KAUNAS UNIVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING AND DESIN

Armanda Šimaitė

ANALAYSIS AND DESIGN OF A TRUCK SPARE WHEEL LIFTING MECHANISM

Final project for Master degree

Supervisor
Dr. Sigitas Kilikevičius

KAUNAS, 2015

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Final project for Master degree
Title of study programme (code 621H77003)

Supervisor
_________ Dr. Sigitas Kilikevičius
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KAUNAS, 2015

KAUNAS UN IVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING AND DESIGN

Approved:
Head of
Production engineering
Department

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(Signature, date)

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(Name, Surname)

MASTER STUDIES FINAL PROJECT TASK ASSIGNMENT
Study programme INDUSTRIAL ENGINEERING AND MANAGEMENT

The final project of Master studies to gain the master qualification degree, is research or applied type project, for completion and defence of which 30 credits are assigned. The final project of the student must demonstrate the deepened and enlarged knowledge acquired in the main studies, also gained skills to formulate and solve an actual problem having limited and (or) contradictory information, independently conduct scientific or applied analysis and properly interpret data. By completing and defending the final project Master studies student must demonstrate the creativity, ability to apply fundamental knowledge, understanding of social and commercial environment, Legal Acts and financial possibilities, show the information search skills, ability to carry out the qualified analysis, use numerical methods, applied software, common information technologies and correct language, ability to formulate proper conclusions.

1. Title of the Project

ANALAYSIS AND DESIGN OF A TRUCK SPARE WHEEL LIFTING MECHANISM

Approved by the Dean 2015 y. _________________ m.__ d. _ Order No. ______________

2. Aim of the project

To design a universal telescopic spare wheel lifting mechanism, which would be operated hydraulically.

3. Structure of the project

1. Introduction. 2. Theoretical part. 3. Practical part. 4. Research part. 5. Conclusions.

4. Requirements and conditions

To lift 150-300 kg, attachable on the sub frame by screws, factor of safety must be equal 2 or more.

5. This task assignment is an integral part of the final project

6. Project submission deadline: 2015 June 1st.

Given to the student Armanda Šimaitė

Task Assignment received ____________________________ ______________________
(*Name, Surname of the Student*) (*Signature, date*)

Supervisor ____________________________ ______________________
(*Position, Name, Surname*) (*Signature, date*)

KAUNAS UNIVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING AND DESIN

(Faculty)

ARMANDA ŠIMAITĖ

(Student's name, surname)

621H77003 Industrial Engineering and Managing

(Title and code of study programme)

Analysis and Design of a Truck Spare Wheel Lifting Mechanism

DECLARATION OF ACADEMIC HONESTY

2015 MAY 29

Kaunas

I confirm that a final project by me, **Armanda Šimaitė**, on the subject "Analysis and Design of a Truck Spare Wheel Lifting Mechanism" is written completely by myself; all provided data and research results are correct and obtained honestly. None of the parts of this thesis have been plagiarized from any printed or Internet sources, all direct and indirect quotations from other resources are indicated in literature references. No monetary amounts not provided for by law have been paid to anyone for this thesis.

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• Šimaitė A. “Analysis and Design of a Truck Spare Wheel Lifting Mechanism” final project / supervisor Dr. Sigitas Kilikevičius; Kaunas University of Technology, Faculty of Mechanical engineering and design, Department of Production Engineering department.

Kaunas, 2015. 56 p.

SUMMARY

This thesis is a theoretical overview of the types of truck, truck wheel, tire parameters, composition and weight proportions. Analysis of various lifting mechanisms introduced various actuators, which can be adapted to the lifting mechanism in order to automate these. Also consider concrete examples already designed mechanisms and establish requirements and desired properties for the lifting mechanism.

In the practical part of this paper work to perform calculations that are necessary for structural decisions: forces, loads, length and other; plotted hydraulic diagram and designed the lifting mechanism of spare wheel.

In research part done in simulation, verified and tested structure, its strength. According to the results of simulation, has been performing of the relevant solutions and improvements. Studies were also conducted preliminary economic calculations and deemed cost to mechanism.

Šimaitė A. "Sunkvežimio atsarginio rato pakėlimo mechanizmo tyrimas ir projektavimas" baigiamasis darbas / kuratorius Dr. Sigitas Kilikevičius; Kauno technologijos universitetas, Mechanikos inžinerijos ir dizaino fakultetas, gamybos technologijų katedra.

Kaunas, 2015. 56 p.

SANTRAUKA

Baigiamojo darbo teorinėje dalyje nagrinėjami sunkvežimių tipai, jų ratai, padangų parametrai bei jų sudėtis ir svoris. Analizuojami įvairūs pakėlimo mechanizmai, pristatytos skirtingos pavaros, kurios gali būti pritaikytos pakėlimo mechanizmui tikslu automatizuoti. Taip pat apžvelgti konkretūs pavyzdžiai jau sukurtų mechanizmų ir išskirti reikalavimai bei pageidavimai būsimam pakėlimo mechanizmui.

Praktinėje darbo dalyje atlikti būtini skaičiavimai, kurie reikalingi konstrukciniams sprendimams įgyvendinti: jėgoms, apkrovoms, elementų ilgiams nustatyti; Nubraižyta hidraulinė diagrama ir suprojektuotas atsarginio rato pakėlimo mechanizmas.

Tiriamojoje darbo dalyje atlikta konstrukcijos simuliacija, patikrintas jos stiprumas. Remiantis gautais rezultatais buvo pasiūlyti pakeitimai ir patobulinimai. Sukurtai konstrukcijai atlikta ekonominė kainos analizė, paskaičiuota jos kaina.

Content

Introduction

Over the past few years, a significant increase in Lithuania heavy vehicles, and of course, more negative consequences. Heavy weights trucks on our highways stamping track in asphalt is a very serious signal drivers to be very attentive, such as road crossings road safety.

In addition to the positive impact on the economy, transport, has an adverse impact on the environment and society. Damage was caused by road accidents, which killed and injured people, smashed vehicles, transport facilities, environmental pollution (Spillage of fuel, oil, transport material, etc.) [1].

Most accidents are caused by drivers fault. Research shows that about 90-94 percent road accidents in the country, directly or indirectly, are due to human - the road user's fault.

Other aspect of safety problems is vehicle accidents in roads minor damage to the vehicle for which it is necessary to stop and make sure whether the possible subsequent use or remove it for example arising extraneous sounds, dirty headlights or tire exploded. The last one will be highlighted in this paperwork.

Obviously, the wheels of a truck on the road can change only physically strong person, because weight of the wheel can seek hundred and more kilograms and diameter 1,5 or more meter.

Particularly important to Lithuania transport system development: on the functioning of the transport system, the entire economy depends on the success of our well-being and security (by the way, transport remains one of the priority sectors of the economy in many countries of the world). So it is not surprising that the rapidly evolving transport sector is facing new challenges, which can be easily and efficiently deal by academics, teachers, researchers.

The main goal of this paperwork is to design a universal telescopic spare wheel lifting mechanism, which would be operated hydraulically.

Main tasks

1. To analyze configurations of trucks constructions and understand possible problems in design phase.
2. To prepare principal schemes of lifting mechanisms.
3. To calculate the parameters of mechanism.
4. To design a mechanism.
5. To analyze the strength of the designed mechanism.
6. To calculate economic costs.

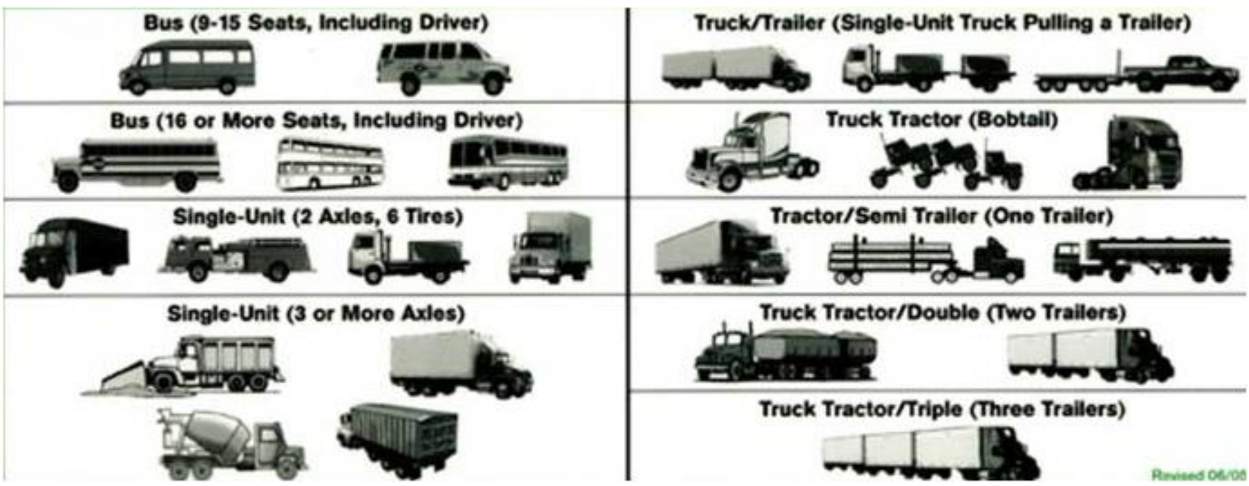
Literature review

The main attention in this chapter is paid to the types of trucks and wheels. It is important to understand what challenges will be faced in designing the lifting mechanism.

1.1. Types of trucks

Every day the roads roll million vehicles. Transport equipment can roughly be defined as all means that enable the transport of goods and/or persons; thus not only passenger cars, buses, lorries, trains (composed of locomotive and wagons), inland waterway vessels and aircraft also road trailers and semi-trailers, rail goods vehicles, bicycles and powered two-wheelers. In the frame of this chapter however, only the main transport equipment related to road, will be highlighted [2].

Picture 1.2.1 illustrates configurations of vehicles. There are many types of heavy weights trucks and buses, but in this paperwork will focus only on Single-Unit 2 or more Axles lorries, because mostly it has problems with positioning and attaching to the body of spare wheel.



1.1.1. Picture: Configurations of vehicles [1]

Vehicles are divided not only by the overall size, weight, number of axles, type of trailer, but also the type of cargo. It may be dump, cargo tank, pole and others (see picture 1.2.2).

1.1.2. Picture: Cargo Body Type [1]

As was mentioned, in this paperwork will be focused only on trucks, which could have problems with *free space* on its body. Mostly there are short wans, dump body type. For example a plow (see picture 1.2.3). There is no free space except place between the cab and bodywork.

1.1.3. Picture: Plows [2]

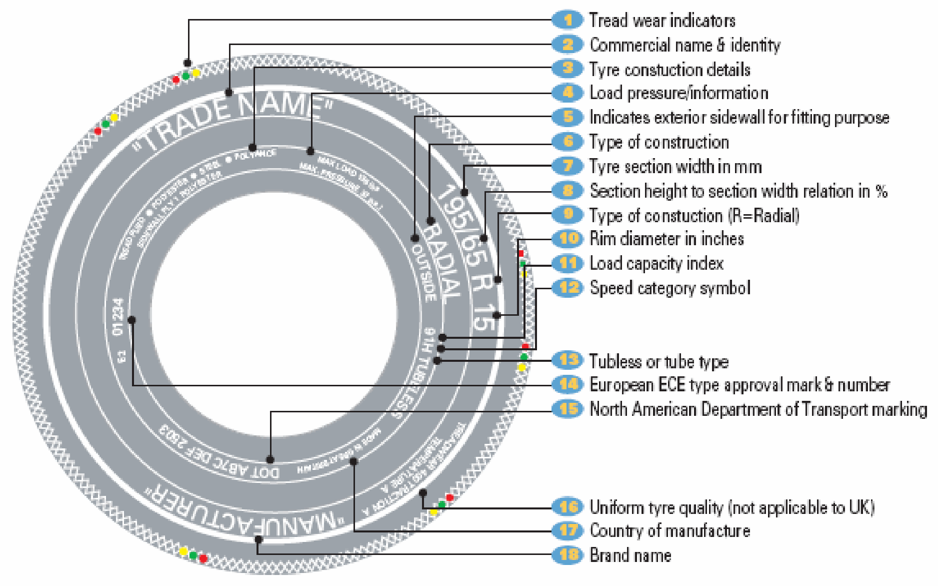
To raise wheel more than one hundred kilograms upper than 1,2 meters height only by human force practically impossible.

1.2. Main tires parameters

Tire manufacturers are looking for ways to at least partially alleviate the situation for those drivers who failed - they tug at large tire through. The first series of its decision to implement Concern tires Bridgestone, which are produced in the size 495/45 R 22.5 "Supersingle GREATECS" model tires supplied new Mercedes Benz Actros trucks trunk. With this tire, when it began to air, can drive at least 25 miles, and while driving speed is not so small - 60 km / h.

Western Europe, that will be enough to reach the city with tire repair shop, gas station, or at least to the highway truck parking [3].

Next will be explained main parameters of tire and meanings of symbols (see picture 1.2.1).



1.2.1. Picture: Tire symbols [3]

Tire Width

Width of the tire measured in millimeters from sidewall to sidewall. The tire in the diagram below is 185 millimeters wide

Aspect Ratio

Ratio of the height of the tire's cross-section to its width. 65 means that the height of the sidewall is equal to 65% of the tire's section width [4].

Wheel Diameter

The width of the wheel from one end to the other. The diameter of the wheel in the diagram above is 15 inches.

Construction

This tells you how the tire was put together. The "R" stands for radial, which means that the body plies cords. These cords are layers of fabric that make up the body of the tire, and run radially across the tire from bead to bead. A "B" indicates the tire is of bias construction, meaning that the body ply cords run diagonally across the tire from bead to bead, with the ply layers alternating in direction to reinforce one another [4].

Load Index

Indicates the maximum load in kilograms that a tire can support when properly inflated and run at its maximum speed. You will also find the maximum load in pounds and in kilograms elsewhere on the tire sidewall [4].

Speed Rating

It shows the maximum service speed for a tire. "H" for example means that the tire has a maximum service speed of 130 miles in one hour. Please note that this rating relates only to tire speed capability, and is NOT a recommendation to exceed legally posted speed limits; always drive within the legal speed limit [4].

DOT

Means the tire is compliant with all applicable safety standards established by the U.S. Department of Transportation (DOT). Adjacent to this is a tire identification or serial number; a combination of numbers and letters with up to 12 digits [4].

Tire Type

American markings define the proper use of the tire. "P" means this is a passenger car tire. "LT" means it is for a light truck.

UTQG

Stands for Uniform tire Quality Grading, a quality rating system developed by the US Department of Transportation (DOT) [3].

Next need to assess possible weight of wheels. “Alcoa wheels” gives a table (see below) where are comparing its production with others.

Configuration example 1	Alcoa (Kg)	Cast Aluminium (Kg)	Steel (Kg)
22.5 x 8.25	136	167	264
22.5 x 13.00	151	191	336
Total	287	358	600
Savings	-	71	313

Configuration example 2	Alcoa (Kg)	Cast Aluminium (Kg)	Steel (Kg)
22.5 x 8.25	499	614	968
Total	499	614	968
Savings	-	114	469

Configuration example 3	Alcoa (Kg)	Cast Aluminium (Kg)	Steel (Kg)
22.5 x 8.25	227	279	440
22.5 x 13.00	151	191	336
Total	378	470	776
Savings	-	91	398

1.2.2. Picture**:** The weight difference between an Alcoa and a steel wheel **[**4]

According *CONTINENTAL* a tire comprises different components, all of which contain elements in varying compositions. These elements vary with the size and type of tire. Listed below are the elements used for the 315/80R22.5 tire. This particular tire weighs approximately 62 kg [5].

1.2.1. Table: Components of *CONTINENTAL tyre*

No.	Component	**Weight**
1	Natural Rubber	18.8kg
2	Synthetic Rubber	3.4kg (5.6%)
3	Halogen Butyl Rubber	1.23kg (2.0%)
4	Other Chemicals (accessory agents, plasticizer, preservatives, vulcanizing agents)	17.3kg (28.1%)
5	Core Wire (electro-plated steel wire)	8.5kg (13.8%)
6	Nylon Fabric	0.12kg (0.2%)
7	Steel Cord (electro-plated stranded steel wire)	12.2kg (19.8%)

To sum up numbers from Picture 1.2.2. and Table 1.2.1, it is clear that 315/80R22.5 one wheel weights more than hundred kilograms.

2. Lifting mechanisms

A load lifting system with the driving pulley is presented in Fig. 2.1. It represents a more complex system for dynamic analysis in comparison with the system which contains a drum as a driving element.

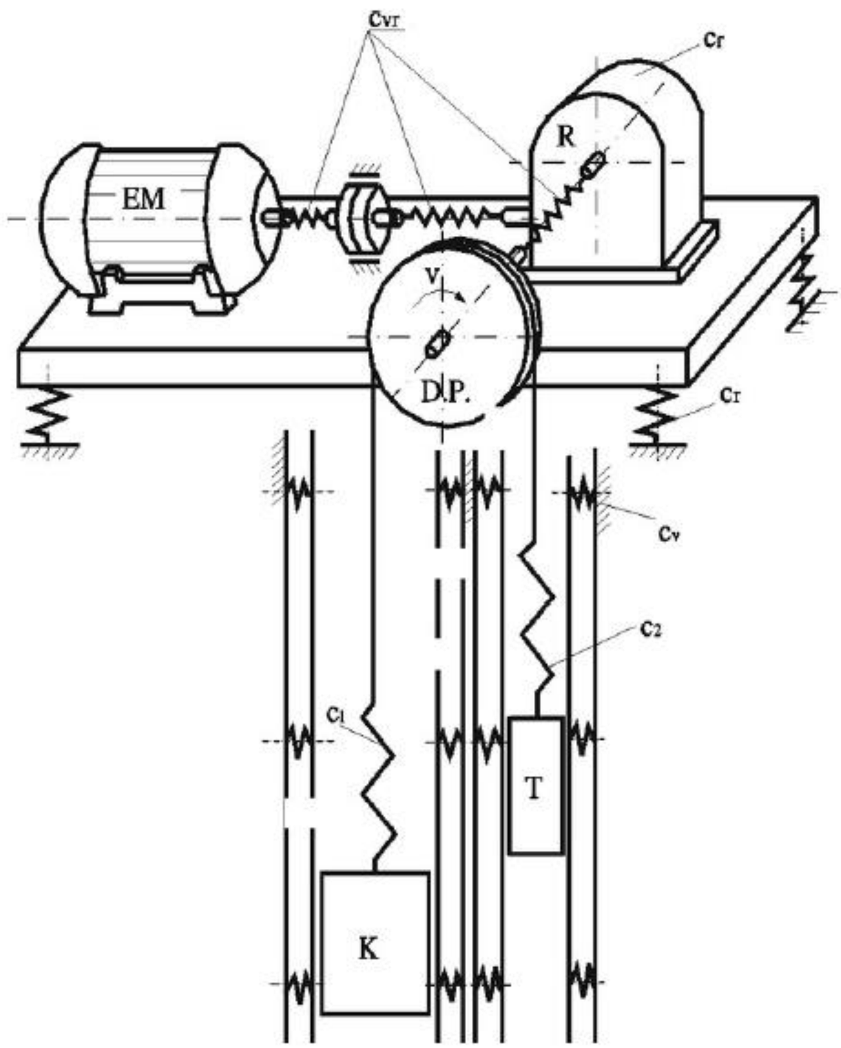


Figure 2.1. Elevator driving mechanism [5]

The variations in rope free length (shortening or lengthening) directly affect the rope stiffness, and therefore also the dynamic behavior of the rope, which is of significant importance in the systems with high lifting velocities. The influence of elastic rope slipping over the driving pulley is considered through the adequate boundary conditions [6].

For driving mechanisms used for vertical load lifting (elevators and cranes), it is necessary to provide adequate conditions for the correct dynamic analysis of their parts' behavior and especially for the rope as the basic element, already in the design phase.

2.1. Lift

A lift is a device designed to pose people and / or goods, vertically or almost vertically. It has guides that retain a constant lifting trajectory. A lift poses by multiple platforms, buckets, cabins, cages, shelves. The lifting force is transmitted ropes, chains, hydraulic telescopic hydraulic cylinders, pinion, screw gear.

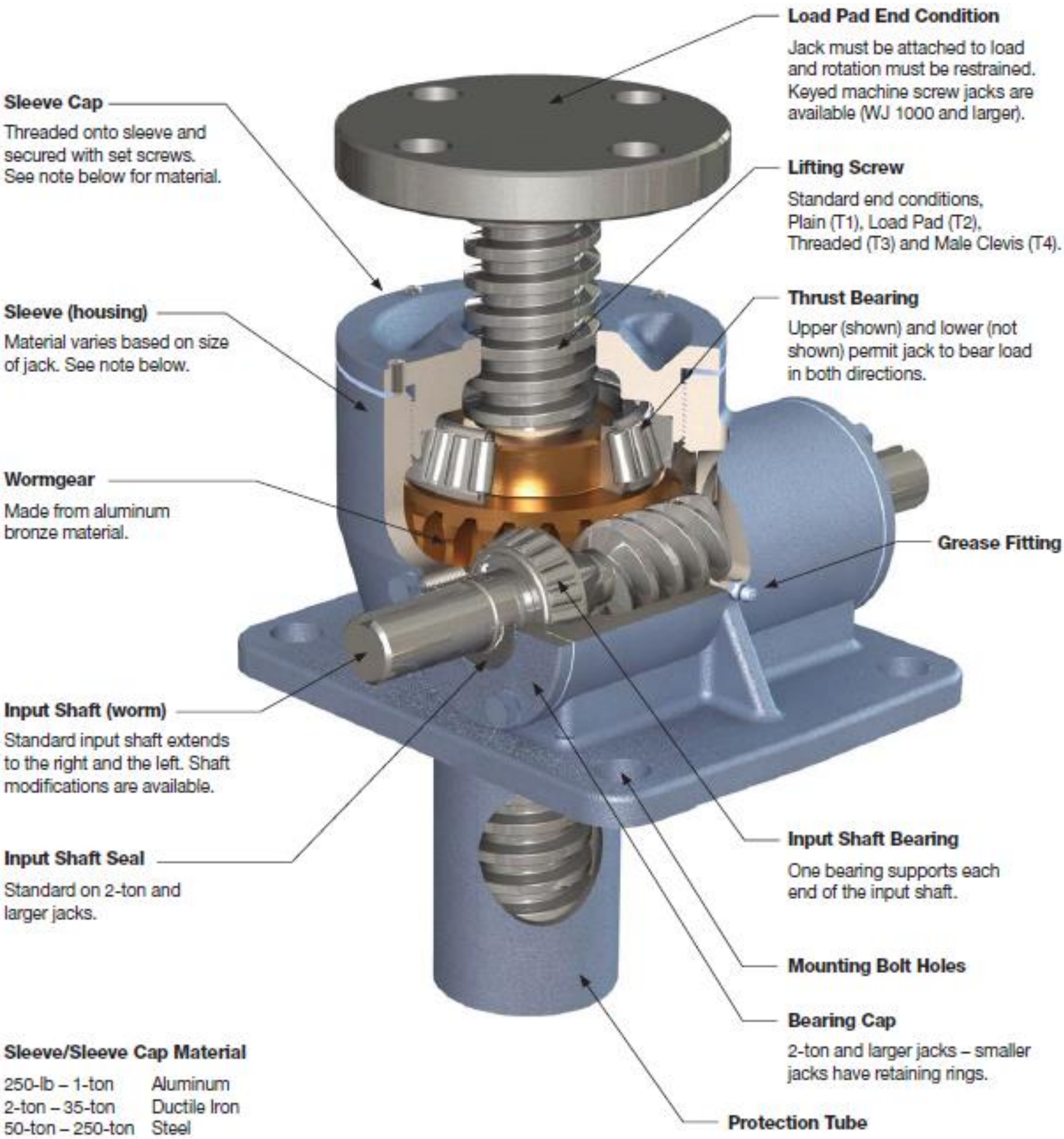
According to the type of work platforms are divided into periodic and continuous, according to the gear into electro-mechanical and electro-hydraulic. Used on construction sites, building materials factories, warehouses, car service companies and elsewhere [7].

2.1.1. Picture: Two stems electro mechanical lift to pose cars [6]

2.2. Jack

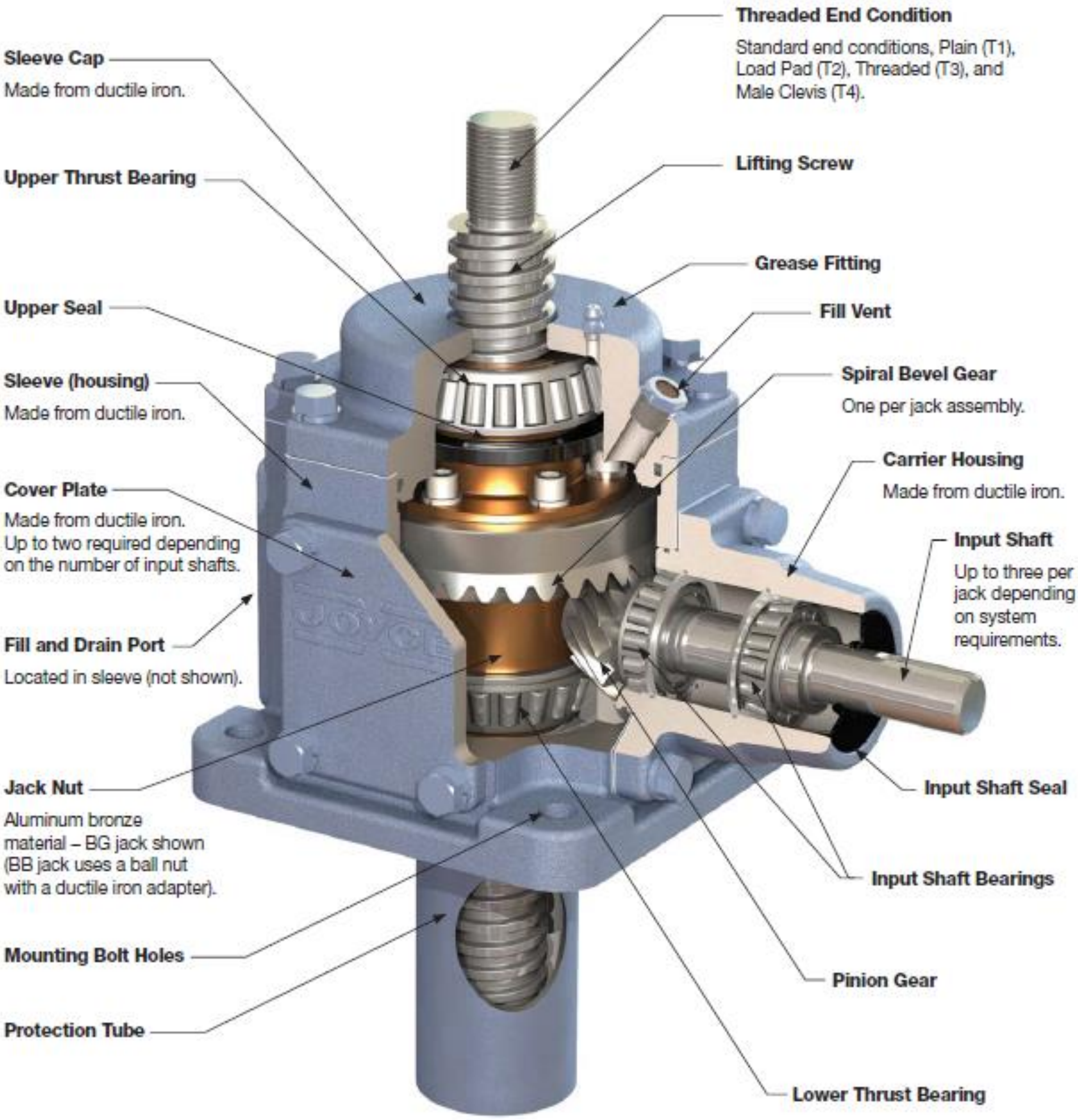
A Jack is stationary portable or moveable goods at a low lift mechanism (usually by 2 meter). Driven manually or electric gear. May have a horizontal sliding mechanism, setting out in detail the jack position after load. Caused by turning the propeller (screw-jack) [8], pinion powered by rack bar (pinion jack) or fluid – driven plunger (hydraulic jack) [9;10]. Lifted load considered self-retaining screw (screw-jack), ratchet mechanism (pinion jack) and valve (hydraulic jack) [7]. The main parameters:

- screw-jack - load capacity up to 20t, efficiency 0,3 – 0,4 (Pic. 2.2.1) ,
- pinion jack - capacity up to 15t, efficiency 0,7 – 0,85 (Pic. 2.2.2),
- hydraulic jack - capacity up to 200t, efficiency 0,75 – 0,8.



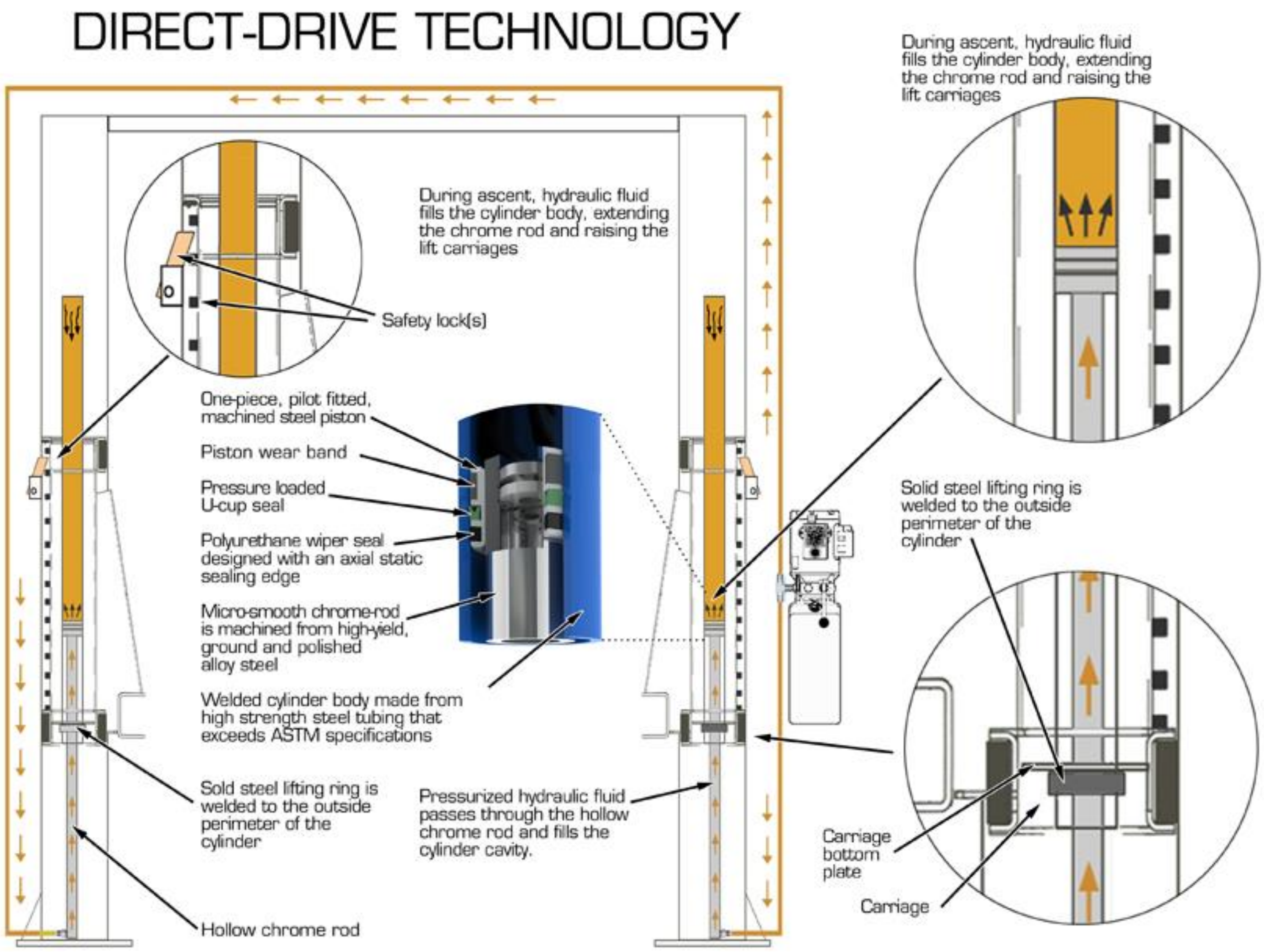
2.2.1 Picture: Worm gear Style Jack [7]

Worm gear jacks typically have slower travel speeds than bevel gear jacks. Bevel gear also offers higher efficiency not only greater speed than other mechanical screw jacks. As an added benefit, these mechanical actuators also act as miter boxes, making them an ideal choice for multi-jack systems. As many as three output shafts may be specified for mounting motors, limit switches, readout devices and other accessories [7].



2.2.2 Picture: Bevel Style Jack [7]

The most commonly used is hydraulic jack, because it is a small footprint, low weight, its capacity and efficiency compared with other jacks is large. Gaps – compare, lifting height is not big and there is no such speed as other jack. Hand pallet jacks housing moves pistons with load restraint. When the lower part of a plunger pump from the reservoir through the suction and pressure valves available in the working fluid, the piston with the load goes up. When you open the discharge valve, liquid load applied force flows back into the tank and piston with the load goes down. Discharge valves, changing the cross sectional areas of the outlet replace the load lowering speed [7].



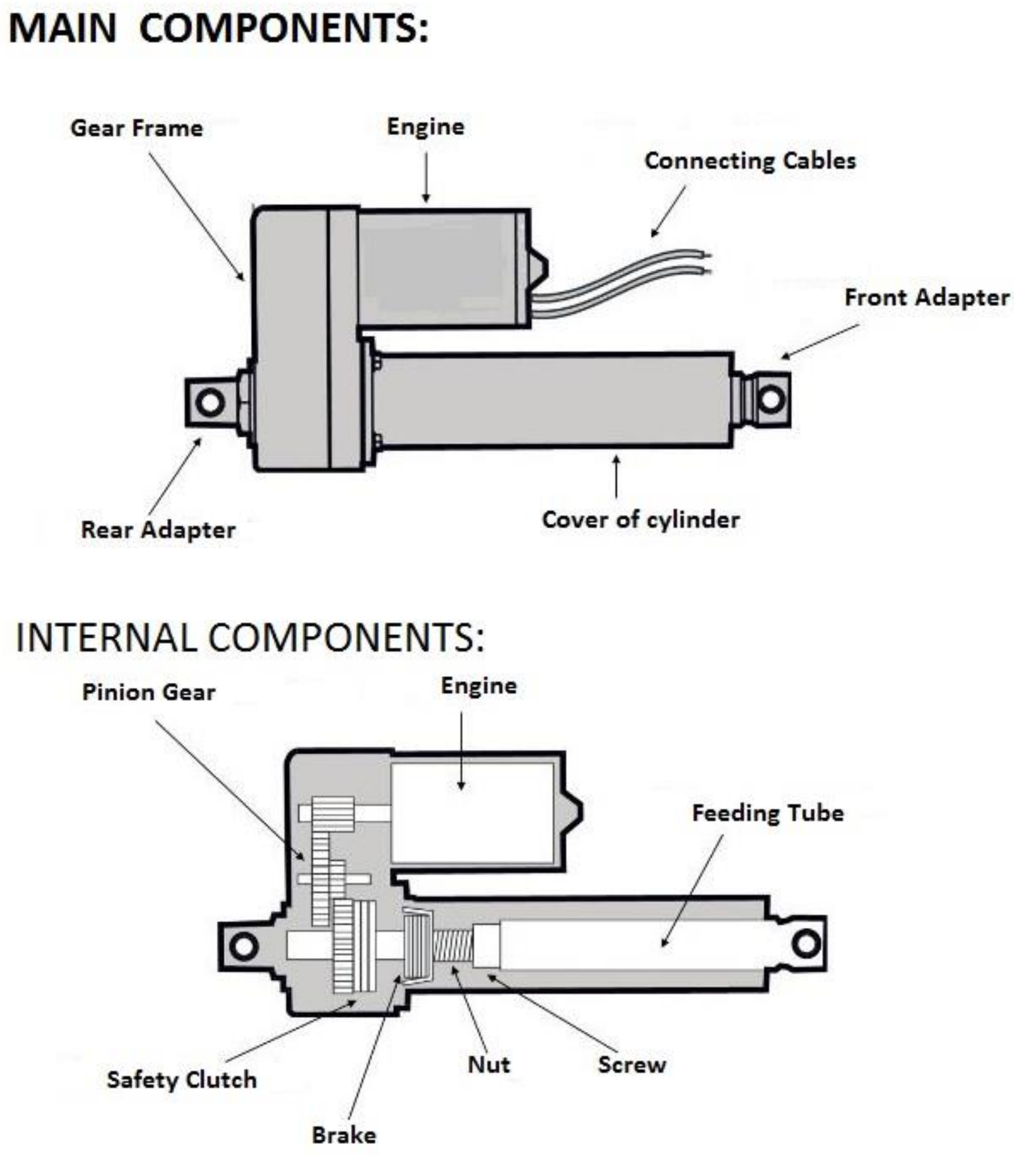
2.2.3. Picture: Scheme of hydraulic jack direct-drive technology [8]

Two-post lifts feature low-pressure HVLP direct-drive cylinders eliminating the need for lifting chains or screw mechanisms most commonly found on other lift designs. Dual HVLP low-pressure cylinders minimize leakage and offer better reliability, smoother operation and less maintenance costs throughout the life of your lift. High-volume, low-pressure equates to less workload placed on the entire hydraulic system.

Direct-Drive technology is preferred on commercial-grade two post car lifts as it has it has fewer moving parts than a chain-over-roller cylinder configuration. Pressurized hydraulic fluid flows from the power-unit, through the hollow cylinder rods then enters the cylinder body and fills the inside cavity. The pressure of the hydraulic fluid extends the piston rod downward raising the cylinder body and lift carriages. A dual-synchronic equalization system maintains equal lifting and provides operators with a stable, level vehicle working condition [11].

2.3. An electric gear

As it was mentioned earlier without hydraulic gears also are used and the electric drives. Main components of electric gear are illustrated in picture 2.3.1.which are Frame, Engine, Cables, Adapters and Cylinder [12].



2.3.1. Picture Structure of electric drive [9]

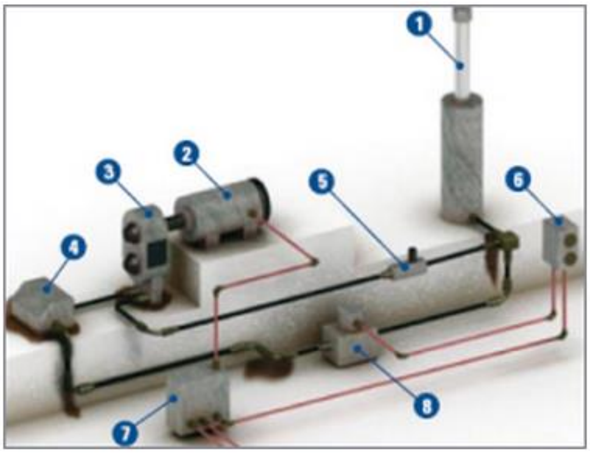
Internal components are Pinion gear, Engine, Feeding tube, Safety clutch, Brake, Nut and Screw. There are many benefits of electric drives:

- Easy to integrate into a working process.
- Ambient temperature -40 °C to + 85°C.

- Supply voltage 12/24/36 VDC and 230/400 VAC.
- Stroke up to 1500 mm.
- The dynamic load of 1 kg to 900 kg.
- No leakage loss.
- More than 10 times saves energy.
- Easily replaces hydraulics or pneumatics.
- Needless service.
- Simple installation.
- Electric motor control.
- Flexible integration in small spaces. [12]

2.4. Comparison between hydraulic and electric drives

Summarizing the information provided above, we can compare the electrical and hydraulic actuators. In picture bellow there is a list of all necessary components for both drives.



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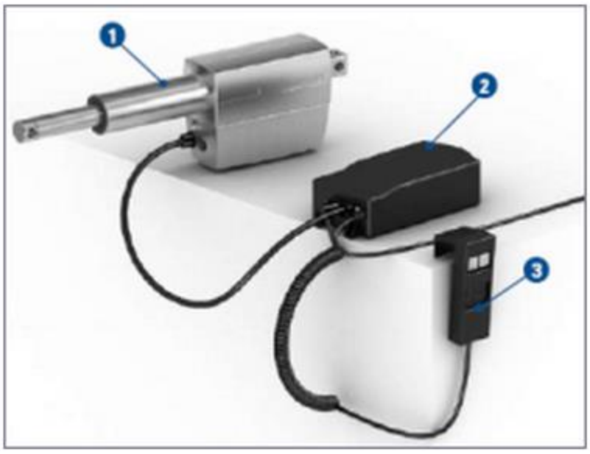


b

2.4.1. Picture: Components of hydraulic and electric drives [9]

HYDRAULIC SYSTEM (Pic.2.4.1,a)

1. Cylinder.
2. The pump motor.
3. The hydraulic pump.
4. Oil capacity.
5. Check valve.
6. Control buttons.
7. The box of electrical relay.
8. Electromagnetic valve.

ELECTRIC SYSTEM (Pic.2.4.1,b)

1. Electric cylinder – actuators.
2. Cylinder control.
3. The operator switches / Management.

2.5. Lift and testing facilities

Lift and testing facilities, garages devices used for car care and repair works, for example, car bridge and up wheels (to be easier inspect and repair carrier, suspension, transmission), transmissions nodes removed and apply. This is a different lifts, deflectors, jacks (one bridge or wheel lift), inspection pit, trestle. The most commonly used platforms. They come in different design – mast (one mast, two masts, multimasts) , scissor and other, by gear – electromechanical, electrohydraulic, pneumo – hydraulic, pneumatic, hydraulic [7].

2.6. Examples of the spare wheel lift system analysis

Example No.1: Military Mercedes-Benz „Actros MP1"– special-purpose truck. There used to handheld pinion lift [13].

2.6.1. Mercedes-Benz » Actros MP1 [10]

Example No.2: Also military truck, but lifting mechanism is a more complex than the previously (see picture 2.6.2). It is repair and evacuation support truck, designed to provide technical assistance measures are unable to continue the engagement on the battlefield, and damaged, broken equipment or equipment up to 30 t pull out of the battlefield (flexible or rigid drawbar, on the front or rear axle on the front or rear wheels). Transport of goods adapted truck for transport platforms with wheels or tracks, equipment, and other goods.

2.6.2. Picture: Military truck spare wheel lift [8]

Example No.3: The armored truck gets hub reduction axles with a provision for inter-axle lock and interwheel differential lock. It also gets a central tire inflation system that provides the operator control over the pressure in each tire (manufacturer's information).

2.6.3.Picture: Lifting mechanism on armored truck [12]

Example No.4: Spare tire carrier which raises the wheel with wire.

2.6.4.Picture: Spare tire carrier [13]

Example No.5: The spare tire carrier consists of two steel wheel cradles which are triangular in shape (Pic.2.6.5.). A steel-framed arm supports each cradle which holds the spare tire. The tire is held in place by a threaded steel clamp.

A single winch, powered by the truck's battery and located between the spare tires, is used to operate both cradles. Each cradle operates independently of the other by using a single, three position winch controller, which can be plugged into either one of two winch plugs, located on either side of the front of the tray.

“The cradle is locked into the arm by a spring latch (spring-loaded latch) which is released by the operator when the tire is ready to be lowered. It also has a safety cut out switch on the tire release lever, making it super safe [13].

2.6.5.Picture: A trial firefighting tanker [11]

The tire carrier was developed to allow members to safely manage the trial unit’s heavier spare tire, which now weighed in at around 90 kilograms.

The design and development of the carrier was necessary to accommodate a heavier tire, following the service’s decision to trial a light truck as a possible replacement for the Landcruiser tray back and the new truck’s conversion from dual rear wheels to super single wheels.

The electrically driven, spare tire cradles, fitted to the tire carrier, were designed to allow for safe storage, removal and replacement of spare tires.

The spare tire carrier is conveniently positioned on the tray between the cab and the firefighting platform. Originally a single spare tire was stowed under the tray’s passenger side, however our fleet crew deemed it impractical not only to hold the heavier spare tires, but because the nature of the bush work made the tires susceptible to damage from logs.

Placing the spare tires in this location allowed a doubling of the spare-tire carrying capacity. This new location also freed up space underneath the tray for a long tool box” [13].

Summary word

Universal lifting mechanism should have as many properties as possible at once. Also it may adapt to the maximum number of trucks. The overviews of the examples give these conclusions:

- Handle lift is cheaper, but sometimes it requires to use a lot of human force;
- A big plus can be a lift mechanism with use in both sides or sometimes possibility to attach two spare wheels;
- Uncomplicated and easy spare wheel mounting to the mechanism is a requirement in all cases;
- Mechanisms should be a compact, safe, easy to use and with as little as possible items that could be damaged;
- The possibility to select options: manual, mixed or fully automated management causes flexible price.

These main conclusions help to select a principal kinematic scheme of lifting mechanism.

3. Lifting mechanism design

In this chapter is presented design process of lifting mechanism with hydraulic gear: calculations of forces, strength, beams and others, also kinematic and hydraulic diagrams.

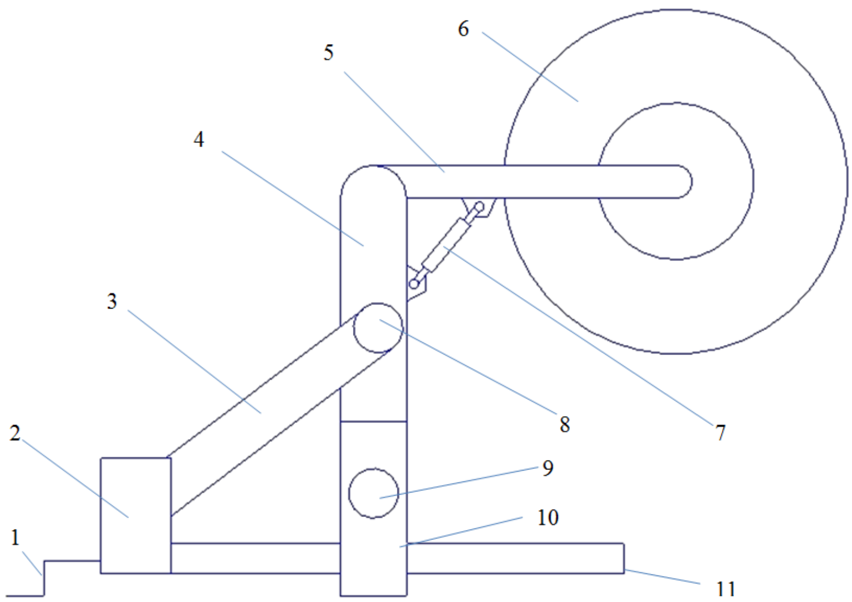
Lifts are generally powered by electric motors that either drive traction cables or counterweight systems like a hoist, or pump hydraulic fluid to raise a cylindrical piston like a jack. [15].

Hydraulic lift design process:

1. Select principal kinematic and hydraulic schemes.
2. Calculate forces and the power required to lift the load.
3. Select, design and calculate the hydraulic system;
4. Unify the main mechanisms of hydraulic lift.

3.1. Principal kinematic and hydraulic schemes

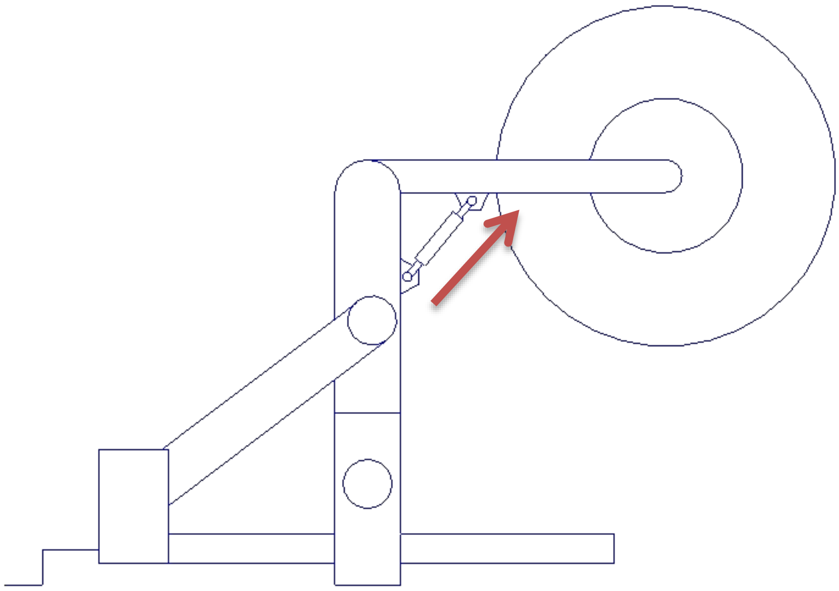
The first design step is to select principal kinematic and hydraulic schemes. At the very beginning, to select kinematic diagram is needed. One of possible is shown below (Picture 3.1.1) [16]



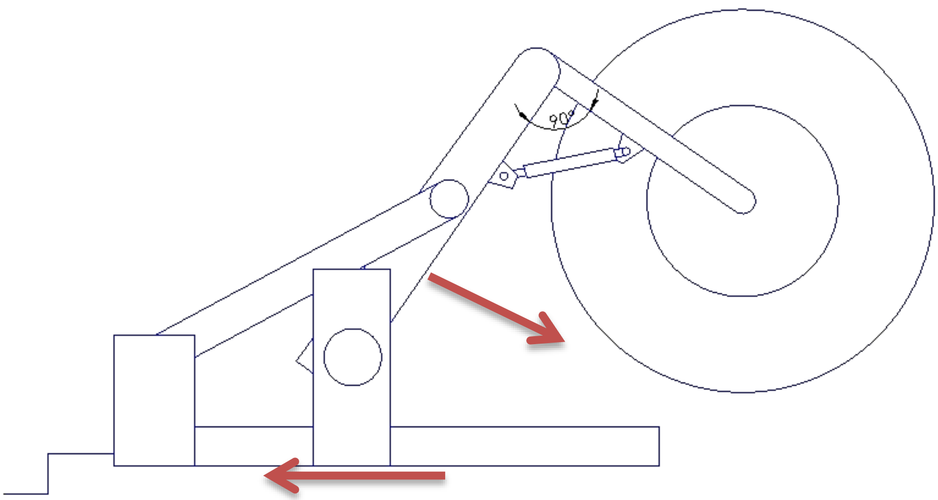
1- Handle, 2- attachment element, 3,4,5- movable elements, 6- wheel, 7- hydraulic cylinder 8,9 – joints, 10-sliding element, 11- bevel jack

3.1.1. Picture: Principal kinematic diagram of lifting mechanism

Dropping down the wheel the hydraulic cylinder 7 lifts element 5 until 85-90°, then turning handle 1element 10 moves to element 2 and let down element 4 until wheel 6 get down. The directions of movements are shown in pictures below. When lifting up every step repeated in reverse procedure.



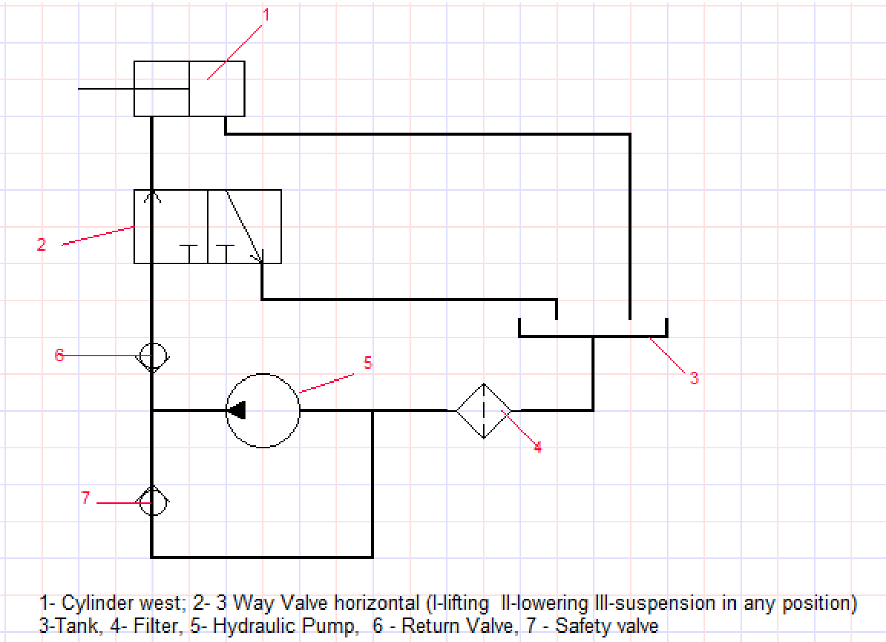
3.1.2. Picture: Lifting wheel



3.1.3. Picture: Movements and directions dropping down

This mechanism may be fully handled, mixed or automated as a client requires. There are no elements which can be damaged very easily; it is easy used, compact and safe.

The principal scheme (see picture 3.1.5) consists of a hydraulic cylinder 1. Gear pump 5, the rotary motion of the shaft receives additional mechanism to connect. The pump supplies oil through a non-return valve, three-way distributor 2. The pump 5 and 2 hydraulic line splitter is a non-return valve 6 Cylinder reaches the maximum position, oil from the draining of the tank 3 and automatically stops the lifting process. Oil tank 3 through the filter 4 is connected to the pump relief valve 5 and 7 [17-20].

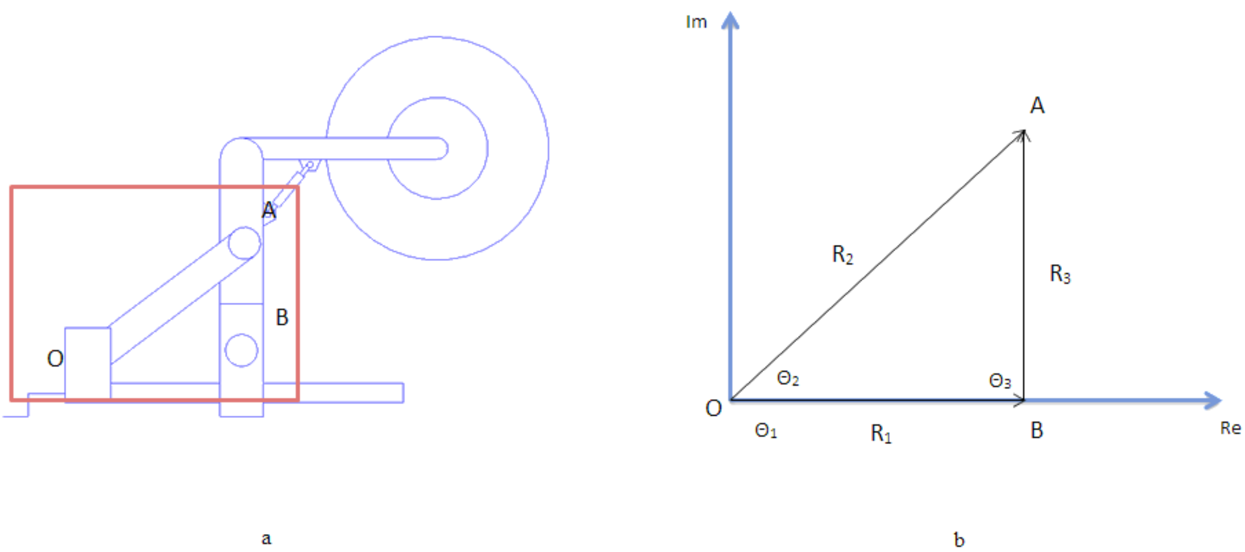


3.1.5. Picture A principal hydraulic scheme

3.2. Prototyping

In this chapter analytical expression for kinematic quantities of lifting mechanism is generated and a possible prototype using principal kinematic with was mentioned before is made.

A loop of mechanism involves traversing along links and through kinematic pairs, to arrive back at the starting point [21]. With reference to part of Figure 3.2.1 a, which is defined by red rectangle, was made vector loop which is shown in Figure 3.2.1 b.



3.2.1 Figure. Kinematic analysis of mechanism

It is possible to write a loop closure equation for vector loop to specify the conditions that the loop must remain closed as the links of mechanism move. The loop closure equation corresponding to the vectors shown in Figure 3.2.1 (b) is:

$$R_2 - R_3 - R_1 = 0 \quad (3.2.1)$$

Using
$$R_j = r_j\left(cos\theta_j + i \cdot sin\theta_j\right) \ ,j = 1,2 \ldots \quad (3.2.2)$$

We obtain
$$r_2\left(cos\theta_2 + i \cdot sin\theta_2\right) - r_3\left(cos\theta_3 + i \cdot sin\theta_3\right) - r_1\left(cos\theta_1 + i \cdot sin\theta_1\right) = 0 \quad (3.2.3)$$

Recognizing that $\theta_1 = 0°$, and $\theta_3 = 90°$, equation (3.2.3) may be simplified to:

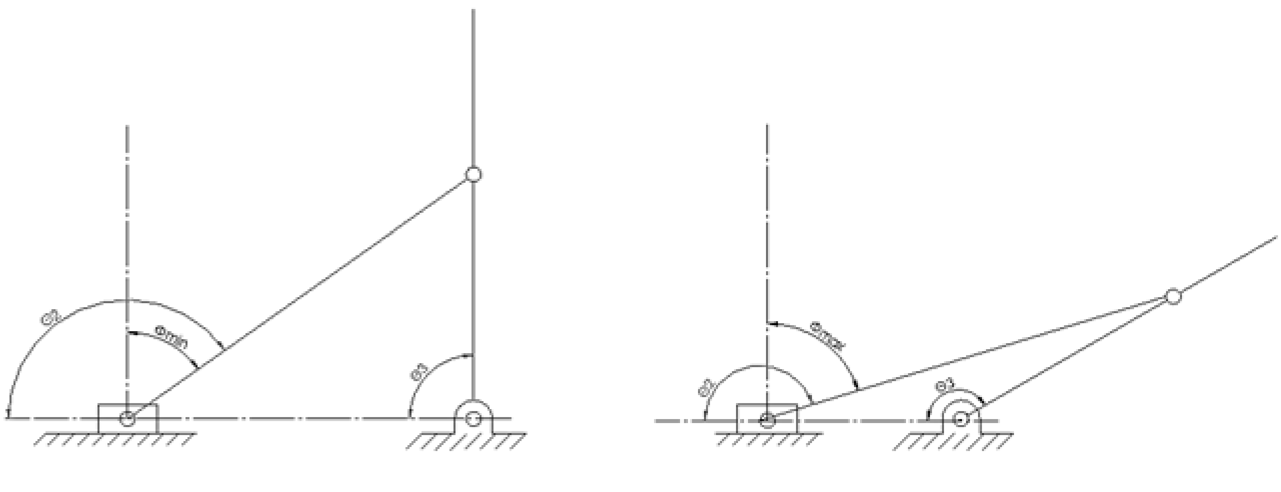
$$r_2 cos\theta_2 - r_1 + i(r_2 sin\theta_3 - r_3) = 0 \quad (3.2.4)$$

Considering the real and imaginary components of Equation (3.2.4), we obtain:

$$r_1 = r_2 cos\theta_2 \quad (3.2.5)$$

and
$$r_3 = r_2 sin\theta_2 \quad (3.2.6)$$

The independent is angular displacement θ_2, and dependent variables are r_1 and r_3. That is, Equations (3.2.5) and (3.2.6) have been arranged to express the dependent variable and a specified link dimension.



a b

3.2.2 Picture. Configurations of mechanism

In picture 3.2.2 figures and b show the configurations of slider crank mechanism where the transmission angle, Φ, is minimum and maximum. Generally acceptable if transmission angles fall the range 45°<Φ<135° [22].

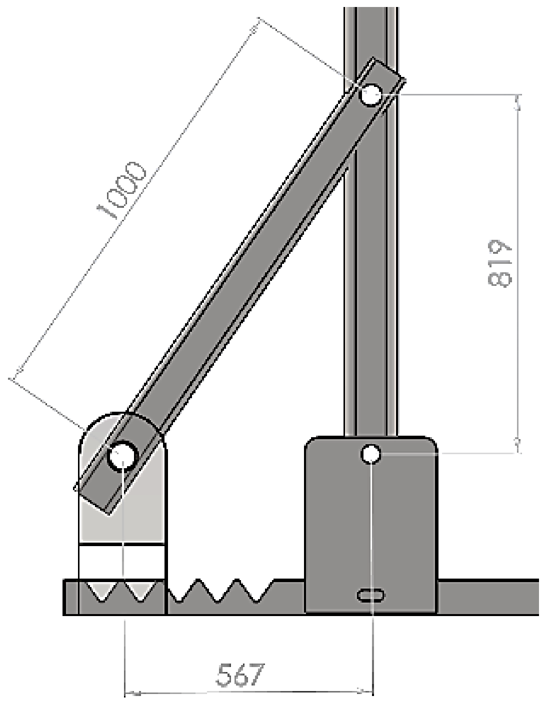
In this case extremum values of the transmission angle for a slider crank mechanism occur when $\theta_3 = 90°$, and $\theta_3 = 150°$.

To make a prototype need to know lengths of beam and distance from the anchorage point to the first hinge. For calculations will be used (3.2.5) and (3.2.6) equations, r_1=1 m, $\theta_2 = 55°$:

$$r_1 = r_2 cos\theta_2 = 1 \cdot cos55 = 0.573\ m$$

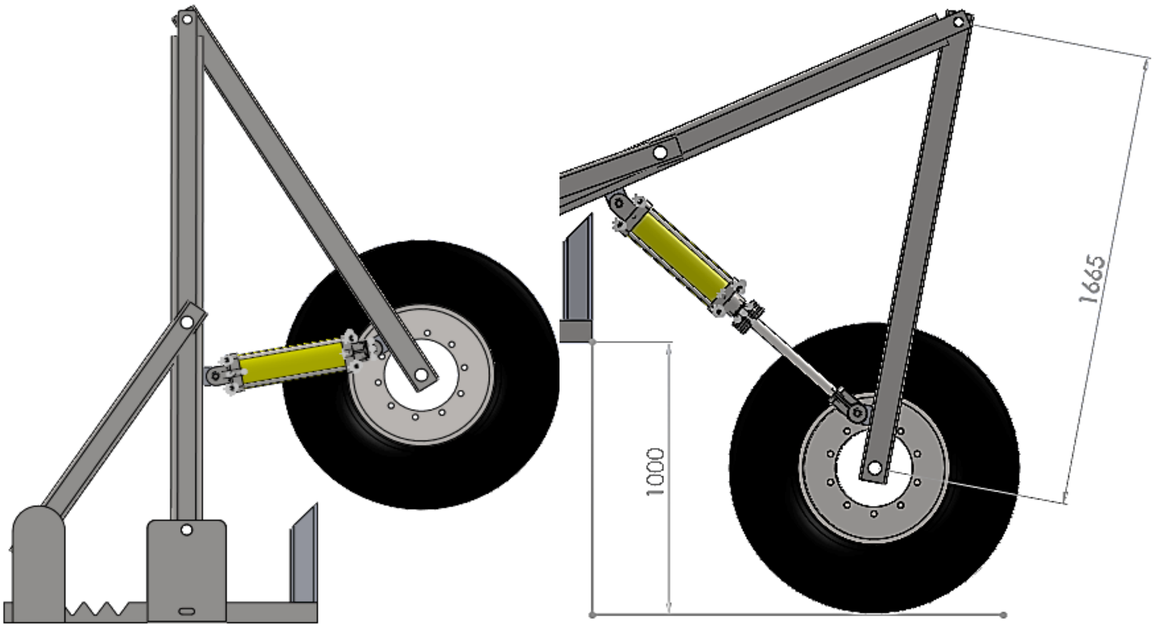
$$r_3 = r_2 sin\theta_2 = 1 \cdot sin55 = 0.819\ m$$

These calculations define distances which help to create a prototype (see picture 3.2.3). As it seen dimensions are sufficiently close to the calculated values.



3.2.3. Picture. The fragment of prototype

Prototype development process revealed that inefficient lift circle of 85-90 degrees. It is enough to just 60 degrees. Since the initial position between the mast and winches are already 30 degree angle, so the maximum raise enough through 30. This will save time, power and road.

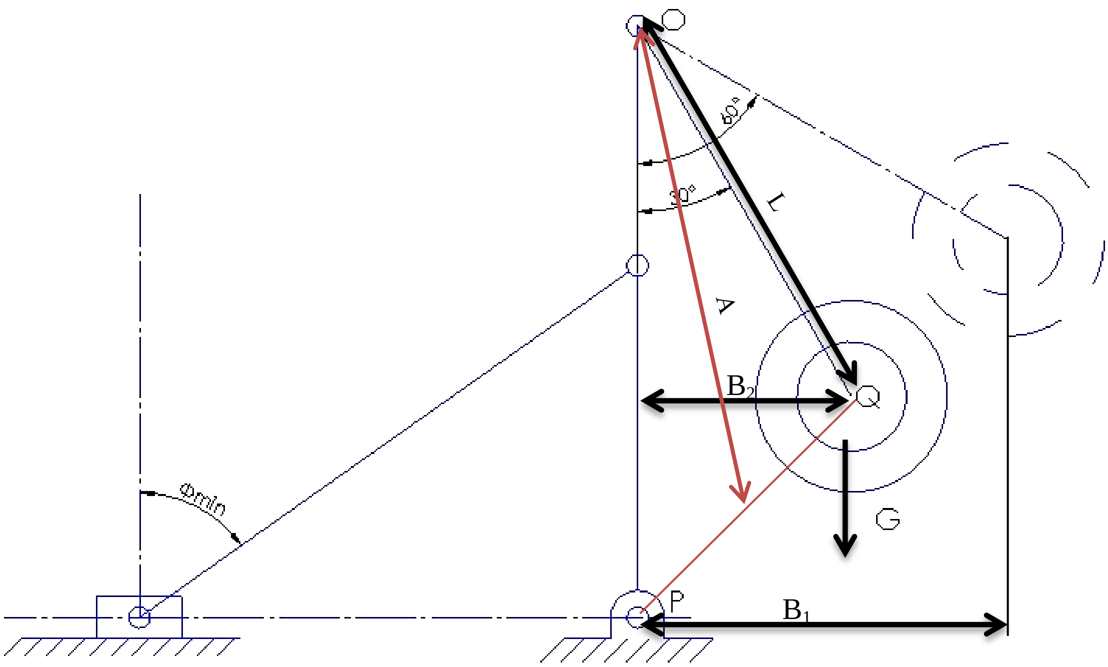


1st position 2nd position

3.2.3 Picture. Prototype of lifting mechanism

3.3. Calculations of the lifting mechanism parameter

Hoisting the spare wheel; calculating the power needed for the wheel hoist cylinder. Make a schematic diagram (as Fig. 3.3.1) and estimate the weight of the wheel and it's center of gravity [23]. The largest force will be at very start to lift the wheel up.



3.3.1. Figure: Main parameters of kinematic diagram

All parameters were systematized and listed in the table 3.1.1 to make it easier to collect and use for calculations. Approximate values were taken from prototype of future model.

3.1.1. Table: Parameters for calculations

Parameter	**Marking**	**Value**	**Unit**
Centre of rotation = the hinge point of the boom	O		
Weight of the spare weel and steam	G	250	kg
Lengh of boom	L	1,4	m
Distance from O to the center of gravity Q			
when boom is up	B_1	1,7	m
when boom is down	B_2	0,75	m
Distance form hinge point to centre of the line PQ	A	1,75	m
The asked for time for boom-hoisting	t_1	3	min
Creeping time for the boom when starting and ending the hoist movement, including latching	t_2	1	min
Time for really hoisting the boom	$t_3=t_1-t_2$	2	min
Efficiency	n	0,86	
free fall acceleration	g	10	m/s^2

Average speed $v = \frac{B_1 - B_2}{t_3} = \frac{1.7 - 0.75}{2} = 0.475\, m/min$

Load in the boom-hoist-tackle, when starting to hoist the boom $F_1 = \frac{G \cdot B_1}{A} = \frac{250 \cdot 1.7}{1,75} = 243\ kg$

Force in the boom-hoist-tackle, when starting to hoist the boom $F_2=F_1 \cdot g=243 \cdot 10=2429$ N

Required motor power $N = \frac{F_1 \cdot v}{60 \cdot 75 \cdot 1.36 \cdot n} = \frac{243 \cdot 0.475}{60 \cdot 75 \cdot 1.36 \cdot 0.86} = 169\ kW$

During the hoisting of the boomthe force F_1 becomes lower as the distance A becomes greater. The influence of the wind from the rear becomes greater when the boom is hoisted.

According to the estimates of the parameters are selected electric cylinder (see Picture 3.3.2) which main parameters are given [24,25].

Size: 40

Working stroke: 30...800 mm

Max. force of the cylinder: 3 kN

Ambient temperature: 0...+60 °C

3.3.2. Picture: Electirc cylinder and it‘s main parameters

3.4. Hydraulic system

The main hydraulic cylinder rod dimensions are calculated according to the size of the applied force [18,19]:

$$d_s' = K_a\sqrt{\frac{4\cdot F}{\pi\cdot[p]}} \tag{3.4.1}$$

Here: d_s' - the calculated value of the piston diameter, mm

K_a - safety factor (1,3…2)

F – maximum force acting on the piston rod; kN

[p] - allowable working pressure of the drive; MPa

When reversing speed is not specified, the piston rod diameter d_k' computational value is determined from the formula:

$$d_k' = K_d d_s' \tag{3.4.2}$$

Pressure p of hydraulic cylinder is determined from formula:

$$p' = \frac{F}{A\cdot\eta_m} = \frac{4\cdot F}{\pi\cdot {d_s'}^2\cdot\eta_m} \tag{3.4.3}$$

From TABLE 1 (see additives) select parameter K_d = 0,4, [p]=6.3MPa, F=2429 N (from section 3.3 calculations)

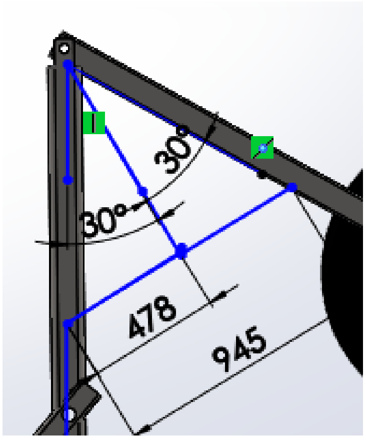
$$d_s' = 1{,}5\sqrt{\frac{4\cdot 2429}{3{,}14\cdot 6{,}3}} = 33.23 \approx 33\ mm$$

$$d_k' = 0{,}4\cdot 33 = 13.2 \approx 13\ mm$$

$$p' = \frac{4\cdot 2429}{3.14\cdot 33^2\cdot 0.955} = 2.973\ MPa$$

The displacement of cylinder approximately is calculated using dimensions from picture 3.4.1

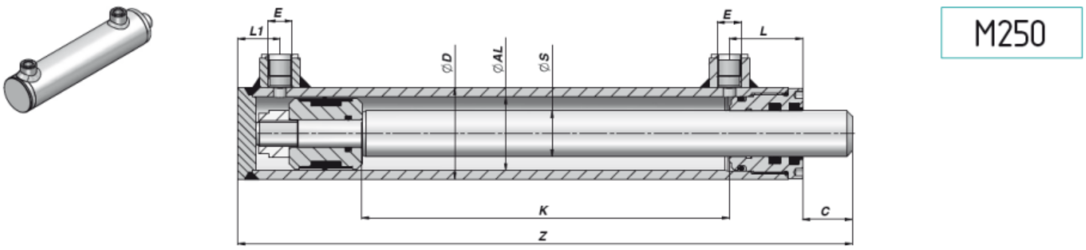
K=945-475= 470 mm



3.4.1. Picture: Displacement of mechanical system

3.4.2.

According to estimated d_s' and d_k' values and the displacement of the work unit K, from directories selected the right type, a certain type of standard hydraulic cylinder with the closest estimated values at the d_s' and d_k' [18;19]. In the picture 3.4.2 is presented DOMINGA SERVICE INDUSTRY fragment of their cylinters catalog



Codice Code Bestell-Nr.	K	Z	kg	E BSP	L	L1	C	Codice Code Bestell-Nr.	K	Z	kg
ØD 35	**ØAL 25**	**ØS 16**									
HM0025160050	**50**	135	0,70	1/4"	33	15	17				
HM0025160100	**100**	185	0,95								
HM0025160150	**150**	235	1,25								
HM0025160200	**200**	285	1,50								
ØD 42	**ØAL 32**	**ØS 20**									
HM0032200050	**50**	155	1,30	1/4"	33	20	16				
HM0032200100	**100**	205	1,60								
HM0032200150	**150**	255	1,95								
HM0032200200	**200**	305	2,30								
HM0032200250	**250**	355	2,70								
HM0032200300	**300**	405	3,00								
HM0032200400	**400**	505	3,70								
HM0032200500	**500**	605	4,40								

3.4.2. Picture. The fragment of DOMINIGA SERVICE INDUSTRY catalog [16]

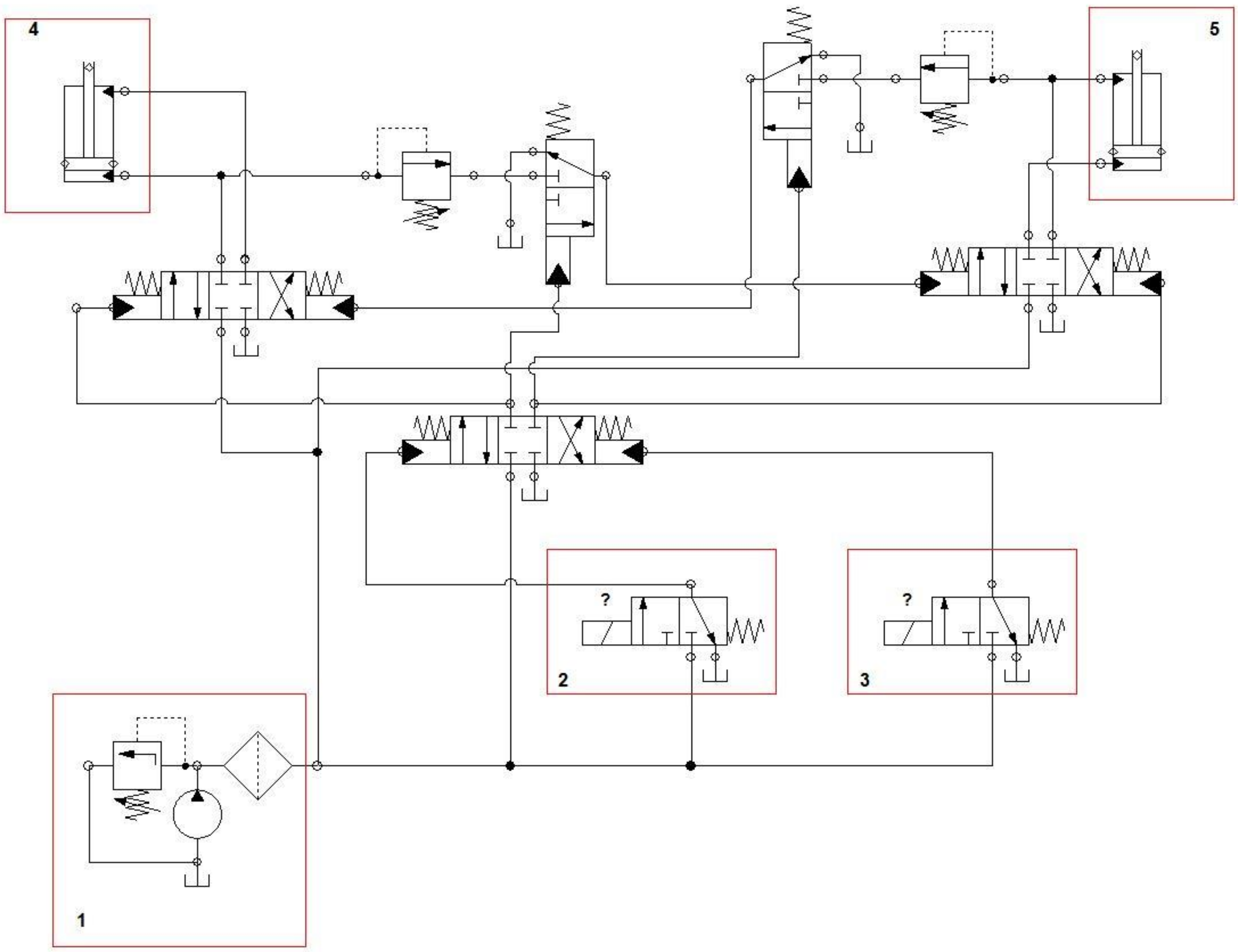
According to the data contained therein is selected cylinder witch $d_s' = 42\ mm, d_k' = 20mm, K = 500mm,\ Z + K = 605 + 500 = 1105mm$. This cylinder let to lift up to 250 kg weight, counting the weight of the boom. Other parameters:

- Temperature ° C: -25 ° + 80 °
- Max. pressure: 210 bar
- Top speed: 0.5 m / s,

- Tube: St 52.3 steel DIN2393 ISO H9
- Rod: Chrome 25 ± 5 Micron Grade 9/120 at ISO 10289
- Rod: Steel UNI C45 - SAE 1045

Then the cylinders are selected, can to prepare a principal hydraulic scheme (see Figure 3.4.2). There used 2 same cylinders. The principle of operation:

1) Press the button number 2, and begins the pushing of the cylinder No. 4, when the end position is reached, then activated valve turns the cylinder No. 5 and when 5 is the rear point , the wheel is standing on the ground.
2) Press the button No. 3 and cylinder No.5 shrinks. In the terminal point of cylinder No.5 the valve is turned on a cylinder No.4 and wheel stands on the special floor of mechanism.



1-hydraulic pump, hydraulic tank and oil filter, 2-electrically operated distributor and the button to drop down the wheel, 3- the button to pick up the wheel, 4 and 5 –cylinders.

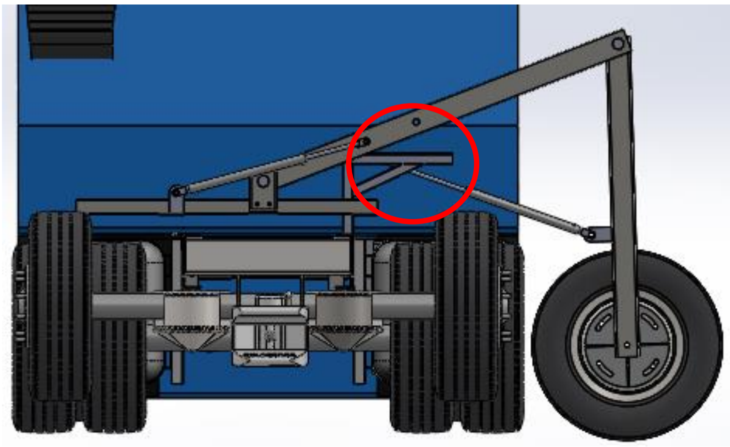
3.4.3. Figure: The principal hydraulic diagram

As can be seen in the picture above, hydraulic control requires a number of additional components as oil filter, hydraulic pump and others.

3.5. Design process

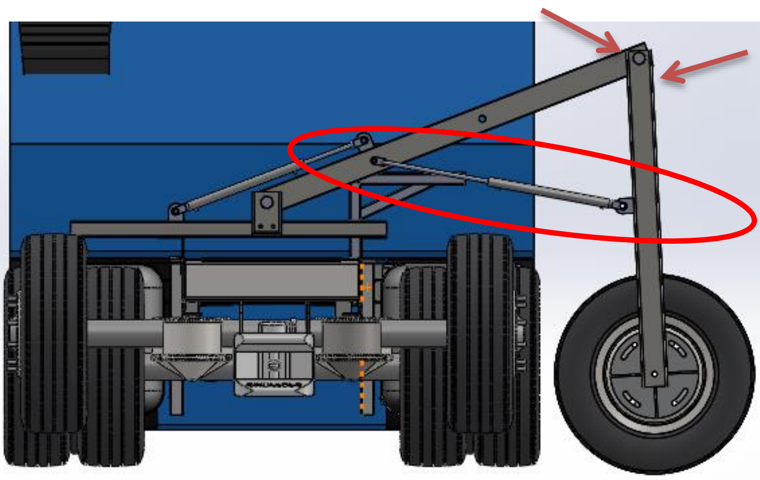
In this section briefly presented the main challenges encountered during the design process and how the designed costruction will fit a particular case – on dump [26].

Main chalanges during design process. At first was calculated lenghts of beams, then calculated and selected cylinders. After using selected cylinder the model shown obvious problem : the cylinder intersects with a floor. It is marked in the picture 3.5.1.



3.5.1. Picture: The model of lifting mechanism with selected cylinder

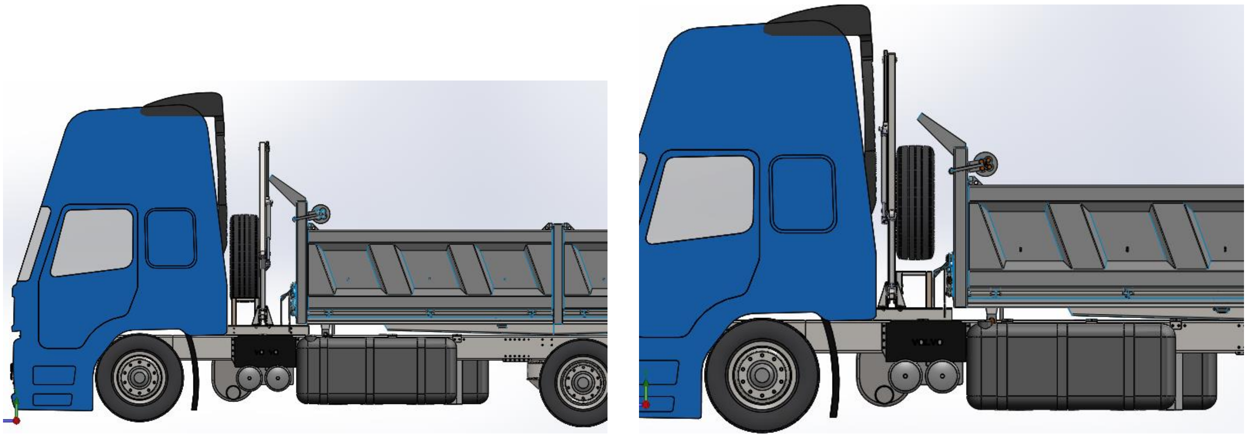
This obvious problem was resolved by changing positions of main beams. This allows for a more convenient place to attach the cylinder. The result is presented in picture 3.5.2. This design decision made to change and another cylinder mounting location.



3.5.2. Picture: The model of lifting mechanism after change of cylinder

It has also been modified primary structure, which was provided at the beginning of the design (Figure 3.1.1). It was refused a supplementary beam pushing move immediately providing cylinder. The purpose was to reduce, facilitate and cheapen construction.

Mirror-structure can be assembled, so the claim can be 2 ways. Picture 3.5.3 illustrate how construction could be fixed on dump.



3.5.3. Picture: Possible ways of assembling and fixing

When the lift mechanism was designed, it was taken to the structural strength verification.

4. Analysis of the strength of the lifting mechanism

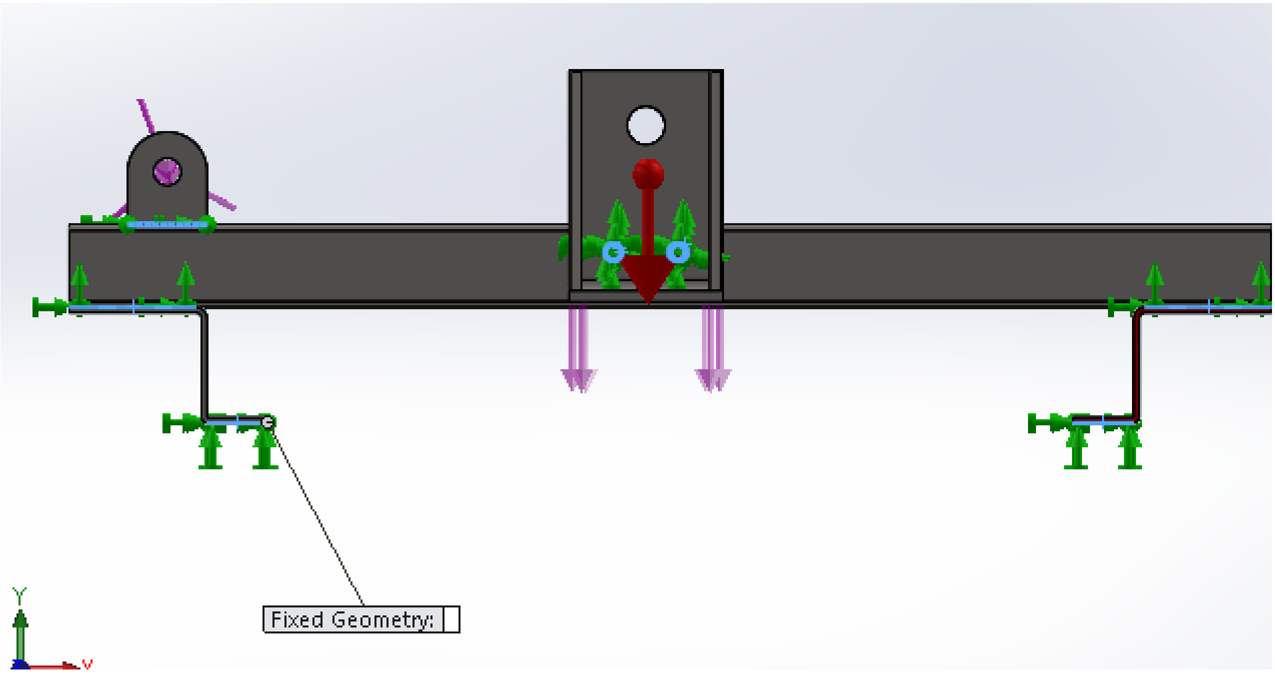
To ensure the security of components and constructions is permitted only lower than the limit stress, which called permissible [27,28]:

$$n = \frac{\sigma_y}{\sigma_{max}} \quad (4.1)$$

here: σ_y – yield strength;

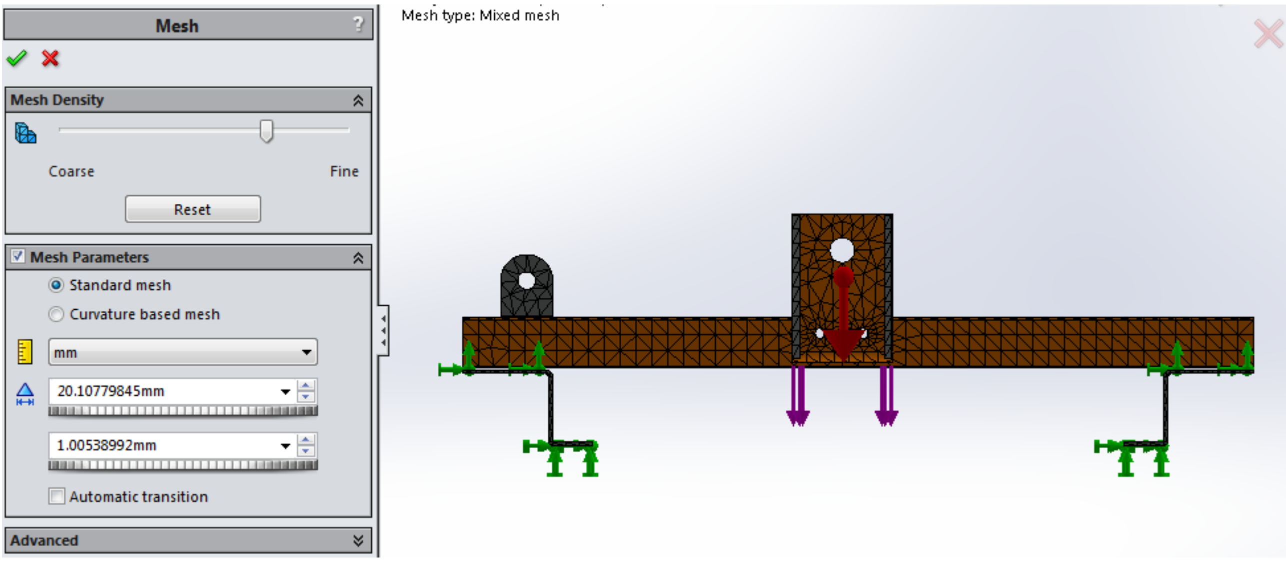
σ_{max} – maximum stress stress;

To check the structural stiffness for static forces carried out a simulation of individual assemblies. All assemblies of construction were loaded of 3 kN. The progress and results of simulation are presented below. For simulation were used *SolidWorks* Static Simulation.



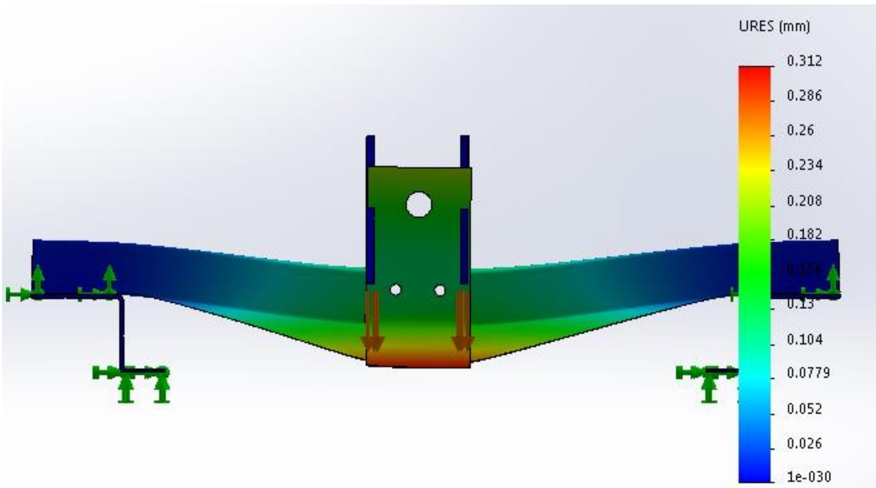
4.1. Picture: Loads of assembly

First had been selected *Materials* of parts: S235 J0, and S355MC, after that designated *Fixtures* (green arrows in picture 4.1), then marked load points (see purple arrows in 4.1) and gravity force. Finally had been selected *Mesh* function and had been created mesh for an assembly. Mesh density and parameters are illustrated in picture 4.2. Mesh type – mixed, standard.



4.2. Picture: Mesh parameters

Results of the Deformation Study are given in picture 4.3.



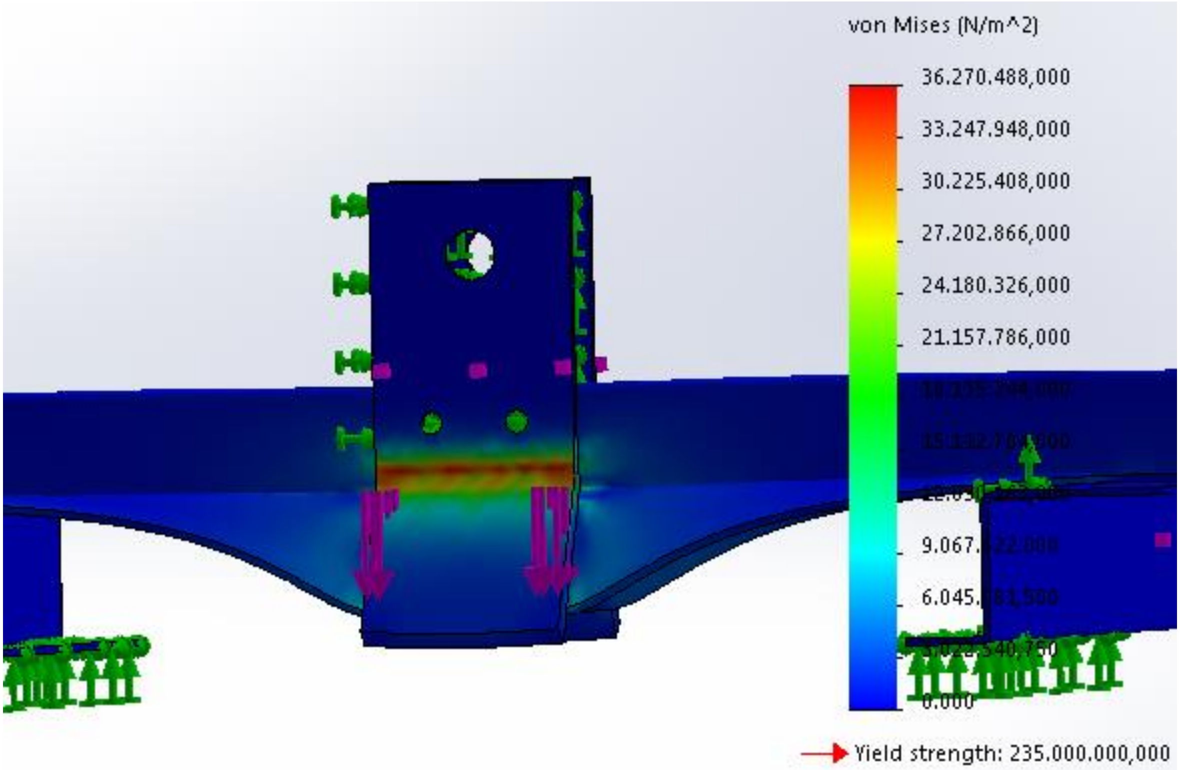
4.3. Picture: Results of the study

Blue shaded least strain assembly points, red - the most. In the assembly ends are minimum load. The maximum deformation 0.312mm visible in the middle of construction, where the biggest load.

Using simulation results from picture 4.4 and formula 4.1 had been calculated factor of safety:

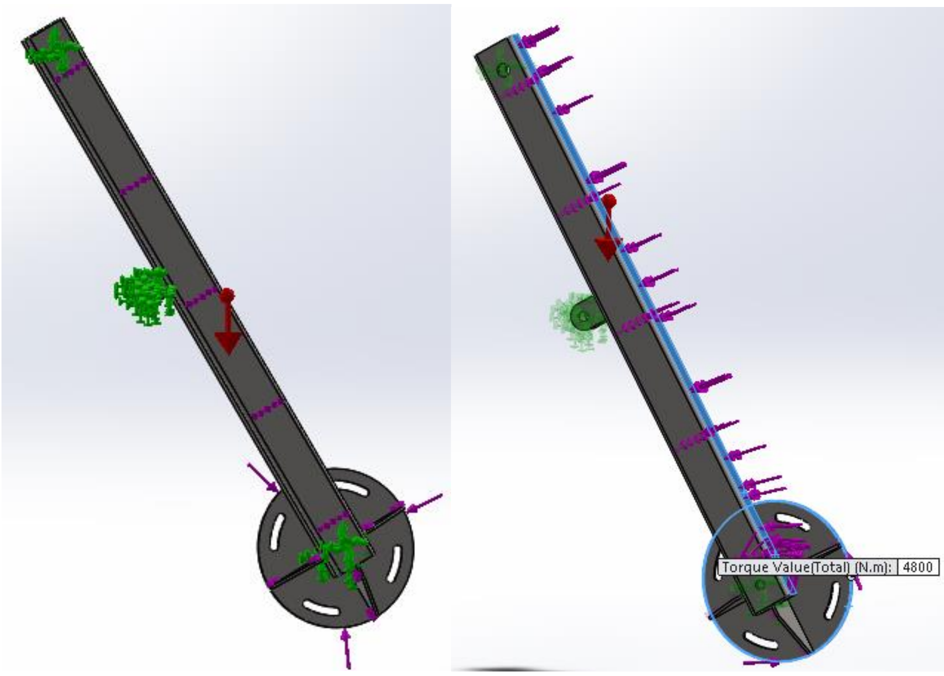
$$n_1 = \frac{235MPa}{36.27MPa} = 6,4$$

Factor of safety is very high. It shows that construction is strong enough.



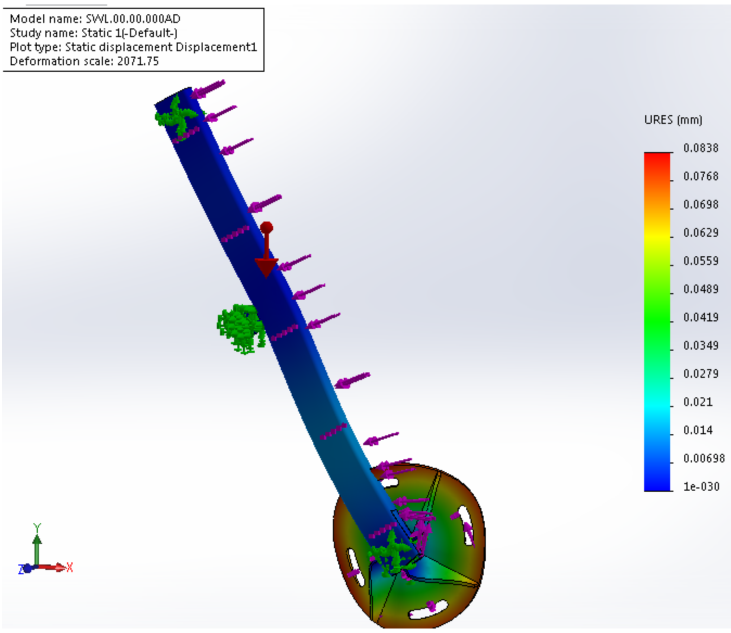
4.4.Picture: Stress chart

The same principle checked other main assemblies. The assembly below were loaded not for only force but torque too (Picture 4.5)



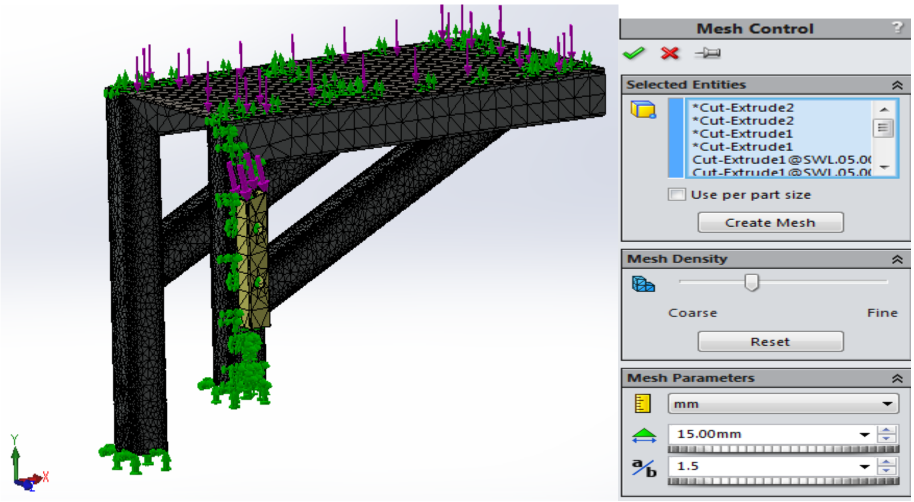
4.5 Picture: Loads of assembly

The simulation revealed that the maximum deflection reaches only 0,084 mm. The maximum deformation observed on the flange where the wheel fixes.



4.5. Picture: Results of assembly simulation

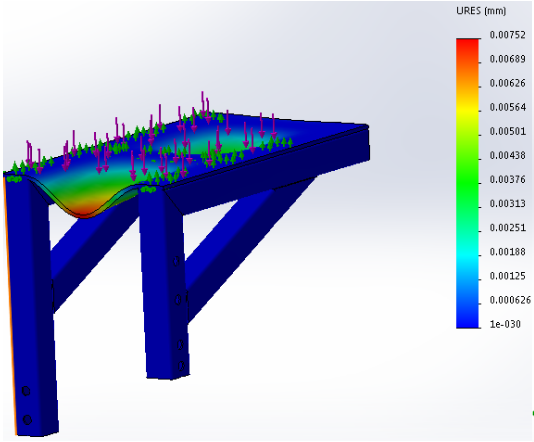
The same principle checked other main assemblies (see picture 4.6).

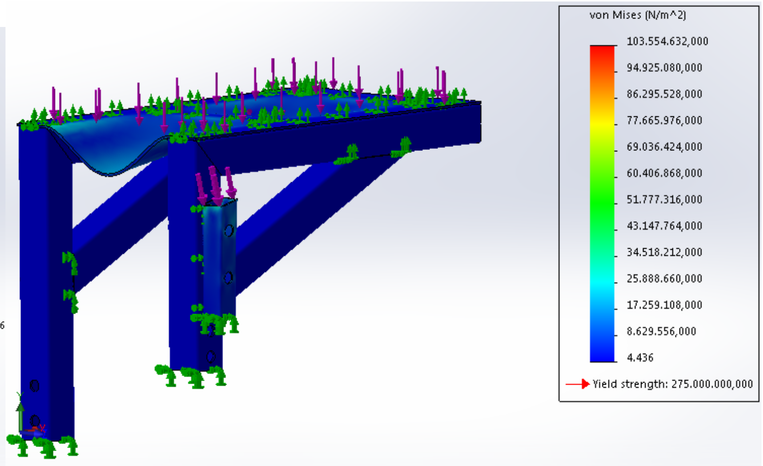


4.6. Picture: Mesh parameters of assembly

The simulation revealed that the maximum deflection of assembly reaches only 0,3 mm. Factor of safety is calculated bellow:

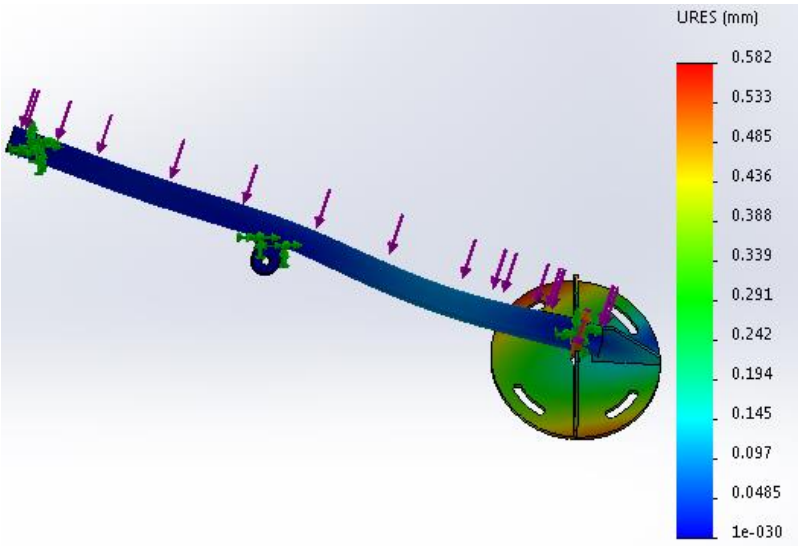
$$n_2 = \frac{275000000}{103554632} = 2.655$$





Results show, that even the maximum deformation is less than 1 mm. Therefore, it was decided to reduce the thickness of the metal. Also this facilitates and cheapens the construction.

Beam which dimensions 120x60x8 had been changed into 70x30x2, beam 120x60x8 had been changed into 100x60x4. The plate thickness of the floor has been changed from 6 mm to 3 mm.



4.7. Picture: Simulation results after changes

Analysis showed that allowed stress seeks 149803872 $\frac{N}{m^2}$. Next is calculated factor of safety:

$$n_3 = \frac{235000000}{103554632} = 2.27$$

These structural changes facilitated construction more than 80 kg, moreover the maximum deformation still is less than 1 mm and factor of safety still is more than 2.

5. Economic analysis of the material cost

When design process is done, need to calculate the price of lifting mechanism. Prices are listed in table 4.1. All metal prices are given in web pages and, other component prices are received from suppliers [28,29].

4.1. Table: Informative prices

	Cost*[1], €	Dimensions
Hydraulic Cylinder	72.70	D42, 605
Electric Drive	3213,86	40, 500
Plate	2356.57 1678.58 816.52 635.94 1317.09	10x500x2000 3.0x600x1400 5x1500x6000 8x1500x6000 50x500x2100

Using these prices given in table 4.1 and other ones had been calculated final price of mechanism. All information and sum are in the table 4.2.

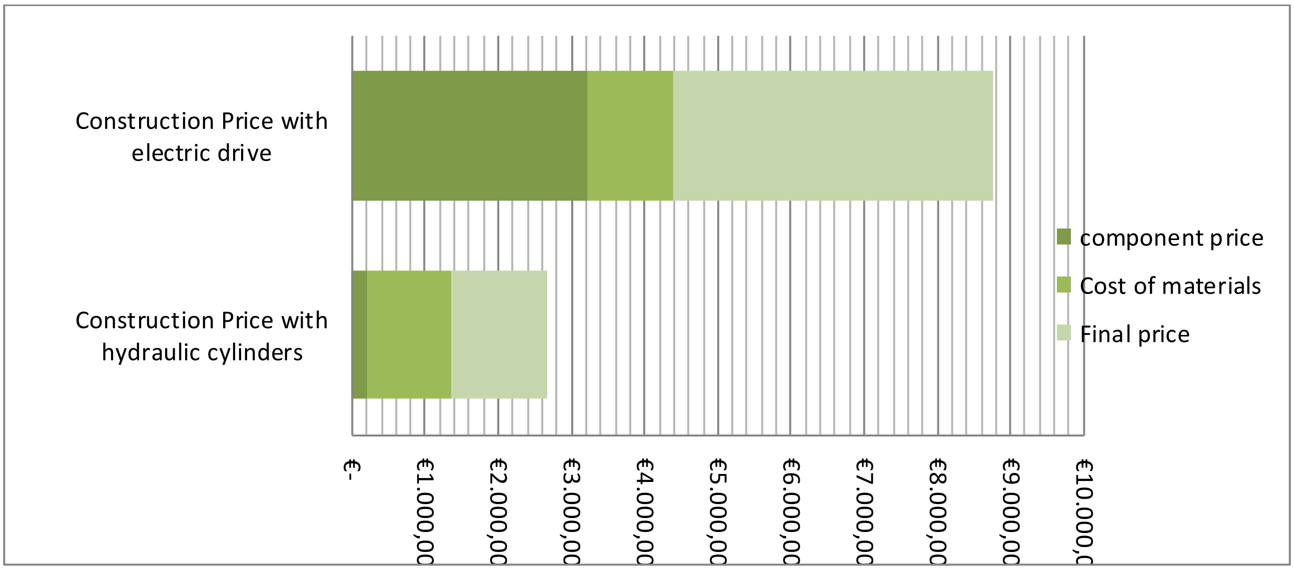
4.2. Table: Cost of materials

ITEM NO.	PART NUMBER	Type	DESCRIPTION	QTY.	Length/thickn., mm	Price per m/per kg, €	Price calculator
1	SWL.01.00.001	Pipe	70x30x2	1	1635	4,1	6,70 €
2	SWL.01.00.002	Plate	100x72	1	40		9,22 €
3	SWL.02.00.001	Pipe	100x60x4	1	2000	7,49	14,98 €
4	SWL.02.00.002	Turned	fi30	1	60	7,24	7,24 €
5	SWL.03.00.001	plate	275x150	2	10		194,42 €
6	SWL.03.00.002	plate	200x70	4	10		131,97 €
7	SWL.04.00.001	plate	420x420	1	8		112,18 €
8	SWL.04.00.002	plate	170x100	3	8		32,43 €
9	SWL.00.00.001	Turned	fi65	1	150		17,56 €
10	SWL.00.00.002	Turned	fi65	1	150		16,66 €
11	SWL.00.00.004	Plate	340x1092	1	5		303,16 €
12	SWL.00.00.005	Plate	90x72	2	40		17,07 €
13	SWL.05.00.001	pipe	50x50x3	1	295	4,99	1,47 €
14	SWL.05.00.002	pipe	50x50x3	1	400	4,99	2,00 €
15	SWL.05.00.003	pipe	50x50x3	2	550	4,99	5,49 €
16	SWL.05.00.004	pipe	50x50x3	2	280	4,99	2,79 €
17	SWL.05.00.006	pipe	30x30x3	2	200	2,71	1,08 €
18	SWL.05.00.005	pipe	300x550	1	3		276,47 €
19	SWL.00.00.006	Turned	fi35	2	90	7,24	9,15 €
20	Lock washer		DIN 6799 - 24	4		0,8 per unit	3,20 €
21	Washer		ISO 8738 - 33	3		2,59	0,08 €
22	Lock washer		DIN 6799 - 15	1		0,8 per unit	0,80 €
23	Lock washer		DIN 6799 - 19	3		0,9 per unit	2,70 €
24			DIN 6921 - M14 x 30 x 30-N	12		2,59	0,31 €
25	Hexagon Flange Nut		DIN 6923 - M14 - N	16		0,02 per unit	0,32 €
26			DIN 6921 - M14 x 70 x 70-C	2		2,59	0,05 €
27			DIN 6921 - M14 x 70 x 70-N	2		2,59	0,05 €
						Sum:	1.169,56 €

[1] Prices are informative, because each company has its own suppliers, their discounts and acquisition preferences

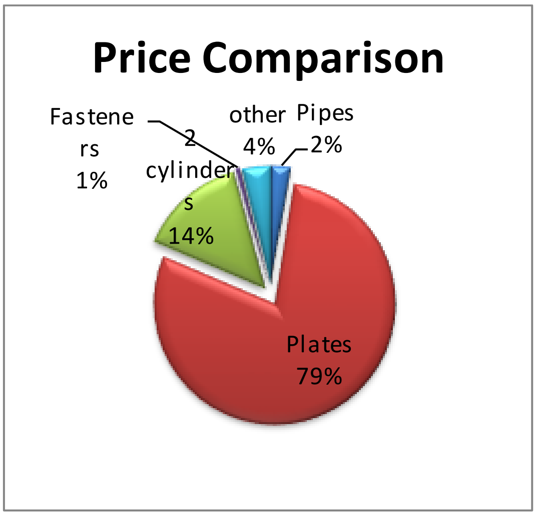
It should be noted that the price is only for materials. Not included labor costs and the cost of buying materials in quantities that are sold on the market. In charts bellow are illustrated the information given in both charts.

Chart 4.1, shows that costruction with electrive drive cost rises more than 4000 €.



4.1. Chart: Comparison of different complete set

Chart 4.2. shows that the biggest price is for plates, almost 80%, so in order to reduce the cost, it is appropriate to start with the cost-cutting of sheets.



4.2. Chart: Comparison of different

The cost of standard components can be estimated from previous company experience or from price quotes from suppliers. The cost of custom-made components is determined by the cost of design, materials, processing and overheads [30].

Conclusions

1. Analyzing types of jacks revealed these following facts: bevel gear offers higher efficiency and greater speed than other mechanical screw jacks; using hydraulic lifts reduces the load lifting and lowering duration; it is more reliable and increases work safety.
2. Although the electric drive requires less additional components, it is many times more expensive than the hydraulic cylinders and the equipment they need. Furthermore, electric cylinders cannot operate in negative temperature which is very common in northern and central Europe. Hydraulic cylinders have no problem operating even at -25^{o}C which is the main reason why the hydraulic system was chosen.
3. Analysis of similar mechanisms disclosed a base hydraulic scheme as well as a kinematic diagram of lifting mechanism. The mechanism is fully automated and there are no easily damageable elements, it is easy to use, compact and safe.
4. Different strokes of cylinders allow changing transmission angles. Changing the length of beam changes mechanism's overall dimensions which means the device can be adjusted for different trucks. Design process revealed that the angle between beams is 60-75 ^{o}.
5. During the design process the first kinematic scheme of the construction was modified owing to some design flaws or new ideas on how to make the device more cost-efficient and simpler. Firstly, movements were transferred to the hydraulic cylinder by discarding the additional tube. Then the assembly was modified by improving the fixing points of the elements in order to resolve structural incompatibilities.
6. A universal spare wheel lift mechanism which is controlled hydraulically has been designed. It is attached on the sub frame by screws and can be easily dismantled into individual elements which mean easy removal and replacement of worn and damaged parts. The mechanism is compact, safe, easy to use and has very few parts that can be damaged.
7. The analysis of the strength of lifting mechanism parts showed that the maximum displacement seeks only 0.3mm. After that some parts were changed and the mechanism became 80 kg lighter. Minimum factor of safety seeks 2.55.
8. The cost of materials and processing includes the price of standard components that are purchased from a supplier, cost of custom made components as well as the cost of assembly and overheads. Given that it is only possible to calculate a theoretical price according to current market prices that are found on the internet which is €1170.

References

1. Viktoras TAMOŠIŪNAS „Šiuolaikinio transporto sistemos problemos'',transporto pasaulis http://www.tp.cargo.lt/content.php?art_id=1652 Last view [2014-10-17];
2. http://ec.europa.eu/eurostat/documents/3217494/5657165/KS-DA-04-001-2-EN.PDF/f83b1414-1f29-4056-ada6-669057c1fd45?version=1.0
3. Liucijus Suslavičius „Superplačios užima rinką (LT)" http://www.liucijus.lt/index.php?option=com_content&view=article&id=707:superplacios-uzima-rinka-lt&catid=30:technika&Itemid=9&lang=ru Last view [2014-11-23];
4. FALKEN „Reading a tire" http://www.falkentyres-uk.com/advice-markings.aspx Last view [2014-11-23];
5. Frequently Asked Questions of CONTINENTAL http://www.conti-online.com/www/transport_uk_en/misc/faq_en.html Last view [2014-12-05];
6. Jovan Vladić* , Petar Malešev , Rastislav Šostakov, Nikola Brkljač, „Dynamic Analysis of the Load Lifting Mechanisms", University of Novi Sad, Faculty of Technical Sciences, Serbia, 07.07.2008 www.dlib.si/stream/URN:NBN:SI:DOC-ZKNLRH3Z/...1dc8.../PDF Last view [2014-12-20];
7. Technikos Enciklopedija, II Tomas /kėlimo ir apžiūros įrenginiai/keltuvas
8. „Methods and structures for monitoring offshore platform supports" inventors: Bernardino Lenders, James Simpson Grant, publication date Dec 25, 2012 http://www.google.com/patents/US8336388 Last view [2014-11-23];
9. „Double-speed hydraulic bottle jack" inventors: Haoying Dai, Jiang Chen, Qiulin Wei, publication date 28 Feb 2008, http://www.google.co.bw/patents/US20080048159 Last view [2014-11-23];
10. ,,Simplified hydraulic circuit for a quick-rise hydraulic lifting jack" inventor Matthew A. Wixey, publication date Jun 24, 2003 http://www.google.com/patents/US6581909 Last view [2014-11-23];
11. „Direct Drive Two-Post Lift Technology Explained" http://www.bendpak.com/car-lifts/two-post-lifts/direct-drive-car-lift/ Last view [2014-10-17];
12. http://www.fabrile.lt/naujienos/elektriniai-cilindrai Last view [2015-05-05];
13. Kariniai „Mercedes-Benz Actros" 2014 http://www.trucker.lt/sunkvezimiai-2/mercedes-benz/kariniai-mercedes-benz-actros/ Last view [2014-12-01];

14. „Innovative Concept the Wheel Deal“ 29 February 2012 http://www.pfes.nt.gov.au/Media-Centre/eDrum/eDrumArchive/2012/Innovative-Concept-the-Wheel-Deal.aspx Last view [2014-10-01];
15. B.Spruogis „Hidraulinės mašinos ir pavaros“,Vilnius MOKSLAS, 1991.
16. Kuang-Hua Chang “Product Design Modeling using CAD/CAE” the CAE Design Series, “Elsevier”,2014
17. B.Spruogis „Hidraulinės mašinos ir pavaros“,Vilnius MOKSLAS, 1991.
18. B.Spruogis „Hidraulinių ir pneumatinių sistemų skaičiavimas ir projektavimas“,Vilnius TECHNIKA, 2008.
19. S.Žiedelis „Hidraulinės ir pneumatinės sistemos“ Kaunas TECHNOLOGIJA, 2009.
20. M.Bogdevičius, O.Prentkovskis „Hidraulinių ir pneumatinių sistemų dinamika“, Vilnius TECHNIKA, 2003.
21. W.L.Cleghorn “Mechanics of Machines” Oxford University Press, New York, 2005
22. Robert L.Norton “Design of Machinery. An Introduction to the Synthesis and Analysis of Mechanisms and Machines” Higher Education, Massachusetts, 2004
23. Angelė Repčienė, Sigita Jarmalavičiūtė „Mechanikos, mechaninių svyravimų ir bangų uždavinių sprendimas“ Mokomoji knyga Kaunas TECHNOLOGIJA 2004
http://www.fizika.ktu.lt/PILNAS.pdf [2015-04-27]
24. James Dredge „Electric Illumination, 1 tomas Cambridge University Press, 2014-12 https://books.google.com.au/books?id=EqeTBQAAQBAJ&dq=electric+cylinders&hl=lt&source=gbs_navlinks_s [2015-04-27]
25. „Engineering Materials and Design“ 29 tomas,
https://books.google.com.au/books?id=_itIAQAAIAAJ&q=electric+cylinders&dq=electric+cylinders&hl=lt&sa=X&ei=fldnVYbdHcGNsgGP0IDACQ&ved=0CHIQ6AEwCQ [201-04-27]
26. Ing.J.Verschoof “Cranes. Design, practice and maintenance” second edition, Professional Engineering Publishing Limited London and Bury St Edmunds, UK, 2002.
file:///C:/Users/Armanda/Downloads/medziagu_atsparumas2.pdf [2015-05-13]
27. Sabaliauskas “Atsparumas”http://techno.su.lt/~sabaliauskas/atsparumas/tempimas.pdf [2015-05-13]
28. UAB LYTAGRA home page http://www.lytagra.lt/ [2015-05-13]
29. Elektroninė prekyba B-A home page http://www.b-a.eu/ [2015-05-13]
30. Mahmoud M. Farag „Materials and Process Selection for Engineering Design, Second Edition“ 2007-12-13,

https://books.google.com.au/books?id=EorLBQAAQBAJ&dq=costs+of+materials&hl=lt&source=gbs_navlinks_s [2015-05-13]

Pictures references

1. Types of vehicles http://www.wsp.wa.gov/traveler/images/cvd/truck_types.jpg Last view [2014-11-10];
2. Tomas Markelevičius „Žiemai pasiruošę kelininkai tą daryti ragina ir vairuotojus" http://www.15min.lt/naujiena/gazas/saugukelyje-lt/ziemai-pasiruose-kelininkai-ta-daryti-ragina-ir-vairuotojus-787-462549 Last view [2014-12-15];
3. FALKEN „Reading a Tire" http://www.falkentyres-uk.com/advice-markings.aspx Last view [2014-11-23];
4. Frequently Asked Questions, *ALCOA WHEELS* http://www.alcoa.com/alcoawheels/asia/en/info_page/faq.asp Last view [2014-12-05];
5. Jovan Vladić* , Petar Malešev , Rastislav Šostakov, Nikola Brkljač, „Dynamic Analysis of the Load Lifting Mechanisms", University of Novi Sad, Faculty of Technical Sciences, Serbia, 07.07.2008 www.dlib.si/stream/URN:NBN:SI:DOC-ZKNLRH3Z/...1dc8.../PDF Last view [2014-12-20];
6. Dviejų kolonų keltuvai http://www.adbaltic.lt/serviso-iranga/keltuvai/dvieju-kolonu-keltuvai/ Last view [2014-11-10];
7. JOYCE „Drawings & Illustrations" http://joycedayton.com/technical-help/drawings-illustrations# Last view [2014-12-20];
8. „Direct Drive Two-Post Lift Technology Explained" http://www.bendpak.com/car-lifts/two-post-lifts/direct-drive-car-lift/ Last view [2014-10-17];
9. FABIRLĖ.Inovatyvios Technologijos http://www.fabrile.lt/naujienos/elektriniai-cilindrai Last view [2015-05-05];
10. Mercedes-Benz Actros MP1 http://www.trucksplanet.com/catalog/model.php?id=888 Last view [2014-12-17];
11. „Daugiafunkcinis sunkvežimis SISU E13TP" http://kariuomene.kam.lt/lt/ginkluote_ir_karine_technika/sausumos_transporto_priemones/daugiafunkcinis_sunkvezimis_sisu_e13tp.html Last view [2014-11-10];
12. „DefExpo India 2014 – Ashok Leyland Super Stallion 10X10 unveiled" http://indianautosblog.com/2014/02/ashok-leyland-super-stallion-10x10-defexpo-india-2014-118328 Last view [2014-11-10];
13. Spare tyre carrier http://www.acsfabrication.com.au/products-page/walkways-truck-plates-chassis/spare-tire-carrier/ [2014-11-10];

14. „Innovative Concept the Wheel Deal“ 29 February 2012 http://www.pfes.nt.gov.au/Media-Centre/eDrum/eDrumArchive/2012/Innovative-Concept-the-Wheel-Deal.aspx Last view [2014-10-01];
15. FESTO https://www.festo.com/cat/lt_lt/products_011101 [2015-05-10]
16. (http://www.dominga.lt/lt/komponentai-pramonei/hidraulika/hidrauliniai-cilindrai-ir-ju-dalys/standartiniai-m250/) [2015-05-02];

ADDITIVES

TABLE 1: Allowable working pressure of hydraulic drive [17]

Force, F,kN		Until 20	20…50	50…100	100..200	200 and more
Allowable working pressure, [p], MPa		6.3	6.3;10	10;16	16;32	32;50
Mechanical efficiency of the hydraulic cylinder η_m	Sealing sleeve seals	0.9	0.92	0.93	0.94	0.95
	Sealing rubber rings	0.955	0.96	0.97	0.975	0,98
$K_d=d_k/d_s$		0.4	0.5	0.5	0.6	0.6

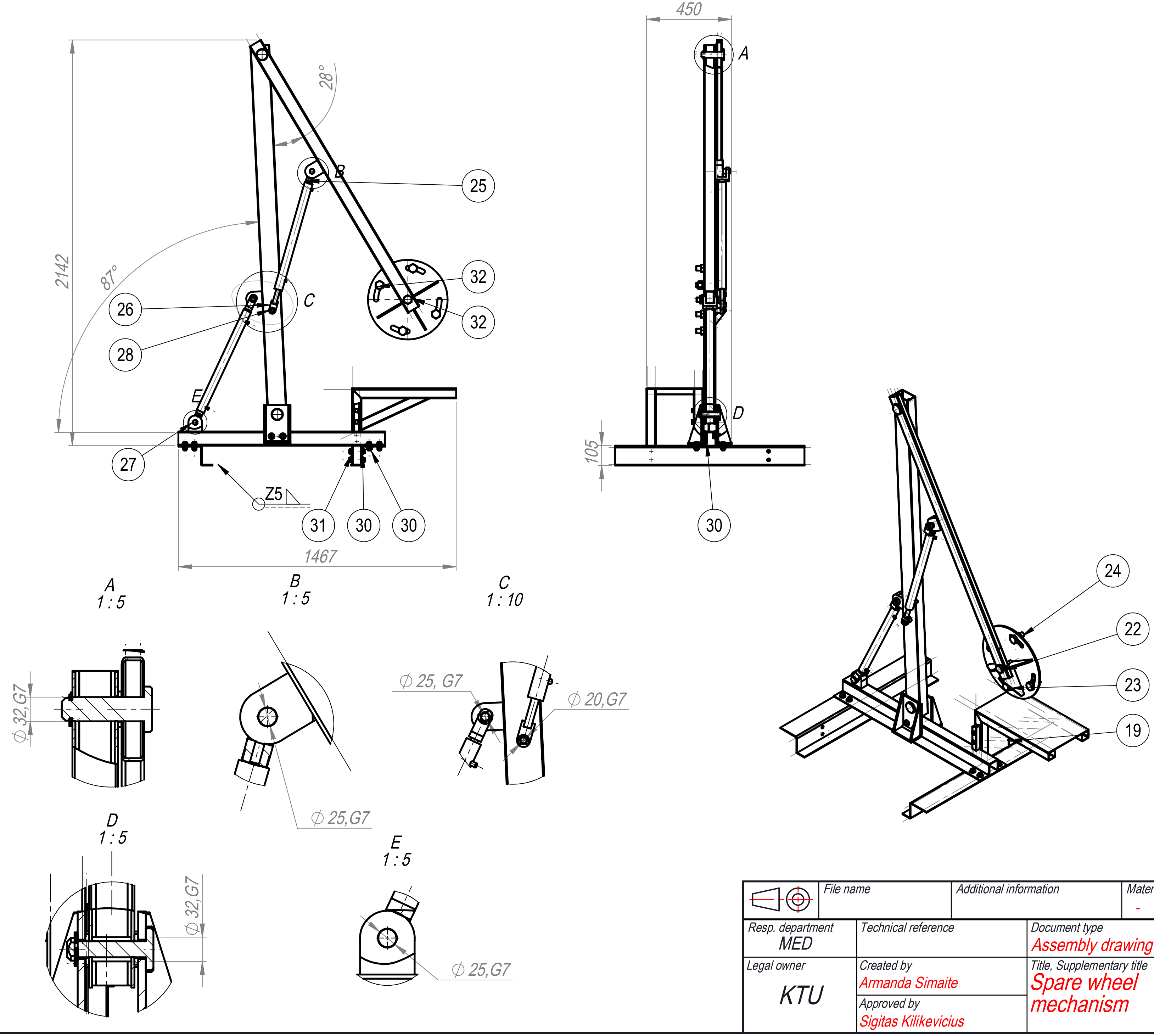
FORMAT	ZONE	NO.	DESIGNATION	NAME	QUANTITY	NOTES
			<u>Documentation</u>			
			Assembly drawing	SWL00.00.000 AD		A3
			<u>Assembly units</u>			
		1	Sub Frame	SUB	1	
		2	Beam 1	SWL.01.00.000AD	1	
		3	Beam 2	SWL.02.00.000AD	1	
		4	Mounting console	SWL.03.00.000AD	2	
		5	Flange	SWL.04.00.000AD	1	
		6	Floor	SWL.05.00.000AD	1	
			<u>Parts</u>			
		7	Pin1	SWL.00.00.001	1	
		8	Pin2	SWL.00.00.002	1	
		9	Base	SWL.00.00.003	1	
		10	Plate	SWL.00.00.004	2	
		11	Pin3	SWL.00.00.005		
		12	Cylinder1	CILIND1	1	
		13	Cylinder2	CILIND2	1	
		14	Wheel	Ratas R22.5 su padanga 315_60_R22.5	1	

Resp. department	Technical reference	Document type	Document status
MED		Parts list	Training

Legal owner	Created by	Title, Supplementary title	SWL-00.00.000			
KTU	Armanda Simaite	Spare wheel lifting mechanism				
	Approved by		Rev.	Date	Lang.	Sheet
	Sigitas Kilikevicius		A	2015-05-27	En	1/2

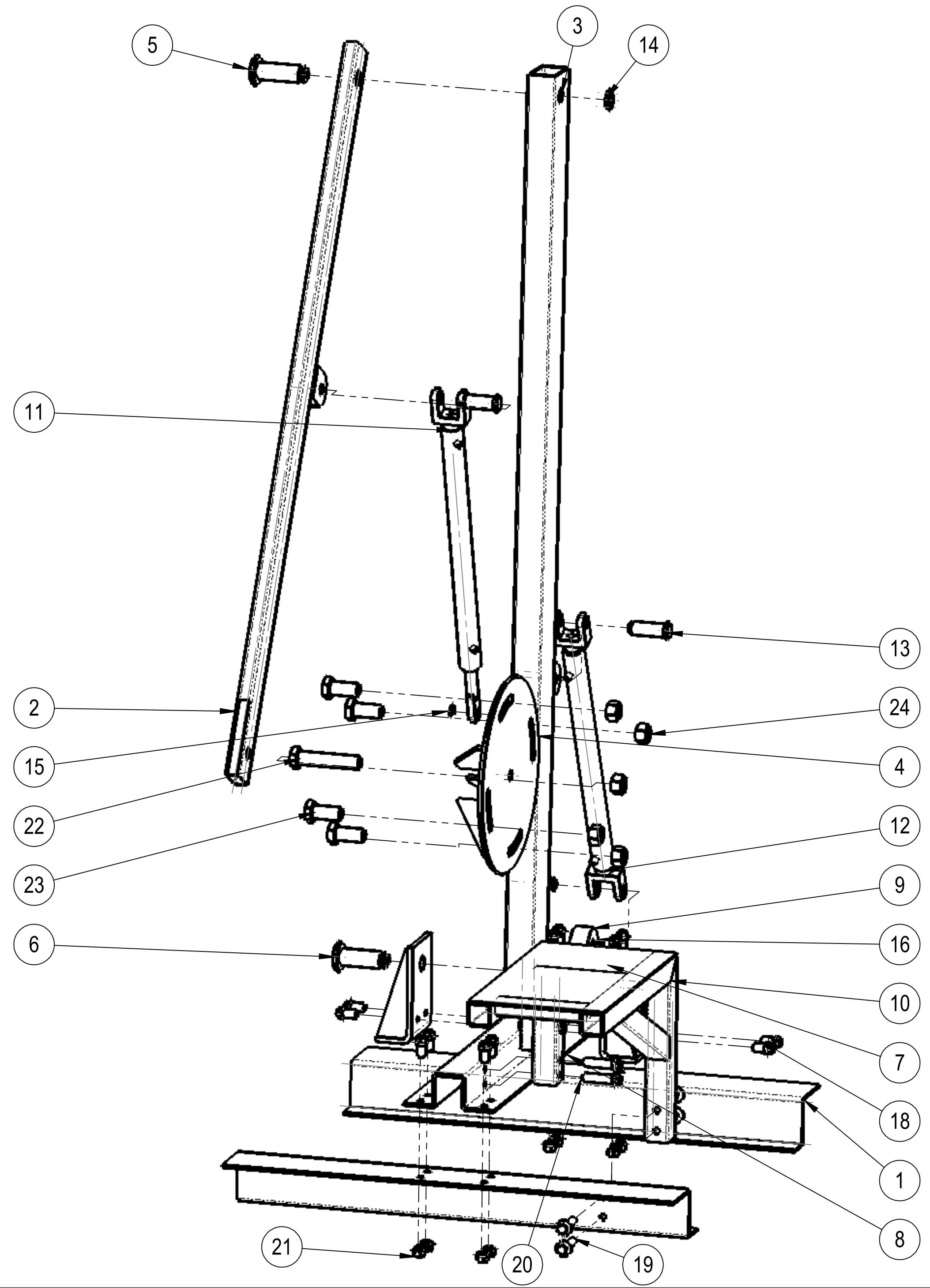
FORMAT	ZONE	NO.	DESIGNATION	NAME	QUANTITY	NOTES
			Conventional parts			
		15	Lock washer DIN 6799 - 24		4	Wurth
		16	Lock washer DIN 6799 - 15		1	
		17	Lock washer DIN 6799 - 19		3	
		18	Washer ISO 8738 - 33		3	
		19	DIN 6921 - M14 x 30 x 30-N		12	
		20	DIN 6921 - M14 x 70 x 70-C		2	
		21	DIN 6921 - M14 x 70 x 70-N		2	
		22	Hexagon Flange Nut DIN 6923 - M14 - N		16	
		23	DIN 6914 - M24 x 135 x 37-N		1	
		24	DIN 6914 - M24 x 60 x 34-N		4	
		25	Hexagon Nut ISO 4034 - M24 - N		5	

Resp. department	Technical reference	Document type			Document status	
MED		Parts list			Training	
Legal owner	Created by	Title, Supplementary title	SWL00.00.000			
KTU	Armanda Simaite	Spare wheel lifting mechanism	Rev.	Date	Lang.	Sheet
	Approved by: Sigitas Kilikevicius		A	2015-05-27	En	2/2



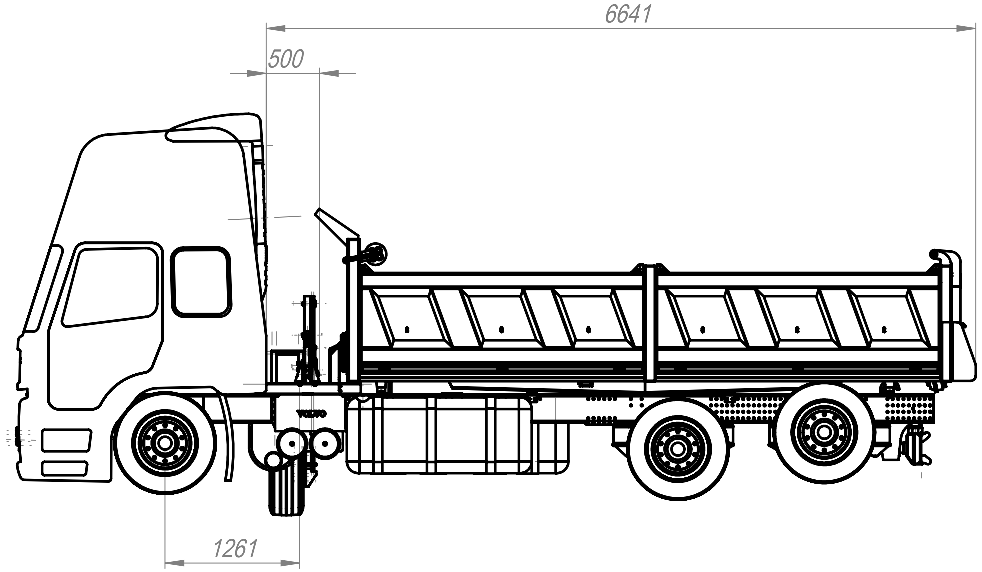
ITEM NO.	PART NUMBER	QTY.
1	SWL.04.00.000AD	1
2	SWL.00.00.001	1
3	SWL.02.00.000AD	1
4	CILIND1	1
5	SWL.00.00.006	3
6	CILIND3	1
7	SWL.00.00.005	2
8	SUB	1
9	SWL.03.00.000AD	2
10	SWL.00.00.002	1
11	SWL.05.00.000AD	1
12	SWL.01.00.000AD	1
13	SWL.00.00.004	1
14	Lock washer DIN 6799 - 24	4
15	Washer ISO 8738 - 33	3
16	Lock washer DIN 6799 - 15	1
17	Lock washer DIN 6799 - 19	3
18	DIN 6921 - M14 x 30 x 30-N	12
19	Hexagon Flange Nut DIN 6923 - M14 - N	16
20	DIN 6921 - M14 x 70 x 70-C	2
21	DIN 6921 - M14 x 70 x 70-N	2
22	DIN 6914 - M24 x 135 x 37-N	1
23	DIN 6914 - M24 x 60 x 34-N	4
24	Hexagon Nut ISO 4034 - M24 - N	5

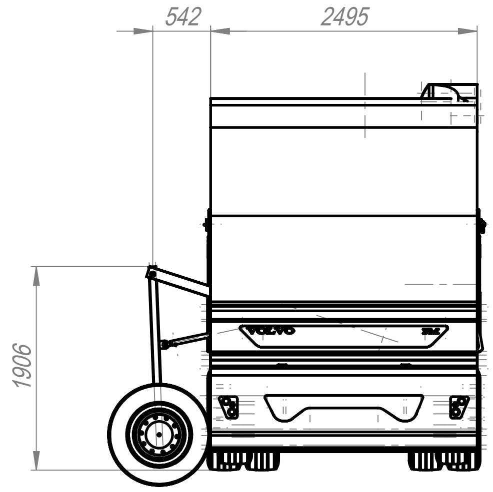
File name	Additional information	Material: -		Scale: 1:20
Resp. department: MED	Technical reference	Document type: Assembly drawing		Document status: Training
Legal owner: KTU	Created by: Armanda Simaite	Title, Supplementary title: Spare wheel mechanism	SWL.00.00.000 AD	
	Approved by: Sigitas Kilikevicius		Rev.: A; Date: 2015.05.21	Lang.: En; Sheet: 1/2

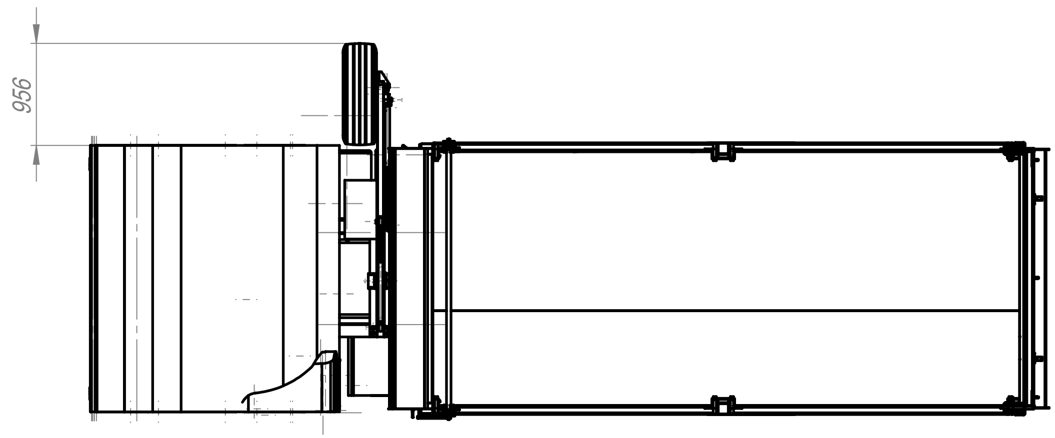


ITEM NO.	PART NUMBER	QTY.
1	SUB	1
2	SWL.01.00.000AD	1
3	SWL.02.00.000AD	1
4	SWL.04.00.000AD	1
5	SWL.00.00.001	1
6	SWL.00.00.002	1
7	SWL.03.00.000AD	2
8	SWL.00.00.004	1
9	SWL.00.00.005	2
10	SWL.05.00.000AD	1
11	CILIND1	1
12	CILIND3	1
13	SWL.00.00.006	3
14	Lock washer DIN 6799 - 24	4
15	Lock washer DIN 6799 - 15	1
16	Lock washer DIN 6799 - 19	3
17	Washer ISO 8738 - 33	3
18	DIN 6921 - M14 x 30 x 30-N	12
19	DIN 6921 - M14 x 70 x 70-C	2
20	DIN 6921 - M14 x 70 x 70-N	2
21	Hexagon Flange Nut DIN 6923 - M14 - N	16
22	DIN 6914 - M24 x 135 x 37-N	1
23	DIN 6914 - M24 x 60 x 34-N	4
24	Hexagon Nut ISO 4034 - M24 - N	5

File name		Additional information	Material		Scale 1:10
Resp. department MED	Technical reference	Document type Assembly drawing		Document status Training	
Legal owner KTU	Created by Armanda Simaite	Title, Supplementary title Spare wheel mechanism		SWL.00.00.000AD	
	Approved by Sigitas Kilikevicius		Rev. A	Date 2015.05.21	Lang. En / Sheet 2/2







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Resp. department MED	Technical reference	Document type Assembly drawing	Document status Training	
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	Approved by Sigitas Kilikevicius		Rev. A / Date 2015.06.04	Lang. En / Sheet 1/1