Abstract: - For the producers of large and medium casted parts the defects management and defects volume reduction has proven to be a very important concern, regarding the cost reduction in the manufacturing process and therefore the margin increase in a stable market with long term profits. Given the tendencies for raw materials and energy on the global market this can be seen also as a survival need of the business unit. Modern approaches like the Six Sigma tools are used to diagnose and improve the casting process for large parts. The main tool considered is DMAIC, which guide the project through the steps of improvement, from problem pinpointing to the implementation of result/solutions into the management system of the business unit.

Key-Words: - casted parts, Six Sigma, DMAIC, improvement, process

1 Introduction
The rush technical and organizational progress of the last years and the always increasing competition have forced the business units involved in the heavy industry to improve their activity by adopting modern tools of problem diagnose and process improvement. Given the specific market realities especially in the area of medium and large castings, the road to improvement is becoming almost mandatory in order that the business unit to be able to survive the always increased costs with raw materials and energy. Among these diagnose and optimizing methods, the 6Sigma instruments have proven their worth, either used at the macro level of the productive unit or locally, where the need arises.

2 Content
Into the following is presented DMAIC 6S Tool, applied by the defects management and defects reduction for a large productive unit, with complete production cycle, from steel melting to pouring and heat treatment. The main products, target of improvement, are large casted pieces, parts of the equipments from hydro-power industry (Ex.: big crowns, bands and blades, components of the hydro-power rotor unit).

DMAIC (Define – Measure – Analyze - Improve – Control) is a structured, disciplined, rigorous approach to process improvement, consisting of five phases, where each phase is linked logically to the previous as well as to the next phase [2]. The reason to follow this rigorous methodology is to achieve the stretch goal of Six Sigma - 3.4 defects per million opportunities – here in this research is considered as objective to reduce the volume of defects in casted pieces to 2% of the total volume of the piece. (Fig.1)

DEFINE, as the first step of DMAIC contains the project’s purpose and scope, introduction of the team, as well as background information on the process and its customer.

Fig.1: The 5 phases of the DMAIC methodology

Goals and boundaries are set, based on the knowledge of the business goals, customer needs and the process that needs to be improved.
The tools used in the Define phase are:
- Project charter, including financial aspects
- Stakeholder analysis
- SIPOC (Supplier-Input-Process-Output-Customer)
- process mapping
- VOC (Voice of the Customer)
- Critical to quality (CTQ) tree
- Affinity Diagram, Kano models, etc..
- By the end of phase 1 all the persons involved are aware of the motives for which the project is considered important, what business goals must the project achieve to be considered successful, what limitations have been placed (budget, time and resources), what key process is involved and its current yield [1].

In phase 2, MEASURE the goal is to pinpoint the location or source of problems by building an understanding of the process conditions and problems and collecting data [6].

6S Tools used here are:
- Data Collection Plan, Data collection Forms
- Control Charts
- Pareto Charts
- Sampling
- Prioritization Matrix
- FMEA (Failure Mode and Effect Analysis)

The parameters measured are the following:

- Melting area: chemical composition and temperature of the steel
- Pouring area: no. of pot’s holes, the dimension of the holes, time of filling, temperature for shaking, the quantity of exothermic powders
- Heat treatment area: furnace temperature at loading, heating rate, heating temperature, holding time [4].

At the end of the measuring step we now have now defined the problems, the current capability and have data to back up our approach, building a baseline performance of the process.

In the ANALYZE phase we developed theories of root causes, confirmed these theories with data and finally identified the root cause(s) of the problem, which is to be the primary target of the improvement. Apart from the 6S used in the previous steps, now we considered Brainstorming, Cause-and-Effect Diagrams (Fishbone Diagram – Fig.2), Design of Experiments, Flow Diagram, Hypothesis Tests, Regression Analysis.

Once the problem has been focused, the team creates a list of potential causes and organizes them in order to see the relationships between cause and effect. An assumption of many of the tools used is that the data roughly fit a normal distribution. Causes are verified so that improvement focuses on the deep cause, not on the original symptom.

![Fig.2 Cause-and-Effect Diagram for the defects apparition at large casted parts](image-url)
The problems that are being focused upon are the following: material shortage, presence of gas in parts, slag, molding material.

By the end of this step we are able to tell which causes are to be focused on in the Improve step, by describing the potential causes identified, the ones that have been investigated and why, what data has been collected and how was that data interpreted.

In IMPROVE step we are able to develop, implement, and evaluate solutions targeted at the verified cause. The goal is to demonstrate with data, that our solutions solve the problem and lead to improvement.

The 6S tools most commonly used here are: brainstorming, consensus, creativity techniques, data collection, design of experiments, flow diagrams, FMEA, hypothesis tests, other planning tools.

Generating solutions is based on review of what we know about the process and the verified cause, collecting and evaluating ideas through brainstorming and creativity techniques and then combining them into solutions. The identified solutions are evaluated using prioritization matrix based on importance criteria and the cost/benefit analysis. To improve the solutions, a pilot test can be organized, thus reducing the risks and facilitating buy-in from the organization.

The result is a detailed action plan which contains the solutions, actions to be made, dates and people responsible to implement each action.

Among other solutions identified, the following ones have direct and quick result:

- enough metal for pouring (covering the lack of material and the percentage of liquid that prevents the slag going into the cast parts)
- use low nitrogen resin and ensure good maintenance of sand reclamation plant
- pouring in parallel with 2 ladles, without any stopping time (the filling time/ piece, excluding the filling of the heads is established by engineers and depends of the size of the part)

This step delivers the solutions identified, their choosing criteria, the results of the pilot test, detailed improvement plans, as well as the integration of the projected changes into the procedural and organizational management system of the productive unit.

The final CONTROL phase ensures that the problem stays fixed on long term and that the new methods can be further improved over time.

From the point of view of quality control, to effectively maintain the new methods as standard it is needed to:

- verify the results and check if the changes integrate to all operating and compliance policies of the business unit;
- document the new methods, so that workers find them easy to use and train everyone who is involved into use of the new methods;
- monitor the implementation and if needed make corrections;

In praxis the implementation of this project made possible the reach of the desired business target, which was to reduce the volume of defects.
from the casted parts to below 2% of their volume. The consequences of that achievement can be viewed from different approaches:

- from financial point of view, the reduction of defects means reduction in materials and manpower needed for repairing the casted parts, which lead to reduction of overall costs of the parts on one hand and improving the margin on that specific products, and on the other hand a reduction of the operating costs for the repairing facility, contributing to the overall cost reduction [3].

- from the point of view of time, this improvement means that the workers implicated in the repair process now can focus on other areas as well, more manpower resources stand available if the need arises, the need of regular extra hours is reduced; also in other support departments as procurement, logistics, quality, or project management the work volume dedicated to the defects management is reduced, meaning those people can focus on other important business tasks

- from the customer point of view, even if not always visible, the defect reduction can translate in reduction of delivery time of the parts to him, better quality and increase of trust in a producer that supports a quality improvement oriented work environment

- taking into consideration the impact of the repair emissions to the atmosphere, one can say that having less to repair by welding and other specific methods can lead also to improve the status of the business unit regarding environment protection and the way that business is viewed by its neighbor units

- last but not the least, the human impact that the project success has: people becoming more aware of the importance of their activities to the overall success of the company, building trust throughout all company layers and contributing to create a good healthy work environment, orientated on creative ideas for improvement and focused to achieve quality [5].

3 Conclusions
Optimizing was proved with data, standards are created and shared with similar projects, also as the final step, recommendations can be made that can lead to future possible improvements.

Besides the very practical and short term positive aspects, the big gain is that the business unit is ensured that the problem identified is the right one, the changes made were based on facts, backed up with actual data and that the improved processes are integrated into the existing management system, ensuring its development and possible future progress. By using the rigorous approach of DMAIC the business unit is capable to reduce the defects volume for the casted parts, which will lead to the decrease of material cost for repairs as well as other costs like energy and manpower used in the manufacturing process.

References