KAUNAS UNIVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING AND DESIGN

Marija Mačiulytė

MODERNIZATION OF GLUE WIPERS IN CARDBOARD TUBES MACHINE

Final project for Bachelor degree

Supervisor
Assoc. Prof. Dr. Inga Skiedraitė

Supervisor *(minor studies)*
Assoc. Lect. Dr. Gitana Valodkienė

KAUNAS, 2015

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Export Engineering (code 612H77003)

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KAUNO TECHNOLOGIJOS UNIVERSITETAS
MECHANIKOS INŽINERIJOS IR DIZAINO FAKULTETAS

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PAGRINDINIŲ UNIVERSITETINIŲ STUDIJŲ BAIGIAMOJO DARBO UŽDUOTIS

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Universitetinių pagrindinių studijų, kurias baigus įgyjamas bakalauro kvalifikacinis laipsnis, baigiamasis darbas yra taikomojo ar tiriamojo pobūdžio projektas, kuriam atlikti ir apginti skiriama 12 kreditai. Šiuo projektu studentas turi parodyti, kad yra sukaupęs pakankamai žinių, yra įgijęs pakankamai gebėjimų ir turi pakankamą pasirinktos studijų krypties analitinio ar projektavimo darbo patirtį. Baigiamuoju projektu bei jo gynimu studentas turi parodyti savo kūrybingumą, socialinės bei komercinės aplinkos, teisės aktų ir finansinių galimybių išmanymą, informacijos šaltinių paieškos ir jų analizės įgūdžius, gilų nagrinėjamos temos supratimą, projektavimo ir inžinerinės analizės įgūdžius, informacinių technologijų naudojimo ir rašytinio bendravimo, taisyklingos kalbos vartosenos įgūdžius, gebėjimą tinkamai formuluoti išvadas.

1. Darbo tema: *Klijų valytuvo modernizavimas kartoninių tūtų įrenginyje*
Modernization of glue wipers in cardboard tubes machine

Patvirtinta 2015 m. gegužės mėn. 11 d. dekano įsakymu ST17-F-11-1

2. Darbo tikslas: *Supaprastinti klijų valytuvų formą išlaikant jiems keliamus reikalavimus, palengvinti jų apdirbimą ir pagalandimą, bei pritaikyti juos kartoninių tūtų įrenginiui, naudojamam UAB „Baltijos Brasta“, kad įmonė patirtų kuo mažesnius nuostolius keičiant senuosius valytuvus naujais.*

3. Darbo struktūra: ***Analizės skyrius:*** *Apžvelgti ir išanalizuoti kartoninių tūtų gaminimo įrenginius.*
Projektinis skyrius: *Modernizuoti klijų valytuvus, parenkant jiems medžiagą, suprojektuojant naują formą bei supaprastinant jų keitimo procesą.*
Ekonominis skyrius: *Apžvelgti UAB „Baltijos Brasta“ įmonę, apskaičiuoti modernizuoto klijų valytuvo gamybos kaštus, palyginti senojo ir modernizuoto klijų valytuvų kainas.*
Grafinė dalis: *Valytuvų brėžiniai.*

4. Reikalavimai ir sąlygos: *Modernizuotų valytuvų dydis: 260 X 30 X 1,20 mm, parinkta medžiaga turi būti atspari korozijai. Supaprastinta klijų valytuvų laikiklio konstrukcija turi palengvinti prietaiso eksploatavimo sąlygas, o kartono valymo procesas atliekamas greitai, tiksliai ir kokybiškai.*

5. Darbo pateikimo terminas 2015m. gegužės mėn. 27 d.

6. Ši užduotis yra neatskiriama baigiamojo darbo dalis

Išduota studentui Marijai Mačiulytei

Užduotį gavau Marija Mačiulytė _____
(studento vardas, pavardė) (parašas, data)

Vadovas Prof. Dr. Inga Skiedraitė _____
(pareigos, vardas, pavardė) (parašas, data)

KAUNAS UNIVERSITY OF TECHNOLOGY

Faculty of Mechanical Engineering and Design
(Faculty)

Marija Mačiulytė
(Student's name, surname)

Export Engineering, 612H77003
(Title and code of study programme)

"Modernization of glue wipers in cardboard tube machine"

DECLARATION OF ACADEMIC HONESTY

19 May 2015
Kaunas

I confirm that a final project by me, **Marija Mačiulytė**, on the subject *"Modernization of glue wipers in cardboard tube machine"* 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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Mačiulytė, M. Modernization of glue wipers in cardboard tube machine. *Bachelor of Industrial Engineering* final project / supervisor Assoc. Prof. Dr. Inga Skiedraitė; Kaunas University of Technology, Faculty of Mechanical Engineering and Design, Production Engineering department.

Kaunas, 2015. 60 p.

SUMMARY

The final Bachelor‘s project examines the existing options of gluing systems in cardboard tubes machines and introduces a special device – the glue wiper that is used that in “Baltijos Brasta” for producing cardboard tubes. In covering paper with glue, the glue wipers are used in order to remove the excess glue from the paper. It is very important to remove properly the excess of glue without damaging the paper for receiving high-quality final product. The analysis of the original glue wiper is conducted in this project, new material for modernized glue wiper is chosen and the shape of it is designed to the existing cardboard manufacturing machines in "Baltijos Brasta", to change heavy and inconvenient for replacement or renewal glue wipers and maintain their necessary properties. In the economic part of this project the private company “Baltijos Brasta” is analyzed, costs for producing modernized glue wipers are calculated and the comparison of original glue wiper and the modernized one prices is performed.

Mačiulytė, M. Klijų valytuvų modernizavimas kartoninių tūtų įrenginyje. *Pramonės inžinerijos bakalauro baigiamasis projektas* / vadovas Doc. Dr. Inga Skiedraitė; Kauno Technologijos Universitetas, Mechanikos inžinerijos ir dizaino fakultetas, Gamybos inžinerijos katedra.

Kaunas, 2015. 60 p.

SANTRAUKA

Baigiamajame bakalauro darbe nagrinėjamos esamos klijų sitemos, naudojamos kartoninių tūtų įrenginiuose ir pristatomas specialus prietaisas - klijų valytuvas, naudojamas gaminant kartonines tūtas UAB "Baltijos Brasta". Klijų valytuvas yra skirtas nuvalyti klijų perteklių nuo popieriaus, todėl norint gauti aukštos kokybės produktą, klijus nuo popieriaus reikia nuvalyti tiksliai, greitai ir kokybiškai. Šiame projekte yra atlikta klijų valytuvo analizė, pasirinkta nauja medžiaga modernizuotam klijų valytuvui, suprojektuota jo forma yra pritaikyta kartoninių tūtų įrenginiui, naudojamam "Baltijos Brasta" įmonėje. Ekonominėje šio projekto dalyje yra išanalizuota UAB "Baltijos Brasta", apskaičiuoti modernizuotų klijų valytuvų gamybos kaštai bei palygintos abiejų valytuvų kainos.

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INTRODUCTION

Packaging process is very important in preparing goods for transport, warehousing, logistics, sale, and end use in these. Packaging is the technology of enclosing or protecting products for distribution, storage, sale, and use [1]. It helps to contain, protect, preserve, transport, inform and sell the product. It is therefore important to manufacture high-quality packaging products, which correspond to all the requirements of the customers.

"BaltijosBrasta" company is established in Lithuania and specializes in making the products used for packages: the carton tubes meant for the industry of paper, films, labels, textile and threads, wrapping of various products and shipping of small parcels by mail; and protective carton edge board, which are used to reinforce and protect the product packages. "BaltijosBrasta" has accumulated big experience and cooperates with the Scandinavian partners. The company is able to implement all the requests of the customers using the raw materials of high quality and modern technologies [2].

This work takes interest in special device – the glue wiper that is used in "BaltijosBrasta" in producing cardboard tubes. For making these packing materials, special paper manufacturing machines are used. To make the cardboard tubes from paper rolls is a long process, where cardboard tube machine is used. Paper is cut, rolled, covered with glue, heated and modeled in order to get cardboard tubes. In covering paper with glue, the glue wipers are used in order to remove the excess glue from the paper. It is very important to remove properly the excess glue without damaging the paper to get high-quality final product. The glue wipers which are being used at "BaltijosBrasta" are heavy and inconvenient for replacement or renewal and clumsy in shape. That is the main reason to look for a new solution in modernizing glue wipers.

The aim of this work is to modify and simplify glue wipers by maintaining their necessary properties, shortening their manufacturing time and adapting their shape and size to existing paper manufacturing machines, so that the company would have the lowest possible cost for replacing the old ones.

The modernizing of glue wipers has several objectives:

1. Design the appropriate shape and size of glue wiper ;
2. Choose the proper material to reduce weight and maintain necessary properties of glue wiper;
3. Simplify manufacturing process of glue wiper;
4. Facilitate sharpening processes of glue wiper.

The objectives of economic part of this work were:

1. Analyze the company “Baltijos Brasta”;
2. Calculate the costs for producing modernized glue wipers;
3. Comparing the prices of original glue wiper with the modernized one.

The modernization and development of machine parts is very important as it may improve the engineering sector in Lithuania to answer the standards of European Union. This work was performed with the purpose to modernize the glue wipers in order to maximize the labor productivity and eliminate deficiency at the company. That is why this work is relevant for the factory manufacturing process. It will bring modernization into the company and facilitate the working process for producing cardboard tubes from paper rolls.

1. CARDBOARD TUBE MACHINE ANALYSIS

1.1.Cardboard tubes production line

Modern industry is full of different cardboard manufacturing machines and replete withvarious manufacturing methods. In order to accelerate cardboard tubes production, the different production lines can be applied: lines to produce standard paper tubes, lines to produce paper tubes with multi-knife cutting assemblies, lines to produce very thin and small diameter tubes, lines to produce construction tubes, lines to produce smooth tubes,lines to produce tape cores, lines to produce textile tubes and lines to produce flat tubes [3].

The standard cardboard tubes production line consists of 5 main parts:

1. Revolver winder which continuously supplies the needed amount of paper. The example of revolver winders is shown in Fig.1.1.

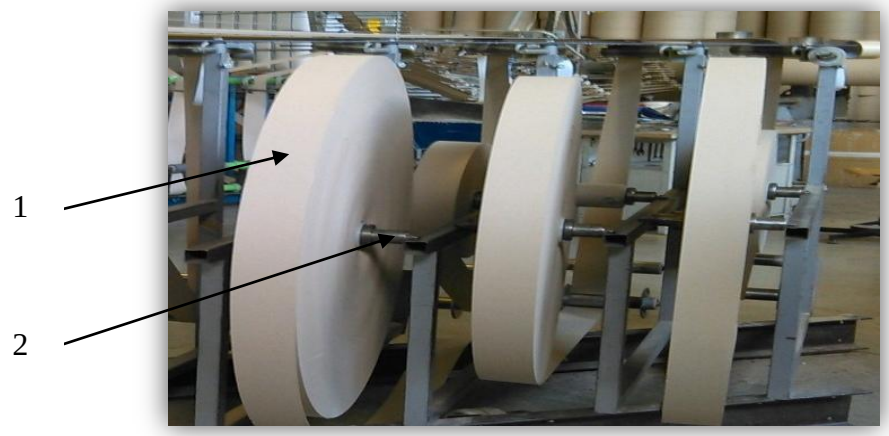


Fig.1.1. Revolver winders in the standard cardboard tubes production line with paper rolls*1* and revolver winder*2*

2. Stretching and retaining system which secures straightens and supports the paper. The example of stretching and retaining system is shown in Fig.1.2.

Fig.1.2. Stretching and retaining system in the standard cardboard tubes production linewith paper stretchers*1*, paper plies*2* and paper retainers*3*

3. Gluing system which lubricates paper with glue and removes the excess glue from paper. The example of one-side spraying glue system for12 paper plies is shown in Fig.1.3.

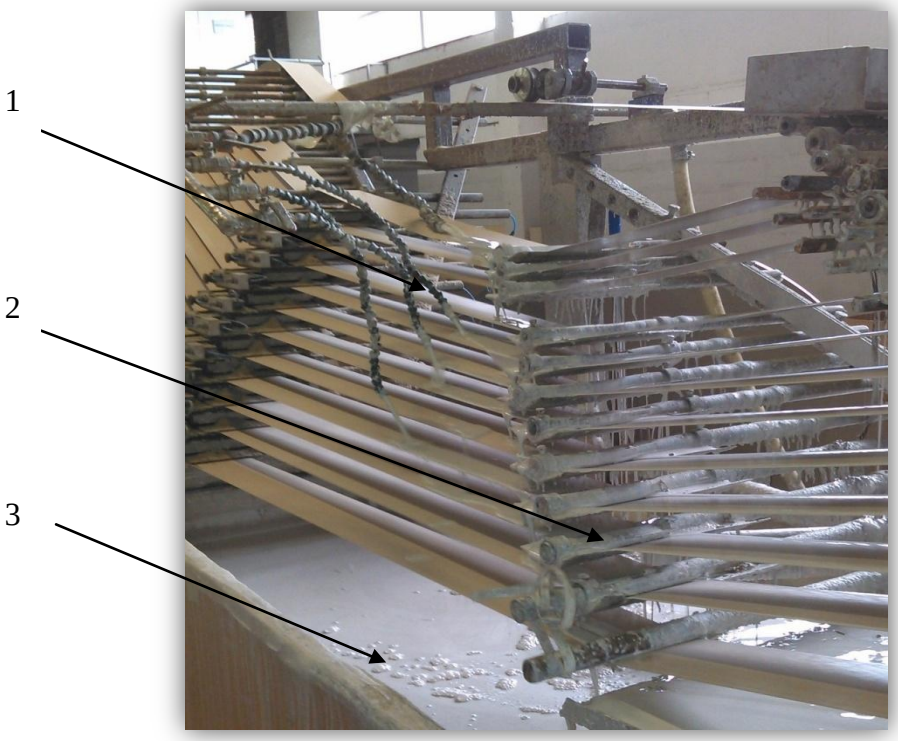


Fig.1.3. One-side spraying glue system with glue sprayers*1*, glue wipers *2*and glue tank*3*

The working principle of such a gluing system is quite simple - glue sprayers cover one side of paper with glue, the excess of adhesives is removed into the glue tank by using glue wipers. From the glue tank the adhesive material travels to glue sprayers and the process is repeated again and continuously.

4. Winding mechanism which winds the needed amount of paper stripes in order to get a paper tube. The example of such winding system is shown in the picture below in Fig.1.4.

Fig.1.4. Winding mechanism in the standard cardboard tubes production line

Such a winding mechanism consists of 3 main parts: belt*1*,two rotating spindles *2*and paper plies*3*. The working principle of such a winding mechanism is as follows. The belt is mounted onto two big spindles which rotate with assistance of the motor. The rotating belt gives the rotation motion to paper plies, so they are rolled and adhered into the shape of a tube.

5. A knife cutter cuts the cardboard tubes into the parts of needed length. Knife cutters for cutting cardboard tubes can be automated or manual. At the picture below an automatic knife cutter is shown when the cutting unit is controlled by infrared sensor (Fig.1.5.).

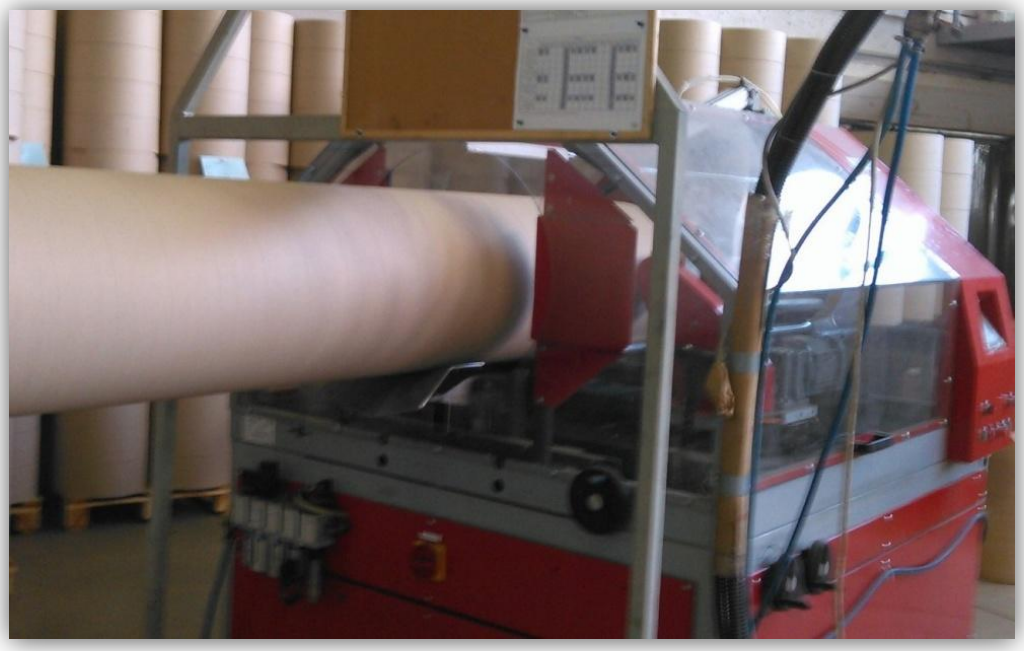


Fig.1.5. Automatic knife cutter

Such a production line can be supplemented by labeling, marking, finishing, decoratingor glue drying mechanisms which give additional features to the manufacturing of cardboard tubes.

1.2.Gluing systems and glue wipers

Different manufacturers of cardboard tube machines use different gluing systems for gluing the paper. The “Pakea” company proposes universal gluing system with glue sprayers [4];the “ATCINT” company offers one-side spraying glue system with a glue tank [5]. “Sunlight Machinery” proposesa few different types of gluing systems. One of them is a glue spraying system for gluing both sides of paper and removing the excess of glue with an independent glue box and a polyurethane scraping blade [6]. Another one is an immersion glue loading machine which immerses the paper into glue and wipes the excess of glue [7].

All different manufacturers’ offers are shown in Fig.1.6. - Fig.1.8.

Fig.1.6. The Pakea company MTU universal gluer [4]

Fig.1.7. The ATCINT company one-side spraying glue system with a glue tank[5]

a) b)

Fig.1.8. Sunlight Machinery different gluing systems: Glue spraying system*a*, Immersion glue loading machine*b*[6,7]

The cardboard tube machine,whose glue wipers will be modernized, has one-side spraying glue system supplemented with a glue tank. It is important, that glue wipers have to remove the exact excess of glue in order to get high-quality cardboard tube. Therefore an optimal amount of glue is essential in manufacturing paper tubes. Because, on the one hand,the final product may be too wet oruneven in shape by the excess of adhesive onto the paper. Or, on the other hand, if there is lack of glue onto the paper, the final product would not stick together. The shape and material of glue wipers are also very important in order to not damage or not to rip the paper. If the paper is damaged or ripped off, the final product will be of poor-quality. The waster, which is made with a worn-out glue wiper, is shown in Fig.1.9. The marked area in the picture shows that a glue wiper is deficient, because it does not remove the exact excess of glue from the paper.

Fig.1.9. Waster of worn-out glue wiper

According to the data of the company, it was determined that 21km of paper was used during 8 working hours to manufacture cardboard products. It was also found out that glue wipers wears-out in about 2 weeks by working in 3 shifts per day (24hours per day) [8]. That is why the more durable glue wipers are needed.Due to a complex shape of the glue wipers, it takes many complicated manufacturing operations to sharpen them. As a result, the sharpening of glue wipers takes a lot of time andthe costs are high. Also the fixing of glue wiper in and out of the machine is messy and time-wasting.

Because of many disadvantages, it is needed to look for a new solution of modernizing glue wipers. In modernizing glue wipers several objectiveswill be solved:

- Choosing proper material for glue wiper;
- Designing appropriate shape and size of glue wiper;

- Reducing weight of glue wiper and maintaining itsnecessary properties at the same time;
- Facilitating manufacturing and sharpening processes of glue wiper.

The primary objectives of this projectare modifying and simplifyingof glue wipers by maintaining their necessary properties, shortening their manufacturing time and adapting their shape and size to existing paper manufacturing machines, so that the company would have the lowest possible cost for replacing the old ones.

2. MODERNIZING OF GLUE WIPERS AND DESIGNING OF THEIR PRODUCTION PROCESS

2.1. Requirements for glue wipers

A key requirement for glue wipers is to remove the exact excess of glue without damaging the paper. However, there are many other requirements that good glue wipers must satisfy in order to get high-quality final product.

It is very important that the material of a glue wiper would be sufficiently hard and durable to hold out high mechanical loads and wearing out as less as possible. Also the material of a glue wiper must not cause chemical reaction in contact with glue, so that a soiled glue wiper would be easily cleaned and the adhesive material would not change its' features and the quality of removing the glue.

Another relevant requirement for a glue wiper is an appropriate shape, which influences not only the quality of cleaning but also the wear rate and suitability for being sharpened. The glue wiper of non-durable shape will wear out quickly and the sharpening of broken-down glue wiper will be long-lasting and complex.

The sharpness is also very important for such a device. A glue wiper has to be sharp enough to remove the excess of glue from paper without rapid wear-out, but not to sharp, so that the paper would not be damaged.

Furthermore a convenient and quick device fixation is significant for producing cardboard tubes. The soiled or worn-out glue wiper must be quickly replaced by a new in order to avoid the retardation at work.

The expenses for sharpening a glue wiper or producing a new one are also relevant in cardboard tubes production, because the more manufacturing operations have to be done to get a glue wiper or sharpening it, the more expenses this device causes. Also the manufacturing time is directly dependent on the manufacturing operations and their complexity, so the more time is needed for manufacturing a glue wiper; the longer the company must wait to get an ordered device.

These requirements are significant to know in order to analyze the former glue wiper and modernize it to a better one.

2.2.Analysis of shape and size of original glue wiper

In order to modernize a glue wiper, the analysis of already existing one must be done. The 3D model of glue wiper, which is used in “BaltijosBrasta”, is shown in Fig. 2.1.

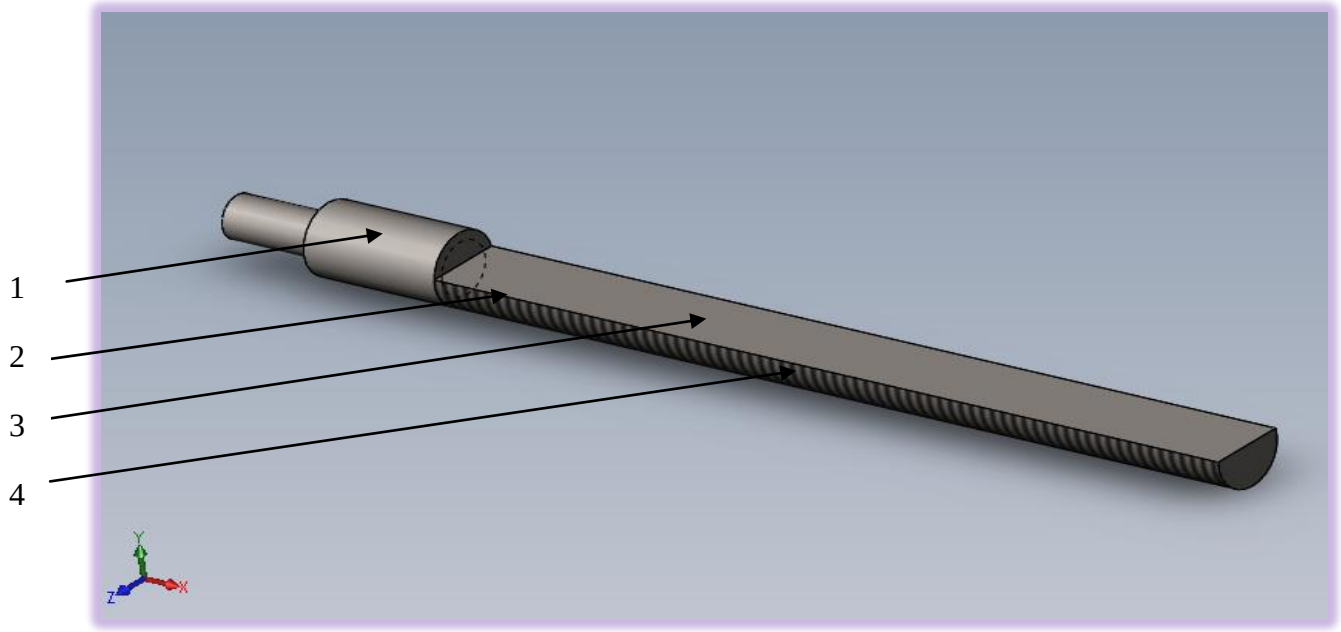


Fig.2.1.3D model of glue wiper

Such a glue wiper has four main parts:

Holder*1*, which is locked in the glue wiper retainer;

Purifying edge*2* that performs glue cleaning process;

Purifying surface*3* that also performs glue cleaning process;

Threaded surface*4* that helps to adjust the removed amount of glue.

A glue wiper holder*1* is quite simple, but not so convenient, because this part of wiping device is smeared and adhered to the glue wiper retainer in glue-cleaning process, so the removing or replacing of the glue wiper with a new one takes some time,patience and strength.

A purifying edge*2* of a glue wiper performs all cleaning process together with purifying surface *3* and threaded surface*4*. A purifying edge is sharp enough to remove the excess of glue from the paper. When it is needed that less of glue material would be left onto the paper, the purifying edge is turned into the position, when it touches the paper and all the excess of glue is cleaned from the paper. When more glue is needed onto the paper, the threaded surface is turned into a position that it would contact with glued paper and more glue would fall through the threaded gaps.

The glue wipers with their retainers are shown Fig.2.2.after one week of work in order to show how soiled they become and that the removing process of glue wipers requires time and expertise.

Fig.2.2. Soiled glue wipers after one week of glue cleaning

The dimensions of a glue cleaning device can vary when glue wiper is sharpened again, but the length of purifying edge should not be smaller than 20mm, in order to clean the paper of different widths (the width of paper does not exceed 18 mm). The diameter of such a device holder is ø12, and the diameter of wiper body is not smaller than 20mm. The drawing of this glue wiper is shown at the Appendix -1.

2.3.Manufacturing operations in brief for producing an original glue wiper and sharpening it

For producing an original glue wiper the needed manufacturing operations are listed below and described briefly:

1. Turning of a glue wiper holding part;
2. Threading of a bottom surface of a glue wiper;
3. Milling of a cleaning surface of a glue wiper;
4. Grinding of a cleaning surface of a glue wiper;
5. Heattreatment of a glue wiper.

2.3.1. Turning of a glue wiper holding part

Turning is a engineering machining process in which a cutting tool, a non-rotary tool bit, describes a helical toolpath by moving more or less linearly while the workpiece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear (in the nonmathematical sense). Usually the term "turning" is reserved for the generation of external surfaces by this cutting action. Turning can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using an automated lathe which does not [9].

By turning of a glue wiper holding part manual engine lathe 16K20 is used.The engine lathe 16K20 and main its‘ parts are shown in Fig. 2.3.:spindle with a three-jaw *1*, centre needle *2*, large slide*3*, tailstock *4*, bed*5*, turret tool post*6*and turning tool*7*.

Fig.2.3. Engine lathe 16K20 and main its‘ parts

2.3.2. Threading of a bottom surface of a glue wiper

In the Fig. 2.1. 3D model of a glue wiper was shown. It is clear that only the one side of a glue wiping device is needed to be threaded. In order to thread deeper the surface besides the purifying edge, non-alignment of a glue wiper is needed to be done first. It is done by inserting a plate into three- jaw chuck. The threading surface besides the purifying edge will be threaded deeper than the threading surface that is further from purifying edge, so the threading surface will be of different depth.

For threading operation the same engine lathe 16K20 will be used (Fig.2.7.).A thread is a uniform helical groove cut on the outside of a workpiece. Cutting threads by using the lathe requires a thorough knowledge of the different principles of threads and procedures of cutting.

Hand coordination, lathe mechanisms, and cutting tool angles are all interrelated during the thread cutting process. Before attempting to cut threads on the lathe a machine operator must have a thorough knowledge of the principles, terminology and uses of threads [10].

2.3.3. Milling of a cleaning surface of a glue wiper

Milling is the machining process of using rotary cutters to remove material from a workpiece advancing (or feeding) in a direction at an angle with the axis of the tool.[11] The milling cutter is a rotary cutting tool with multiple cutting points. As opposed to drilling, where the tool is advanced along its rotation axis, the cutter in milling is usually moved perpendicular to its axis so that cutting occurs on the circumference of the cutter. As the milling cutter enters the workpiece, the cutting edges (flutes or teeth) of the tool repeatedly cut into and exit from the material, shaving off chips (swarf) from the workpiece with each pass. The cutting action is shear deformation; material is pushed off the workpiece in tiny clumps that hang together to a greater or lesser extent (depending on the material) to form chips. This makes metal cutting somewhat different (in its mechanics) from slicing softer materials with a blade [12].

After threading of bottom side of the workpiece, the upper side is milled by using vertical milling machine "Žalgiris" in order to get a smooth cleaning surface. Such a milling machine and its' parts are shown in Fig. 2.4.

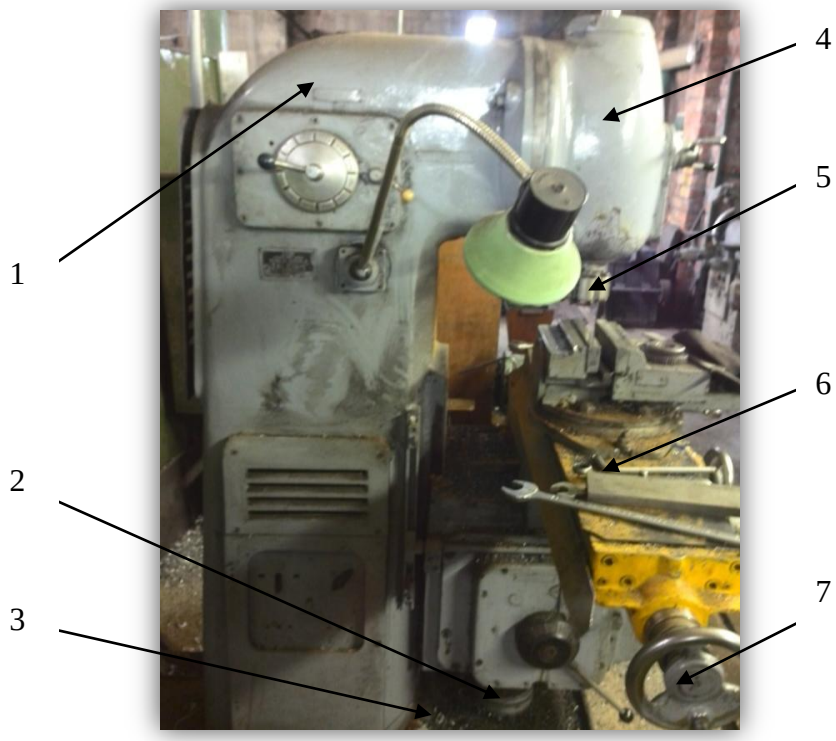


Fig. 2.4. Vertical milling machine "Žalgiris" and main its' parts: ram *1*; vertical positioning screw *2*; knee *3*; vertical head *4*; quill *5*; table *6* and table handwheel*7*.

As material passes through the cutting area of a milling machine, the blades of the cutter take swarfs of material at regular intervals. Surfaces cut by the side of the cutter (as in peripheral milling) therefore always contain regular ridges. The distance between ridges and the height of the ridges depend on the feed rate, number of cutting surfaces, the cutter diameter. With a narrow cutter and rapid feed rate, these revolution ridges can be significant variations in the surface height [13]. InFig.2.5. the regular ridges of a milled surface of a workpiece cleaning surface are shown.

Fig. 2.5. Regular ridges of a milled cleaning surface of a glue wiper

2.3.4. Grinding of a cleaning surface of a glue wiper

Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool. Surface grinding is used to produce a smooth finish on flat surfaces. It is a widely used abrasive machining process in which a spinning wheel covered in rough particles (grinding wheel) cuts chips of metallic or nonmetallic substance from a workpiece, making a face of it flat and smooth.Surface grinding operation will be used as a finishing operation for cleaning surface of a workpiece[14].

For this operation the planar grinding machine 3G71 will be used. This machine is forming flat surfaces of the parts. Grinding is made by central surface of the disk. The detail is fixed on the electromagnetic plate, which is more convenient than fixing on the table by bolts and other devices. The machine can polish planes of details with high accuracy. This device is generally used at single-piece and batch production.

In Fig. 2.6.the planar grinding machine 3G71 and main its' parts are shown.This machine consists of:grinding head*1*, grinding wheel*2*, electromagnetic plate*3*, table*4* and stand*5*. Table surface is 380 X 120 mm. Obtained surface tolerances are not more than 0.004 mm. The roughness of machined surface is not more than R_a=0.16 μm. Dimensions of Grinding disc – 250 X 25 X 75 mm [15].

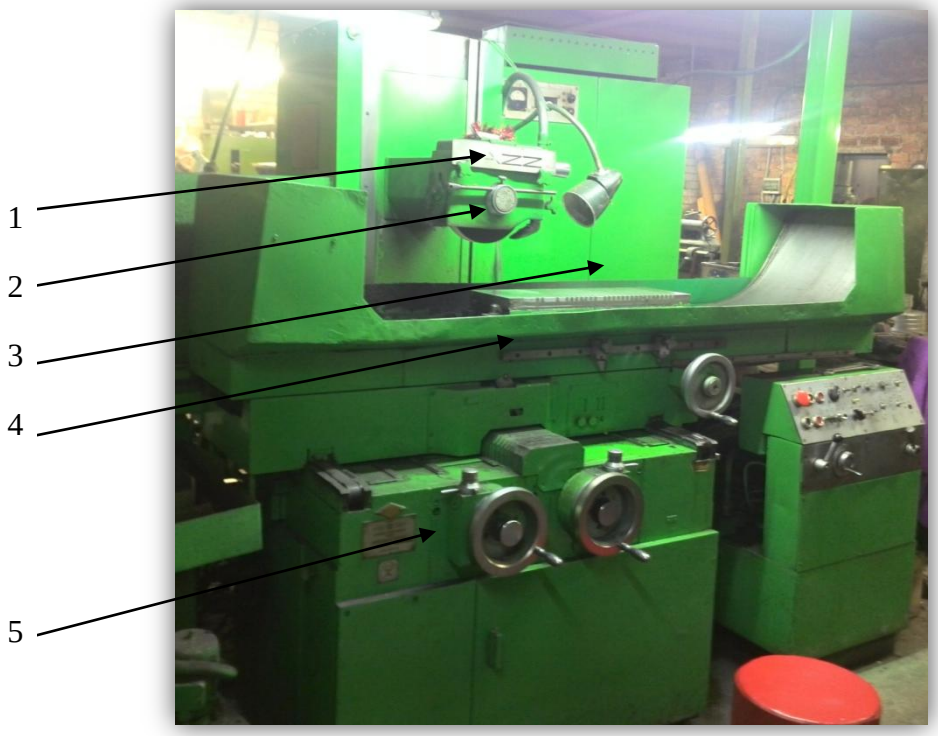


Fig. 2.6. Planar grinding machine 3G71 and main its' parts

2.3.5. Heat treatment of original glue wiper

Heat treatment – it is a process when metal and alloy are being heated till the right temperature, holding the right temperature and then in a regulated speed metal is cooled off, so when the structure of a metal is changed, you get the needed properties [16]. The use for heat treatment could be for many things: before cutting steel, its hardness and strength could be manipulated so it would be easier to cut it, the plasticity is also gained for hardened metal by cold deforming, increased hardness and wear resistance, internal stresses are being removed on which it can become distorted.

In the production heat treatment is applied, when it is wanted to facilitate processing or to give the desired product properties. In the first case heat treatment is often referred to as Pre-, on the second – it is referred as Final. The latter is usually the most important manufacturing operation,

which determines the performance characteristics of the product. Improper heat treatment may undermine the entire work which was put in to manufacture a product [17].

Of all three important operations for thermal processing quality: heating, temperature maintenance and cooling. However, the heat treatment method and the gained effects depend on the heating temperature and cooling rates.

There are four main heat treatment waysfor steel: annealing, normalization, hardening and tempering. In annealing, normalizing and tempering the steel, it is heated to a temperature at which the austenitic structure is formed. These differ in cooling speed. For annealing, which is preheating after tempering, preheating temperature is lower and the cooling rate is less important. Annealing - the slowest heated to the austenitic structure cooling of the steel, often with oven. Normalization - faster steel cooling in air by itself. Hardening - most rapid to austenitic structure heated steel cooling, usually with water or oil[18].

Thermal treatment technology for a glue wiper

Material - steel 45

Needed hardness after treatment –55-60 HRC

Temperature of critical points is shown in the Table 2.1.

Table 2.1. Temperature of critical points of steel 45 [19]

Critical point	Ac_1	Ac_3	Ar_3	Ar_1	Mn
Temperature, ^oC	730	755	690	780	350

By tempering steel 45 we have heated it to 800 °C temperature, at the beginning rate of 150°C/h and in the end at rate of 250°C/h. Steel is being held at 800 °C temperature and the cooled in water at first rate of 270 °C/s, in the end at rate of 100 °C/s. After that the release is applied: Steel is heated to 340 °C temperature at the rate of 150 °C/h, and then it is held and cooled in the air at the rate of 3 °C/h. After the test we get continuous test subject hardness of 60HRC. Total steel 45 heat treatment time consists approximately 9 h [20].

2.3.6. Sharpening of an original glue wiper

In order to sharpen original glue wiper, first of all the annealing operation must be done. Annealing can be applied as pre operation for metal to get mild before mechanical treatment or as a finishing operation, when the product has to be plastic, without inner stresses. Sometimes steel is being annealed just in order to equalize the chemical composition or structure of the metal.

In this case annealing will be applied as a pre operation in order to get mild product before mechanical manufacturing.

After annealing of workpiece, the same threading and milling operations that were made to manufacture an original glue wiper are used to sharpen a glue wiper for reuse.

After mechanical manufacturing operations, the same thermal treatment technology that was used to harden already manufactured glue wiper, will be used as a finishing operation of sharpened glue wiper.

2.4.Analysis of a material of an original glue wiper

The material of an original glue wiper is steel 45 (GOST 1050-88), that is assigned to high quality structural carbon steels. These steels are made with a lower amount of harmful (such as sulphur or phosphorus) impurities. High quality structural steels have less non-metallic inclusions, their microstructure is more even than microstructure of plain carbon steels that is why high quality structural steels are used in producing more important products and thermally processed parts[21]. The density of steel 45 is $\rho = 7826 kg/m^3$. It can be substituted by these grades: 40X, 50, 50Г2. Steel 45 is used for producing tempered and annealed details of medium dimensions to getdurable and reliable production [22]. The table belowshows main analogs for steel 45.

Table 2.2. Main analogs for steel 45 [19]

USA	Germany	England	China
-	DIN, WNr	BS	GB
1044	C45E	060A47	45H
1045	C45R	080M	ML45
1045H	Cf45	080M46	SM45
G10450	Ck45	1449-50CS	ZG310-570
M1044	Cm45	1449-50HS	ZG345-570

High quality structural carbon steels are marked by two-digit number, which shows the amount of carbon in steel by a hundredth of a percentage, so steel 45 has about 0,45% of carbon [18]. The chemical composition of steel 45 is shown in the Table 2.3.

Table 2.3. Chemical composition in % for steel 45 [19]

C	Si	Mn	Ni	S	P	Cr	Cu	As
0.42 - 0.5	0.17 - 0.37	0.5 - 0.8	max 0.3	max 0.04	max 0.035	max 0.25	max 0.3	max 0.08

From technical perspectives steel 45 is hardly weldable, has a weak tendency to flakes and is not predisposed to brittleness.Mechanical properties of steel 45 are shown in the Table 2.4.

Table.2.4. Mechanical properties of welded steel 45 [19]

$\sigma_в$ (Tensile strength)	$\sigma_т$ (Yield stress)	δ_5 (Specific elongation at fracture)	ψ (Reduction of area)	KCU (Impact strength)
MPa	MPa	%	%	kJ / m^2
600	355	16	40	49

Physical properties of steel 45 are shown in the Table 2.5.

Table.2.5. Physical properties of welded steel 45 [19]

T (Test temperature)	E 10^{-5} (Young modulus)	α 10^6 (Coefficient of linear expansion)	λ (Termalcondition coefficient)	ρ (Density)	C (Specific heat)	R 10^9 (Electrical resistance)
Grade	MPa	1/Grade	Watt/(m·Grade)	kg/m^3	J/(kg·Grade)	Ohm·m
20	2			7826		
100	2.01	11.9	48	7799	473	
200	1.93	12.7	47	7769	494	
300	1.9	13.4	44	7735	515	
400	1.72	14.1	41	7698	536	
500		14.6	39	7662	583	
600		14.9	36	7625	578	
700		15.2	31	7587	611	
800			27	7595	720	
900			26		708	
T	E 10^{-5}	a 10^6	l	r	C	R 10^9

2.5.Designing the appropriate shape and size for modernized glue wiper

In designing process, the main idea was to take into consideration all the disadvantages of original glue wiper and create modernized one.

The main disadvantage of an original glue wiper is a long and complicated manufacturing of a workpiece in order to get final product. The less manufacturing operations product needs the faster and cheaper it can be produced, so there was searched for a new and at the same time simple shape for a modernized glue wiper, that would satisfy all the requirements.

The original glue wiper weighted 450g, the weight of modernized glue wiper had to be reduced, because the less material is used for producing glue wiper, the less the price of it is.

Durability is also very important, because the original glue wiper can withstand approximately 2 weeks and then it has to be sharpened, so the modernized wiper has to be more durable and reusablein order to slower the depreciation of it.

The sharpening of an original glue wiper consumes a lot of time and money, so the sharpening of a modernized glue wiper must be cheap, easy and fast.

After many experiments, discussions with the cardboard tubes machine manager and metal manufacturing specialists, the final shape of a rectangle plate were chosen in order to satisfy simplicity, lightweight, durability and high-quality glue cleaning. The chosen length of a plate was 260mm, width–30mm and the thickness of plate - 1,2mm. The length of plate was chosen in order to clean paper with different widths, the thickness of a plate were chosen in order not to damage the paper, because the smaller thickness of a plate is, the sharper its edges are. The plate with smaller thickness could damage and rip up the paper or hurt the workers. In the Fig. 2.7. the 3D model of modernized glue wiper shape is shown.

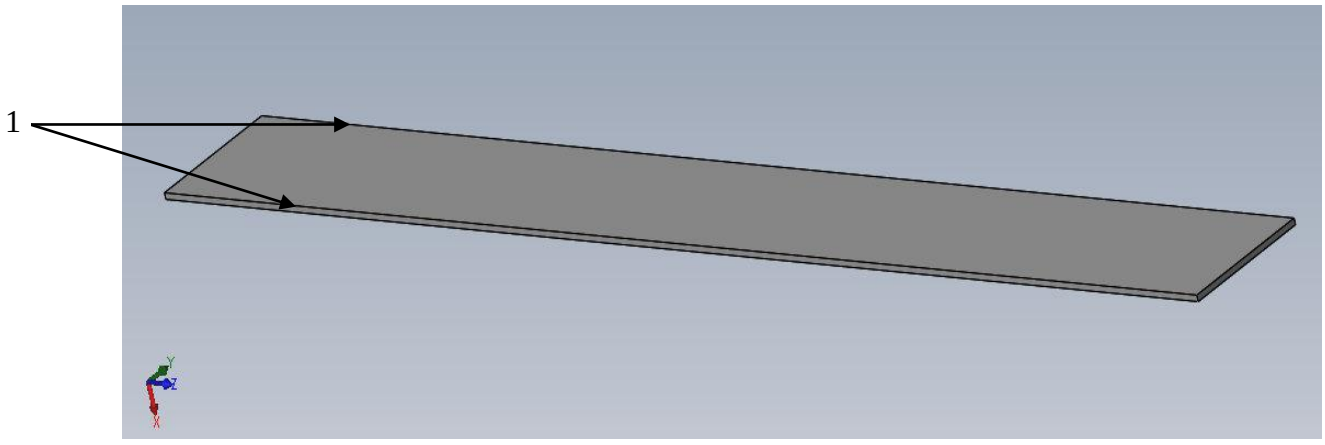


Fig.2.7. 3D model of modernized glue wiper shape with two cleaning surfaces *1*

In order to diminish the amount of manufacturing operations for producing modernized glue wiper, such a simple shape has been chosen. Although is looks really simple, but in practical experiment that was made at “BaltijosBrasta” it cleans the paper exact and quick.

In order to increase the durability and reuse of glue wiper, such a shape was chosen. After one cleaning surface is worn-out, the second cleaning surface can be easily swapped and the glue cleaning process continues.

Because of simple shape of a modernized glue wiper, it can be easily sharpened with grinding machine. A quite big width of a modernized glue wiper increases the times to be sharpened, so it can be sharpened more times than an original one.

Appropriately chosen material for this shape of a modernized glue wiper will give additional features and will improve the quality of glue cleaning.

2.6.Proper material choosing for a modernized glue wiper

By choosing material for a modernized glue wiper many experiments were made and many materials were rejected in order to find that only material which would satisfy all the requirements.

At first, spring steel plate as a material for modernized glue wiper was chosen. Such steelis widely used in machine manufacturing formanufacture flat and round springs, springs, brake bands, and the details that require high strength and durability [23]. Nevertheless such a material is inappropriate for a modernized glue wiper, because after tempering operation it deforms unacceptably and damages the paper, so spring steel plate was rejected.

Steel plate was also rejected, because after tempering it is difficult to reach the needed hardness, as a result such material is either too mild or too hard for cleaning the excess of glue from paper.

Stainless steel plate was too hard and too sharp, so it was also neglected for modernized glue wiper.

Later, metal rulers, various knife-blades and metal putty spatulas were tested. Material of a metal ruler was too mild and didn’t clean the paper; knife-blades were too sharp and damaged the paper. Putty spatulas were quite suitable for cleaning the glue from paper, but the price for them was too high, so they had also to be rejected.

After many unsuccessful tests, quite accidentally, band saw blades were tested. After cutting into pieces of needed length and grinding the teeth of band saw blade, this material was tested as a modernized glue wiper. As a result, this experiment was successful and the material of band saw blade was perfect for this device.

In manufacturing bimetal band saw blades, two materials: high-speed steel (HSS) for saw teeth and alloy tool steel for the base of saw are connected by a special welding process [24].

In Fig. 2.8. the welding process of connecting the base and teeth of band saw blade is shown.

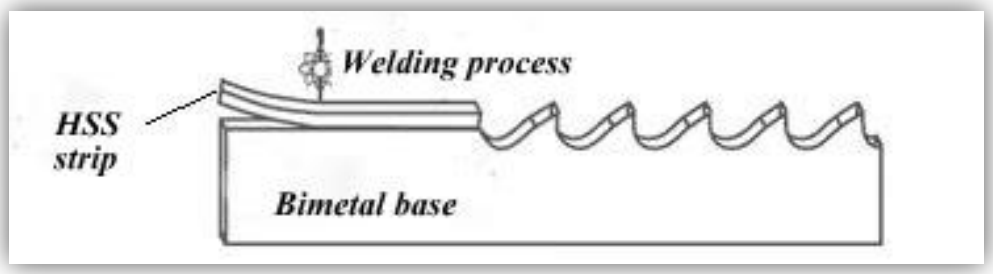


Fig.2.8. Welding process of band saw blade [24]

The alloy tool steel base of saw is 6X4M2ΦC (GOST 5950-2000), that is assigned as I group of alloys, which is used for making cold pressing tools [25]. The chemical composition of this steel is shown in Table 2.6.

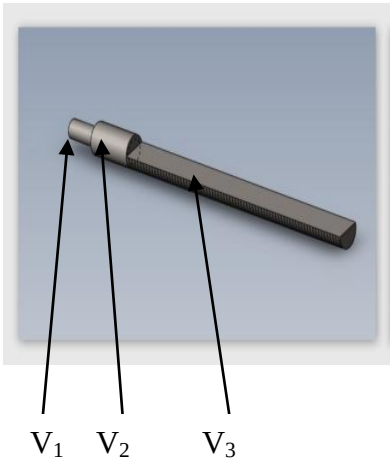
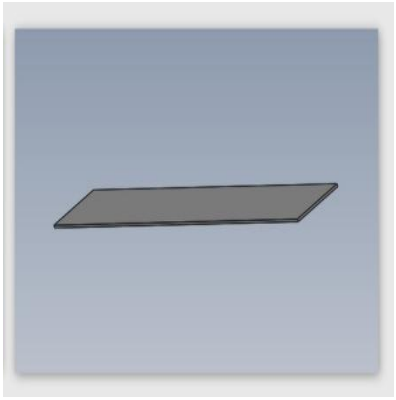
Table 2.6. Chemical composition in % for grade 6KH4M2FS (6X4M2ΦC) [26]

C	Si	Mn	Ni	S	P	Cr	Mo	V	Cu
0.57 - 0.65	0.7 - 1	0.15 - 0.45	max 0.4	max 0.03	max 0.03	3.8 - 4.4	2 - 2.4	0.4 - 0.6	max 0.3

The alloyof baseof band saw bladehas 4% chromium impurities that provide durabilityathuge mechanical loads. Special welding process saves the most important properties of high-speed steel and tool steel [24]. That is why such a material is durable and heat treatment is not needed. Also this material is cheap, because in producing modern glue wipers there is no purpose to buy new band saw blades with completely new teeth. When the teeth of a band saw blade depreciate, they are thrown away, so the reproducing them again as modernized glue wipers is more ecological and cheaper wayat the same time.

In order to compare the weight of both glue wipers the calculations of both glue wipers masses are shown inthe Table 2.7.

Table 2.7. Calculation of masses of glue wipers

Original glue wiper  	Volume formula: $V_1 = \pi r^2 \cdot \mathrm{h}$; $V_2 = \pi r^2 \cdot \mathrm{h}$; $V_3 = \frac{\pi r^2 \cdot \mathrm{h}}{2}$; $V = V_1 + V_2 + V_3$ Mass formula: $\mathrm{m} = \rho \cdot \mathrm{V}$	Calculation of Volume: $V_1 = \pi \cdot 6^2 \cdot 25 = 2\,826\ mm^3$ $V_2 = \pi \cdot 10^2 \cdot 35 = 10\,990\ mm^3$ $V_3 = \frac{\pi \cdot (11.5)^2 \cdot 210}{2} =$ $= 43\,602.825\ mm^3$ $V = 2826 + 10990 + 43602.825 =$ $= 57\,418.825\ mm^3$ Calculation of mass: $\mathrm{m} = 7826 \cdot 0.0000574188 =$ $= 0.44946\ \mathrm{kg} \approx 450\ \mathrm{g}$
Modernized glue wiper 	Volume formula: $V = a \cdot b \cdot c$ Mass formula: $\mathrm{m} = \rho \cdot \mathrm{V}$	Calculation of Volume: $V = 260 \cdot 30 \cdot 1.2 = 9\,360\ mm^3$ Calculation of mass: $\mathrm{m} = 7850 \cdot 0.00000936 =$ $= 0.073476\ \mathrm{kg} \approx 74\ \mathrm{g}$

As a result the band saw blade is a perfect material for the modernized glue wiper; the material is cheap, durable at huge mechanical loads, of perfect hardness and does not injure paper or workers. Also this material is quite flexible, so it can adjust to the paper for removing the excess of glue from it perfectly. One more advantage of this material is weightless; a modernized glue wiper from this material weights only 74g, when the original glue wiper weights 450 g, as a result, modernized glue wiper is 376 g lighter.

2.7.Manufacturing operations for producing a modernized glue wiper and sharpening it

In order to produce a modernized glue wiper the following steps have to be done:

1. Shear the band saw blade into pieces of needed length with a sheet metal shear. In the Fig.2.9. the sheet metal shear (*a*) and a band saw blade shearing process(*b*) are shown.

a) b)

Fig.2.9. The sheet metal shearing device:*a)*a shear; *b)*shearing process of a band saw blade

In theFig.2.9, a) a handle*1*, the blade*2* and a rack *3*of a sheet metal shear are shown. By taking down the handle the shearing process is performed. In Fig.2.9, b) an adjustable measuring plate *4*and shearing of a band saw*5* are shown.

2. After shearing the band saw into pieces of needed length, the pieces of a band saw are tightened with special holders from both sides. The process of tightening the band saw pieces is shown in Fig. 2.10.

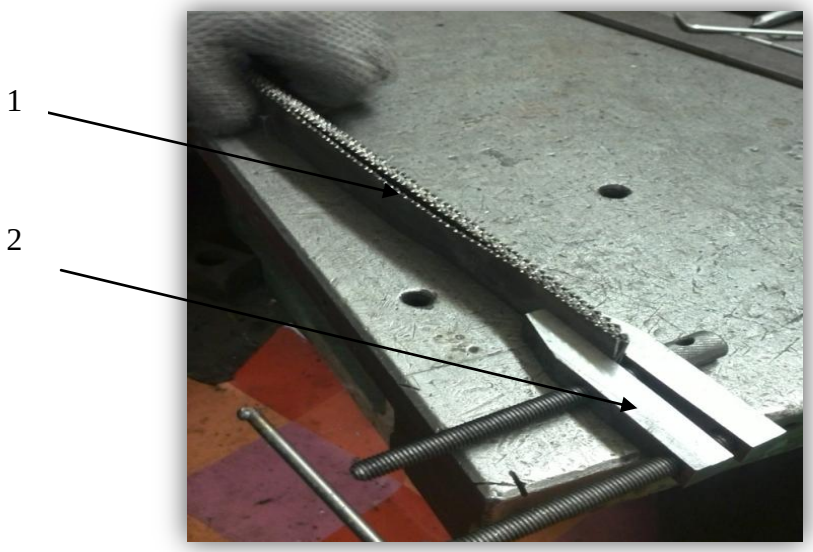
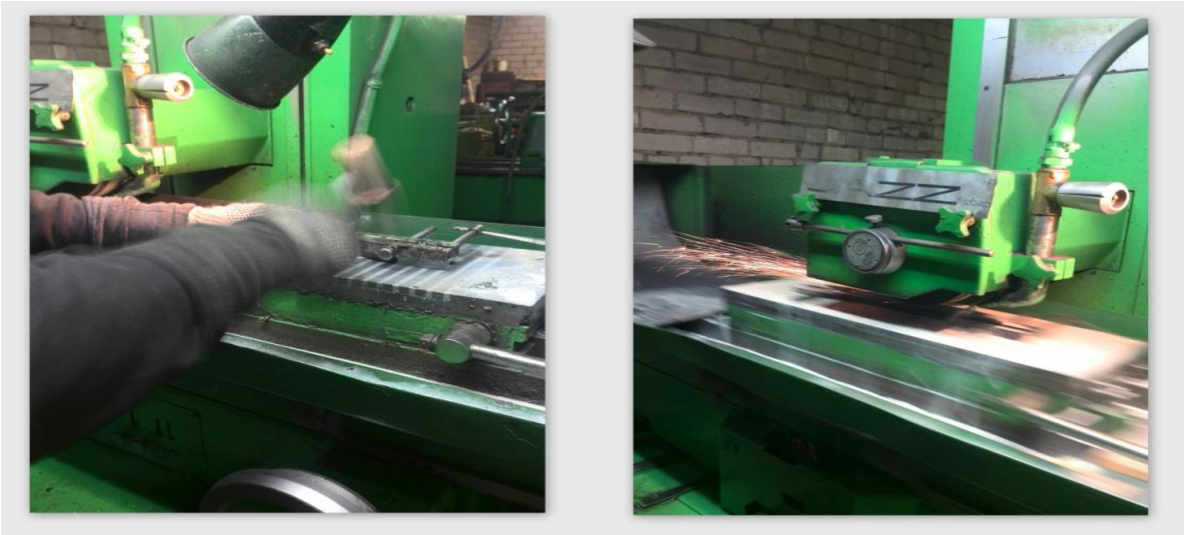


Fig.2.10. Tightening the band saw pieces *1* with a special holder *2*

3. After tightening both sides of the band saw pieces, they are fixed to a magnetic chuck of a grinding machine manually by using a copper hammer. Then the saw-blade is grinded and cleaning surface is created. After this, the other side of band saw pieces is grinded in order to get second cleaning surface.

The most comfortable way to grind the cleaning surfaces of band saw is by tightening and grinding 4-12 band saw pieces, so that the pieces would not move in grinding operation.

The Fig. 2.11. shows the fixing of band saw pieces to a magnetic chuck of a grinding machine by using a copper hammer (*a*) and a grinding operation of cleaning edges of band saw pieces (*b*).



a) b)

Fig. 2.11. The fixing to a magnetic chuck of a grinding machine: *a)*by using a copper hammer and *b)*a grinding operation of cleaning edges of band saw pieces

4. After grinding both cleaning edges of band saw pieces, the pieces are cleaned and that is all, the modernized glue wipers are done. The already produced glue wipers are shown in Fig. 2.12.

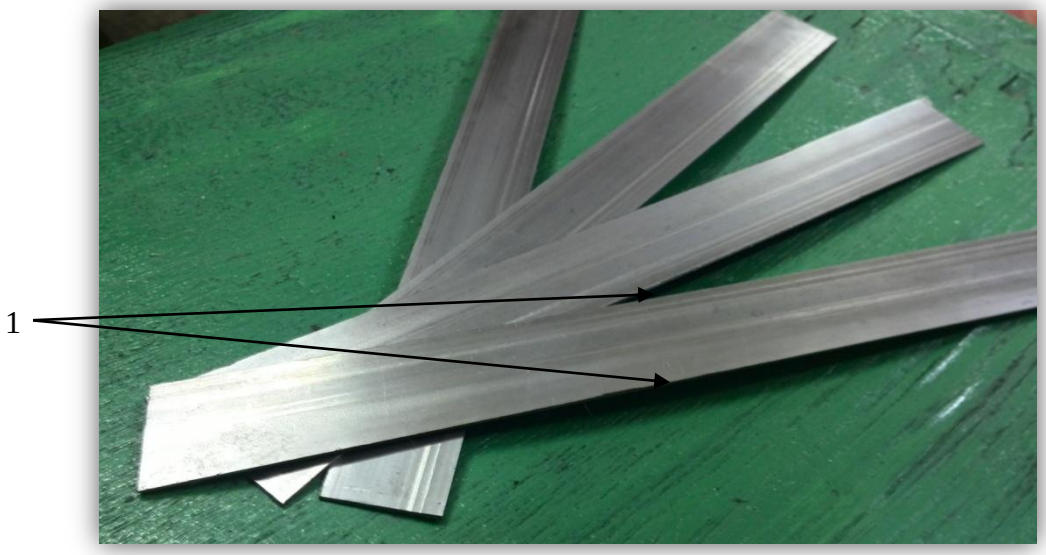


Fig. 2.12. Produced glue wipers with two grinded cleaning surfaces *1*

A modernized glue wiper has two cleaning surfaces, so after one surface is worn out, it is easily changed into another one. In order to recycle the completely worn-out glue wiper, it must be sharpened again. After wiping process, the modernized glue wiper is also soiled; however, the cleaning of adhesive from it does not require a long soaking and cleaning process; the conceived cleaning process of a glue wiper takes just two minutes and then two worn-out cleaning surfaces are grinded again in order to sharpen the glue wiper. The soiled and worn-out glue wiper is shown in Fig. 2.13. in order to understand that a simple metal whisk cannot clean such a glue wiper.

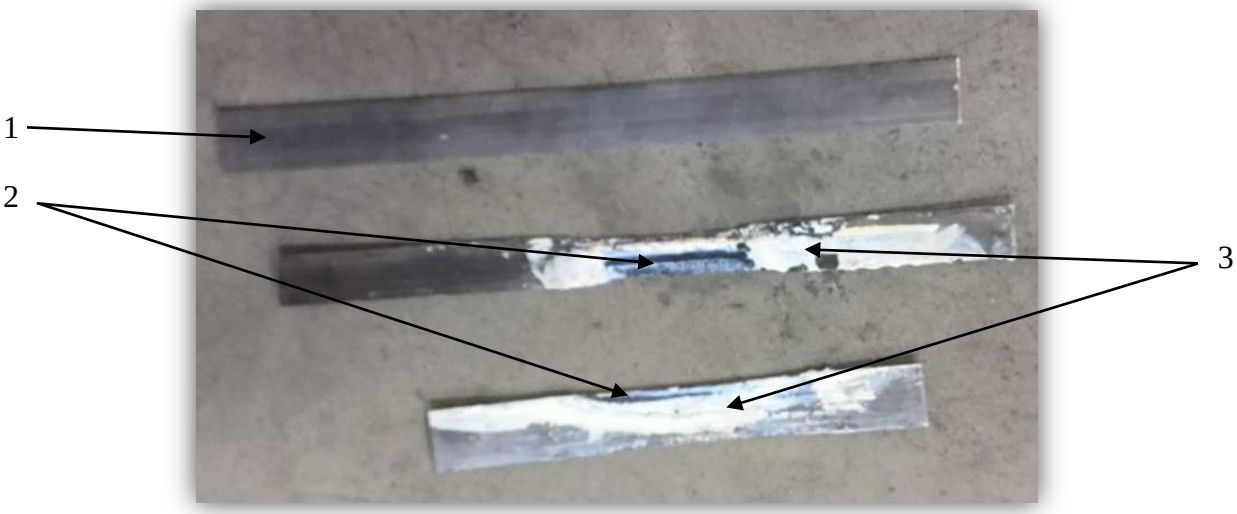


Fig. 2.13. The difference between new*1*, worn-out*2*and soiled *3*glue wipers

The conceived cleaning process of a soiled and worn-out glue wiper saves a lot of time and is effortless. First of all two magnets needed to be fixed at the bench vise. Then the soiled glue wiper is put onto the magnets in order not to move. The fixing of magnets and putting on the soiled glue wiper is shown in Fig.2.14.

Fig.2.14. The fixing of two magnets *2* into the bench vise *3* and putting on the soiled glue wiper *1* onto the magnets

After that the both sides of a glue wiper is cleaned with a Bosch grinder. Owing to magnets and a bench vise, the soiled glue wiper doesn't move and abides onto the magnets. The Fig. 2.15. shows a grinding process of a soiled glue wiper by using Bosch grinder.

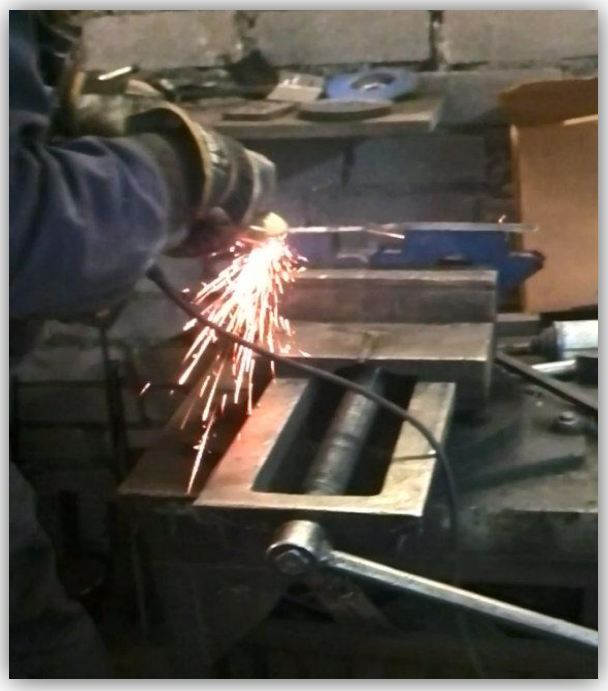


Fig. 2.15. Grinding process of a soiled glue wiper by using Bosch grinder

When a soiled glue wiper is cleaned from both sides by using Bosch grinder, the grinding of cleaning surfaces have to be done in order to sharpen both cleaning surfaces of it. The already cleaned glue wiper is shown in Fig. 2.16.

Fig. 2.16. Cleaned glue wiper after using Bosch grinder

After grinding of soiled glue wiper the cleaned surface*1* of is shown. However, the wear-out*2* of a cleaning surface of a glue wiper is not grinded by using Bosch grinder. Such a wear out of a cleaning surface can be sharpened by using grinding machine like it was used for removing the bland saw blades and grinding two cleaning surfaces.

2.8.Adaptation of fixing device for modernized glue wiper

2.8.1. Available fixing device for original glue wiper

The fixing device for original glue wiper consists of two main parts: frame and glue wiper, which operates as a glue wiper and paper lifter at the same.The fixing device of original glue wiper and main its' parts are shown in Fig. 2.17.

The frame is concluded of the basis*4* and the pipe*3*, which is inserted into one of three holes of the basis. Two holders*1* can be attached with bolts on both sides of the pipe in order to fasten the paper in place and to prevent it from sliding out of the line. The frame of fixing device is mounted into the rack of cardboard tube machine. One glue wiper*3* is inserted into the corpus of fixing device and it is used for lifting the paper in order to clean the excess of glue, so the cleaning process is going to be done easier and of higher quality. If no lifting of paper is needed, the glue wiper-paper lifter can be removed. One more glue wiper *2* is inserted into another hole of the basis and it is used for removing the glue from paper.

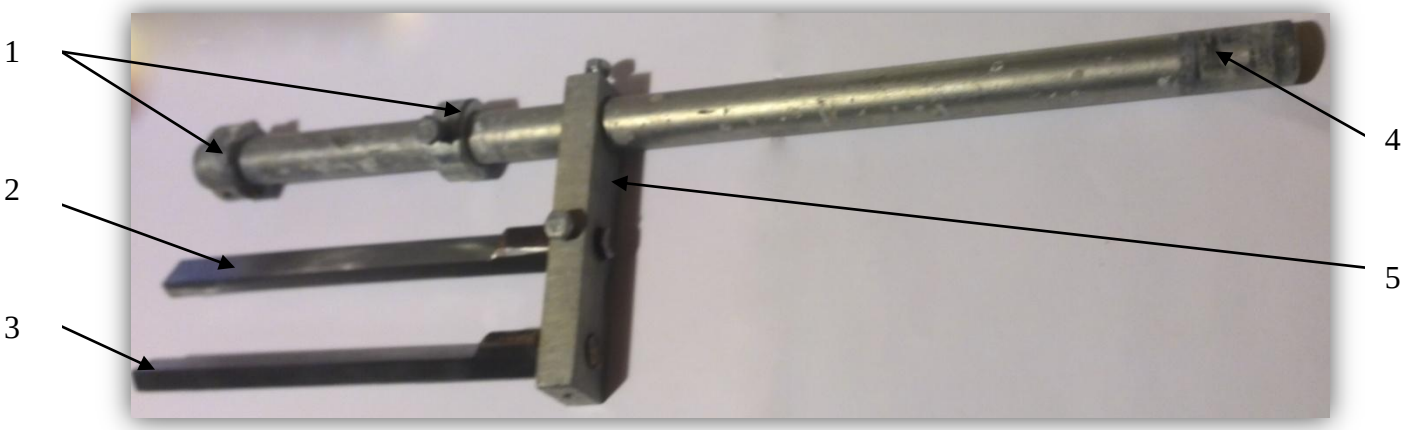


Fig.2.17. Fixing device and its' main parts

Another hole at frame of this fixing device is used for inserting and fixing the original glue wiper. A glue wiper holder is quite simple, but not so convenient, because this part of wiping device is smeared and adhered with glue, so the removing or replacing of the glue wiper with a new one takes some time, patience and strength. The smeared glue wipers are shown in Fig.2.18. in order to understand that the holding part of glue wiper is adhered to the hole of fixing device and cannot be pulled out without using force.

Fig.2.18. Smeared original glue wipers

2.8.2. Available fixing device for modernized glue wiper

The fixing device for modernized glue wiper was designed and produced by one Swedish company. This device is similar to the fixing device of an original one. The fixing device of a modernized glue wiper and main its' parts are shown in Fig.2.19.

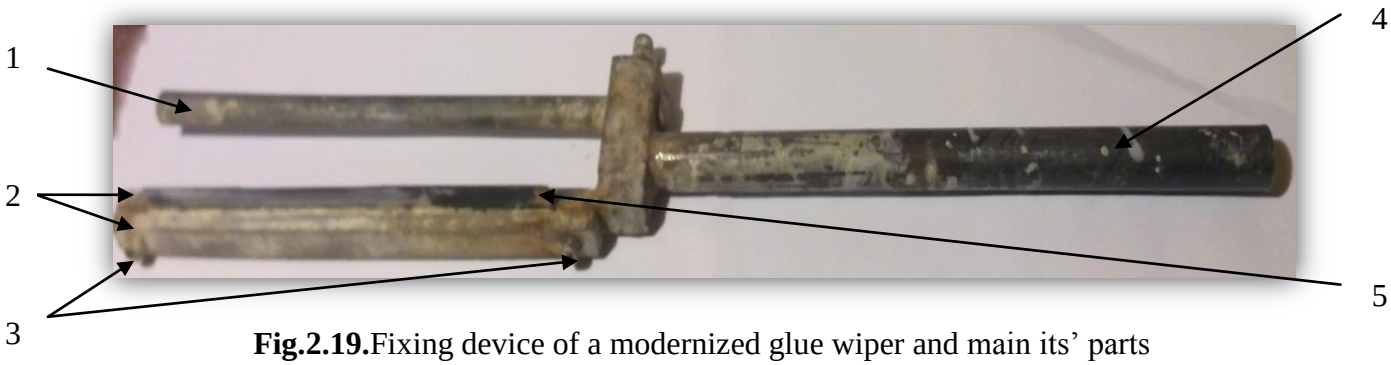


Fig.2.19. Fixing device of a modernized glue wiper and main its' parts

It also has similar corpus*4*, but the paper lifter*1* is of a simple rod shape. The main difference between modernized fixing device and original one is that modernized fixing device has two clampers*2*, which are made to fix the glue wiper *5*. They are fastened with two screws*3*. One of the clampers is welded to the corpus of a fixing device. The clamping strength is adjusted by these screws, so the worn-out glue wiper can easily be changed by new one. The disadvantages of fixing device of original glue wiper were taken into account in creating the fixing device for modernized glue wiper.

2.9.Results of a modernized glue wiper

After successful experimenting with a prototype of modernized glue wiper, the produced modernized glue wipers were tested in cardboard tubes machine gluing system. The experiment, made at "BaltijosBrasta" had shown that all key requirements for glue wiper were satisfied and the glue cleaning quality was high without damaging the paper and without the spoilage at removing glue from the paper.

The material of a modernized glue wiper was enough tough and durable to hold out high mechanical loads and the depreciation of this material was slower than by using original glue wiper material. In comparing these two materials steel 45 used for original glue wiper and alloy tool steel 6Х4М2ФСwith 4% of chromium impurities for modernized one, a modernized glue wiper wears out in 3-4 weeks by working in 3 shifts per day, when an original glue wiper depreciates in approximately 2 weeks. As a result, the bigger durability with a modernized glue wiper was achieved by using band saw blade material.

Simplified shape of a modernized glue wiper and reutilized material gave a great opportunity to lower the expenses for producing a glue-removing device. The amount of machining operations, used for manufacturing o modernized glue wiper was diminished and the complexity level of machining operations was facilitated. Reusability of material gave a chance to look more ecologically to a modernization of a glue wiper and saved the money for producing new material.

The shape and material of modernized glue wiper were chosen thoughtfully, no prohibited material reactions with glue were observed. Even the cleaning process of a soiled modernized glue wiper was easier, simpler and more time consuming in comparison with original one. If earlier the cleaning of soiled glue wiper was designated to the workers of "BaltijosBrasta" , then now the enterprise that suggests modernized glue wipers is responsible for the cleaning of soiled modernized glue wipers. It is because the new and faster cleaning of modernized glue wiper can be applied by taking into account the modernized shape and more durable material of glue removing device.

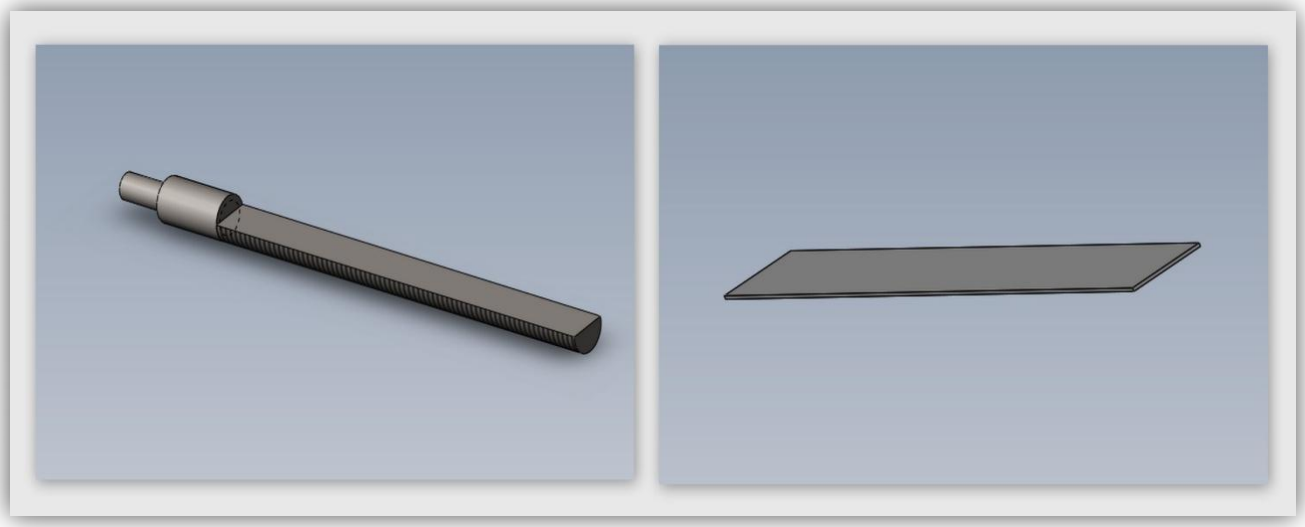
Because of such a shape and material of modernized glue wiper, it can be sharpened easier and faster. It means more expenses are consumed for the "BaltijosBrasta"company. Also the weightless of modernized glue wiper should be taken into consideration, because more material is saved and the changing process of rejected wiper into new one is easierin comparison with original glue wiper.

The fixing device was designed for modernized glue wiper in order to alleviate the fixing process of device and consume some time for changing the worn-out glue wiper by new one. The fixing device of modernized glue wiper is more convenient in comparison with fixation device of original glue wiper.

2.10.Original glue wiper in comparison with a modernized one

In comparing original glue wiper and modernized one, these features were analyzed: shape, material, weight, manufacturing operations complicity,wiping quality,soiled wipers cleaning complicity, sharpening operations complicity, durability of wiping device and the complicity of fixation.

Shape of original glue wiper is clumsy and complicated to manufacture, when the shape of modernized glue wiper is way simpler and easy to manufacture. The 3D models of original and modernized glue wipers are shown in Fig.2.20.



a) b)

Fig.2.20. 3D models of *a)*original and *b)*modernized glue wipers

The material for producing an original glue wiper has to be new. This wiping device is made from steel 45. The material of modernized glue wiper is reused from rejected band-saw blade. The material of modernized glue wiper is alloy tool steel6X4M2ΦC, having 4% of chromium impurities. The width of band- saw blade perfectly fits for cleaning operation, the in order to have appropriate length material is cut into shorter pieces.

Weight of modernized glue wiper (74g) is approximately 6 times lighter in comparing with the original one (450 g). The reused material and lighter weight of modernized glue wiper is more ecological choice in comparison of taking new and heavier material.

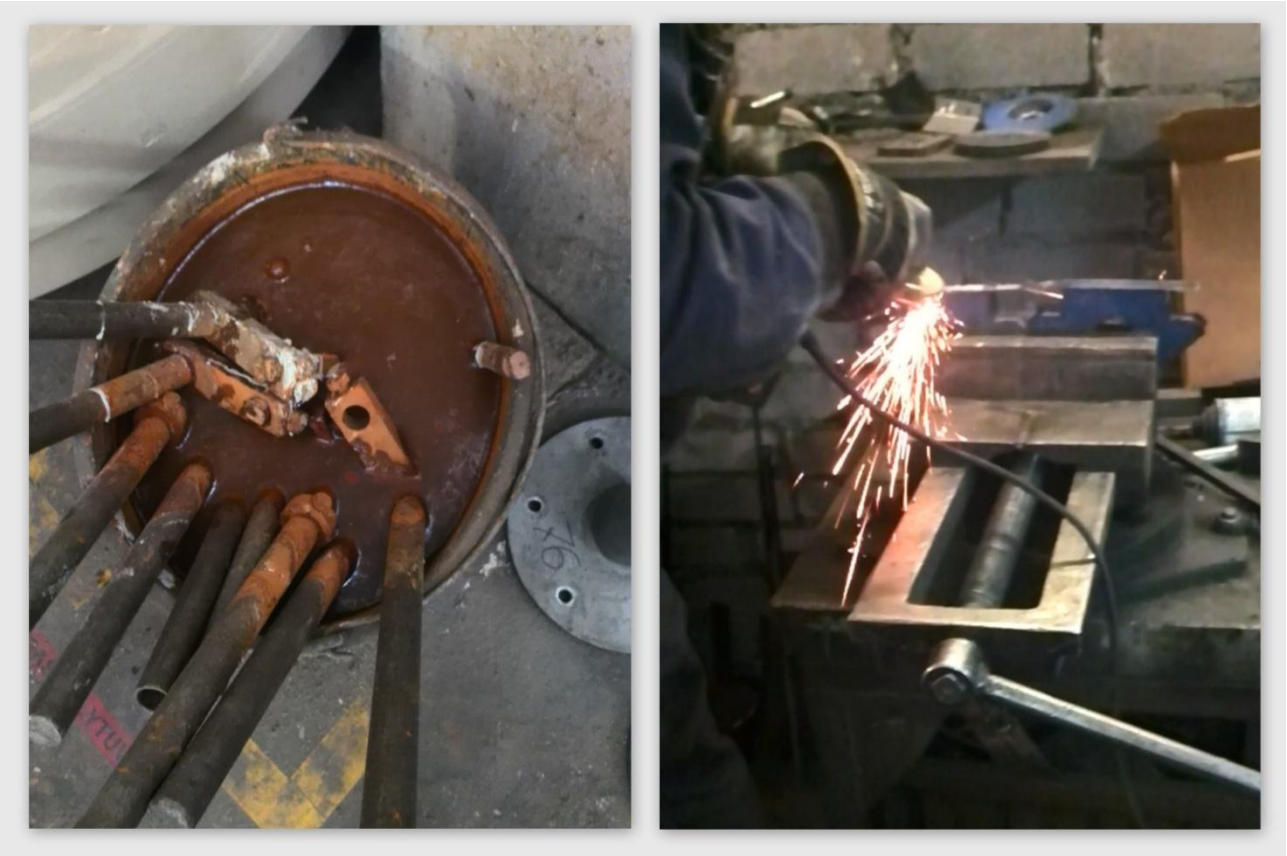
For producing of original glue wiper 5 complicated operations are needed to be done: turning of a holding part, threading of bottom surface, milling of cleaning surface, grinding of a cleaning surface, and heat treatment of final product. In order to produce modernized glue wiper just 2 completely simple operations are needed to be done: cutting band-saw blade into pieces of needed length and grinding of two cleaning surfaces.

Such an improvement does not change modernized glue cleaning quality, even opposite, this improvement increases the quality of cleaning and consumes some money. In comparing cleaning quality the picture of both- original and modernized glue wipers cleaning processes is shown in Fig. 2.21. In this picture the both types of glue wipers are shown after 1,5 week and the difference is obvious. Fig. 2.21, a) shows the waster of original glue wipers, which is tried to diminish by sticking some paper that the needed excess of glue would be removed. The soiled modernized glue wipers are shown in Fig. 2.21, b). Despite of dirty appearance, the quality of cleaning process of these glue wipers is way higher and no waster is done.

a) b)

Fig.2.21. Cleaning process after 1,5 week : *a)*the waster of original glue wipers and *b)*high quality of cleaning process of modernized ones

The cleaning of soiled original glue wipers is prolonged and muggy soaking process that wastes the time forthe workers. The created cleaning process of modernized glue wiper is faster and cleaner due modernized shape and more durable material.Basically, it is a grinding of glue from modernized glue wiper with Bosch grinder. Such modernized glue wiper cleaning takes 2min, when the soaking of soiled glue wipers takes hours, depending on the soil of them. In the picture below two cleaning processes of soiled glue wipers are shown inFig. 2.22.:a) cleaning process of original glue wiper, b)cleaning process of modernized ones.



a) b)

Fig. 2.22. Cleaning of : *a)* original glue wipers and *b)*cleaning of modernized glue wipers

The sharpening process of modernized glue wiper is also way easier and more time consuming in comparing with sharpening of original ones, due to the modernized and simplified shape and appropriate material. In order to sharpen both cleaning surfaces of modernized glue wiper only simple grinding operation is need. In order to sharpen an original glue wiper first of all the annealing pre operation has to be applied in order to get mild product before mechanical manufacturing of the product. After that threading and milling operations have to be repeated and then thermal treatment technology should be used as a finishing operation of sharpening the wiper.

The durability of original glue wiper is worse in comparison with modernized one. It is because of more appropriate material and shape. If the original glue wiper wears-out after 2 weeks of working 3 shifts per day, then the modernized one can work from 3 to 4 weeks without the depreciation.

The fixation of a modernized glue wiper is also more convenient and easier to perform, when fixation of original glue wiper is more complicated, because the holding part of glue wiper is adhered to the hole of fixing device and cannot be pulled out without using force.

In the Table 2.8. a brief comparison of the original glue wiper with the modernized one is done.

Table 2.8. Comparison of the original glue wiper with the modernized one

	Original glue wiper	Modernized glue wiper
Shape	Complicated, clumsy	Simple
Material	Steel 45	6Х4М2ФС (Reused from band saw blades)
Weight	450g	74 g
Manufacturing operations complicity	Complicated and time-wasting operations	Simple, easy and time-saving operations
Wiping quality	Medium high	High
Cleaning complicity of soiled wiper	Prolonged soaking process	Quick and simple grinding with Bosh grinder
Sharpening operations complicity	Complicated and time wasting	Simple, easy and time saving
Durability	Lower	High
Fixation complicity	Quite complicated	Easier

3. PERFORMANCE IMPROVEMENT THROUGH INNOVATION OF PRIVATE COMPANY "BALTIJOS BRASTA"

3.1. Private company "BaltijosBrasta" purpose, functions and activities

Private company "BaltijosBrasta" was established in 1996. The headquarters is in Kaunas city. In other Lithuanian and foreign country cities the organization is represented by reliable and experienced partners. Special and long lasting relationships are linked with Finland. In 1999 a subsidiary company "BaltijosBrasta Ukraine" started its activities in Ukraine. The production is being exported Baltic, Scandinavian countries, Russia, Byelorussia, Ukraine, Africa, Middle East, East and West of Europe [27].

"BaltijosBrasta" is successfully working in several, totally different business areas. The main scopes of the company are – shower stalls and toilet, office partitions, packing material and also building materials trades. The goal of the company is - different product presentation for a customer and ensuring highest quality. It is achieved when it is seen to every area and also collaborating with trustworthy partners in Lithuania and abroad. Many of the products were offered to Lithuanian market first by private company "BaltijosBrasta". The organisation considered in to ascending needs from the consumers, constantly looking for to face new challenges, rapidly expanding its activities. After all, the private sector organizations have to react more quickly and more flexibly in to constantly changing needs of the clients.

Active participation in global exhibitions, seminars, business meetings gives even more experience to improve. Private company "BaltijosBrasta" is one of the Lithuania's roofers Association founders, USA roofers, Lithuania packer association member. In 2006 It joined the European tube Manufacturers Association [27].

Quality and environmental management system, meets the LST EN ISO 9001:2008 and LST EN ISO 14001:2005 standard requirements, ensures quality and environmental policy implementation of commitments across the whole organization. Manufactured products are eco-friendly, could be used for recycling [28].

3.2. Private company “BaltijosBrasta” mission and strategic goals

Private company “BaltijosBrasta” heads of departments entrust tasks to employees based on the mission and seek to implement strategic objectives in the same way as the public sector organizations and their leaders.

Mission - supplying customers with the highest quality output, applying modern production and business management systems.

Purpose of the organization - to achieve the highest standards in relation to work and product quality, helping to earn high consumer recognition, to hold the leader position in Lithuanian market, to develop business with foreign partners. Realizing a clean, friendly environment importance, constantly improve the environmental management system for review, seeking to exploit the most advanced production technologies and the rational use of natural resources and reduce environmental impact.

Strategic goals:

1. Continuously monitor and improve the organization's functioning quality and environmental management system in accordance with LST EN ISO 9001:2008 and LST EN ISO 14001:2005 standard requirements;
2. Placing on the market of consumer needs qualified products;
3. Promote response to market changes;
4. Systematically improve staff competence and professionalism;
5. Work consistently, efficiently and stably;
6. Improve the production technology and implement technical innovations;
7. Continuously improve the environmental management system for review in accordance with the principle of pollution prevention;
8. pursuing that each employee worked qualitatively, within its capabilities, conserve resources and protect the environment from pollution.

Private company “Baltijos Brasta” management, in order to achieve the objectives, commit:

1. ensure for high-quality and productive employees work, appropriate and safe working conditions;
2. promote teamwork, assessing the merits of staff working together to reach goals;
3. promote meaningful creative initiatives, ideas and suggestions for realization;
4. follow environmental and other legal requirements, regulating organization's activities;

5. pay the resources devoted to the established quality and environmental objectives and targets;
6. to give priority to suppliers of products for production, with reduced environmental impact;
7. economical and rational use of natural and energy resources, to comply with the waste sorting requirement and the principle.

3.3.Brief analysis of private company „Baltijos Brasta“

In the table 3.1. the main data about the company „Baltijos Brasta“ are shown.

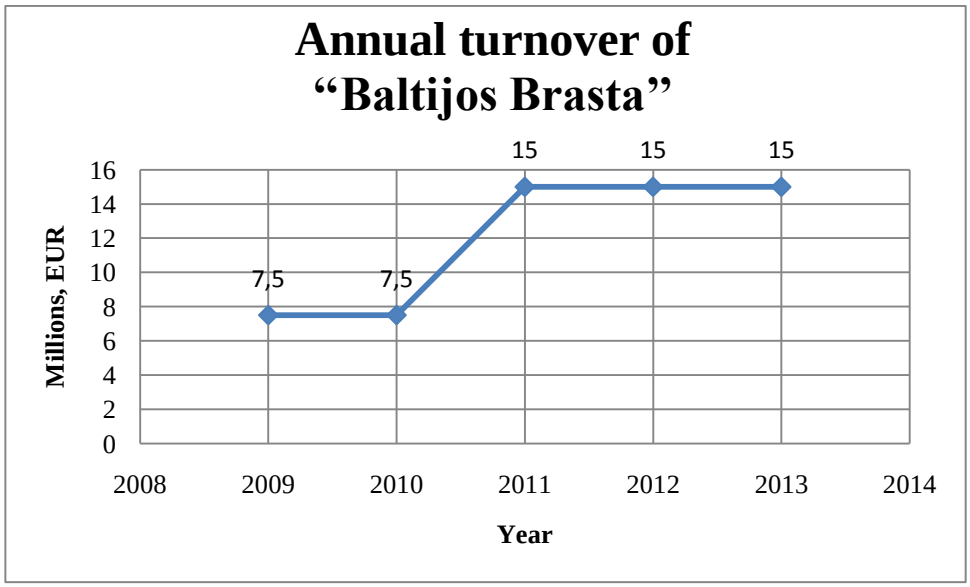
Table 3.1. Main information about „Baltijos Brasta“[29]

	“BaltijosBrasta”
Type	Private company (UAB)
Establishing data	1996
Location of parent company	Lithuania, Kaunas
Foreign shareholders	Finland
The company's users	Companies; individual users
Company Activities	diversified: ● shower enclosures production and sale; ● toilet and office partitions production and sale; ● packaging materials production and sale; ● construction materials sale.
Number of employees	2015-05-24 there were 166 employees (insured)

From the Table 3.1 it is clear that “ BaltijosBrasta” is private company, existing already 19 years. The latest number of insuried employees at the company is 166. Annual turnover

of year 2013 is 10 000 000 – 20 000 000 EU. In the Table 3.1.the annual turnover of‘‘BaltijosBrasta’’ (Year 2009-2013) is shown.

Table 3.2. The annual turnover of ‘‘BaltijosBrasta’’ (Year 2009-2013) [29]



In order to understand technological, legal – political, ecological, demographic, economic and competitive environments the manager of the company Vytenis Petraitis was questioned (oral interview). The development of company, penetration into the Lithuanian market, penetration in foreign markets and activity specifics were also discussed and briefly analyzed below.

Technological environment: Company uses both old and new technologies. Human workis essentialat the company, so the trainings and seminars are organized constantly and so the competence of employees is rising. Although the company still has old production lines, but there are investments in installation of new technologies and upgrading old. The company also updates its information technology, which allows for more efficient document management and accounting, quicker information share between members of the organization.

Legal and political environment:Lithuanian legal environment was termed asa positive for development, there are no significant legal restrictions that would impede the development of the company. Company is using the assistance of state-owned enterprise ,,Invega", also sends the applications for funding, when adopting new staff. “BaltijosBrasta” does not get EU support for the new technologies.

Ecological environment: Company complies with all the required environmental standards and environmental laws. It has a TUV certificate. Company does not participate in the Ecological actions, but sorts waste and encourages its employees to be friendly to the environment.

The demographic environment: Company does not feel big demographic changes, but feel the sufficiently diminishing number of skilled workers. Consumers tend to buy the company's products, because of confidence in the quality, proposed in Lithuania. Increasing level of education in the country has an impact on the company's operations, because the guarantees, better service and better quality of products are required.

The economic environment: Users can be natural and juridical persons. Company most of its production exports to foreign countries. Workers have differentiated salary system, new employees receive slightly higher than the minimum wage, at the end of the probationary period employee has the opportunity to raise its position and get average or higher than average income. Supply meets demand; the company is operating according to the orders, so when the amount of orders increase, the number of employees also increases and working hours are extended. Rising inflation in the country does not any significant impact on the company's activities. Company sales are growing steadily. In Year 2011“BaltijosBrasta”has received the certificate "Strongest in Lithuania," by creating a better economic futureinLithuania.

The competitive environment: There are some competitors, however, private company :BaltijosBrasta” is one of the leading companies in the Baltic countries. Company stands out from its competitors by providing guarantees; high quality and diversity of production; fulfillment individual orders and taking into account customers needs. A loyal customer base is created, so the company does not feel strong competitive pressure. A large part of the production is exported to foreign countries.

The development of company: The goals of developing the company are to create more jobs, raise the level of the Lithuanian economy, increase the company's visibility both in Lithuania and abroad, increase the company stability and the pursuit of higher profits. The ways of development in the company: participation in exhibitions, the internet searchingfor potential customers, secondments and meetings with potential clients.

Penetration into the Lithuanian market:„BaltijosBrasta“ is the parent company in Lithuania, previously having a completely different nature. As a foreign-owned company, it began operate 19 years ago. Company founders are Lithuanians, foreign investor is Finn. Since two of the three shareholders are Lithuanians, so it was determined that the parent company should established in Lithuania.

Penetration into foreign markets: The aim to achieve a higher market share in foreign countries and obtain higher incomehas pushed company to export its production. Foreign markets are chosen by taking into account the demand for the company's products in a particular country and which market share is still not complete, as well as taking into account which contacts can be

bounded in the certain country. Information on the foreign market is collected online and by taking interest in the country's economic and legal situation in social media.

Activity specifics: Company's activities are totally different - from producing and selling showers, partitions, cardboard tubes and angles to selling of building materials. Marketing techniques: Each department is responsible for its own advertising activities; all the news published online www.baltijosbrasta.lt in Lithuanian, English and Russian languages. Customers are informed about the news individually; the company logo is created and used on company stand, documents, website, and on products.In Fig. 3.1.the logo of the company "BaltijosBrasta" is shown.

Fig. 3.1. Logo of "BaltijosBrasta" company [30]

Internet advertising is used at the company, also its logo is placed on cars and gifts to customers or partners. Contacting with new customers can be directly and indirectly. The relationship with existing customers is constantly maintained by sending gifts or traveling to meetings.

3.4.Modernized glue wiper costs

The ultimate goal of engineering solutions is the satisfying of human needs. But they cannot be met without costs. Various engineering solutions requires for different volumes of costs. Evaluate cost engineering solutions will be best if the end result will be even competing goals [31].

The company "BaltijosBrasta" orders glue wipers from private enterprise (liet. - individualiįmonė)"EgidijausMačiulio firma". Because of many disadvantages of original glue wipers, "EgidijausMačiulio firma" started to modernize glue wipers for their client "BaltijosBrasta" company. Afterfinalmodernizedgluewipersafisfiedthecustomer, "EgidijausMačiulio firma" started to produce modernized glue wipers for "BaltijosBrasta" company.

As a result, the modernized glue wipers are created at private enterprise "EgidijausMačiulio firma" and produced for "BaltijosBrasta" company so it is important for private enterprise "EgidijausMačiulio firma" to have exact data about costs and saved resources in order to estimate the financial and economic project benefit to the company.

In order to analyze the expenses of company “EgidijausMačiulio firma” to modernize and produce glue wiper, the costs calculation will be used.

Costs are certain monetary costs for the purchase of needed supplies, materials, equipment, energy resources, labor, taxes, and charges and so on. Thus, the costs can be considered as the monetary value of all goods and services for the manufacturing necessary production[32].

In assessing the engineering solutions, all costs are first divided into the fixed and variable costs.

• **Fixed costs (FC)**do not change when the production output is changing, e.g., premises rent expenses, insurance expenses, administrative expenses, interest paid on borrowed funds and etc [33].

• **Variable costs(VC)** vary when the production quantities are changing, e.g., raw materials, energy consumption in the manufacturing process, the workers’ wages and etc [33].

General costs are costs that company makes in producing a certain quantity of production or providing certain services. They can be calculated by summing fixed and variable costs [33]:

$$GC=FC+VC \quad (3.1)$$

when FC – fixed costs, VC – variable costs.

The average general costs (AGC) shows the expenses that company makes by producinga certain amount of products or services. They can be calculated according to formula [33]:

$$AGC= GC/Q \quad (3.2)$$

whenGC - general costs, Q- the amount of produced product.

The average variable costs (AVC) show the amount of expenses for one unit being produced.They can be calculated according to formula [33]:

$$AVC= VC/Q \quad (3.3)$$

whenVC – variable costs, Q- the amount of produced product.

The table 3.3.shows fixed, variable, general, average general and average variable costs in creating a modernized glue wiper and producing it.

Table 3.3. Costs of "Egidijaus Mačiulio firma" to produce modernized glue wiper

Fixed costs (for 1 month)	Salaries for workers	3600 €
	Premises rent expenses	580 €
	Maintenance expenses (electricity, water)	290 €
	Insurance expenses	150 €
	Testing costs	50 €
	Producing costs of test samples	200 €
Total fixed costs	**FC=3600+580+290+150+50+200**	**4 870 €**
Variable costs	Raw material costs (for producing modernized glue wipers for 7 cardboard tubes machines, when the average amount of wipers per machine is 14 and the using period is 1 month)	1 piece/3 € 98 pieces/294 €
	Equipment costs (fixations for producing modernized glue wiper)	30 €
	Producing costs	1 piece/3 € 98 pieces/294 €
Total variable costs	**VC=294+30+294**	**618 €**
General costs	**GC= Fixed costs + Variable costs = 4870 + 618**	**5488 €**
Average general costs	**General costs/ amount of produced product = 5488 / 294**	**18.67 €**
Average variable costs	**Variable costs/ amount of produced product = 618 / 294**	**2.10 €**

The calculations of fixed, variable, general, average general and average variable costs were performed and the results are shown in Table 3.3.

3.5. Comparing of glue wipers prices

As the price of original glue wiper is known (30 €) the price of modernized glue wiper should be calculated in order to compare these two prices. For calculating the price of modernized glue wiper, the cost plus method is used. It is a pricing strategy in which the selling price is determined by adding a percentage markup to a product's unit cost. It can be calculated according to formula [34]:

$$\mathbf{P=I_{unit}+ \% I_{unit}} \quad (3.4.)$$

where: P-product price, I_{unit}-expenses for one production unit, $\%I_{unit}$- The percentage profit supplement in price.

In our case the expenses for one production unit consist of raw material price (RMP) and production price (PP). So, the expenses for one production unit can be calculated:

$$\mathbf{I_{unit}= RPM + PP ;}$$

$$\mathbf{I_{unit} = 3 + 3 = 6 €.}$$

Then the product price can be calculated:

$$\mathbf{P=I_{unit}+ \% I_{unit};}$$

$$\mathbf{P= 6 + 4 = 10 €.}$$

In comparing original glue wiper price (30 €) and modernized one price (10 €), the significant big difference can be seen. Three modernized glue wipers can be bought instead of one original wiper.

In conditions when modernized glue wiper can work 20 days until wearing out and the original one can work 10 days before wear out, the amount of savigs in 1 Year when modernized glue wipers are used insteal of original ones can be calculated.In the Table 3.4.the conditions,in which the costs of glue wipers after 1 year period will be compared, are shown.

Table 3.4. Conditions for comparing costs for glue wipers after 1 Year period

Original glue wipers working time until depreciation	10 days (or 2 weeks with weekends)
Modernized glue wipers working time until depreciation	20 days (or 4 weeks with weekends)
Price of original glue wiper	30 €
Price of modernized glue wiper	10 €
Amount of weeks in 1 Year	52 weeks
Amount of cardboard tubes machines	7 machines
Average amount of paper plies	14 plies
Amount of glue wipers for one paper ply	1 glue wiper for one paper ply

The amount of original wipers (OGW), used in 1 Year for 7 cardboards tubes machines, when 14 wipers are used for one machine:

OGW= (amount of weeks in 1 Year / Original glue wipers working time (in weeks) until depreciation)*Average amount of paper plies;

OGW= (52/2)*14=364 original wipers.

The amount of modernized wipers (MGW), used in 1 Year for 7 cardboards tubes machines, when 14 wipers are used for one machine:

MGW= (amount of weeks in 1 Year / Modernized glue wipers working time (in weeks) until depreciation)*Average amount of paper plies;

MGW= (52/4)*14=182 modernized wipers.

Then the price for 364 original glue wipers (POGW) is:

POGW= OGW*Price of original glue wiper;

POGW= 364*30= 10 920 €.

The price for 182 modernized glue wipers (PMGW) is:

MOGW= MGW*Price of original glue wiper;

MOGW= 182*10= 1 820 €.

Savings, which can be saved by using modernized glue wipers instead of orifinal ones in 1 Year period are:

Savings (S)= POGW-MOGW

Savings (S)= 10 920-1 820 = 9 100 €.

As a result, 9 100 € can be saved in 1 Year by using modernized glue wipers instead of original ones.

4. CONCLUSIONS

The aim of this bachelor work was to modify and simplify original glue wipers that are used in cardboard tube machines, because of their ponderous and clumsy shape, non-durable material and time-consuming manufacturing operations, needed to be done to produce this device.

While performing the modernization of an original glue wiper, the recommendations and advices of lathe operators were considered. In this work the particularities of original glue wiper, such as the material, shape, size, manufacturing and sharpening complicity were analyzed in order the best results would be achieved in modernizing it.

1. The technological part was about choosing the material and designing shape and size in such a way that the modernized glue wiper would be lighter, easier manufactured and sharpened in comparing with the original; but still would clean the glue from the paper at a high quality.

2. By choosing the material, many experiments were done in order to find enough tough and durable material to hold out high mechanical loads and wear-out less. The selected material for modernized glue wiper was alloy tool steel (6Х4М2ФС) with 4 % of chromium impurities, which is reused from rejected band-saw blade. This material perfectly cleans the excess of glue from the paper in cardboard tube machine and is more ecological choice in comparison with the original one.

3. The simplified but still fulfilling high quality requirements shape and sized werereconsidered and redesigned for a modernized glue wiper. Also the weight of this wiper was 6 times reduced in order to diminish expenses for the material and alleviate the exchange of these devices.

4. Instead of 5 long and complicated manufacturing operations to produce original glue wiper, just 2 easy and quick operations are need to be done to manufacture the modernized one. Also fast and effortless cleaning and sharpening processes of modernized glue wipers were considered and analyzed.

The economical part of this workwas about analyzing the private company “Baltijos Brasta”, calculating costs for producing modernized glue wipers and comparing the original glue wiper and the modernized one prices.

1. The analysis of“BaltijosBrasta” was made by reviewing the technological, legal and political, ecological, demographic, economic and competitive environments of the company and investigation of penetration and development of the company.

2. The calculations of fixed, variable, general, average general and average variable costs were performed in order to discover the costs of the private enterprise “Egidijaus Mačiulio firma” to produce modernized glue wiper.

3. After calculating of modernized glue wiper price and comparing original glue wiper price (30 €) and modernized one price (10 €), there was found that three modernized glue wipers can be bought instead of one original wiper. The expenses of original and modernized glue wiper in 1 Year period were also calculated and compared. As a result 9 100 € can be saved in 1 Year by using modernized glue wipers instead of original ones.

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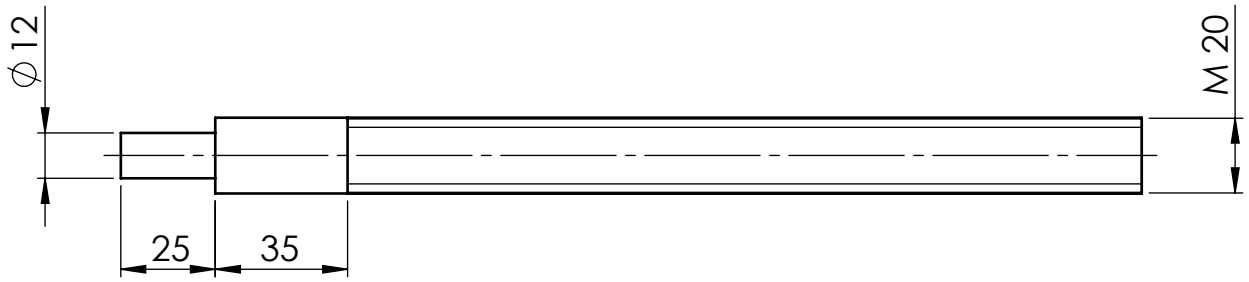
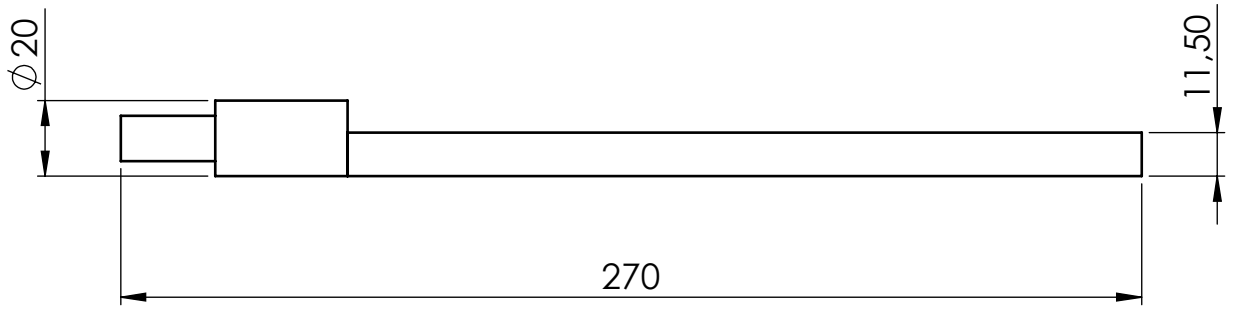
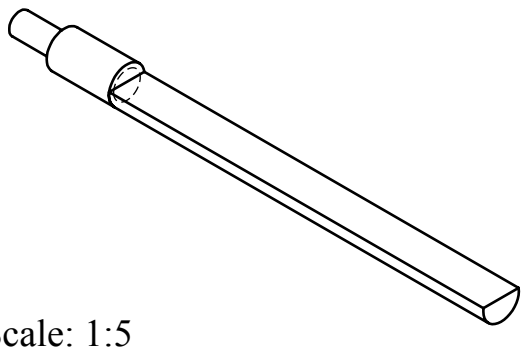
APPENDIX A: Drawings

Appendix -1: GLUE WIPER

Appendix -2: MODERNIZED GLUE WIPER

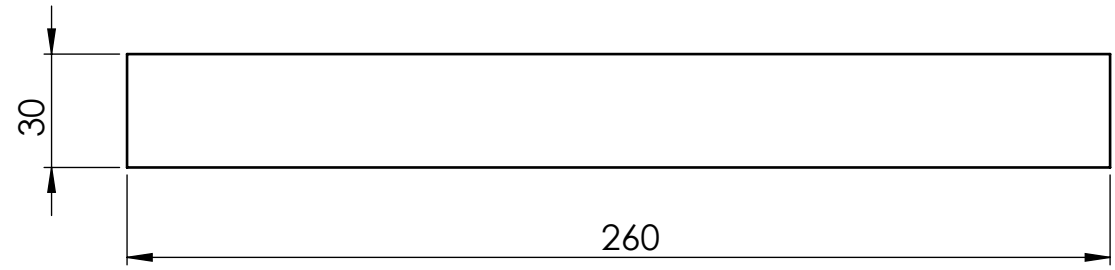


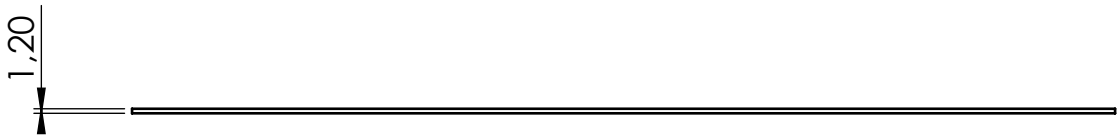




Scale: 1:5

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:	FINISH:		DEBUR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION	
	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	M. Mačiulytė		2015.03.15	Glue wiper		
CHK'D	I. Skiedraitė		2015.03.17			
APPV'D						
MFG						
Q.A				MATERIAL: Steel 45	DWG NO. DWG OGW 1	A4
				WEIGHT: 450 g	SCALE: 1:5	SHEET 1 OF 1





UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:	FINISH:		DEBUR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION	
	NAME	SIGNATURE	DATE	TITLE:		
DRAWN	M. Mačiulytė		2015.03.17	Modernized Glue Wiper		
CHK'D	I. Skiedraitė		2015.03.19			
APPV'D						
MFG						
Q.A				MATERIAL: Alloy tool steel 6Х4М2ФС	DWG NO. DWG MGW 1	A4
				WEIGHT: 74 g	SCALE: 1:2	SHEET 1 OF 1