INJECTION PROCESS IMPROVEMENT USING SIX SIGMA*

Ioana Catalina ENACHE[1], Ionel SIMION[2], Florina CHISCOP[3], Marius Adrian CHISCOP[4]

Besides its statistical significance Six Sigma is a management program and a method of optimizing. Has been shown that this method can be can be used successfully for any project or process. Through these methodologists we tried to improve the injection process for a given part. Since this optimization method is very complex, requiring covering of six stages in this paper we will focus only on the analysis phase.

Keywords: Six SIGMA, DMAIC, improvement, process optimization

1. Introduction

Six SIGMA was developed by Motorola in 1980's to implement the Japanese quality ideas and control systems. It is a problem solving approach that is created to solve current problems and design new products/processes based on six sigma quality standards [1].

As its benefits become known, Six SIGMA has started to be used in service industry as well. It has spread over supplier industries from main industries. It contains improvement tools and problem solving techniques. It is a successful quality improvement methodology used to improve processes and products by the organizations like Motorola, Texas Instruments, Allied Signal, General Electric, Boeing and Sony [2].

The central question, of any producer is related to the possibility of reducing the price / unit, without compromising the functionality of the product and the quality expected by the client [3].

[1] Assistant, Department of Engineering Graphics and Industrial Design, University POLITEHNICA of Bucharest, Romania, e-mail: dobre.catalina@yahoo.fr
[2]Professor, Department of Engineering Graphics and Industrial Design, University POLITEHNICA of Bucharest, Romania, e-mail: ionel_simion@yahoo.com
[3]Lecturer, Department of Machines and Manufacturing Systems, University POLITEHNICA of Bucharest, Romania, e-mail: florinachiscop@gmail.com
[4]Student, Department of Machines and Manufacturing Systems, University POLITEHNICA of Bucharest, Romania, e-mail: marius_chiscop@yahoo.com
The results presented in this article were obtained withthe support of Ministry of Labour, Family and Social Protection through Sectorial Operational Programme Human Resources Development 2007-2013, Contract no. POSDRU/107/1.5/S/76813.

We can say that there are three possibilities for this: shorten the running of the technical process, the use of new materials, with price advantage and implementation of innovative technologies.

The objectives are:

- Conceiving a methodology;
- Establishment of a project timeline;
- Familiarization with the process and identifying weaknesses;
- Proposing concrete solutions to optimize production process;

A pragmatic definition of Six Sigma program could be formulated as: "Six Sigma aims to satisfy entirely from economic point of view, the customer requirements."[4]

The purpose is to improve the interaction between customer and producer Fig.1 Producer should satisfy the price, lead time and quality expectations of the customer by decreasing the cost, defect rates and cycle time.

Process management continuously analyzes the relations between outputs and the inputs which are the main sources of the variability.

Statistical tools provide methods to understand how these sources of variability affect outputs.

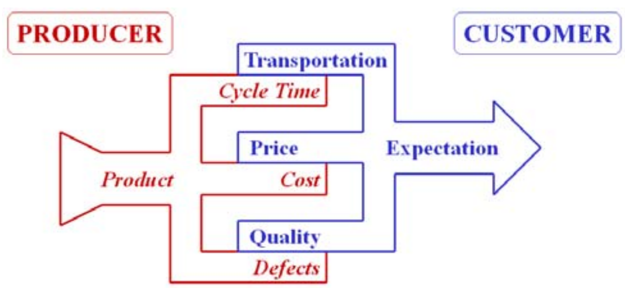


Fig. 1. Relation between producer and customer

To standardize the procedure for action, in order to solve structured problems under Six Sigma thinking, DMAIC model was created (Define-Measure-Analyse-Improve-Control).

In the workshop PEX two parts are done named Component 1 and Component 2. These two parts can be molded together or individually in the case of *Component 1*. Because the customers demand for a greater number of components it is necessary to find ways for improving the production process (Fig. 2 & 3).

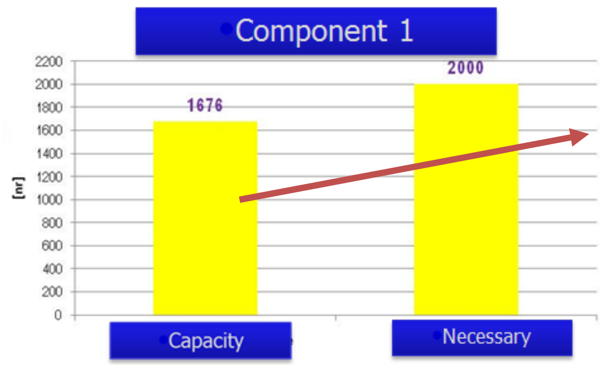


Fig. 2. Capacity vs. necessary for *component 1*

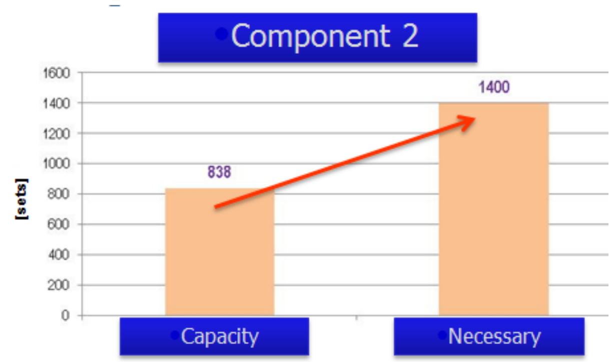


Fig. 3. Capacity vs. necessary for *component 2*

2. Define and Measure phases

In the *Define* phase the aim is to understand the boundaries of the project taking into account the client's needs.

The main techniques and instruments used in this step are:

The expectations after each step are: process charter, VOC-CTQ (Voice of Customer-Critical for Quality), flow chart, SIPOC (Supplier, Inputs, Process, Outputs, Customer), cause - effect diagram.

In the *Measure* phase a data collection plan was respected. The Gage R & R, Control Charts and Capability Analysis [5] show that the operators don’t influence measurement procedure or results because they strictly respect the same measurement method. The components geometry gives the biggest variations (Fig. 4).

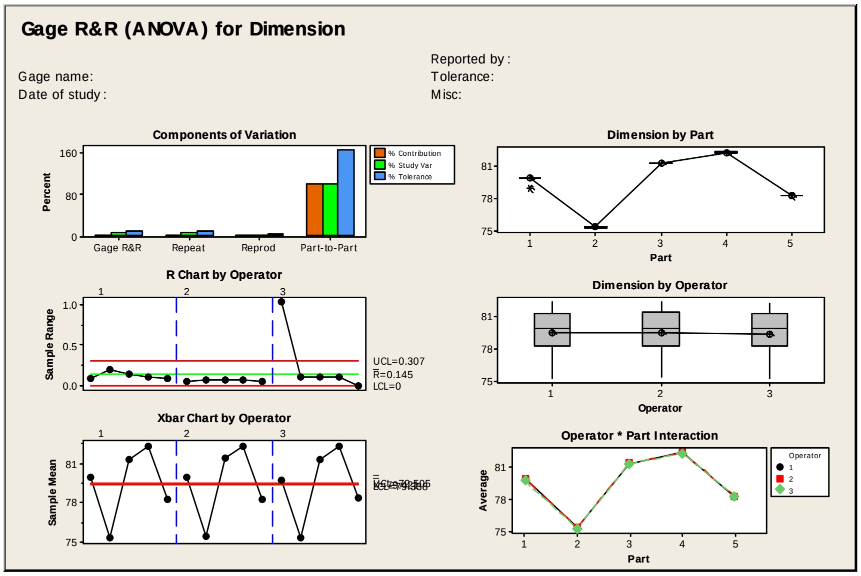


Fig. 4. Gage R&R analysis

Fig. 4 shows that the values obtained for each operator have the same trend and we have for the studied process a good repeatability and reproducibility of measurements. In generally the capability for the entire system [5] is outside specification limits (Fig. 5).

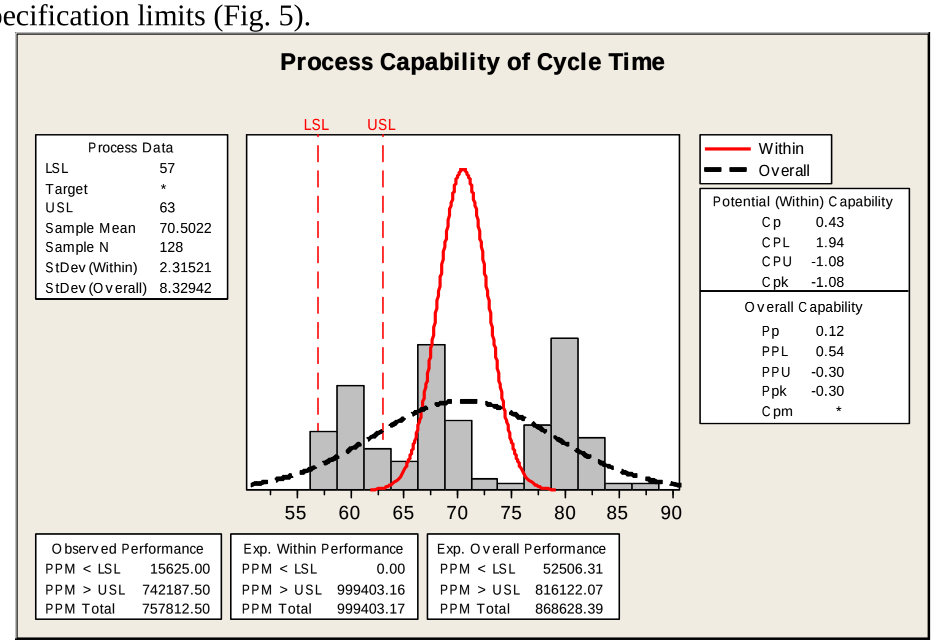


Fig. 5. Capability analysis for the injection process

3. Analysis phase

If in the measure phase we see that a major problem exists in the injection process, then in this phase we seek the causes that have an important impact on the process. As a function of the “client” we established that too matrix configurations can be used (Table 1).

The first configuration is formed by two cavities for *component 1* and the second one is formed by two cavities *component 1* and two cavities *component 2*.

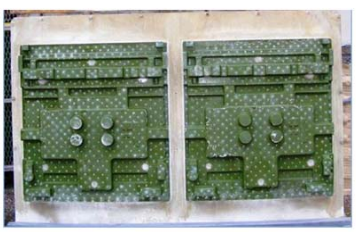
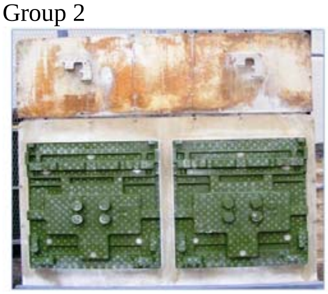
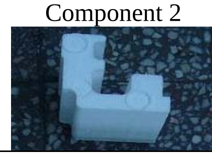
Depending on these configurations a new set of measurements was made. The values were organized as a function of work shift and group. Cycle time was measuring same time, same mold by three operators. An electronic chronometer with a precision of 0.01 seconds it was used.

A measurement methodology was established:

1. Start elapsed time measuring on parallel machine cycle;
2. Observe and compare intermediary elapsed steps;
3. Stop the chronometer at the end of cycle;
4. Reading of shown value;
5. Writing down the shown value.

Table 1

The mold group configuration

Matrix injection	Name	Cavities	Mass [Kg]
Group 1 	Component 1 	2	0.433
Group 2 	Component 1 	2	0.433
	Component 2 	2	0.037

The information collected will be used as input for a statistic analyze performed in Minitab software.

For comparing the two groups of subjects we used ANOVA techniques (Fig. 6).

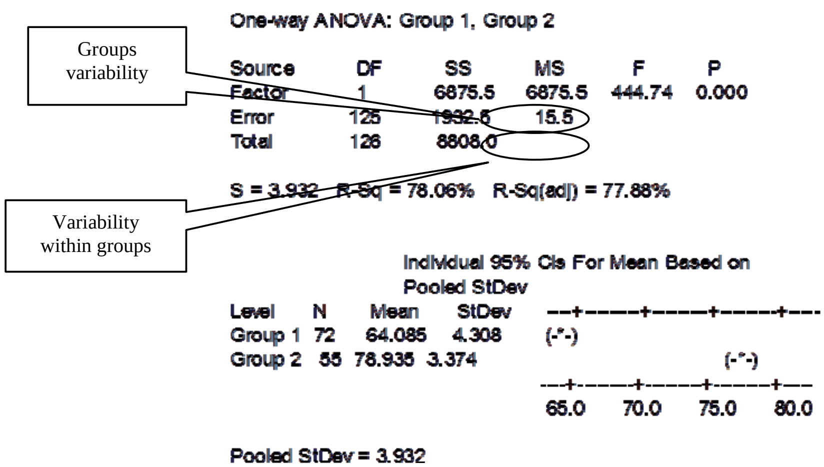


Fig. 6. ANOVA

Analyzing the relationship between the times required for obtaining the parts and the configuration of the two groups we obtain:

1. The groups averages are different because P value < 0.05
2. Conclusion, the groups are statistically different
3. The difference is showen by F value, 444.74

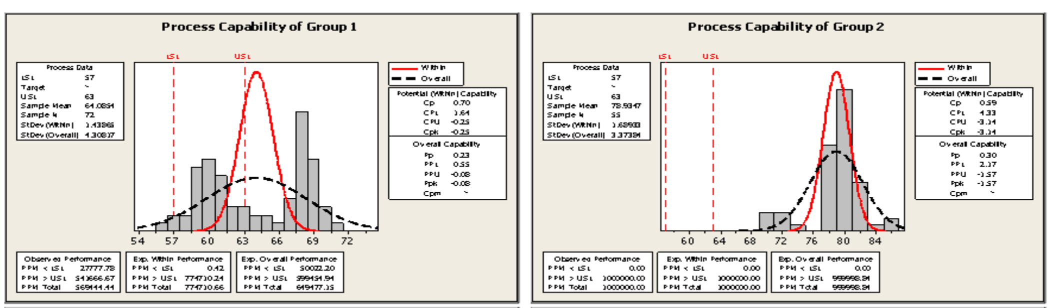


Fig. 7. Proces capability for the two analyzed groups

The graphic representation of process behavior shows that the capability differs in function of analyzed groups (figure 7) considering that we keep the same specifications limits. Lower specification limit (LSL) was established at 57 seconds and upper specification limit (USL) was established at 63 seconds. The capability index for *group 1* has proved to be closer to the desired capability in comparison with *group 2*.

$$Cp_{group1}=0.7 > Cp_{group2}=0.59$$

In the case of *group 1* almost 50% of measured values are under the specification limits.

In the case of *group 2* all measured values are outside specification limits.

These results highlight the fact that although the two groups are not centered, an equipping injection machine with *component 1* only is a superior system than the one in which the machines are equipped with both matrix *component 1* and *component 2*.

Even in the first case the middle to the process is nearest of the upper specification limit and in the second studied group all the process is outside the limits we conclude that the two proposed systems are unacceptable.

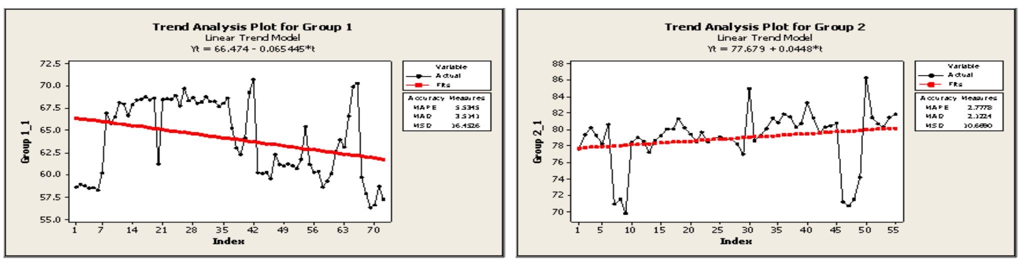


Fig. 8. Trend analysis

A trend analysis plot for the two studied group, show that they have different behavior in time (Fig. 8).

- For the measured values obtained during a production cycle the *Group 1* tends to have a decreasing trend. This means that in time this group tends to be more centered under specification limits.
- *Group 2* tends to have an upward trend, which means that over time this one tends to depart from specification limits.

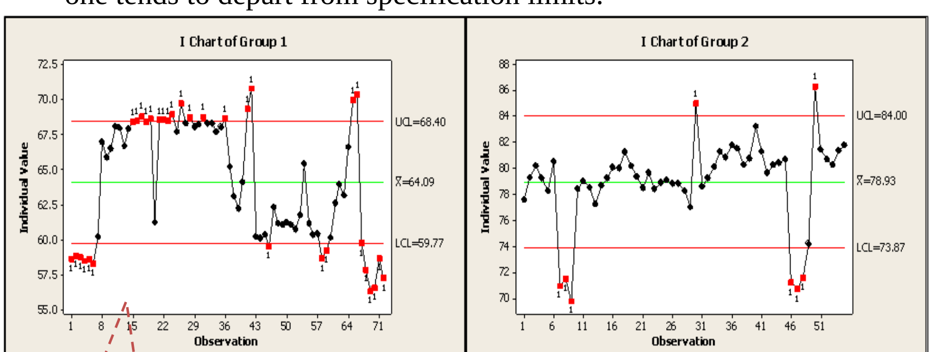


Fig. 9. Analysis of measured values

Special causes

An analysis of individual values (Fig. 9) for the two groups highlights the fact that in the case of *group 1* is recorded the existence of a larger number of special cases than in the case of *group 2*.

In this situation it is necessary to analyze also the causes that lead to a low productivity using a cause – effect diagram (Fig. 11).

After we put in evidence all the factors that can influence the productivity, we identify the main causes – the unprocessed geometry.

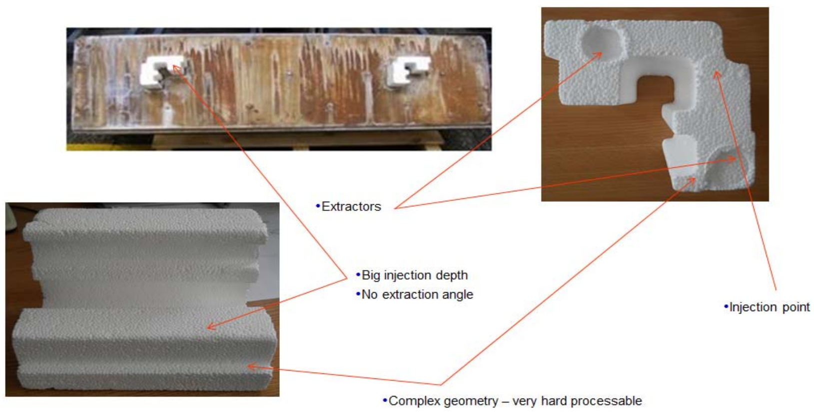


Fig. 10. *Component 2* geometry analysis

The geometry of *component 2* injection matrix that was studied is shown in Fig. 10.

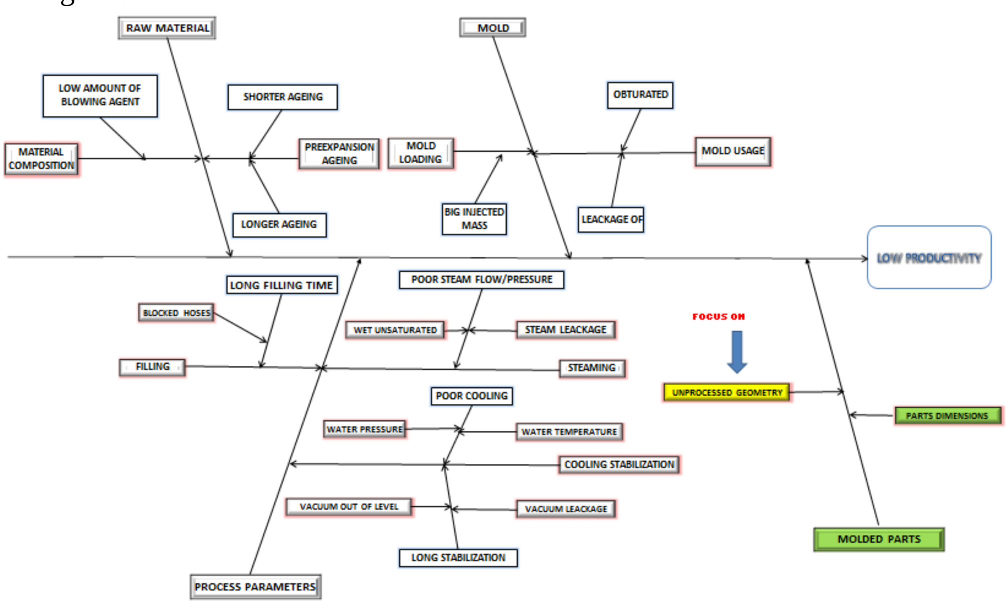


Fig. 11. Cause – Effect Diagram

This diagram will help the team to identify the causes that lead to the results that creates satisfaction and dissatisfaction. Such a diagram has the shape of a fish bone - head is the effect and bones possible causes.

5. Conclusions

The purpose is to identify the main reasons that determine unacceptable functioning of the process:

1. work piece height adversely affect the process of injection;
2. the lack of an extraction angle;
3. the complex geometry of the part is difficult to execute.

All these drawbacks have led to the conclusion that it is necessary to change the product design with one that has the same functionality and much simpler geometry.

Also for improving the process one must find a solution to increase the number of products executed in one cycle.

Solution 1 – son matrix is a large unused space that can be used to insert more parts with a simplified geometry (Fig. 12).

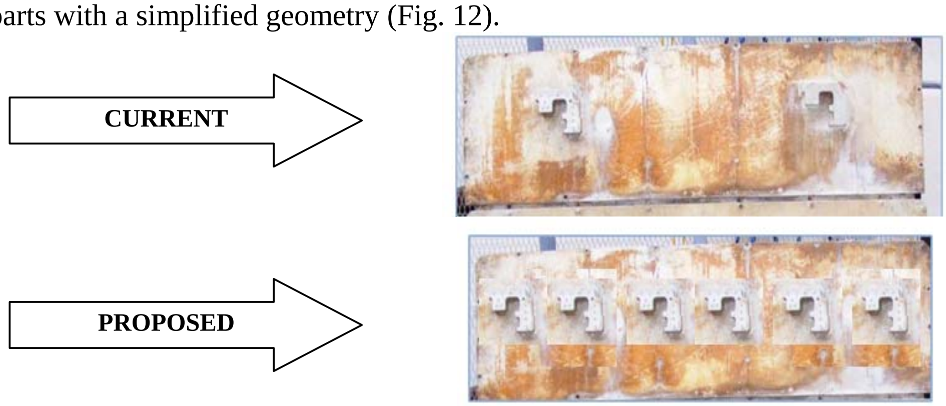


Fig. 12. Solution 1

Solution 2 - Changing the settlement of the part in the matrix and the geometry.

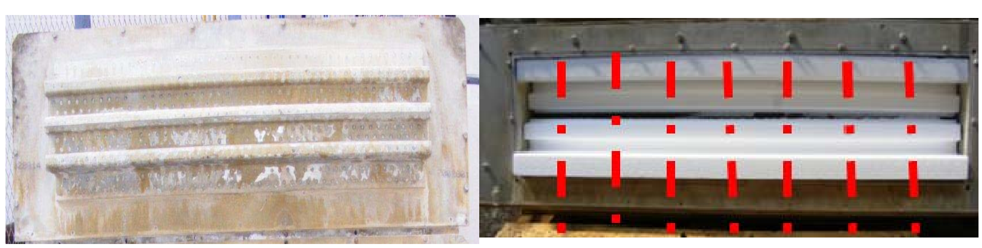


Fig. 13. Second solution

For the improving phase of Six SIGMA process the second proposed solution was chosen, because the first one would have meant a complex injection process due to necessary number of injection points.

Another reason is the number of achieved parts 16 instead of 6.

In conclusion the new mold configuration gets:

- More simple shape;
- Same functionality;
- Biggest productivity;
- Good process conditions.

R E F E RE N C E S

[1] *P. Thomas*. The Six SIGMA Handbook – A Complete Guide for Green Belts, Black Belts, and Managers at All Levels, New York, Chicago, San Francisco, Lisbon, London, Madrid, Mexico City, Milan, New Dehli, San Juan, Toronto, Mc Graw Hill, 2003, ISBN 0-07-141596 -3&0-07-141015-5

[2] *Graeme Knovles*, Six Sigma, ISBN 978–87–7681–852-4, London, 2011

[3] *Graeme Knovles*, Quality Management, ISBN 978–87–7681–875-3, 2011

[4] *Christian Astalosch*, Structuri si metode pentru executia eficienta a proiectelor in industria de automobile, PhD Thesis, Brasov, 2011

[5] *Ioana Catalina Enache, Narcisa Valter, Florina Chiscop*, Solution to improve production capacity,Buletinul Stiintific al Universitatii Politehnica din Timisoara, Tom. 58(72), Fascicola Suplimentara, 2013, pp 221-224