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isep

Tire inspection spreading machine

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ERASMUS PROJECT

Tire inspection spreading machine

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Abstract

The aim of the project was to design in Solidworks and improve an existing Tire inspection machine. The project was developed in Gislotica - Mechanical Solutions, guided by ing. Rui Manuel Fazenda Silva who is a professor in ISEP. The designed device relates to the inspection of automobile tires for holes and weak places caused by punctures and usage. Such inspection include careful examination of the inside surface of the tire which is difficult because of its cylindrical shape, stiff and resistant nature of the material out of which the tire is made.

The whole idea is to provide a machine by which the walls of the tire may be spread and hold apart, presenting the inner surface for the worker to control. The device must also perform rotational and vertical movement of the tire. It is meant to provide inspection in which there is no need for the controller to use force. It makes his work easier and more efficient.

Keywords

Tire inspection machine, Gislotica-Mechanical Solutions, Solidworks, rotational movement, horizontal movement, motors, rack and pinion, bearing, shaft

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List of Symbols and Abbreviations

ECTS	European Credits Transfer System
EU	European Union
ISEP	Superior de Engenharia do Porto
SBR	Styrene-butadiene rubber
BR	Polybutadiene rubber

1. INTRODUCTION

Company characterization

The problem

Methods

1. Introduction

This work was carried out based on an Erasmus Project in order to get 30 ECTS in the academic year of 2015/2016, first semester. The main goal of this work is the design of a Tire inspection machine in association with the company Gislotica-Mechanical Solutions.

1.1. Company characterization

The company name is Gislotica - Mechanical Solutions and it is located in Rua Sidonio Muralha, n^{o}12 Perafita, Portugal. It is an engineering company specialized in the study and development of projects from Logistic to construction of special machines. Gislotica develops all projects and delivery keys in the hand having in the branches: design, fabrication and automation. Gislotica is pledged in supplying innovation and in doing so, it collaborates with its clients, helping them to realize their visions. For some projects Gislotica works in partnership with other companies, specialized in other branches in order to serve all kind of interests of the customer. This company employs forty workers and twelve of them are engineers. All employees of the company work in the same building, where on the first floor design offices are placed and on the ground floor production hall and workshop. The founder of the company is ing. Rui Fazenda who is also a professor in Instituto Superior de Engenharia do Porto.

1.2. The Problem

The problem which is being solved in this project is finding the best solution to design a machine for tyre inspection. At the beginning the shape of the machine and older solutions of the construction have been known. The machine should realize three movements. At first it needs to pick up the tire to the line of the controller arms to make his work easier and more comfortable. The next step is to spread the walls of the tire and keep it in that position during rotational movement in order to present the whole inner surface for the worker. That means that the main problems were related with the mentioned tree functions which the machine must ensure. For example, one of the biggest issues connected with vertical movement was how to guide the platform on which the tire stands during raising and lowering the platform and what solution to use to make this movement. Similar challenges have been solved during projecting the remaining two movements. At every level of the work smaller or bigger challenges have been faced and problems that require better solutions were solved.

Also, Solidworks was causing problems at the beginning, but after a few weeks it becomes a very helpful tool. Official website of the company: http://www.gislotica.pt/pt/.

1.3. Methods

In order to design the received project it was necessary to get to know basics of Solidworks. In this case very helpful were tutorials of the program, internet with big amount of instructional videos and priceless knowledge of the oldest colleges from the company. Very handy to create this machine was watching already existing and built machines in the company. Mechanical literature such as: Leonid W. Kurmaz, Podstawy Konstrukcji Maszyn, Projektowe Wydawnictwo Naukowe PWN, Warszawa 1999, was also very helpful to solve every technical problem and doubt. At the beginning the whole project was divided into four main parts. At first the base of the machine was constructed, then the columns, platform and at the very end the spreading system.

1.4. Methods

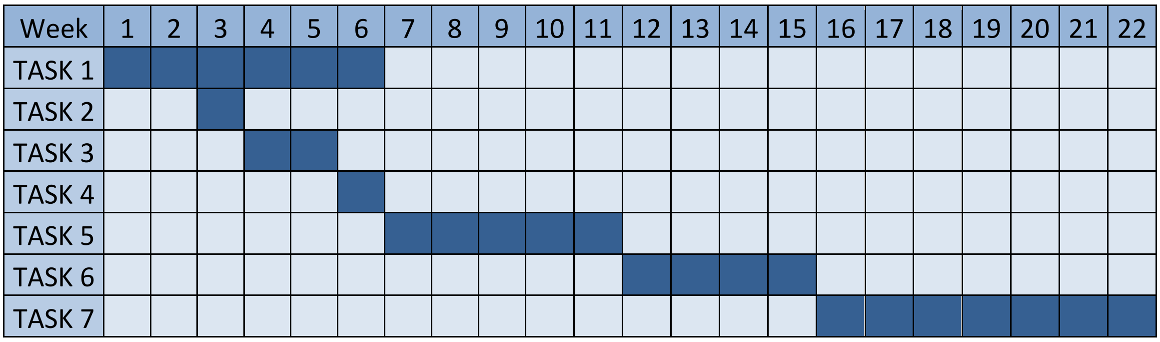

Figure 1.4.1. GANTT diagram with the time schedule.

Table 1.4.1. Name of the tasks.

TASK 1	Learning Solidworks
TASK 2	Familiarization with the subject of the project
TASK 3	Creating base of the machine
TASK 4	Creating columns holding the platform
TASK 5	Creating the platform on which tire is rotating
TASK 6	Creating the spreading system
TASK 7	Design examination and making improvements

2. BACKGROUND

Manufacturing process

Tire inspection

Tire structure

2. Background

A tire is an advanced engineering product made of much more than just rubber, fibre, textile and steel cord. Manufacturing process of a product, which is made of so many different materials, is very complex. It requires technology, heavy equipment and instruments with high precision and qualified people. Some of activates that go into the tire creation cycle are: preparation a materials, fabrication the components, building the tire and inspection.

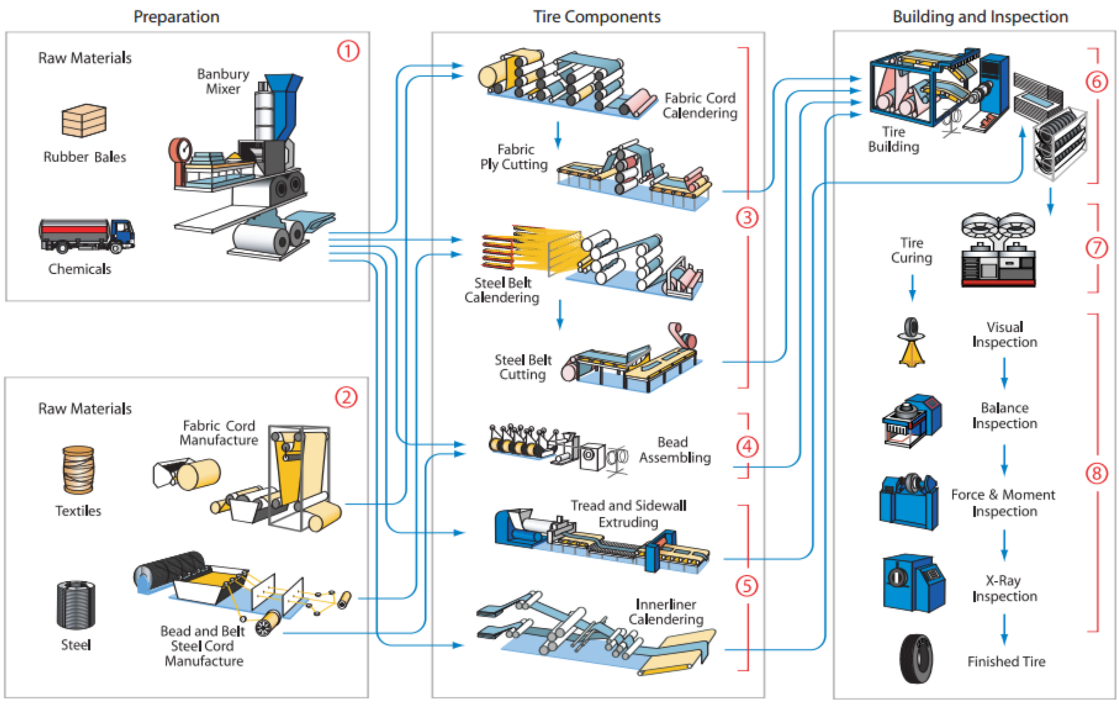

Figure 2.1.1. Process of tire creation [1].

2.1. Manufacturing process

Rubber preparation is a process of rubber compound formulation. There are two main components. First is rubber and the second is filler. Different composition of these two components, result into other characteristics of the tire. It can be achieved through the careful selection of one or more types of rubber. The type and amount of filler blended with the rubber is also important. That is the way to optimize performance and achieve maximize traction in either wet and dry conditions, or superior rolling resistance. In general, there are four major rubbers used: natural rubber, styrene-butadiene rubber (SBR), polybutadiene rubber (BR), and butyl rubber (along with halogenated butyl rubber). The first three are primarily used as tread and sidewall compounds, while butyl rubber and halogenated butyl rubber are mainly used for the innerliner, or the inside portion that holds the compressed air inside the tire. There are two basic fillers, one of them is carbon black and the second one is silica, both of them have several types. The selection depends on the performance requirements, as they are different for the tread and sidewall. [2]

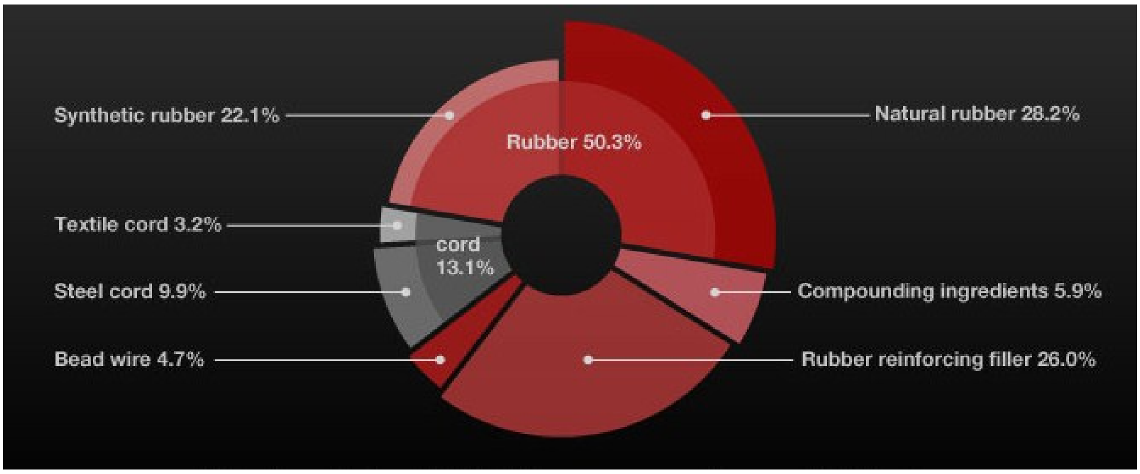

Figure 2.1.2. Tire raw material weight composition [3].

The next step is rubber component mixing. This process is a batch operation. Usually aach batch produces more than 200 kilograms and takes less than 3 - 5 minutes. The mixing process is to break down the rubber bale, fillers, and mix them with other ingredients. The mixing temperature can rise as high as 160 - 170 degrees Celsius. It is very preside stage because in to high temperature compounds can be damaged. That is why the sequence in which the ingredients are added is so important. To achieve expected results, tire manufacturers are using . After this process, produced mixture is sent to another machine to form it into product call “slap”. To achieve expected results, tire manufacturers use a mixer with mixing chamber inside. After this process, produced mixture is sent to another machine to form it into product call “slap”.

Fabric and steel cord preparation. To provide strength and to reinforce the rubber, producers add a steel and fabric cords to the construction of tire. To produce the cord, first the used yarn is twisted, next two or more spools of yarn are twisted into a cord. Fabric cord quality is based on its strength, stretch, shrinkage, and elasticity. Before it arrives at the factory it is kept in special rooms, where temperature and humidity are controlled. The reason of these special conditions is that the temperature, humidity and tension must have proper value before the fabric cords are calendared with rubber compound. Steel wire cords are manufactured from steel rod with high carbon content. Steel cords are coated strands by brass and twisted together into cords. Because the steel wire is brass coated, it is important to keep them in temperature and humidity controlled rooms once they arrive at the factory.

Belt and ply calendaring is a process where the rubber compound is connected with cords. The rubber is pressed on and into cords. The calendar is a machine used to this process; this heavy-duty device has three or more chrome - plated steel rolls, shown on Figure 2.1.3. Rolls are revolving in opposite directions and their temperature is controlled by steam and water. The calendaring process is an important step in whole tire producing process because the bonding of rubber with fabric or steel is critical to performance. The whole process look like this: first, a pre - set number of fabric or steel cords under proper tension are continuously pressed through two steel rollers. Rubber compound is added to the opening area between the rollers. Then the rubber compound is pressed into, on top of and on the bottom of the fabric or steel cords. A continuous sheet of cord - rubber composite goes through several rollers to ensure good penetration and bonding between the rubber and cords. Quality is measured by the thickness of the sheet, spacing between cords, the number of cords and the penetration of rubber into the composite sheet. The composite sheet is then cut into appropriate sizes, shapes, and angles depending on the desired contour of the tire.

Figure 2.1.3. Calendaring machine.

Inner liner calendaring is the process of creation the most inner layer of the tire. Its main functions are to retain the compressed air inside the tire and maintain tire pressure this stratum is very thin and also make by calendaring. Due to its low air permeability, butyl rubber or halogenated butyl rubber compounds are the primary compounds. Finish of the process with no - defect surface and gauge control are critical to retaining air pressure.

The bead component of the tire is a non - extensible composite loop that anchors the body plies and locks the tire onto the wheel assembly. The tire bead component includes several layers: The steel wire loop, apex or bead filler; the chafer, which protects the wire bead components; the chipper, which protects the lower sidewall; and the flipper, which helps hold the bead in place. The bead wire loop is made from a continuous steel wire covered by rubber and wound around with several continuous loops. The bead filler is made from a very hard rubber compound, which is extruded so as to form a wedge. The bead wire loop and bead filler are assembled on a sophisticated machine. The precision of the bead circumference is critical. If it is too small, tire mounting can be a problem. If it is too loose, the tire can come off the rim too easily under loading and cornering conditions. After the circumference is checked, the bead component is ready for the tire building operation. [2]

Tire components such as tread, sidewall, and apex are prepared by forcing uncured rubber compound through an extruder to shape the tire tread or sidewall profiles. Extrusion is one of the most important operations in the tire manufacturing process because it processes most of the rubber compounds produced from the mixing operation and then prepares various components for the ultimate tire building operation. The extruder in a tire manufacturing process is a screw-type system, consisting primarily of an extruder barrel and extruder head. First, the rubber compound is fed into the extruder barrel where it goes through a heating, blending, and pressurizing process. Then, the rubber compound flows to the extruder head where it is shaped under pressure. The modern cold-feed extruder is computer-controlled for accuracy.

Tire tread, or the portion of the tire that comes in contact with the road, consists of tread itself, tread shoulder, and tread base. Since there are at least three different rubber compounds used in forming this complex tread profile, the extruder system consists of three different extruders sharing an extruder head. Three rubber compounds are extruded simultaneously from different extruders and are then merged into a shared extruder head. The next move is to a die plate where the shape and dimensions are formed, and then through a long cooling line from 100 to 200 feet long to further control and stabilize the dimensions. At the end of the line, the tread is cut according to a specific length and weight for the tire being built. The tire sidewall is extruded in a way similar to the tire tread component; however, its structure and the compound used are quite different from tread. Sometimes the sidewall extrusion process can be more complicated, and four extruders may be needed; for example, when building a tire with white sidewalls or with white lettering on the sidewalls.

Finally, the tire is ready to be built by a highly robotized machine which ensures quality and efficiency. All components—bead assemblies, calendared plies, belts and innerliner, tread and sidewall sections—are assembled and the building process begins. A typical radial tire is built on a flat drum in a two-stage process. In the first stage, the innerliner is wrapped around a drum and the first body ply is wrapped on top, followed by the second body ply. The bead assemblies are then positioned, and a bladder on the drum is inflated and pushed in from both ends of the drum, forcing the body plies to turn up to cover the bead assemblies. The sidewall sections then are pressed onto both sides. In the second stage of the tire building process, another machine is used to apply the belts, nylon cap, and tread on top of the first stage. At this point, the tire still needs curing because there is no tread pattern on it.

In this final step, curing occurs through a series of chemical reactions. In addition, the sidewalls and tread are moulded. Tire curing is a high-temperature and high-pressure batch operation in which the uncured tire is placed into a mold at a specified temperature. After it is closed, the rubber compound flows in to mold the shape and form the tread details and sidewall. It cannot be opened until the curing reaction is completed.

2.2. Tire inspection

Tire manufacturing quality control is never finished. At the beginning of production process all of the materials to be used for tire construction are inspected for any imperfections to avoid defective products. Companies are also testing the half products into every step of the process. Even after all this tests that goes into every step of the process, it's still important to check the tire by controller to make sure they meet quality standards.

First step of tire inspection process is x-ray test. Statistically random samples of each type of produced tire are automatically x-rayed. This test gives sure that inner steel cord meets specifications. If a tire appears to be damaged in any way, the tire will be x-rayed a second time, by a skilled operator, who can determine whether the tire is suitable to sell.

Figure 2.2.1. YLX-2Z1527 TBR Tire x-ray testing machine [4].

During balance inspection regardless of type, tires are attached to a machine that emulates the vehicle. In order to properly measure the specifications of each tire assembly. Tires that fail this test are checked for air pressure and overall build. After that depending on the damage, tires are repair, to ensure proper size and weight on all tires. Items that are beyond repair are automatically rejected.

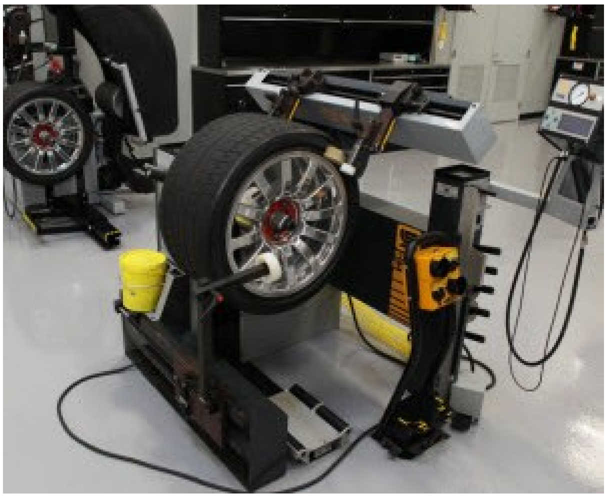

Figure 2.2.2. Tire balance inspection machine [5].

The last stage of tire inspection process is visual inspection. It is the only test where the main job is done by a worker. People who do this test are skilled and special trained for this work. Inspectors look at every tire, inside and out, both with their eyes and with their hands. They are looking and feeling for any irregularities. It seems to be very serious to find small imperfections but when workers looked at and handled tires every day for a while, the slightest difference from one tire to the next becomes very obvious. After this inspection tires are released to the dealer.

Figure 2.2.2. Tire visual inspection machine [6].

2.3. Structure of the tire

Every tire may look similar, but there is many differences in their internal structure, rubber constituents, shape and design. Most of them have nine main parts which are presented on and describe above.

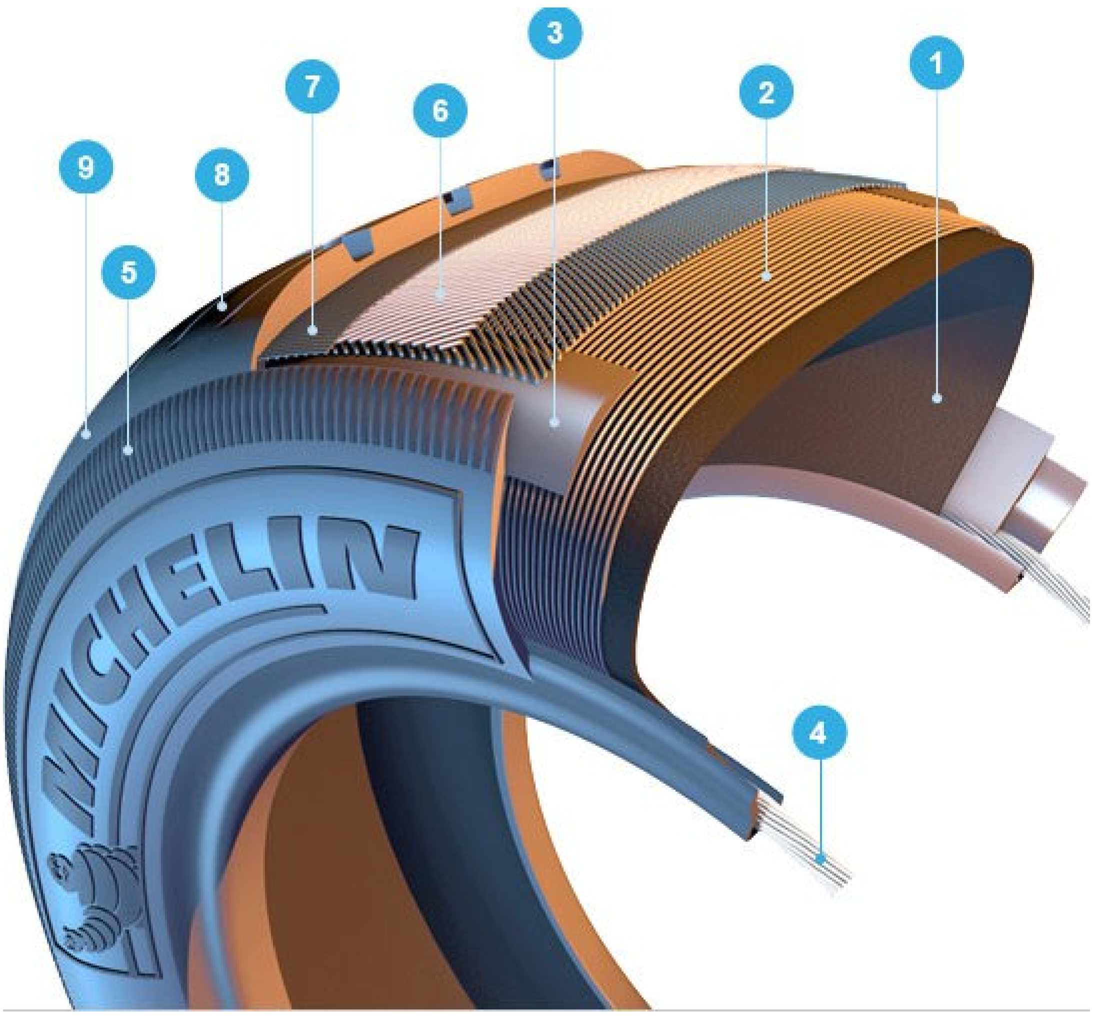

Figure 2.3.1. Tire structure [7].

1 Inner liner is an airtight layer of synthetic rubber which keeps air inside of the wheel.

2 Carcass Ply is a layer bonded into the rubber which consist thin fibre cords or cables. These cords largely determine the strength of the tire and help it resist pressure. Each cord is able to resist 15 kg, and standard tire contain about 1,400 cords.

3 Lower bead area is where the rubber tire grips the metal rim. The power from the engine and braking effort is transmitted from the rim of the tire to the contact area with the road's surface.

4 Beads are special cables which are clamp firmly against the tire’s rim to ensure an airtight fit and keep the tire properly seated on the rim. Each wire can take a load of up

to 1800 kg without risk of breaking. There are eight of them on your car - two per tire. That's a massive 14400 kg of resistance strength. An average car weighs about 1200 kg.

5 Sidewall is protecting the side of the tire from impact with curbs and the road. All important details like size or model are wright on a sidewall.

6 Casing ply largely determines the strength of the tire. It's made up of very fine, resistant steel cords bonded into the rubber. This means the tire can resist the strains of turning, and doesn't expand due to the rotation of the tire. It's also flexible enough to absorb deformations caused by bumps, potholes and other obstacles in the road.

7 Cap ply is important safety layer, which reduce friction heating and helps maintain the shape of the tire when driving fast. To prevent centrifugal stretching of the tire, reinforced nylon based cords are embedded in a layer of rubber and placed around the circumference of the tire.

8 Crown Plies or belts provide the rigid base for the tread.

9 Tread provides traction and turning grip for the tire and is designed to resist wear, abrasion and heat. [7]

3. DEVELOPMENT

Problem Analysis

Brainstorming and Preliminary drafts

Selecting the best idea

Developing the main idea

List of parts

Critical Analysis and Prospects of Development

3. Development

3.1. Problem analysis

At the beginning of the project the main requirements were established by Prof Fazenda. First of theme was that Machine will be able to test tires with minimum size of 14" and maximum size of 22". Second one was about dimensions of the machine. Width of the machine could not be bigger than 700 mm, length than 1050 mm and height than 1000 mm. Also the final shape and work cycle of the machine was known. It was known that this device have to realize tree movements. At first the platform on which stands the tire need to pick it up. Next the spreading system should spread the walls of the tire and kip them like this during rotation of the tire. At the end, platform should go lower with the tire. The main problem of this work was to invite and project all single parts and assembles of this machine. Every single part should combine not only functionality and reliability but also implementation of this part should be as cheap as possible. Moreover design of the machine was also very important.

3.2. Brainstorming & Preliminary drafts

At the beginning of projecting the machine in Solidworks, problems and solutions of every single part were not considering. It was known how the device should work and look. The first step of the designing process was base of machine, after that were columns holding platform and spreading system, next was the platform and in the end spreading systems. The biggest problems associated with the individual parts and assembles, which were solve in this project, have been planted to the tables with the number of solution. Experience and knowledge of oldest colleagues from the company were very helpful during solving the problems.

3.3. Selecting the best idea

For problems which had to be solved during designing this machine there were created tables which are below. The tables are shown in order to compare the features of every solution. The scale is presented in Table 3.3.1.

Table 3.3.1. Grading scale.

***	Very good
**	Good
*	Sufficient

There were two concepts for base of the machine; properties of both solutions are presented in table 3.3.2. The base in Concept I consist of four laser cut and bent U-shape parts (grey colour on Figure 3.3.1.). They are connected to each other and to the columns by welding, which makes them very difficult to divide. They were designed with laser cut holes to make the whole construction lighter. Holes creation generates costs and is not so important in this machine. The base on Concept II also consists of four laser cut and bent in U-shape parts, but they are connected to each other and to the columns by screws. Differences in presenting figures are caused by the fact that concept II had been create almost at the end of my work in Solidworks. I choose solution number two.

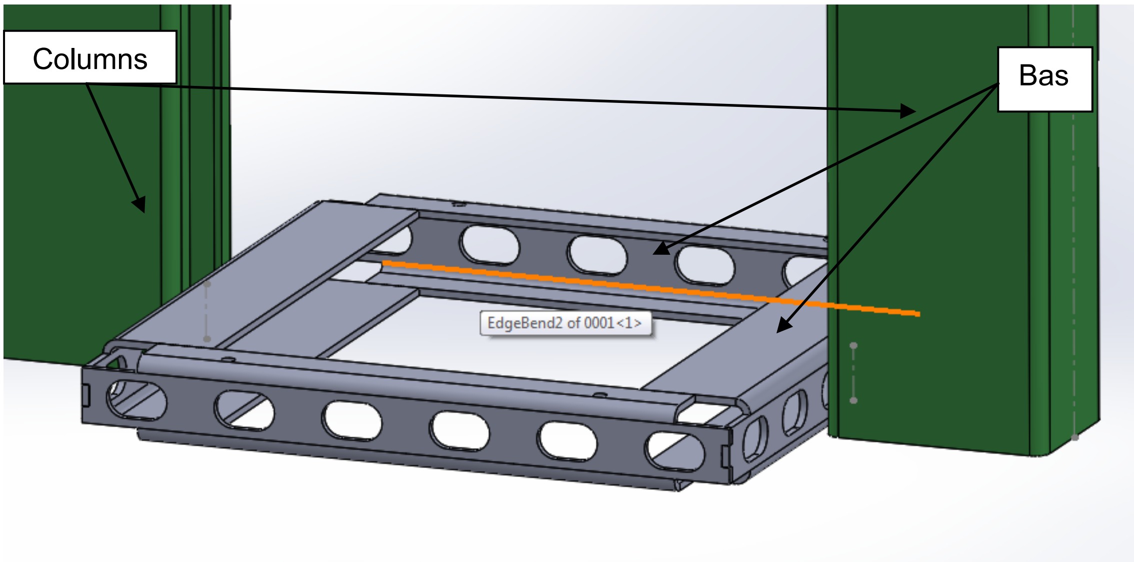

Figure 3.3.1. Concept I.

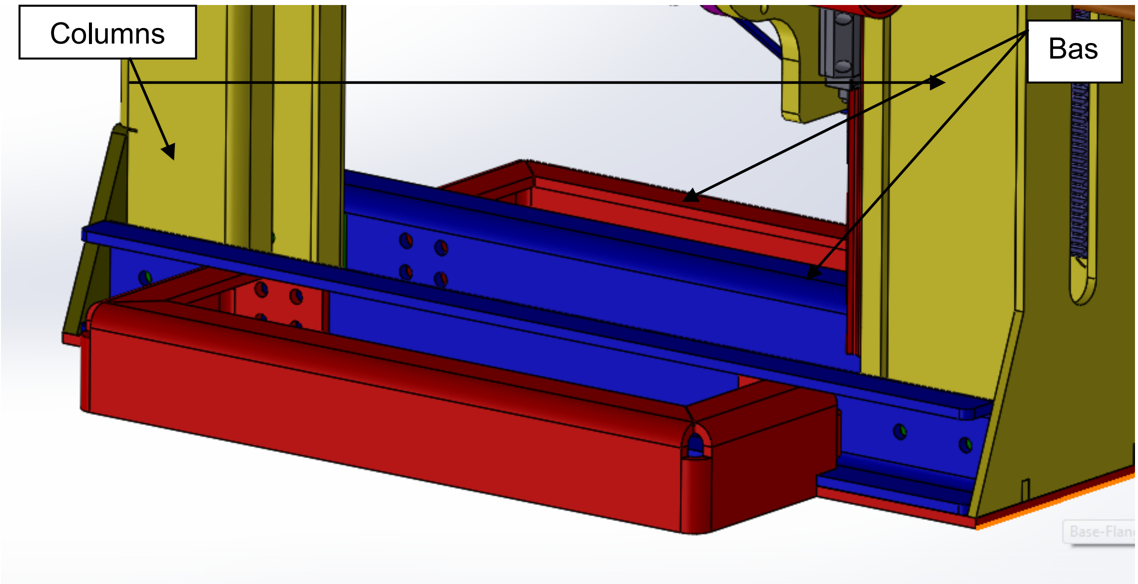

Figure 3.3.2. Concept II.

Table 3.3.2. Table of properties.

Driver	Concept I	Concept II	Explanation
Functionality	**	***	Parts in concept II are connected by screws, not welded like in concept I, it is possible to divide it and arrange one more time.
Reliability	**	***	Concept II has less components and provide better reliability.
Design	*	***	In my opinion concept II has better design.
cost	**	***	Simple shape to cut and screws instead welding make concept II cheaper.
implementation	**	***	Simple shape of parts.

Platform lift system is a point where it has to be deciding what will be better to pick up and leave the platform. The concept I was rack and pinion and the concept II was electric actuator. Rack and pinion was selected, mostly because Prof. Fazenda counselled to always use rack and pinion for heavy parts. Cost of the solution was also very important.

Table 3.3.3. Table of properties.

Driver	Concept I	Concept II	Explanation
Reliability	**	**	Both have similar.
Design	**	**	Both components are hide.
cost	***	*	Rack and pinion is cheaper.
implementation	**	**	Both concepts have their plusses and minuses related with implementation.

At the beginning of work in Gislotica, There was projected a platform which was support by two columns, on both of them were guiding systems. In Concept I, these guiding systems were consisted of wheels set, which lead platform in vertical movement. At a later stage of work ing. Pedro Nunes suggested the guiding system INA brand and that is Concept II. It simplifies the construction and allowed to support the platform on only one column.

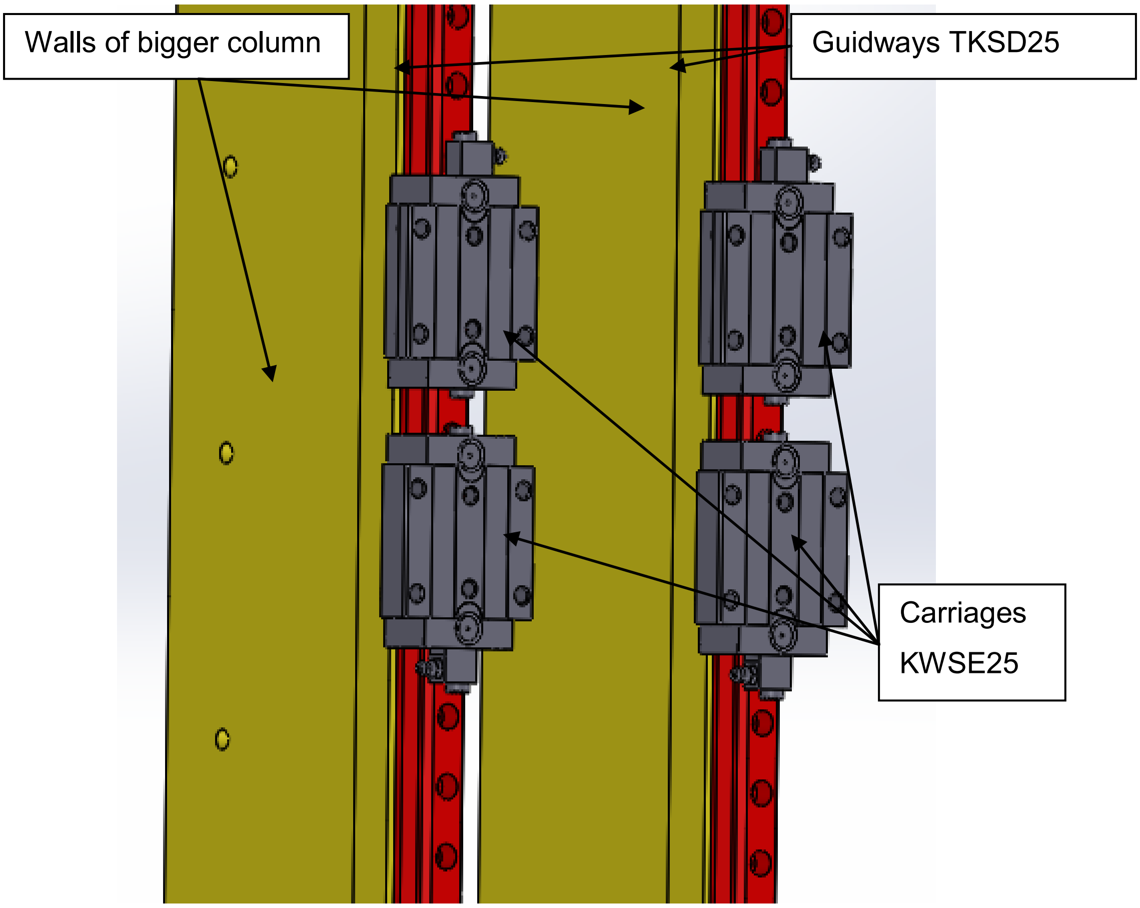

Figure 3.3.3. Guiding system INA brand, concept I.

Table 3.3.4. Table of properties.

Driver	Concept I	Concept II	Explanation
Reliability	***	**	Concept I is much more reliable.
Design	***	**	Concept I looks better.
cost	*	**	Concept II is cheaper.
implementation	***	**	Concept I is much more easy to implement.

There were two solutions how to connect the rollers on which stay tire with shafts to provide the rotation movement. First there was idea which planes to use key and retaining ring. After Professor Fazenda show the part like expandable assembler, presenting as a concept II. concept II was selected.

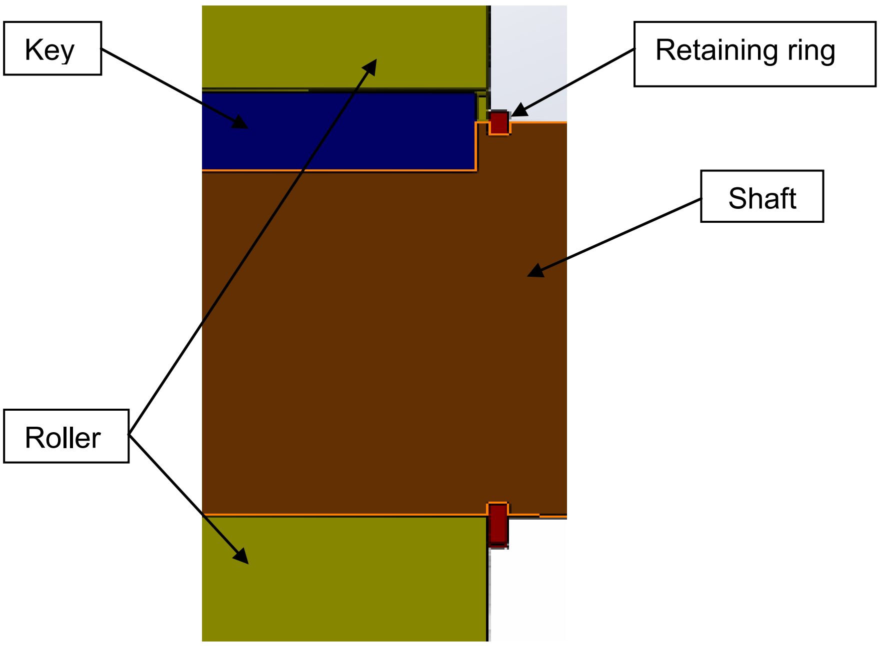

Figure 3.3.4. Key and retaining ring, concept I.

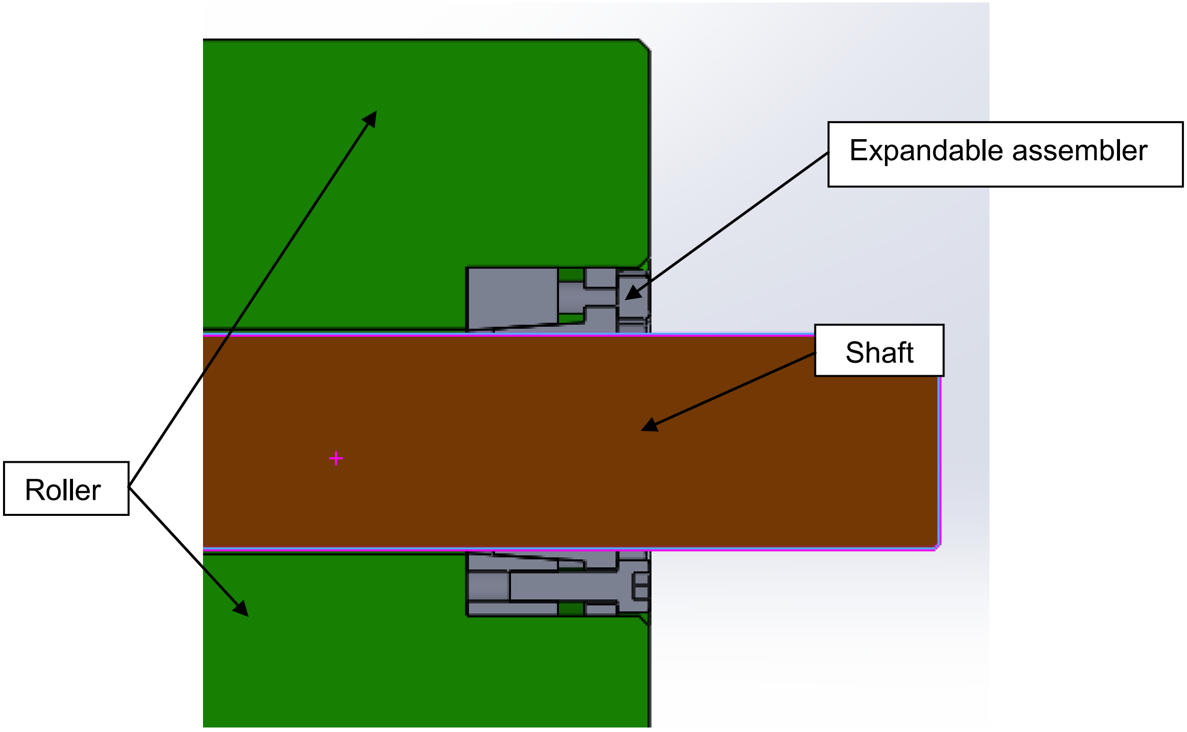

Figure 3.3.5. Expandable assembler, concept II.

Table 3.3.5. Table of properties.

Driver	Concept I	Concept II	Explanation
Functionality	**	***	Both concepts are functional.
Reliability	**	***	Concept II is more reliable.
Design	***	***	Both solutions are hide.
cost	**	***	Expandable assembler (concept II) is more expensive then Key and retaining ring but in concept I we have to also cut a hole in shaft and roller for the key.
implementation	**	**	In concept II we use only screws, in concept I we have to use force to put rolls for a shaft (it has to be well-fitting).

In this machine tire stay on two rolls which spin around. One of them is connected in straight way with the motor, but the second one need to be rotated by power transmission. Concept I in this situation was a belt transmission and concept II was chain transmission. In this specific situation the properties of both concepts were not compared. Selection of the solution was based on knowledge and experience of oldest colleges from the company. They suggest that in this situation the best solution will be belt transmission.

After the type of power transmission was selected, the system which provide tension of belt have to be created. I invite two solutions of this problem and create both of them. Both concepts are presented at figures 3.3.6 and 3.3.7. Main difference was number of tension adjustment screws. Finally concept II was selected.

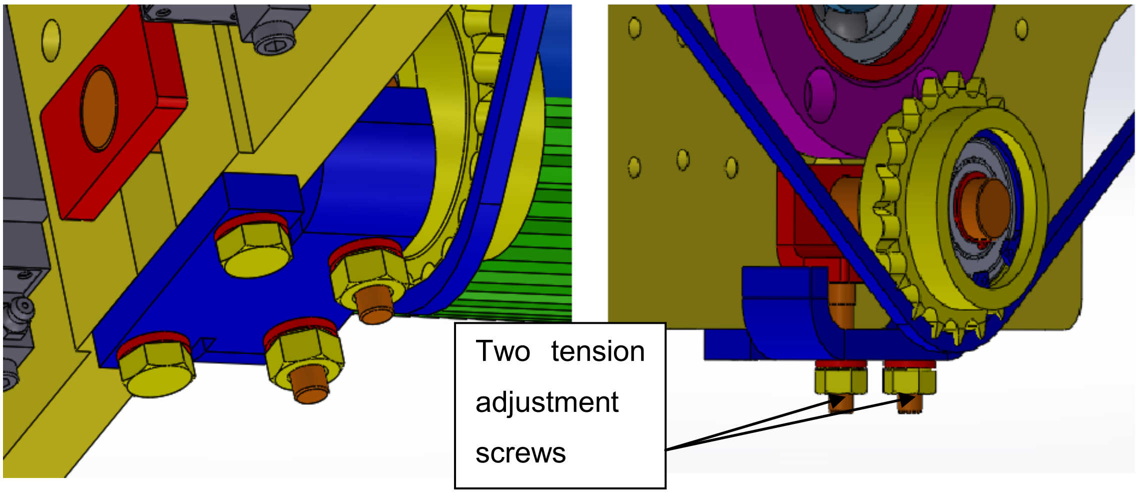

Figure 3.3.6. Conception I.

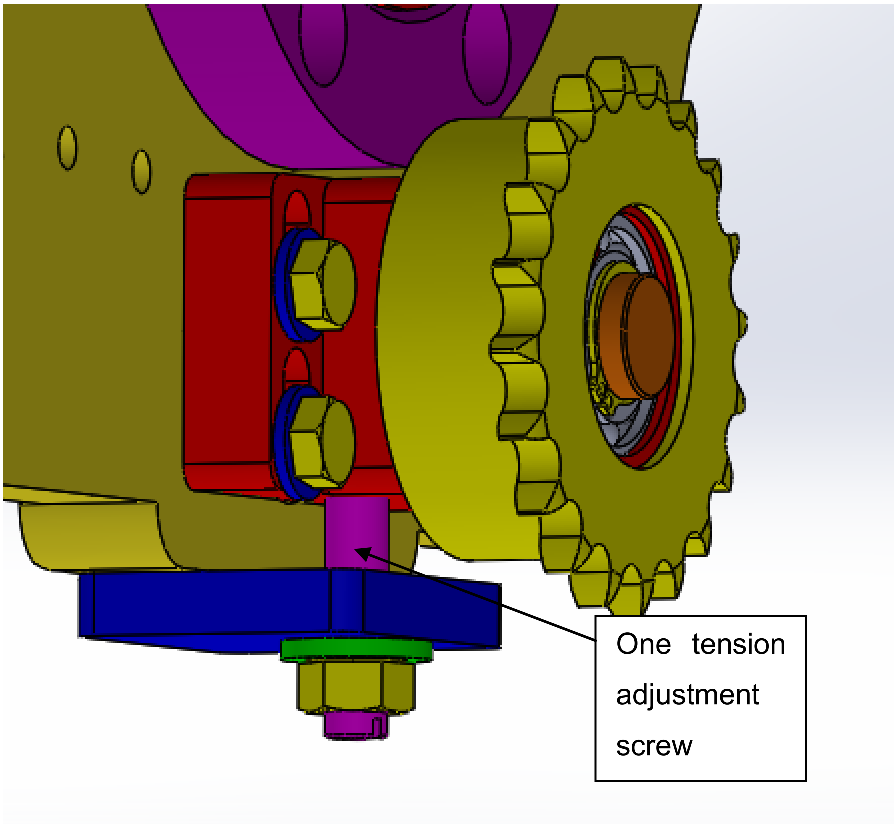

Figure 3.3.7. Conception II.

Table 3.3.6. Table of properties.

Driver	Concept I	Concept II	Explanation
Functionality	**	***	In concept II we use only one screw to regulate the tension of a belt, we also have to loosen four another screws but it is still more comfortable then solution in concept I.
Reliability	***	***	Reliability of both concepts are similar.
Design	***	***	Both concepts look alike.
cost	*	***	Cost of both solutions is similar.
implementation	**	***	Implementation of concept II is more simplified.

Guiding system of spreading fingers was a very similar problem to the agitated above platform guiding system, but the chosen solution was different. At the beginning there were two concepts how to project spreading system. First concept was about creating guiding system with wheels, analogue to concept II from platform system. Concept II in this case was using special guiding system with shafts, shaft support blocks and linear ball bearings. After checking the properties of both solutions concept II was selected.

Table 3.3.7. Table of properties.

Driver	Concept I	Concept II	Explanation
Functionality	**	***	Functionality of concept II is much bigger.
Reliability	*	***	Reliability of concept II is much bigger.
Design	***	***	Both concepts are hide.
cost	***	**	Cost of construction concept I is cheaper than guiding system used in concept II.
implementation	**	***	Concept II is composed of ten ready to use parts, it is very easy to implement this system.

3.4. Developing the main idea

The whole idea of presenting device is to project a machine by which the walls of the tire may be spread and hold apart, presenting the inner surface for the worker to control. The device must also perform rotational and vertical movement of the tire. It is meant to provide inspection in which there is no need for the controller to use force, to makes his work easier and more efficient.

3.4.1. The machine work cycle

To understand why these solutions during projecting were chosen it is necessary to know how this machine works. That is why cycle of tire inspection process is shown in few steps below. Firstly the controller roll the tire on the platform, two ramps on both sides of the machine make his work easier.

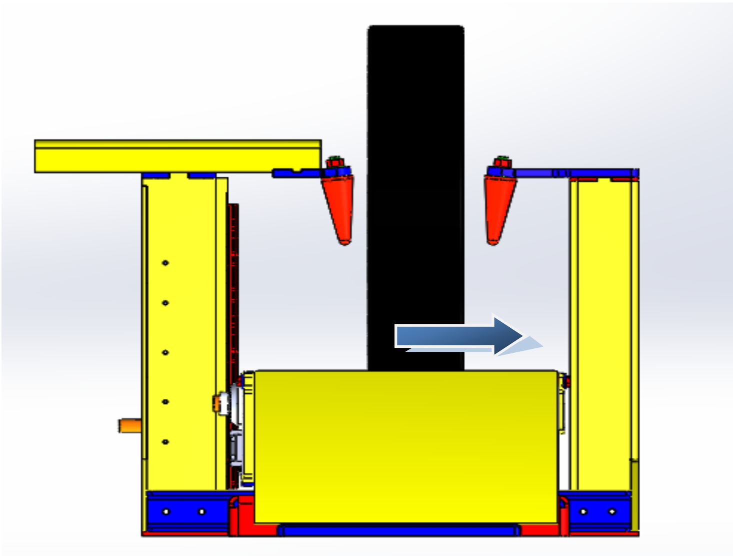

Figure 3.4.1.1. Tire on the platform.

When the tire is in wright place the controller move it closer to the right side of the machine (blue pointer on Figure 3.4.1.1.; right side of spreading system is fixed). Second side of spreading system extend to the position in which red fingers are inside the tire.

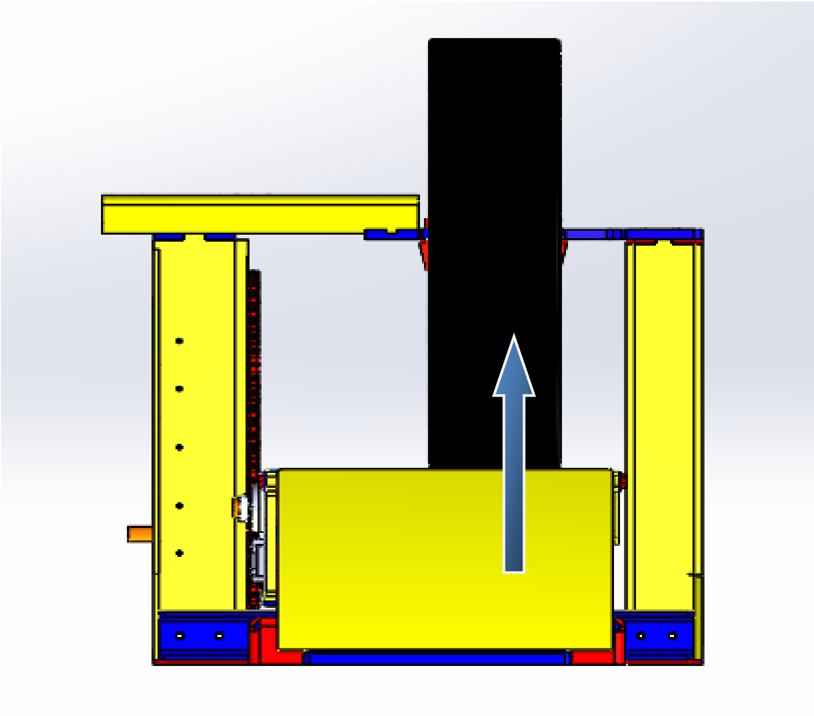

Figure 3.4.1.2. Spreading system inside the tire.

After that machine work starts and the platform with tires in proper position go up (blue pointer on Figure 3.4.1.2.).

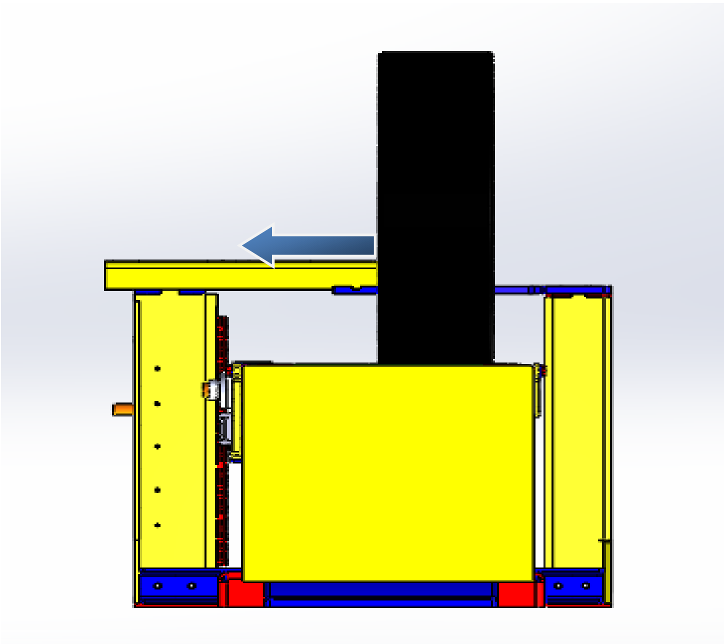

Figure 3.4.1.3. Platform on higher position.

When the tire is on higher position, left side of spreading system move back to left side and open the tire (blue pointer on Figure 3.4.1.3.). Machine keeps the tire in this position and provides its rotational movement by two green rolls which are under the tire.

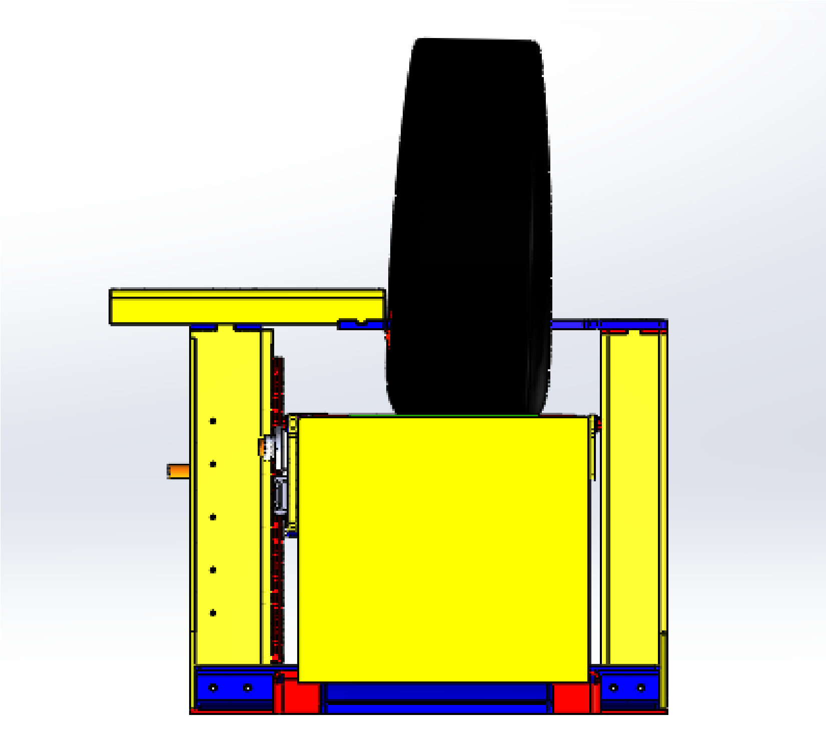

Figure 3.4.1.4. Spreading the tire.

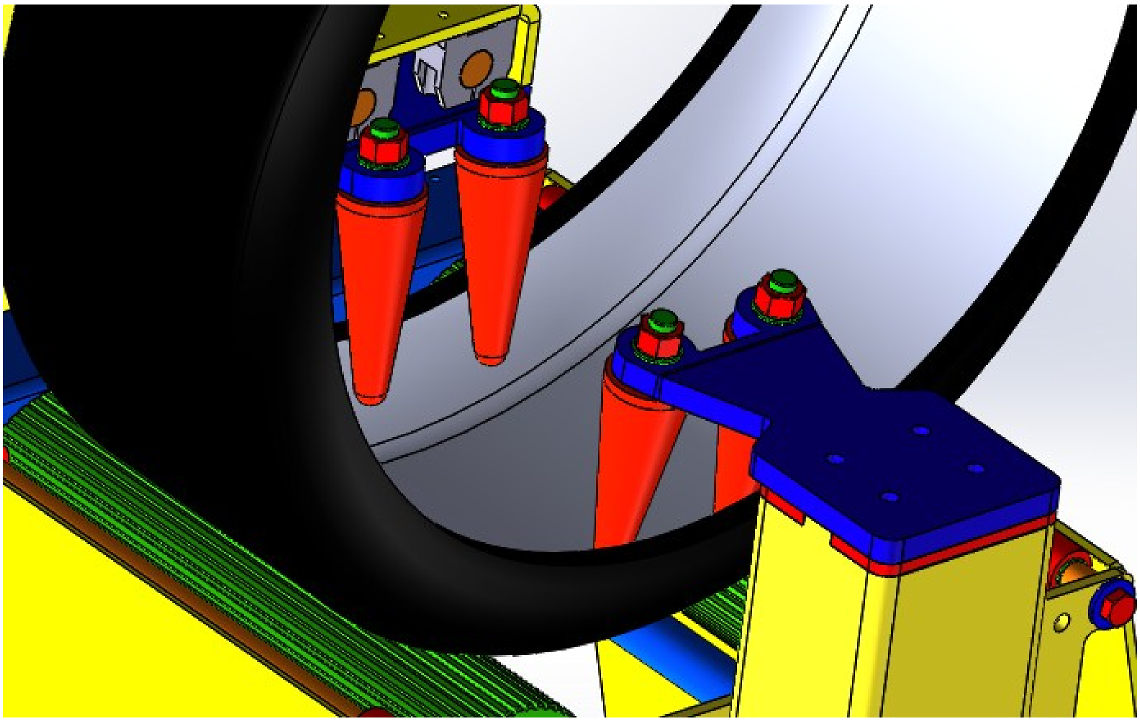

Figure 3.4.1.5. Details view of the tire and spreading system.

After control rotational movement of the tire stops, platform goes down and spreading system back to starting position. Controller rolls down the tire from the opposite side and rolls next for control.

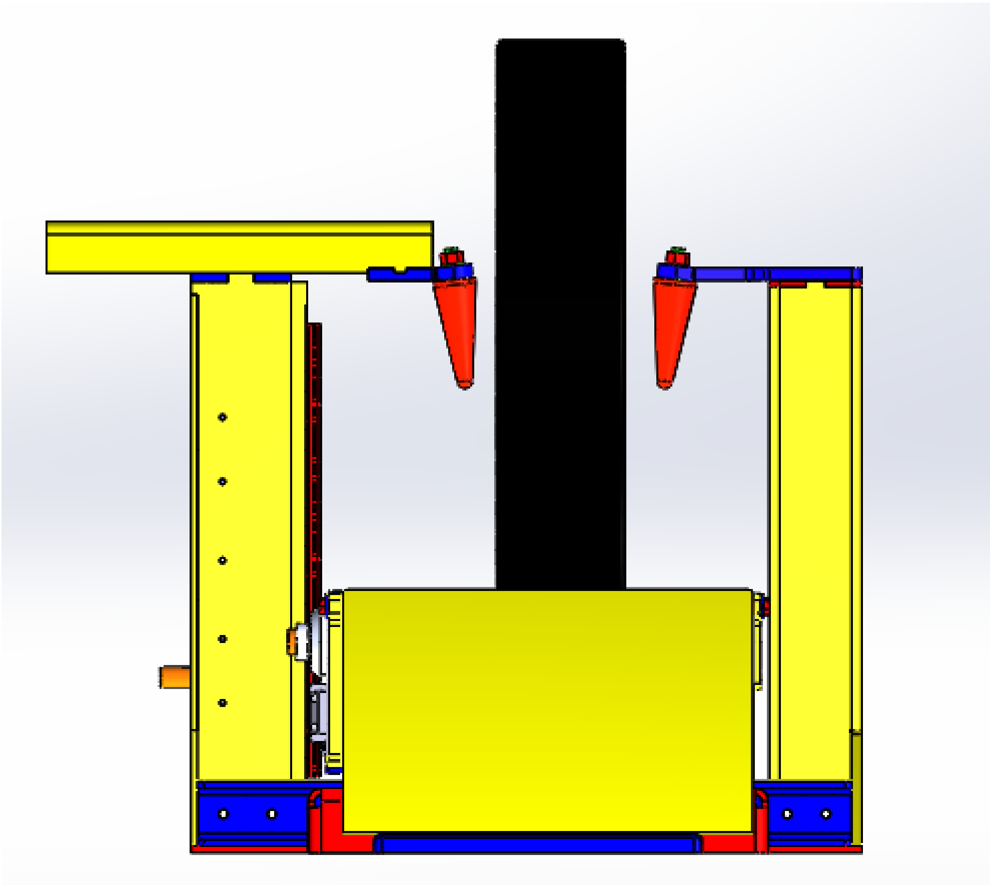

Figure 3.4.1.6. Final position.

3.4.2. Structure of the machine

In order to better present the final idea the machine was divided for four main assemblies, which are: base of the machine, column holding platform, platform, spreading system. They are presenting in exploded view on Figure 3.4.2.1.

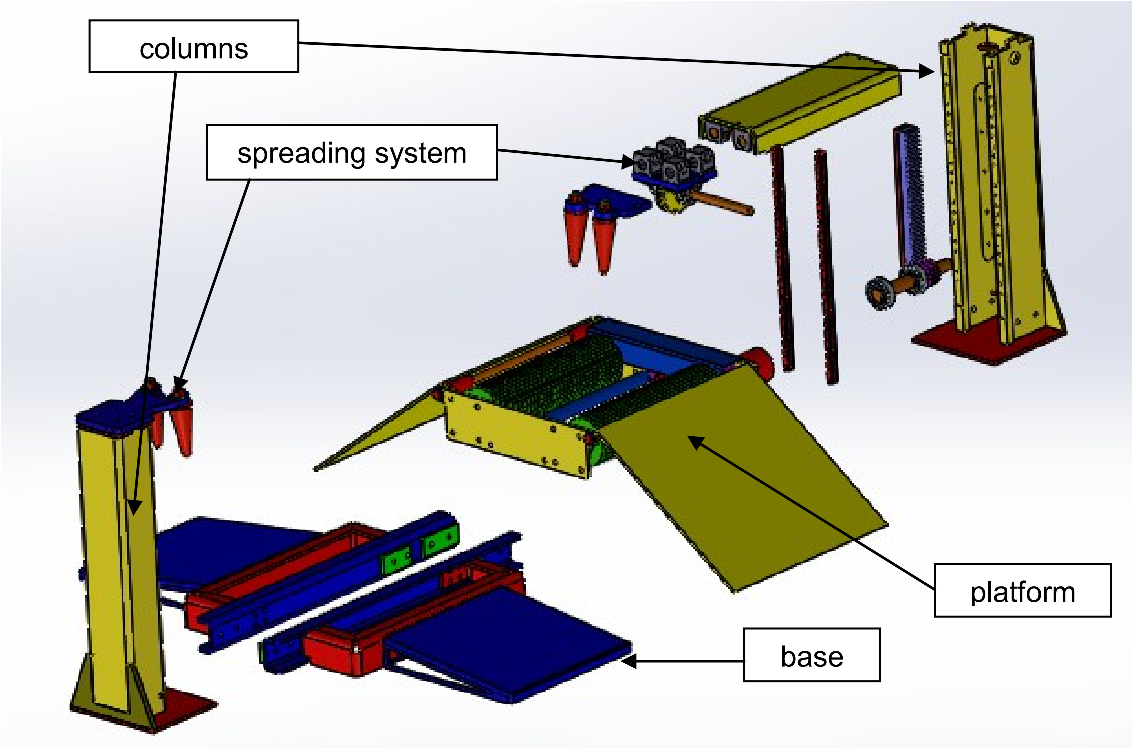

Figure 3.4.2.1. Exploded view of the machine.

Projecting started from the base of the machine and in this order it will be presenting. Base is made from two main parts. First one is U-channel with laser catted holes for screws. Second is banded and laser catted profile. They are connected to each other and to the columns of machine by screws.

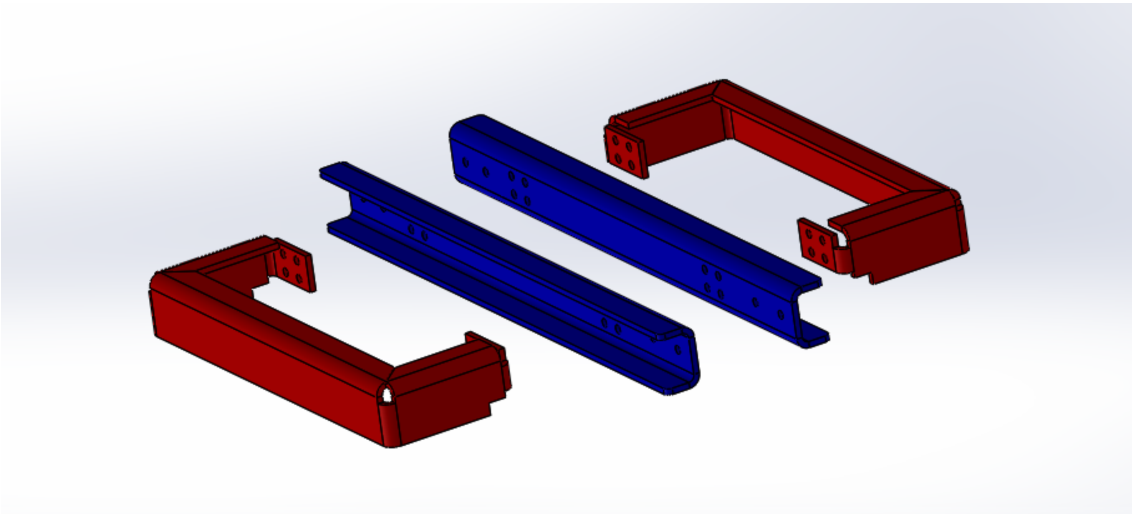

Figure 3.4.2.2. Main parts of Base.

Figure 3.4.2.3. Laser catted and bended profile in flatten view.

Next main assembling are two Columns and guiding system unit. There are two columns which are responsible for holding platform and spreading system. Thanks to the use of guiding system SCHAEFFER brand, which consist carriages KWSE25 and guide ways TKSD25 it was possible to fix the platform to only one column. Because of that this column had to be much stronger, it is shown on Figure 3.4.2.2. Rack and pinion is fixing to the same column which provide the vertical movement of the platform.

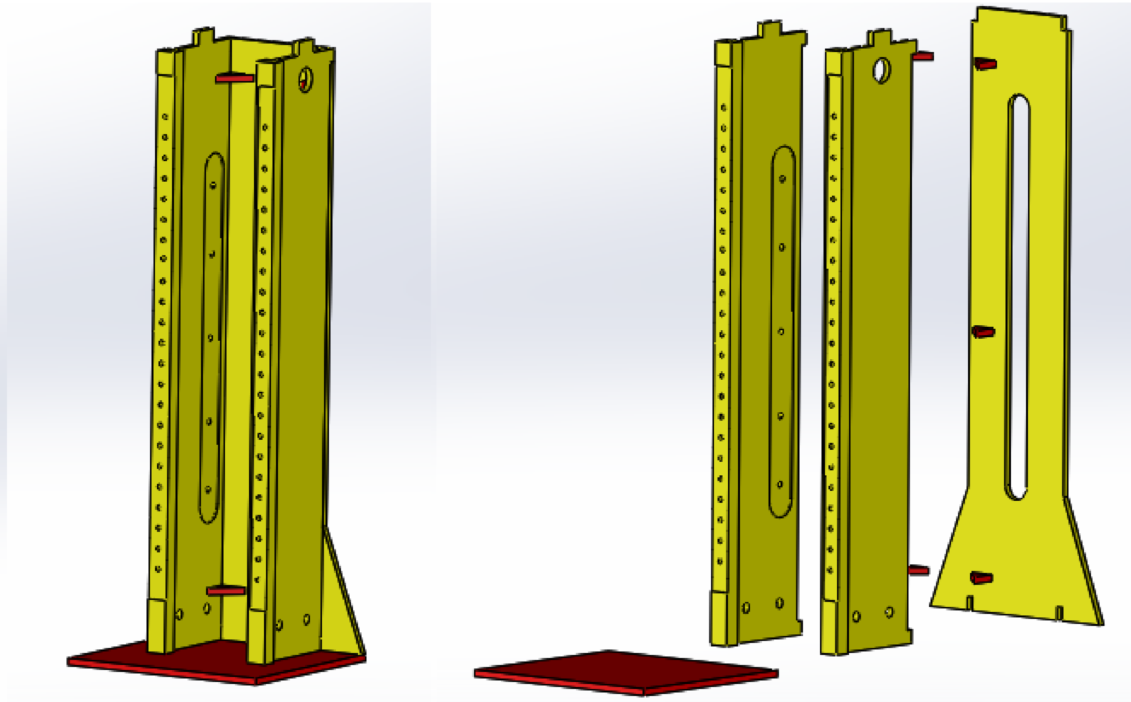

Figure 3.4.2.4. Bigger column.

Bigger column is made from tree separate steel plates and five fins. They provide better stability and strength of construction; all holes and shapes are catted by laser. Only the holes for rack and for carriages from guiding system are milled, to ensure high accuracy. The shaft that can be seen above with rack and pinion are responsible for vertical movement of platform, on the second side of that shaft, is located engine. At the bottom the column is connected with steel plate, this solution and special shape of rear wall stabilize the machine.

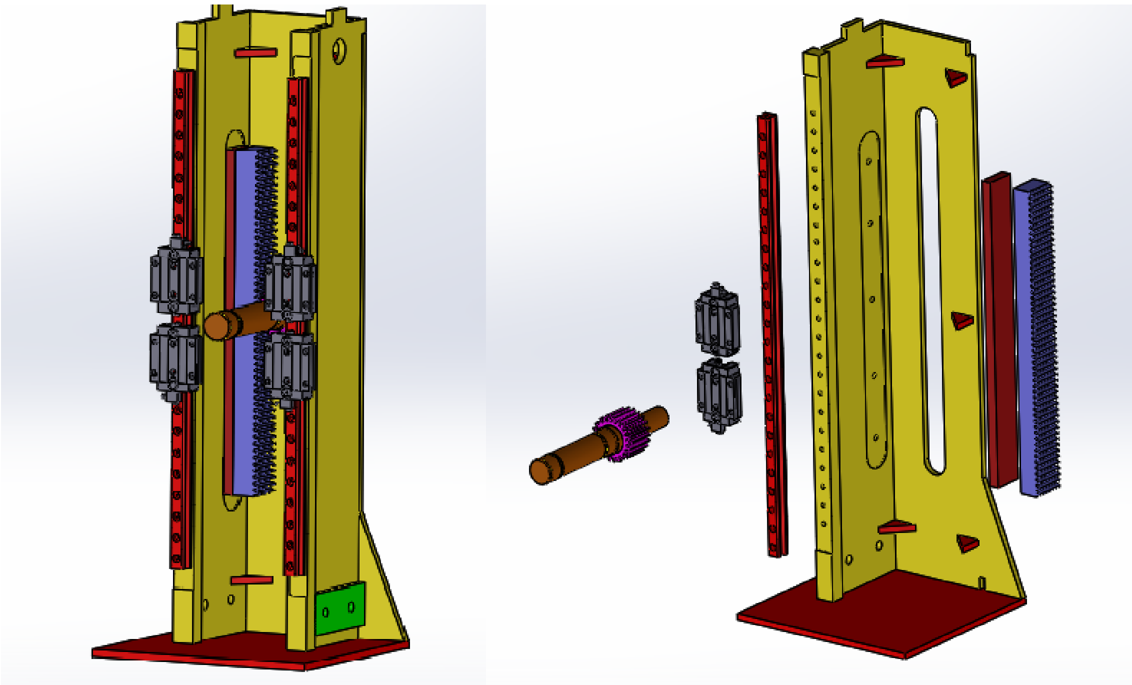

Figure 3.4.2.5. Bigger column with rack, pinion and guiding system.

The shaft that can be seen above with rack and pinion is responsible for vertical movement of platform, on the second side of that shaft, is located engine. At the bottom the column is connected with steel plate, this solution and special shape of rear wall stabilize the machine.

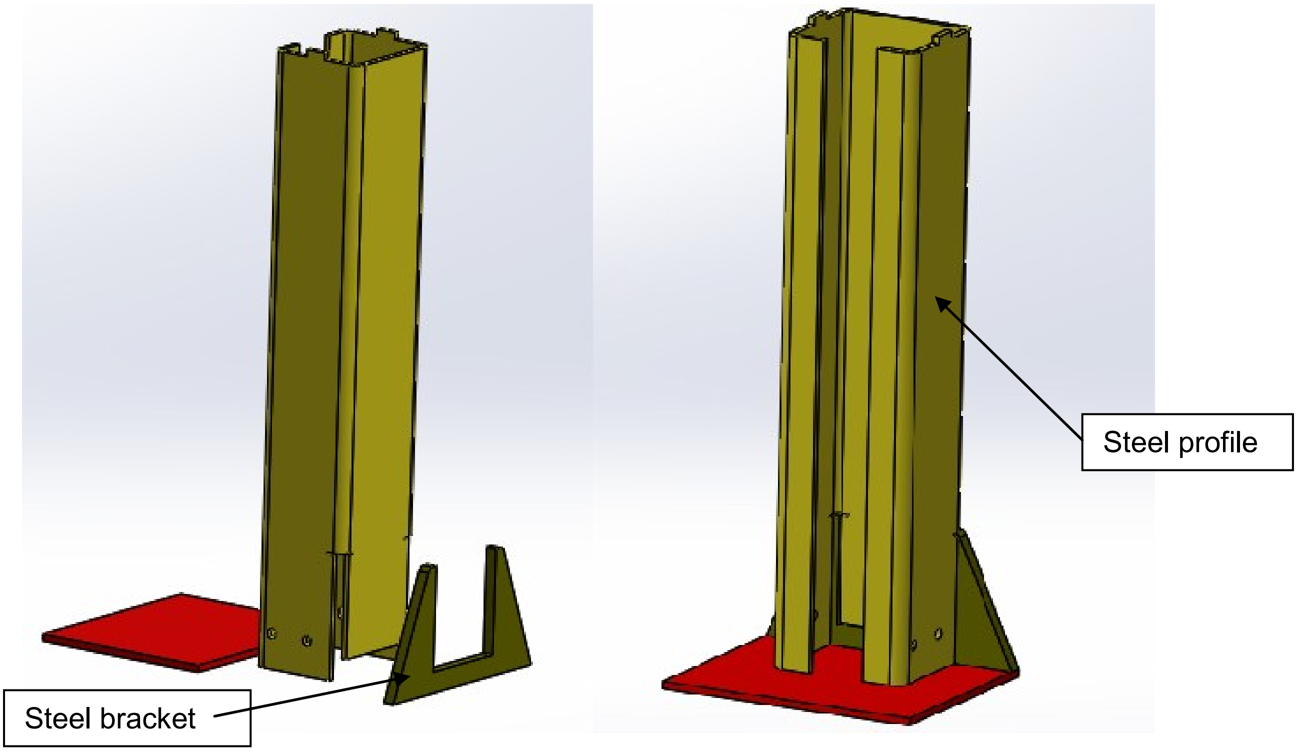

Figure 3.4.2.6. Smaller column.

Second column is responsible for maintain one side of spreading system; it is made from profile with laser catted holes. At the bottom is connected with steel plate and laser catted steel bracket which increase stability. All three parts are connected by welding.

Platform is a part of machine, responsible for rotational movement of tire.

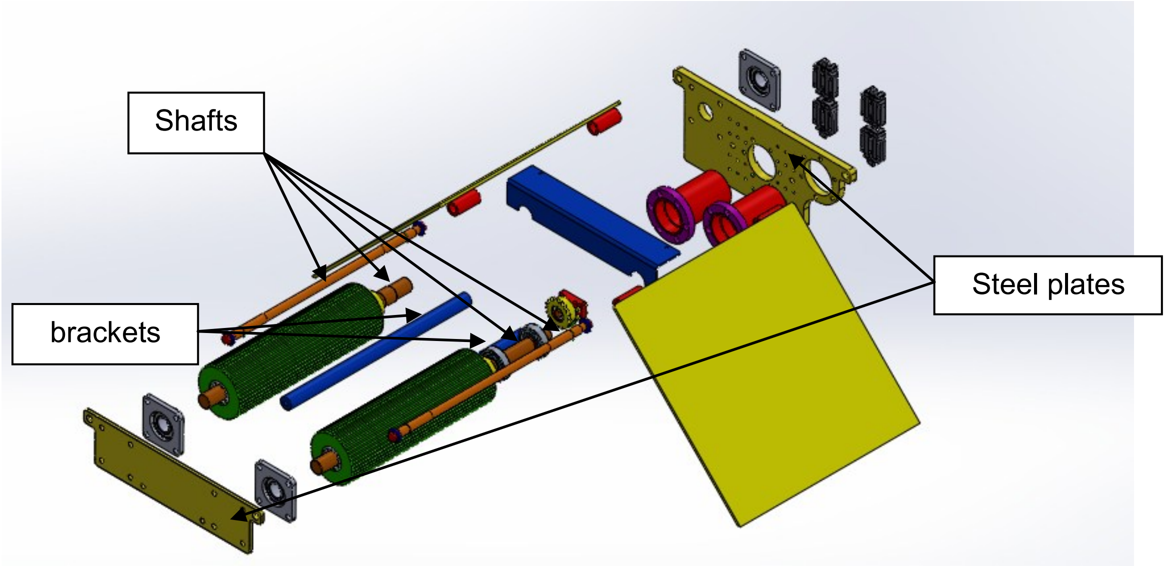

Figure 3.4.2.7. Platform exploded view.

Its frame is composed of two steel plates, connected by the brackets and shafts. Booth the brackets and the shafts are connected with plates by screws.

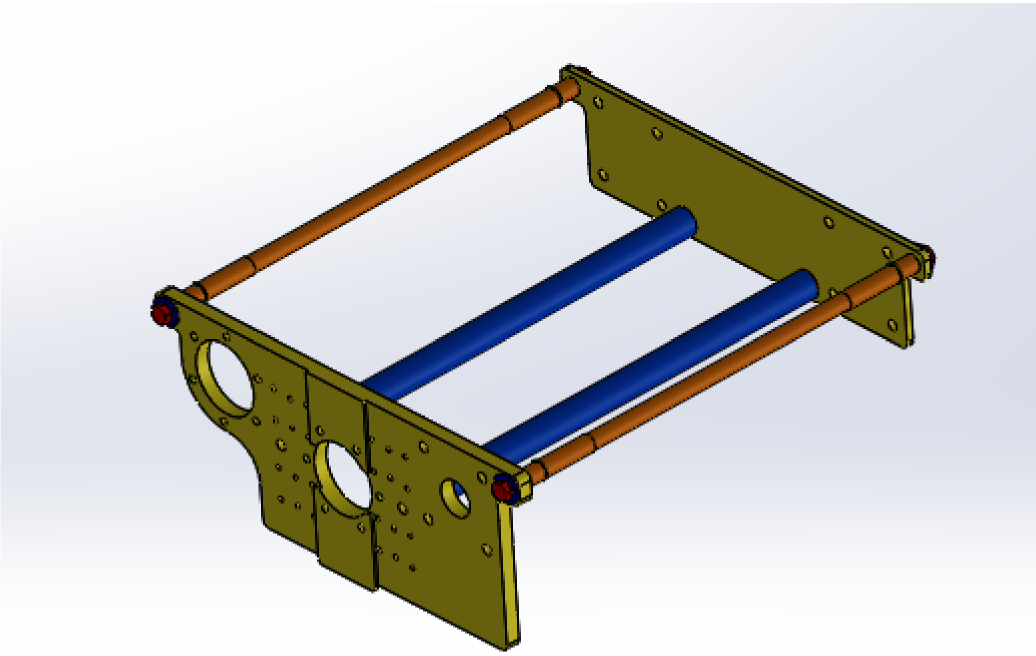

Figure 3.4.2.8. The frame of the platform.

Plate from the bigger column side is two times thicker and stronger; it has to be like this because all weight of platform and tire bases on it. To this plate are fixed guiding system and shaft with rack and pinion. All holes and shapes on this plate are laser catted.

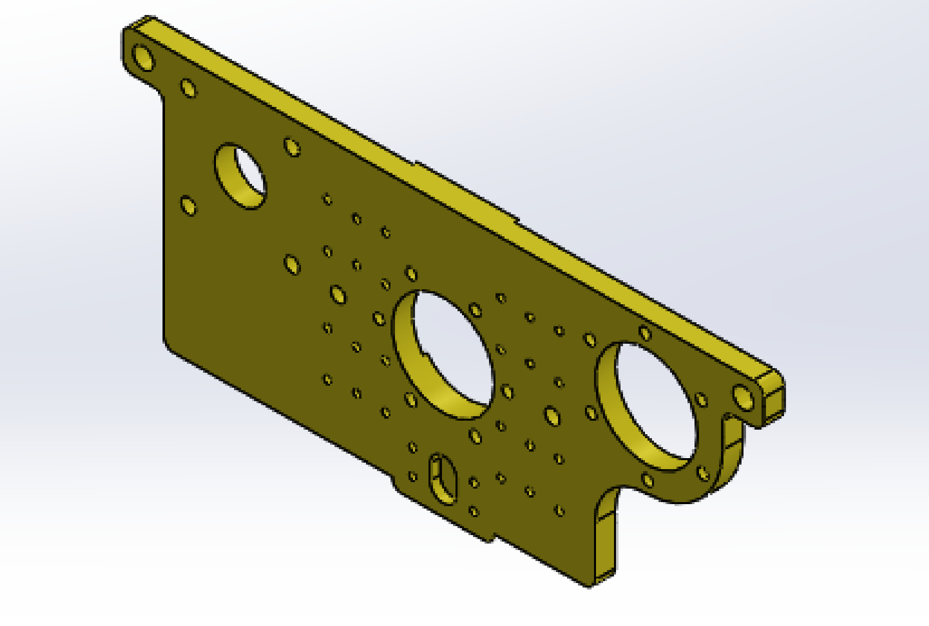

Figure 3.4.2.9. Stronger plate.

Holes and shapes of the second plate are also laser catted. To this plate are fixed only bearings, brackets and shafts.

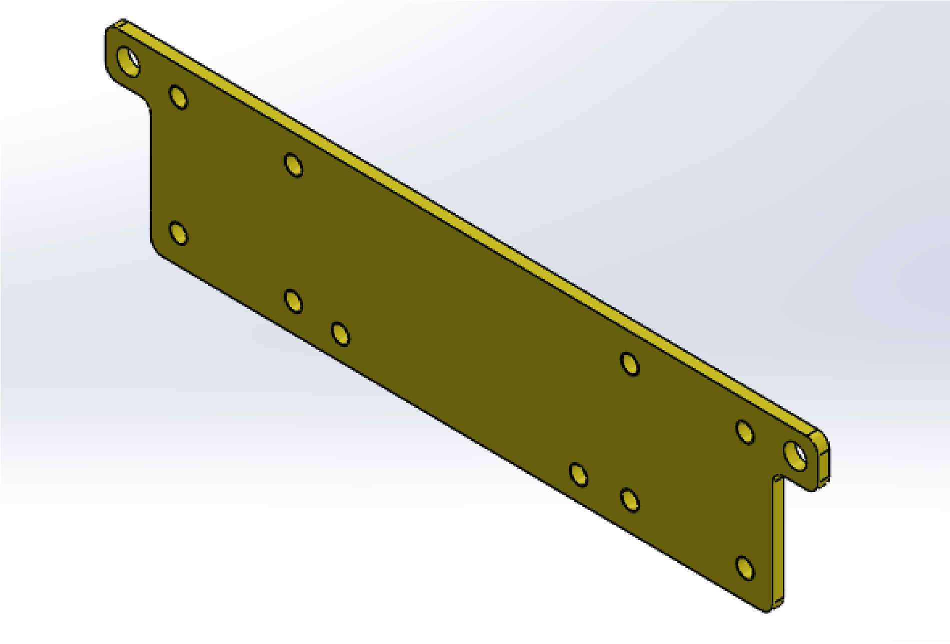

Figure 3.4.2.10. Weaker plate.

It is possible to rotate the tire through the two rollers. They are connected with shafts by expandable assembler which is the best way to join the shaft with another cylindrical part. The hole through the roller has bigger diameter than the shaft, it allows putting the rollers easily and without damaging the shaft or the roller. In case of any damage during exploitation it is possible to change only expandable assembler.

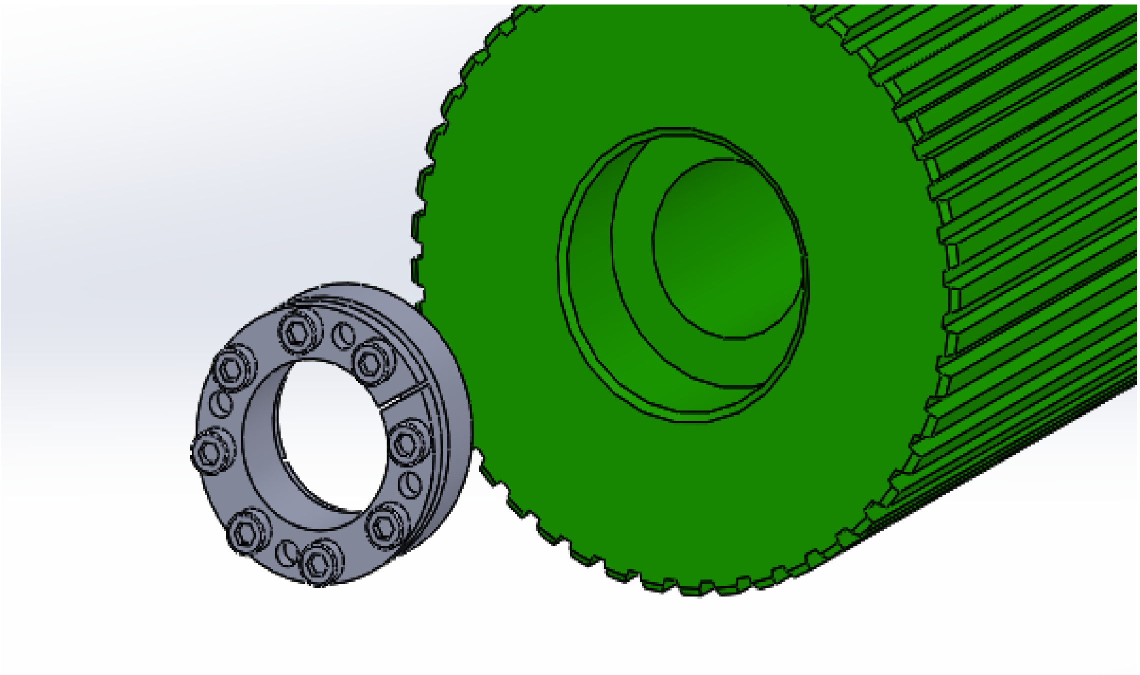

Figure 3.4.2.11. Expandable assembler.

The bigger shaft is driven by the motor, and transfer the speed to the second shaft by chain transmitter. To install a motor on platform I project cylinder with collar, inside of cylinder are located two deep grove ball bearings 6038, made by SCHAEFFER. In this solution shaft has tree bearings. These two bearings on side with motor reduce the force that acts on the third bearing. Because of that it is possible to use weaker and, what is more imported cheaper bearings. It was the major criterion of bearing selection.

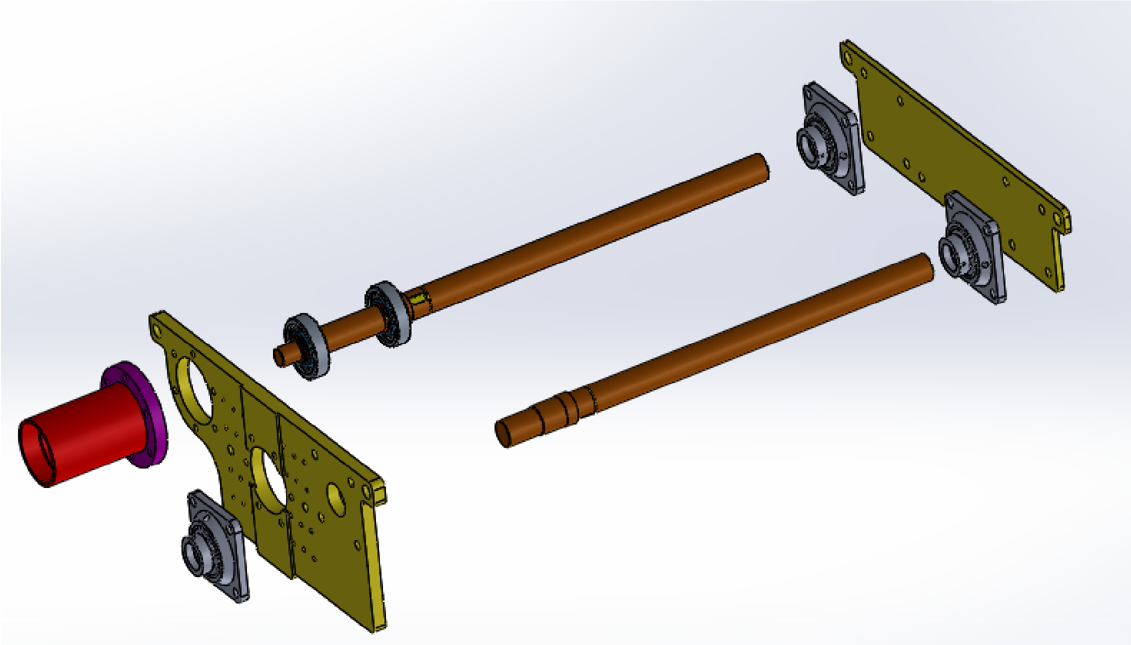

Figure 3.4.2.12.. Shafts and bearings.

Rotational movement of the tire is provided by fixed engine and chain transmitting. The biggest challenge in this transmission was projecting the tension system. It was difficult because of limited space on stronger plate. Final solution is showed at figure 3.4.2.13.

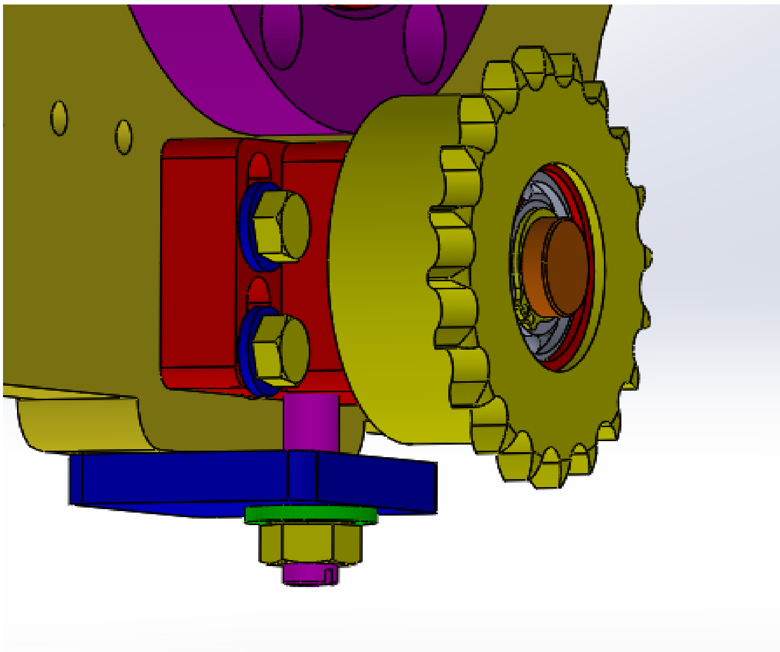

Figure 3.4.2.13. Tension system.

It was decided to use tree the same gears. It was done because shaft in tension system is not moving, that's why hole inside gear was enlarged, and two small bearings went inside. They are protected by retaining rings. To tension of chain, it is necessary to loosen four screws (yellow on Figure 3.4.2.14.), and then change the position of third gear by manipulating a big screw (pink on Figure 3.4.2.14).

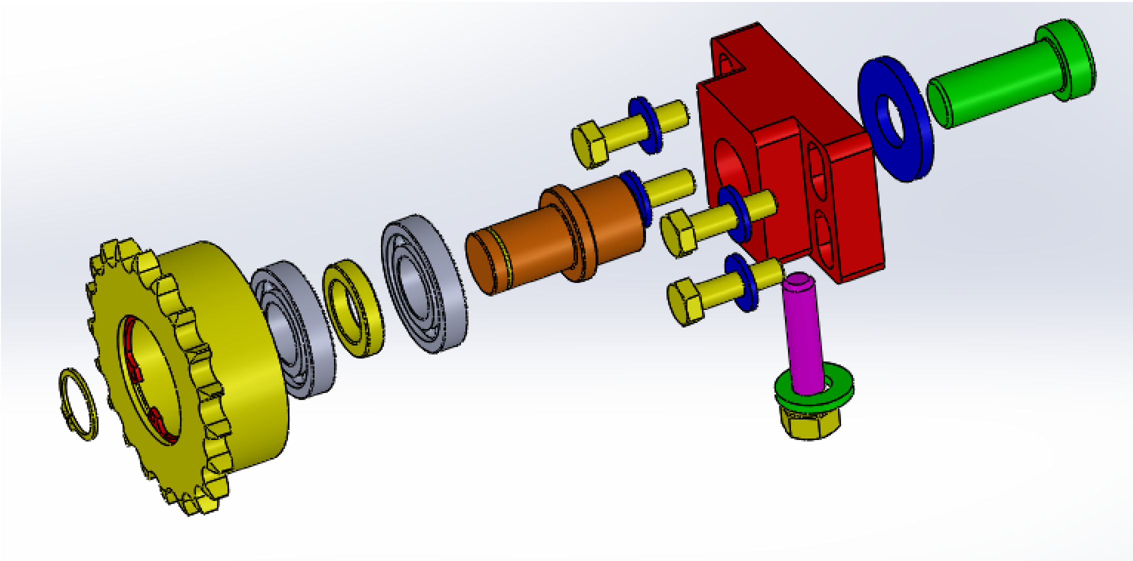

Figure 3.4.2.14. Tension system exploded view.

Spreading system is responsible for spreading the walls of the tire and kip them in this position during rotation of the tire. It is located at the top of the columns, on both sides. Only one side is moving, second one is still.

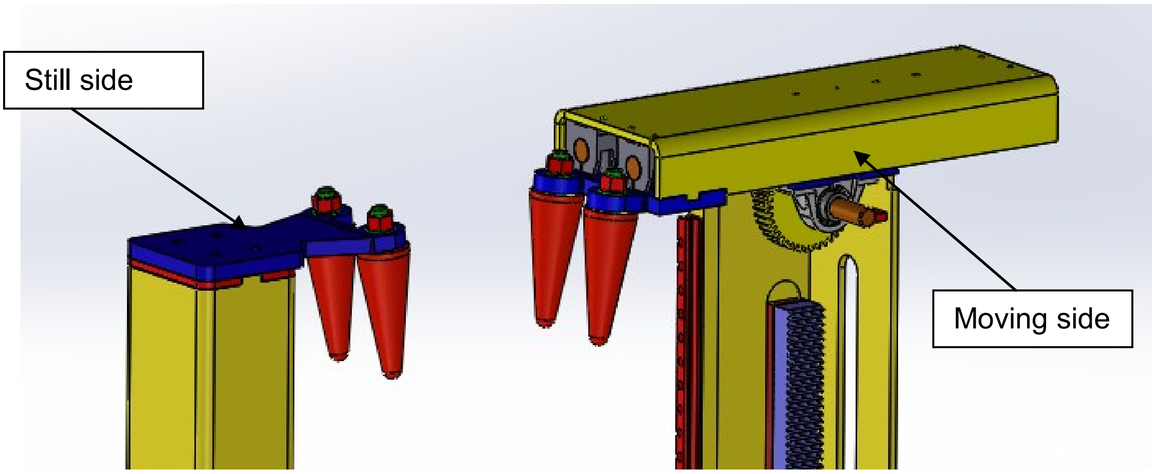

Figure 3.4.2.15. Two sides of spreading system.

The horizontal movement of one side is possible by using rack and pinion connected by shaft with a motor. Motor is not shown. Rack with his base is screwed to the top cover. There is a special milling hole, to provide high accuracy of transmission rotation from pinion to rack. To keep the pinion in correct position, the shaft is held by two bearings, which are screwed to the steel plate at the top of column. Bearings with Plummer bloc housing unit PASE25-N SCHAEFFER brand were used. The main criterions were price and limited place. This steel plate is laser catted and has cuts on sides which fit to the shape of column, thanks to that the construction is stronger and easier to submit.

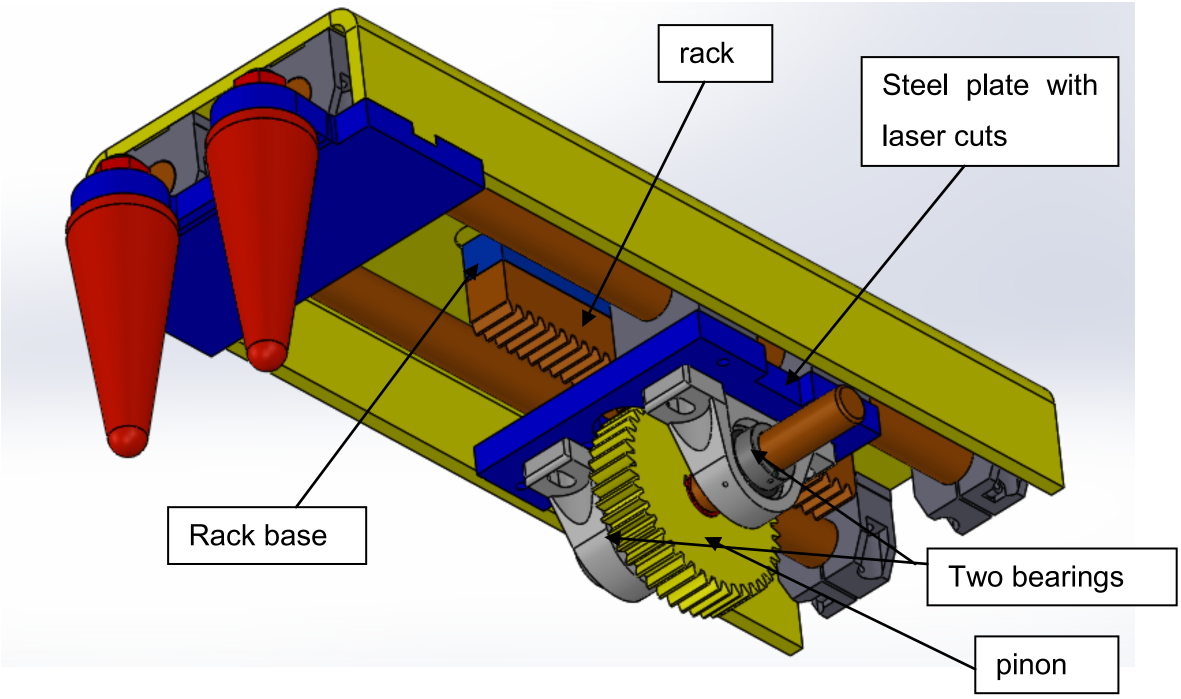

Figure 3.4.2.16. Horizontal movement.

The top cover is made from banded and laser catted steel plate. There is also milling hole for rack and pinion and holes for all screws.

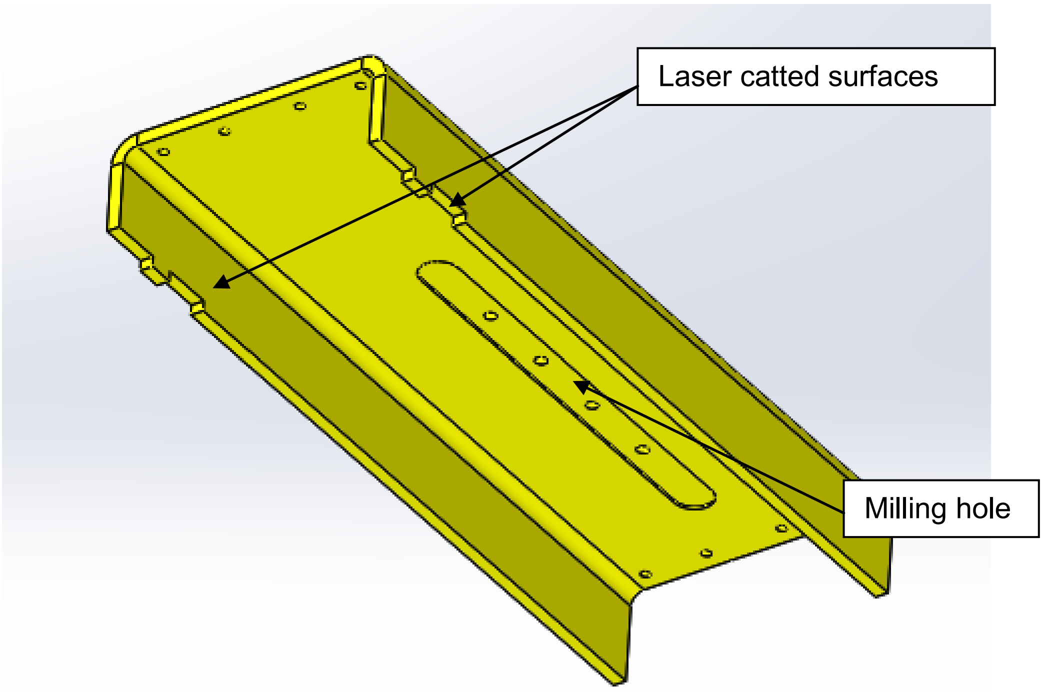

Figure 3.4.2.17. Top cover.

Top cover is moving on special guiding system. To create which were used only parts made by SCHAEFFER. There are four linear ball bearings with housing units KGHK30-B-PP-AS, four shaft support blocks GWH30 and two solid shafts W30. All linear ball bearings are screwed to the steel plate at the top of the column. Shaft support blocks are screwed to the cover and connected with linear ball bearings by shafts.

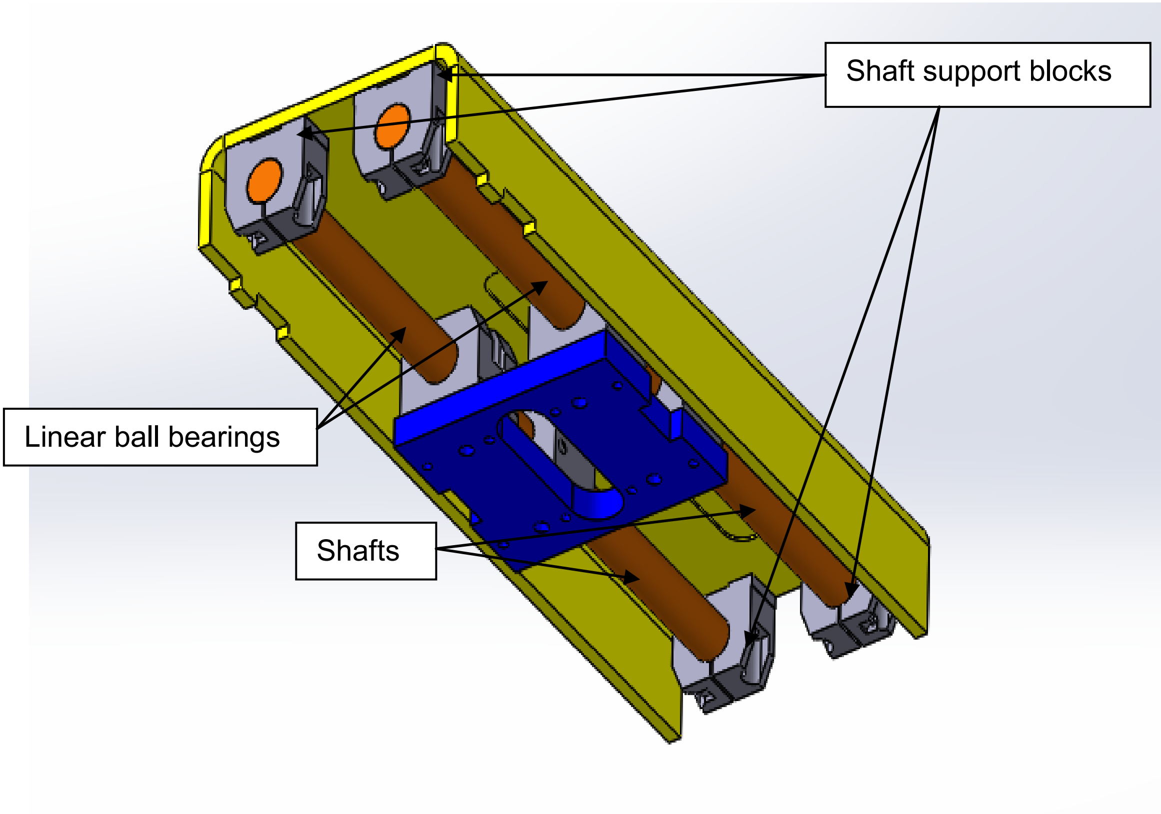

Figure 3.4.2.18. Guiding system.

Spreading the walls of the tire is possible thanks to spreading fingers. They are hollow inside and and attached to the small shaft by bearings. Thera are two bearings in every finger. Smaller is Deep groove ball bearing 6202 and bigger is Deep groove ball bearing 6205, both INA brand. At figure 3.4.4.5 are shown ale parts of the finger, and at figure 3.4.4.6 is a section view of it. Because of the inside shape of the finger, there is no need to secure the smaller bearing with and retaining ring.

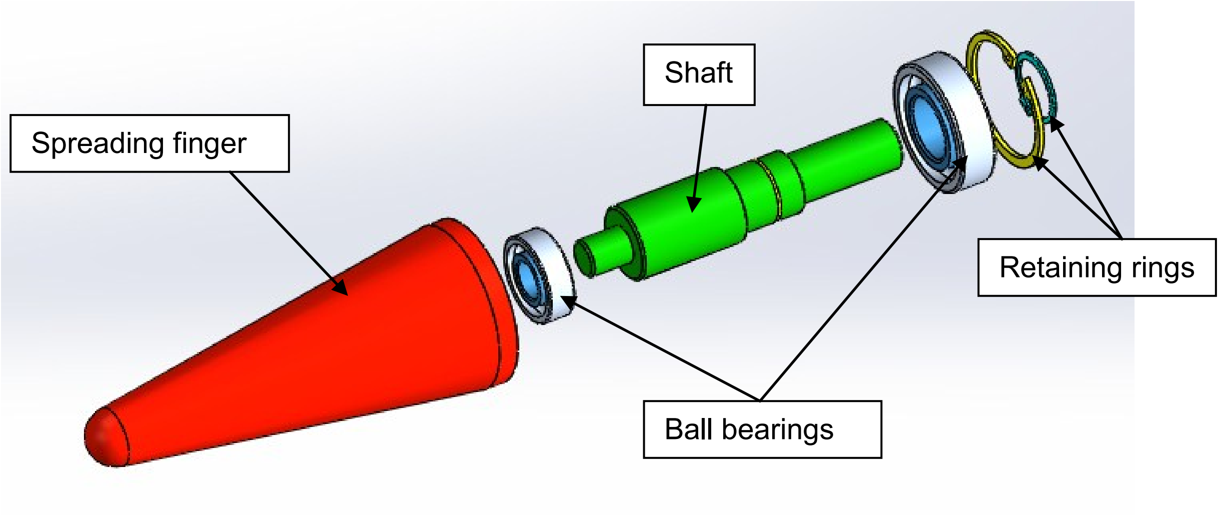

Figure 3.4.2.19. Exploded view.

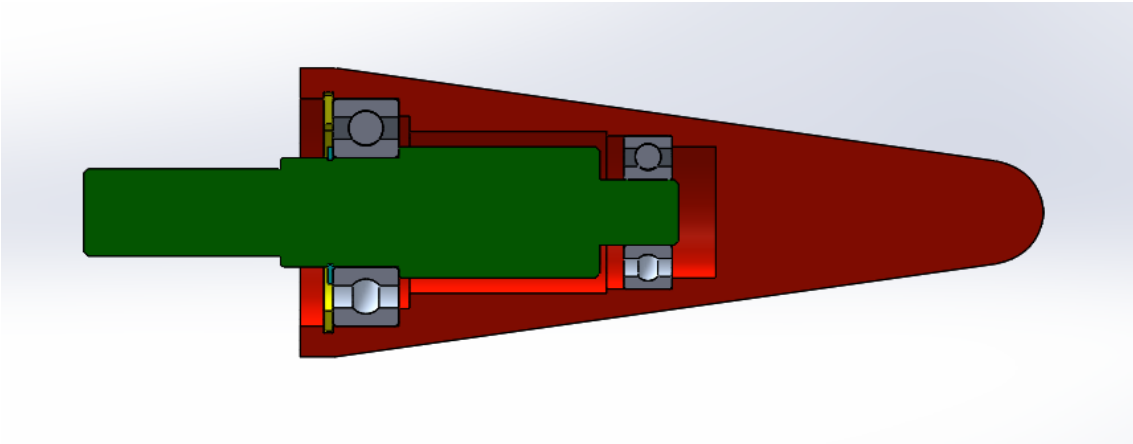

Figure 3.4.2.20. Section view.

Shafts are thread at one side and screwed to specially formed holders, which line up shafts at a slight angle. Holders on both sides have different shapes and method of attachment. The one who is on moving side is welded, second one is screwed.

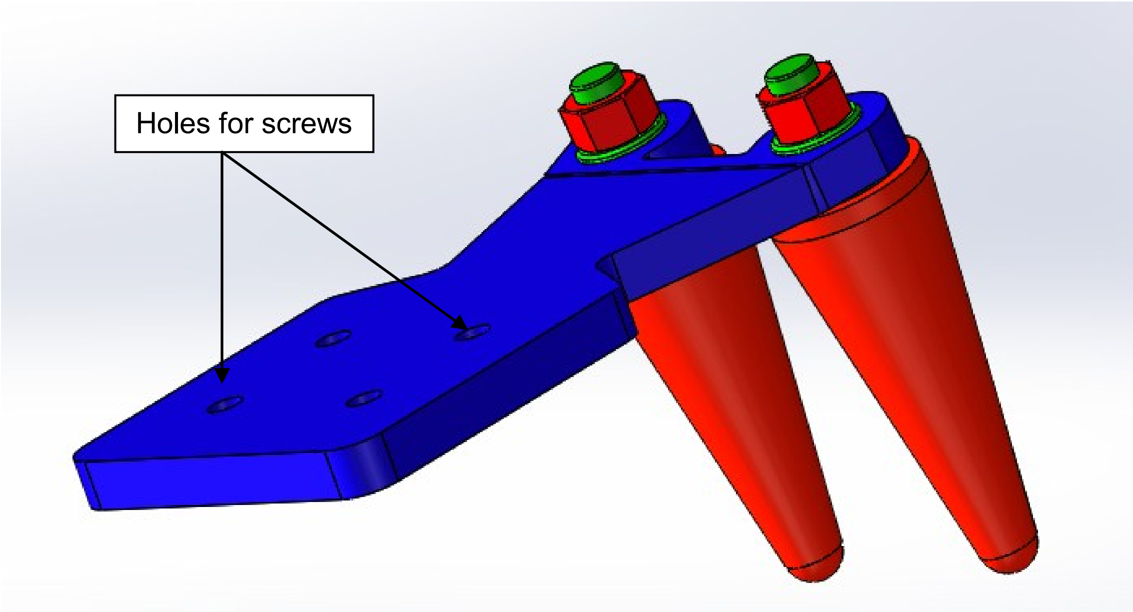

Figure 3.4.2.21. Screwed holder.

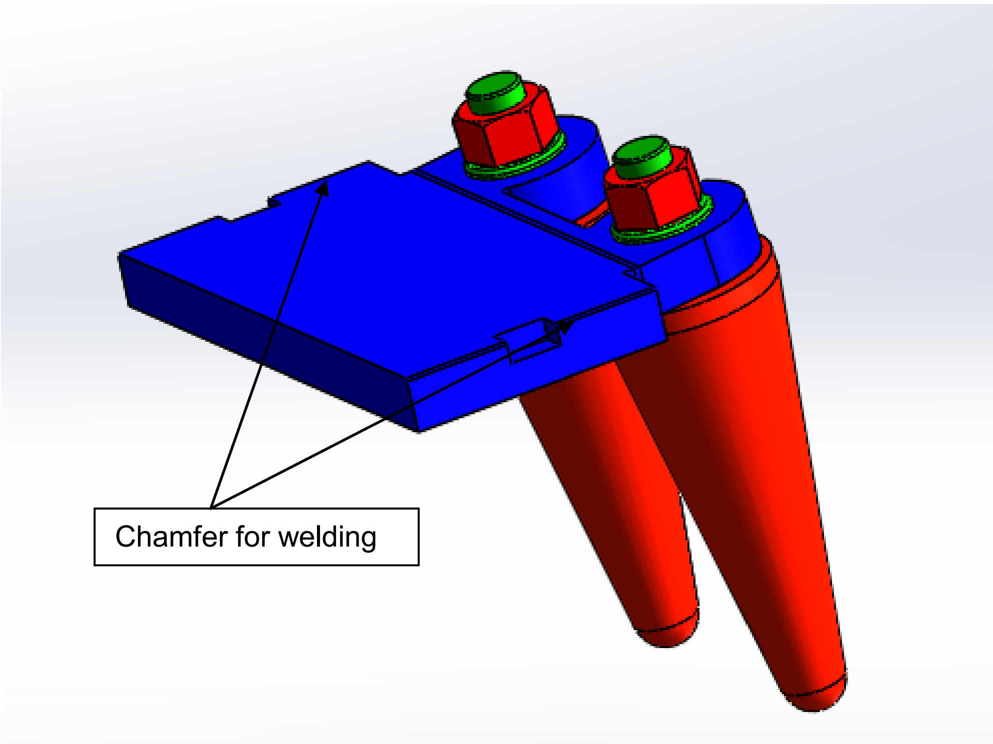

Figure 3.4.2.22. Welded holder.

3.5. List of parts

In table below I collect whole serial and new created parts used for this device.

Table 3.5.1. List of standard and not standard parts.

Part name	Part number	Material	Description	Quantity
plate	**20160019-012**	ST 37	laser	1
plate	**20160019-013**	ST 37	cut	1
plate	**20160019-014**	ST 37	laser	1
plate	**20160019-015**	ST 37	laser	1
part	**20160019-016**	ST 37	cut	5
base	**20160019-017**	ST 37	cut	1
gear	**20160019-018**	C43	milling	1
guideways	**20160019-019**	TKSD 25	INA	2
plate	**20160019-020**	ST 37	laser	1
linear ball bearings and housing units	**20160019-021**	KGHK30-B-PP-AS	INA	4
plummer block housing units	**20160019-022**	PASE 25-N	INA	2
solid shafts	**20160019-023**	W30	INA	2
shaft supporting blocks	**20160019-024**	GWH30	INA	4
base	**20160019-025**	ST 37	cut	1
housing	**20160019-026**	ST 37	laser	1
rack	**20160019-027**	C43	milling	1
smaller column	**20160019-028**	ST 37	laser	1
plate	**20160019-029**	ST 37	laser	1
plate	**20160019-030**	ST 37	laser	1
spreading finger	**20160019-031**	PA 6	molding	4
deep groove ball bearing	**20160019-032**	6205	INA	4
shaft	**20160019-033**	CK45	lathing	1
deep groove ball bearing	**20160019-034**	6202	INA	4
support	**20160019-035**	ST 37	cut	1
support	**20160019-036**	ST 37	cut	1
plate	**20160019-037**	ST 37	laser	1
part	**20160019-038**	PA 6	drill	1
deep groove ball bearing	**20160019-039**	6308	INA	4
shaft	**20160019-040**	CK45	lathing	1
plate	**20160019-042**	ST 37	laser	1

plate	**20160019-043**	ST 37	laser	1
shaft	**20160019-044**	CK 45	lathing	1
rolls	**20160019-045**		molding	2
plate	**20160019-046**	ST 37	laser	1
housing units	**20160019-047**	PCF40	INA	3
carriages	**20160019-048**	KWSE25	INA	4
bracket	**20160019-049**	ST 37	cut	2
shaft	**20160019-050**	CK 45	lathing	1
part	**20160019-051**	ST 37	milling	1
collar	**20160019-052**	ST 37	cut	2
chain wheel	**20160019-053**	OB-2108	NOZAG	3
cylinder	**20160019-054**	ST 37	cut	2
collar	**20160019-055**	ST 37	cut	1
sides plates	**20160019-056**	ST 37	cut	2
plate	**20160019-057**	ST 37	cut	1
cylinder	**20160019-058**	ST 37	cut	2
shaft	**20160019-059**	CK 45	lathing	2
shaft	**20160019-060**	CK 45	lathing	1
Spur gear	**20160019-061**	C43	milling	1
shaft	**20160019-062**	CK 45	lathing	1
shaft for chain transmitter	**20160019-063**	CK 45	lathing	1
deep groove ball bearing	**20160019-064**	16004	INA	2
plate	**20160019-065**	ST 37	cut	2
plate	**20160019-066**	ST 37	cut	2
U profile	**20160019-067**	ST 37	laser	2
base profile	**20160019-068**	ST 37	laser	2
ramp	**20160019-069**	ST 37	laser	2
circlips for shafts	**20160019-070**	DIN 471	INA	19
circlips for holes	**20160019-071**	DIN 472	INA	5
cone clamping element	**20160019-072**	RLK132	RINGSPANN	4

3.6. Critical analysis and prospects for improvement

The project outcome gave satisfying results. A whole new machine in computer - aided engineering software program Solidworks was designed. Now after finishing the project and rapport few parts and solutions should be solved in different ways to make this machine better then the competition. Two of them are presented below.

One of them is Spreading system which should be solved in different way. In the existing solution only one side of this system is moving; second one is fixed to the column. Because of that when the tire is on the platform controller need to set the tire in correct position. In new idea, both sides would move and set the tire instead the controller. Next thing which could improve the machine in future would be constructing it using less part then now. Instead of big amount of small parts there would be less smart parts. Submission process would be easier and strength of the construction would increase.

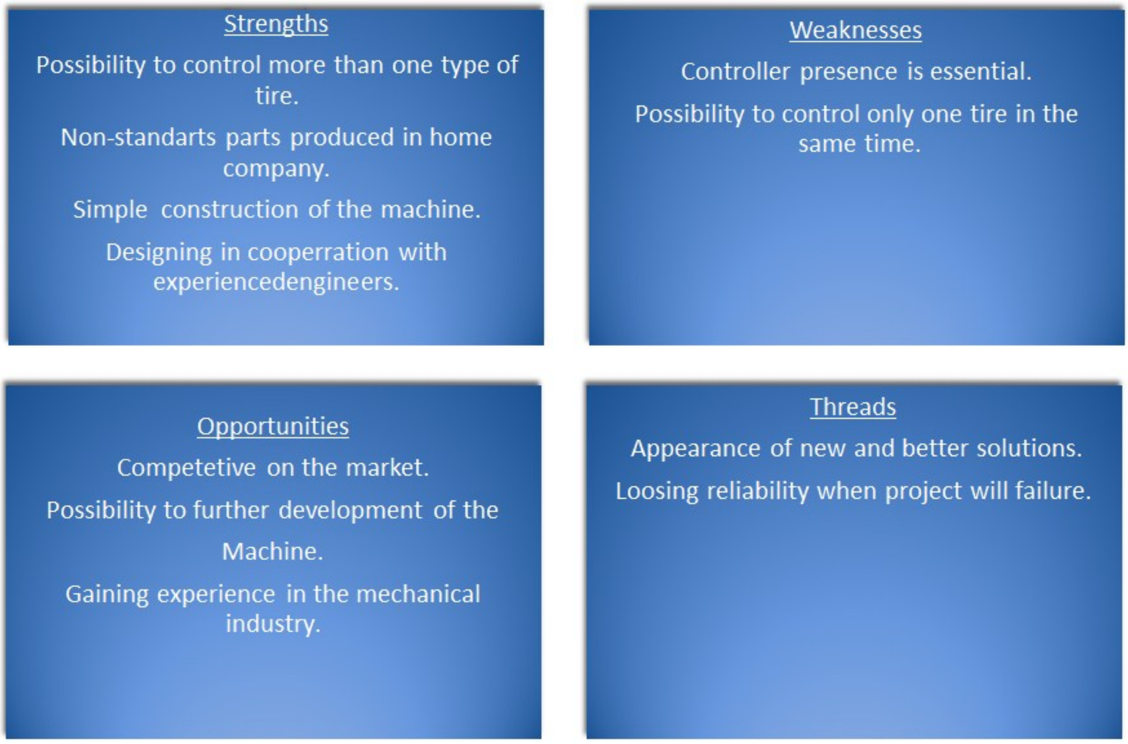

Figure 3.6.1. SWAT analysis.

4. CONCLUDING REMARKS

4. Concluding remarks

Project which I realize during my Erasmus+ exchange was a challenge for me but also a great opportunity to learn new skills. I never work with any computer-aided engineering software for 3D models. But after last four months I draw whole new machine in one of them. At the beginning, creation of simple part in Solidworks took me a couple of hours, now drawing similar part takes less the half an hour. During working on my project I thought that solutions which I choose for single problems are the best. But when I finish it and start righting the report, I was finking about it again. I saw that I could make this machine better. I already wrought about exact solutions in point 3.6. I think it is caused by my small experience in this type of works. It is my first mechanical designing project. Now I know that I should spend more time for analyse the problem carefully. During projecting already exist machine, at first I should find out its strong and weak sides.

During projecting this device I was focused on one part which I was drawing in Solidworks. When I finish this part I invite solution for next one and start work on it. I had a lot of help from my older colleges in Gislotica. They were very helpful and always try to find time for me, even when they were busy with their projects. When I had my own concept of solution for some problems they always told me what they think about it. If in their opinion it was not the best solution they suggest me another. During my stay in the Company I learned a lot about mechanical constructions from my oldest colleges. We were spiking in English and both sides were training their language skills. They also told me many interesting thing about Portugal and its culture. We were talking about it during coffee breaks or lunches which were provide by the company. Thanks to that I had a great opportunity to try original Portugal food. We were eating in small local restaurant, located near to our office. I must admit that Portugal kitchen is one of my favourite. In the meantime of my stay in Portugal it happens that not every restaurant serves me good food, but in this special one every meal was delicious. I know only one local where serve better food. It is the restaurant close to Douro River. I was there with Professor Silva and another Erasmus student. We try there the best steak and bacalao in Portugal.

I was working in Gislotica four days a week. For rest of the time I try to tour and see as much of Portugal as possible. I saw the south coast, the mountains in central Portugal, main cities like Lisbon and Coimbra. It is just a part of the places but I regret that I have not seen more. Every single place which I visit was worth seeing and the people were open and friendly.

At the end of my work I want to wright about my stay at the Instituto Superior de Engenharia do Porto. At first I have to say thanks to Professor Silva who gave me opportunity to connect my Erasmus project with internship in Gislotica. It was surprise for me because I never hear about anything like this before at my University and I did not expect that. After this four mounts I can say that making projects in the company was the best solution for me. It gives me chance to learn new skills and collect professional experience. Another great solution which I saw at ISEP and big surprise for me are evening classes for Master Degree. In Poland it is almost impossible to work and make a master degree in one time. You can connect it but if you study at weekends, you have to pay for it.

My Erasmus student exchange was better than I expect. I meet great people and make new friendships. I visit almost whale Portugal. I realized my dream about surfing. But I also learn new skills and collect professional experience, it could not be better.

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