Optimization of Serviceability of Vulcanizing Presses of Commercial Tires in Continental Barum s. r. o.

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Diploma thesis
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Zásady pro vypracování:

Úvod

I. Teoretická část

- **Vypracujte literární rešerši teoretických poznatků využitelných v pratické části.**

II. Praktická část

- **Analyzujte současný stav na pracovišti lisovna komerčních plášťů v Continental Barum s. r. o.**
- **Na základě analýzy vypracujte návrhy, vedoucí k optimalizaci a zlepšení současného stavu.**
- **Zhodnoťte navržené alternativy a aplikujte je do projektové části.**

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ABSTRAKT

Diplomová práce je zaměřena na řešení konkrétní úlohy v Continental Barum s. r. o. s použitím metod průmyslového inženýrství. Teoretická část obsahuje vysvětlení pojmů, týkajících se průmyslového inženýrství, produktivity a měření práce včetně vzájemných souvislostí. Praktická část je složena z části analytické a projektové. Analytická část obsahuje popis firmy Continental Barum s. r. o. a analýzu vybraného pracoviště, zejména pomocí časových snímků. V projektové části jsou konkrétní návrhy pro optimalizaci obslužnosti vulkanizačních lisů komerčních plášťů včetně propočtů časových úspor a navrhovaných změn.

Klíčová slova:

Průmyslové inženýrství, produktivita, analýza a měření práce, časový snímek, optimalizace obslužnosti

ABSTRACT

The diploma thesis is focused on solving of specific problem in Continental Barum s. r. o. with application of industrial engineering methods. The theoretical part contains explanation of terms relating to industrial engineering, productivity and work measurement, including mutual contexts. The practical part consists of analytical and project part. The analytical part contains a description of the company Continental Barum s. r. o. and analysis of selected workplace, especially by time snapshots. In the project part there are concrete proposals for optimization of serviceability of vulcanizing presses of commercial tires, including calculations of time saving and proposed changes.

Keywords:

Industrial engineering, productivity, analysis and measurement of work, time snapshot, optimization of serviceability

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My special thanks belong to my family, P. Mgr. Petr Bulvas and fellowship RR49.

I do not have any brilliant bank account, I do not have any glittery jewellery, I do not have any exhibition buildings, I do not have any great wealth. But I have friends and people whom I can devote my favour. And that is important – the people, whom you can help to become better. Than you become better too. *Jan Pivečka* (Zelený, c2005)

I hereby declare, that the printed and the electronic version of this diploma thesis, uploaded in IS/STAG are identical.

CONTENT

INTRODUCTION

Nowadays we can see more clearly around us globalization, the increase in the volume of goods, services and information, along with the ever accelerating progress and constant pressure for higher efficiency due to competitiveness of countries, companies and actually every of us.

According to expert estimates, in European Union there became extinct approximately 40 million jobs as a result of the industry transfer and production towards cheaper labour in Asia. In our country, industry creates about third of gross domestic product. At first glance, it seems why a lot of people see in industrial engineering (which is focused on increasing productivity and efficiency) our future and nearly salvation. In addition, the economic recession has shown that the services sector only in our economy is not enough.

The main objective of this thesis is to propose a project to increase the efficiency of serviceability in concrete workplace in Continental Barum s. r. o. It means the application of industrial engineering, increase of productivity and efficiency on the basis of what I learned at school and in the real situation of this company.

However, I would like to return to the first paragraph of the introduction. While creating this diploma thesis I want to also consider, if the way marked above is really the best for us. In other words, I want to try to work as an industrial engineer in the world class company and enrich this project with my approach, which I have learned in my life. I would like to call this attitude as *industrial engineering with human face*.

Note: From 1 January 2013, the company Barum Continental, spol. s r. o. was renamed to Continental Barum s. r. o. However, some sources used in those work was signed by older name.

I. THEORETICAL PART

1 INDUSTRIAL ENGINEERING AND ITS SIGNIFICANCE

Let´s do imperceptible thing, but let´s do it the best way in the world.

(Baťa, 2002, p. 92)

Already in Tomáš Baťa's thoughts and activities we can find what nowadays we call world class manufacturing. Today it is not enough, to be the best company in its region, country, or even continent. One of the positive aspects of globalization is that the customer has huge choice during process of making purchasing decision. Because of that, businesses must constantly strive to be better. This is the only way to be successful in that hard competitive environment.

1.1 The importance of the concept "to be better"

The practical meaning of the words **to be better** is permanent improving of the efficiency (thus decreasing of volume of input, which is needed for creating output), productivity, lowering prices and improving the quality of the goods. At first glance, these concepts may seem contradictory. It is therefore necessary to ask whether it is possible to reduce costs and improve quality of product in the same time? And here is the point, where industrial engineering (IE) is getting the word.

1.2 Industrial engineering

Industrial engineers (IEs) are responsible for designing integrated systems of people, machines, material, energy, and information. An industrial engineer may be responsible for the quality of automobiles coming off the end of a manufacturing line, the scheduling of a hospital's emergency room, or even designing a better cockpit to improve the performance of a fighter pilot. (University of Louisville, 2013)

Industrial engineering is a multidisciplinary field that combines technical knowledge of engineering and knowledge of management. Rationalisation, optimizing and improving the efficiency of manufacturing and non-manufacturing processes are typical for industrial engineering. Industrial engineering is systematically engaged in designing, planning, implementation and improvement of processes and also helps to ensure high efficiency and competitive innovation. In practice, industrial engineering ensures the efficient functioning of people, information, machines, materials and energy. Industrial engineering can thus be understood as a searching for easier, better and cheaper way to implement and manage business processes. (API, © 2005-2012a)

Industrial engineering mainly covers activities as projection, implementation and improvement. It uses the four basic groups of methods and techniques: (Mašín and Vytlačil, 2000)

- *Planning, designing and management (for example work measurement, calculation of capacity or creating of incentive salary system).*
- *The implementation of human dimension (for example design of production and service teams, ergonomics or program for process improvement).*
- *Technological aspects (for example design of manufacturing cells or design for assembly).*
- *Quantitative and creative methods (for example simulation of processes or industrial moderation).* (Mašín and Vytlačil, 2000, p. 82)

In figure 1 we can see the breakdown of IE focused on proposal and improvement.

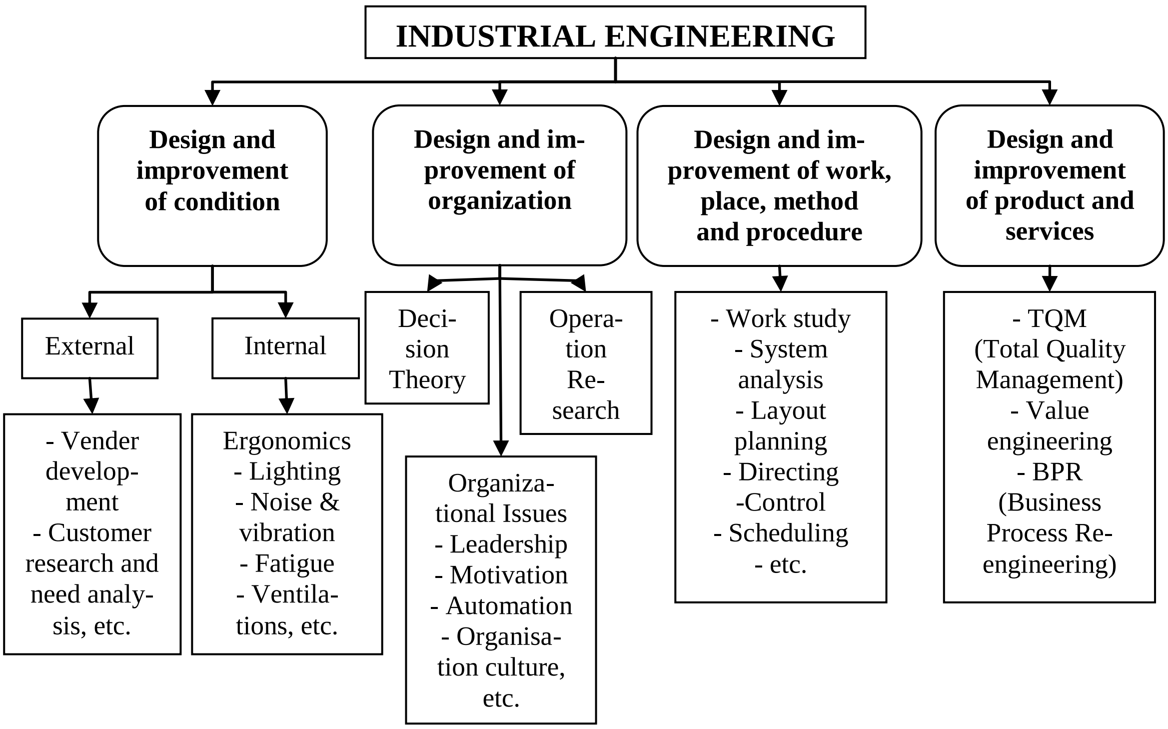

Figure 1: The scope of industrial engineering (Transtutors, 2013a)

Industrial engineering is a field, which is focused on elimination of wasting, unevenness, irrationality and overloading of the workplace due to more sophisticated performance of work. The results of industrial engineering, doing in right way, is creating of quality products and services in easier, faster and cheaper way. (Mašín and Vytlačil, 2000)

1.2.1 Historical development of industrial engineering

According to various authors, there are several views (based on different attitudes) on the history of industrial engineering. I personally tend to the idea, that development of industrial engineering can be divided into six stages: (Transtutors, 2013b)

- *Phase 1: Pre-Industrial Revolution Era (up to early 1800s)*
- *Phase 2: Industrial Revolution (early 1800s to late 1800s)*
- *Phase 3: Scientific Management Phase (1890 to 1940)*
- *Phase 4: Operations Research and Quantitative Phase (late 1940s to early 1980s)*
- *Phase 5: Automation and Computer Integrated Manufacturing Phase (since early 1980s)*
- *The future trend is towards more automation, computer controlled manufacturing, information handling through computers, and integration of manufacturing systems.*

From a practical point of view, there are important inventions and discoveries of people, which led to an increase in productivity and efficiency. These major events are chronologically recorded in the figure 2 on the next page.

1.2.2 Present and future of industrial engineering

At present, the industrial engineering is more and more connected with IT technologies. In connection of usage of IT technologies, the speed and exactness of information transfer are increasing. Latest manufacturing factories are on high level of automation and robotics. At the same time, however, in industrial engineering the art of communication and creative thinking are important because machines are not able to do it.

It is difficult to estimate development in the future. However, nowadays it seems clear that the worldwide trend looks towards the increasing automation and robotics in manufacturing and non-manufacturing organisations too. Employees will gradually shift away from production to maintenance, services and creative thinking. The question remains, if these sectors will be enough for satisfying employment.

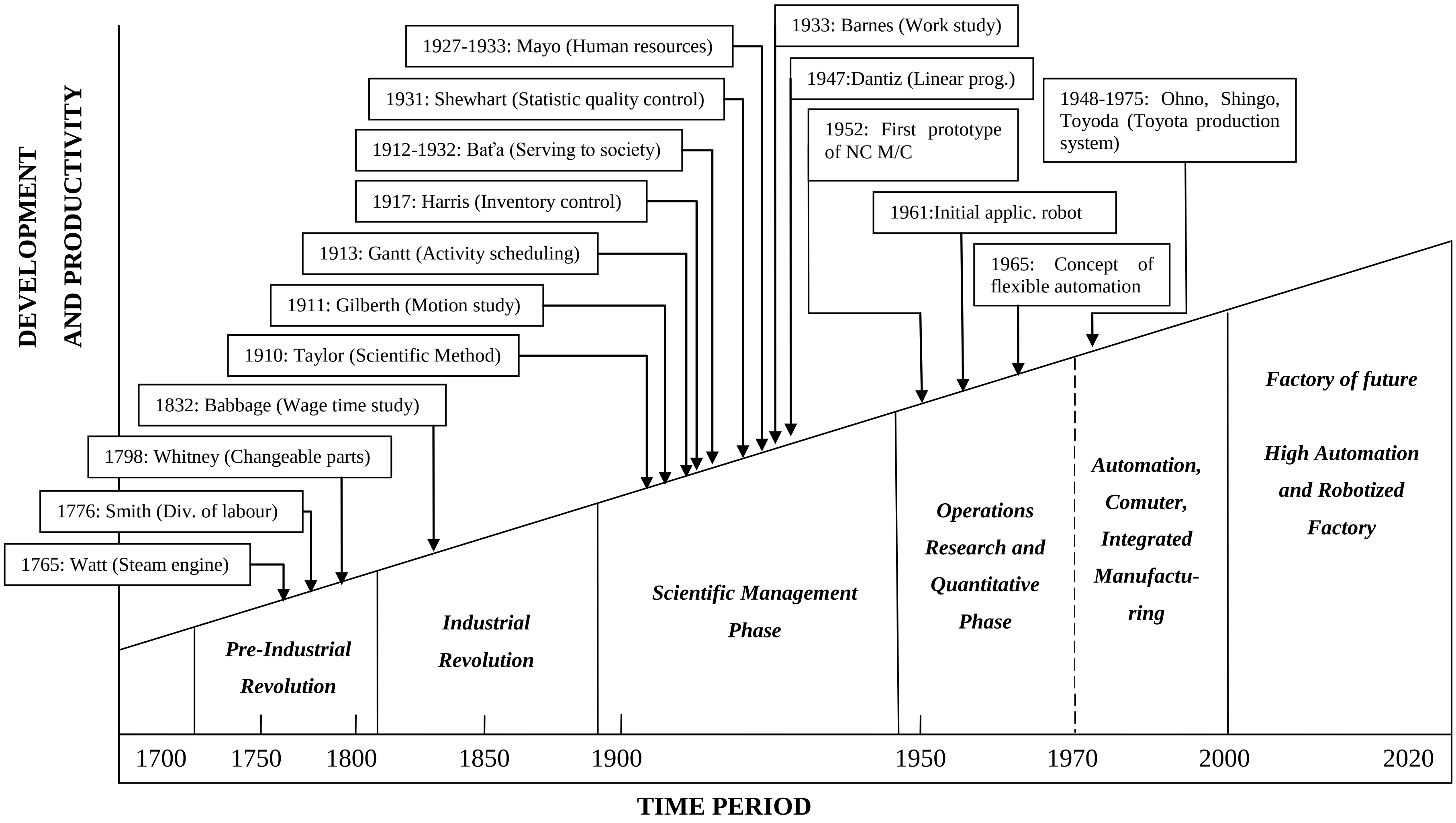

Figure 2: Development of IE (Transtutors, 2013b)

1.3 Business processes and their improvement

The process is a set of activities that change inputs to the outputs. Topic of business processes is mainly about order from customer and its getting by business processes as quickly as possible while complying with the required standards and at minimum costs. The longer order delays during getting by business processes, more and more costs "stick" on it and that means longer delivery time for customer and waiting of company for its money too.

(Košturiak, 2010, p. 15)

Process improvement is based on its knowledge.

We recognize and improve processes by using standard procedures, which consist of particular steps. The most used procedures are models as PDCA (Plan-Do-Check-Act), SCORE (Select-Clarify-Organize-Run-Evaluate) and DMAIC (Define-Measure-Analyze-Improve-Control). (Svozilová, 2011)

The last mentioned model is used by Continental group. That is why I am going to write more details about DMAIC later.

Any manufacturing and non-manufacturing process includes activities, which add or do not add value. This is shown in the figure 3. Customer is willing to pay only for value-added activities. The principle of industrial engineering is an elimination of activities, which do not add value.

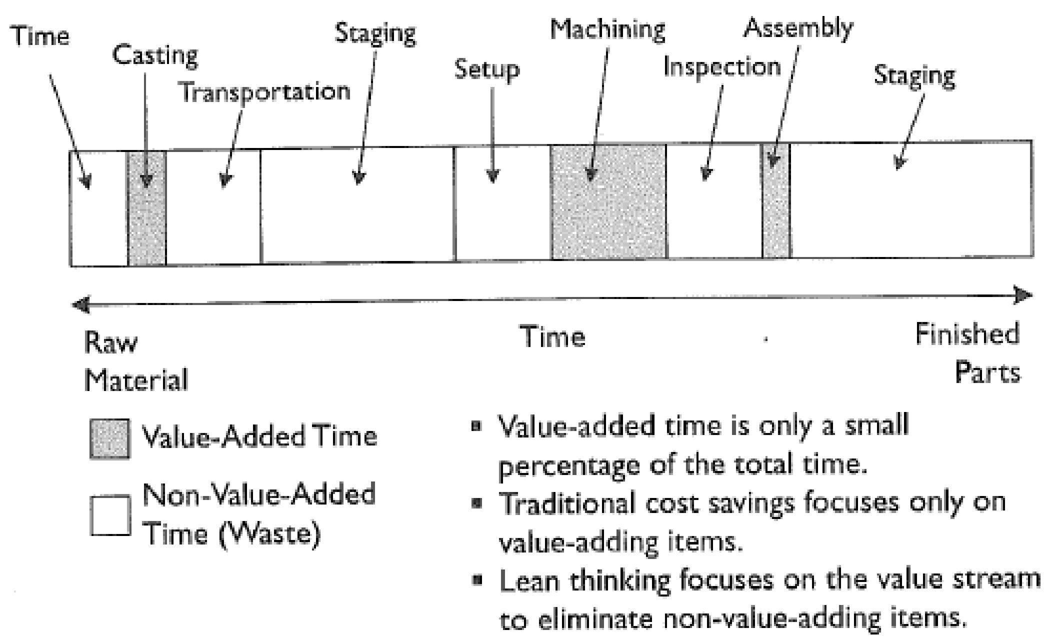

Figure 3: Waste and value (Liker, 2004, p. 30)

1.3.1 Waste

We call activities, which do not add value, as waste. The task (or let us say "daily bread") of an industrial engineer is **identification and elimination of waste**.

We define 8 kinds of waste for easier finding: (Liker, 2004, p. 28-29)

1. Overproduction is production without orders. Consequences of overproduction are other costs (overstaffing, storage and transportation) for increasing inventory.

2. Waiting (time on hand) means, that workers are waiting for next processing step of automated machine or they do not have part or tool, which they need for their work. Workers have to wait because of delays of material and capacity bottlenecks also.

3. Unnecessary transport or conveyance. It is caused by long distances between workstations or warehouses. Typical key tool for identification of this wasting is making of spaghetti diagram.

4. Overprocessing or incorrect processing. Processing can be inefficient due to using of poor tools, product design and defects. During overprocessing there is danger of inattention, injury and of course decreasing of performance.

5. Excess inventory we can find, if we have higher quantity of raw material, WIP (work in progress) or finished goods than we really need. Transportation is more expensive and it requires more time.

6. Unnecessary movement means each motion of employee, which is done over to efficient operation sequence. For example complicated moving with product (if there is easily way in standardized operation sequence), looking for something, etc.

7. Defects are reason for wasting as rework, repair or scraping of defected production. Decreasing of quality is in business with high competition serious problem.

The last kind of waste was added separately (we can find only seven sort of waste in some materials).

8. Unused employee creativity is probably the most difficult for identification. Industrial engineers should never forget to ask worker, who is working according to concrete operating sequence, if he or she has some idea for improving of that process.

Figure 4 shows elimination of waste in Toyota Production System.

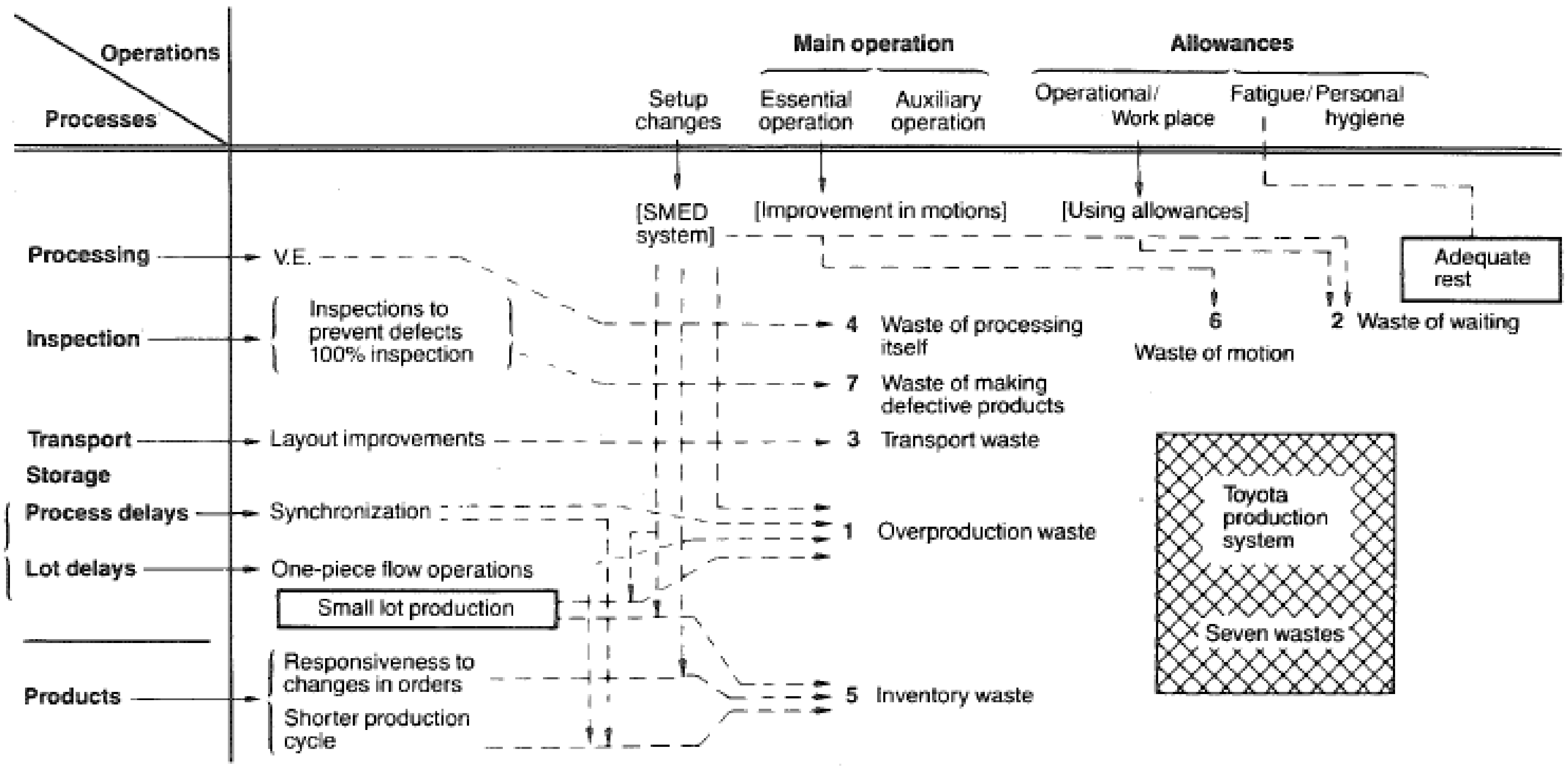

Figure 4: Elimination of waste in Toyota Production System (Shingo, c1989, p. 193)

1.3.2 DMAIC Cycle

We can find DMAIC tool often in the area of process improvement. This acronym stands for: Define-Measure-Analyze-Improve-Control. During **define**, we determine customer of the process, the problem itself, the current versus future state and the scope of an improving process. For **measure** we need to know scales of the process, accuracy and reliability of measuring, data availability and the system of measurement process. Next step is **an analysis** in which we are interested in problems of process, its causes, availability and quality of resources and risks of process too. For **improve** step there are important suggestions for troubleshooting, verification, simulation and modelling, implementation of changes and optimization of suggestions and changes. We are doing **control** phase with activities measuring, monitoring, optimization, observation and correcting of process, stabilizing changes and evaluating of results. (Svozilová, 2011)

The entire DMAIC process is to be repeated, so final step in this model is not the final step of the whole process of improving. This is illustrated by following figure 5 from the concern Continental.

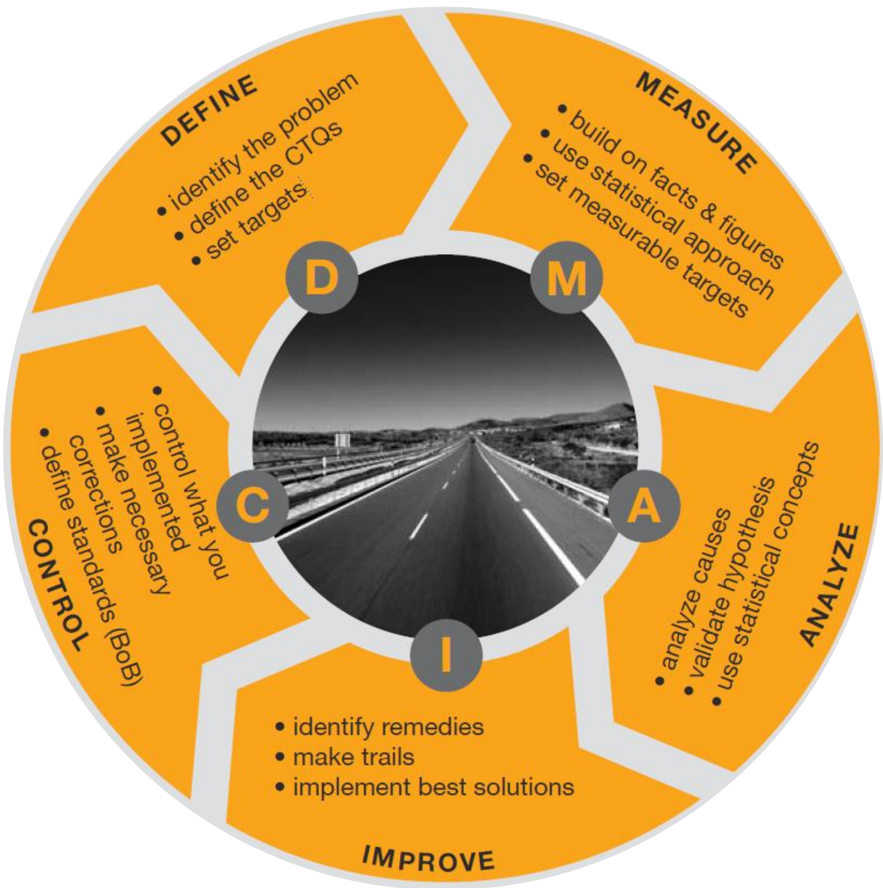

Figure 5: DMAIC in Continental (Barum Continental, 2012)

When we are talking about improving of processes, it is necessary to mention **kaizen**. It is a way of thinking (we can say philosophy) that would be common for all employees in company (from managers to workers). The Japanese word kaizen means the change for better and the goal is continuous improvement of processes in whole organization. (Košturiak, 2010)

1.4 Toyota way – example of process improving

In 1970, die changeovers on a 1 000-ton press took four hours to complete. After learning that Volkswagen in West Germany routinely changed equivalent dies in two hours, the department head requested that we reduce our changeover time similarly... Three months later, the department head again contacted me about improvements (...) to reduce press setup time to three minutes! (Shingo, 1989, p. 24)

Toyota Productive System (schematically show on figure 6) is called *Manufacturing System That Changed the World.* (Liker, 2004, p. 22). One of the roots for Toyota´s success was philosophy of Toyoda family: *to think beyond individual concerns to the long term good of the company, as well as to take responsibility for problems.* (Liker, 2004, p. 19)

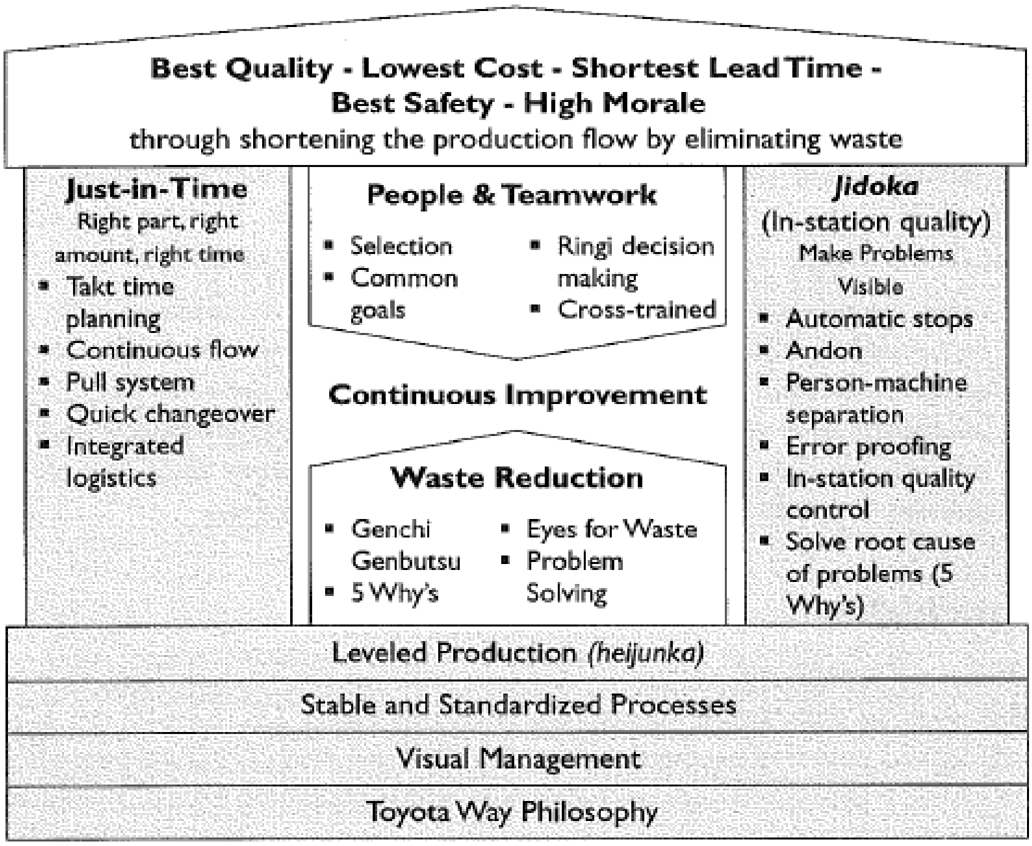

Figure 6: Toyota Production System (Liker, 2004, p. 33)

Three main persons of Toyota Productive System were Sakichi Toyoda, his son Kiichiro Toyoda and production engineer Taiichi Ohno. After Second World War and visiting of Ford Motor Company and General Motors in USA, Toyota accepted the challenge, which seemed impossible: To be more efficient than mentioned American companies. Toyota started with hard work, which consisted of learning (by doing) from the best and improving it for overtake. Toyota was inspired by Ford´s moving assembly line, but instead of Ford´s mass production Toyota focused on *low volumes of different models using the same assembly line*. Pull system was inspired by American supermarkets. One-Piece flow was became a core principle of Toyota Productive System. (Liker, 2004, p. 20 - 22)

From above picture of Toyota Productive system it is clear that productivity is important, but without flexibility and efficiency the system cannot be successful.

We should realize that building of high level of productivity, flexibility and efficiency is not all about eliminating of waste only. It can be explained by Three M´s principle: (Liker, 2004, p. 114)

- *Muda (Non-value-added)*
- *Muri (Overburdening people or equipment)*
- *Mura (Unevenness)*

Previous information is captured graphically in the figure 7. The three M´s are interconnected, so it is important to work on eliminating all of them.

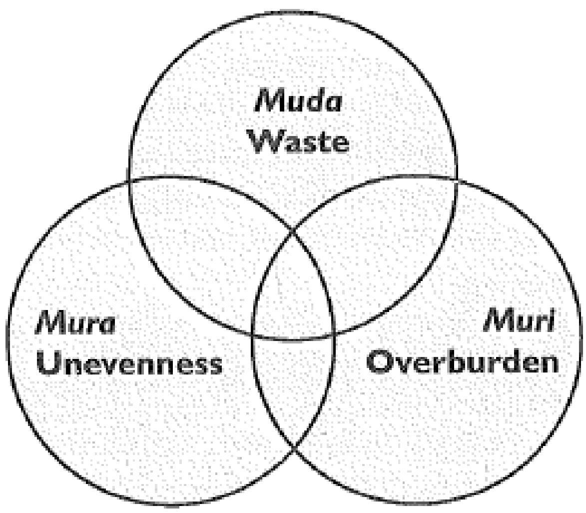

Figure 7: Three M´s (Liker, 2004, p. 115)

Finally I need to say that it is mistake to reduce Toyota Productive System only to eliminating three M´s, or increasing productivity, flexibility and efficiency. Toyota way is way of thinking, which should be implied in corporate strategy and in thinking of all employees of concrete company.

In the figure 8 we can see that process of elimination waste is a part of long term ambition and application.

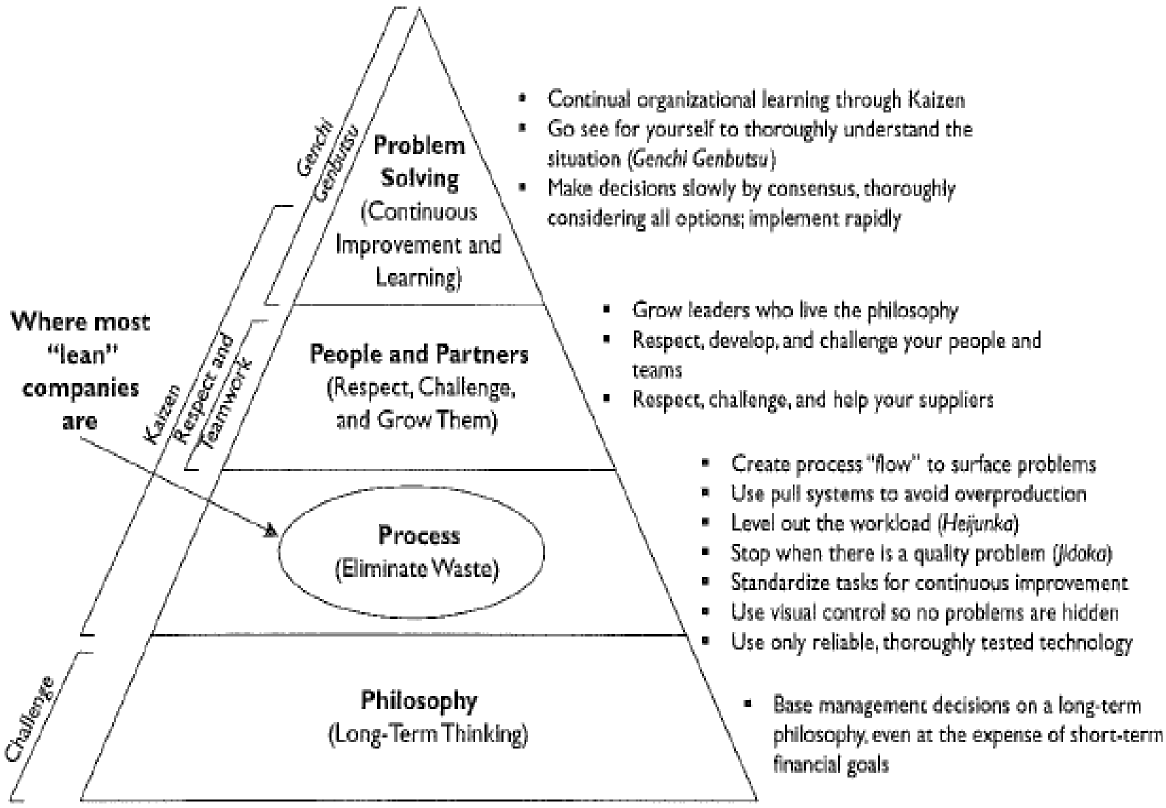

Figure 8: „4P“ model and where most companies are (Liker, 2004, p. 13)

In this way Toyota Productive System can be inspiration for current companies and organizations. We can be successful only if we unite demands of customers with requirements of owners and managers. Toyota Productive System is not only history, it is living example.

2 PRODUCTIVITY AND PRODUCTIVE WORK

Day has 86 400 seconds. (Baťa, 2002, s. 61)

2.1 Productivity as a reason for work measurement

Productivity is an expression of how well we use resources to create products and services. The basic and most general expression is ratio of output and input.

Basic expression of productivity = output / input

Output is expressed in units (for example tons, litres, pieces) or in financial units. Inputs are generally divided into different categories (for example labour, production device, material, capital). We can compare productivity of various nations, sectors, companies, teams or individual productivity. Basic expression of productivity is often modified on partial productivity, index of productivity, total productivity and total factor of productivity. (Mašín and Vytlačil, 2000)

Partial productivity is used to measure individual resources. It can be expressed for example as a number of products per 1 hour of worker, a number of products per 1 work hour or a number of products per 1 unit of material. (Mašín and Vytlačil, 2000)

Partial productivity = total measurable output / 1 class of measurable input

For being able to monitor productivity over time and compare individual results, we use index of productivity. We can count it as current productivity divided by standard of productivity and then multiplied by hundred. We are using standard results from past, results of competition, results of concrete sector or results from analysis of industrial engineers. Index of productivity shows actually how much we fill (or exceed) percentage of predetermined standard. (Mašín and Vytlačil, 2000)

Index of productivity = (current productivity / standard of productivity) * 100

During counting of total productivity we can include more resources with different measure units to the calculation, and therefore we have to convert different units to the same (financial) unit. The result shows us how many pieces of production are counted for 1 financial unit. It is recommended to calculate total productivity on the level of whole company.(Mašín and Vytlačil, 2000)

Total productivity = total measurable output / total measurable input

Total factor of productivity considers as expended resources only labour costs and capital inputs. It is appropriate to calculate total factor of productivity in such processes, in which is low level of material and high level of labour and capital resources. (Mašín and Vytlačil, 2000)

Total factor of productivity = total measurable input / (labour + capital)

Productive work belongs to key factors, which have major influence on productivity. In the usable working time of each employee in any organization we can find productive work (graphically shown in the table 1), which has to be maximized. Productive work can significantly affect the productivity of whole organization. It is clear that analysis and measuring of work are as important as measuring of the productivity.

Table 1: Usage of worker time (Mašín and Vytlačil, 2000, p. 39)

<table>
<tr><td colspan="4">Actual working time</td></tr>
<tr><td colspan="2">Waiting</td><td colspan="2">Work</td></tr>
<tr><td colspan="2">Lost time</td><td rowspan="2">Unnecessary work</td><td rowspan="2">Productive work</td></tr>
<tr><td>Worker</td><td>Management</td></tr>
<tr><td colspan="3">Non productive</td><td>Productive</td></tr>
</table>

3 ANALYSIS AND MEASUREMENT OF WORK

Analysis, measurement and scaling of work are in companies often perceived from two perspectives. One group considers this topic as a necessary evil, with main purpose on continual increasing of performance at any cost. The second group of people see main advantages of this methodology in detection of potential to improve current productivity and streamline performing of individual work tasks... Really we are trying to increase performance of working process, but certainly not by excessive load of workers, or even threats to their health. We are trying to increase performance by simplifying work and using time more for necessary than not necessary work. Suitable optimisations of work tasks, use of aids and tools to reduce the time and effort are bringing grow of efficiency of workers and machines. Productivity does not mean to work faster, but to work more rational. (IPA Slovakia, 2012)

Analysis and measuring of work mean using of tools and methods for this purpose. Thus we can mark out waste in work processes. The objective of work measurement is to determine the time consumption of concrete work. We settle this consumption of time based on direct (for example time snap-shoot of day) or indirect measurement (for example MOST). Positives of analysis and measurement of work are increasing of productivity with fairly low costs, definition of time norms, increasing of level of security and identification of waste. They can serve also as base for rewarding of workers. (API, © 2005-2012b)

3.1 Study of methods of work and work measurement

In the study of methods of work (work analysis) we can receive information about work processes and we try to find the best way (by elimination of waste) how we should carry on concrete work process. Work measurement means application of techniques for determining the time, required for concrete work process. Now we are getting close to make norms of work, which is carried on qualified worker and concrete required performance too. (API, © 2005-2012b)

Study of work is illustrated in the figure 9.

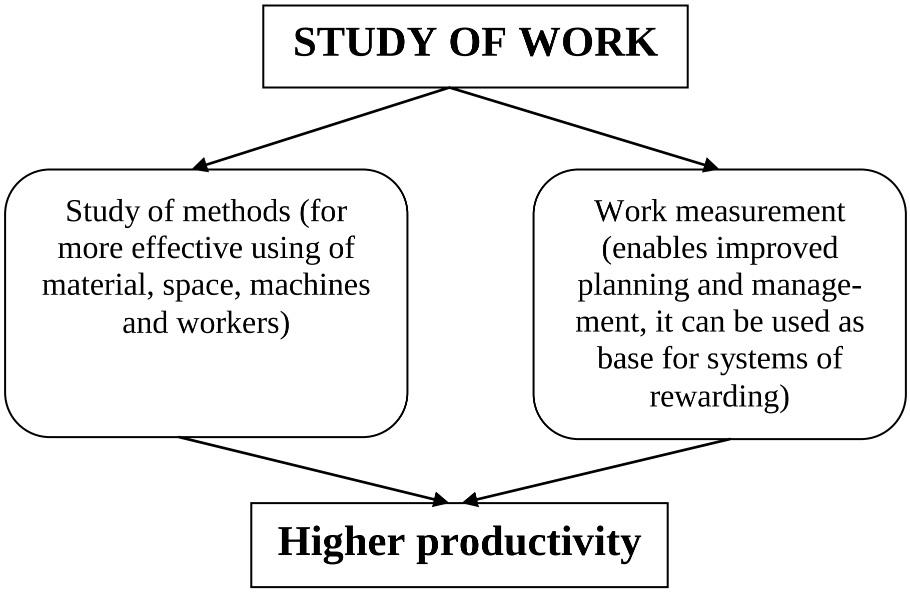

Figure 9: Study of work (Mašín and Vytlačil, 2000, p. 90)

3.1.1 Factors influencing the consumption of time

In an ideal situation, the company manufactures its products in minimal time. Ideally it is not possible to reduce that time, because it is *basic working time.* The question is: Is it possible for this time to be a real working time? Yes, but only under ideal conditions. And ideal conditions are not available on 100 % in reality. In real conditions, consumption of time is influenced by many factors that we can more or less eliminate. One of those factors, which increase the basic working time, is a human factor. Workers may be burdened by poor organization of workplace, they may be badly or inadequately qualified for the job or they can have bad working discipline. The solution is to use an incentive system, thanks to which qualification and discipline will be increasing. Basic working time is extended also by using inefficient working methods. These factors are mostly identified during measurement of the work. These include poor or inadequate tools and utilities, frequent failure, improper handling or poor workplace layout and usage of space. Basic working time can be extended also by bad design. The problem arises when designers and engineers do not cooperate. A practical example may be too high number of bolted joints. During carrying on visualization of times, which extend basic working time, we get the following figure 10. (Višňanský, Krišťak, Kyseľ, 2012)

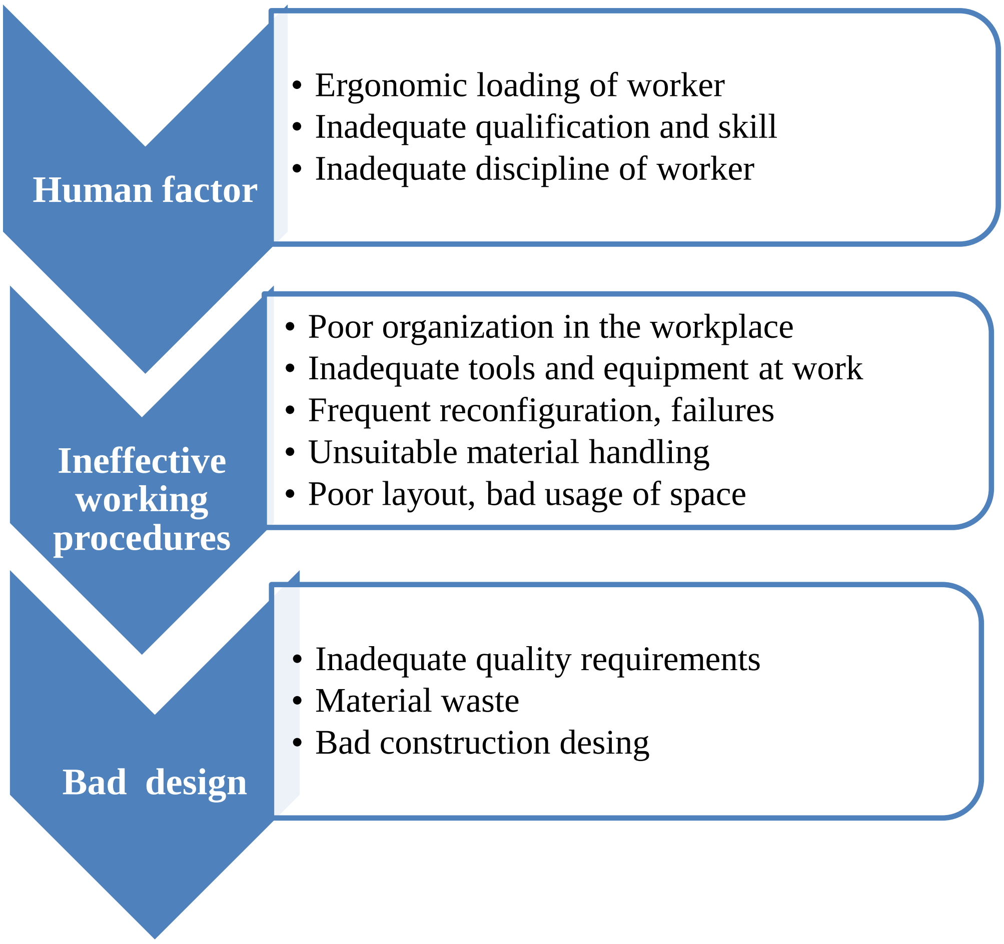

Figure 10: Factors extending consumption of basic working time (Višňanský, Krišťak, Kyseľ, 2012, p. 10)

3.2 Methods of work study

Methods of work study are focused on systematic and process approach. During studying of the work, we are mostly using the following methods and techniques: (Lhotský, 2005)

3.2.1 Written analysis of used methods of work

It is often performed in the early stages of work study. We make it for basic familiarization with the content, conditions and procedure of monitored activities. The essence of this analysis is a clear, brief and concise description of the conditions and procedure of monitored activity and the recording of basic numerous data (such as duration of the process). Findings of facts are then verified in terms of their necessity, expediency. The result of written analysis of used work methods are descriptions of used and improved procedures, improved organizational and technical conditions and characteristics of machines, tools and products. (Lhotský, 2005)

3.2.2 Questioning technique

Questioning technique is a controlled critical selection of an optimal solution. This is done by sets of questions prepared in advance. Then it is time for analysis of answers. While we are doing this analysis, we can identify necessity or uselessness in the working process and options for improving it too. (Lhotský, 2005)

The questions of questioning technique are mainly focused on: (Lhotský, 2005)

- Objectives, which should be fulfilled by the process – the question WHAT?
- Sequence and duration of certain activities – the question WHEN?
- Persons, who carry on specific activities – the question WHO?
- Way of doing activities – the question HOW?

It is recommended to continue by question WHY? In Toyota production system is technique *Five times why* widely used. This technique is sometimes called as *integral part of kaizen.* (Liker, 2004, p. 252)

3.2.3 Graphs and charts of working process

Graphs and charts are combination of graphic symbolization, verbal and numerical data. The observed real estate is then critically evaluated. Subsequently, we have to make proposed (ideal) estate by the same method (specific graph or chart of working process). Those two files are compared and we are searching specific ways for concrete improving. For example, German system *REFA* (which is used by Continental company) is based on characterizing the content of work (*Arbeitsgestaltung*) due to a condition that exists (*Ist*) and design of desirable state (*Soll*). We can use other techniques, as *Value Stream Mapping*, thread charts or *spaghetti chart*. Graphs and charts are mapping working and manufacturing procedures or flow of material in real business environment. (Lhotský, 2005)

At this point, I would like to mention to *process analysis*, because it is a part of practical part of my diploma thesis. According to its name it is probably clear that process analysis maps processes in the company. We can use it in manufacturing and non-manufacturing companies too. We use for it symbols as *the operation, waiting, checking, storage and transportation.* This analytic method describes effectiveness and efficiency of critical operations with a higher share of transfer, waiting and obstacles. The result of process analysis is the process diagram, which graphically illustrates the sequence of activities and contains numeric data. (API, © 2005-2012c)

3.2.4 Motion and spatial studies

Motion and spatial studies are used to explore and improve working movements of employees, objects and resources. The results of these studies are concrete suggestions for more effective arrangement of operations, material flows, handling routes, workplace and whole working process. In reality, it often happens that the original arrangement of the project has to be changed. The purpose of the motion and spatial studies is to find the best possible way for performing certain operations while eliminating unnecessary movements (and other waste). Simulations and models of concrete situations in the organization are closer related to these studies. (Lhotský, 2005, p. 61)

3.3 Methods of time measure

We can measure the consumption of time for work, which meets following three requirements: (Višňanský, Krišťak, Kyseľ, 2012, p. 19)

- *It is quantifiable* (for example: number of pieces, litres, m^2 etc.).
- *It is performed by defined standardized procedure.*
- *It has sufficient capacity.*

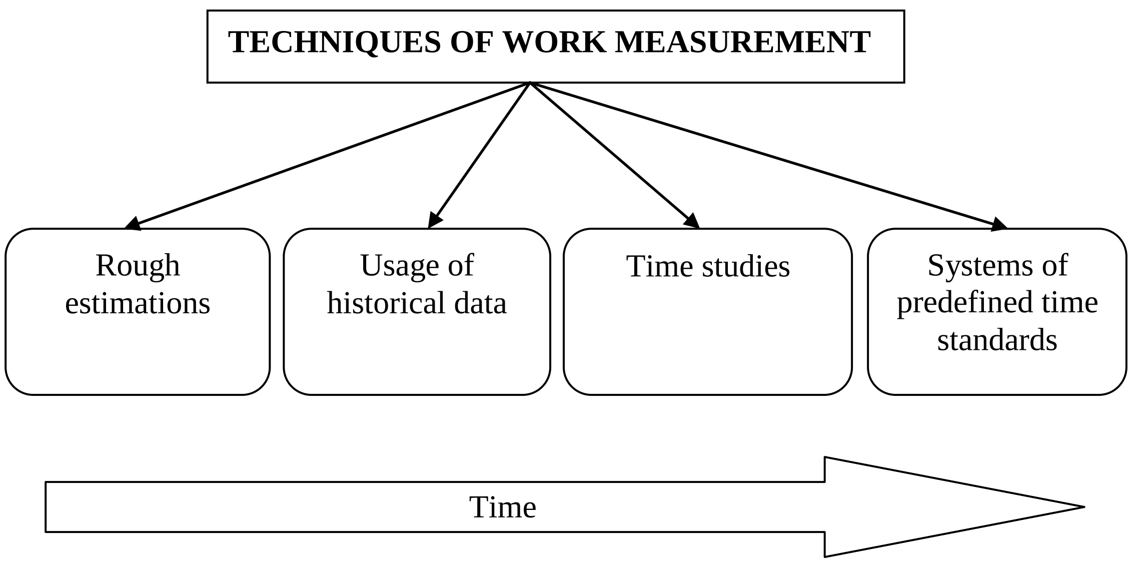

Figure 11: Development of techniques for work measurement in time (API, © 2005-2012b)

The figure 11 above shows gradual development of techniques for work measurement. This does not mean that for example estimates are not used nowadays. It always depends on a concrete situation.

Methods of measurement of time can be divided to two main groups, direct and indirect. **Indirect measurement** is carried on by methods of predefined times. *For usage of systems of predefined time standards it is characteristic reduction on setting the optimal motion formula for doing the task and the assignment of individual times of basic movements.* (Mašín and Vytlačil, 2000, p. 92)

Methods of predefined time standards are including for example: (API, © 2005-2012b)

- MODAPTS (Modular Arrangement of Predetermined Time Standards)
- MTM (Methods Time Measurement)
- UMS (Universal Maintenance Standards)
- USD (Unified Standard Data)
- UAS (Universelles Analysier System)
- MOST (Maynard Operation Sequence Technique)
- REFA (Reichsausschuss für Arbeitszeitermittlung)

Methods of **direct time measure** (in the figure 12) are based on concrete measurement with stopwatch and recording form, or making an electronic record. On one hand these tasks are difficult and generally unpleasant for both, the worker performing the measurement and the worker who is measured. On the other hand, direct time measure is necessary, because it shows real estate. It serves as a base for improving of processes. (Lhotský, 2005)

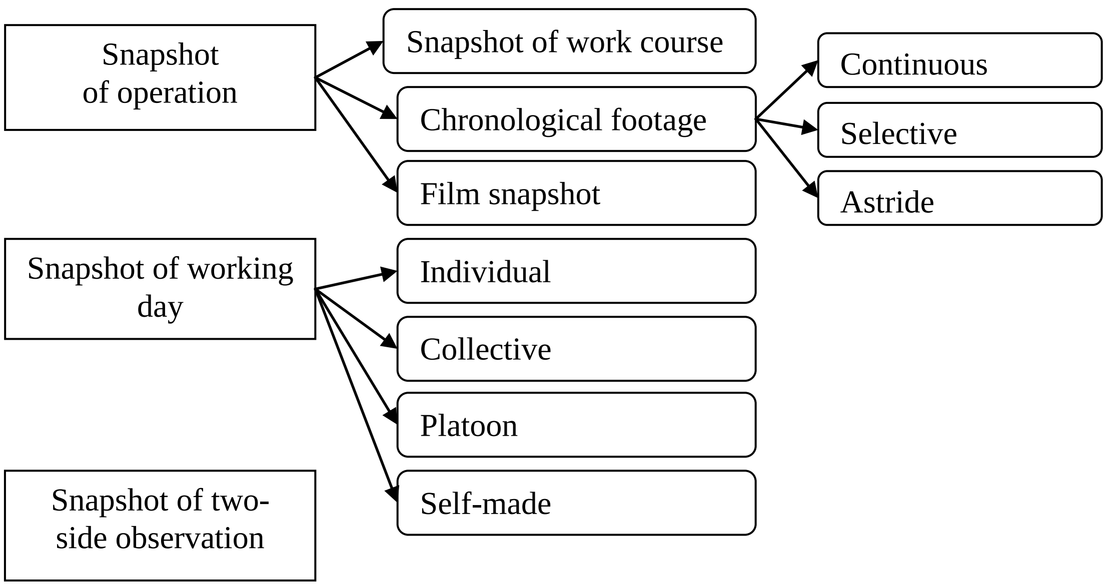

Figure 12: Direct measurement (API, © 2005-2012b)

A further problem arises from knowing what to observe and how often to observe it. (Stanton, c2005, p. 28-2)

Now I would like to focus more on the making of individual snapshot, because this method creates the large part of this diploma thesis.

3.3.1 Individual snapshot

Observation of people interacting with a device to perform a task provides a way of capturing data on errors and performance time as well as providing some insight into the case of difficulty with which the task is performed. (Stanton, c2005, p. 28-1)

Making of snapshot of individual worker is composed from following steps: (Višňanský, Krišťak, Kyseľ, 2012)

1. Preparing of the snapshot – we determine our goals, select workplace and worker and schedule time.

2. Recording the basic information about worker, workplace, date and shift into the prepared form.

3. Recording of each activity during observation into the form.

4. Evaluation of the snapshot, analysis and calculation of percentage appreciation and utilization of time of worker.

According to my own experience, before making a snapshot I recommend to contact a measured worker and introduce yourself. While we are informing him/her that his/her activities will be observed, we should briefly explain the reasons of measurement and also ask him/her about his/her questions, problems and ideas.

A sweeper knows about cleaning the workshop more than a manager of production or a chief executive officer. Sweepers can teach me better what to do for keeping cleanness in company, than all managers and officers together. (Zelený, c2005, p. 47)

When we are analysing a snapshot, it is necessary to compare found data with objective or standards. It should be followed by project part, in which we propose concrete action for improving of the process.

4 SUMMARY OF THEORY, OBJECTIVES OF WORK AND OTHER METHODICS

4.1 Summary of the theoretical part of the thesis

In today's highly competitive business environment companies are under constant pressure on grown of their productivity and efficiency.

Industrial engineering is a multidisciplinary field that combines technical knowledge of engineering and knowledge of management. For industrial engineering it is typical rationalisation, optimizing and improving the efficiency of manufacturing and non-manufacturing processes. Industrial engineering is systematically engaged in designing, planning, implementation and improvement of processes and also helps to ensure high efficiency and competitive innovation. (API, © 2005-2012a)

The process is a set of activities that change inputs to the outputs. (Košturiak, 2010, p. 15)

Process improvement is based on their knowledge. For exploring and improving business processes there is a number of models. Continental corporation uses DMAIC model. Any manufacturing or non-manufacturing processes include activities, which add value and activities, which do not add value. The customer is willing to pay only for activities with value added. The main principle of industrial engineering is identification and elimination of activities, which do not add value. We call these activities the waste.

The waste is *overproduction, waiting, unnecessary transport or conveyance, overprocessing or incorrect processing, excess inventory, unnecessary movement, defects* and *unused employee creativity.* (Liker, 2004, p. 28-29)

A pioneer and inspiring example of usage of industrial engineering is Toyota Production System, which is focused on identification and elimination of *non-value-added, overburdening people or equipment* and *unevenness.* (Liker, 2004, p. 114)

Process analysis is a tool that maps business processes. This analytical method describes the effectiveness and efficiency of critical operations and its result is process diagram, which should be followed by concrete actions. (API, © 2005-2012c)

Productivity is an expression of how well we use resources to create products and services. The basic indicators of productivity are *partial productivity, index of productivity, total* *productivity* and *total factor of productivity.* Productivity of work belongs to key factors, which influence productivity of the whole company. (Mašín and Vytlačil, 2000)

We analyse and measure work in the company. For this purpose we are using various methods and techniques according to different requirements. I will be looking closer at the individual snapshots in this diploma thesis.

4.2 Objectives of the diploma thesis

Main objective:

Propose the project, leading to increase efficiency of serviceability in the workshop pressing shop of commercial tires in Continental Barum s. r. o.

The main objective will be further elaborated according to SMART methodology in the practical part of this diploma thesis.

Secondary objectives:

Create the analysis of activities of workers from pressing shop based on snapshots.

Interconnect knowledge from study to practice from world class manufacturer and create your own opinion on this issue.

4.3 Other used methods

In my thesis I will use three tools, which I would like to describe briefly at this point.

SWOT analysis is a method by which we can identify the strengths, weaknesses, opportunities and threats for concrete organization, in this case for Continental Barum s. r. o.

RIPRAN method (RIsk PRoject ANalysis) *presents empirical method for analysis of project risks.* (Ripran, 2012)

Logical Framework *is a basis for managing of the project, we are using it to identify and analyse problems and simultaneously we are defining objectives and identifying specific activities for reaching them.* (NIDV, ©2010)

II. PRACTICAL PART

5 CONTINENTAL BARUM S. R. O.

Continental Barum s. r. o. is the largest tire factory in Europe and simultaneously the biggest employer in the region of Zlín. In 2012, the company celebrated the triple anniversary: 80 years of the tire production in this region (started by Baťa´s tire production), 40 years from the beginning of the production in the factory in Otrokovice and 20 years since the signing of the contract with concern Continental AG. Continental Barum s. r. o. is successful because of the combination of the tradition with the latest know how and high technology.

The Continental corporation is one of the worldwide leaders in the automotive industry. The company employs approximately 150 000 people in 36 countries. In the Czech Republic, Continental has 6 branches with approximately 13 000 employees. (Continental, © 2013)

5.1 Basic characteristics of the company

The following data were drawn primarily from the Annual Report for 2011. (Barum Continental, 2012)

Company name:	Continental Barum, s. r. o.[1]
Address:	Objízdná 1628, Otrokovice, Zlín region
Average number of employees:	3 559 persons
EAT (earnings after taxes):	1,93 billion CZK
Total assets:	28,227 billion CZK
Equity:	15,497 billion CZK
Surface area of the company:	738 600 square meters

[1] From 1st January 2013 the company was renamed from "Barum Continental, spol. s r. o." to "Continental Barum s. r. o."

5.2 Economic data

5.2.1 Time development of EAT

Continental Barum s. r. o. is a stable company that regularly makes earnings after taxes. On the figure 13 is also possible to see the impact of the global economic crisis and the successful fight of the company with it. In recent years Continental Barum s. r. o. has also focused on high quality tires with high added value.

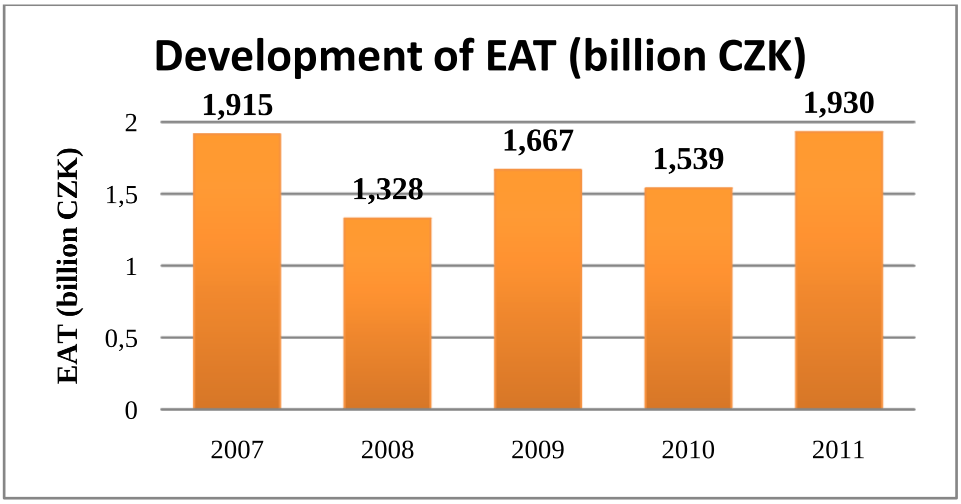

Figure 13: Development of EAT (by author & Barum Continental, 2012)

5.2.2 Time development of the number of employees

The figure 14 shows the number of employees in Continental Barum s. r. o. Those numbers are converted to the full time working. Continental Barum s. r. o. is the largest and one of the most prestigious employers in the Zlín region.

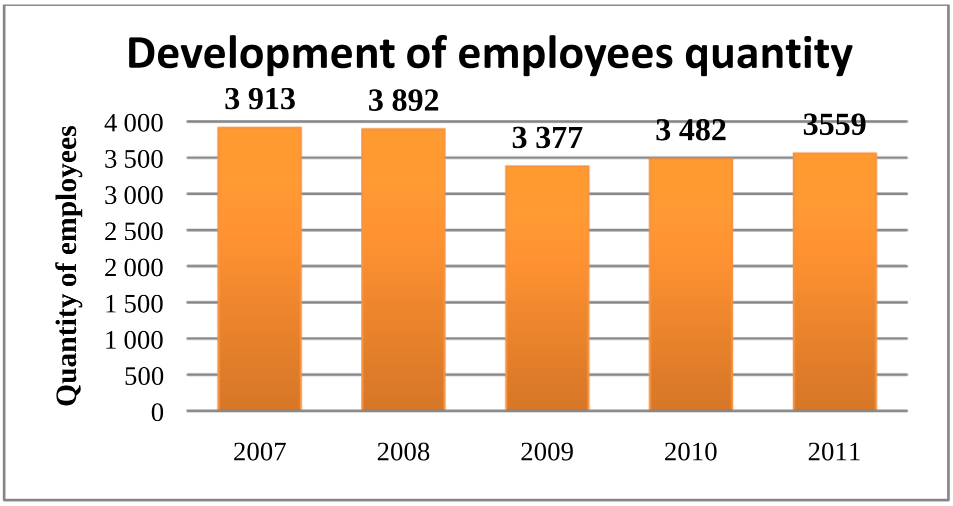

Figure 14: Development of number of employees (by author & Barum Continental, 2012)

5.2.3 Time development of production

Continental Barum s. r. o. mainly produces three types of tires:

- passenger (for passenger cars and light truck) - PLT
- commercial (for trucks) - CVT
- industrial (for industrial vehicles such as airport trolleys)

According to the figure 15 it may seem that commercial and industrial tires are not so much important as tires for passenger cars, because the most of the production are passenger tires. But Commercial and industrial tires are really important products, which complete product portfolio. Due to their high quality and utility value we can see those tires on various vehicles, from construction machines to military vehicles. Continental Barum s. r. o. produces also forms for production of passenger tires and bladders for vulcanizing presses.

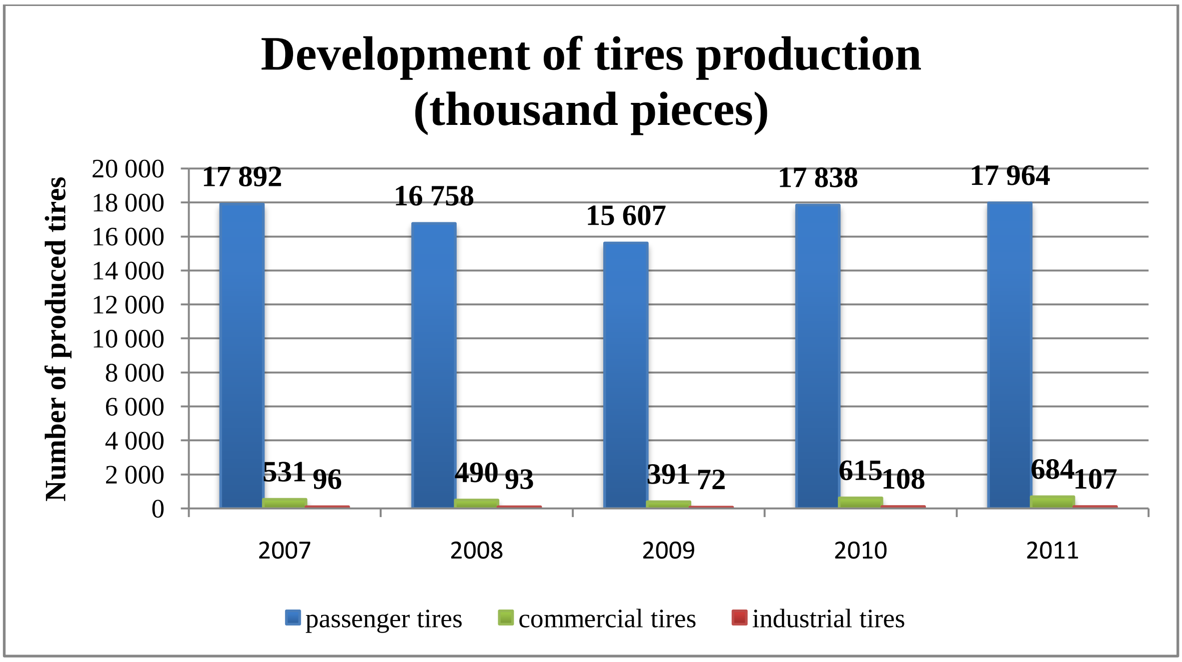

Figure 15: Development of production (by author & Barum Continental, 2012)

While in 2005 Continental Barum s. r. o. stopped the production of rear tractor tires, industrial tires have been produced here since 2002. Nowadays the company has impressive production capacity of 65 000 passenger tires and 2 500 industrial tires per day.

In the Zlín region there is certainly no other industry that would be its size and global importance to equal the production of tires. (Barum Continental, 2012, p. 53)

5.2.4 Time development of productivity

On all those graphs there is apparent impact of the global economic crisis on the automotive industry and Continental Barum s. r. o. too. The figure 16 also shows the company effort to increase productivity (the number of tires produced per one employee). Despite the unstable economic situation, Continental Barum s. r. o. strives to maintain high productivity and its growth in order to remain competitive. To the figure 16 it is also necessary to add that it shows last, not ideal or perfect years, due to the difficult situation on markets. Since the integration of Barum to Continental concern in 1992, the productivity in the company has raised several time.

Figure 16: Development of productivity (by author & Barum Continental, 2012)

The figure 16 above can slightly distort view on data, because production was counted as the sum of all types of produced tires (with different devoted work expenditure). The *quality first* approach is very important for the company. This is confirmed by the fact that Continental Barum s. r. o. does not sell DA (defective appearance) goods for lower prices. If some scrap appears during production, it must be destroyed. A customer can be sure, that he will receive only the best quality products (1A). That is demonstrated by regular very good placement in the charts of various tire tests.

5.3 The management and structure of the company

Composition of the executive committee (EC) of Continental Barum s. r. o. is following:

- **Ing. Libor Láznička**
    - managing director, chairman of the EC, responsible for production
- **Ing. Dalibor Kalina, Ph.D.**
    - managing director, member of the EC, responsible for sales
- **Ing. Miloslav Bjalek:**
    - managing director, member of the EC, resp. for finance and controlling

The current organizational structure is shown in the table 2.

Table 2: Organizational structure of Continental Barum s. r. o. (Barum Continental, 2012)

PRODUCTION & TECHNOLOGY SECTION	MARKETING & SALES SECTION	FINANCE & CONTROLLING SECTION
Division of protection of the company		
Division	Division	Division
Production I (PLT)	PLT RE SK	ICO systems
Production II (CVT)	PLT RE CZ	Finance and accounting
Plant engineering	TRUCK RE CZ/SK	IT Services
Plant operation	Marketing CZ/SK	
Industrial engineering	Sales logistics CZ/SK	
Human resources	Production of forms	
Material resources		
Product industrialization		
Quality		
Factory controlling		
ESH		

5.4 About Commercial Vehicle Tire (CVT)

The content of the practical part (means analysis and project) has been developed for the division of CVT production. From this reason I think it is important to make introduction of Commercial Vehicle Tires from the practical point of view.

Figure 17: Example of commercial vehicle tires (ContiTrade Services, ©2013)

5.4.1 Legal and standardized signification of CVT

Standard signification of commercial vehicle tire can be for example following:

315/80 R 22.5 156/150 L (154/150 M) TL

This signification means following data: (Barum Continental, 2011, p. 5)

315	width of tire in mm
80	cross-sectional ration height: width in %
R	radial design
22,5	diameter of rim (in inches)
156	4 000 kg is tire load capacity (J) in single tire fitment
150	3 350 kg is tire load capacity (D) in dual tire fitment
L	speed 120 km/h
(154/150 M)	alternative index of speed and load capacity
TL	tubeless tire

We can find various signs on the concrete commercial vehicle tires as you can see in the figure 18. Now we are going to explain the signification of them.

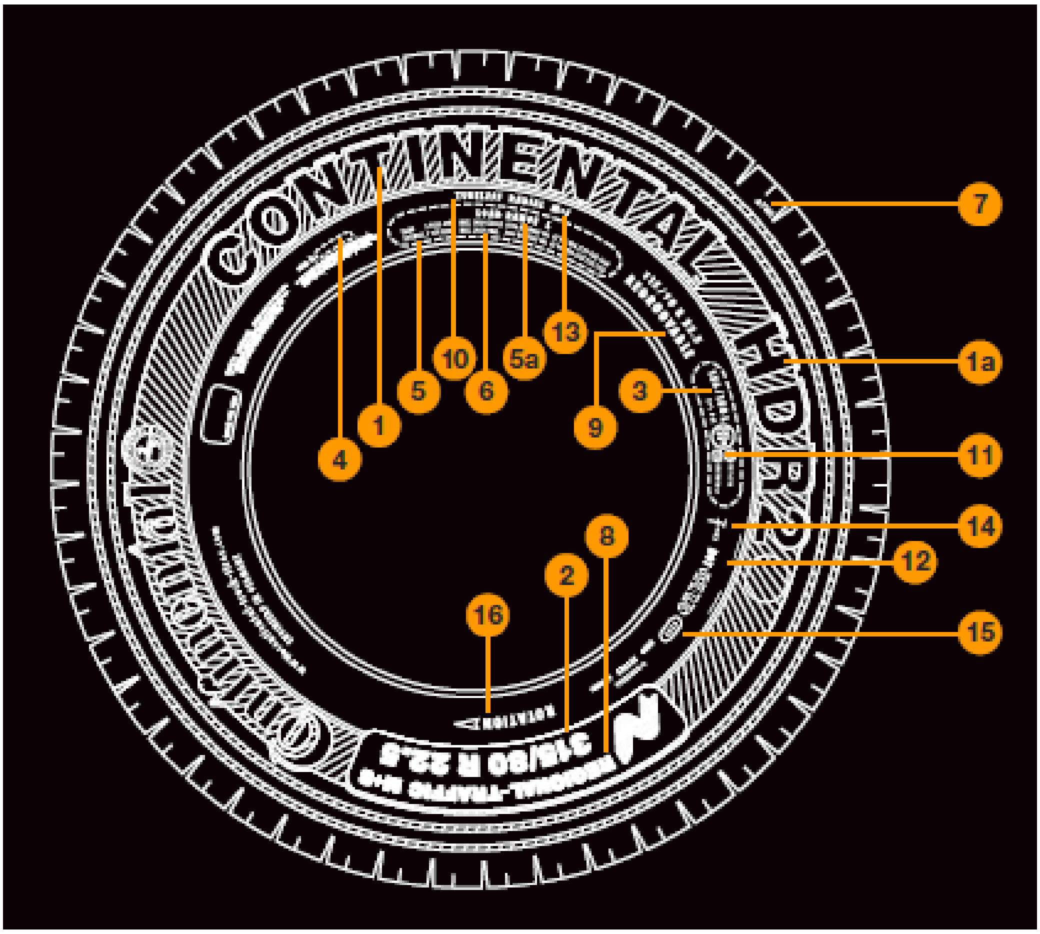

Figure 18: Signification on CVT (Barum Continental, 2011, p. 5)

1 Manufacturer (name or logo)

1a Tread pattern signification

2 Size signification

3 Technical parameters

4 Country of manufacture

5 Data according to USA security standards

5a Load range according to USA standards

6 Load capacity according to USA standards

7 TWI (Tread Wear Indicator)

8 Recommended application

9 Options of regrooving

10 Tubeless or tube type

11 E = tire complies with direction ECE-R 54

4 = code of country, which give homological certification

12 DOT (Department of transportation of USA), responsible for safety

13 M+S (Mud and Snow)

14 Identification for Brazil

15 Code of manufacturer (production date: week/year)

16 Rotation (recommended direction)

5.4.2 Components of CVT and their functions

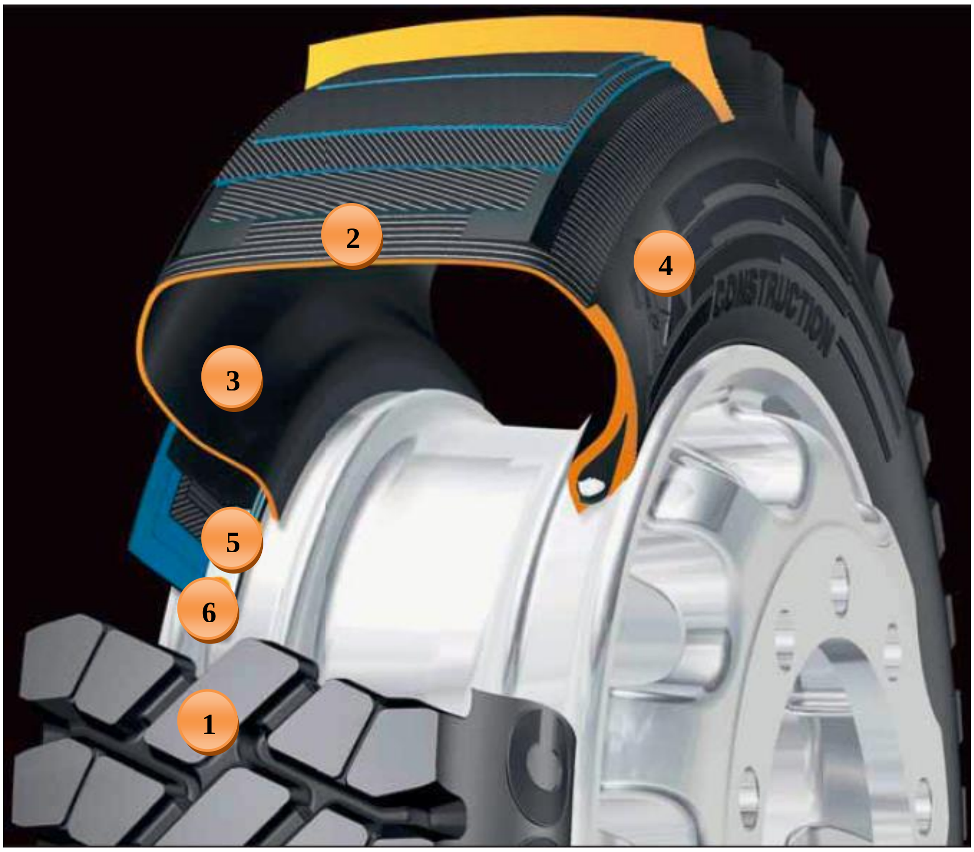

Figure 19: Components of CVT (Barum Continental, 2009, p. 6)

Table 3: Parts of CVT and their function (Barum Continental, 2009, p. 7)

Part	Material	Function
1 Tread strip	Rubber compound	High durability and grip in all driving conditions.
2 Steel belt	Steel cord	Ride comfort, structural strength and higher resistance to operational deformation.
3 Inner rubber	Rubber compound	Prevents ingress of air and moisture.
4 Sidewall	Rubber compound	Protects against abrasion and weather conditions.
5 Bead reinforcement	Nylon, aramid, steel cord	Increase resistance against cracking ensures end of steel belt in bead.
6 Bead core	Steel wire embedded in rubber compound	Ensures tight fit of bead on the rim.

5.4.3 Material flow in production of tires

Continental Barum s. r. o. performs the production of tires from mixture of basic compounds to final control of finished product. The company is buying only small quantity of semi-finished goods as for example: wires for production of bead wide, rubberized cords, braided ropes. Flow of material is shown in figure 20.

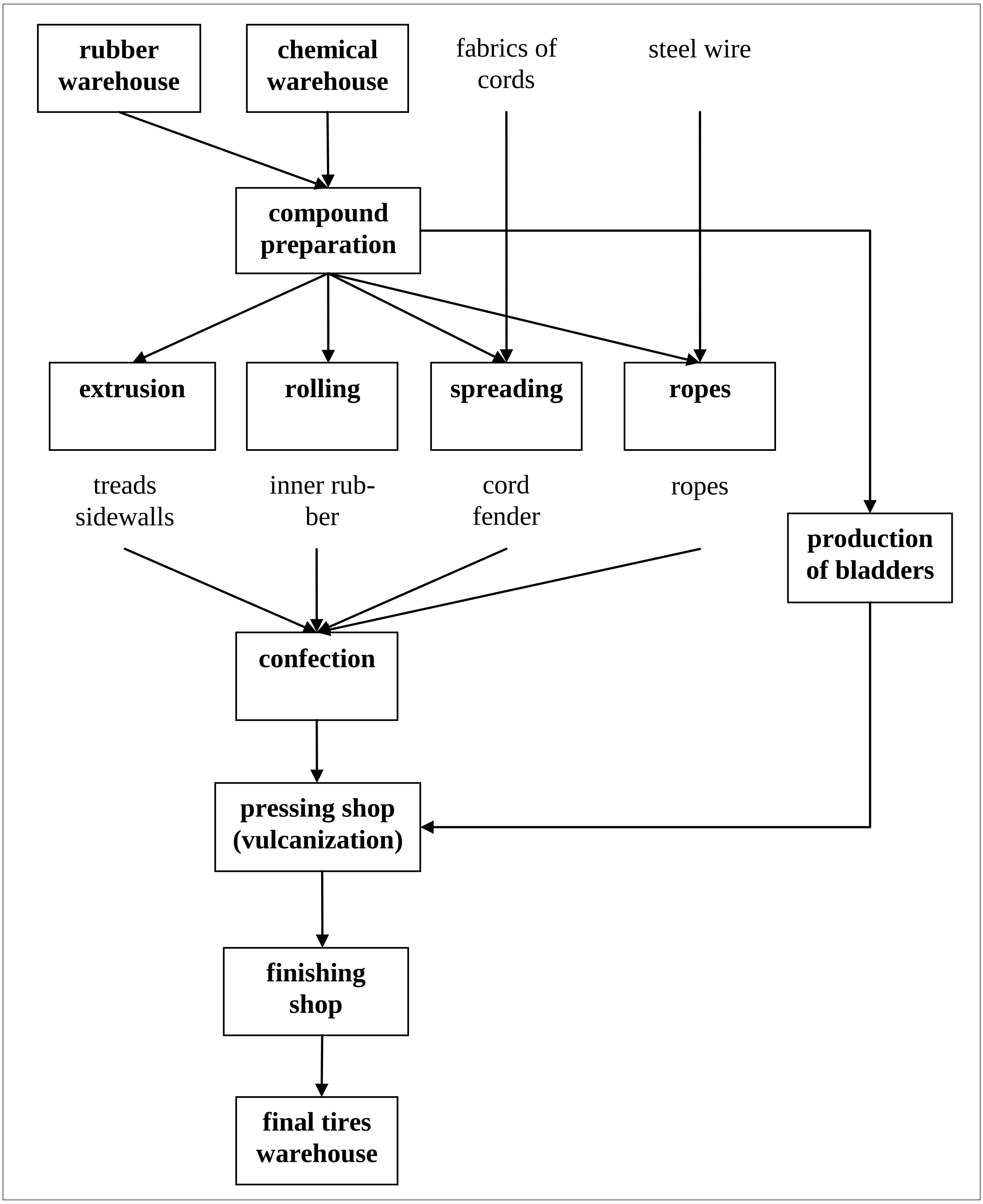

Figure 20: Material flow in tire production (Barum Continental, 2012, p. 62)

5.5 Continental Tire Manufacturing System

Our manufacturing processes create a significant benefit for our customer and thereby increase the value of our company… To utilize our valuable resources in the best-possible way and to align all activities to our strategic goals, all plants started to invent and implement their own Production System. We join our forces to combine these well established ideas and tools in one powerful approach: ***CT.MS – the Continental Tire Manufacturing System.*** (Winkler, Continental AG, 2008, p. 38)

The Continental Tire Manufacturing System is a concept that is used by all rubber companies of the Continental concern. This system allows mutual learning, cooperation, innovation and helps to better understand to tire production. CT.MS combines the philosophy of continual improvement and lean manufacturing tools. It focuses on specific objectives derived from the corporate strategy. (Winkler, Continental AG, 2008)

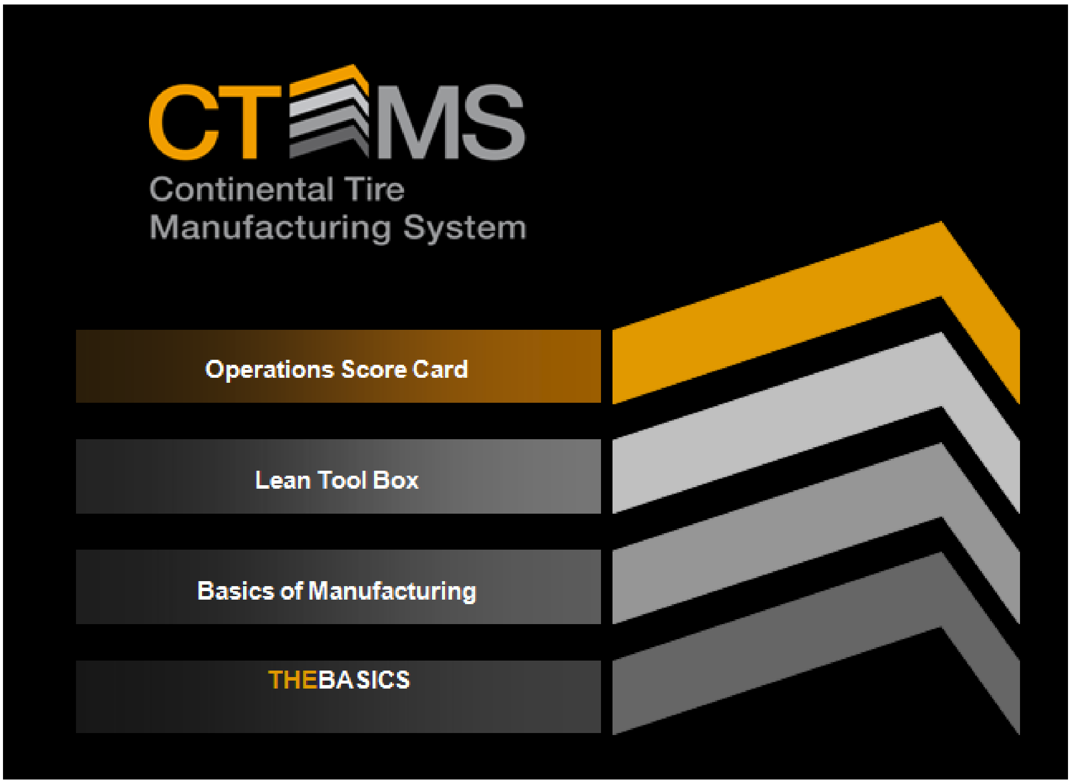

Figure 21: CT.MS logo and content (Winkler, Continental AG, 2008, p. 32)

As is shown in Figure 21, CT.MS is composed from four sections. Explanation of every section is following. (Winkler, Continental AG, 2008, p. 38)

The Basics are the foundation of Continental company:

- *We make individual mobility safer, more comfortable and more sustainable.*
- *Performance is our passion.*
- *Creating value is our driving force.*

The manufacturing basics means focus on internal and external customers of Continental.

- *...to continuously improve our working environment, our processes and our division´s market position.*

The lean manufacturing toolbox is composed from tools, which are improving all (not only) manufacturing processes.

- *...streamlining all our activities and increasing the share of value adding.*

The operation scorecard is transforming operational goals for every division from strategic plans of Continental plants.

- *...only those of our activities are performed that directly lead to a benefit for our company and our colleagues.*

Implementation of CT.MS runs in each Continental rubber factory individually based on GAP analysis (comparison of the current and potential output). This implementation is coordinated, so managements from various rubber factories have opportunity for mutual exchange of experience. Nowadays CT.MS is transforming to CAPS (Continental Automotive Production System), which will be uniform for entire Continental group (not only for rubber factories, as CT.MS is, but for whole automotive). (Winkler, Continental AG, 2008)

5.6 SWOT analysis

Individual strengths and weaknesses (in the table 4), opportunities and threats (in the table 5) are evaluated by percentage according to their importance. This evaluation I attached them according to my personal experience and attitude.

Table 4: SWOT - strengths and weaknesses (by author)

STRENGHTS	
23 %	Modern technology and manufacturing process.
20 %	Stability of the company as an employer, supplier and customer.
20 %	Reputation of the company, high market share.
15 %	Background of strong mother company.
12 %	Certifications, CT.MS.
10 %	Cooperation with high schools and universities.
WEAKNESSES	
35 %	Rapid obsolescence of technology (as in the entire automotive industry).
20 %	Energy intensity (mainly due to the nature of production).
20 %	Environmental burden.
15 %	Bureaucracy in decision making (need approval from mother company).
10 %	Competition within the concern.

Continental Barum s. r. o. can use its good name in the Czech Republic and abroad too. But being a traditional producer is not enough, especially in the automotive sector. It is necessary to improve business processes continuously and to monitor the newest trends in product and production technologies. Cooperation with universities and high schools supports innovative environment. Projects in this area should also focus on finding solutions of the high energy dependence and environmental burden. “Tax” for stable background and continual transfer of know-how from strong partner company is bureaucracy in decision making and competition inside of whole concern. However, this competition (in reasonable limits) leads to increasing of efficiency and productivity in whole Continental.

Table 5: SWOT – opportunities and threats (by author)

OPPORTUNITIES	
33 %	New discoveries in automotive industry.
30 %	Growth of cars demand and following growth of automotive sector.
20 %	Improving of processes in the company by own initiative of employees.
10 %	Larger contracts for governments.
7 %	Subsidies and financial support for modern technologies and higher employment.
WEAKNESSES	
30 %	Low-cost competition (mainly from Asia).
28 %	Weakening of automotive industry (decrease of demand).
15 %	Higher taxes and other levies.
15 %	New (for example environmental) standards and increase of bureaucracy.
12 %	Tariffs, quotas (barriers for import to other countries).

Continental Barum s. r. o., as other companies of automotive sector, is dependent on the demand of cars. This trend can significantly affect the success of the company in positive or negative way. Continental Barum s. r. o. focuses a part of its production capacity on the most modern tires with high added value – for example ContiSeal technology (tire puncture resistant). The emphasis on quality is also the best defence against low-cost competition. The company should motivate employees to come out with their own improving proposals. The Czech government and the European Union offer various subsidies for employers and in the government sector there is also opportunity for larger contracts (for example tires for military trucks), but of course we cannot take it for granted. Likewise, the government is unpredictable in the problem of raising taxes, levies and bureaucratic burden. However, it is important to act with government and live in mutual symbiosis. This is the best way of solving of eventual international contradictions (for example tariffs caused by protectionist policy).

6 SNAPSHOTS AND PROCESS ANALYSIS

6.1 CVT pressing shop – introduction of workplace

In the pressing shop of commercial vehicle tires there is located 70 vulcanizing (that means curing) presses in 4 rows. Vulcanizing presses operate on principle of warming by heating plate or steam. For our purpose we will use simplified segmentation on single-dome presses (with one form, used for the largest tires, showed in figure 22), double-dome presses (with two forms and domes, which are closing in the same time, showed in figure 23) and independent vulcanizing presses (with two forms and domes, which are closing in different time, showed in figure 24).

Figure 22: Single-dome vulcanizing press (Rotas strojírny, ©2013)

Figure 23: Double-dome vulcanizing press (Rotas strojírny, ©2013)

Figure 24: Independent double-dome vulcanizing press
(ThyssenKrupp Rubber Machinery, © 2003-2005)

Vulcanizing presses are served by 7 operators in one shift. Each operator has his sector of presses and this serviceability is shown in figure 25. Presses have different level of automation and activities of operator are dependent on type of press and produced tire. All activities of operators (summed of different presses and tires) are following:

- hanging of green tire (GT) on spreader,
- loading of green tire (GT) into the press,
- walking among presses,
- moving with trolley for green tires,
- unloading of cured tire (CT) from press,
- spraying of green tire (due to non adhesiveness of bladder),
- sticking of barcode on green tire,
- sticking of identification (ID) label on green tire,
- manual shaping of bladder (inflation and test of bladder),
- various setup of press (in software of concrete machine),
- spraying of form (only first/morning) shift, due to non adhesiveness of form,
- preparation and inserting of aluminous ID plate on green tire,
- manual transfer of green tire from trolley,
- software – signing on and off (start and end of work shift),
- filling of a paper (number of usage of bladder),
- work communication (with foreman and other workers),
- nonstandard work (due to breakdown of press, sucking of water from form etc.),
- waiting and pauses.

When all presses are closed (vulcanization is running) and every press has a green tire hanged on the spreader, the operator is waiting for the end of vulcanization. During this time he can go to lunch, have a smoking or personal pause, but in other time he should be present in workplace. During my work I made 7 time snapshots, that means one snapshot for each row of presses (3 snapshots for the first/morning work shift, 2 snapshots for the second/afternoon work shift and 2 snapshots for the third/night work shift). My task was to analyse of operator activities and identification of waste. Making of snapshots was difficult and time consuming, but it went off without serious problems. I think it is always important to introduce myself to the measured operator, briefly explain to him what will be done and be polite. Measured times will be compared in this part of thesis and prepared for concrete proposals in the project part.

1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1821	1822	1823	1824	1825	1826	1827
SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	ID	DD	ID	DD	ID	ID	ID	ID	ID	ID	ID
												ID	DD	ID	DD	ID	ID	ID	ID	ID	ID	ID

DD	DD	DD	DD	DD	ID	ID	ID	ID	ID	ID	ID	ID	DD	DD	DD	DD	DD	DD	DD	DD	DD
DD	DD	DD	DD	DD	ID	ID	ID	ID	ID	ID	ID	ID	DD	DD	DD	DD	DD	DD	DD	DD	DD
1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711	1712	1713	1714	1715	1716	1720	1721	1722	1723	1724	1725

801	802	803	804	805	806	807	808	809	810	811	812
DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD
DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD

DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD
DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD
701	702	703	704	705	706	707	708	709	710	711	712	713

SD *Single-dome or plate press*

DD *Double-dome or plate press*

ID *Independent double-dome or plate press*

701 *Press identification number*

¦ *Separating wall*

Serviceability:

operator 1	*operator 2*	*operator 3*	*operator 4*	*operator 5*	*operator 6*	*operator 7*
red	light purple	green	blue	yellow	magenta	cyan

Figure 25: Current serviceability of vulcanizing presses of commercial tires (by author)

6.2 Time snapshot 1: for presses 705 – 713

- Work shift: first/morning
- Date: October 2012
- Time: 5:12 – 13:00

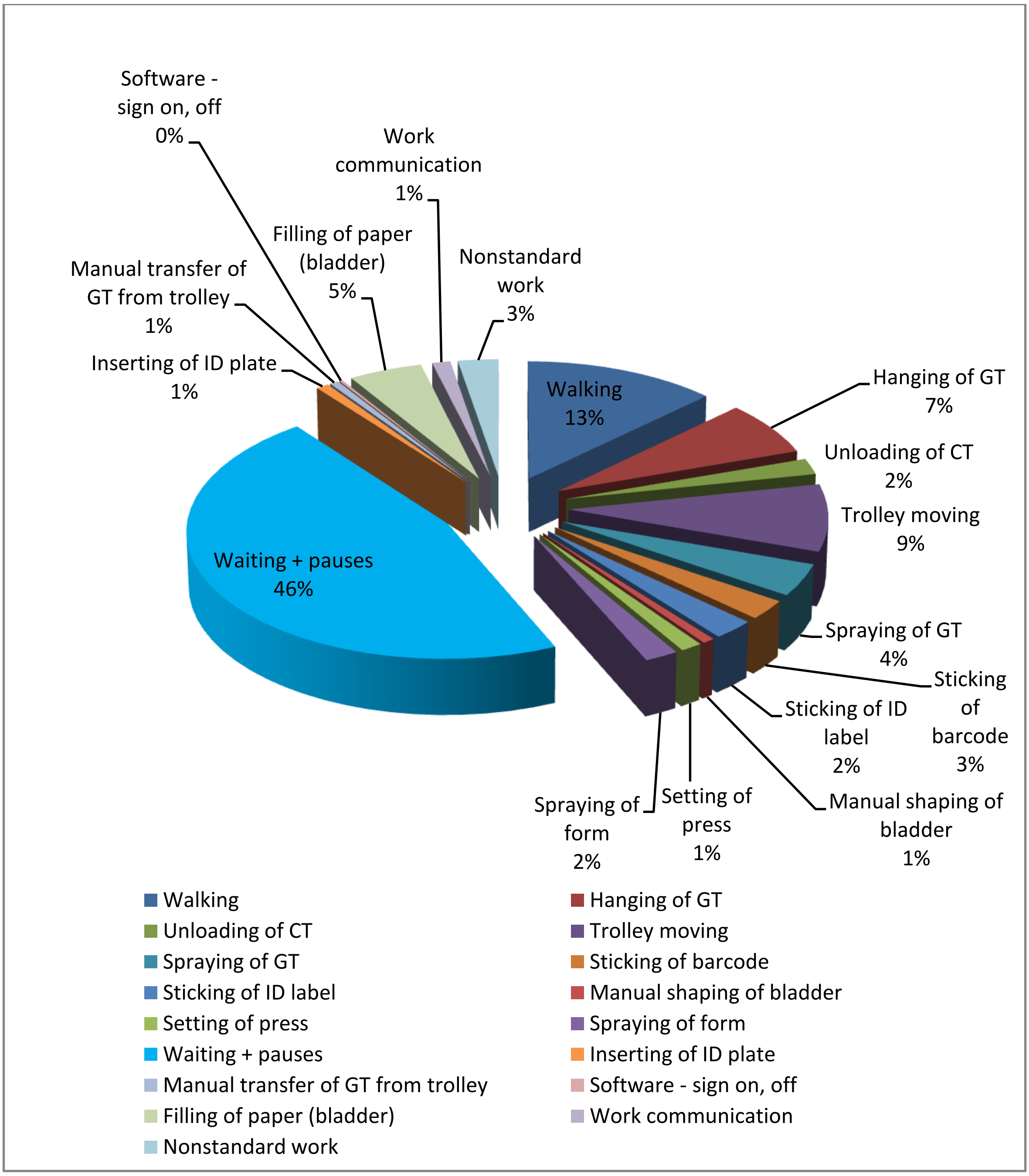

Figure 26: Time snapshot of serviceability of vulcanizing presses 705 – 713 (by author)

6.3 Time snapshot 2: for presses 704 - 804

- Work shift: third/night
- Date: November 2012
- Time: 21:11 – 4:59

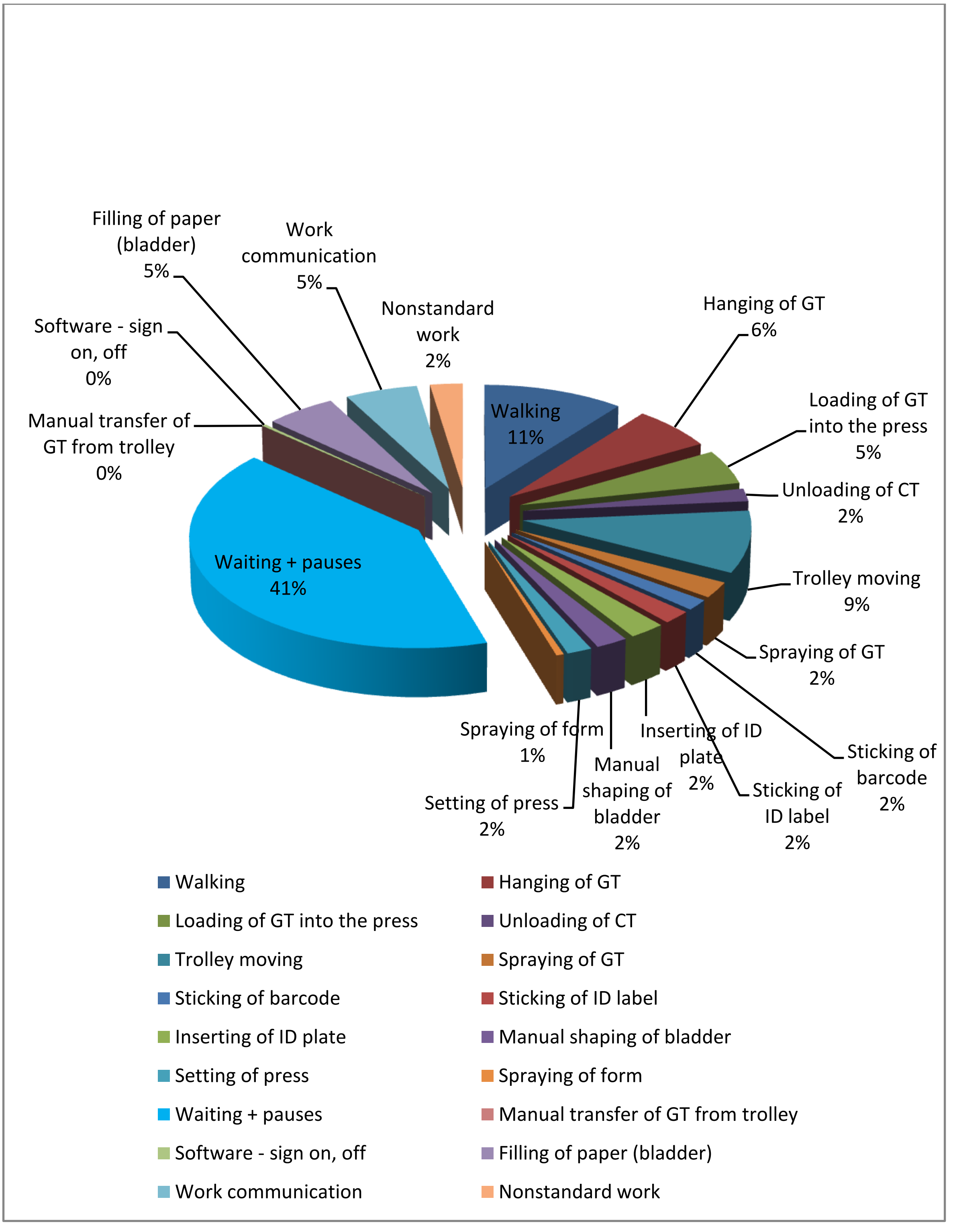

Figure 27: Time snapshot of serviceability of vulcanizing presses 704 – 804 (by author)

6.4 Time snapshot 3: for presses 805 - 812

- Work shift: fist/morning
- Date: November 2012
- Time: 5:15 – 12:52

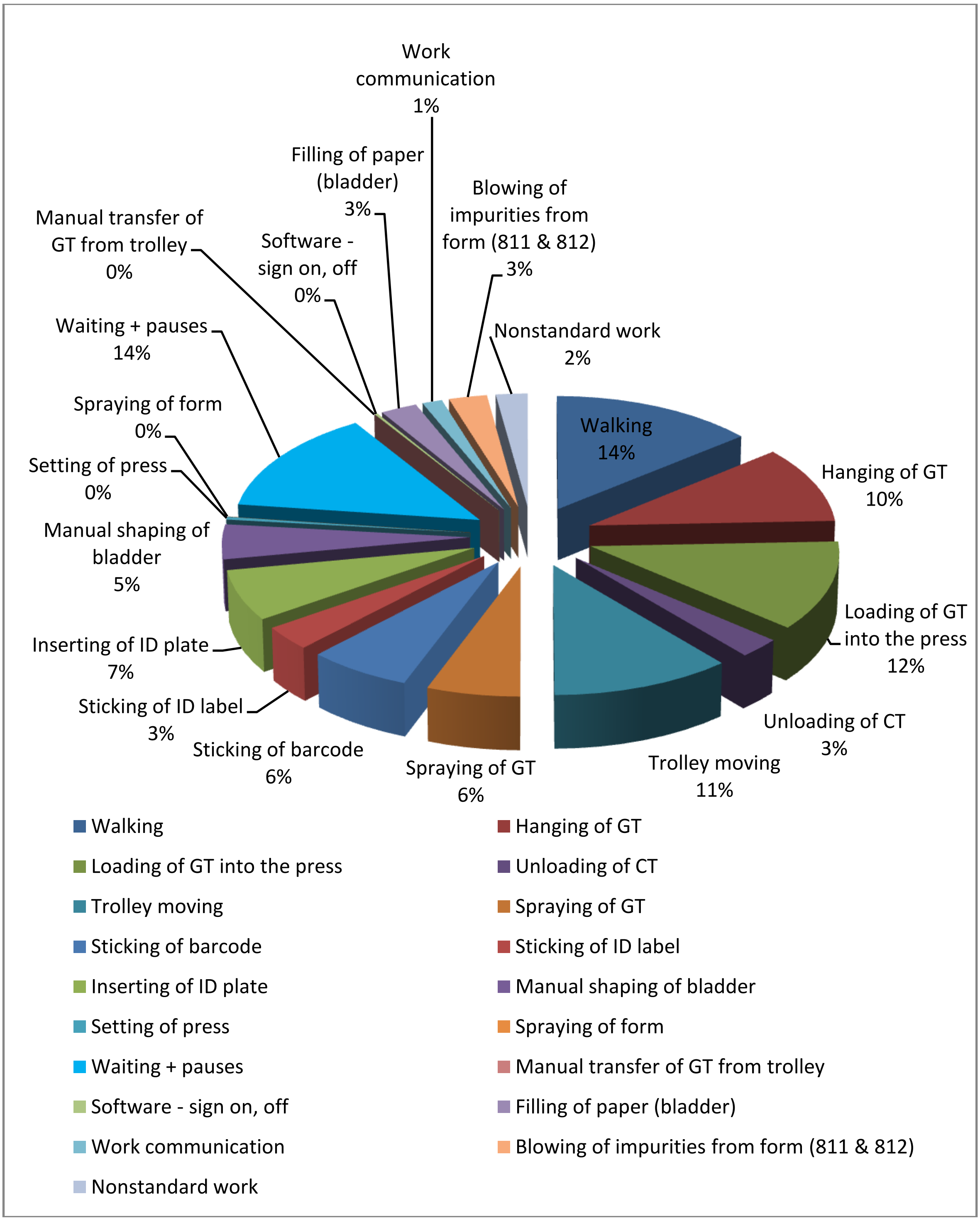

Figure 28: Time snapshot of serviceability of vulcanizing presses 805 – 812 (by author)

6.5 Time snapshot 4: for presses 1701 - 1713

- Work shift: second/afternoon
- Date: November 2012
- Time: 13:19 – 21:05

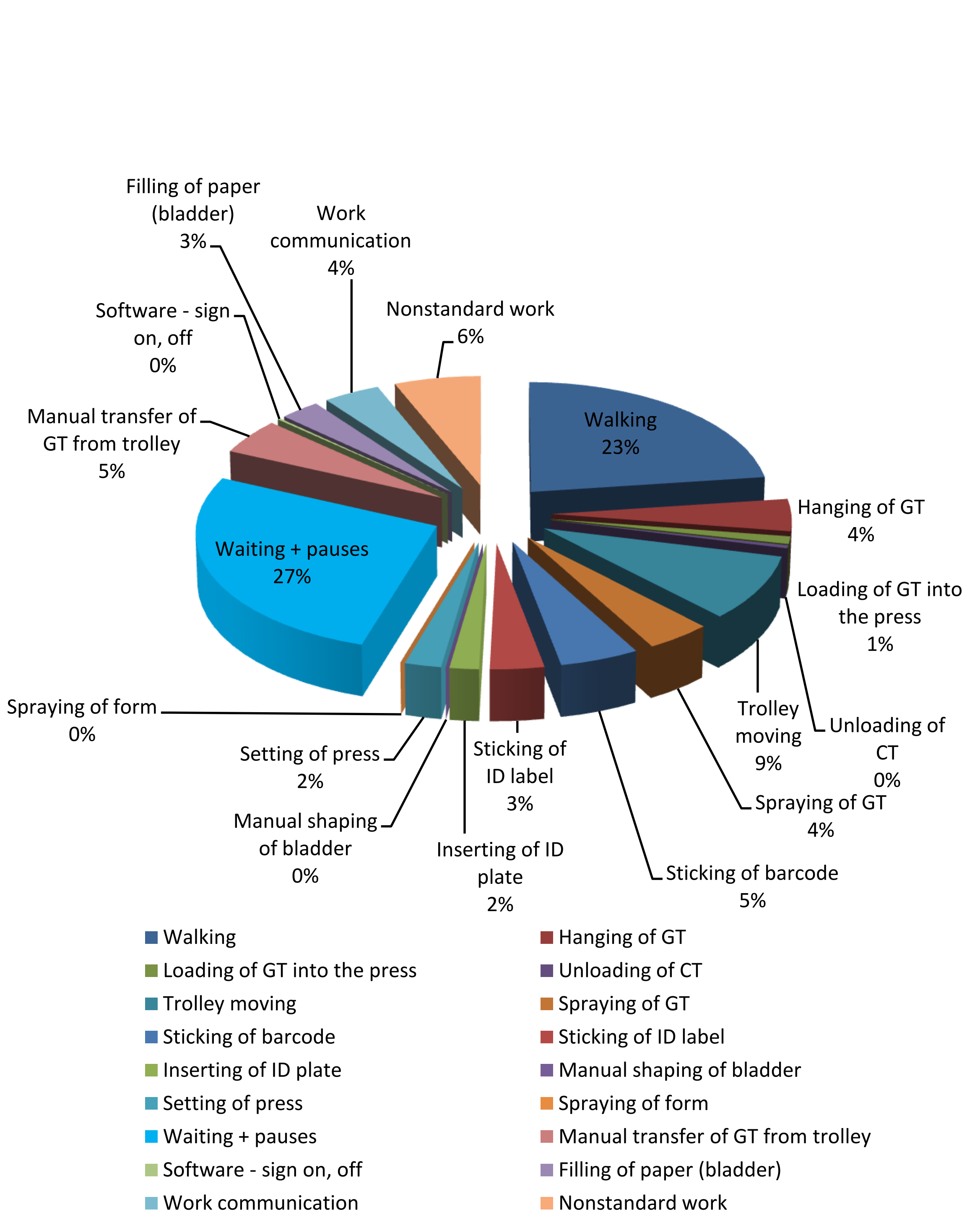

Figure 29: Time snapshot of serviceability of vulcanizing presses 1701 – 1713 (by author)

6.6 Time snapshot 5: for presses 1714 - 1725

- Work shift: third/night
- Date: December 2012
- Time: 21:15 – 5:10

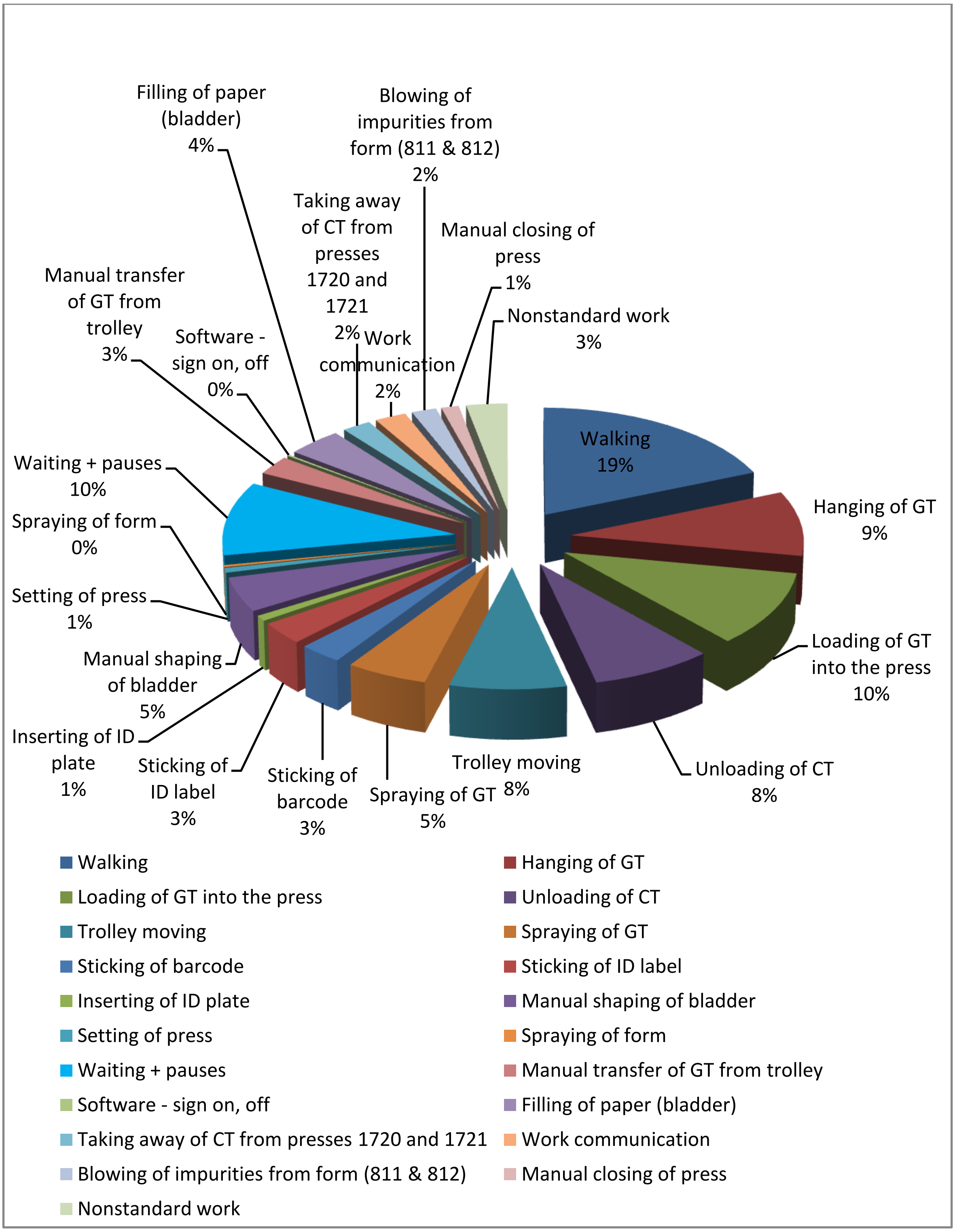

Figure 30: Time snapshot of serviceability of vulcanizing presses 1714 – 1725 (by author)

6.7 Time snapshot 6: for presses 1801 - 1813

- Work shift: first/morning
- Date: October 2012
- Time: 5:15 – 12:25

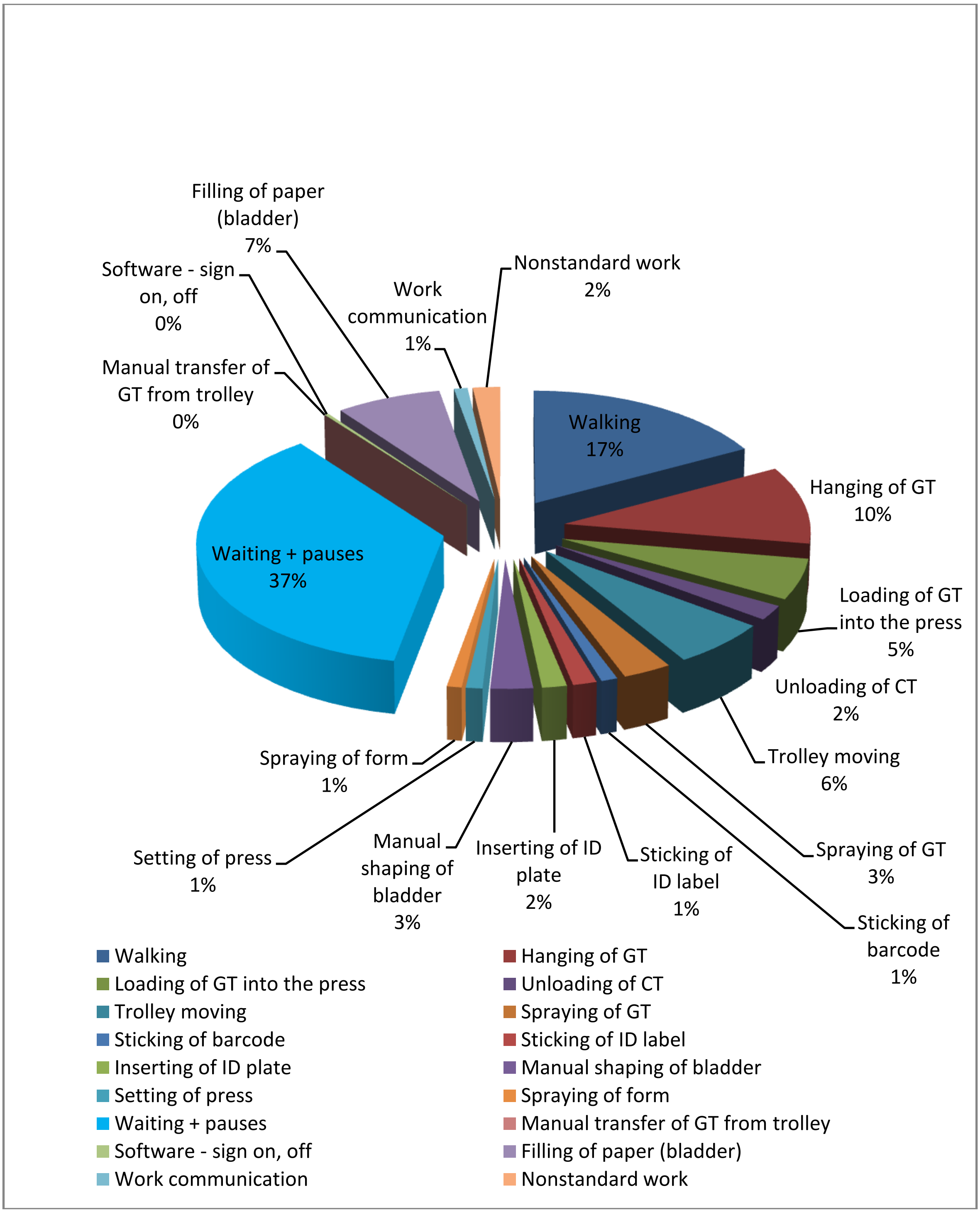

Figure 31: Time snapshot of serviceability of vulcanizing presses 1801 – 1813 (by author)

6.8 Time snapshot 7: for presses 1814 - 1827

- Work shift: second/afternoon
- Date: October 2012
- Time: 13:25 – 21:01

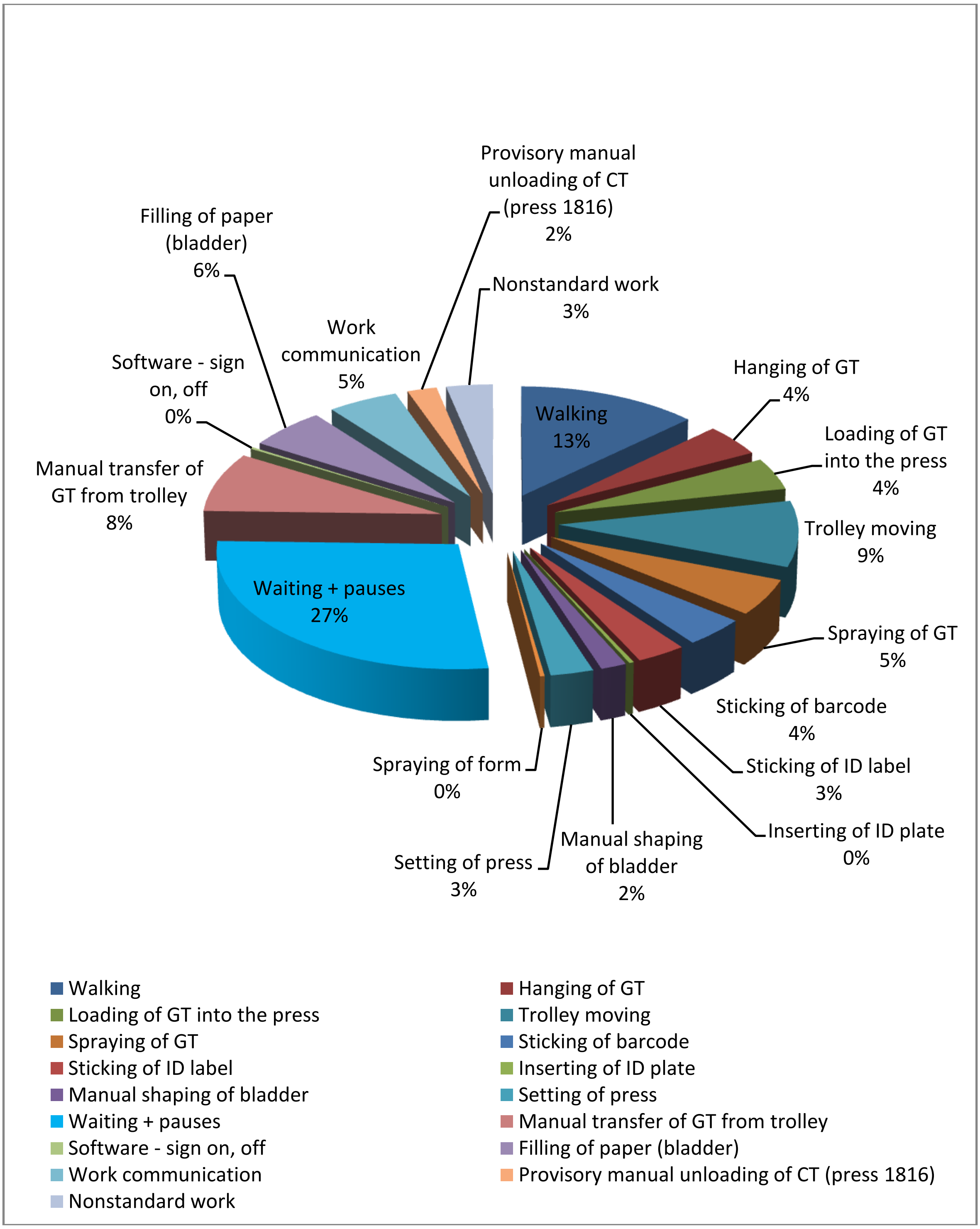

Figure 32: Time snapshot of serviceability of vulcanizing presses 1814 – 1827 (by author)

6.9 Analysis of snapshots

Table 6: Comparative analysis of identified activities (by author)

ACTIVITY (minutes)	PRESSES						
	705-713	**704-804**	**805-812**	**1701-1713**	**1714-1725**	**1801-1813**	**1814-1827**
Walking	60	49,4	64,3	106,4	89	73,5	58,6
Hanging of GT	32,3	29,1	47	20,5	43,7	44,6	19,8
Loading of GT into the press	0	23,3	54	4,8	49,8	23,4	20
Unloading of CT	9,6	8,7	11,9	1,9	38,3	8,5	0
Trolley moving	40,1	42,2	51	41,6	36,6	26,1	41,3
Spraying of GT	19,3	10,9	26,3	19,4	25,6	13	22,8
Sticking of barcode	11,7	7,4	29,3	23,5	13,6	4,4	18
Sticking of ID label	11,5	8,9	14,6	16	14,8	6,4	14,3
Inserting of ID plate	4	11,5	30,7	8,7	3,8	6,6	1,4
Manual shaping of bladder	3,4	10,1	21,2	0	23,1	11,3	7,5
Setting of press	6	7,9	1,7	10,8	3,2	4,4	12,5
Spraying of form	9,3	2,4	0	0	1,3	3,9	1,3
Waiting + pauses	215,8	193,5	63,6	125,9	49,8	156,9	124,6
Manual transfer of GT from trolley	2,8	0	0	22,8	12,8	0	37,3
Software – sign on, off	1	1,4	1	1	1	1,2	1,2
Filling of paper (bladder)	22,9	24,7	11,6	13,4	19,2	31,4	25,4
Work communication	5,7	25,4	6,3	18,9	11	4	22,9
Nonstandard work	12,6	11,4	10	28,7	14,4	8,1	15,1
Taking away of CT from presses 1720 & 1721	0	0	0	0	10,1	0	0
Blowing of impurities	0	0	12,1	0	8,7	0	0
Manual closing of press	0	0	0	0	6,1	0	0
Provisory manual unloading of CT	0	0	0	0	0	0	9,6
TOTAL TIME (minutes):	**468**	**468,2**	**456,6**	**464,3**	**475,9**	**427,7**	**453,6**

We can compare measured absolute times for various activities and rows of presses in the table 6. Marked activities are mostly not automated, so we find out here the opportunity for increasing of efficiency. The table 7 contents simple calculations of productivity, which are only approximate, due to various vulcanization (cure) times and different levels of automation too. Those problems were consulted with industrial engineer from Continental Barum s. r. o. Following activities were identified as unproductive: *Waiting + pauses, Work communication, Nonstandard work.* Productivity indicators in the table 7 are always considered per 1 work shift. They were calculated from measured times.

Table 7: Comparative analysis of partial productivity (by author)

PRODUCTIVITY (partial)	PRESSES						
	705-713	**704-804**	**805-812**	**1701-1713**	**1714-1725**	**1801-1813**	**1814-1827**
Number of produced tires (pieces)	118	102	118	189	162	64	196
Productive time on 1 produced tire (minutes)	1,98	2,33	3,19	1,54	2,47	4,04	1,48
Number of working press domes (pieces)	13	14	16	20	16	11	19
Number of produced tires on 1 working dome (pieces)	9,1	7,3	7,4	9,5	10,1	5,8	10,3

In the table 8 we can find calculation of disposable time of each operator. This time will be used for other work (serviceability of more presses in the project part). After the consultation with industrial engineer from Barum Continental s. r. o. were determined the following allowances: *Software – sign on, off, Filling of paper (usage of bladder), Work communication.* Time of nonworking forms was made as the calculation of productive times on one form and this number was multiplied by number of forms, which were not working.

Table 8: The calculation and comparative analysis of disp. time of operators (by author)

TIME (minutes)	PRESSES						
	705-713	**704-804**	**805-812**	**1701-1713**	**1714-1725**	**1801-1813**	**1814-1827**
Waiting + pauses	215,8	193,5	63,6	125,9	49,8	156,9	124,6
- 30 (legal pause)	- 30	- 30	- 30	- 30	- 30	- 30	- 30
+ identified allowances	+ 29,6	+ 51,5	+ 18,9	+ 33,2	+ 31,2	+ 36,6	+ 49,5
- 45 (10 % as personal need according to REFA)	- 45	- 45	- 45	- 45	- 45	- 45	- 45
working time per 1 working press dome	15,59	16,99	23,53	14,54	25,03	23,52	16,17
number of nonworking press domes	5	3,5	0	6	2	2	1
- time for nonworking press domes	-77,95	-59,47	- 0	-87,24	-50,06	-47,04	-16,17
DISPOSABLE TIME	**92,5**	**110,5**	**7,5**	**- 3,1**[2]	**-44,1**[3]	**71,4**	**82,9**

[2] The number is negative, because presses 1704 and 1705 are new, so far in test mode. In real function they will have higher level of automation.

[3] The number is negative, because in calculation of productive time per 1 press dome was included also productive time from old presses 1720 and 1721, which are more time consuming for operator. That was leading to distortion of average productive time per 1 press dome.

6.10 Process analysis

Production process of CVT is large and difficult, so I decided to make simplified process analysis of operation *serving of one vulcanizing press*. On this workplace (CVT pressing shop) I am making optimization of serviceability. In the figure 33 there are showed general activities of operator and times, which were determinate by qualified estimation based on time snapshots.

Number	Activities with need of operator	Operation with tire	Walking of operator	Activity time (s)
1	walking		➡	4
2	spraying of form	●		3
3	walking		➡	2
4	manipulation with trolley	●		5
5	walking		➡	2
6	hanging of GT on spreader	●		4
7	walking		➡	2
8	spraing of green tire (GT)	●		5
9	walking		➡	3
10	sticking of barcode on GT	●		2
11	sticking of ID label on GT	●		2
12	loading of GT into press	●		1
13	walking		➡	3
14	inserting of aluminous ID plate	●		2
15	walking		➡	3
16	manual shaping of bladder	●		5
17	start of vulcanization	●		1
18	unloading of cured tire	●		1
	Total time of activities(s)	**31**	**19**	**50**
	Total number of activities	**11**	**7**	**18**
	Total number of operators	**7**		

Figure 33: Simplified process analysis – current status (by author)

7 SUMMARY OF THE ANALYTICAL PART OF THE THESIS

Continental Barum s. r. o. is the largest tire factory in Europe and simultaneously the biggest employer in the region of Zlín. In 2012, the company celebrated the triple anniversary: 80 years of the tire production in this region (started by Baťa´s tire production), 40 years from the beginning of the production in the factory in Otrokovice and 20 years since the signing of the contract with concern Continental AG. Continental Barum s. r. o. is successful because of the combination of the tradition with the latest know how and high technology. The company reached EAT 1,93 billion CZK for 2011.

Continental Barum s. r. o. mainly produces three types of tires:

- passenger (for passenger cars and light truck) - PLT
- commercial (for trucks) – CVT
- industrial (for industrial vehicles)

The Continental Tire Manufacturing System is a concept that is used by all rubber companies of the Continental concern. This system allows mutual learning, cooperation, innovation and helps to better understand to tire production. CT.MS combines the philosophy of continual improvement and lean manufacturing tools. It focuses on specific objectives derived from the corporate strategy. (Winkler, Continental AG, 2008)

Continental Barum s. r. o. can use its good name in the Czech Republic and abroad too. But being a traditional producer is not enough, especially in the automotive sector. It is necessary to improve business processes continuously and to monitor the newest trends in product and production technologies.

Continental Barum s. r. o., as other companies of automotive sector, is dependent on the demand of cars. This trend can significantly affect the success of the company in positive or negative way. Continental Barum s. r. o. focuses a part of its production capacity on the most modern tires with high added value – for example ContiSeal technology (tire puncture resistant). The emphasis on quality is also the best defence against low-cost competition.

In the pressing shop of commercial vehicle tires there is located 70 vulcanizing (that means curing) presses in 4 rows.

Vulcanizing presses are served by 7 operators in one shift. Each operator has his sector of presses (serviceability). Presses have different level of automation and activities of operator are dependent on type of press and produced tire.

During my work I made 7 time snapshots, that means one snapshot for each part of workplace pressing shop (3 snapshots for the first/morning work shift, 2 snapshots for the second/afternoon work shift and 2 snapshots for the third/night work shift). My task was to analyse of operator activities and identification of waste.

Waste was identified after analysis of snapshots, productiveness and processes. That means opportunity for improving of effectiveness at this workplace, which will be solved in detail in the project part of the thesis.

8 THE PROJECT OPTIMIZATION OF SERVICEABILITY OF VULCANIZING PRESSES OF COMMERCIAL TIRES

8.1 Objectives, time table and project team

8.1.1 Objectives of the diploma thesis

Main objective:

Propose the project, leading to increase efficiency of serviceability in the workshop pressing shop of commercial tires in Continental Barum s. r. o.

Main objective according to *SMART methodology*:

S (specific): Use waiting time of operators and improve serviceability of vulcanizing presses on press shop of CVT in Continental Barum s. r. o.

M (measurable): Use disposable time of operators at least from 50 % and increase serviceability at least 2 vulcanizing presses more per one operator by automation.

A (achievable): Create and analyze time snapshots for operators of all rows of CVT vulcanizing presses in various work shifts. Count and propose automation of concrete activities.

R (realistic): Regularly consult proposal of the project with industrial engineer from Continental Barum s. r. o. and with supervisor of thesis from Tomas Bata University in Zlín.

T (time tabled): Present designed project in Continental Barum s. r. o. in April 2013 and defend the diploma thesis on Tomas Bata University in May 2013.

Secondary objectives:

My diploma thesis has two secondary objectives too. The first one is to create the analysis of activities of workers from pressing shop based on snapshots.

The second secondary objective of my thesis is to interconnect knowledge from study with practice from world class manufacturer and create my own opinion on this issue.

8.1.2 Time table of the project

Progress of the diploma project in time is illustrated by Gantt chart in the figure 34. After presentation of results in Continental Barum s. r. o, I will defend my diploma thesis on Tomas Bata University in Zlín. The defence of my thesis does not belong to the project itself, so it is not included in Gantt chart.

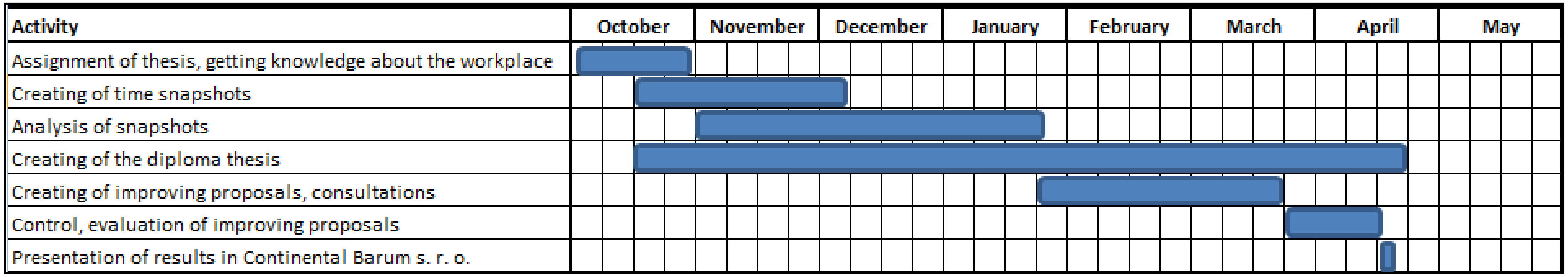

Figure 34: Gantt chart of the project (by author)

8.1.3 Team of the project

The project team consists of the following people:

- Bc. Josef Biernát - student of Tomas Bata University in Zlín, trainee, author of the diploma thesis
- Zdeněk Fryštacký – industrial engineer in Continental Barum s. r. o., consultant of the diploma thesis
- Ing. Roman Novák – head of Commercial vehicle tires department in Continental Barum s. r. o., reviewer of the diploma thesis
- Ing. Pavlína Pivodová – industrial engineer, PhD student and educator at Tomas Bata University, supervisor of the diploma thesis

8.2 RIPRAN of the project

The table 9 includes terms: ID (identification number), DT (diploma thesis), TBU (Tomas Bata University) and CB (Continental Barum s. r. o.).

Table 9: Risk project analysis of the project (by author)

ID	THREAT	PROBA-BILITY	ID	SCENARIO	PROBA-BILITY	IMPACT	VALUE OF RISK	PRECAUTION
1	Uncooperative CB management	Low	1.1	Bad communication during creating of diploma thesis	Low	High	Medium value of risk	Agreement about cooperation between CB and TBU
		Low	1.2	Necessary data are not provided	Low	High	Medium value of risk	Consultations about possibility of providing concrete data
2	Uncooperative CB operators	Medium	2.1	Distorted, unreal data	Medium	High	High value of risk	Inform operators about measure-ment, be polite on operators
3	Injury during practice	Medium	3.1	Unfinished diploma thesis	Medium	High	High value of risk	Seminar about safety, student should be rested and prepared
4	Breakdown of PC, loss of data	Medium	4.1	Loss of data for diploma thesis	Medium	High	High value of risk	Regular saving of data on three places
5	Bad quality of diploma thesis	Medium	5.1	Wrong calculations in analysis and project	Medium	High	High value of risk	Getting real data and continuous consultations in CB
		High	5.2	School theory vs. business practice, unreal project	Medium	High	High value of risk	Long term practice in CB for get-ting practice knowledge
		Low	5.3	Low formal level of diploma thesis	Low	Medium	Medium value of risk	Regular consultations with super-visor of DT on TBU

8.3 Logical framework of the project

The table 10 includes terms: ID (identification number), DT (diploma thesis), TBU (Tomas Bata University) and CB (Continental Barum s. r. o.).

Table 10: Logical framework of the project (by author)

OVERAL OBJECTIVE(S)	OBJECTIVELY VERIFIABLE INDICATORS	SOURCES OF VERIFICATION	ASSUMPTIONS AND RISKS
Main purpose: Increase efficiency and productivity in pressing shop of CVT in CB	Calculation of partial productivity – quantity of produced CVT tires per one operator in CVT pressing shop	Statistics of production	Number of produced CVT tires depends on demand
Project purpose: 1. Propose the project, leading to increase efficiency of serviceability in the workshop pressing shop of commercial tires in Continental Barum s. r. o.	Productive time of operators, number of operators in CVT pressing shop	Headcount of CVT pressing shop Tables with calculations based on snapshots of operators in CVT pressing shop	Problem with identification of productive and non-productive time in snapshots
Results: 1.1 Proposal - new layout of serviceability on CVT pressing shop 1.2 Presentation of proposals for improvement of processes	New layout of serviceability, concrete improving proposals for the CVT pressing shop	Diploma thesis Proposal of the project Presentation for Continental Barum s. r. o.	Conflict school theory versus company practise (unreal proposals)
Activities: 1.1.1 Making 7 time snapshots 1.1.2 Analysis of snapshots 1.1.3 Process analysis 1.2.1 Visual control of workplace 1.2.2 Consultation with industrial engineers	**Means:** Computer MS Excel MS Power Point MS Word Paper forms for snapshots Stopwatches	**Time table:** 10-12/2012: making of time snapshots 10/2012 - 4/2013: creating of diploma thesis 4/2013: presentation in CB 5/2013 – defence of diploma thesis on TBU	Cooperation with Continental Barum s. r. o. and Tomas Bata University **Preliminary conditions:** Practice in Continental Barum s. r. o. via project Talented students of TBU, choice of competent supervisor of diploma thesis and approval of DT assignment by TBU

8.4 Results of the project, improving proposals

During analysis of time snapshots two main tasks appeared: The first task was to use time of operator in better way, because the large part of work shift was covered by waiting. The second task was to propose and calculate the automation of the specific activities. For each snapshot, I tried to detect individual problems too, for concrete improving proposals.

8.4.1 Improving proposals for each row of vulcanizing presses

The row of vulcanizing presses 705 – 713

The problem 1: In this workplace I find the problem of breakpoint (for trolley with green tires), which was wrongly fixed on the ground, showed in the figure 35. Consequence of this problem is incorrect hanging of green tire on spreader and this activity is taking more time than it basically needs.

The proposed solution 1: I suggest a revision of conditions of breakpoints for trolleys with green tires.

Figure 35: Damaged breakpoint for trolley with green tires (by author)

The row of vulcanizing presses 704 – 804

The problem 1: In this row of vulcanizing presses I found the same problem with break-points for trolleys as in row of presses 701 – 713.

The proposed solution 1: I suggest a revision of conditions of breakpoints for trolleys with green tires.

The problem 2: When both domes of one double-dome vulcanizing press are curing the same kind of tire and for those two domes there is only one trolley with green tires. The operator has to move the trolleys between two domes, which is time consuming.

The proposed solution 2: I suggest finding out, if the reason is a small number of trolleys or green tires and according to this investigation finally solving this problem. But if the situation with one trolley for two domes appeared because of finishing of the production, it is all right.

The problem 3: For high number of presses occurs the problem with unloading of cured tires – tire is blocked and for press it is impossible to unload it without assistance of operator.

The proposed solution 3: I suggest inspection of this row of presses by maintenance workers, who should set it to the right point.

The row of vulcanizing presses 805 – 812

The problem 1: In this row of presses there is the same problem with breakpoints for trolleys.

The proposed solution 1: I suggest the same solution as was mentioned above.

The problem 2: Often problem is also when only one trolley with green tires is available for two domes of one double-dome vulcanizing press.

The proposed solution 2: As I wrote above, it is important to find the real reason of that problem and solve it.

The problem 3: Operator has to blow impurities out of presses 811 and 812 often.

The proposed solution 3: Workers of maintenance should find the reason and manage that those presses will be in the same condition as other presses.

The row of vulcanizing presses 1701 – 1713

The problem 1: In case of failure, operator has to contact workers of maintenance for service, but the telephone is too far from him. If in this moment other presses are opened (finished vulcanization), the operator must choose malfunction of one press or cooling of other presses, which stay opened.

The proposed solution 1: I suggest supplying the operator with a cell phone, which can be used for contacting workers of maintenance.

The problem 2: A major problem is the function of central conveyor, which is moving cured tires to warehouse. This conveyor keeps breaking down quite often which causes its stop. Vulcanizing presses cannot unload cured tires and they cannot work.

The proposed solution 2: Workers of maintenance or Plant engineering department should find exact reason and solve it.

The problem 3: Software (specific error message) of some presses (for example press 1701) is in English language. Operator knows, what he should do, but he does not know why. In case of unpredictable situation problem might appear.

The proposed solution 3: The solution is to train of operators for English software of new presses or translation of software to the Czech language

The row of vulcanizing presses 1714 - 1725

The problem 1: The important problem of this row of presses is stopping of central conveyor.

The proposed solution 1: The solution is described above.

The problem 2: During unloading of cured tires from presses 1722, 1723 and 1724 the operator has to do this activity by his hand. This is dangerous and time consuming for him.
The proposed solution 2: The solution is higher level of automation for those presses.

The problem 3: Presses 1720 and 1721 are antiquated and the operator has to do moving of cured tires manually by a small trolley.

The proposed solution 3: I suggest the installation of automated unloading device for those two presses, which will save 10 minutes of operator time per one work shift.

The row of vulcanizing presses 1801 – 1813

The problem 1: Once again there is the same problem with stopping of central conveyor.

The proposed solution 1: The same solution, as was mentioned above, is valid.

The problem 2: Workers of maintenance are leaving repaired vulcanizing press before its launching.

The proposed solution 2: In case of repair of defect of the press, workers of maintenance should wait for start of vulcanization of the press and confirm its functionality. Implementation of cell phones for operators of presses seems to be effective also there.

The problem 3: The operator deals with most of his activities (for example hanging of green tire on spreader or unloading of cured tire from press) in manual mode, because presses do not have exact movements. This is time consuming.

The proposed solution 3: The solution is modernization (higher level of automation), or at least careful inspection of presses by workers of maintenance.

The row of vulcanizing presses 1814 – 1827

The problem 1: In this row of vulcanizing presses has been found that the operator cannot serve all presses in time, because there are short vulcanizing times and the high number of those presses for one operator.

The proposed solution 1: I suggest redistribution of the number of presses for this operator (a few presses should be added to other operator with longer time of waiting and pauses), or automation of some of his activities.

The problem 2: The press 1816 has provisory handle unloading of cured tire.

The proposed solution 2: I suggest local horizontal conveyor, which can move cured tires to central conveyor. This means saving 9,6 minutes of one operator per one work shift.

The problem 3: This workplace also depends on functionality of the central conveyor.

The proposed solution 3: Workers of maintenance or Plant engineering department should find exact reason and solve it.

The problem 4 and its proposed solution: Because the operator is too busy it would be useful to supply him with cell phone for contact of workers of maintenance for the case of defects.

General suggestion for all presses

The problem: For all presses one frequent problem occurs: fluctuations in temperature and pressure. That causes slight extension or contraction of vulcanizing time.

The proposed solution: I suggest checking by technologists, why this mistake appears and if there is a possibility to change setup (toleration) of vulcanizing presses.

All forenamed problems and proposals for their solution were presented in Continental Barum s. r. o. and they were forwarded there in a written form. A large part of the problems can be solved by automation, which was chosen as key instrument for increase of productivity and efficiency in CVT pressing shop, based on time snapshots. Now we are going to deal with topic of automation and concrete calculations of its gains.

8.4.2 Design of automation and impact on number of served presses by one operator

In the table 6 there were identified the activities suitable for automation. In the following table 11 there are calculated time savings (per one operator on one work shift). This savings can be reached by realization of automation. In the table 11 there is also the impact on the number of vulcanizing presses, which can be served by one operator in addition. The table 11 contents also calculation of presses per one operator in addition by usage of disposable time, calculated in the table 8.

For example, the table 11 shows for the row of presses 705 – 713 that one operator currently serves 9 vulcanizing presses. The serving of one vulcanizing press (which can be really added in advance to that operator) takes 31,1 minutes of operator´s time per his work shift. To utilise his disposable time (92,5 minutes – calculated in the table 8) we can add to him 3 presses for serving. If moving with trolley for green tires will be automated, we will reach time saving 40,1 minutes per one work shift. That means we can add to him in advance 1,3 vulcanizing press for serving. And so on.

Table 11: Automation and its impact on number of served presses (by author)

Savings / rows of presses	705-713	704-804	805-812	1701-1713	1714-1725	1801-1813	1814-1827
CURRENT COUNT – operator serves number of presses	**9**	**8**	**8**	**13**	**9**	**13**	**10**
Time of serving of one added press in minutes	31,2	34	47	29,2	32,4	32,4	50
Disposable time (minutes)	92,5	110,5	7,5	0	0	71,4	82,9
Presses in addition (pieces)	3	3,3	0,2	0	0	2,2	1,7
Time saving: automation of GT trolley moving (minutes)	40,1	42,2	51	41,6	29,6	26,1	41,3
Presses in addition (pieces)	1,3	1,2	1,1	1,4	0,9	0,8	0,8
Time saving: automation of hanging of GT (minutes)	27	24,5	41,7	12,8	36,4	41,5	13,7
Presses in addition (pieces)	0,9	0,7	0,9	0,4	1,1	1,3	0,3
Time saving: automation of spraying of GT (minutes)	19,3	10,9	26,3	19,4	20,7	13	21,2
Presses in addition (pieces)	0,6	0,3	0,6	0,7	0,6	0,4	0,4
Time saving: automation of loading GT into press (minutes)	0	23,3	54	4,8	49,8	23,4	20
Presses in addition (pieces)	0	0,7	1,1	0,2	1,5	0,7	0,4
Time saving: automation of unloading of CT (minutes)	9,6	8,7	11,9	1,9	38,3	8,5	9,6
Presses in addition (pieces)	0,3	0,3	0,3	0,1	1,2	0,3	0,2
V1: Time saving: automat.of GT transfer from trolley (minutes)	-7	-8,5	-9,8	7	4,5	5,3	1,5
V1: Presses in addition (pieces)	-0,2	0,3	-0,2	0,2	0,2	-0,2	0
V2: Time saving: automat.of GT transfer from trolley (minutes)	2,8	0	0	22,8	10,4	0	34,6
V2: Presses in addition (pieces)	0,1	0	0	0,8	0,3	0	0,7
Automation: total presses in addition per one operator	**5,8**	**6,2**	**3,9**	**3**	**5,5**	**5,5**	**3,8**
DESIGNED COUNT – operator serves number of presses	**14**	**14**	**12**	**16**	**15**	**18**	**13**

The highest time saving can be achieved by automation of moving of trolley with green tires. Instead of trolleys there will be used an overhead conveyor with cranes, which will move green tires. Minority of tires (industrial tires with specific smaller dimension) will be moved by trolleys. Those trolleys will be moved by operators and that is why time saving of conveyor with cranes will be not same as measured time of trolley moving. Time savings per one work shift were calculated through one produced tire and with real time from measured snapshots. For vulcanizing presses, which will cure tires, moved in the future by trolleys with operators (minority of industrial tires), we have to reduce time saving about time of operators for manipulation with trolley and tires.

Hanging of green tire on spreader of press will be automated by pressing of button. This time saving was reduced about time for pressing of button.

Green tires will be spraying by machine in central storage of green tires. Operators will spray only green tires (minority of industrial tires with specific dimension), which will be moved by trolley. Time savings of operators for this operation were reduced. Machine for spraying of green tires is being used in the production of PLT.

The loading of green tire into vulcanizing press will be automated too, so it will carry on without any activity of operator. Nowadays this is functional for independent double-dome presses. For other presses, time saving is full time, which was used by operator for loading of green tires into vulcanizing press.

Unloading of cured tire on central conveyor will be automated for all vulcanizing presses. Time saving will be full time. Functionality of the central conveyor, mentioned in the previous chapter, will be a key factor for work of that innovation.

As it was mentioned above, green tires will be transferred by cranes on overhead conveyor. Version 1 (V1 in table 11) was calculated with the condition that crane will transfer green tire exactly to spreader of vulcanizing press. But after consultation we found out, that this solution is not possible so far. Because of this I made version 2 (V2 in table 11), crane will lay green tire in front of the vulcanizing press. The operator will transfer green tire from this place to spreader of vulcanizing press (approximately 2 meters). This activity of the operator is necessary and it will be time consuming for him, so we have to calculate negative time saving. This negative time saving is higher for rows with (dependent) double-dome or plate presses. But from the table 11 it is clear, that construction of the overhead conveyor with cranes will bring significant time savings.

The manual shaping of bladder is a difficult activity, during which the operator controls the membrane of press also. Because of this reason, after consultation we made a decision, that shaping of bladder would be provided by operator manually. This activity will be not automated so far.

Every proposal of automation was calculated by real data from time snapshots. In those calculations different types of vulcanizing presses were also taken into the count. The calculation of presses for each operator in addition was based on serving times of presses, which will be added to operator.

In pressing shop currently 7 operators are serving 70 presses. After complete implementation of proposal automations and usage of disposal time of operators, those 7 operators will be able to serve 102 presses. The company made a decision that due to uncertain demand, financial challenge and absence of place in this production hall it is not good idea to receive new presses. Preferred solution for growth of efficiency is reduction of number of operators.

8.4.3 Design of new layout of serviceability

The number of CVT presses operators per shift was reduced from 7 to 5. This designed layout of serviceability is based on a complete implementation of proposed automations. Executed double-check calculation confirms, that each operator will have enough time for serving of his row of presses. However, especially during beginning of implementation it will be important to control activity and utilization of operators.

1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1821	1822	1823	1824	1825	1826	1827
SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	ID	DD	ID	DD	ID	ID	ID	ID	ID	ID	ID
												ID	DD	ID	DD	ID	ID	ID	ID	ID	ID	ID

DD	DD	DD	DD	DD	ID	ID	ID	ID	ID	ID	ID	ID	DD	DD	DD	DD	DD	DD	DD	DD	DD
DD	DD	DD	DD	DD	ID	ID	ID	ID	ID	ID	ID	ID	DD	DD	DD	DD	DD	DD	DD	DD	DD
1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711	1712	1713	1714	1715	1716	1720	1721	1722	1723	1724	1725

801	802	803	804	805	806	807	808	809	810	811	812
DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD
DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD

DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD
DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD	DD
701	702	703	704	705	706	707	708	709	710	711	712	713

SD *Single-dome or plate press*
DD *Double-dome or plate press*
ID *Independent double-dome or plate press*

701 *Press identification number*
¦ *Separating wall*

Serviceability:

operator 1	*operator 2*	*operator 3*	*operator 4*	*operator 5*
(red)	(green)	(blue)	(yellow)	(magenta)

Figure 36: Designed serviceability of vulcanizing presses of commercial tires (by author)

An important advantage of a new layout of serviceability in the figure 36 is usage of separating wall (for rows of presses 17 and 18), which will have function as simple visualization and it will help operators to control effectively their rows of vulcanizing presses.

8.4.4 Process analysis after implementation of changes

When we specify the work of operator (serving of vulcanizing press) to simplified process analysis, we will get the figure 37. The old process analysis (figure 33) contented 11 activities (31 seconds) and 7 times walking of the operator (19 seconds). Average time for serving of one press was 50 seconds, after implementation of changes it is 35 seconds. We can see here a significant time saving, due to we can reduce number of operators on press shop from 7 to 5 persons per 1 work shift.

Number	Activities with need of operator	Operation with tire	Walking of operator	Activity time (s)
1	walking		➡	4
2	spraying of form	●		3
3	walking		➡	2
4	transfer of GT towards to press	●		5
5	walking		➡	2
6	sticking of barcode on GT	●		2
7	sticking of ID label on GT	●		2
8	hanging of GT on spreader	●		3
9	walking		➡	2
10	inserting of aluminious ID	●		2
11	walking		➡	2
12	manual shaping of bladder	●		5
13	start of vulcanization	●		1
	Total time of activities(s)	**23**	**12**	**35**
	Total number of activities	**8**	**5**	**13**
	Total number of operators	**5**		

Figure 37: Simplified process analysis – designed statue (by author)

We can also compare productivity, but only with an estimated numbers, because we do not have statistics of production with realized changes. What we know is that productivity in the old serviceability of CVT pressing shop (calculated from snapshots) was approximately 136 cured tires per one operator per one work shift. With the same volume of production productivity after implementation of changes will be approximately 190 cured tires per one operator per one work shift. That means increase of partial productivity about 40 %.

8.5 Resume and presentation of the project

On 16th April 2013 I presented the results of my work in Continental Barum s. r. o. The employees were interested in my presentation, so already during the presentation I answered a few questions. Then I was even asked about the calculation of quantity of operators in CVT pressing shop by their time limits for cross-checking of my results. The presentation and especially the results of my work were valuated as precious and very good.

I was also briefly introduced with the project CVT MAX, which leads to increase of CVT production. I was pleased that conclusions of my analysis are similar to the calculations for mentioned project from industrial engineers of Continental Barum s. r. o. My diploma thesis provides detail data, useful for the project CVT MAX. The implementation of this project has already started. After a few months the capacity of production will be increased on 3 000 pieces of CVT per one day.

According to my opinion and experience I would like to evaluate the cooperation with Continental Barum s. r. o. as perfect one. Whenever I asked for data, which I needed for calculations, my personal access directly to the production or professional consultation, I was satisfied. The positive fact is also that I received the submission of work, which is really important for the company. This illustrates mutual trust, which is a base of our successful cooperation.

CONCLUSION

In my diploma thesis I focused on optimization of vulcanizing presses serviceability in workplace pressing shop for commercial tires in Continental Barum s. r. o. In the theoretical part, I performed the literature search about industrial engineering, business process optimization and work measurement with focusing on productivity. In the practical part, firstly I introduced Continental Barum s. r. o. and concrete workplace for optimization. I made totally 7 time snapshots of operators, which I analysed. I proposed specific ways of automation of chosen activities and other improving proposals, based on calculations and consultations with industrial engineers. According to the calculation of savings, I create new layout of serviceability of CVT vulcanizing presses. Due to this proposal, the number of operators can be reduced from 7 to 5 persons. I presented proposal of the project in Continental Barum s. r. o., where I successfully accomplish my task. Industrials engineers introduced to me the project CVT MAX, for which they will use this diploma thesis.

I am really glad that I could create my diploma thesis in Continental Barum s. r. o. I want to thank to industrial engineers (especially Zdeněk Fryštacký), who helped me to get into practice of industrial engineering in the world-class company. My thanks also belong to operators of CVT pressing shop, who behaved to me well and for their patience during my taking of time snapshot and asking questions.

The optimization of the number of operators is difficult and not enjoyable work. But as professor Ján Košturiak wrote, the successful company at all costs does not only reduce the quantity of its employees, but it is looking for opportunities for them. General attitude says that in a company we can replace everyone and everything. In my opinion, it is the most difficult to replace a loyal employee. I am therefore pleased that Continental Barum s. r. o. is trying to transfer employees to other work, as it is for example a new production hall, which will be supplied in the near future. This new production seems to be an opportunity during increasing of efficiency and productivity.

I tried to use my knowledge, gained during my studies and also practical experience from the company to meet the objectives of the work. I created the proposal of the project, which will lead to increase of productivity and efficiency of work on CVT pressing shop. I believe, that this work should make sense and it is worthy finish of my studies at Tomas Bata University in Zlín, which I have always tried to represent as the best as I could.

Industrial engineering is an important part of successful companies nowadays. It helps us to answer the question of how an organization can work more effectively. Industrial engineering with human face offers one more question - why do we work more effectively and what is actually our real objective.

It may sound like only an idealistic phrase and we are serious people, who do not have time for those thoughts. But we should realise, that Tomáš Baťa was not only a serious, but also honourable man. And this truly successful human being can inspire us when he says:

High progress in production is based on small improvements manifested in every step and human movement. In factory, all employees should make an effort to reach progress, but especially entrepreneur should do this. The biggest obstacle can be overcome by entrepreneur, who will understand, that he is called to fairly and promptly divide profits from progress of production among workers, customers and factory. (Baťa, 2002, p. 68)

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LIST OF ABBREVIATIONS

IE Industrial engineering.

TPS Toyota production system.

CVT Commercial vehicle tires.

PLT Passenger and light truck tires

ESH Environment safety and health

ICO Inter company

CT.MS Continental Tire Manufacturing System

CB Continental Barum s. r. o.

DT Diploma thesis

RR49 Right Road 49

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APPENDIX P I: USED PAGE OF THE FORM FOR TIME SNAPSHOT

3. MĚŘENÍ

Datum: 31. 10.
Směna: ODPOLEDNÍ
Od do: 13:20 - 21:00

Pozorovací list
Pro snímek pracovního dne
a snímek průběhu práce

List č.: 6
Pozorovatel: J. B.
Pozorovaný:

Pracoviště: BA. CO. - LISOVNA KOMERČNÍCH PLÁŠŤŮ
Výrobek:

Postupný čas	Symbol	Popis	Postupný čas	Symbol	Popis
2:02	PŘP		35:50	M	
2:20	LI		~~35~~ 36:30	PR	
2:28	PŘ		36:45	N	
2:40	LB		37:00	PŘ	
3:00	M		37:29	RUČNÍ VYTAŽENÍ PNEU - PROVIZORNĚ L 1816	
3:35	PŘ		38:25	PŘ	
4:00	PŘP		38:46	BOMB.	1814
4:12	M		39:01	UM (v	[illegible] čas [illegible]
5:40	N		39:45	LI	
6:00	PŘP		39:51	LB	
6:08	LI		40:03	LI	
6:11	M		40:15	LB	
7:00	PO		40:29	PO	
7:16	PŘP		41:15	M	
7:30	PŘ		41:52	PŘ	
7:43	VP		42:07	Po	
8:46	PŘ		42:15	PŘP	
9:11	PO		42:22	LI	
9:14	PŘ		42:30	M	
9:35	Č		42:35	PŘ	
4:24:06	PŘP		42:41	BOMB	
24:20	M		43:00	UM	1816
25:15	KOM - o [illegible]		44:00	RUČNÍ CENTROVÁNÍ UMÍSTĚNÍ SP	
27:50	Po		44:28	PO	
27:53	PŘP		44:43	PŘP	
28:00	LI		45:04	LI	
28:10	LB		45:12	VP	
28:18	PŘ		47:00	PŘ	
28:40	PŘP		47:30	KOM	
28:53	LB		49:04	PŘ	
29:03	M		49:45	BOMB.	
29:45	PŘ		50:04	PŘP	
30:30	UM		50:40	PO	
30:39	PŘ		50:42	PŘP	
31:00	PITT		50:54	LB	
32:00	PŘ		51:04	PŘP	
33:33	PŘ		51:11	LB	
34:10	M		51:30	LI	
34:34	PŘP		51:40	PŘ	
34:40	LB		51:55	PŘP	
34:56	LI		52:06	LI	
35:03	PR		52:09	LB	
35:17	UM		52:15	PO	
35:21	PŘ		52:18	PŘP	
35:33	PŘP		52:32	LI	
35:45	LB		52:36	LB	
35:48	LI		52:40	PŘ	