Six Sigma Approach for the Reduction of Transportation Costs of a Pipe Manufacturing Company

M. Küçük[1], A.Y. Orbak[2]
[1]Industrial Engineering Department, Uludag University, Bursa, 16059, Turkey
[2]Industrial Engineering Department, Uludag University, Bursa, 16059, Turkey
(metink2002@msn.com , orbak@uludag.edu.tr)

Abstract - **Logistics is among the most important three businesses that will be improved in 21st century together with information technology and micro biology. Logistics is efficiently planning, implementing and controlling materials in the supply chain, services and information flow. In the future, competition of companies won't be about products which they produce or about countries where these products are consumed, but it will be about the supply chains they use. Competition of companies will be raised by improving logistics processes. To reduce transportation that do not add value to the products and to deliver the products to customers in a short time will lead to reduce logistics' costs and in addition they will raise customers' satisfaction. Therefore, companies should optimize their logistics processes. This paper deals with the reduction of transportation costs of a pipe manufacturing company. For this purpose, the six sigma approach is utilized and its results are analyzed.**

Keywords – **DMAIC cycle, logistics, reducing transportation costs, six sigma.**

I. INTRODUCTION

Although logistics, which is one of the most important three businesses in this century, does not add value to the products, it raises customer's satisfaction because of supplying the products to customers in a short period of time. Satisfying external customer, which is the end user, primarily is strongly linked with satisfaction of internal customer. Satisfaction of company, which is the internal customer, is possible when transportation costs are reduced.

In today's competition conditions, in addition to the cheaply production of quality products, it is important to optimize supply chain and logistics processes that elevate the competition power of a company.

In Ahn et al.'s, they consider a logistics system for parts manufacturer distribution center (depot) to supply the parts to the parent company. They formulate a mathematical model to minimize the sum of inventory holding costs at the depot, and the transportation and inventory costs at parts manufacturer [1].

In Salema et al., they propose a generalized model that contemplates the design of a generic reverse logistics network where capacity limits, multi-product management and uncertainty on product demands and returns are considered. Then a mixed integer formulation is developed which is solved using standard branch-and-bound techniques. The model is applied to an illustrative case [2].

In Goetschalckx et al., the overall focus of the research is to demonstrate the savings potential generated by the integration of the design of strategic global supply chain networks with the determination of tactical production–distribution allocations and transfer prices. For this purpose, two models and their associated solution algorithms are introduced [3].

From above discussion it is obvious that generally mathematical models are used to solve transportation and logistics problems. But mathematical models can be generated generally for 'well defined' systems. On the other hand, if the system at hand is not 'well defined' in its current state, another approach should be used to understand the underlying problem and its causes, and then some improvement may be achieved. In such cases, six sigma is usually chosen as the first preferred methodology as it possesses several powerful statistical tools to find and solve the problems that exist. Additionally it has many improvement approaches and it is in fact not only a set of methods but also a philosophy.

In this paper, the reduction of transportation costs of a pipe manufacturing company will be examined. The system at hand is not a well defined system, and it has many deficiencies. Therefore, to solve the inherent problems and improve this logistic system, as a first approach the six sigma methodology is implemented to reduce the project time and the total cost of the project. For this purpose the DMAIC (**D**efine, **M**easure, **A**nalyze, **I**mprove and **C**ontrol) cycle of the six sigma approach is utilized. The results and relevant improvements are also discussed.

II. METHODOLOGY

In this section, the tools that will be used throughout this paper will be given. For this purpose, first the six sigma philosophy and DMAIC cycle will be explained briefly.

A. Six Sigma

Six sigma methodology was originally developed by Motorola in 1987 and it targeted a difficult goal of 3.4 parts per million (ppm) defects [4]. At that time, Motorola was facing the threat of Japanese competition in the electronics industry and needed to carry out drastic improvements in their quality levels [5]. In 1994, six

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sigma was introduced as a business initiative to 'produce high-level results, improve work processes, and expand all employees' skills and change the culture' [6]. This introduction was followed by the well-revealed implementation of six sigma at General Electric beginning in 1995 [7].

Sigma is the Greek letter that is a statistical unit of measurement used to define the standard deviation of a population. It measures the variability or spread of the data. Six Sigma in general is also a measure of variability. It is a name given to indicate how much of the data falls within the customers' requirements. The higher the process sigma, the more of the process outputs, products and services, meet customers' requirements – or, the fewer the defects. This determination is shown in Figs. 1 and 2.

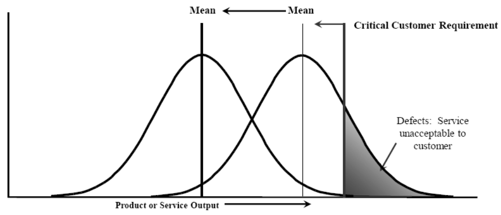

Fig. 1. Effects of moving the mean.

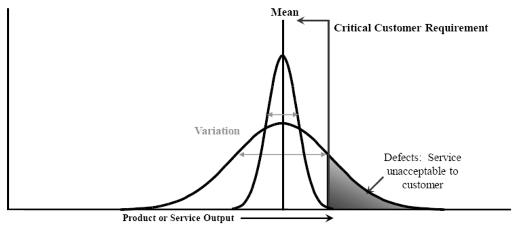

Fig. 2. Reduction of the process output variation.

With performance at 2 sigma level,

- 69.146% of products and/or services meet customer requirements with
- 308,538 defects per million opportunities.

With performance at 4 sigma level,

- 99.379% of products and/or services meet customer requirements ...
- but there are still 6,210 defects per million opportunities.

and with performance at 6 sigma level,

- 99.99966% – as close to flaw-free as a business can get, with just 3.4 failures per million opportunities (e.g., products, services or transactions).

One can see sigma versus cost of poor quality relationship in Fig. 3.

B. DMAIC Cycle

The six sigma method has two major perspectives. Its origin comes from statistics and statisticians [8]. The real focus of six sigma methodology is to reduce potential variability in processes and products by define measure analyze improve control (DMAIC) cycle [9,10].

DMAIC is an abbreviation which consists of first letters of lean 6 sigma improving process.

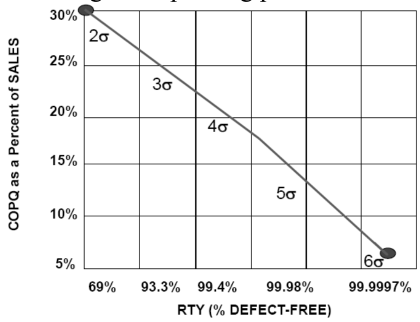

Fig. 3. Sigma level vs. cost of poor quality.

This method consists of **D**efine, **M**easure, **A**nalyze, **I**mprove and **C**ontrol phases and is used to improve existing product and services to lean six sigma quality. Recently, this approach has been used extensively in reducing completion times and scrap reduction especially in the automotive industry [11].

For bringing out real root causes, it uses the data and appropriate statistical methods. Thus the effort which is needed will be minimized to generate and test solutions. This method in summary,

- Focuses on "real problems" directly related to the bottom-line
- Realizes results in 4-6 months
- Utilizes multiple tools and techniques including rigorous statistical methods when needed
- Sustains improvement over the long-term
- Disseminates improvement throughout the organization
- Acts as an agent of change

Below is a summary of each phase of the DMAIC cycle:

Define phase

In this phase, the purpose is to identify and/or validate the improvement opportunity, develop the business processes, define critical customer requirements, and prepare them to be an effective project team.

Measure phase

The purpose of this phase is to identify critical measures that are necessary to evaluate the success meeting critical customer requirements and begin developing a methodology to effectively collect data to measure process performance. To understand the elements of the Six Sigma calculations and establish baseline sigma for the processes the team is analyzing.

Analyze phase

The purpose of this phase is to stratify and analyze the opportunity to identify a specific problem and define an easily understood problem statement. To identify and validate the root causes that assure the elimination of "real" root causes and thus the problem the team is focused on.

Improve phase

The purpose of this phase is to identify, evaluate, and select the right improvement solutions. To develop a change, management should approach to assist the organization in adapting to the changes introduced through the possiblele solution implementation.

Control phase

The purpose of this phase is to understand the importance of planning and executing against the plan and determine the approach to be taken to assure achievement of the targeted results. To understand how to disseminate lessons learned, identify replication and standardization opportunities/processes, and develop related plans.

In this paper, the following tools are actively used: for define phase, fishbone diagrams (also called Ishikawa diagrams, cause-and-effect diagrams or Fishikawa) which are causal diagrams that show the causes of a certain event - created by Kaoru Ishikawa are used. Common uses of the fishbone diagram are product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation [12].

For measuse, analyze and improve phases, the mathematical software Minitab 15.0 is used.

As explained before, in this paper, the elements of six sigma and the DMAIC cycle will be applied to a pipe manufacturing company in order to reduce its transportation costs. Its results and possible improvements of the transportation system will be explained.

III. TRANSPORTATION SYSTEM

In this section the transportation system of a pipe manufacturing company will be presented:

Once the necessary steel rods are supplied, pipes in various size are produced. The production capacity of the company is currently 900,000 tons per year.

Sales department usually indicates to the production department which pipe and how many tons have to be produced. Production planning and control department then evaluates the terminal dates of these pipes. Once these dates are estimated, the renting company is allowed to rent required vessels and the dates when the vessels should arrive are planned. These dates are very important. Because when a vessel arrives at the port all the required production should have been completed. If not, loading operations won't be regular and the company will have lots of problems. Placement of pipes into the vessel is another and very important issue because of work security and lashing. The main purpose of all these operations is to send the pipes in good quality. Therefore one of the quality measurement points is the transportation quality.

Once pipes are produced, they are stocked in a stock area of the company. When the production of pipes is totally completed, the vessel is ready for loading. The company exports pipes which are produced in the factory via vessels. Pipes which will be loaded into a vessel are transported with trailers between stock area and the port.

In the highly fragmented truck load transportation industry a substantial fraction of truck movements involves empty trucks, i.e., moves that will reposition the trucks. However, reducing the amount of truck repositioning is difficult because the need for a carrier to reposition its trucks depends on the interaction between the shippers the carrier it is serving. Through collaboration, shippers may be able to identify and submit sequences of continuous loaded movements to carriers, reducing the carriers' need for repositioning, and thus lowering the carriers' costs. A portion of the carriers' cost savings may be returned to the shippers in the form of lower prices [13].

A. Sea Transportation Process

Vessel hutch plans for the vessel which will arrive and be ready. The tonnage which will be loaded in a day and in a shift is then determined.

After vessel arrives at the port, loading and unloading operations which is suitable for the plan begins. Trailers are loaded by workers via crain in factory stock area and they are towed by tow trucks to the port. The load which is on the trailer is unloaded by workers via crain at the port and the load is loaded into the vessel by another set of workers. The flow of the sea transportation process can be seen in Fig. 4.

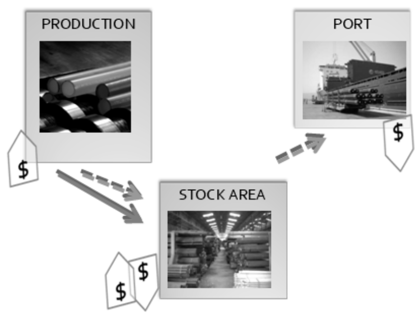

Fig. 4. Sea transportation process.

There are three main problems about the transportation time and costs as listed below:

- Production has to be totally completed before a vessel arrives at the port.
- Stock area is inadequate. For this reason, some types of pipes have to be placed in different places. This situation causes an increase in loading time and therefore increases the transportation costs of the company.
- The shape of a vessel's hutches affects loading time and therefore the transportation costs. Loading into box type hutches is easier than loading into other types of hutches.

B. Application of the DMAIC Cycle

In this subsection the application of the DMAIC cycle to the sea transportation system will be explained.

Define phase

In this phase the problems that arise in the sea transportation system is examined. It is observed that there are some essential problems of the current system; transportation time is too long, transportation costs are too much and company have to pay too much money for loading and unloading processes. Additionally, company has to pay too much money for renting as well. The reason for this is, vessel have to be wait for a long time during the loading process.

In today's world, competition between companies is great; therefore company intends to reduce transportation time and costs. The system structure is believed to be convenient for six sigma approach and DMAIC cycle.

Measure phase

For measure phase, one has to measure the right process and in the right time. It is so important for latter phases of the project. So the transportation process in the stock area as well as in the port has been analyzed and relevant times are measured. During this measurement process the transportation process has once more been investigated to see if there were any overseen problems that had not been observed before. The aveeage daily rate of the load that is loaded into the vessel is 1253 tones. It is shown in Fig. 5. Before DMAIC, average waiting rate was %26 as shown in Fig. 6.

Analyze phase

After it is decided that correct and enough data is collected the analyze phase has begun.

During the analysis of the data it is determined that there are four main problems that directly affect the transportation time and costs, namely inefficient transportation process, inappropriate stock area, insufficient completion of production before loading and transportation vessel without box type hutch. Within these problems, the least known by the management was the insufficient completion of production. It is, on the other hand, an essential problem.

To analyze the data, Minitab 15.0 is used. Two graphs in Figs. 7 and 8 is created which indicate the distribution of the average loading and unloading times respectively. It has been concluded that the average loading time in stock area is 51 minutes while average unloading in port is 31 minutes.

Improve phase

In improve phase, relevant solutions are investigated. While searching for solutions, their applicability is also taken into account. Additionally, its cost should be low. As a result, stock area was tidied up totally, renting company which rents vessel for company started renting vessels with box type hutch and production of pipes had been completed before vessel arrived at the port.

With these changes and improvements, workers began working efficiently, there is no waiting time due to insufficient completion of production, and all pipes are ready to be loaded. And now average daily rate is 2470 tones as shown in Fig. 9.

When six sigma implemantation is used to reduce the transportation cost of a pipe manufacturing company, the main problems are easily found by using a fishbone diagram. We are also able to evaluate the relevant data by using Minitab.

The approach is implemented step by step. For this purpose, DMAIC cycle is chosen. At the end, awareness among people who are associated with the sea transportation system is raised. People've changed their old and wrong ideas and now workers know how to work effeciently. The radio communication between the port and stock are is also improved. Now, there is no communication problems.

The lunch time of the workers who work at the port and in the stock area differs. Due to this difference, there could be free time when trailers can not be towed and is inefficient. The lunch time is set to be the same.

Control phase

The control phase is applied such that the changes are indeed is valid in the transportation system. Therefore the waiting time and transportation costs are being examined continually.

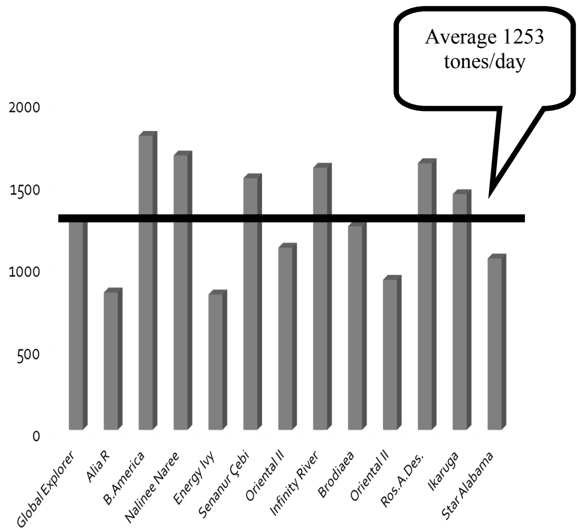

Fig. 5. Average daily loading rate (before).

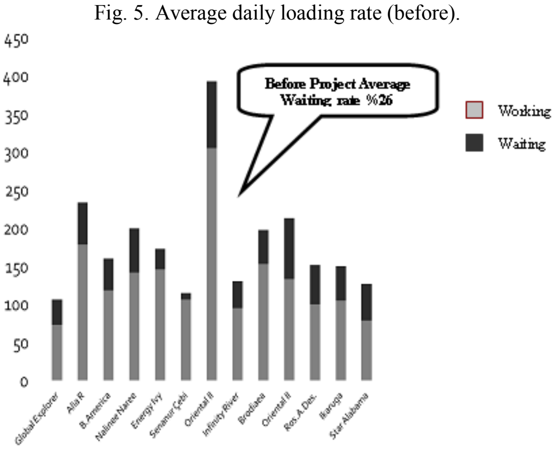

Fig. 6. Average waiting rate (before).

After DMAIC cycle is implemented, average waiting rate became %13 as shown in Fig. 10.

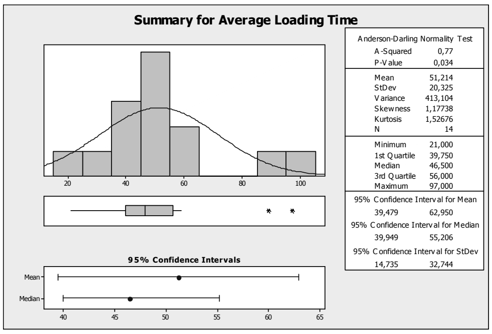

Fig. 7. Average loading time in stock area.

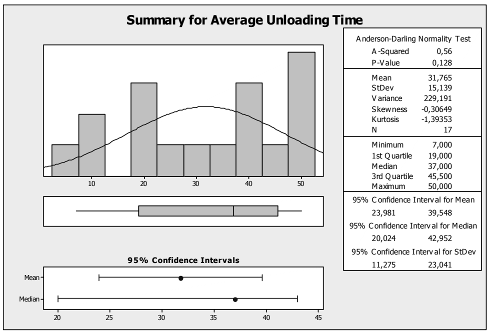

Fig. 8. Average unloading time in port.

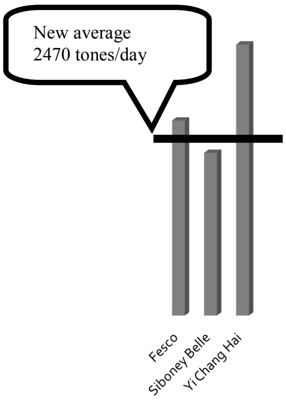

Fig. 9. Average daily loadıng rate (after).

III. RESULTS and CONCLUSIONS

In this paper the transportation system of a pipe manufacturing company is analyzed, its problems are identified and these problems are solved using the DMAIC cycle of six sigma approach. As a result the layout of the stock area is changed and now workers know where the pipes are stocked and workers won't be searching pipes in the stock area during loading of a vessel. Renting company has started renting vessels with box type hutch.

There is no waiting due to insufficient completion of production and as result of these changes the transportation time is reduced and the loading capacity is doubled.

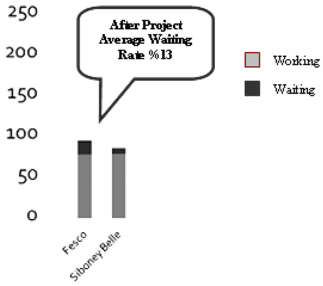

Fig. 10. Average waiting rate (after).

For future work communication and awareness of the workers and the management should be improved.

In addition several mathematical models can be generated that will optimize the possible improvements of the transportation system.

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