TRIZ METHOD APPLICATION FOR IMPROVING THE SPECIAL VEHICLES MAINTENANCE

by

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TRIZ methodology provides an opportunity for improving the classical engineering approach based on personal knowledge and experience. This paper presents the application of TRIZ methods for improving vehicle maintenance where special equipment is installed. A specific problem is the maintenance of the periscopes with heating system. Protective glass panels with heating system are rectangular glass elements. Their purpose is to perform mechanical protection of built-in prisms and provide heating of the prisms. Aging and long-term use leads to failure of these elements. The practice requires solutions in order to extend the lifetime of the system. New solution is evaluated by simulation and experiment.

Key words: *maintenance, TRIZ, glass coating, special vehicles, temperature gradient,*

Introduction

A variety of special equipment is installed on a certain class of vehicles, as shown in Figure1, which are used to transport people in the areas of peacekeeping operations, to clear mine fields or to extinguish fire in fuel depots, etc. These vehicles are usually made by altering i.e. adding security features to their basic versions (metal armour, bulletproof glass, etc.). They are very expensive, which means that they are not often written off, and their maintenance is a problem particularly due to the fact that they are more than 20 years old and one of the major problems of their maintenance is the inability to supply spare parts because they are no longer produced.

Which problem will be solved?

In defining the problem that needs to be solved, tools in the range "Six Sigma" are used, which are Statistical Process Control and Pare to analysis. They provide the best answer to the question what the most cost-effective action to take is, in order to achieve the best improvement in terms of solving (specific) problem [1]. Applying these aforementioned

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methods, on a sample of 300 vehicles, it has been discovered that the dominant problem is maintaining periscope devices, i.e. protective glass panels with heating system on them (over 1500 malfunctions). Protective glass panels with heating system are glass elements of rectangular shape, fig. 2. Their purpose is to provide mechanical protection of built-in prisms and especially to enable heating of the prisms. This is done in order to prevent fogging and icing of the surface at lower temperatures.

Figure1. Vehicles for applying TRIZ method

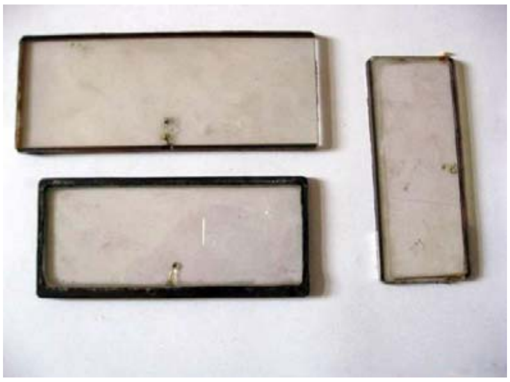


Figure 2. Glass Panels

The current solution is such that the glass is coated with a special transparent and electrically conductive material. Thermocouple is embedded in the glass for the purpose of automatic control operation. When defrosting of glass is needed (similar to the wind screen of passenger cars), electric circuit closes, fig. 3., and the glass defrosts by heating of conductors (special coating). Figure 4 shows the installation of Protective glass panels with heating system: T_h.

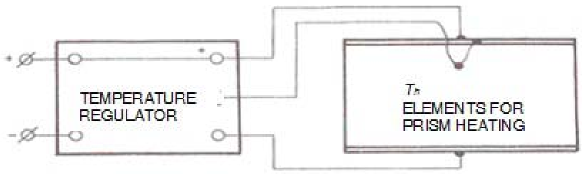


Figure 3. Electric circuit for prism heating.

Solving of the specific problem demands finding technical solutions to maintain or redesign the periscope, actually altering the construction of Protective glass panels with heating system so it could be produced in a local company with a minimum import of components, applying systematic methods of scientific research [2]. The possible import of a complete periscope is not taken into consideration due to extremely high prices. There is need to replace the existing solution since the technology of special coating application is unfamiliar to us as well as its chemical composition. Glass would be the only component imported for a small batch of windscreens with heating system.

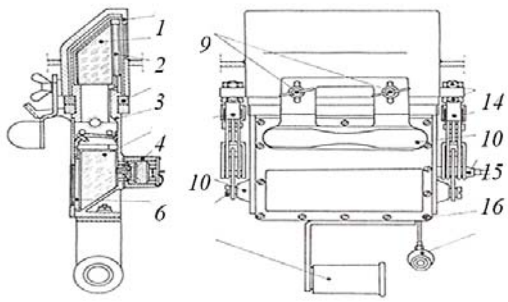
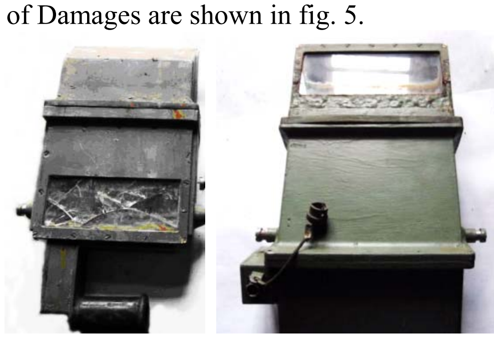


Figure 4. Driver'sPeriscopePVS-1 (source: Operator manual and Troop maintenance manual for Serbian Armoured Personnel Carrier M80)
1 -Periscope mount, 2 – Upper prism, 3 -Protective glass panels, 5 - Periscope body, 6 – Lower prism; 11 – Periscope older

The main types of Damages are shown in fig. 5.



(a) (b)

Figure 5. Types of Damages: mechanical (a); chemical (b)

Troubleshooting for TRIZ methods application

TRIZ methods and method of application are described in [3], [4] and [5].
Technical parameters that are needed to improve are selected and compared to the parameters that are consequently worsened in the Altshuller matrix (see: www.triz40.com). The matrix states what principles should be used to solve the problem.

a) For contradictions: 36 the complexity of the devices and 34 the simplicity of maintenance, the improvement principles are recommended (only the recommendations that are recognized as acceptable are mentioned above).

1. Segmentation, which means:

Divide an object into independent parts.

Make an object easy to disassemble.

b) The contradictions: 32production simplicity and34 the simplicity of maintenance, improvement principles are recommended:

9. Preliminary anti-action, which means:

If it is necessary to do an action with both harmful and useful effects, this action should be replaced with counter-actions to control harmful effects.

c) For contradictions: 17 temperature and 13object stability, improvement principles are recommended:

1. Segmentation, which means:

Divide an object into independent parts.

Increase the degree of fragmentation or segmentation.

d) For contradictions: 13 object stability and 35adaptabilityor universality, improvement principles are recommended:

30. Flexible shells and thin films, which means:

Isolate the object from the external environment using flexible shells and thin films.

By solving technical contradictions, etc., then by applying defined improvement principles the following solutions are chosen:

Instead of applying the special electric conductive surface coating, on the entire edge of the glass base electrical conductor as a heater is built in, thermocouples retained for temperature control which not only simplifies design and production, but it also increases the reliability and durability.

Special," commercial", nano -materials in the form of spray are applied to the glass base to ensure water and humidity are not retained on the glass base and thereby it significantly reduces possibility of fogging and freezing.

Verification of the obtained solution

By TRIZ method recommendations, engineering solution should be tested before a final decision about adoption.

a) Verification by Simulation

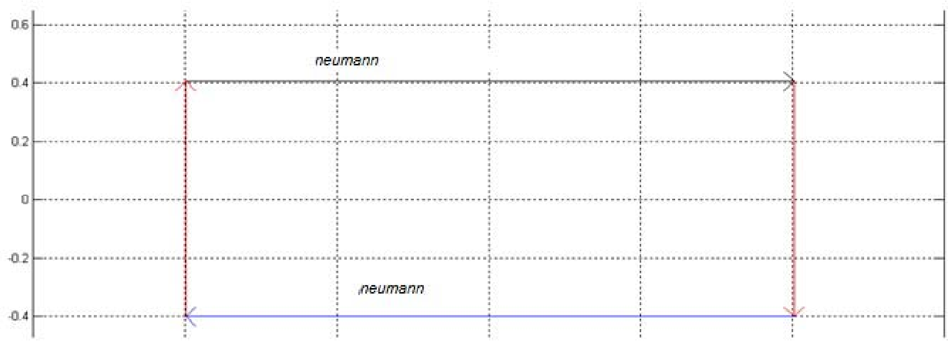


Figure 6. Defining of the geometry and boundaries of Protective glass panels

The simulation is performed in Matlab PDE tool, heat transfer, (Matlab Partial Differential Equation Toolbox™) in order to verify the obtained solution. Being the fact that length and with of the Protective glass panels are substantially greater than its thickness, the simulation is performed in two-dimensional domain. The spread of heat on the surface of the glass is simulated as well.

For a description of heat transfer, the following form of parabolic differential equation is used (1), which describes heat transfer for the symmetric surface [6].

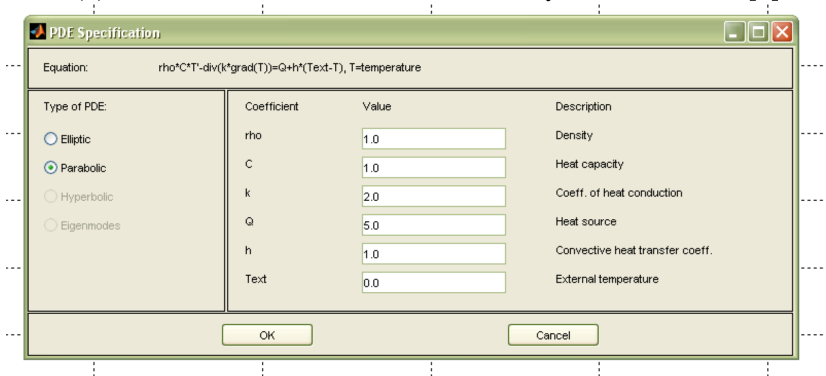


Figure7. Specifying partial differential equations of our problem

$$\rho C\frac{\partial T}{\partial t}-\nabla\left(k\nabla T\right)=Q+h\left(T_{ext}-T\right) \tag{1}$$

where ρ [kgm^{-3}], is the material density C [$Wskg^{-1}$°C^{-1}] is the heat-capacity, k [$Wm^{-2O}C^{-1}$] is coefficient of thermal conductivity, Q [Wm^{-3}] is the heat source, h is convective heat transfer coefficient ,T_{ext} is external temperature (environment). Otherwise, approximately realistic description of the heat transfer model is extremely complex [7,8]. Heat transfer model for the current solution is shown in fig. 8. Model of the new solution is shown in fig. 9.

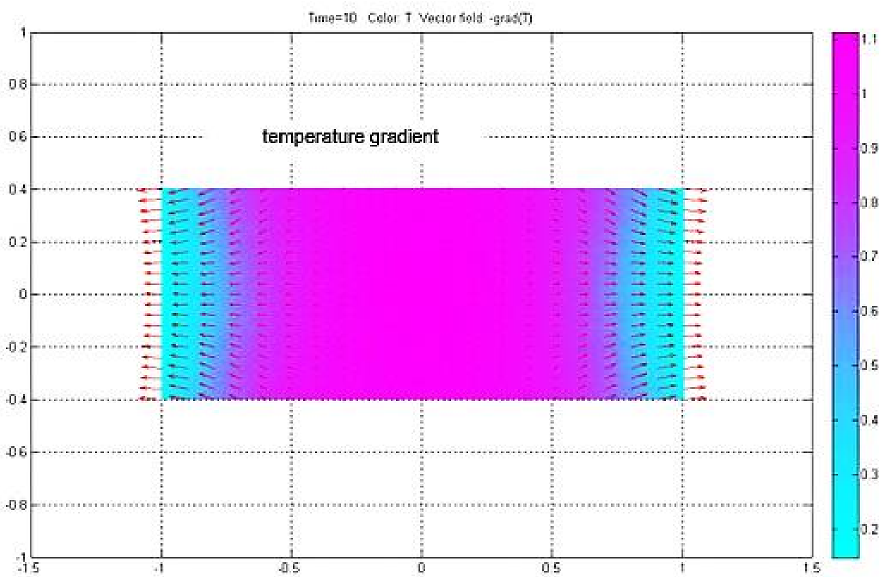


Figure 8. Old solution, the temperature gradient

The simulation shows that the glass defrosting is appropriate, being aware of the all approximate assumptions made in the simulation due to the ignorance of the properties of the glass material used. Figures 8 and 9 shows the distribution of the surface temperature gradient on glass panel. Particularly interesting is the fig. 9, which result is later confirmed by experiment. Verifying the solution by experimenting, a prototype of the new solution has been made, as in fig. 10.

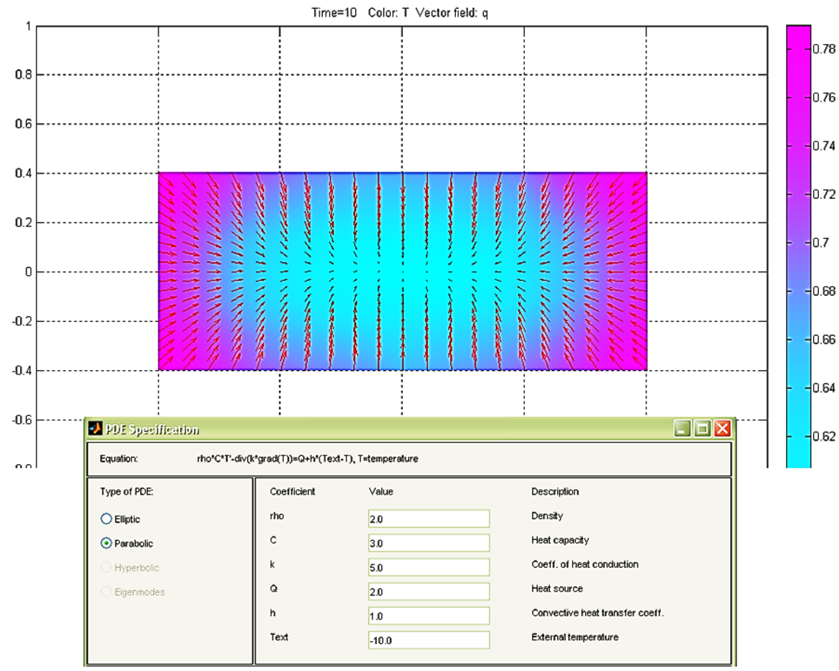
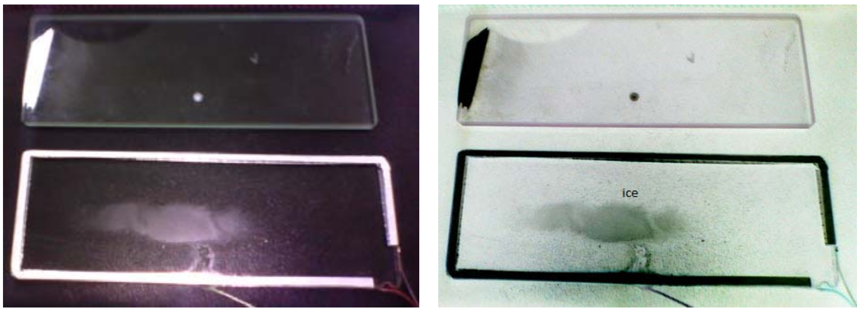


Figure 9. The new solution, external temperature -10 °C

Figure 10. Prototype of new solution.

The course of thawing is shown in figs. 11 and 12. In fig. 11, the top position Protective glass panels is untreated glass, bottom position Protective glass panels is "frozen" glass. The shot represents thawing at some point of the thawing process (the ice in the central part which has not still melted is seen). In fig. 11(b) is also shown protective glass but colours are inverted to better detect frozen surface on glass panel.



(a) (b)

Figure 11. Protective glass panels: normal colour (a); inverted colour (b)

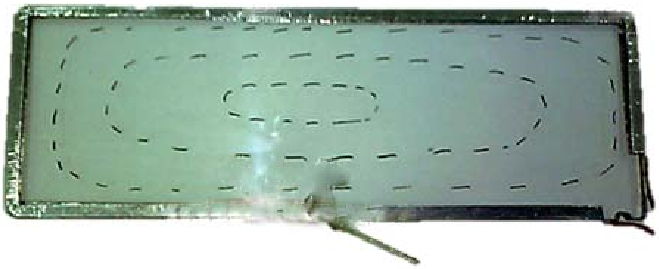


Figure12. Thawing stages, results similar to the simulated model

As a protective coating, a new material is used, a commercial one, based on silicon dioxide. The product for the so-called "*glass coating*" was chosen commercial product, based on nano-technology of applying in extremely thin layers of silicon dioxide film (http://www.nanocare-ag.com/startseite/), which is shown in fig.13.

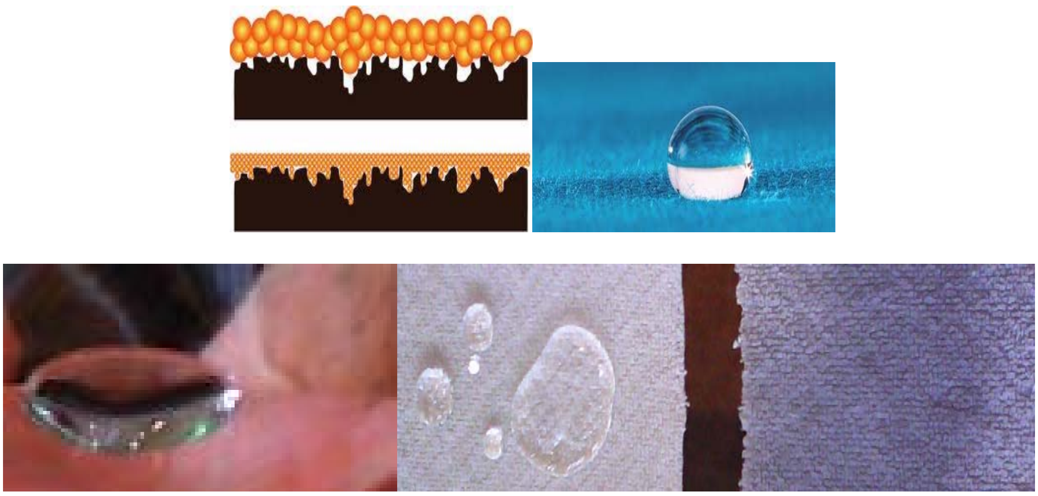


Figure 13. Thin layers of silicon dioxide film and their effects.

Its property of a hydrophobic material contributes to unfavourable retaining conditions of water (humidity) on the surface of the windscreen therefore, defrosting is easier and faster. In addition, cleaning windscreens is significantly simpler.

Conclusion

Applying TRIZ method offered a new solution for the vehicle maintenance and production of a small batch of Protective glass panels with heating system. The price of the new solutionis¼ of the old one. The website http://www.triz40.com/ was used for the TRIZ application. "Six Sigma" tools, especially Statistical Process Control (SPC) and Pareto analysis identified the predominant problem. In order to overcome it, TRIZ method was used. The new solution was analysed by simulation in Matlab programming environment, the partial differential equations module. The prototype of the new solution was created and it was tested in manufacturer's laboratory.

The success of the application of TRIZ method lies largely in the ability of those who apply it to properly interpret the instructions – recommendations provided by TRIZ. The fact that most of the engineers deal with the same problems and seek answers to questions already asked many times and, more importantly, the real purpose of this method is provided as the answer.

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