Ptak & Słupiński, 2012; Chybowski & Idziaszczyk, 2015).

The MLM combined with the use of abstraction in the definition of a situational problem ensures the total breakaway of the analyst from the initial problem. This is the basis of the TRIZ method, in which, in order to find detailed problem, a general problem statement is created. The general solution for this problem is searched for, which is finally converted into detailed solutions (of the initial problem). This approach is opposite to the approach used in the method of trials and errors, where a detailed solution to the detailed problem stated is searched for directly.

Acknowledgments

The research presented in this article was carried out under the Grant 1/S/IESO/17: "Increasing operational effectiveness of complex technical systems by systematic development and implementation of innovations using novel materials and modifying the object's structure".

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