Improvement Of Designing Laboratory Scale Plastic Chopping Equipment With The Triz Method (Theorija Rezhenija Izobretatelskih Zadach)

Rafiqa Fijra[1]*, Zulkiffli Saleh [2], M. Rifqi Adinugraha [3], Merisha Hastarina[4], Bayu Wahyudi [5]

[1,3,4,5] Program Studi Teknik Industri, Fakultas Teknik, Universitas Muhammadyah Palembang Sumatera Selatan, Indonesia
[2] Program Studi Teknik Elektro, Fakultas Teknik, Universitas Muhammadyah Palembang Sumatera Selatan, Indonesia
*Corresponding Author:
Email: fijrarafiqa@gmail.com

Abstract.
The practical use of plastic increasing the demand for plastic. Plastic waste is difficult to decompose, currently many efforts have been made to reduce this plastic waste. A plastic chopping machine is a tool used to produce shredded plastic items into small pieces of a certain size, which can later be used for further processing as a recycling effort. This study improves the design of an existing plastic chopper that focuses on increasing reliability and convenience by the user. The analysis was carried out using a fishbone diagram and the TRIZ design method. The research resulted in a number of causes for the emergence of problems in the operation of the plastic chopper and a new design for the tool, namely improvements in terms of the type of blade, type of motor, and size of the tool.

Keywords: *Improvement designing, plastic chopper, fishbone diagram, and TRIZ method.*

I. INTRODUCTION

The practical use of plastic makes the demand for plastic continue to increase. In 2006 plastic waste ranged from 825 tons, increasing to 1038.5 tons in 2008 [1]. This number continues to increase every year. Based on information on plastic Debris Entering The World Ocean, Indonesia is the second largest contributor to plastic waste in the world for the category of waste disposal into the sea [2]. The efforts to keep plastic waste to a minimum within a certain time limit and save resources. There have also been many activities carried out by the community to reduce plastic waste, one of which is by carrying out 3R activities, namely Reduce, Reuse and Recycle. Utilization of plastic waste can be done by reducing its use (reduce), besides that it can be done by reuse (reuse) and can also recycle it (recycle). One of the efforts to recycle plastic is to use a plastic chopper, in which this tool produces shreds of plastic items into small pieces of a certain size, which can later be used for further processing which will eventually become plastic product materials that are used to make plastic products. Thus, through this research activity, the author hopes to contribute a small part of the plastic waste reduction effort that is good for the environment. The design of the existing plastic chopper still has a number of problems that affect the quality of results and user comfort. Therefore, it is necessary to improve the design of the plastic chopper in order to improve the quality of the results and the comfort of the user.

II. LITERATURE REVIEW

Research on the effect of blades on plastic waste machines by Asroni et al [3] found that to get the maximum quality and quantity of chopping results, using a V-blade and using 800 rpm with small plastic seeds yielded 1000 grams per minute. Then the results obtained were followed by a zig-zag blade type with a rpm of 600 and produced 800 grams per minute. Burlian F et al [4] designed a plastic bottle crusher tool and concluded that using a zig-zag blade resulted in a larger capacity than a straight blade and V-blade. Selan et al [5] designed a plastic waste chopper machine designed specifically for cutting plastic materials. PE (Polyethylene) type. Angraeni and Latief [6] designed a plastic chopper machine with a scissors type with 5 blades, but no testing has yet been carried out. Silitongan et al [7] designed a PET (polyethylene terephthalate) type plastic chopper for the household industrial scale. Masruri et al [8] used the Quality Function Deployment (QFD) method, it's just that improvements are still needed to the design, in this study

improvements were made to the design using the TRIZ method (Teorija Rezhenija Izobretatelskih Zadach).

Fishbone Diagram

Fishbone diagram is used for a cause and effect analysis of a specific problem created by Ishikawa (1990). The Cause and Effect Analysis was originally developed as a quality control tool, such as product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause is a source of variation of the phenomena understudy. Causes are usually grouped into major categories to identify the overall sources of variation that lead to a main effect [9]

TRIZ Method

The TRIZ is an innovative design method was developed by Altshuller, who had analyzed over 400,000 patents to establish 39 engineering parameters (Table 2.1), there are 40 inventive principles (Table 2.2) and contradiction matrix. Which is effective to help designers in solving contradiction problems and improving product design [10]

The problem-solving mode (Figure 1) with the following steps [10]:

Step 1: Find the contradictory characteristics in product's system.

Step 2: Match of each contradiction with two appropriate parameters from the 39 engineering parameters.

Step 3: Choose three or four of the most frequently used solutions from the 40 principles for solving a design problem

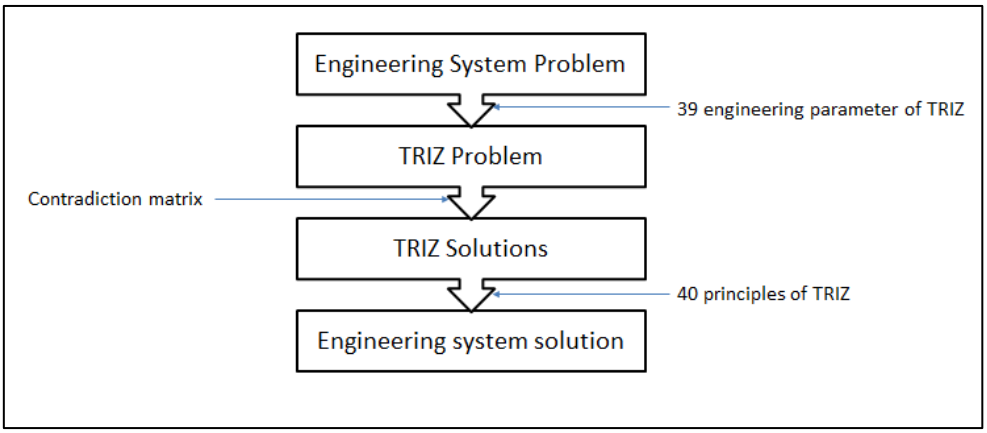


Fig 2.1. Problem Solving of TRIZ Mode

Table 2.1. 39 Engineering Parameter of TRIZ

No.	Engineering parameter	No.	Engineering parameter
1	Weight of M	21	Power
2	Weight of non-M	22	Waste of energy
3	Length of M	23	Waste of substance
4	Length of non-M	24	Loss of information
5	Area of M	25	Waste of time
6	Area of non-M	26	Amount of substance
7	Volume of M	27	Reliability
8	Volume of non-M	28	Accuracy of measurement
9	Speed	29	Accuracy of manufacture
10	Force	30	Harmful factors acting on object
11	Tension/pressure	31	Harmful side effects
12	Shape	32	Manufacturability
13	Stability of object	33	Convenience of use
14	Strength	34	Reparability
15	Durability of M	35	Adaptability
16	Durability of non-M	36	Complexity of device
17	Temperature	37	Complexity of control
18	Brightness	38	Level of automation
19	Energy spent by M	39	Productivity
20	Energy spent by non-M		

M: moving object.

Table 2.2 40 Principles of TRIZ

No.	Principle	No.	Principle
1	Segmentation	21	Skipping
2	Taking out	22	Blessing in disguise
3	Local quality	23	Feedback
4	Asymmetry	24	Intermediary
5	Merging	25	Self-service
6	Universality	26	Copying
7	Nested doll	27	Cheap short-living object
8	Anti-weight	28	Mechanics substitution
9	Preliminary anti-action	29	Pneumatics and hydraulics
10	Preliminary action	30	Flexible shells and thin films
11	Beforehand cushioning	31	Porous materials
12	Equipotentiality	32	Color changes
13	The other way round	33	Homogeneity
14	Spheroidality-curvature	34	Discarding and recovering
15	Dynamics	35	Parameter change
16	Partial or excessive actions	36	Phase transition
17	Another dimension	37	Thermal expansion
18	Mechanical vibration	38	Strong oxidants
19	Periodic action	39	Inert atmosphere
20	Continuity of useful action	40	Composite materials

III. METHODS

The study began by finding a number of complaints about the use of plastic choppers, then a literature study was conducted regarding product design improvements. Observations on the operation of the plastic chopper were carried out for data collection and obtained a number of activities which were classified into non-effective and non-efficient activities.Non-effective and non-efficient activities will then be analyzed using fishbone diagrams to identify possible causes of problems according to categories, namely humans (labor), materials, methods, environment, machines and measurements.A number of causes of problems are also caused by the design of the tool, where the problem if solved has a number of contradictions with the desired design criteria that remain in the design of the tool. So that the analysis of the tool design is carried out using the TRIZ method (*Teorija Rezhenija Izobretatelskih Zadach*) which can solve design problems with contradictions that occur A number of criteria for improving the design of the tool are outlined in a design concept that appears in the form of a 3D design, using SketchUp Software which will be used in the manufacture of plastic chopping tools in the Manufacturing Laboratory of the Industrial Engineering Study Program of UM Palembang, some component that cannot be done in the laboratory have been completed in the laboratory partner workshop. The research method is shown in Figure 3.1.

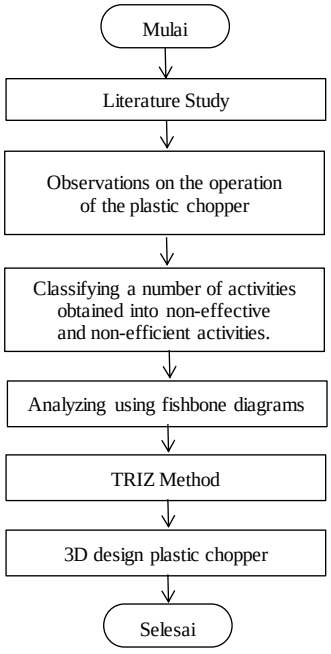


Fig 3.1. Research flow chart

IV. RESULT AND DISCUSSION

DATA DESCRIPTION

Collecting data on complaints about the use of plastic choppers through interviews and direct observation. Data on complaints about the use of tools are listed in Table 4.1.

Table 4.1 Non-Efficient and Non-Effective Activities

No	Non-Efficient	Non-Effective
1	The blade is easy to rust	Not chopping well (there are plastic parts that isn't chopped)
2	Vibration occurs in the tool, making it difficult for the counting process (motor is not compatible)	Some of the chopped results are scattered due to vibrations

Source: Author's Source

Non-effective and non-efficient activities will then be analyzed using fishbone diagrams to identify possible causes of problems according to categories, namely humans (labor), materials, methods, environment, machines and measurements.

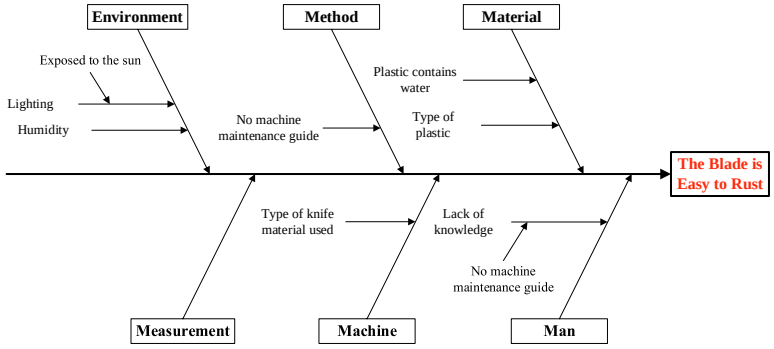


Fig 4.1 Fishbone diagram on the problem of rusty blades

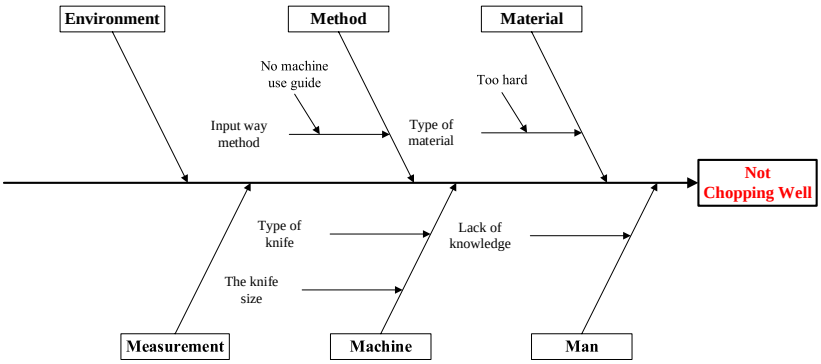


Fig 4.2 Fishbone diagram on the problem of not chopping well

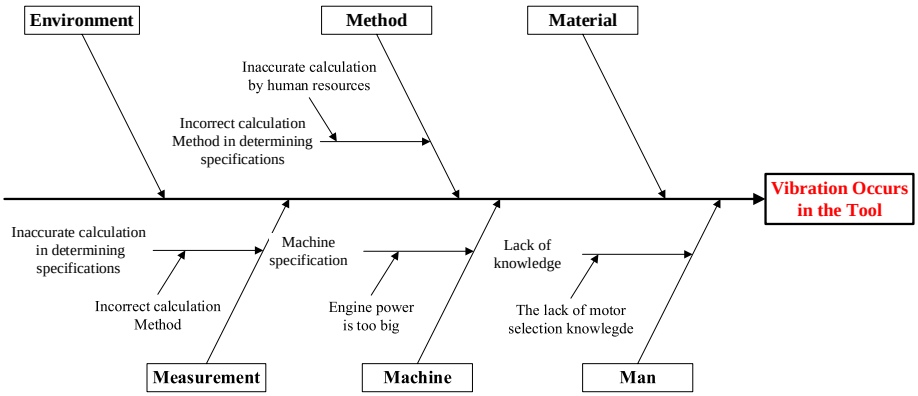


Fig 4.3 Fishbone diagram on the problem of rusty blades

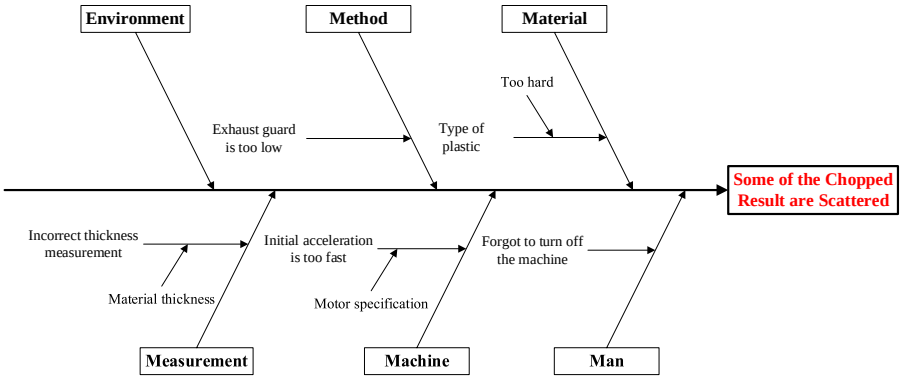


Fig 4.4 Fishbone diagram on the problem of scattered the chopped results

Thus, obtained a number of causes for each problem in the Fishbone diagram.

A number of causes of problems are also caused by the design of the tool, where the problem if solved has a number of contradiction with the desired design criteria that remain in the design of the tool. So that the analysis of the design of the tool is carried out using the TRIZ method (*Teorija Rezhenija Izobretatelskih Zadach*) which can solve design problems with contradictions that occur.

The steps for solving the problem model in the design of a plastic chopper with the TRIZ model are as follows:

1. Identify the design problems of the plastic chopper

a. How to get the tool to chop powerfully, quickly and uniformly?
b. How to prevent the tool from vibrating loudly during operation?
c. How to keep the blade from shaking when chopping?
d. How to keep the tool from rusting?
e. How to make the tool more comfortable for users to use?

2. Identify problems with 39 engineering parameters of TRIZ

Based on the problems in the design of the enumerator, it will be identified based on 39 Engineering Parameters of TRIZ obtained from Gadd (2011) [11]. Thus, the desired engineering parameters in the design of the plastic chopper are obtained in Table 4.2 below.

Table 4.2 Identification of Altshuller's 39 Parameters on the design problems of plastic chopping equipment.

No	Description	Parameter	Code
1	How to make the chopper can chop firmly, quickly and uniformly	#27 realibility #9 Speed	27 9
2	How to prevent the chopper from vibrating when operating	#27 realibility	27
3	How to keep the chopper blade from shaking when chopping	#27 realibility	27
4	How to keep the chopper from getting rusty	#34 Ease of repair	34
5	How to make the enumerator convenient for users to use	#33 Ease to operate	33

There are 4 parameters which are the desired parameters in the design of the plastic chopper, namely:

- #27 reliability
- #9 Speed
- #34 Ease of repair
- #33 Ease to operate

3. Define conflicting parameters (contradiction matrix)

However, these 4 parameters also have other contradicting parameters (cons), the contradicting parameters are written in the parameter contradiction matrix in Table 4.3 below.

Table 4.3 The contradiction matrix of the parameter you want to improve vs the parameter that hinders (Barrier parameters)

No	Parameters you want to improve	Barrier parameters
1	#27 Realibility	#37 Difficulty detecting and measuring, difficulty monitoring complex systems, takes time and effort to set up and use of blade components that are
2	#9 Speed	#13 Stability of object composition- the chopper is unstable (vibrates) during operation which reduces the quality of the work.
3	#34 Ease of repair	# 27 *Reliability*
4	#33 Ease to operate	# 27 *Reliability*

4. Formulate a solution for repairing the design of the plastic chopper

After being made in the form of a contradiction matrix, a solution is formulated based on the matrix using the 40 Principles of TRIZ obtained from https://triz.org/principles [12]. Then the design solution for the plastic chopper is formulated in Table 4.4 below.

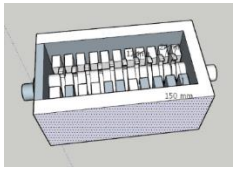
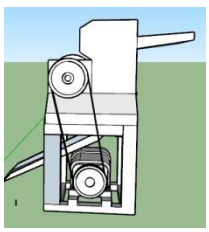
Table 4.4 Design solutions for plastic choppers

No	Parameters you want to improve	Barrier parameters	TRIZ Solutions
1	#27 Realibility	#37 Difficulty detecting and measuring, difficulty monitoring complex systems, takes time and effort to set up and use of blade components that are	#5 Consolidate • Consolidation in homogeneous or contiguous operating times. • Consolidate the blade in a zig zag shape, and move together to crush the object to be chopped. #6 Universality • An object can perform several different functions, therefore other elements can be omitted. • Static blade removed. #14 Spheroidality • Change the linear part to the curved part. • Change the flat blade to a curved surface #15 Dynamics • If an object doesn't move, make it move, make it interchangeable, and divide an object into elements capable of changing their position relative to one another. • Change the static blade to dynamic, and the blade consists of a number of elements.
2	#9 Speed	#13 Stability of object composition- the chopper is unstable (vibrates) during operation which reduces the quality of	#5 Consolidate • Consolidation in homogeneous or contiguous operating times. • Consolidate the blade in a zig zag shape, and move together to crush the object to be chopped

No	Parameters you want to improve	Barrier parameters	TRIZ Solutions
		the work.	#35 Parameter change • Change the physical state of the system. • Change the drive motor with a smaller phase.
3	#34 Ease of repair	#27 Reliability	#1 Segmentation • Create sectional objects (to facilitate assembly and disassembly) #35 Parameter change • Change the physical state of the system. • Change the shape of the blade that is easy to disassemble and install.
4	#33 Ease to operate	#27 Reliability	#35 Parameter change • Change the physical state of the system. • Adjust tool size according to user's anthropometry.

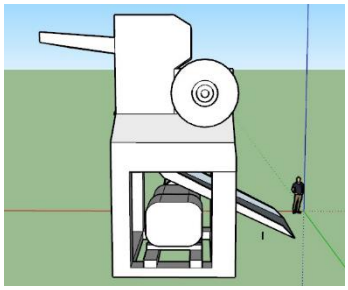
Based on the TRIZ solution obtained, it is stated in the form of suggestions for improving the design of the plastic chopper, so that there are changes to the tool, which are listed in Table 4.5 below. Burlian F et al (2019) designed a plastic bottle crusher tool and concluded that using a zig zag blade produces a larger capacity than straight and V blades. So one solution is to replace the blade in a zig zag position.

Table 4.5 Comparison of Current Plastic Chopping Equipment and Improvement Plans

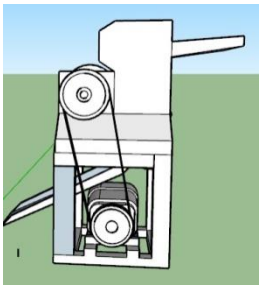
No.	Kriteria	Saat ini	Rencana Perbaikan
1	Motor yang digunakan	*Three phase* (daya 3 kW)	*Single phase*
2	Ukuran *body* alat	Panjang 1000 mm, Lebar 340 mm dan Tinggi 1500 mm	Panjang 380 mm, Lebar 380 mm Tinggi 1000 mm
3	Mata pisau	*Flat* (1 mata pisau tetap dan 3 mata pisau bergerak.	*Shredder* 
4	Rancangan alat		

The concept of tool repair is made in the form of a 3D design which is fully contained in Figure 4.1 below.

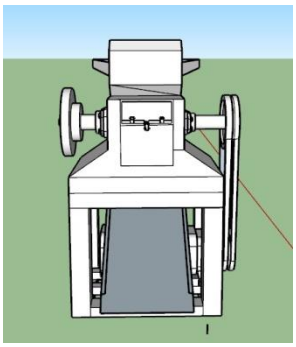
Side view 1:



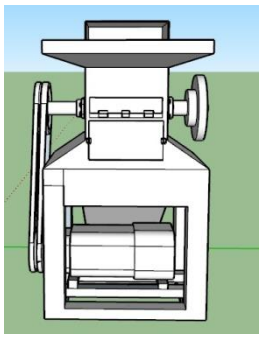
Side view 2:



Front View:



Back View:



Top View:

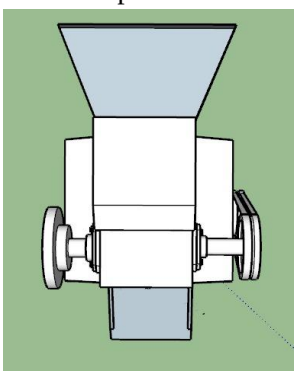


Fig 4.1 3D design of plastic chopper repair design

V. CONCLUSION

The research resulted in an improvement in the design of the plastic chopper using the TRIZ method which was made in a 3D design, and analyzed a number of root causes of problems in the operation of the plastic chopper.

REFERENCES

[1] Yuli Yetri, Hendri Sawir and, Rahmi Hidayati (2016), Rancang Bangun Mesin Pencacah Sampah dan Limbah Plastik, Seminar Nasional Pengabdian Kepada Masyarakat 2016. ISSN 978-602-6428-05-9.

[2] Agrivani A.Soleman (2019).Kantong Plastik Berbayar Sesuai Regulasi Nasional. *Berita Kedokteran Masyarakat,* Vol 35,No 4. ISSN 2614-8412 (online)

[3] Asroni,M., Djiwo,S., Setyawan,E,Y., 2018, Pengaruh mata pisau pada mesin sampah botol plastik, ***Jurnal aplikasi dan Inovasi Ipteks*** *"SOLIDITAS", Vol 1, No 1, April*.

[4] Burlian,F., Yani,I., Ivfransyah, Arie J,S., 2019, Rancang Bangun Alat Penghancur Sampah Botol Plastik Kapasitas ±33 Kg/Jam, *Seminar Nasional Teknoka, Vol 4.*

[5] Selan,R,N., Maliwenu,E,U,K., Pinto,G,P,M,.2021, Perancangan Alat Pencacah Sampah Plastik Sebagai Bahan Baku Aspal , ***Jurnal Fisika Sains dan Aplikasinya***, Vol 6,No 1, April.

[6] Anggraeni ,N,D., dan Latief,A,E, 2018,. Rancang bangun mesin pencacah plastik tipe gunting***, jurnal rekayasa hijau,*** No 2, Vol 2.

[7] Silitonga, Y,F., Kardiman, dan Hanifi,R.,2020, Rancang bangun mesin pencacah plastik jenis pet skala industri rumah tangga (*home industry*) , ***Journal of infrastructure & Science Engineering***, Vol 3, No 2.

[8] Ansyori Masruri, Zulkifli Saleh, Zamza Satria, and Merisha Hastarina (2021), Perancangan Mesin Pencacah Plastik Skala Laboratorium dengan Metode Quality Function Deployment, ***Integrasi Jurnal Ilmiah Teknik Industri*** (6)(1).

[9] Mario COCCIA (2017, The Fishbone diagram to identify, systematize and analyze the sources of general purpose technologies, ***Journal of Social and Administrative Sciences***, Volume 4 December 2017 Issue 4

[10] Lin,S,Y, dan Wu,C,T.,Application of TRIZ inventive principles to innovate recycling machine,2016, *Advances in Mechanical Engineering, Vol. 8(5) 1–8*

[11] Karen,G., 2011, TRIZ for engineers: enabling inventive problem solving, first edition, *John Wiley & Sons, Ltd.*

[12] Technical Infrmation Centre. Inc. https://triz.org/principles