Reengineering a production process and materials management

Case Technopolis ltd.

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Abstract

This paper introduces a study aimed at improving the manufacturing processes of the "Technopolis" Ltd. company. The objective was to help the company become more competitive, effective and prepared for the challenges of the upcoming years.

The theoretical background presents an overview of the manufacturing industry trends, practices and the current situation in Russia. Moreover, the methods of future research were studied in order to understand the research instruments and methods discussed in this paper. Qualitative research was mainly used in this thesis work, conducted in observation and interview.

Thus, the author was able to describe and define the possible solutions and actions of developing the manufacturing processes of this company and to write them in this paper. Several ideas and proposals for optimization of production processes were presented and discussed with the company.

Keywords/tags (subjects)
Production, industrial engineering, materials management, lean manufacturing, optimization

Miscellaneous

Contents

Figures

1 Introduction

In the recent years, in the field of commodity circulation in a number of countries, there have been significant changes. At a time when the growth of production and expansion of national and microeconomic bonds has led to an increase in distribution costs, the attention of entrepreneurs has concentrated on the search for new forms of the optimization of market activities and reduction of costs in this area. In economic practice, new methods and technologies of delivery of the goods are used. They are based on the concept of logistics.

On the world level, there have been many new concepts and methods of management and production organization during the recent years: business process reengineering, total quality management, balanced scorecard, the statistical-mechanical process control, lean manufacturing, ERP, and others. The concept of Lean Manufacturing takes one of the most prominent places among the modern management solutions.

With the spread of the Lean Manufacturing principles, many organizations are adopting this philosophy in order to achieve an advantage over their main competitors in their field of business. However, this goal cannot be achieved by all.

Logistics covers the entire scope and range of activities of the enterprise, and at all stages of development, it aims to reduce costs and release products, given the quantity and quality in a timely manner and in the prescribed place. The same concepts could be applied to the production processes.

Production logistics aims to ensure that each machine and workstation receives the right product in the right quantity and quality at the right time. The concern is with production, testing, transportation, storage and supply. Production logistics can operate in existing as well as new plants: since manufacturing in an existing plant is a constantly changing process, machines are exchanged and new ones added, which gives the opportunity to improve the production logistics system accordingly. (Nyhuis & Wiendahi, 2009.) In the past decade, Russia has considerably increased interest in the questions of management, production logistics and transformation of the organizational structures of companies.

1.1 Brief history of production optimization

For centuries, people have been searching for ways to optimize the processes of producing goods and to save significant and valuable resources by reducing waste or to save time. This endless search has led to the division of labor, steam engine and the industrial revolution, but even with such major advances that have flooded the market with goods and products, there have been and there still are plenty of possibilities for improvement. This is where production logistics and industrial engineering have their origins, as a business dictionary states:

The discipline of utilizing and coordinating humans, machines, and materials to attain a desired output rate with the optimum utilization of energy, knowledge, money, and time. It employs certain techniques (such as floor layouts, personnel organization, time standards, wage rates, incentive payment plans) to control the quantity and quality of goods and services produced. (Businessdictionary.com, 2017.)

With the beginning of the industrial revolution, the benefits from productivity were clearly visible as technological advancements and division of labor. However, this was not enough because there were still big challenges in calculating and measuring manufacturing performance. This led to the emergence of the scientific management approach in the late 19^{th} and at the beginning of the 20^{th} century when people like Frederick W. Taylor laid the basis for future manufacturing science and industrial engineering practices.

While Frederick W. Taylor did not use the term industrial engineering in his work, his writings and talks are generally credited as being the beginning of the discipline. One cannot presume to be well versed in the origins of industrial engineering without reading Taylor's books: Shop Management and The Principles of Scientific Management. (Zandin, 2004, 1.5 .)

When the World War 1 finished, scientific management securely captured global manufacturing. Immense organizations utilizing techniques of mass production were common in those days. However, the whole growth and improvements were extensive, far less attention was paid to the improvement of processes and operations, until in 1927, H.B. Maynard, G.J. Stegmerten and S.M. Lowry wrote The Time and Motion Study, highlighting the importance of studying motion and good methods. In 1932 A.H. Mogenson published Common Sense Applied to Time and Motion Study, in which he derived the concept of the study of motion through an approach, he called a simplification of the work. Most of described actions primarily concerned with the task of creating and exploring methods, as well as creating time standards, although other types of operations, such as the arrangement of equipment and processing of materials. Measures for managing production during routing and scheduling, also were contained in this definition. (Zandin, 2004, 1.8.)

After the World War 2, new questions were and problems related to production optimization arose. Hence, new practices were needed to solve the requirements of the new world and its demand. The 1950s marked the transition of industrial technology from its pre-war empirical roots to an era of quantitative methods. The practice of industrial engineering in the 1950s continued to work on the fundamental concepts of measuring work, although the emergence of a powerful scientific base affected this area. An important event that became known over those years was the predetermined motion time systems. (Zandin, 2004, 1.11.)

The ubiquity of early computer systems and advancing electronics opened new opportunities and powers for manufacturing and management, so it did not take long that these opportunities were utilized because by the early 1960s, many companies used digital computers to perform routine accounting functions. With the complexity and stinginess of planning and managing the inventory, it was natural to try use the computer for these operations. One of the pioneers in this field was IBM, where Joseph Orlicky and others designed what later became known as material requirements planning (MRP), and then its successors MRP II and ERP. (Hopp & Spearman 2008, 109.)

As the industrial environment now consists of a huge variety of complex computerized systems and machines, the development and implementation of information systems that would be able to control and work with the data related to product efficiently became an important part of the industrial engineer's tasks. The automatic generation of production plans, bills of materials, timetables, and performer manuals and the utilizing of robotics in various manufacturing settings are cases where industrial engineering played a leading role in the 1980s. Most of these actions include operations critical to the success of computer-aided design (CAD), computer-aided manufacturing (CAM) or computer-integrated manufacturing (CIM). All this led to an extension of the systems-related side of industrial engineering in many production companies. (Zandin, 2004, 1.13.)

A production process brings plenty of challenges, questions and problems, such as how to manufacture goods and what kind of supply strategy there should be as well as what the output plan is. Moreover, one needs to be prepared for unpredicted and unexpected issues and situations during the process. To answer these questions and prepare for the challenges, accurate and careful planning is needed. A correctly done production plan can help significantly to reduce the costs of manufacturing and reduce the causes of sudden events.

1.2 Current economic situation in Russia

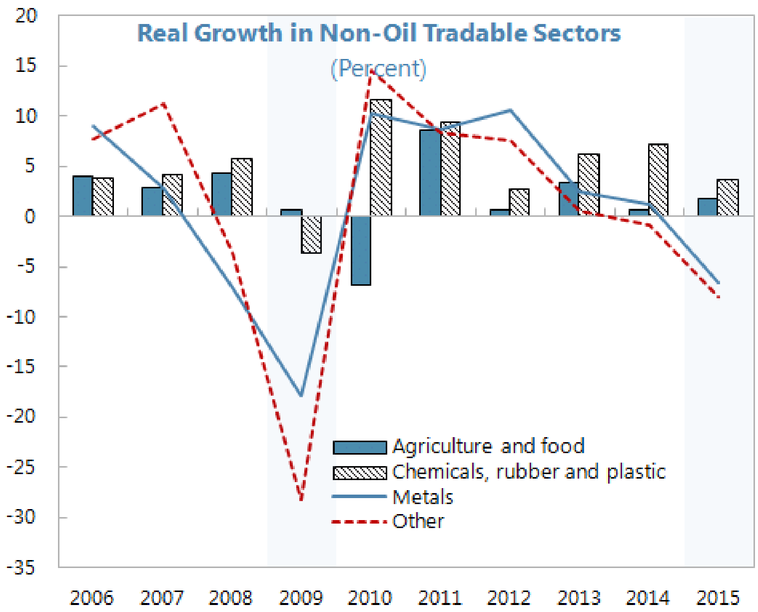

Figure 1. Real Growth in Russian non-oil industry (IMF Country Report No. 16/229)

For the emerging markets, the year 2016 started with lower production activity. A significant slowdown in investment growth could also be clearly seen following the tightening policy and small supply of capital, especially in countries in which the economies were based on commodity export. China is undergoing a major re-balancing of its domestic market with the stable growth of services and governmental measures softening the slowdown in the industrial performance. Brazil and the Russian Federation are in a period of recession. The world goods trade is still depressed, reacting to China and the lower demand from the exporters of commodities.

The Russian economy is facing a hard phase (Figure 1). The year 2015 registered a fall of the GDP by 3.7% and a huge fall in consumption and in households' wealth, which lead to serious problems in the industry (fall of industrial production in 2015 by 3.4%. Although 2016 showed more stability in inflation and oil prices and although the prognosis for 2017 had a more positive view, the fact that Russia will return to a 1% growth situation is far from pleasant. Lower oil prices and the needed fiscal adjustment will keep the economy in recession in 2016 with an expected decline in real GDP of 1.2 percent, but growth is expected to resume in 2017 and reach 1 percent, as domestic demand slowly recovers because of the easing financial conditions and increasing demand. (IMF Russian Federation country report, 2016.)

These trends have made companies focus on optimizing their costs and processes and led to reorganizations and cutting expenses. One of the first industries that was affected by the crisis is the automotive industry. In order to stay competitive, the manufacturers have to work on lowering prices, avoiding high inventory levels and rework, simply because they cannot afford it these days.

1.3 Brief information about the company

Figure 2. CTT Exhibition 2009. (Dizel.net)

"Technopolis" Ltd. has operated on the Russian market of commercial transport since 1999. It has grown from a small truck repairing company to a well-known producer of high quality modifications for commercial transport.

Nowadays, it works with such companies as Volkswagen, Mercedes Benz, Citroen, Volvo, Hyundai, Yuejin, Tata, Isuzu, Unic, Palfinger, Hilltip, ZIL, Kamaz. “Technopolis” was the official partner of Volkswagen in supplying the Sochi Olympiad 2014 with the cargo transport.

More than 15 years of experience and constant development have helped to gather a significant amount of technological and design solutions. Taking part in several ambitious and innovative projects has made the manufacturer ready to solve challenging problems and troubles during the planning and production process. The company has attended and won prize places in dozens of different exhibitions and competitions, such as Komtrans, CTT (shown in Figure 2) and Security System Expo.

An individual approach to every client's ideas and demands, scrupulous analysis of customer needs in order to create the best solutions and decisions make this company more of a studio for commercial transport than just a refit center. All this makes the company a serious player in the market of commercial transport.

The focus products of the company are:

- Production of superstructures for various purposes: vehicle-borne platforms, superstructures, manufactured goods and isothermal vans including ones from sandwich panels;
- Assembling hydraulic devices (evacuator platforms, cranes, lifters) for the main world producers Palfinger, Unic, Hiab.

The wide range of products and technologies used, from hydraulics and electronics to pressing sandwich panels, brings the need of well-trained, high skilled professionals that can solve different tasks. This is achieved with different educating programmes implemented in cooperation with the company's partners and suppliers. These measures help to maintain a high quality of service and work.

The "Technopolis" company works according to the make-to-order or even in some cases engineer-to-order principles. There is a wide range of different, highly variable products and projects, which makes it difficult to standardize and systematize the production process and material planning.

In order to provide "Technopolis" Ltd with its needed materials in accordance with the identified requests, the logistics department solves a great variety of tasks. They include identifying the needs of "Technopolis" in material and technical resources, finding possibilities to meet these needs, the organization of the storage of materials and their delivery, as well as monitoring the quality of the received materials and technical resources.

To solve this problem, the supply department employees of “Technopolis” should study and take into account the technical documentation coming from the design department. This includes documents on all consumables and their price levels and their changes in order to choose the most cost-effective form of product distribution, to optimize the inventory as well as to reduce transportation and procurement and storage costs.

For the smooth functioning of the production at the plant, the supply system should be well-established and mistakes brought to minimum. Especially considering the company’s products, the great variety of parts and materials makes it difficult to store all possibly needed materials at the warehouse. Thus, all procurements and purchases should be done as soon as possible in order to reduce lead time.

The organization of the warehouses, their technical equipment and accommodation of the territory are essential for the operation and economy of “Technopolis”. The organization of the storage facilities has an impact on the capacity of warehouses, productivity and the cost of storage operations, the value of intra-factory transportation costs and so on.

To ensure normal operations of “Technopolis”, it is very important to organize rapid inventory regulating. For this purpose, the state of the remnants in the warehouses is controlled. Thus, stocks do not only have storage and preparation function for issuing materials to production, but they also help to adjust consumption quickly.

The development prospects of “Technopolis” Ltd are entirely dependent on the optimization of the company’s logistics and material management. Moreover, the shorter the period for completing the order, the better should the organization of all procurement and logistics processes be.

2 Information about the research, objectives and goals

For successful operation of enterprises in the current unstable economic situation in Russia it is necessary to effective manage operations, be ready to quickly adjust to difficult market situations and make informed governed and weighted solutions which reduce business risks. Naturally, such decisions are not possible without reliable information on the status of production and movement of inventory.

To start with decisions and solutions for improvement, it is important to first look through and analyze current state of the company manufacturing and processing. Broaden comprehension and conception of the situation, problems and strengths are needed to come up with right and suitable strategies and actions. The project work is based on different research methods such as: theoretical research and qualitative research.

The way material management, procurement and manufacturing strategies, production processes are done was studied during thesis work. Needed information was gathered by two main approaches: the first one was interviewing employees of the company, responsible for the operations and processes, which are included and being studied in my thesis project. The second was own practical experience, recieved after doing part-time job and practical trainings in the company.

Theoretical research gives insight of what already has been studied concerning the problem and what solutions and decisions were made by specialists and professionals on the questions received from interviewing and practical experience.

2.1 Objectives of the research

Subject of the research is production logistics and material management. Object of the research is production activities and processes of “Technopolis” Ltd.

Thesis project, which was discussed and decided with the company, consist in analyzing manufacturing processes and material management procedures of the manufacturer. And by applying recent trends and theories in operations management to bring out solutions and advices to optimize and improve these processes and bring production to an efficient and modern level. This goal lead to a lot of questions and tough challenges, in order to focus and limit studies done, work will concentrate on one particular product of the company: skip loader. And bring out solutions, recommendations and practices concerning this model, which, in case of success, can be later applied to the whole company's production system.

To achieve stated aim, several possible tasks can be defined:

1. Create company's overall depiction;
2. Study the production management and material handling theoretical basis;
3. Analyze production processes and identify issues and what is influencing them;
4. Develop recommendations for optimizing and improving material handling and production processes of the "Technopolis" company.

Final goal of this research is to present management of the company number of solutions and recommendations, concerning manufacturer's operations, where are weaknesses of the process and on which particular points to concentrate resources and actions in order to improve work flow.

After studying deeper operations management some speculations, listed below, can be made about possible issues that usually accompany manufacturer during its processes and affecting the result in undesirable way:

1. Not enough spare parts or rough material in the warehouse;
2. Wrong parts were purchased;
3. Parts delayed by the supplier;
4. Mistakes done in the production or assembling processes.

The theoretical and methodological basis of the work made comes from production logistics and industrial engineering theories, originating from huge variety of study literature and research papers, methods of analysis, pro-prediction and simulation of production processes, publications, internal company documents, different Internet articles and web resources.

It is important to state, that this research is mainly a set of advices for the company. Due to time limitations and budget constraints such complex and money demanding themes in production optimization such as technology improvement and ERP system development would not be studied thoroughly, instead research will focus on solutions, that could be implemented a lot sooner and bring results in a short run.

2.2 Case study

The case company of this thesis is a car manufacturing company specializing in commercial transport and special equipment. It operates in Russia, having dealers all around the country, head office and production plant is located in Kaluga region, Borovsk town.

This case study features particular product of the company – skip loader, reason is that company is looking for ways to decrease its lead time and increase productivity, because there are inefficiencies in its operations. There is overlap and missing data, mistakes in procurement and unnecessary processes in production. Ineffective considered to be inventory management, supply and manufacturing itself.

The aim of the thesis is to determine which changes and solutions are suitable for the manufacturer to improve its performance indicators. During the study period of this thesis several interviews and observations were made in the company. This case study intends to aid the company by providing analysis of its present production processes and to present feasible solutions and decisions which could be implemented later on.

2.3 Foreword about the research and methods used

Operating in today’s manufacturing environment brings a lot of challenges and constraints, objectives and subject of research leads to such particular problems, as high variety in production. Standardization of the company’s processes can become quite problematic, due to the number of spare parts and models. Company decided to bring changes to production process as well as some improvement in procurement and supply, because some inefficiency is present during operations: missing, out-dated or overlapped information about the materials and warehouses. Production, inventory and accounting data systems are separated and are not connected well enough between each other.

In this particular case, company is orientated in individual orders and projects, thus the idea of the thesis is to spot if there is actual need in changes and what changes could be done. Several interviews, as well as observation through participation were done during research period of thesis work.

Thesis work will use two main approaches: literature overview and qualitative research, more precisely its case study method. This will help to get broaden view of the current state of the problem and come up with right ideas and decisions.

Overview of the literature provides with expirence and knowledge of proffessionals, that already have studied this particular problem, what have they found out and what is still questionable and under discussion. It is done by using certain practices, like quoting, abstracting and bibliography.

A literature review is an objective, thorough summary and critical analysis of the relevant available research and non-research literature on the topic being studied (Doing a Literature Review, Hart, 1998). Its goal is to bring the reader up-to-date with current literature on a topic and form the basis for another goal, such as the justification for future research in the area. A good literature review gathers information about a particular subject from many sources. It is well written and contains few if any personal biases. It should contain a clear search and selection strategy (Carnwell and Daly, 2001). Good structuring is essential to enhance the flow and readability of the review. Accurate use of terminology is important and jargon should be kept to a minimum. (Colling, 2003).

(Cronin, Ryan & Coughlan, 2008, 38.)

Qualitative method is needed mainly to understand and define ideas and opinions, roots of the current situation, it helps to get a deeper view of the problem and develop some theories for solution, in other words, according to Denzin and Lincoln (2005), qualitative research is a localized activity that puts the observer in the environment. It consists of a set of explicative, material practices that show us the world. These practices transform environment by turning it into a number of representations, including field notes, interviews, discussions, pictures and other.

This means that quality researchers analize phenomena in their natural conditions, making effort to seize or explain them in terms of the values that people yield in them. (3)

Case study – method of research used nowadays in various different sciences and disciplines, starting from sociology to engineering questions. As a part of qualitative research it shows state in its normal conditions, focusing on the scope of the problem, rather than on separated values, makes it very useful, when the research cannot be done outside original environment of the object. Case study is a primary technique when the subject of research should not be separated from the scope, the attention is on the current scene. This particular qualitative method is the most prevalent in information systems, and is suitable for the research, when organizational questions are considered and not the technical. The case study is based around plural sources of information and various record collecting methods techniques. Six most important sources for information were: documents, archival records, interviews, direct observation, participant observation. (Iacono, Brown & Holtham, 2009, 39 – 46.)

3 Literature review

3.1 Definitions of operations and materials management

Operations management

Is the field concerned with managing and directing the physical and/or technical functions of a firm or organization, particularly those relating to development, production, and manufacturing. Operations management programs typically include instruction in principles of general management, manufacturing and production systems, factory management, equipment maintenance management, production control, industrial labor relations and skilled trades supervision, strategic manufacturing policy, systems analysis, productivity analysis and cost control, and materials planning. (U.S. Department of Education Institute of Education Sciences, Classification of Instructional Programs, 2009.)

Materials management

The planning and control of the functions supporting the complete cycle (flow) of materials, and the associated flow of information. These functions include: identification, cataloguing, standardization, need determination, scheduling, procurement, inspection, quality control, packaging, storage, inventory control, distribution, and disposal. Also, called materials planning (Businessdictionary.com, 2017).

Materials management is a practice of planning, structuring and monitoring of all actions that mainly deal with the material flow into the company.

The domain of Material Management changes from enterprise to enterprise and consists of material scheduling and check, production planning, procurement, production control, material transfer and waste management. This is a business function for procuring, transporting and keeping materials in an optimal mode, which helps the company to reduce or eliminate different costs.

(Definition & Scope of Materials Management, 2017.)

3.1.1 Item coding

The product number is a unique identifier of goods that are stored in inventory or involved in manufacturing. They are very important for monitoring a unit's movement and performance in the organization. Codes of goods also play the role of reducing the descriptions. It is not necessary to use the full description or the name of an element when its number can be specified. This makes the material and information movement more rapid and accurate.

Assigning code numbers to items in accordance with a reasonably planned circuit sounds simple, but almost two-thirds of issues in the inventory are due to the inability to do that. Besides source materials and finished goods, enterprises should keep immense and various amounts of spare parts, consumables, technical equipment and accessories to ensure a smooth production. Failing to have one particular detail at hand can have catastrophic consequences, especially for continuous processes, so that those who make the decision to maintain the inventory are inclined to carry surplus stocks. On the other hand, the growing inventory value cause major disturbances to the top management. Despite the fact that plants tend to balance between surplus stock and stock-out, most of them do not know how to keep the accumulation in control. In most cases, the answer is correct codification. (Iyer, 2005, 70-71.)

3.1.1.1 Codification approaches

According to Iyer (2005), there are four approaches for codifying inventory, such as:

Non-intelligent codes: Usually these are computer-generated, non-repetitive or incidental numbers that cannot be broken down into informative subgroups. For example, if we review the serial code 2000007648, we can see that this part number does not provide any information about the features or application of the element. A non-intelligent approach to the number can be performed quickly, since planning is not required for the classification of elements. However, there is an inclination that there are multiple code generations for a particular element. As the product code transmits minimum information, the search for this item by someone who does not know the code will be challenging.

An intelligent numeric code based on item usage: In this approach, the symbols that form the full code are divided into meaningful groups and subsets based on operations and equipment units for which this part is utilized. Some numbers may represent a family of equipment that the component belongs to and the process that controls that element.

An intelligent numeric code based on item characteristics: If, for example, we need to codify a single-row, deep groove ball bearing that carries the designation, 608, we know that this item refers to the family of anti-friction bearings. The bearing is of single-row deep-groove design; this portrays a sub-group. Lateral to this classification is a "sub-sub group," the size of the bearing. Additional digits can be issued to represent variations in the design of the part. This particular ball bearing can be codified as, for example, 6200006080 where the figure 62 represents the anti-friction-bearing family, the next two digits, 00, represent the ball bearing class and the fifth and sixth digits, also 00, represent the sub-sub group or variant group consisting of single row, deep-groove bearing. The next three digits, 608, represent the size and designation of the bearing, and the last digit, O, represents any design variations that give the item its unique characteristics. The appeal of this approach is that all deep-groove ball bearings are assigned to one group and kept in one area. This will avert numerous code generations for a particular part. The flaw is the hardship to decrypt what every digit means, but over time, employees become accustomed to the scheme.

Intelligent alphanumeric code based on item characteristics: The single-row deep groove ball bearing, 608, can be codified as, for example, SRDG 608 in an alphanumeric intelligent codification system. The convenience is in fast decoding; the deficiency comes from issue that computers operate with numeric codes more efficiently than with alphanumeric ones. (Iyer 2005, 70-78.)

3.1.2 Bill of material

The bill of materials (BoM) is, actually, a list of items or parts required for finished good assembling. It presents the item code and the needed amount of every detail. In addition, it can be formed with a slightly more complex approach as a multilevel record, which represents the data of all sub-assemblies, transitional assemblies and various technical descriptions. It is also possible to include source information in it, such as part specifications and CADs or technical drawings.

The bill of materials is often used to communicate among manufacturing partners, or it can be assigned to only one enterprise. The bill of materials tends to be closely linked to the production order that issues demands for materials that are in stock and procurement for parts that are out.

A bill of materials (BOM) scheme depends on the organized layout of the data for preparing secure schedules, forecasts and production plans. Commonly used BOMs include: 1. The Modular Bill of Material that is used for products which have some options. It helps to forecast, issue orders and plan. 2. The Pseudo Bills of Material, also called ''superbills'', ''K-bills'' or ''S-bills'', are used when there is a need to apply assembly numbers to different parts, for example, bearings or nuts. 3. Percentage Bills of Material are applied in a situation when it is hard to forecast the order for individual variants. The percentage comes from the historical demand data and safety stocks level. 4. The Adelite Bill of Material determines a special item as a standard one and prescribes which parts are to be removed and which are to be supplemented. (Ramalingam, 1983, 22.)

The list in the BOM is hierarchical. It shows the number of each element required to finish one unit of its parental part. The pattern of this facet of the specification is visible when the product structure is considered. It provides a demonstrative picture of the subassemblies and items required to make the product. (Stevenson 2012, 512.)

Inaccuracies in stock record documents or bills-of-materials can lead to unpleasant situations, beginning from a lack of particular items to supplying surplus amounts of one type of parts and too little of others, as well as an inability to work according to the plan. All this contributes to an inefficient use of resources, longer lead-times and low level of customer service. Enterprises are also required to enforce planning discipline and have prepared standard procedures for maintaining and updating the bills of materials. (Stevenson, 2012, 526.)

3.2 Manufacturing engineering

3.2.1 Manufacturing process structures

Production conditions vary much depending on the structure of their processes, this means, how the material moves in the factory. For example, the continuous flow in a chemical plant behaves a lot different and furthermore leads a completely another way of administration, than a one-time handwork environment in a specialized mechanical studio. Several categories of process structures can be defined:

1. Job shops. Small amount of goods is produced with a different and various routing in the production. Flow through the factory is mixed, setups occur often, and the environment has an atmosphere more of design work. For instance, a commercial printer, where each project has unique demands, will usually be organized as a job shop.

2. Disconnected flow lines. Batches of products are produced on a limited number of identifiable routes through the production. Although the routings are clear, the individual stations inside lines are not connected via a step-by-step system, so that stocks can accumulate between stages. Most industrial systems to some extent resemble the disconnected flow line environment. For instance, a heavy equipment producer will use clearly defined assembly lines, but due to the scale and complexity of the operations at each station, in general, would not automate and accelerate the transferring between working stations.

3. Connected flow lines. This is a classic moving assembly line, famed by Henry Ford. The product is manufactured and mounted on a rigid line connected to a material handling system with paced motion. Car frames transfer along a moving assembly line between stages, where various parts are fixed – this is a classic application of a connected flow line. But, in spite of the popularity and historical appeal, this type of system is, in fact, a lot less utilized than disconnected flow lines in the industry.

4. Continuous flow processes. Continuous product (food, chemicals, oil, roofing materials, fiberglass insulation, etc.) flows constantly and autonomous down a defined

route. Many food processing factories, such as sugar refineries, make use of continuous flow in order to reach high level efficiency and sameness of the product. (Hopp & Spearman, 2008, 8.)

3.2.2 Facility Layout

As in other areas of system design, layout decisions are important for three basic reasons: 1. they require substantial investments of money and effort; 2. they involve long-term commitments, which makes mistakes difficult to overcome; and 3. they have a significant impact on the cost and efficiency of operations.

(Stevenson, 2012, 248.)

According to Stevenson (2012) the most important challenge in deciding which facility layout to use belongs to positioning of the departments involved. Departments must have prescribed locations. The question is to work out a fairly good layout, certain arrangement would be more attractive than another. For instance, some stations or workshops may profit from communicating positions, whereas others better be placed apart from each other. A lab with fragile tools should not be placed close to the work station with strong vibrating equipment. On the other hand, two departments that utilize same tools and machines would be more effective if placed together. (267.)

Altogether, the inputs to the layout determination process, as Chase (2007) says, can be listed as follows:

1. Specifying of the goals and appropriate characteristics, which will be used to assess the design. The amount of space needed, and the range that must be overcome between units in the layout, generally are primary criteria;
2. Estimation of requirements for services or goods on the structure;
3. Process demands for amount of operations and value of flow between the units in the layout;
4. Space needs for the units in the layout;

5. Area size within the facility itself, or when this is a new building project, probable variants. (187.)

The patterns by which departments are located within the plant are described by the general nature of process flow. There are three basic types (process layout, product layout, and fixed-position layout) and one hybrid type (group technology or cellular layout).

A process layout (also called a job-shop or functional layout) is an arrangement in which same equipment or processes are located together, for instance, all lathes in one area and all stamping machines in the other. The part that is processed is then moved in accordance with the established sequence of operations from station to station where the respective machines are located for each action. This type of layout is usual for hospitals, for instance, where departments are intended for specific types of care, such as maternity wards and intensive care units.

A product layout (also called a flow-shop layout), where elements or operations are organized in accordance with the gradual stages on which goods are produced. The path for every detail represents a straight line. Manufacturing lines for footwear, chemical plants and car washes all use product layout.

Assembly lines are a special example of a product layout. In general, the term "assembly line" applies to a paced assembly united by some material handling equipment. The common speculation is that there is some form of movement presented, and the defined throughput time is equivalent for all stages. Inside this general definition, there are huge distinctions between various line types. Some of them are determined by equipment for moving material (belt or roller conveyor, bridge crane) or line configuration (U-shaped, straight, branching). Others defined by pacing (mechanical, human), assortment of products (one product or several products) or characteristics of the workstation (workers may sit, stand, walk with the line, or ride the line) and length of the line (few or many workers). The examples of products partially or fully produced on lines include toys, appliances, autos, planes, guns, garden equipment, clothing, and a broaden variety of electronic components. Apparently, almost any product that has multiple details and sub-assemblies and is manufactured in large volume utilizes assembly lines to some degree.

A group technology (cellular) layout locates different machines into job centers (or cells) to work on goods that share close shapes and processing. A cellular layout is like a process layout in that cells are arranged to perform a specific set of operations, and it is at the same time as a product layout in which the cells are devoted to a limited range of products.

In a fixed-position layout, the product (because of its size or mass) remains at the same place. Manufacturing equipment and tools are transported to the product instead of the other way. Construction sites are common examples of this type.

Many production plants use a combination of two formats. As an example, one manufacturing area can have process layout, while another area can be based on product layout. Example – part production area followed by a subassembly, with a final assembly area ending the whole process. Different layout types could be used in each location, with a process layout used in manufacturing, group technology in subassembly, and a product layout utilized in final assembly. (Chase, 2007, 187-188.)

3.2.3 Concept of push and pull production systems

Hopp and Spearman (2008) distinguish push from pull by the action that triggers the flow of work in the structure. In fact, the impulse for production releases occurs from outside the push system, but from within the pull system. The push and pull systems can be defined in a more formal way, as authors say:

“A push system schedules the release of work based on demand, while a pull system authorizes the release of work based on system status”

(Hopp & Spearman, 2008).

The difference between push and pull system is shown in the scheme in Figure 3. The push system inputs order into a manufacturing process (factory, line, or workstation) exactly at the time, when triggered to do that by a defined schedule, and this order time is not affected somehow by what is going on in the process itself. Opposite is a pull system, which only issues an order onto the production when a signal coming from an alteration in status of the line asks for it. Generally, as in the Toyota manufacturing system, also called Kanban system, these permission calls are the result of the completion of job at some station within the line. Important to note, that this description has nothing common with who actually moves the work. If an operator from a downstream station receives job from an upstream process, but is doing this in accordance with defined plan, then that process is push. If an upstream worker delivers job to the downstream agent, but does this responding to changing status of the downstream station, then this is called pull.

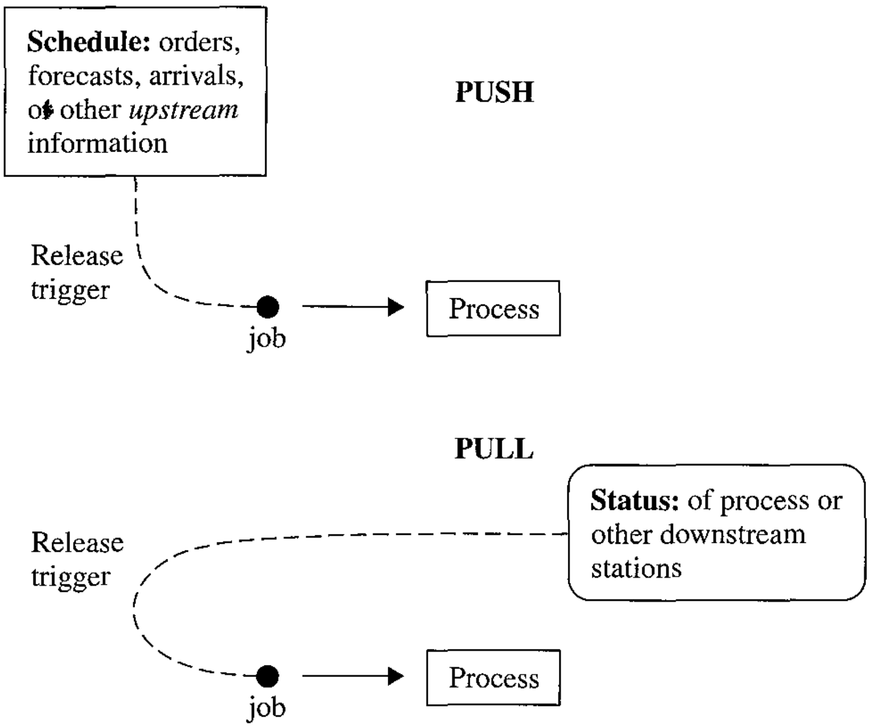

Figure 3. *Push and Pull Production Systems* (Hopp & Spearman, 2008).

Another helpful method to distinguish between push and pull systems comes from that push systems are basically make-to-order while pull systems are make-to-stock. The schedule that moves a push system is dependent on forecasts and orders, but not by the status of structure itself. The signs that issue production in a pull system are hollows in an inventory level at some place in the system. That means, the general inventory model, which releases orders when stock drops lower, than a defined level, is a pull system. An MRP system, which triggers release in the system in accordance with a plan, based on customer demand, is a push system.

Clearly, most real-world structures utilize modes of both push and pull. As an example, if work is planned to be released by MRP, but is stopped because the line is thought to be too overloaded, then the result becomes a hybrid push-pull system. Contrary, if a kanban system generates a card issuing manufacturing but the actual job release is delayed due to the lacking demand for this product, then becomes too a hybrid system. A lot effort was put into somehow combining push and pull into hybrid systems. (Hopp & Spearman, 2008, 340-341.)

3.2.3.1 Push-pull interface

The problem if pull can be used and how to do so is just the section of the whole, where to use it is also significant part of the challenge. Even in a single manufacturing system, it could be arranged to set part of it as pull. A helpful solution for deciding to use pull structure comes from the push-pull interface, which separates manufacturing operations to pull and push parts. Picking location of this interface wisely can provide the whole system with strategic excellence of pull advantages and, at the same time, keeping the customer controlled nature of push.

But how to decide which location of this interface is the best for a system we have? Because it is influenced by both the physical aspects of manufacturing operations and customers' precedency, it is a challenging question.

First of all, it is important to note that main cause for placing the push-pull interface near the customer is promptness. That is why it is reasonable only to do it when higher rate would result in a perceptible rise in service level from the customer's point of view. Secondly, important to remark, that amount of variable positions of the push-pull interface is influenced a lot by the process.

Finally, the efficiency of push-pull interface location depends on level of customization of the product while it goes through the system. When there is little amount of finished product variations (like in a plywood mill that uses small range of raw material types, such as wood and glue and manufactures several variable thicknesses of plywood), the push-pull interface at finished products would suit well. On the other hand, in plant with huge variety of end goods (like a computer assembly production, where components are compiled into broaden assortment of finished PCs), keeping stock at the final stage would cost much.

(Hopp & Spearman, 2008, 341-343.)

3.2.4 Lean manufacturing

Lean manufacturing is one of the latest and advanced ways of organizing production processes, starting originally in Japan, now it spreads around the world globe. More and more manufacturers implementing its practices, due to its effectiveness in terms of cost and waste reduction. The popular definition of Lean Manufacturing and the Toyota Production System usually consists of the following:

It is a comprehensive set of techniques that, when combined and matured, will allow you to reduce and then eliminate the seven wastes. This system not only will make your company Leaner, but subsequently more flexible and more responsive by reducing waste. (Wilson, 2010, 9.)

As Womack (2003) says in his book, lean practices give us a method to receive instant assessment of our actions to turn muda(waste) into the value making the work more satisfying. Also, in staggering contradiction with the latest fashion for process reengineering, lean grants manner to form new jobs but not just eliminating them on behalf of performance. (15)

The crucial basic term for understanding lean is value. Only final customer can determine value. Moreover, it has sense only when is outspoken in terms of a definite good (a service or a product, or even both) which fulfills the customer's demands at a certain time and at a certain price. Producer creates the value. This is the reason, from customer's point of view, why producer subsists. (ibid, 16.)

The Toyota Production System or TPS is commonly used together with the expressions Lean Manufacturing and Lean Production. It is defined as Lean due to the point, that, operations can run:

- Utilizing fewer material
- Lower investment amount needed
- Lower inventory level
- Less space is consumed
- Fewer people needed

Which is more important, a Lean process, if it is the TPS or any other, would be distinguished by a flow and predictability that greatly decreases the ambiguity and disorder of general production companies. It is not only more effective in terms of economy and processes, it is emotionally much more lifting, than other practices. Employees perform with a larger reliance and with more comfort and tranquility, than in the typical production facility, with pressuring schedules, constant overtimes and unpredicted challenges. (Wilson, 2010.)

Wilson (2010) continues his discourse with defining the main benefit of Lean as its ability to handle multiple variations of a product. Usually, at the mass production, if there is variety in model types, they are typically manufactured in large lots even when they utilize similar production facilities. Cause for this operation in batches is due to, when shifting between models, readjustments are needed. The Lean solution provides with the idea of product combined leveling. For instance, there are three model types of our good. They are called A, B, and C, and are manufactured on similar production equipment. The model mix means there would be produced 50 percent of A, and 25 percent of each B and C. These products would be manufactured simultaneously in a cell, in order of ABACABACABAC. Certainly, to achieve this we need to implement in a cell either single minute exchange of dies (SMED), or quick setups, or its more advanced technique, OTS (one-touch setups). (9-10.)

An important attitude and approach to quality improvement in Lean manufacturing is described by Wilson (2010), author specifies that personnel, and the right appeal to employees —involving education, planning of career, and the obligation to the work are at the heart of lean manufacturing. Highly professional and trained operators are needed in the production, because of two main reasons. First of all, in order to approach improvement of processes it is commonly crucial to reform or remove some of the operations. And this usually leads to the repartition of the job. Moreover, workplaces are organized the way, that it should be possible to operate them by one or several workers, depending on changes in orders. When employees are not multiskilled, the dynamics of lean is lost. Multiskilled workers stay as pillars for the flexibility and agility of Lean.

It is expected that employees will settle simple problems, and the Toyota production system includes a time trigger for escalated problems and involving others. How failures are deliberated in the TPS framework differ a lot from the usual approach toward challenges. Problems in a common western factory are perceived as a nuisance and even symbol of the incompetence of the management, engineers or even the operator himself. Consequently, problems become something to hide and look away from. Nobody wishes to take the resulting guilt and many problems remain unresolved, although they are quite obvious. Contrary, inside the lean framework, problems are seen as a debility of the system and the ability to improve it and make it more reliable. Problems and failures are resolved and reviewed and guilt is avoided. (60.)

3.2.4.1 Waste elimination

Muda means "waste", more precisely it means any human actions, that absorb resources but do not produce value. Waste comes from mistakes which need correction, manufacturing of products no one really needs, so that stock is piling up, processing stages which are not necessary, transfer of workers and material from one area to another without any aim, teams of employees in downstream stations standing around waiting due to the delays in upstream stages, and products and services that do not satisfy demands of the customer. (Womack, 2003, 15.)

One of the main pillars of lean management and manufacturing is clearing processes from non-valuable operations and activities, waste elimination, as it is called. Wilson (2010) specifies word elimination, not reduction, but complete removal, according to the author, founders of TPS divided waste into seven different categories, which slow down production and rise costs:

• Overproduction is the worst of all the wastes, because it is not only a waste itself, but also escalates all other six wastes. For instance, the surplus amount must be transferred, kept in inventory, checked, and may also have flaw parts. Overproduction is not just manufacturing of goods you would not sell, but, as well, producing earlier, then needed. A sapid point about overproduction is that almost any product surplus is planned. It is scheduled, and often for some various well-sounded causes. For instance, to guarantee companies have enough finished products, many of them schedule extra production and procure additional raw materials and spare parts, due to the reason they would meet drop out in quality during the operations. This planning actions are indeed just guessing and add a lot to the variability in the process. Moreover, many enterprises work hard to regulate this scheduling mode in order to reduce the waste of overproduction, that is planned. This means, that there is already critical resource of technical manpower struggling to get rid of the overproduction, which is originating from the planning and scheduling. Which started due to the quality defects which influence manufacturing quantities. Point of removing quality waste and thus getting rid of overproduction and waste of manpower is typically missed;

• Waiting, this means operators not performing for various reasons. This could be short waiting, which occur in a poorly balanced line, or longer ones, originating in equipment failure or insufficient inventory;

• Transportation is the waste of transferring materials around. It happens between manufacturing steps, between line stations, and occurs when finished goods are being delivered to the client.

• Overprocessing means treatment of goods over level what the client wants. Engineers who design technical characteristics, which are above the requirements of the customer usually form this waste in the project stage. Choosing inefficient or poor production equipment raise this waste too.

• Movement, this waste is a meaningless motion of employees — such as workers moving around, looking for right equipment or parts. Commonly, this is not considered as waste. Because of how active and busy look people. The point is not whether workers are active, but if they are producing value. Process design and workshop layout is a crucial agent here;

• Inventory, that is a classical type of waste, every stock is a waste, if it is not converts straight into sales. There is no distinction, is it raw materials warehouse, work in progress, or finished products. It is waste if it is not directly reserving sales.

• Making defective parts, this type of waste commonly is labeled as scrap. But it is not just the defective part as a waste, but also the work and raw materials spent to produce it. In this case, it is not only the loss in production unit, furthermore it is the circumstance where precious time, struggle, and energy were spent, in order to produce the unit — and all of that was lost, not just the product. (25-26.)

3.2.4.2 5S Method

5S is a number of practices, that begin with the letter “S.” These techniques are utilized to improve workplace and contribute visual monitoring and Lean implementation. The 5Ss in Japanese and English languages mean: Seiri(Separate), Seiton(Set to order), Seiso(Shine), Seiketsu(Standardize), Shitsuke(Sustain). (Wilson, 2010.)

- Seiri(Separate) – Sorting through resources, in order to keep only the important items needed to fulfil tasks and goals. This technique includes looking through all equipment at a workplace to define what is required and what is allowed to be removed. Anything that is not needed for completing a task has to be removed from the working area.

- Seiton(Set to order) – All items should be organized and have a prescribed place and location. All tools left in the workspace should be arranged in a logical way so they help to improve performance and task solving of workers. This usually means locating tools and parts in ergonomic places where people would not have to perform extra movements to reach them (bend or walk).
- Seiso(Shine) – Proactive work to have workspace clean and in order to secure purpose-driven activities. It includes cleaning and maintaining the well-organized workplace. It can involve different routine actions, like sweeping, dust cleaning and others. Also, performing service on equipment and tools.
- Seiketsu(Standardize) – Provide a number of standards and rules for both administration and processes. This is the point, where first three S's should be taken and rules introduced on how and when different actions, concerning these S techniques should be performed. Those rules could consist of plans, charts, tables, diagrams.
- Shitsuke(Sustain) — These new actions should be supported and periodical assessment performed, in order to keep discipline. This implies, that all of the above four S's must be maintained over time. It can be reached by mastering an importance of self-discipline in workers.

(5S, Creativesafetysupply.com, 2017.)

3.2.4.3 Quality control and improvement

The basis of high quality has two approaches. First one is the education and constant improvement of the personnel and its attitude. Next one is the work to ensure, that processes are steady and can fulfill customer requirements. This is a strategy developed to reach high level of quality delivered. (Wilson, 2010, 59.)

Today, the deployment of the quality function (QFD) further strengthens this idea of "understanding the cause". QFD efforts to provide an objective assessment of the concrete aspects, advantages and disadvantages of the goods compared to competing products, so that the producer will be able to see the willingness or unwillingness of customers to buy their products. Thus, determine ways to improve the product to meet the requirements of customers in the best possible way. Most quality control departments classify imperfections or faults and report them periodically. Using Pareto analysis of these events, an minimization of poor quality and attack against it can be performed. However, to a large extent, the reason for poor quality is the original design of the product. Much attention is currently being paid to product design, for instance, having the design team incorporated also with production engineers, to eliminate the reasons for production quality failures at the root. (Zandin, 2004, 1.93.)

Quality control should produce a specified number of rules that can be used by product groups to ensure that each good is correct at any time, without reverse flows and without any of bad products moving to the customer. In fact, the traditional quality task has to be connected to the performance function (or "Lean") to create a "quality improvement function" that can remove undesirable waste. (Womack, 2003, 280.)

3.2.4.4 Lead time

Two important aspects that most enterprises do not measure in any way, but that all of them would like to have are flexibility and responsiveness. They are connected, with one, you also get the other. And they are critically important. Every planner, when asked what he wishes for, tells, that after right forecasts it is the ability to swiftly reform plans and still fulfill terms of time. It became visible how lead time was transformed into an advantage in business. Critically important are two types of lead times, they can be defined as:

• First piece lead time, this means how long will it take for the first item to produce and be at the packaging stage. The first advantage of this characteristic is that, usually, the last quality check is done just before packaging process and so this is the reply time that is required to confirm that the quality is good or that a change in the process is required

• Shipment lead time is amount of time it takes to produce entire order. This, certainly, is the most important characteristic used in scheduling. (Wilson, 2010, 74.)

Wilson (2010) then provides several tools and solutions on how to effectively reduce lead time in production:

1. Reducing Production Time

Reducing production time is a combination of: a) removing unneeded processing stages, b) lowering amount of scrap, c) reworking the current system, so those production stages which are at the moment important, but not valued added, can be removed;

2. Reducing Piece Wait Time

Balancing the flow, in order to make it synchronized;

3. Reducing Lot Wait Time

It means the time an item, within a batch, is waiting to be manufactured. To reduce Lot Wait times, it is needed to cut lot size and adjust the model mix. The ending aim of minimizing lot size is one item. When Lot Wait time is lowered, first piece wait time also becomes lower. This metric is commonly missed, but it is significant. There would always be quality and manufacturing problems and these problems have to be spotted fast, to be solved. First piece lead time is usually the basis to become flexible and prepared to quality issues.

4. Reducing Process Delays

Process delay is the period, when whole lot is waiting for the process. It is also usually called queue time. In order to remove it, we have to adjust amount of producing goods, operating capacity and synchronize the flow in the whole factory as well. Generally, it is caused these delays due to incompatible capacities and batch manufacturing. This can originate from absence of timing and by delays in movement and transfer.

5. Managing the Process to Absorb Deviations and Solve Problems

Different variations raise manufacturing lead times, like equipment breakdowns and intermissions for quality issues. All of these issues make inventories increase, and stock is the main problem in Lean manufacturing—we tend to reach zero stock level if we can. When there is deviation in the system, inventory should not be added. The variation itself must be attacked. One of most prominent practices to monitor operations is the idea of transparency. When the state of the process is transparent, then Rapid Response PDCA (Plan, Do, Check, Act) can be issued.

6. Reducing Transportation Delays

One piece flow, synchronization, and product leveling all put accent on transportation, which is a waste. To lower this waste, several techniques can be introduced. Kanban is commonly first coming to thought, but kanban has inventory and produces a second delay, the delay in information flow.

7. Reducing Changeover Times

Every time an equipment has multiple applications, there is need in switch-overs inter manufacturing runs. To keep production before and after this equipment, there are inventory buffers installed that, while they enable continuous manufacturing, the overall flow loses speed. Therefore, if time for changeovers is reduced, stock before and after the machine can be lowered. This lead time reduction and productivity technique, is called SMED (single minute exchange of dies) will commonly result in stock level reduction and moreover enhance lead time and flow significantly. (84)

4 Research implementation

This chapter contains results of the research and analysis done, description of the company's structure and operations and advices and solutions presented to the company as guidance for future development and improvement.

4.1 Questions stated for the interviews and for observation processes

Information for the thesis about current state of company's processes and structure was gathered through two main approaches: interview and observation. Interview helped to clarify all questions, that were brought up by the theme of the research and stated goals, observation than showed how all of the operations and actions work in real life environment, what are problem points and errors and where is everything running smoothly.

Interview questions, that were presented to director, production manager and procurement manager:

1. What is company's organization structure?
2. What is the facility layout of the production?
3. What are production processes and how are they organized?
4. How does procurement and supply organized?
5. Do you have item coding?
6. Does production operate efficiency?
7. Are there any problems, concerning procurement?

Observation was conducted through the participation in procurement, production planning and material management on the particular case of the skip loader manufacturing. During this process, study questions stated in the interview could be viewed on practice, this helped to get another viewing angle and better understand all possible underwater rocks.

4.2 Information about company’s organization structure

Analysis of organization structures is an important part of understanding company’s operations, functions, management processes. Within the framework of this system, the entire managerial process takes place, in which managers of all levels, categories and professional specialization take part. The system of organization management structures is built in order to ensure that all the processes in it are carried out in a timely and high-quality manner. Hence the attention paid to it by the heads of organizations and specialists, with a view to continuous improvement, development of both the system as a whole and its individual components.

To effectively manage the organization, it is necessary that its structure be consistent with the goals and objectives of the enterprise and be adapted to them. The organizational structure creates a framework, which is the basis for the formation of individual administrative functions. The structure identifies and establishes the relationships of employees within the organization. The structure of the organization also determines the structure of sub-objectives, which serves as criteria for selection in the decision-making process in various parts of the organization.

The organizational structure of the company can be schematically represented as a "tree" (Figure 4), since “Technopolis” Ltd. has a hierarchy in the relationships of employees and departments. Delegation of authority is linear, which means, that power is transferred directly from the superior to the subordinate and then to other subordinates. Because of that structure, the leader gets the legal authority to direct his subordinates to achieve the set goals. He has the right to make an independent decision within the limits established by the organization and legislation.

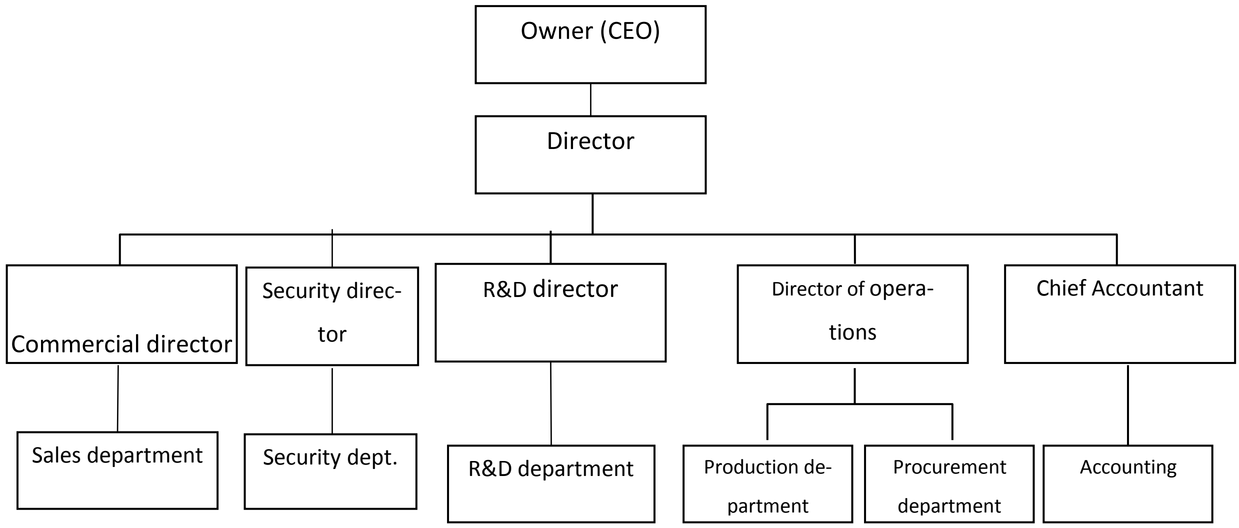

Figure 4. Organizational structure of “Technopolis” Ltd.

Before to start describing the individual links of this scheme, it should be noted that because of the small size of the company and rather small number of employees (the average list size is 50 people) it is quite difficult to draw a clear boundary between the levels of management and their functions. Traditionally, three levels of management are being distinguished: the highest, medium and operational. In addition to managers in any organization, there are employees who carry out the assigned plans and solve routine tasks, that is, those who are directly involved in the production or service delivery process.

In the company "Technopolis" in departments (with the exception of production department) there is no division into teams with the separation of team commanders. Some of the operational functions (for example, drawing up reports, customer call schedules, etc.) are assigned to the direct executors: engineers, engineers-designers, managers and operators. Employees themselves plan their work schedule. The heads of departments monitor the level of work quality, the amount of work performed, the timely submission of reports, etc. Thus, it can be conditionally considered, that operational management is represented by employees (executors) and heads of departments.

Production department differs from overall company's organization structure as there are several teams of workers, which are managed by leaders. Team leaders receive plans and orders from director of operations and submit reports to him. And take part in meetings, concerning operations schedule and order release.

The highest level to which refer the owner and the director, who is subordinate to the CEO. Not only perform the strategic, but frequently also the tactical policy of the firm (long- and medium-term planning of management and development of financial, marketing and production activities). Representatives of the middle level: heads of departments – are responsible for the work of departments in general, detailing and implementation of plans, reporting.

For the company "Technopolis" such a management scheme is rationally justified. At the moment, there is no need to increase the staff of managers or to change the structure of management or the organization as a whole.

The R & D department consists of engineers, whose functions include:

• Development of technical documentation (drawings, technical maps, computer models) of issued orders;

• Search for new solutions to optimize and improve product quality;

• Interaction with representatives of outside organizations on relevant issues (for example, discussion of the technical terms with the client together with the production manager);

• Ensuring compliance with the rules of operation, maintenance and supervision of machinery;

• Control over compliance with the quality standards of products;

• Provision of established reporting.

The main functions of the employees of the purchasing and logistics department are:

• Procurement of components, warehouse management, preparation of production kits;

• Delivery and support of components / finished goods;

• Organization of document circulation with representatives of outside organizations (acceptance of invoices, accompanying documentation from suppliers);

• Submission of established reporting.

The sales and marketing department consists of sales managers. It conducts market research, analytical work on competitors and is engaged in the search for new customers. The sales department is responsible for selling products and selling services. The manager's function includes a detailed story about the services provided with the provision of a price list, the conclusion of contracts, the provision of workflow, the submission of established reporting on serviced requests and concluded contracts.

The accounting department is responsible for:

• Development of the accounting policy of the enterprise (chief accountant);

• Keeping records of property, inventory and transactions related to the acquisition of inventory, production costs, sales of products and services, reckoning with suppliers and buyers, as well as services of third-party organizations;

• Receipt and control of primary documentation;

• Timely preparation of data and reporting (accounting and tax);

• Supervision of the safety of documents and the formation, maintenance and storage of a database of accounting information;

• Keeping records of the personnel of the organization, accounting of wages.

Production department is responsible for:

- Execution of production, in accordance with the technical order and documentation received from the production manager and R & D department;

- Provision of services, in accordance with the order;
- Submission of established reporting.

Security department responsibilities:

- Ensuring security in the enterprise;
- Ensuring the safety of the material and technical base and warehouse;
- Providing control over the pass to the territory of the enterprise, ensuring that no non-authorized person enters production.

4.3 Production processes description

The whole production is conducted in a job shop (or process) layout and includes metal processing workshop, sandwich panel workshop and two assembly working areas, for superstructures (hydraulic lifters and cranes) and another for cargo vans (truck box bodies). At final assembly areas, we can say, that they are organized in a fixed-position layout, due to the size of final product. General scheme of the whole manufacturing facility layout is shown in Figure 5.

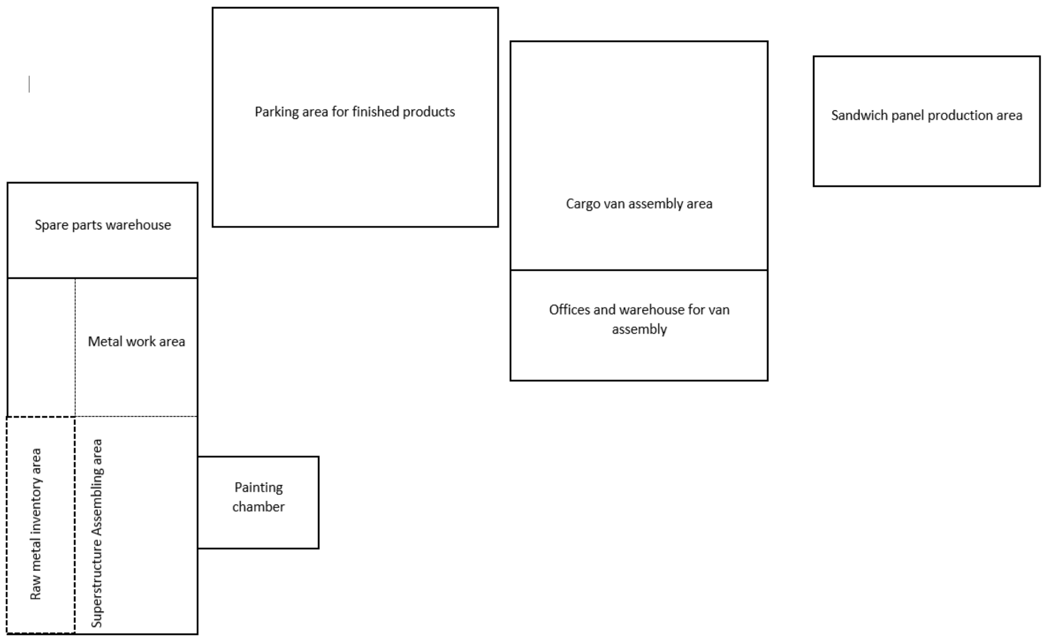

Figure 5. Facility layout of “Technopolis” Ltd.

All operations start after order is issued from the sales department to the operations director. He then places this order to the schedule and, if it is necessary (new project or product type) sends technical description to the R&D department, where all the documentation and technical drawings are prepared. During project development procurement department starts looking for raw materials and spare parts needed for the production, if there are no suitable or lack of them in the warehouse. After technical drawings are ready production can be started.

Problems and challenges appear at the procurement level. As there are lot of different product types it is not possible to keep all spare parts, that could be needed in the inventory, costs will be unbearable, except from raw materials, like metal, plastics, wood and polyester. This question is partly solved by issuing procurement at the beginning of blueprint and project development, so at the time, when there are schemes and instructions ready or workers, spare part and components arrive. However, this system is vulnerable to suppliers' delays and shortages.

Inventory management is organized into three warehouses: metal workshop warehouse, sandwich panel and van assembly warehouse, tools and spare parts warehouse. Metal workshop warehouse located near metal processing zone and consists of raw materials (tubes, metal sheets, metal corners and some consumables). Sandwich panel warehouse stores raw material needed for sandwich panel production, for example plastics, wood, polyester, glue and other consumables. Third warehouse consist of most expensive spare parts, tools and materials, all fittings and electronics, as well as hydraulics and tools stored there. Existing item coding is not correctly implemented to the company's inventory control system, for the spare parts and raw materials there are no codes or numbers applied, only part numbers of finished parts or sub-assemblies appear, but that affects only assembling process. This leads to errors and ambiguities with the arrival and consumption of materials, continuing in a huge waste of time, when looking through the residues due to preparing and compiling of materials for new order.

4.3.1 Skip loader manufacturing processes

As it was mentioned in chapter 2, the research is taken out on the skip loader mainly, variety of different products is ignored to simplify the analysis, because each product type has its own process steps and description of each and every one is unreasonable, as it is important how processes are conduct and not what are the processes, also important to say, that solutions and decisions, that could be brought up on skip loader case later on can be implemented to the whole production. On this product, usually a team of 7 people is involved. Three on metal processing, one painter and three on final assembling.

For better understanding it is important to describe structure of skip loader and principles of how it works. Skip loader, Figure 6., is a special equipment truck, used to carry out operations, like transportation and lifting, with bulk material containers. Overall design consists of three main nodes: platform, two hydraulic booms and two outriggers, to support vehicle during lifting.

Figure 6. Skip loader.

Production of that kind of superstructure can be divided into several processes:

1. Metal processing
2. Painting
3. Mounting on a truck chassis
4. Final assembly (hydraulics and electronics)

In the case of skip loader, all technical drawings and instructions are ready and completed (Figure 7. shows computer 3D model) so when order is issued from the sales department it goes straight to the production. After procurement department checks and prepares raw materials needed for metal work, which are stored in the amount of one month production capacity, because of the supplier's policy it is most cost effective to transport that batch size.

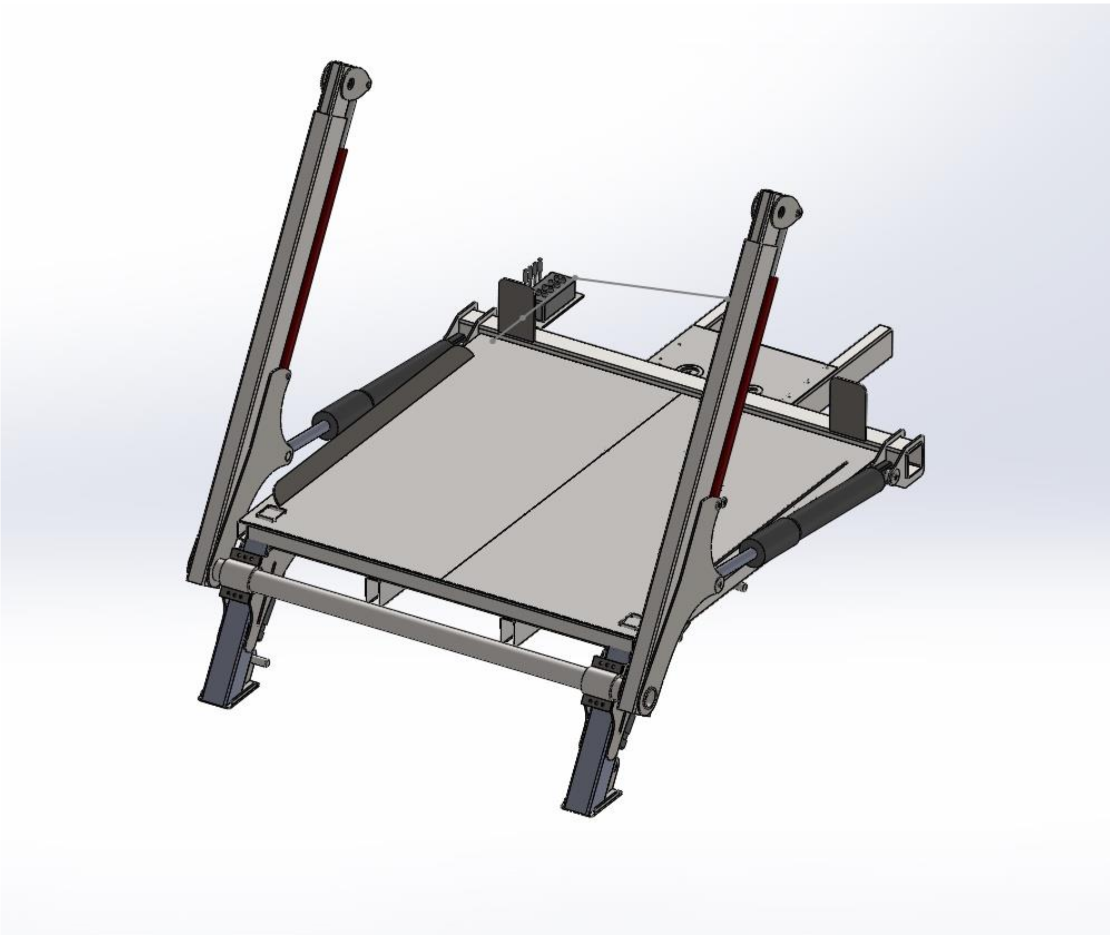

Figure 7. Skip loader 3D Model

However, there are all blueprints and models there is no unified and complete Bill of material for this product. All metal parts, hydraulics and tools are scattered around several tables and lists of parts. Figure 8 represents part from tables for metal materials and for hydraulic components.

КАЛЬКУЛЯЦИЯ № 5
Фактических затрат на сборку мусоровоза на шасси Фусо

N п/п	Наименование.	Ед. измер	Расход	Цена за един.	Сумма
	Материалы				
	Г/цилиндр на аутригер ЦГ-63. 40x990.11	шт	2	12 059,0	
1	Г/цилиндр на аутригер ЦГ-80. 50x400	шт	2	6 271,0	
2	Г/цилиндр на аутригер ЦГ-110. 56x1240.11	шт	2,0	12 559,3	
	Ст.труба 180x100x5	м	5,0	566,7	
	Ст.труба 160x80x4 (4+6м)	м	10	405,7	
	Ст.труба 100x60x4	м	14	269,7	
	Ст.труба 140x140x4	м	4,5	385,6	
	Ст.труба 120x120x4	м	2,0	325,3	325,3
	Ст.труба 100x100x4	м	2	272,0	**272,0**
	Ст.труба Dy 108x10мм.	м	2,5	929,9	
	Ст.труба Dy 127x9мм.	м	0,6		
	Ст.лист 3,0x1500x6000	$м^2$	7,7		
	Ст.труба 109 вн. + 9мм стенка = 127 нар.	м	0,35		
	Палец Ø50 мм.(-0,2), L - 130 мм	шт.	2		
	Палец Ø50 мм.(-0,2), L - 120 мм	шт.	2		
	Палец Ø40 мм.(-0,2), L - 70 мм	шт.	2		
	Палец Ø40 мм.(-0,2), L - 160 мм	шт.	2		
	Палец Ø30 мм.(-0,2), L - 140 мм	шт.	2		
	Палец Ø30 мм.(-0,2), L - 100 мм	шт.	2		

	Наименование	Количество	Описание
4	Гидрораспределитель		
5	Гидрораспределитель Badestnost model A1A1A1A16KZ1	1	
6	Адаптер (Штуцер) BSP 3/4" на 3/4"	1	Устанавливается для подключения шланга d20, идущего к баку.
7	Адаптер (Штуцер) BSP 1/2" на 1/2"	2	
8	Адаптер (Штуцер) BSP 1/2" на M22x1.5	1	Срез в отверстии прямой.
9	Адаптер (Штуцер) BSP 1/2" на M18x1.5	4	Срез в отверстии прямой.
10	Кольцо уплотнительное 3/4"	1	Устанавливается между штуцером и телом распределителя
11	Кольцо уплотнительное 1/2"	11	
12	Фитинг BOLT banjo 1/2"	2	
13	Фитинг BANJO 1/2" d12	2	
14			
15	Регулятор потока		
16	РВД 2SN - 12 600 mm	1	Присоединяется к Banjo
17	Муфта 1SN/2SN d=12	2	
18	Фитинг DKOL (г) M22x1.5 d12 (90)	1	
19	Штуцер (Адаптер) BSP 3/8" на 22x1.5	2	Срез в отверстии прямой
20	Кольцо уплотнительное 3/8"	2	
21	Регулятор потока с обратным клапаном VRFU 90 3/8"	1	
22	Тройник (г-ш-ш) M22x1.5	1	Вход с гайкой. Штуцеры - срез в отверстии прямой.
23			
24	Выход с тройника		
25	Фитинг DKOL (г) M22x1.5 d=12 (90)	2	
26	Муфта 1SN/2SN d=12	4	
27	РВД 2SN - 12 600 mm	1	
28	РВД 2SN - 12 1100 mm	1	
29	Фитинг DKOL (ш) M22x1.5 d=12 (0)	2	Срез в отверстии прямой
30	Выход с распределителя на Тройник 2		
31	Фитинг BSP (г) 1/2 d=12 (90)	1	Взят со скада. Нет в счетах
32	Муфта 1SN/2SN d=12	2	
33	РВД 2SN - 12 600 mm	1	

Лист1 / Лист2 / Лист3

Figure 8. Initial lists of materials.

First step is metal processing, which consist of welding, bending and cutting. Several parts, due to their 10mm thickness are being plasma cut, at the metal structures factory by subcontracting. These plasma-cut parts as with the raw materials case are stored in the warehouse, at the amount of one month output for this product.

Whole metal processing can be divided to several stages, which overall take 19 hours for one product:

1. Main frame welding
2. Combining frame with platform and outrigger holders, plasma parts.
3. Welding of small parts: emphasizes and brackets.
4. Welding of booms.

After that, ready metal components go through painting process. There is only one chamber for painting works, so some waiting could be an issue, if there are other products being processed. This is the main bottleneck in whole manufacturers operations. Painting and drying processes take 22 hours, after they are done it can be proceeded to the final step: assembly and mounting on a truck chassis.

During painting process, all hydraulic parts: fittings, hosepipes, crimp rings and other metal ware are compiled and send to crimping, done by the subcontracting, it takes 8 hours, but it is done during painting, so does not affect all throughput time. This leads to a huge amount of different spare parts stored at the inventory, as well as extra work caused by sorting and preparing all spare parts. Additionally, big influence for inventory is coming from hydraulic cylinders – as crucial components and because of their huge lead time. Hydraulics production company in Yelets city has a lead time of one month for completing and shipping the order.

Last step begins with mounting platform on the truck chassis, then cylinders and hydraulic booms, side protections are assembled to the platform. After these operations comes hydraulic components and electronics assembly. It takes 12 hours, to mount, fix platform and assemble all hydraulic kits and electrics. Figure 9 represents diagram of assembling one skip loader and Figure 10 represents plan of one month throughput at full capacity, with this allocation of processes. So, for one skip it takes 53 hours, to complete. With right planning, it is possible to assemble around 7 skip loaders during one month by one team.

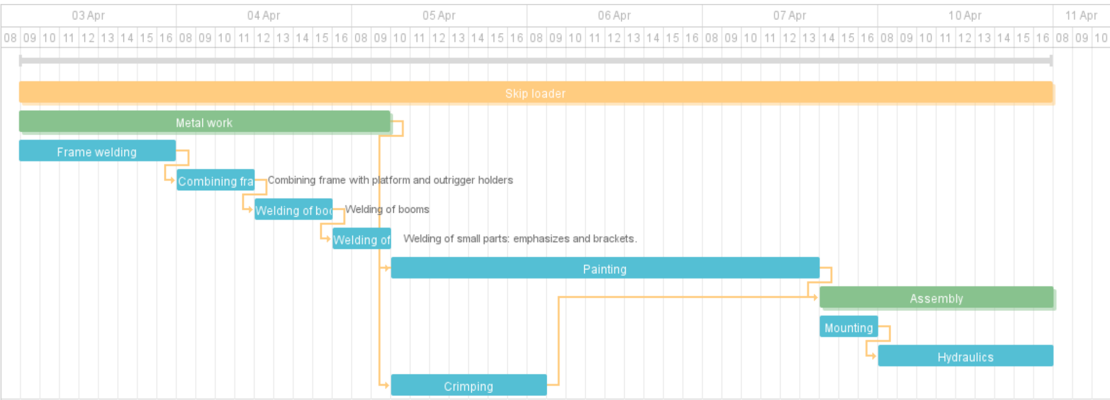

Figure 9. Production process diagram initial variant.

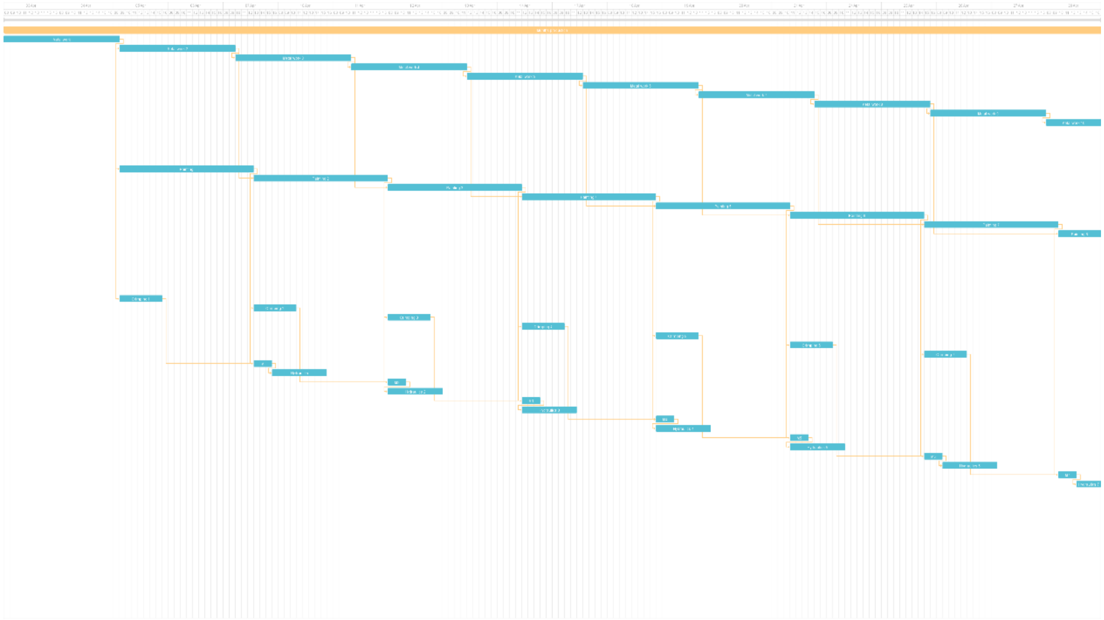

Figure 10. Maximum one month output with initial process layout.

4.4 Solutions on production reengineering

Each manufacturer faces issues and some problem points in its operations. So, there is always some space for improvement. This subchapter consists of general suggestions and advices, that were brought up after the research on “Technopolis” Ltd. production processes. It can be divided in several stages, like the production itself – all starts from procurement and planning, if it is done rightly, then next steps will be easier to understand and correct.

4.4.1 Item coding

Item coding is a base for correct operations and for future development. Coding eases process of inventory control and material management, by reducing errors and mistakes done. Rightly done, it allows to a lot faster check through residues of materials and prepare for the new order. Moreover, part numbering is important for successful implementation of ERP system, which can be considered later in the future. Intelligent alphanumeric code system was decided to be implemented, because this is a production company, so there is need in a code, which will also provide information and description of the detail or material it is assigned to. Big challenge for providing new code comes from a huge amount of different part types, which appear in production. Due to make-to-order strategy and in some cases, engineer-to-order, there are lots of different product types and models.

In this case skip loader, mounted on FUSO truck is analysed and described. First of all, starting from raw materials and spare parts. This part of the item code consists of seven digits, for instance, 01 01 001. Where, first pair represents material or process type, where it is applied, for example 01 – metal work. The next one is product family, it describes whether this metal is steel tube or steel sheets, for example 01 – represents tubes. Last three digits are assigned to a concrete part type, so that 001 – means tube of dimensions 160x80x5mm.

Question arises how to separate parts already processed in the production, which are stored or prepared for future work. This is where assembling part number is added, it starts with alphabetic symbols, representing which product is produced and for which truck model, so that “БФ” – means skip loader based on chassis of FUSO truck and number, which represents particular truck model. After that comes number, representing sub-assembly, so, for example, 1 – means platform assembly and 2 – hydraulic booms assembly. Then there is number in case of more sub-assemblies down the process and last three numbers – spare part serial number. To this part number – raw material code is added, which represents which raw material was used in its production.

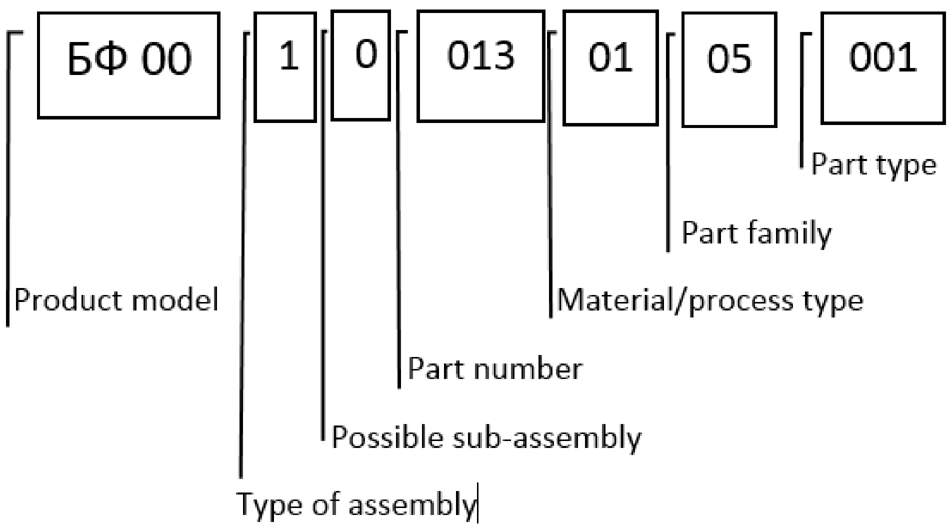

Figure 11. Item coding proposal.

In the end, we have code, which looks like the one presented on the Figure 11 and means: plasma cut steel plate used in assembly of platform for skip loader on FUSO truck base.

4.4.2 Reworked Bill of Material

Previously was mentioned, that for this particular product there were several different bills of material and other part lists, not connected to each other. This caused confusion and misunderstanding, especially for new personnel, who is not yet acquainted with processes and procedures. It was decided to prepare one bill of material, which contained all metal work, hydraulic parts, electrics and consumables in one list.

Skip Loader/ Бункеровоз		
Item code	*Description*	*Pcs.*
Skip Loader/ Бункеровоз		
Item code	*Description*	*Pcs.*
БФ00.1.0.001_0101003	Труба 140x140x4мм сталь профильная, L=2550 мм	1
БФ00.1.0.002_0101002	Труба 10x60x4мм сталь профильная, L=2236 мм	2
БФ00.1.0.003_0101002	Труба 10x60x4мм сталь профильная, L=2170 мм	2
БФ00.1.0.004_0101002	Труба 10x60x4мм сталь профильная, L=682 мм	3
БФ00.1.0.005_0101002	Труба 10x60x4мм сталь профильная, L=1240 мм	2
БФ00.1.0.006_0101004	Труба10x10x4мм сталь профильная, L=2170 мм	1
БФ00.1.0.007_0101002	Труба 10x60x4мм сталь профильная, L=652 мм	1
БФ00.1.0.008_0103001	Уголок 25x25x3мм стальной, L=180мм	1
БФ00.1.0.014_0101005	Труба 50x25x3мм сталь профильная, L=642 мм	1
БФ00.1.0.015_0101001	Труба 160x80x5мм сталь профильная, L=350 мм	2
БФ00.1.0.017_0101005	Труба 50x25x3 мм сталь профильная, L=450 мм	2
БФ00.1.0.018_01010010	Труба n42 стальная, L=630	4
БФ00.1.0.013_0105001	Пластина толщина 10 мм	4
БФ00.1.0.012_0105002	Пластина толщина 10 мм	4
БФ00.1.0.016_0102001	Лист 1050x5 мм стальной, L=2236мм	2
БФ00.1.0.019_0102003	Упор боковой	2
БФ00.1.0.020_0103002	Уголок под упор	1
БФ00.1.0.021_0102003	Упор контейнера	2
БФ00.1.0.022_0106001	Палец цилиндров платформы	4
БФ00.1.0.023_0105003	Крышка пальцев цилиндров платформы	4
БФ00.1.0.024_0501001	Гидроцилиндр-80.50xS.17	2
БФ00.1.0.025_0501002	Гидроцилиндр-110.56	2
БФ00.1	СБ Платформа/Platform Assembly	1
БФ00.2.0.02_0101007	Труба 160X80x4 мм сталь профильная, L=20 мм	2
БФ00.2.0.01_0101008	Труба 180x10x4мм сталь профильная, L=2350 мм	2
БФ00.2.0.03_0105004	Косынка на рога	4
БФ00.2.0.04_0105005	Лист 10x10мм стальной, L=20 мм	4
БФ00.2.0.05_0105006	Косынка телескопа	4
БФ00.2.0.06_0101011	Труба n 108 стенка 10 мм стальная, L=240 мм	1
БФ00.2.0.07_0501003	Гиброцилиндр-63.40x990.11	2
БФ00.2.0.08_0106002	Палец n30 мм.(-0,2) L=140 мм	2
БФ00.2.0.08_0106003	Палец n30 мм.(-0,2) L=10 мм	2
БФ00.2.0.09_0105007	Крышка пальцев цилиндров рогов и аутригеров 10	4
БФ00.2	СБ Рогатка/Boom Assembly	1

Figure 12. Reworked Bill of Material proposal.

New Bill of material, Figure 12 (full table can be seen on Appendix 1), made on a principle of Super Bill of Material. That whole product is divided into several sub-assemblies or processes: platform, booms, painting, mounting on chassis, hydraulics, electrics. Each one contains list of spare parts and raw material used during related stage. Improving bill of material should improve a wide range of activities, related to the production from procurement process, where clear view, of what parts and material are required is a crucial point, to assembly itself, where clear instructions reduce amount of errors and defect.

4.4.3 Lean manufacturing principles

Due to the Lean management discussions and forums originate in 2006, it can be stated that Russia for several decades is falling behind other countries regarding acquaintance with Lean. Considerable interest in this philosophy during current time is, above all, the desire to catch up, as well a necessity, virtually the only way to increase competitiveness in the domestic and foreign markets. However, "Technopolis" company has a job shop and operates on a make-to-order strategy, there is still space for lean principles and manufacturer can benefit from implementing them in order to optimize its processes.

There is one last point to make about lead time in a job shop environment, and it is absolutely critical to understand. Unlike the typical automobile supplier, job shops often do not have a promise of three years' worth of work on the horizon; usually they live from job to job. Typically, their jobs are competitively bid, and very often quoted delivery time is a crucial decision making criteria, second only to cost in the final bid analysis. If you are not able to deliver on time, even with the low bid, you will lose the job. So, lead time is crucial to these entrepreneurs. Although short lead times will not guarantee success, long lead times will almost certainly guarantee failure. Short lead time is equal to future business to these dynamic businesses.

(Wilson, 2010, 83.)

A key point of the conversion the company to the Lean concept is to create an integrated system with its major suppliers and consumers. This means that the introduction of the concept only at the company does not lead to the elimination of the losses, reducing of costs and increasing of profits. It is important that suppliers provide the company with necessary materials and semi-finished goods and operate in accordance with the basic principles and values of the Lean Manufacturing, it was important to mention, because in Russian industry suppliers tend to delay deliveries and increase lead times, due to a wide range of reasons. So, there is need in a hard work of procurement department to negotiate with vendors, set up conditions and rules and search for other suppliers, if necessary.

4.4.3.1 Production processes optimization and Lead time reduction.

As Wilson (2010, 75) mentions in his book: “Responsiveness and flexibility are the life blood of a typical job shop. For them, these advantages can be achieved through the reduction of lead times.”

Actions done on organizing new BOM and item coding opened up possibilities to reorganize procurement processes and production operations. First suggestion comes with hydraulic, as it is shown in BOM, Appendix 2, - all connection (hosepipes and fittings) units are collected to complete sub-assembled parts, which are ordered in ready and crimped kits from sub-contractor, lead time for a set of these units is one working day. This allows to noticeably decrease inventory, since keeping all spare parts separately is excluded and they are stored at vendor’s warehouse. And get rid of 8 hours of work done by a worker to sort all details and prepare them for crimping.

Company is operating in a push production system. And, due to the make-to-order strategy, it is irrelevant to change all its operations to the pull system. Push-pull interface can still be implemented at the purpose of reducing lead time. In the particular case of skip loader, push-pull interface is suggested at the metal work stage. More precisely: during platform production, main frame is a complex part, which takes significant amount of time to process, but it is similar in all skip loader models, even if truck chassis skip loader is based on are different, only variation in this case will be width between longerons (supporting beams) and outrigger height, advice is that platforms kits are produced in a pull system, by two workers, with cycle stock of four kits. Kit consists of all parts prepared, but longerons and outrigger details are not welded and fixed. These kits are then assembled by another worker, when order comes. With frames being ready and some of the parts prepared beforehand we save around of 12 hours for the production process of final product. During time first four skip loaders are assembled new kits for future orders will be ready.

Painting process takes most of the time, and slows down whole process a lot. It is possible to cut down time needed, by sending several parts, such as retractable part of booms and outrigger supports to zinc coating. By applying this solution not only 6 hours of working time will be saved, because zinc coating is done by sub-contracting, but also there will be benefit from corrosion resistance, these are moving parts, so their paint coating damages faster, then other parts of the skip loader and zinc coating will be able endure longer.

By reforming processes and sub-contracting other there is a possibility of saving 18 hours of production time, total time for assembling one skip loader becomes 35 hours, which leads to an increase of maximum month’s output of ten skip loaders done by one team. Figure 13 shows optimized production process and Figure 14 one month’s production schedule at full capacity, where at the top can be seen process of frames welding, which is done in a pull system.

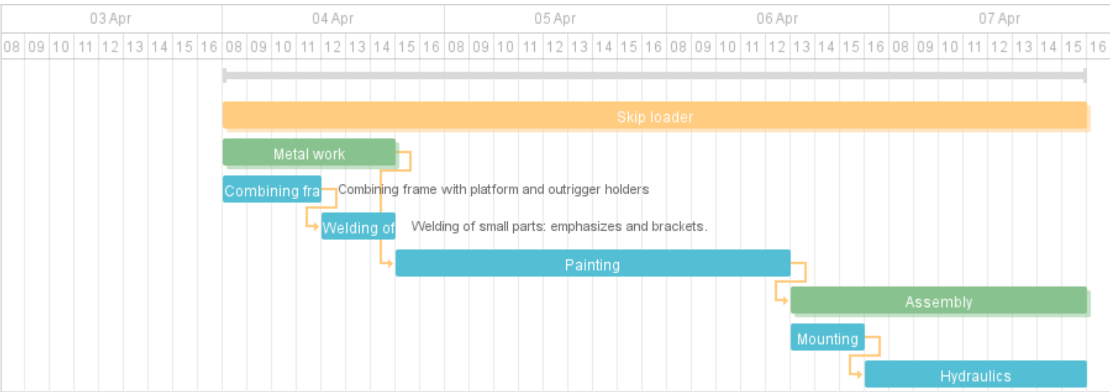

Figure 13. Production process optimization proposal.

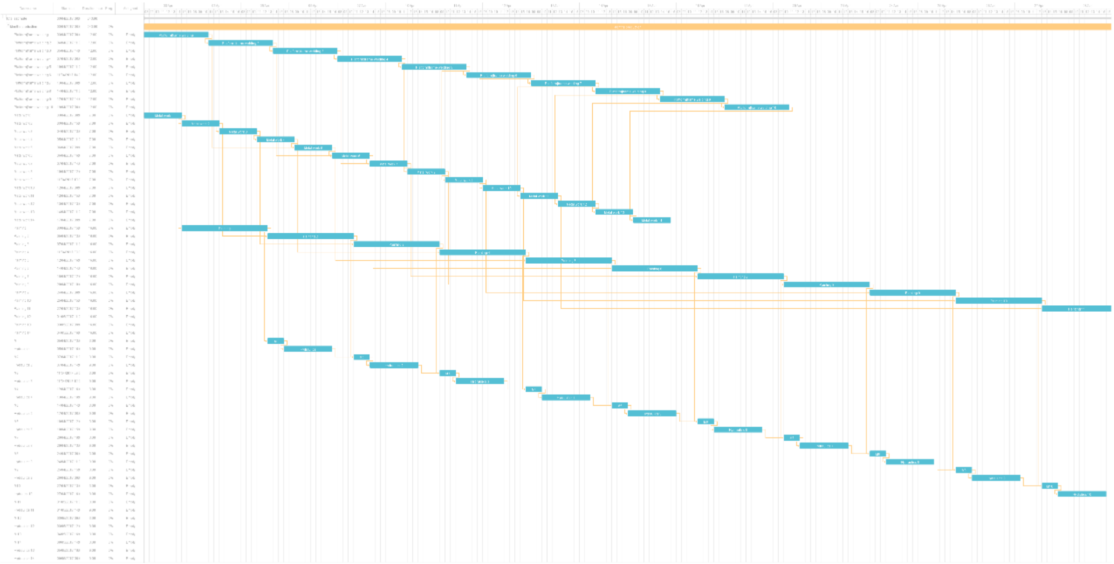

Figure 14. Maximum one month output with new process layout.

4.4.3.2 Quality control

As one of the main wastes, low quality, resulting in scrap and rework bring a lot of costs and other losses, like loss in trust and reputation. So, it is important to pay much attention and put effort, in order to eliminate quality issues. This can be done by a series of different actions, some of them are suggested below:

1. To reduce the level of reject:

• By carrying out measures on perfecting technological processes in each shop;

• By strengthening of control by R&D on a number of nomenclature positions having the highest level of defectiveness;

• By holding weekly quality meetings.

2. Minimize the repeated control (due to the system of measures called "Built-in quality");
3. Reduce the proportion of parts that undergo additional reprocessing.

4.4.3.3 5s method

Implementing 5S principles should start from changing culture and attitude in the company, so that Sustain principle could be fulfilled, because even if everything is in order and organized, without control and reorganizing it is effortless. As for separating and setting everything to order: tool boxes and containers, shelves, instructions and signs, as well as floor markings – all these should be organized in a way to help and support operations and not interrupt them. These are complex procedures, that should be done in a cooperation with all teams of workers.

5 Conclusions

In conclusion, following recommendations and solutions were provided to the company:

Proposed solutions	*Who is responsible*
Item coding implementation	Procurement and R&D department
Bill of material implementation	Procurement and R&D department
Lead time optimization	Director of operations and R&D dept.
5S method implementation	Director of production and team leaders
Quality improvement	Director of operations

After collection of the information, observations and analysis several solutions were offered for improvement and optimization. In addition to material management advices and lead time reduction suggestions, there were also additionally presented practices and methods of Lean Manufacturing, as well as some issues being highlighted: quality control and negotiation with suppliers.

All described advices can be, with due attention, implemented in company's operations. As goals of this thesis were to provide with advices and possible solutions, that later on can be implemented, project work can be considered successful. As topic of production reengineering is wide and complex and in this thesis case attention was focused on only one product of the company, further research can be done in implementing all these practices and ideas to the whole system, as well as, controlling this implementation process. Another important topic, that was not discussed, but can be and should be mentioned is an implementation of an ERP system.

Problems associated with improving the efficiency of operations and production processes are constantly arising before the leaders of any company. These problems are relevant to most of the modern enterprises and “Technopolis” Ltd is not exceptionable. Main reasons for this are factors stated below:

• Rapid development of enterprises;

• Constant search of place in new markets (including international);

• The search for new investments and the realization that a low organizational culture is holding back their inflow.

Summarizing, it is necessary to note once again that the organization of production processes is a delicate tool in hands of the manager, with which he can lead the enterprise to success, prosperity and stability, but with inept or inappropriate use, the opposite results appear and can be catastrophically. Therefore, it is necessary to study methods of improving the organization of production, monitor its formation, improve and regulate its changes. It should become an organic part of the whole enterprise, be adequate to modern requirements dictated by economic and technological development and, consequently, improve the efficiency of the enterprise.

6 Discussion

Main purpose of this work was to register and research problems inside the manufacturing processes, go through their roots and outcomes. Also, propose advices and solution to improve operations, which were found to be causing disruptions and slips. Secondly, another goal was to give hints and directions, on which themes and operations to focus, in for the future improvement. Qualitative research methods showed to be successful and served well for the tasks of this thesis.

In order to realize and keep working – all presented solutions need well defined cooperation and communication between departments, as well as control of fulfillment of routine tasks, that would sustain newly developed processes and system.

Further topics for research, that either appeared during thesis work or were left unsolved due to time and resource limitations could be these: improvement of organizational structure, implementation of complex ERP system, applying other types of lean practices, deeper examination of layout and its possible reform and other.

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Appendices

Appendix 1. Reworked Bill of material

	A	B	C	D	E
1		Skip Loader/ Бункеровоз			
2		Item code	Description	Pcs.	
1		Skip Loader/ Бункеровоз			
2		Item code	Description	Pcs.	
3		БФ00.1.0.001_0101003	Труба 140x140x4мм сталь профильная, L=2550 мм	1	
4		БФ00.1.0.002_0101002	Труба 10x60x4мм сталь профильная, L=2236 мм	2	
5		БФ00.1.0.003_0101002	Труба 10x60x4мм сталь профильная, L=2170 мм	2	
6		БФ00.1.0.004_0101002	Труба 10x60x4мм сталь профильная, L=682 мм	3	
7		БФ00.1.0.005_0101002	Труба 10x60x4мм сталь профильная, L=1240 мм	2	
8		БФ00.1.0.006_0101004	Труба10x10x4мм сталь профильная, L=2170 мм	1	
9		БФ00.1.0.007_0101002	Труба 10x60x4мм сталь профильная, L=652 мм	1	
10		БФ00.1.0.008_0103001	Уголок 25x25x3мм стальной, L=180мм	1	
11		БФ00.1.0.014_0101005	Труба 50x25x3мм сталь профильная, L=642 мм	1	
12		БФ00.1.0.015_0101001	Труба 160x80x5мм сталь профильная, L=350 мм	2	
13		БФ00.1.0.017_0101005	Труба 50x25x3 мм сталь профильная, L=450 мм	2	
14		БФ00.1.0.018_01010010	Труба n42 стальная, L=630	4	
15		БФ00.1.0.013_0105001	Пластина толщина 10 мм	4	
16		БФ00.1.0.012_0105002	Пластина толщина 10 мм	4	
17		БФ00.1.0.016_0102001	Лист 1050x5 мм стальной, L=2236мм	2	
18		БФ00.1.0.019_0102003	Упор боковой	2	
19		БФ00.1.0.020_0103002	Уголок под упор	1	
20		БФ00.1.0.021_0102003	Упор контейнера	2	
21		БФ00.1.0.022_0106001	Палец цилиндров платформы	4	
22		БФ00.1.0.023_0105003	Крышка пальцев цилиндров платформы	4	
23		БФ00.1.0.024_0501001	Гидроцилиндр-80.50x5.17	2	
24		БФ00.1.0.025_0501002	Гидроцилиндр-110.56	2	
25		БФ00.1	СБ Платформа/Platform Assembly	1	
26		БФ00.2.0.02_0101007	Труба 160X80x4 мм сталь профильная, L=20 мм	2	
27		БФ00.2.0.01_0101008	Труба 180x10x4мм сталь профильная, L=2350 мм	2	
28		БФ00.2.0.03_0105004	Косынка на рога	4	
29		БФ00.2.0.04_0105005	Лист 10x10мм стальной, L=20 мм	4	
30		БФ00.2.0.05_0105006	Косынка телескопа	4	
31		БФ00.2.0.06_0101011	Труба n 108 стенка 10 мм стальная, L=240 мм	1	
32		БФ00.2.0.07_0501003	Гиброцилиндр-63.40x990.11	2	
33		БФ00.2.0.08_0106002	Палец n30 мм.(-0,2) L=140 мм	2	
34		БФ00.2.0.08_0106003	Палец n30 мм.(-0,2) L=10 мм	2	
35		БФ00.2.0.09_0105007	Крышка пальцев цилиндров рогов и аутригеров 10 мм	4	
36		БФ00.2	СБ Рогатка/Boom Assembly	1	
42		БФ00.3	СБ-Направляющая аутригера	2	
43		БФ00.4.01_0102004	Кронштейн крепеж к раме	6	
44		БФ00.4.02_0106003	Бугель	4	
45		БФ00.4.03_0107002	Гайка накидная M18x1,5	24	
46		БФ00.4.03_0107010	Болт M18x1,5	24	
47		БФ00.4	Сборка и крепеж к шасси		
70		БФ00.5	Сборка гидравлики		
73		БФ00.6	Покраска		
74					

Appendix 2. Hydraulics kits

БФ00.4.03_0107010	Болт М18х1,5	24
БФ00.4	Сборка и крепеж к шасси	
БФ00.5.0.001_0502001	Гидрораспределитель Badestnost model A1A1A1A16KZ1	1
БФ00.5.0.002_0502002	Регулятор потока с обратным клапаном VRFU 90 3/8"	1
БФ00.5.0.003_0502003	Тройник (г-ш-ш) 3/8 на М22х1.5	3
БФ00.5.0.004_0502004	Делитель потока V-EQ 30 (V1006) 3/8 на М22х1.5	1
БФ00.5.0.005_0502005	Гидрозамок VPDE 3/8"	2
БФ00.5.0.006_0503001	L1225 (1,41) DKOL M22x1,5 (90 +Ш)	2
БФ00.5.0.007_0503002	L1225 (1,41) DKOL M22x1,5 (90 +90)	3
БФ00.5.0.008_0503003	L1225 (0,91) DKOL M22x1,5 (90 + Ш)	1
БФ00.5.0.009_0503004	L1225 (0,91) DKOL M22x1,5 (0 + 90)	1
БФ00.5.0.010_0503005	L1225 (0,80) DKOL M22x1,5 (90) + BANJO 1/2"	1
БФ00.5.0.011_0503006	L1225 (0,80) DKOL M22x1,5 (0) + BANJO 1/2"	1
БФ00.5.0.012_0503007	L1225 (0,21) DKOL M22x1,5 (90 + Ш)	2
БФ00.5.0.013_0503008	L1225 (2,10) DKOL M22x1,5 (Ш) + BSP 1/2" (0)	4
БФ00.5.0.014_0503009	L2025 (0,72) BSP 3/4 (0 + 90)	1
БФ00.5.0.015_0503010	L1025 (0,92) DKOL M18x1,5 (Ш+0)	4
БФ00.5.0.016_0503011	L1025 (0,71) DKOL M18x1,5(Ш) + BANJO 1/2"	2
БФ00.5.0.017_0503012	L1025 (0,71) DKOL M18x1,5(Ш) + DKOL M22x1,5(90)	2
БФ00.5.0.018_0503013	Трубка гидравлическая 15х1.5 1500mm	2
БФ00.5.0.019_0503014	Трубка гидравлическая 12х2 1800 mm	4
БФ00.5.0.020_0503015	Трубка гидравлическая 12х2 100 mm	4
БФ00.5.0.021_0701001	Гайка накидная М22х1,5	12
БФ00.5.0.022_0701002	Гайка накидная М18х1,5	8
БФ00.5	Сборка гидравлики	