Walnut Cracking Machine

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Bragança 2020

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Bragança 2020

Acknowledgment

In terms of writing this project,

We always thank our god

The one who always lights up our lives with knowledge,

He guided us on the right path.

At the end of this work, we wish

We express our gratitude and gratitude

Heartfelt thanks:

To my supervisors: Mr. ***Luís Manuel Frölén Ribeiro***

And Mr. ***Yassin Ferchichi***

They managed to guide me

Provide guidance throughout the preparation period

my final project.

All my family, teachers and friends

Who encouraged me to do this thesis,

And the Escola Superior de Tecnologia e Gestào of Institudo Politécnico de Bragança and branch Electromechanical Engineering in the Université Libre de Tunis

Abstract

The traditional strategy of breaking walnuts physically, utilizing a hammer or cut cutter is labor-seriously, moderate, and repetitive. We report this project of walnut cracking machine technical drawing for the construction of the cracking machine and the belt conveyor are also presented. the prototype consists of a belt conveyor transport the walnut to the cracking machine. A breaking unit works on the rule of attraction utilizing crushing drive from tow rollers.

The aim of this project is to create a nut-cracking machine that will be able to reliably accomplish both cracking as well as conveying of nuts. and crack the different sizes of shells. for the construction of the cracking machine, 51% of the components are standard and 49% will have manufactured. A device of this nature can be manufactured for small entrepreneurs and industrial-level applications in the countries where the bulk of the world walnut is produced.

Resumé

La stratégie traditionnelle de casser les noix physiquement, en utilisant un marteau ou un cutter, est un travail sérieux, modéré et répétitif. Nous rapportons ce projet de dessin technique de machine de craquage de noix pour la construction de la machine de craquage et le convoyeur à bande sont également présentés. Le prototype consiste en un convoyeur à bande transportant la noix vers la machine de craquage. Une unité de rupture fonctionne selon la règle de l'attraction en utilisant l'entraînement par écrasement des rouleaux de remorquage.

Le but de ce projet est de créer une machine à casser les noix qui sera capable de réaliser de manière fiable à la fois la fissuration et le transport des noix, et casser les différentes tailles de coquilles. Pour la construction de la machine de craquage, 51% des composants sont standards et 49% l'auront fabriqué. Un dispositif de cette nature peut être fabriqué pour les petits entrepreneurs et les applications de niveau industriel dans les pays où la majeure partie de la noix mondiale est produite.

Contents

List of Figures

List of Tables

Chapter 1 : Introduction

1.1. Introduction

The walnut is an old species starting from Central Asia which always had a good nutritional value but at present, it has developed commercially all through Southern Europe, Northern Africa, Eastern Asia, the USA and Western South America. Walnuts are receiving such interest as healthy food stuff due to the fact that their customary utilization has been shown to diminish the chance of coronary heart illness. The world generation of entire walnut (with shell) was around 3415000 metric tons in 2011. China, Iran, USA and Turkey were the major makers, with almost 48.4, 14.2, 12.2 and 5.4 percent of the whole generation, separately in 2011. In the past, walnuts have been physically broken by an individual using a pound on a gathering line, at the same time. Such breaking strategy has delivered great results, but is slow, extremely labor extensive, and, thus, very costly to maintain and hardly adaptable to scale up operations and large-scale projects.

In the recent years a number of nut cracking machines have been developed with different designs and different functionalities such as cracking and nut from kernel separation, these different designs can be studied as a reference to develop our own nut cracking solution.

1.2. Objectives

The aim of this project is to create a nut-cracking machine that will be able to reliably accomplish both cracking and separation as well as conveying of nuts. The cracking unit therefore needs to have a flexible range of cracking, to efficiently process different sizes of shells.

1.3. Structure of thesis

This dissertation contains 5 chapters. The first chapter is the introduction in which the objective and the framework are introduced.

The second chapter is the theoretic foundations in which previous studies in cracking machine and production of walnuts all over the word are presented as state of art. Also, the choice of pieces of the cracking machine is examined based on functional analysis.

The third chapter is materials and methods. It contains the machine dimensionnement.

The fourth chapter is discussion of results obtained from the machine designing.

Finally, the fifth chapter contains the conclusions of the thesis and proposal for future work.

Chapter 2 : Theoretic Foundations

2.1. State of the art

2.1.1. Choice of eatable nut

Nuts are a food group that includes almonds, Brazil nuts, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios, peanuts and walnuts. Due to their particular high content in fats and low water and the reason to consume nuts is associated with better cardiovascular health due to their content in arginine, magnesium, selenium, polyphenols, and unsaturated fatty acid profile and she help improve glycemic control, blood pressure and blood lipids (cholesterol levels), therefore they are recommended for diabetes, obesity or metabolic syndrome this pushed us to talk about the nuts of production in the world, where the USA is the leading tree nut producer. In 2017/2018 it accounted for 38% of total tree nut production, amounting to over 1.6 million MT: 95% of the U.S. tree nut production was composed of almonds (62%), pistachios (17%), and walnuts (16%). Turkey and China accounted for the following 10% and 9% of the world share respectively, followed by Iran (7%) and India (5%). In turn, 83% of the tree nut production in Turkey was hazelnut and 11%pistachio; in China, 96% was walnut. China is the world's biggest producer of walnuts. In the year 2017/18, the country produced 871,849 metric tons of walnut China and the USA were the world's top producing countries, accounting for 42% and 29% of the share, respectively, Chile (7%), Ukraine (6%), Iran (4%) and France (2%) completed the ranking [1].

Table 1: Walnuts production in the world in metric tons[1]

Rank	Country	Walnut production 2017/18 (metric tons)
1	China	369,000
2	United States	259,389
3	Chile	65,000
4	Ukraine	51,750
5	Iran	38,000
6	France	17,500
7	Others	80,210

In Portugal, the main edible nuts produced and exported are listed in Table 2, among these nuts are walnuts, hazelnuts, and almonds are the ones that we can choose to design a nutcracker, because the nature of chestnuts requires a different process such as exfoliation and cracking of blood vessels.

Table 2: Production amounts of different nuts in Portugal in metric tons

Years	Almonds	Chestnuts	Hazelnuts	Walnuts
2010	7012	22350	342	3350
2011	7680	18271	343	3731
2012	7178	19130	299	4216
2013	4446	24739	337	5609
2014	9033	18464	352	4133
2015	10090	27628	360	4062
2015	8713	26780	321	4315
2017	23140	29875	307	5485
2018	14304	34165	240	4576

http://www.fao.org/faostat/en/#data/QC

The first step in this project will be the choice of the adequate edible nut, as the differences in sizes and hardness will prevent us from designing a single system. According to the table, the edible nuts, which are produced the most are chestnut and almonds, respectively followed by walnuts and hazelnuts.

Since chestnut has no hard shell, is mostly exported in fresh or dried state and not peeled, the remaining targets for the project are either almonds, walnuts, hazelnuts, or a combination.

2.1.2. Types of nut crackers

We can distinguish several types of nut crackers and we can differentiate them via several criteria, for example: automated vs non automated, shell breaking only vs shell breaking and separation.

The following examples represent some nutcracking machines available on the market:

2.1.2.1. Manual nutcracker without separation

While there are thousands of models for manual nutcrackers, this model is one of the most popular with a main principle of a funnel that directs the nuts inside a rectangular box in which a rotating dented wheel presses the nuts against a hard surface which cracks the shells. The mixture of shells and kernels is then expelled from a single outlet.

This particular product weighs 3 kilograms and is made out of steel and her price is 35.44€.

Figure 1: Hand Crack manual nutcracker [1.1]

2.1.2.2. Electrical nutcracker without separation

The basic automatic electric nutcracker is product has a small size which has to be screwed to a surface to operate optimally. At optimal output it can reach between 70 kg of walnuts per hour. The essential principle is the same as the manual cracker, which is a dented rotating wheel against a hard surface, and her price is 620.01€.

Figure 2: Basic Automatic Electric nutcracker [1.2]

2.1.2.3. Electrical nutcracker with separation

Examples from articles:

- **Case 1:**

The variable size nutcracker design was presented by the university of Lagos Nigeria,[2], in which an electrical motor controls both cracking and separation. The cracking mechanism is based on a rotating wheel that presses the nuts against a hard-curved surface.

The separation of kernel from shells is addressed via a two-stage separation tray supported by a compression string.

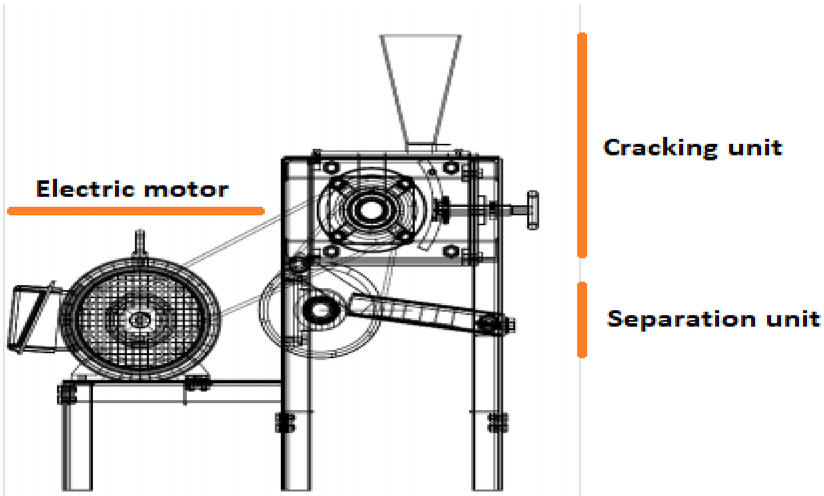


Figure 3: nutcracker with separation [2]

The dual-purpose machine is made up of three major components, the cracking unit, support frame and sorting unit. The cracking unit comprises of a pyramidal frustum hopper and rectangular box housing the cracking drum and compression plate, while the sorting unit is an agitated two stage separating tray supported by compression spring. The frame provides support and housing to all components of the cracking and sorting unit as well as the electric motor and the two pulleys which provide the motion driving the cracking drum and the separation tray. The cracking drum, which is driven by a v-belt connected to an electric motor, also provides the agitation to the separating tray via a v-belt connected to a cam mounted shaft that helps push the tray against stationary springs which in turn return the tray to its initial position upon the dwell of the cam [2].

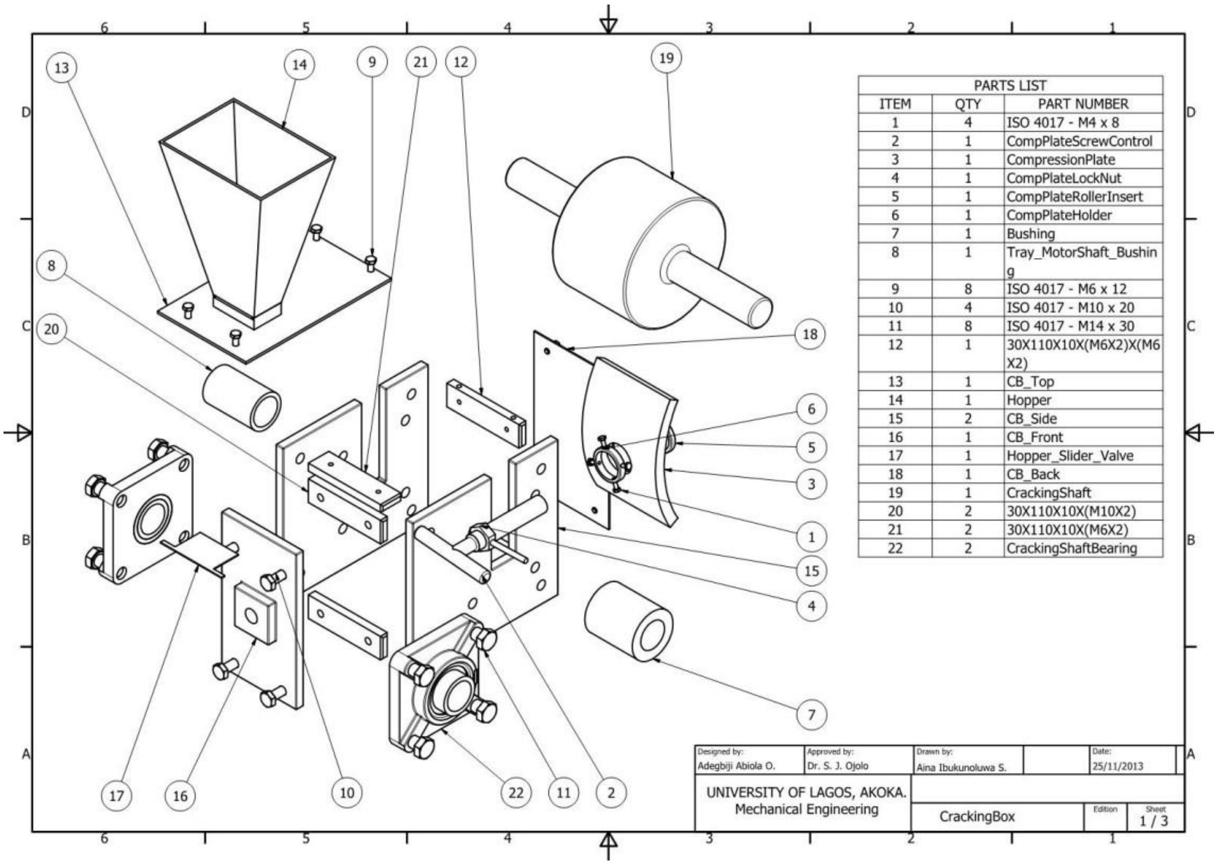


Figure 4: Bill of materials of the machine [2]

The machine performs satisfactorily when tested with palm kernel, the strongest of the class of nuts with a cracking efficiency of 87% and whole kernel recovery of 87%. The machine is adaptable to the cracking requirements of some number of nuts, the theoretical throughput capacity of the machine is about 73.7 kg/min. The power requirement for cracking palm kernel nut 1.82 kW and the theoretical throughput capacity 73.7 kg/min is relatively comparable to 1.76 kW and 94.2 kg/min.

- **Case 2**

The second case is the one published by Urmia university for a walnut cracker that focuses on the difference in size between nuts.

In this machine, 6 semi-cone shaped funnels are used to break walnuts. Maximum and minimum diameters of the funnel were determined according to the largest and the smallest walnuts in the sample which appeared respectively to be 45 and 25 mm. Each funnel has a lengthwise groove in its sidewall. There is spout-shaped bar in each groove. The bar will be forced inside the funnel which will break the walnut inside. Afterwhich, a spring will retract the bar to its initial position and the funnels will perform a 154° rotation to deverse their contents on collection tray [3].

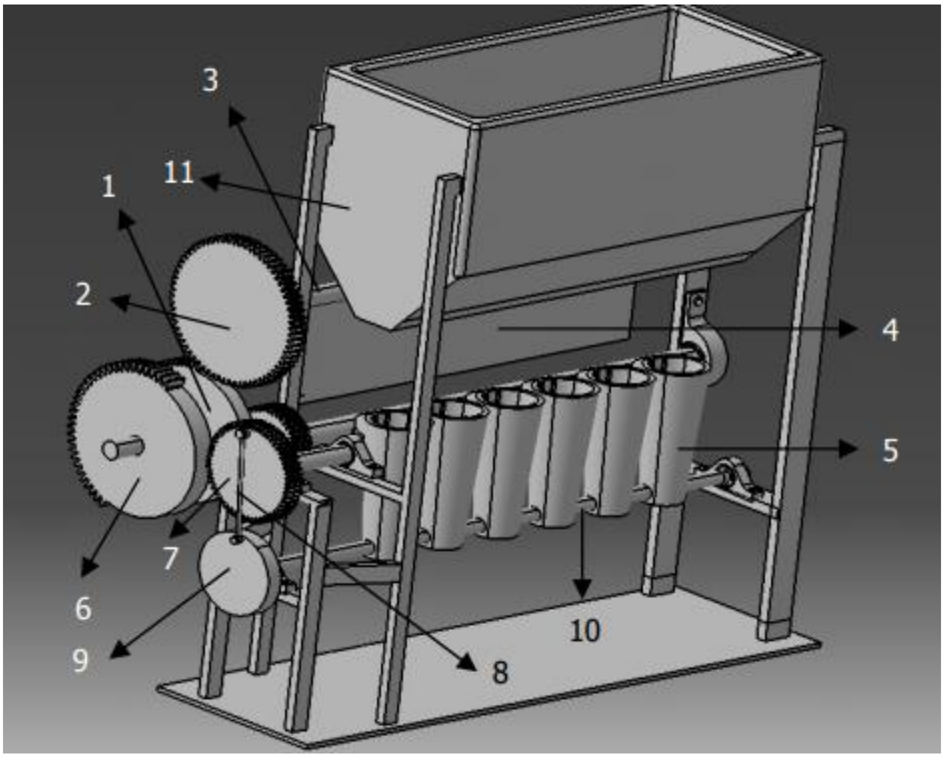


Figure 5: Complete machine pattern from the Urmia machine [3]

The components are as follows: 1, 2, 3, 4- Walnut transmitting mechanism. 5- Funnel, 6- Gear, driving crank-and-rocker mechanism. 7, 8, 9- crank-and-rocker mechanism. 10- Funnels shaft.11- Walnut bin [3].

Each funnel has a lengthwise groove in its sidewall. There is spout-shaped bar in each groove which bottom end of this bar is fixed to the funnel, whereas the top end of it is free. The bar will be forced inside the funnel by special cam mounted on the cam rod driven by its own gear. This action will break the walnut inside the funnel. As soon as the cam passed the bar, a spring, which is located near the bottom of the bar, will return the bar to its original position. Following the breaking action. The funnel shaft rotates about 154 degrees around its axial. This results in emitting all funnels to the collecting plate. The funnel shaft again rotates back to its original position. The rotation of the funnel shaft and its return action is provided through a crank-and rocker mechanism. Funnel shaft speed was calculated according to the time required for emitting and returning the funnels, 3 seconds, which appeared to be 20 rpm. After this, a lag of 3 seconds was provided during the rotation of funnel shaft. This period was considered for funnel filling and walnut breaking [3].

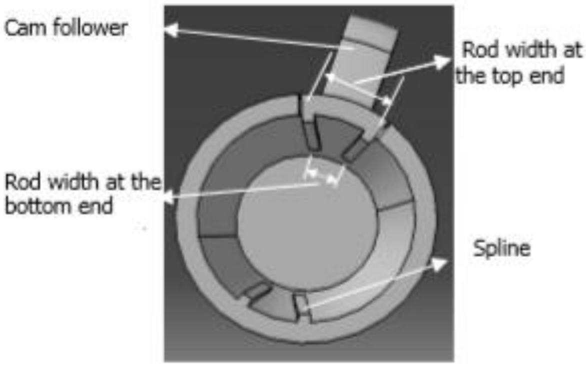


Figure 6: The funnel inside view [3]

The power required for the operation of 3 different mechanisms; walnut transmitting, walnut breaking, and funnel emitting, was provided by employing an electromotor with a capacity of about 50 Watt. Electromotor shaft has 3 different gears. Gear no. 1 which toothed only 60 degrees of its circumference, incorporate for walnut transmitting. This special pattern of the gear opens the bottom plate of the bin and let a spring action to close it again. The time calculated for this action was 1.5 seconds. The breaking action receives the required power through 2 gears; First one is mounted on the electromotor shaft and the other one wich engaged with the first one is located on the cam shaft. The emitting action of funnels provided by gears no. 6 and 7. Gear no. 6 has been toothed only 180 degrees which causes the funnels to turn over for emptying and then to return to its original position [3].

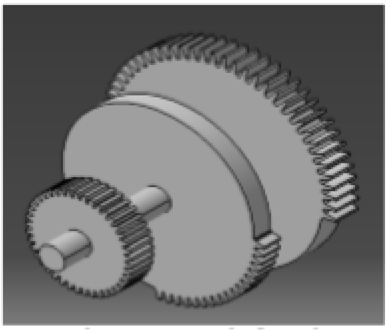


Figure 7: Electromotor shaft with 3 gears [3]

After Mechanical/Biomechanical tests, the optimal force and power to crack a single walnut is of 797 N/ kN and 1.99 W.

There is no separation system included this specific case, but it can be added separately as a step after the collection inside the tray (not shown in figure).

- **Case 3:**

The nutcracker is a design published by University of Lagos and Landmark [4] consist of cracking chamber, as shown in Figure 8.

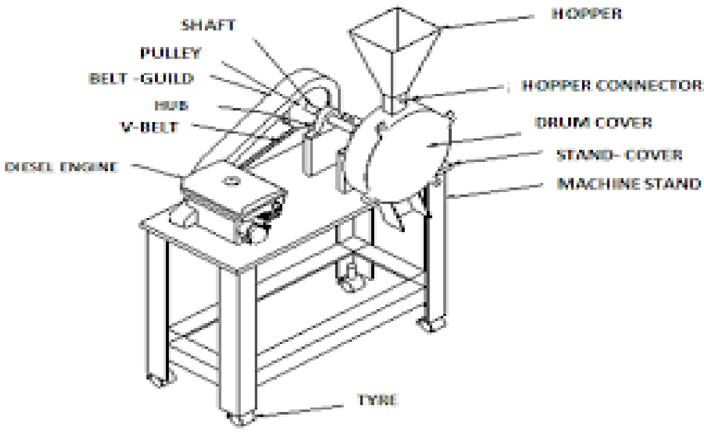


Figure 8: Design of an improved palm kernel shelling and sorting machine [4]

The cracking chamber, as shown in Figure 9 (b) using computer aided design (CAD), takes the shape of a hollow cylindrical tube with rectangular (channel-shaped) impeller blades at its core. The cylinder measures 375 × 400mm in its minor and major diameters respectively, and 175mm in its length. The cracking chamber is bored at a diameter of 80mm at the back surface to enable the passage of the driving shaft to the core of the chamber through the ball bearing. However, the core of the cracking chamber is characterized with the impeller tube and blades; the tube being the carriage for the rotary motion of the blades. The schematic view of the cracking chamber and its core is as shown in Figure 9. The cracking process is achieved by the impact force exerted on the kernels by the impeller blades against the walls of the cracking chamber. This impact force is generated by the kinetic energy of the impeller blades; the latter being facilitated by the high velocity rotary motion of the carriage tube on which the impeller blades are attached. Each kernel nut being fed to the cracking chamber is struck against the walls of the chamber by the high velocity impeller blades, thus creating sufficient impact force to lose each kernel seed from its shell covering. The cracking unit is also made of mild steel [4].

The optimal capacity of the machine is 59 kg/h and the power is 1,55 kW.

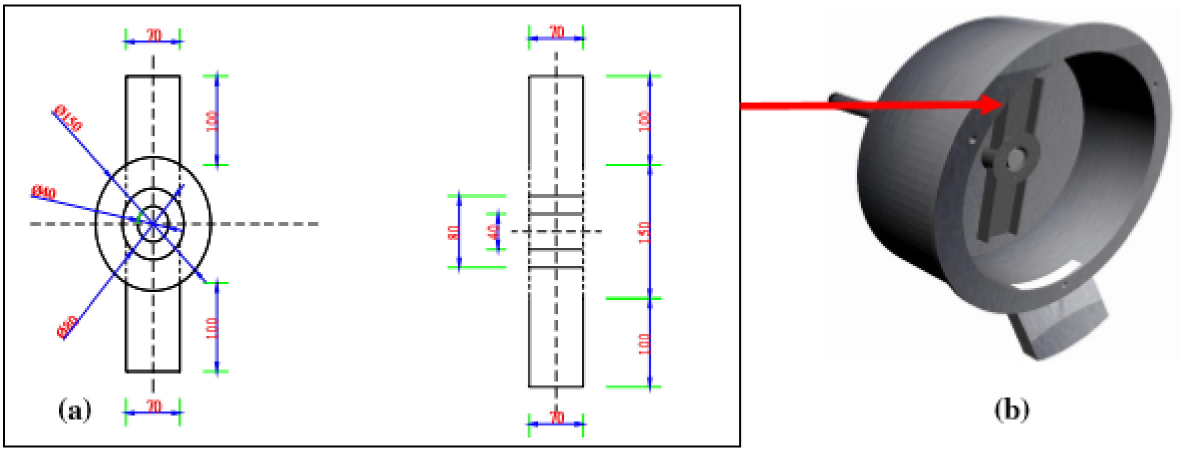


Figure 9: (a) Schematic view of the cracking impeller (b) The CAD drawing of cracking chamber [4]

- **Case 4:**

The machine is a simple device, it consists of six main components assembled. The cracker, which consists of the stand, a hopper equipped with a flow control device, a cracking unit, a tank and a feeding system, works on the principle of attrition using the crushing force of a cylinder and a propeller. The outer cylinder is made of polyethylene, with a length of 200 mm and a diameter of 125 mm. The hopper is also made of polyethylene, with a length of 300 mm and a diameter of 140 mm [5].

The cracking unit consists of a cylindrical hull and a propeller that cracked walnut withstanding between them. The propeller can rotate freely inside the stationary outer cylinder when fed from the shaft via a chain arrangement. The propeller is mounted to give less clearance than walnut with a cracked cylinder surface. The distance between the propeller and the cylinder is variable and this is enough to crack nuts, the average diameter of which is about 30 to 40 mm [5].

After biomechanical tests, the optimal power needed to crack the walnut is 391.86 kW and the capacity of the machine was estimated to be about 25.2 kg/hr.

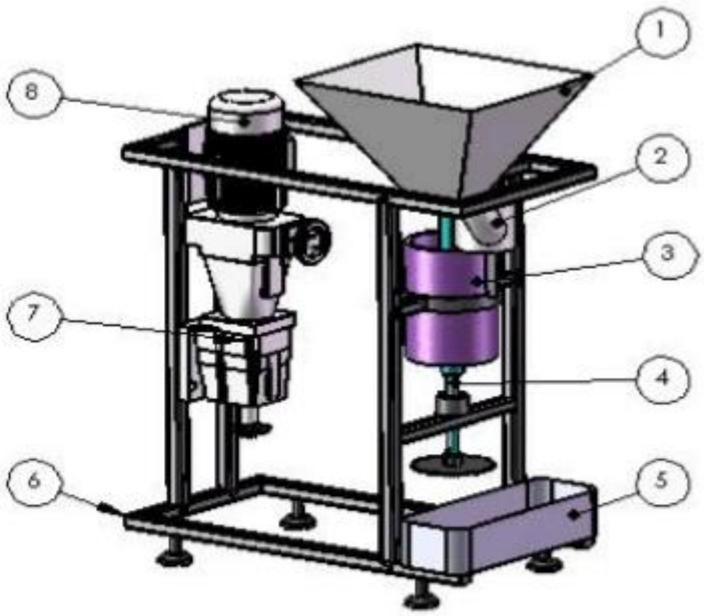


Figure 10: Schematic of a complete assembly of the walnut cracker (1.hopper, 2.flow divider, 3.Cylinder, 4.Helix, 5. Reservoir, 6. Stand, 7.Gearbox, 8.Electromotor) [5]

2.1.3. Types of transports walnuts (conveyor)

The transports systems have many different designs and uses. Common conveyor types are belt conveyors, roller conveyors, motorized roller conveyors and overhead conveyors. Use them to move products from point A to B, create buffers and deliver products in sequence in a production process. Speed can be variable with a variable speed drive

Belt conveyor

A belt conveyor is one of the simplest conveyor types. It moves parts from one end to the other. Speed can be variable with a variable speed drive. They many types of belts conveyor per example flat belt conveyor and roller bed belt conveyor and cleated belt conveyors

- **Case 1:**

Cleated belt conveyor features vertical cleats or barriers in their designs. These cleats can keep loose materials secure during inclines and declines, to provide consistent spacing between items, and more, cleats come in different shapes, it is designed to carry loose materials up a steep incline.

Figure 11: Cleated belt conveyor [1.3]

- **Cases 2:**

Roller bed belt conveyor is a kind of conveyor which uses several rollers which are set up on the fixed support according to a certain distance to transport goods. Roller bed belt conveyor is suitable for all kinds of boxes, bags, pallets and other pieces of cargo transportation, mostly used for station or airport luggage sorting [1.3].

Figure 12: Roller bed belt conveyor [1.3]

- **Cases 3**

Trough belt conveyor has a large loading and conveying capacity, the conveyor belt of the trough belt conveyor adopts multi-layer rubber belt, with the belt width of 500mm, 650mm, 800mm, 1000mm, 1200mm and 1400mm. The carrying side conveyor belt is supported by a troughed idler that composed of 3 rollers (the angle of the trough can reach 45°), and the return idlers are supported by flat rollers. Trough belt conveyors are widely used in electric power, iron and steel, mining, port, cement, grain, feed processing industry. Trough belt conveyors can transport bulk materials with large proportion such as coal, ore, soil, chemical raw materials, grain, etc., which are more suitable for a relatively poor production environment [1.3].

Figure 13: Flat belt conveyor [1.3]

- **Case 4**

loor mounted chain conveyors are great for heavy items and especially for items that have an uneven lower surface. The chains provide two or three contact points on the bottom of the load, and as the chain moves it carries the product forward. They are used to carry pallets and large industrial containers. If necessary, products can be mounted on a fixture, or "skid" and the fixture can be carried along the chains. This is a common application in auto plants. They are heavy duty, and generally move at slow speeds [1.3].

Figure 14:Chain conveyor [1.3]

2.1.4. Type of separation units

The primary purpose of the separator unit is to separate shell, nuts and cracked pieces after cracking we can use many things per example air blower and machine to separate

2.1.4.1. Air blower

In the study present by [6], a winnowing column is used for the dry separation of kernel and shell from the nut's cracked mixture. The system consists of five winnowing columns that can cater about 10 t/h of the cracked nut mixture throughput was developed. In addition to aiming for a totally dry process, it is also designed to improve the separation efficiency of the cracked nut mixture to provide better kernel recovery and shell removal. Figure 15 (left) shows a single-stage winnowing column, whereas Figure 15 (right) shows a dry separation system, the five-stage winnowing column system. Each column is designed with different specifications, viz. airflow rate, column height, inlet level and outlet level. The shell and core part of this system works on the principle of the specific gravity differential of materials in the presence of high-speed airflow produced by a blower operating by electrical engine. Each stage, as shown in Figure 15 (left), consists of a blower, an ablation column, stream and cyclone, where separation occurs in each column, but separate matter not necessarily discharged. Circular air ducts connect the upper end of the shaft to the cyclone. The first column empties most of the crust after the cyclone unit where the core is heavy, the shell is sent to the second column. The second column discharges most of the core and the remaining shells and a light core are sent to the third column. Light materials that go into the twister is still a mixture of kernel and crust that will once again be subject to more rigor separation in the following stages. Its quality is not critical. In the fifth stage of the system, separation takes place the shaft will lift almost all of the shells and deposit them in the cyclone due to reduced height hurricane and Canal. If some small, broken, and crusted kernels remain, they will still be it is discharged from the lower chute of the 5th shaft. Casing removal drum unit with a grid size between 14 and 16 mm placed between the first and second columns to remove any contaminant, especially thick husks (large and small) and unbroken nuts. Proceed to the next chapter column. These shell fragments are removed at an early stage. It reduces the load of the cracked mixture to be separated in the later stages [6].

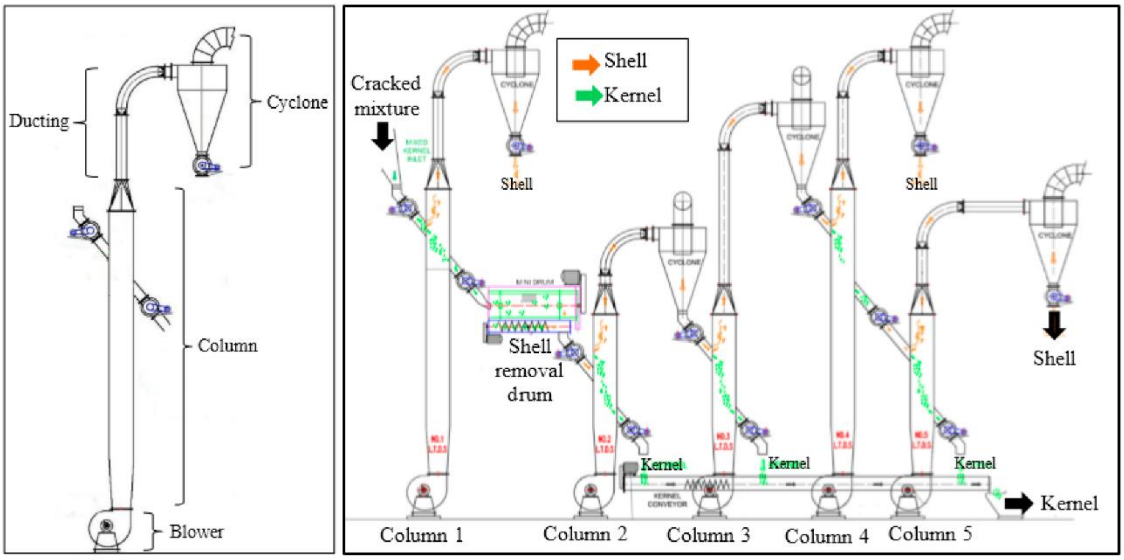


Figure 15: (Left) The single stage consists of a blower, shaft, channel and helical unit; And (Right) a five-stage column winnowing system to separate the kernels from the crushed nut mixture [6]

2.1.4.2. Automatic separation units

The sorting unit is made up of a rectangular metallic mesh with uniform rectangular grooves of diameter 10mm. This unit is directly attached to the nut outlet discharge of the cracking chamber, and it spans a total length of 400mm, width of 180mm, and height of 100mm. This unit operates in the form of an agitated basket and is stimulated by the vibration effect from the electric motor; an action which toggles it forward, backward and sideways. The cracking chamber, however, ensures that the shell coverings are effectively crushed to smaller particles compared to the kernel seeds. This crushing ensures that the variation in size between the kernel seeds and the shells is large, hence the feasibility of the sieving-separation approach. More so, the diameter of the mesh grooves selected is smaller than the average kernel seed diameter (15mm) and this ensures that the kernel seeds are not ejected along the sorting route. Along the sorting route is a part referred to as a speed breaker. The speed breaker, a functions to reduce the velocity of discharge of the nuts and shells from the cracking chamber, with a clearance of 20 mm from the sorting tray (Figure 16), to ensure efficient sieve separation experimental observation proves that palm kernel seeds have a dynamic angle of repose of approximately 20° on mild steel; an angle which is lesser than the dynamic angle of repose of the shells on mild steel. This implies that the kernel seeds will develop a higher velocity coefficient along the slope, compared to their shell counterpart and hence will avoid expulsion through the grooves. Therefore, the sorting tray is inclined at an angle of 20° to the horizontal, thus ensuring that the kernels seeds freely slide over the mesh grooves while the shells are properly expelled from the mesh grooves. action along the sorting route [4].

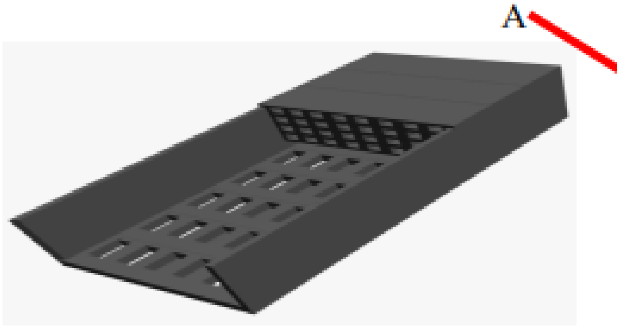


Figure 16: separation unit [4]

2.2. Functional analysis

2.2.1. Introduction

Functional analysis consists in identifying characterizing or giving hierarchical and valuing all the functions of a product throughout its life cycle. For a given product the functional analysis uses interdependent point of view. The external point of view is that of the user, who expects the product of the services, or the function of the services. The internal point of view is that of the designers who carry out technical functions capable of ensuring the service functions.

- **Specification**

Project tittle: Study, design walnut cracking machine.

Name of the software used: Solid works

Product characteristics

Use: Easy to design, build and use.

Capacity: System adaptable for all different size of the walnuts

Security: Satisfy a minimum of security

Allotted time: 10 months

2.2.2. Functional analysis of the system

2.2.2.1. Global function

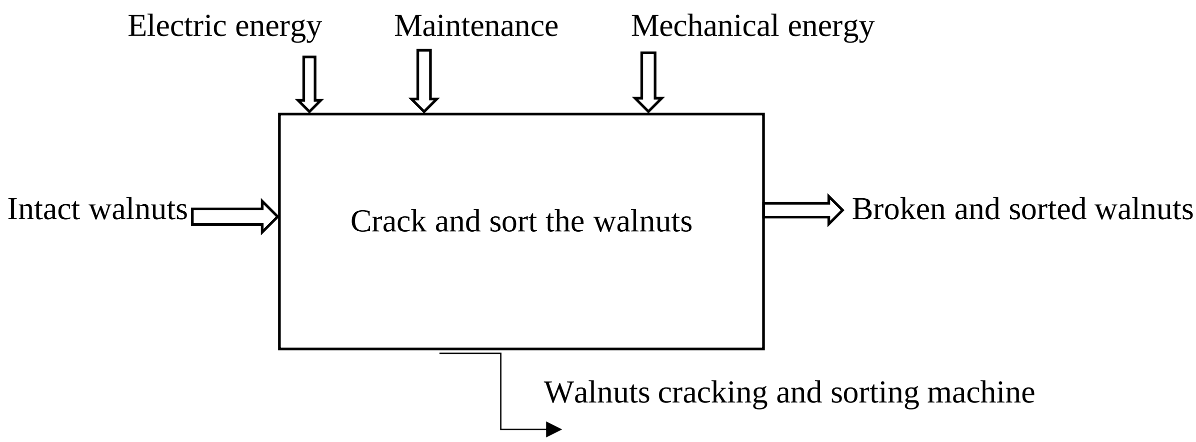


Figure 17: Usage function

2.2.2.2. FAST Diagram (function analysis system technique)

Is a type of diagram that shows a way of thinking, acting, or talking? The FAST diagram is constructed from left to right, in the following logic: from "why" to "how". Thanks to their technical and scientific culture, the engineer develops the service functions of the product into technical functions. The choose solutions to ultimately build the product. The FAST diagram then constitutes a set of essential data allowing to have a good knowledge of a complex product and thus, to be able to improve the proposed solution. The next figure shows a sample for fast diagram.

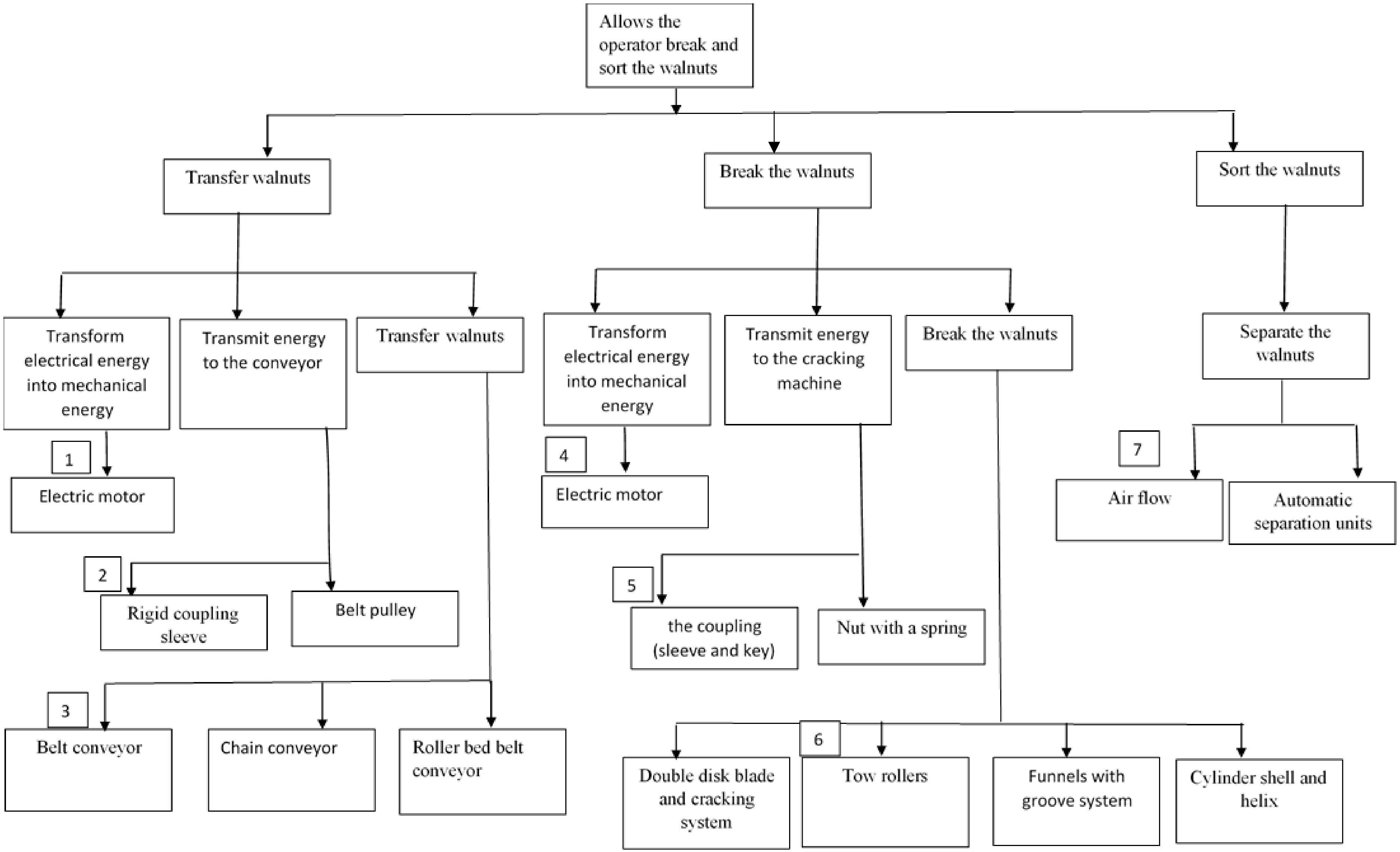


Figure 18 : Diagram FAST

- Choices

This project consists 3 parts (transfer walnuts, break the walnuts and sorts the walnuts). The first part we ask how to can transfers the walnut to the break nuts also in the second part how to can break the walnut then finally how to can sorts the walnuts.

1) The electric motor converts the electricity supplied by the standard grid into mechanical energy, almost zero pollution, silent operation and easy driving.
2) These coupling are exceptionally common and comprise tow isolated flanged part that are blasted together, easy to collect and dismantle, tall torque transmitting capacity, simple in construction, easy to plan and fabricate.
3) Reduction in energy consumption, silent continuous transport and require less manpower, less prone to breakdowns and less accident manpower and multipoint loading is convenient.
4) The electric motor converts the electricity supplied by the standard grid into mechanical energy, almost zero pollution, silent operation and easy driving.
5) It is the best sort of inflexible coupling made of fetched, it comprises of an empty barrel whose inside diameter is the same as that of the shaft, it is mounted on the closes of two shafts by implies of a flat-head key.
6) Facilitates the design and build and if and if we want to change the nuts, we have another solution, the rolls should be covered with rubber or wood.
7) Large air volume against, low pressure and relatively small size and low noise level.

Chapter 3 : Materials and Methods

3.1. Need analysis

- **Horned beast**

It is a process which consists in analyzing a product by examining it both from the inside and from outside in order to pay attention to interaction between the different elements and its environment.

specify the object and the limits of the study asking the following three questions.

Question 1: To whom (to what) does the product serve?

Answer: The operator

Question 2: On what (on whom) it acts?

Answer: The walnut

Question 3: What purpose?

Answer: To brake and sort.

For this effect, we place these data in a graph called beast with horn.

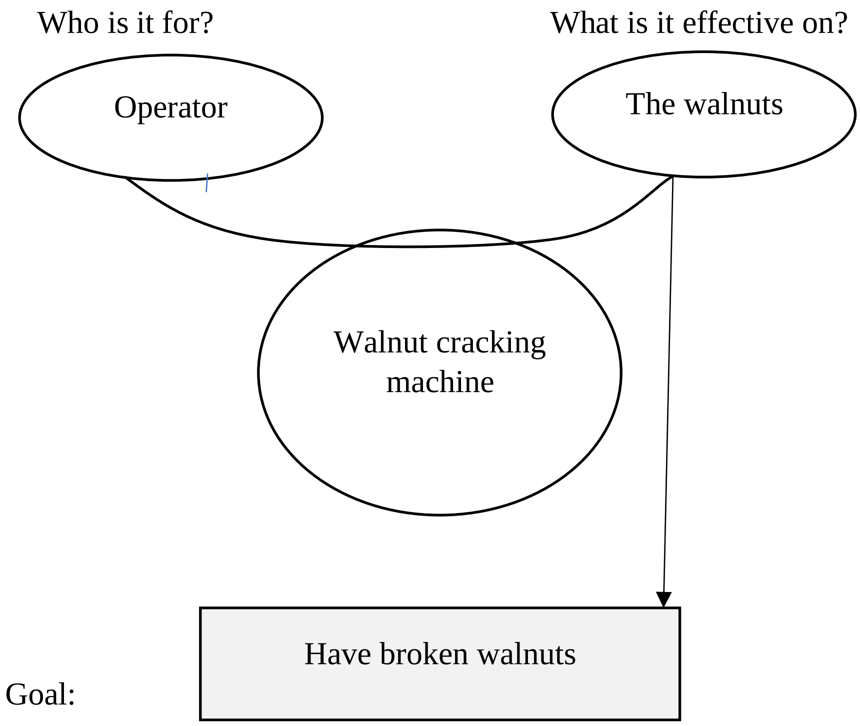


Figure 19: Horned beast diagram

The environmental element of product:

- Operator
- Break the walnuts
- The size of the walnuts
- Electric energy
- Cost
- Control
- Outdoor atmosphere

- **Octopus diagram**

The octopus diagram has for everyone to identify the service functions of a product. This diagram consists of the product at the center and around the elements of its environment. The surrounding environment of a product is the set of physical, human, economic components. In relation to the product during its life cycle (matter of work, energy, user, convenience store, atmosphere withdrawal from services.

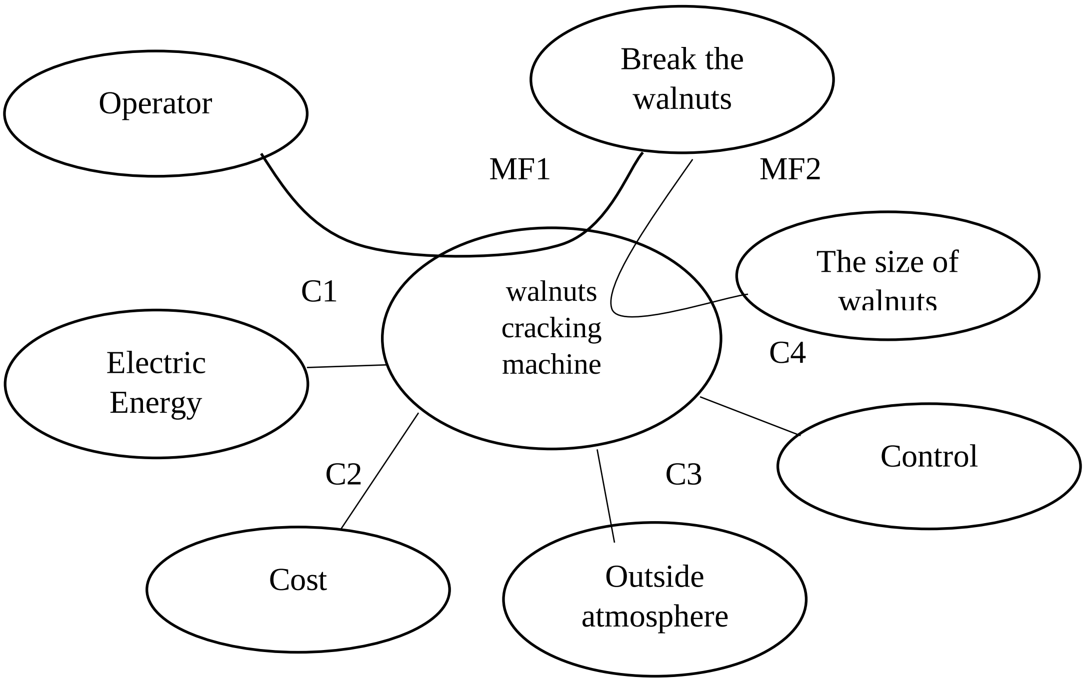


Figure 20: The octopus's diagram

Table 3: Service functions

MF1	Allows the operator to break the walnuts
MF2	Be adaptable for a different size of walnuts
CF1	Be supplied with electrical energy
CF2	Have reasonable design and manufacture
CF3	Resist the outdoor atmosphere
CF4	To be controlled

3.2. The objective

the objective of this chapter to determine the dimensions of the main components of cracking machine and consists:

- Belt conveyor
- Support
- Break the nuts (tow rolls)
- Separator (separating nutshell from kernel)

3.2.1. Belt conveyer

3.2.2.1. Definition of the belt conveyor

The function of belt conveyor is to continuously transport mixed or homogeneous bulk product over distances ranging from a few meters to ten of kilometers and is designed to transport product continuously on the upper side of the belt. The electrical and mechanical components of conveyors such as rollers, drums, bearing, motors are manufactured to the highest standards.

The advantage for belt conveyor is many and we chose this:

- Reduction in energy consumption
- Long intervals between maintenance periods
- Reduction in operating costs

3.2.2.2. Dimension and design

- **Belt Details Dimension, Capacity and Speed**

The design of a belt conveyor system takes into consideration the followings: dimension, capacity and speed, belt power and tension, idler spacing, motor, type of drive unit, control mode, intended application and maximum loading capacity.

Given:

Height: 80 mm

Angle of inclination: 30°

Width of cleats: b= 40mm

Height of cleats: h=40mm

Distance between cleats: bm=200 mm

Band width: B=400 mm

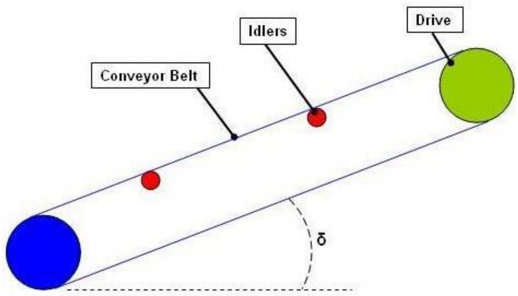


Figure 21:Conveyor belt

And

The circumference of the rollers is given as Equation 1.

$$V = \pi * d \quad (1)$$

where.

V is the belt speed (m/s); D is the diameters of rollers (m); and $\pi = pi$

Capacity is the product belt cross sectional area, material density and speed as expressed by Equation 2.

$$BC = 3{,}6 * A * p * V \quad (2)$$

A is the belt sectional area (m^2), ρ is the material density (kg/m^3); and V is the belt speed (m/s).

$$BC = 9{,}357\ tonnes\backslash h$$

The material density (tones/m^3)) can be determined from the annex 1, and the belt sectional area (m^2) determined from the annex 2.

The mass of Materials (live load) per meter (kg/m) loaded on a belt conveyor is given as Equation 3.

$$M_m = \frac{C}{3{,}6*V} \quad (3)$$

Where, C is the conveyor capacity(tones/hr.), and V is the belt speed (m/s).

$$M_{m=14{,}36\ Kg}$$

- **Roller diameter**

The roller bolster belt and encourages simple and in addition free pivot of the belt transport in all course.

Revolution per minute is expressed as Equation 4

$$N = \frac{1000*V}{\pi*D} \tag{4}$$

Where

N is the no of revolution per minute; D is the roller diameter (mm); and V is the belt speed (m/s)

The belt width is designed as 400 mm, the belt speed is 0.18 m/s, the roller diameter is therefore designed as 60 mm. From Equation 6, the no of revolution per minute

N is 95 tr\min.

$$The\ conveyor\ lenght = \frac{horizantal\ distance}{inclination\ angle} \tag{5}$$

The inclination angle is 30°, the conveyor length is 1,15m, and the conveyor height is 1 m

The roll diameter for belt is expressed as Equation (6)

$$D = \sqrt{d^2 + (0{,}01273 * L * G)} \tag{6}$$

Where

D is the overall diameter (m); d is the core diameter (m); L is the belt length (m); and G is the belt Thickness (mm)

The length of a belt on roll is given as Equation 7

$$L = H * N * \pi \tag{7}$$

Where

N is the no of wraps of the belt H is the height of the center core (m)

$$L = 4{,}97\ m$$

- **Belt Power and Tensions**

The longer the length of the belt, the more the force required for the transport and the higher the vertical separation of the lift, the higher the greatness of force required. The force PP (kW) at drive pulley drum expressed as equation 8.

$$P_P = \frac{T_{SS} * V}{1000} \tag{8}$$

Where

T_{SS} is the belt tension at steady state (N); and V is the belt speed (m/sec)

The belt of the conveyor always experiences tensile load due and the belt. Belt tension at steady state is given as equation (9).

$$T_{SS} = 1{,}37 * f * L * g * [2 * M_m + (2M_b + M_m) \cos\theta + (H * g * M_m) \tag{9}$$

T_{ss} is the belt tension at steady state (N); f is the coefficient of friction (0,02) we choose the coefficient of friction according to annex 3 because In European regions and normal working conditions, the value of 0.020-0.021 should be used; L is the conveyor length (4,97 m); (Conveyor belt is approximately half of the total belt length) g is the acceleration due to gravity (9.81 m/m^2); Mi is the load due to the idlers (1.5 kg); Mb is the load due to belt (12 kg); Mm is the load due to conveyed materials (8.6 kg); θ is the angle of inclination angle of the conveyor (30); and H is the vertical height of the conveyor (m). From Equation 9 (KN).

T_{ss} *=104.567 kN*

During the start of the conveyor system, the tension in the belt will be much higher than the steady state. The belt tension while starting is given as Equation 10

$$T_S = T_{SS} + K_{SS} \tag{10}$$

Where

T_S is the belt tension while starting (N); T_{SS} is the belt tension the steady state (kN); and K_{SS} is the startup factor annex 5.

From Equation 10 T_S= 105.576 kN

- **Diameter of the shaft**

The belt conveyor is mounted on this rotating shaft; the power was transmitted to this shaft via a rigid coupling sleeve. The design is based, fatigue stresses, combined shock and torsional moments.

The standard size of transmission shaft is

25 mm to 60 mm with 5 mm

60 mm to 110 mm with 110 mm

110 mm to 500 mm with 20 mm

Stress for transmission shaft

The maximal permissible shear stress taken:

[a] 56 MPa for shaft without allowers for keyways

[b] 42 MPa for shaft with allowers for keyways

J: plan moment of inertia

$$J = \frac{\pi}{32} * d^4 \tag{11}$$

τ: shear stress: Defined by equation (12)

$$\frac{T}{\frac{\pi}{32} * d^3} = \frac{\tau}{\frac{d}{2}} \tag{12}$$

$$d = \sqrt[3]{\frac{T*16}{\tau}}$$

The acceleration of the conveyor belt is given as Equation 11

$$A = \frac{T_{S\_}T_{SS}}{[L*(2*M_i+2*M_b+M_{m)}]} \tag{13}$$

where

T_{SS} is the belt tension while starting (kN); T_S is the belt tension at the steady state (kN); L is the conveyor length (m); M_i is the load due to the idlers (kg/m); M_b is the load due to belt (kg/m); M_m is the load due to conveyed materials (kg/m), A is Acceleration (m/m^2).

We choose motor GEARED MOTORS CM026 his characteristic is: The couple value 0.8 to 17 N.m, the speed is 30 to 600 rpm, and the reduction ratio is 0.23.

3.2.2. Main frame of the crack

The main frame is the support of the cracker. It must be strong enough to support both self-weight and the weight due to the load of walnuts. The frame is designed of iron in terms of length is 700 mm and width are 40 mm it consist of for legs for ease of movement.

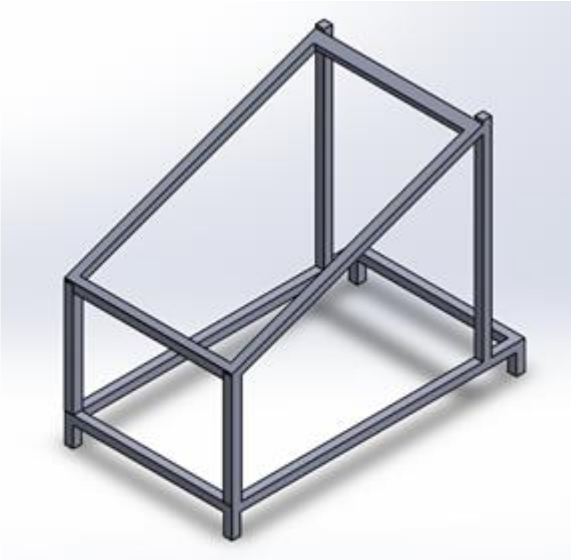


Figure 22: Model of main frame

3.2.3. Break the nuts (tow rollers)

- **Definition**

The name is rollers cracker easy to design and to build and she made up of tow rollers cylindrical form(counter rotating) to crack the walnuts also the dimension between two rollers is the size of the walnuts (from the biggest diameter to the small diameter), the goals is crack the walnuts and not to pass it except broken so we need to determine the dimension between tow rollers exactly.

- **Dimension and design**

Design procedure

given

Big walnuts:

Length= 26,74 mm

Weight= 23,46 mm

Diameter= 24,46 mm

Width= 21,20 mm

Small walnuts:

Length= 20,35 mm

Weight=19,11 mm

Diameter=19,87 mm

Width= 15,09 mm

Coefficient of friction: Steel on steel (f=0,74)

Diameter of the rollers =45mm

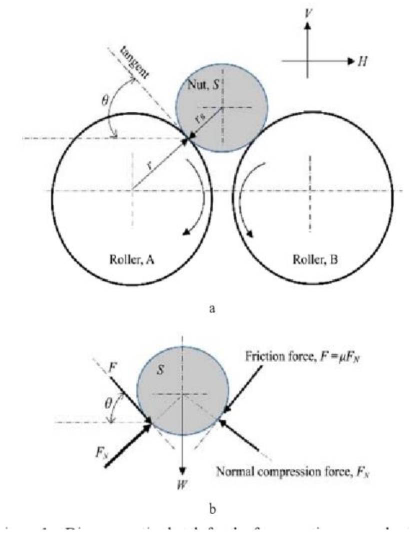


Figure 23: Tow rollers[7]

The power required for cracking walnuts is given in equation

$$P = n_r * T * w \tag{14}$$

Then:

n_r: Number of the rotating rollers

W: The angular velocity of the rollers (rad/s)

$$w = \frac{2\pi N}{60} \tag{15}$$

T: Torque (Nm)

$$T = r * F_t \tag{16}$$

F_t: Total friction force induced between roller surface and loaded walnuts

For one walnut per example, we can see the topical force deformation normal compression is 200N and the deformation is 1mm.

Calculation

$P = n_r * T * w$

$n_r = 2$

$w = \frac{2\pi N}{60}$

$$V = \pi * d \quad (17)$$

V is equals to 0,1413 m/s

$$N = \frac{1000*v}{\pi*D} = 1000 \text{ rpm} \quad (18)$$

W is equal to 104 rad/s

We have steel on steel F_t is equal to 3,33 N

Then P is equal 692 W

The tow rollers are mounted on this rotating shaft; the power was transmitted to this shaft via engine. The design is based, fatigue stresses, combined shock and torsional moments.

The standard size of transmission shaft is.

25 mm to 60 mm with 5 mm

60 mm to 110 mm with 110 mm

110 mm to 500 mm with 20 mm

Stress for transmission shaft.

The maximal permissible shear stress taken.

[a] 56 MPa for shaft without allowers for keyways

[b] 42 MPa for shaft with allowers for keyways

- **Diameter of the shaft**

$$\frac{T}{J} = \frac{\tau}{r} \qquad (19)$$

J: plan moment of inertia

$$\mathrm{J} = \frac{\pi}{32} * \mathrm{d}^4 \qquad (20)$$

τ: shear stress: Defined by equation (23)

$$\frac{\mathrm{T}}{\frac{\pi}{32} * \mathrm{d}^3} = \frac{\tau}{\frac{\mathrm{d}}{2}} \qquad (21)$$

$$\mathrm{d} = \sqrt[3]{\frac{\mathrm{T} * 16}{\tau}} \qquad (22)$$

calculate the coupling (sleeve and key)

$$\mathrm{C} = \frac{\mathrm{P}}{\mathrm{w}} = \frac{\mathrm{P} * 30}{\pi \mathrm{N}} \qquad (23)$$

Then

$$C = 6{,}611\ Nm$$

Electric Motor MS 713-2 his caracterstic is: The power factor value 0.82, the number of revolution 1500 rpm, and the power is 0.75kW.

Chapter 4 : Results and discussions

4.1. Model description

The machine could be a basic device, it comprises of belt conveyor and cracking machine. The belt conveyor transports the walnuts to the cracking machine to break it, it includes tow cylinders, one of them has assembled to shaft with a pulley and snap ring and the second pulley are mounted to the engine shaft with a key.

The cracking machine consists of two counter-rotating cylinders (rollers) to crack walnuts, the gap between tow roller is the size of the walnuts (from the smalls diameter to the big diameter), the square flange, the roller support, and the bolt can make us control the dimension and to fixed the rollers, then the rollers mounted assembly to the engine with the muff coupling and key.

- Costs

In which concerns the costs of the prototype of the cracking machine, it was estimated based on some site web, as presented in table (4). Also, some compounds from this list can be constructed.

Table 4 : The costs of the pieces for the cracking machine

None	Type	Number	Price €
Maine frame	-	1	30
Engine	Motor MS 713-2	2	120
Engine Support	-	2	10
Roller	Steel roller ¤ 45 mm	2	30
Roller support	-	4	10
Square frange	CHDF	4	14
Key	Feather	2	2
Blot and Nut	Hexagon Bolt and nut M10 28mm	12	1
Trough	-	1	5
Protection trough	-	2	15
Support for P.r	-	4	5
Muff coupling	Cylindrical Shape with groove	2	15

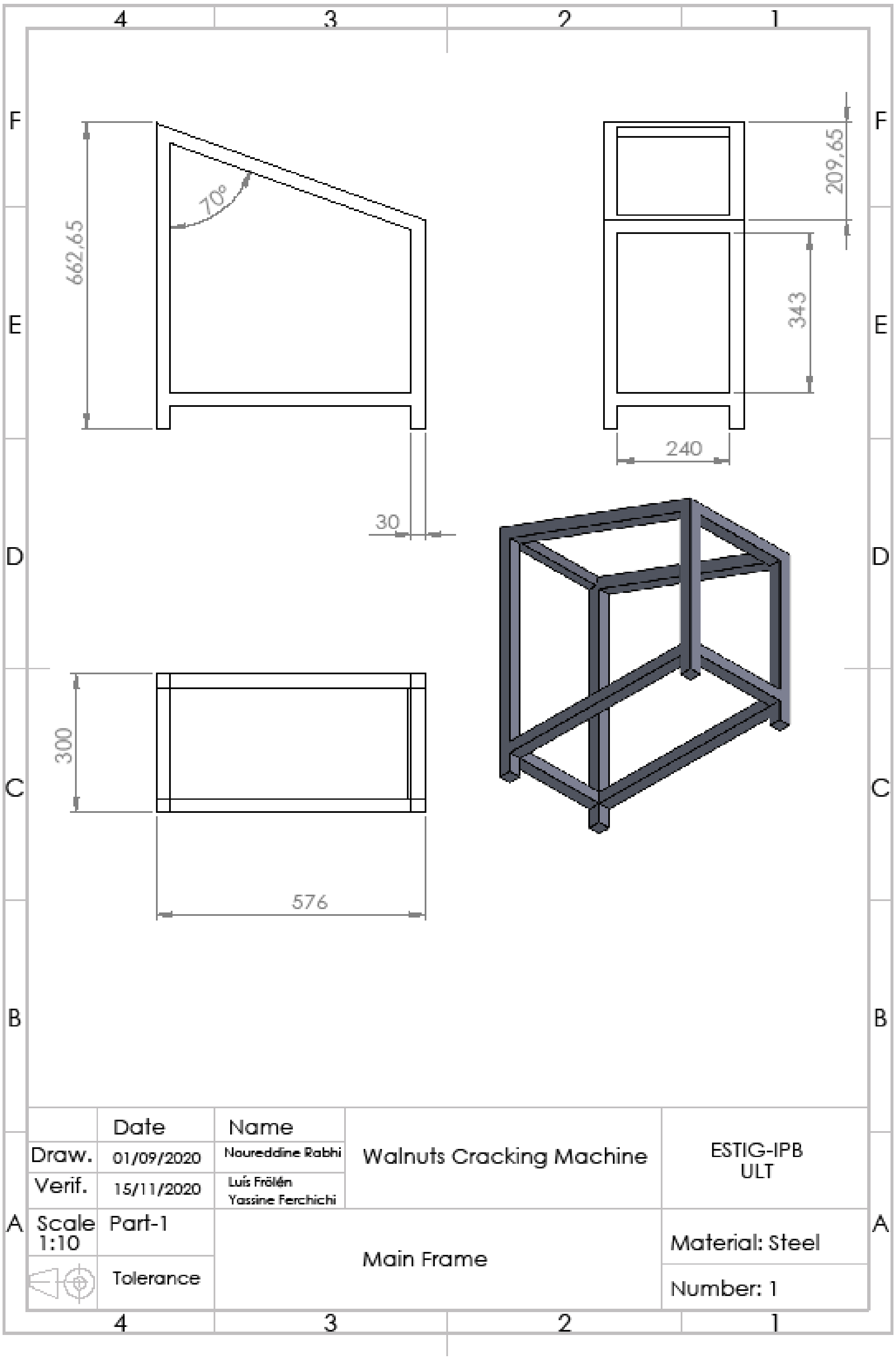
According to the table above, the budget of the construction can be calculated, which is equal to 547 €.

4.2. List and part Numbers

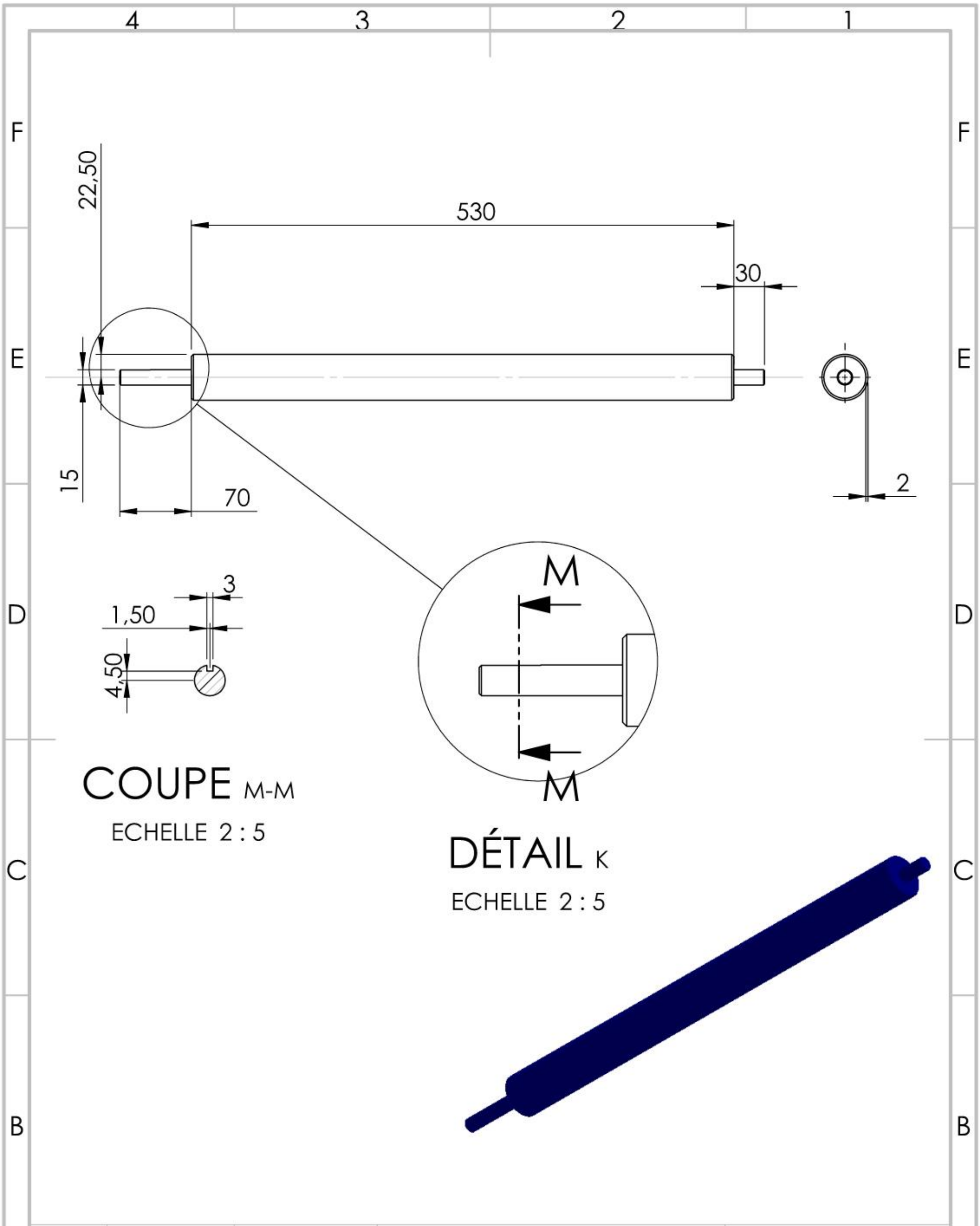
List and part numbers of the cracking machine and the belt conveyor for four varieties (reference, name of the pieces, matter, and quantity) are demonstrated in table 4.

Table 5: List of the pieces

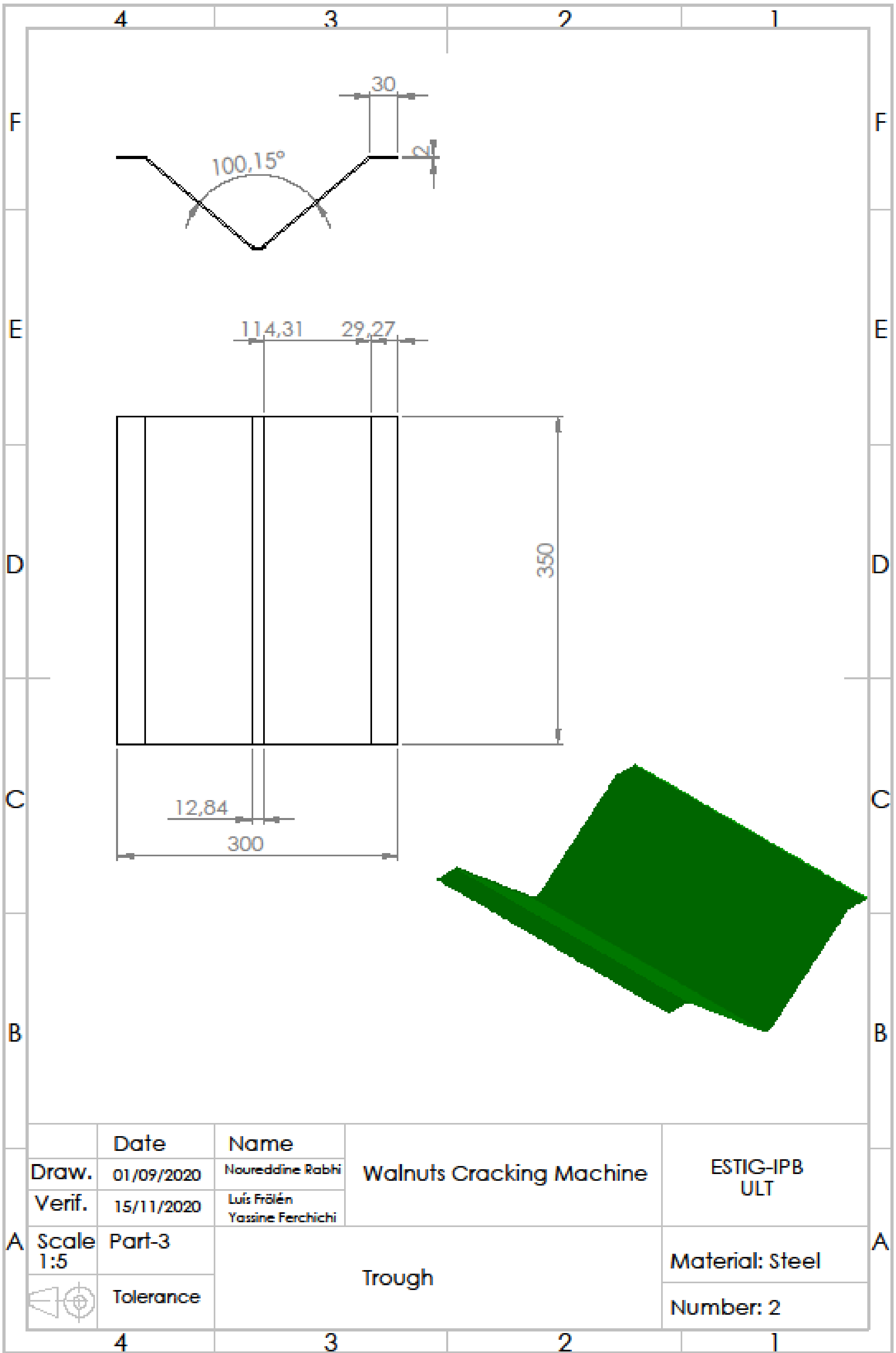
Number	Name of the pieces	Matter	Qt.
01	The main frame	Steel	01
02	Roller	//	02
03	Trough	//	01
04	Key	//	03
05	Muff coupling	//	02
06	Hexagon bolt full thread 4 mm *long 27,80 mm	//	12
07	Nut M4	//	12
08	Nut bolt washer	//	12
09	Square flange	//	04
10	Roller support	//	04
11	Engine support F	//	01
12	Engine support D	//	01
13	Protection trough	//	02
14	Cover	//	01
15	Shaft cylinder	//	02
16	Rigid coupling sleeve	//	01
17	Coupling Nut	//	01
18	Cylinder	//	01
19	Side support conveyor left	//	01
20	Side support conveyor right	//	01
21	Conveyor Belt	Rubber	01
22	The Base	//	04
23	Front column A	Steel	01
24	Front column B	//	01
25	Back column A	//	01
26	Back column B	//	01
27	Support for protection trough	Steel	04



662,65
70°
209,65
343
240
30
300
576
Date
Name
Draw.
01/09/2020
Noureddine Rabhi
Verif.
15/11/2020
Luís Frölén
Yassine Ferchichi
Walnuts Cracking Machine
ESTIG-IPB
ULT
Scale
1:10
Part-1
Main Frame
Material: Steel
Tolerance
Number: 1



	Date	Name	Walnuts Cracking Machine	ESTIG-IPB ULT
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-8	Roller		Material: Steel
	Tolerance			Number: 2



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300
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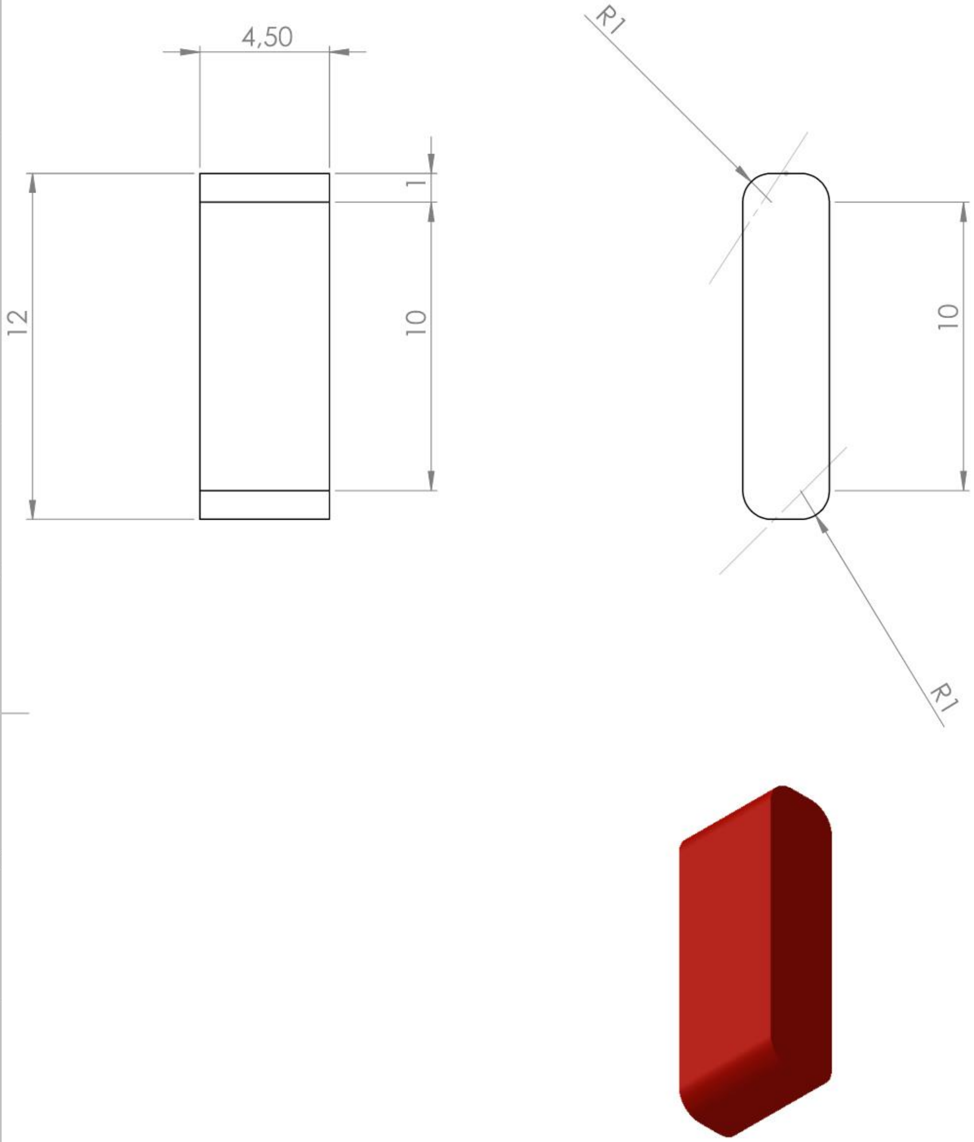
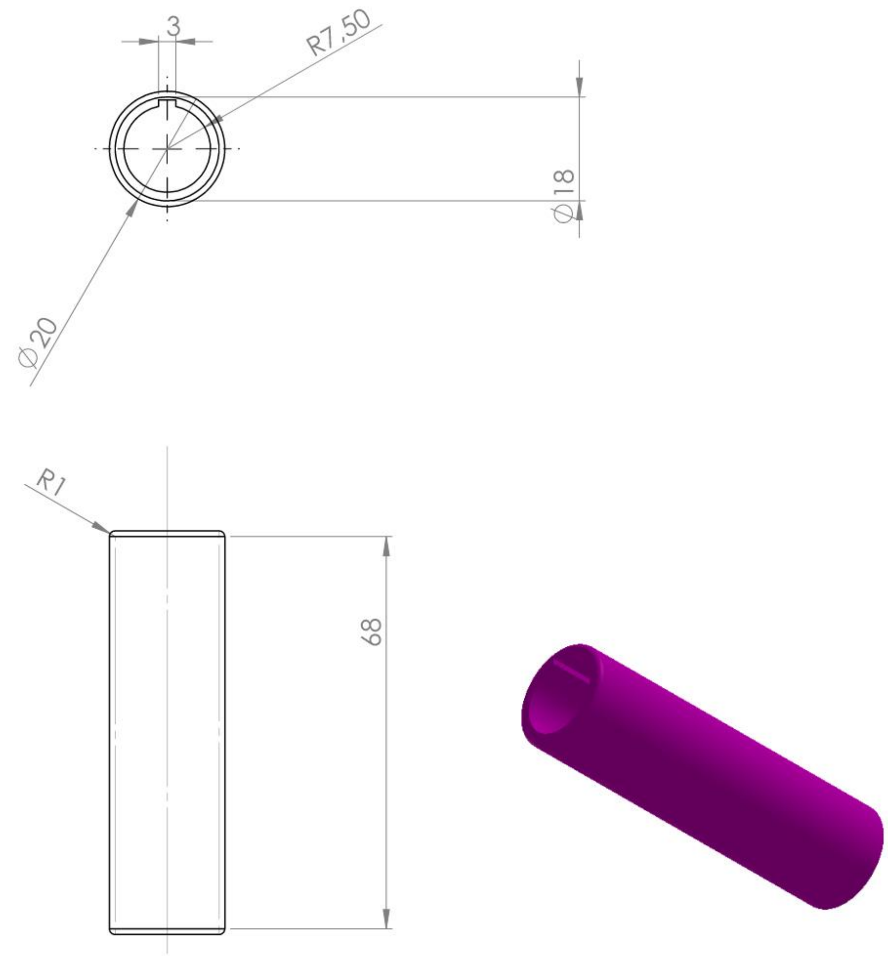
01/09/2020
Noureddine Rabhi
Verif.
15/11/2020
Luís Frölén
Yassine Ferchichi
Walnuts Cracking Machine
ESTIG-IPB
ULT
Scale
1:5
Part-3
Trough
Material: Steel
Tolerance
Number: 2



	Date	Name	Walnuts Cracking Machine	ESTIG-IPB ULT
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-4		Key	Material: Steel
	Tolerance			Number: 2



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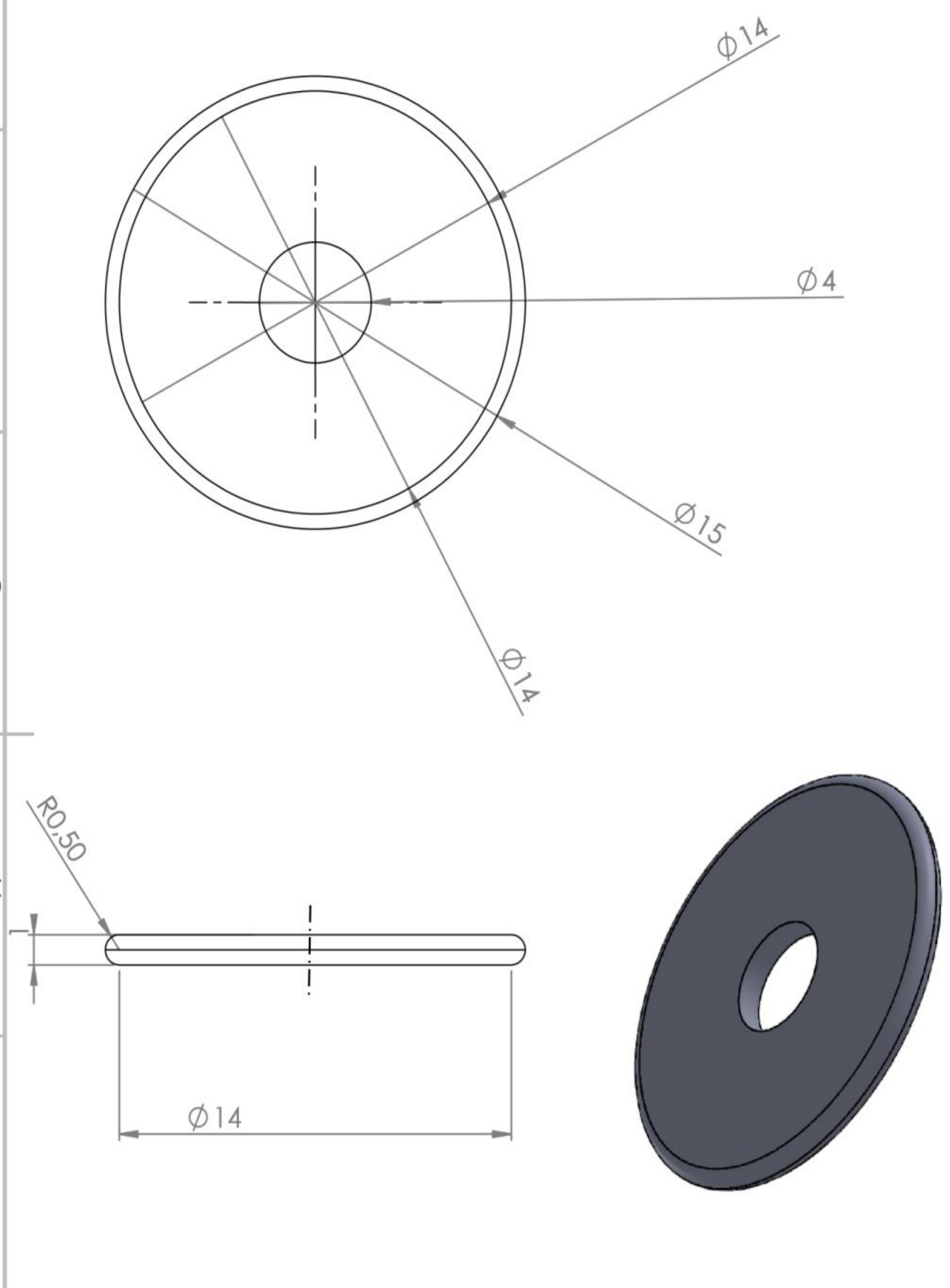
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-5		Muff coupling	Material: Steel
	Tolerance			Number: 2



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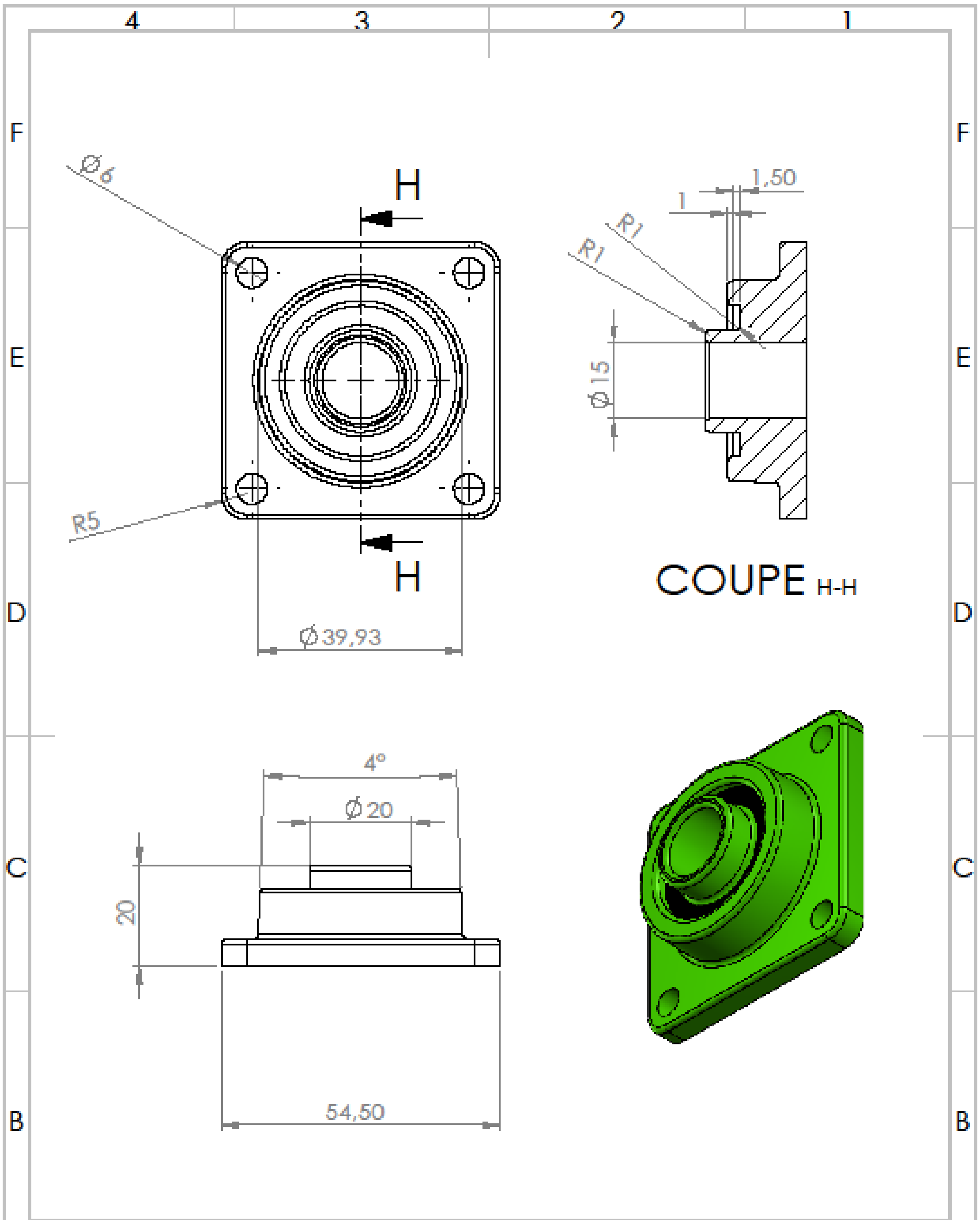
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 5:1	Part-08	Nut bolt washer		Material: Steel
	Tolerance			Number: 12



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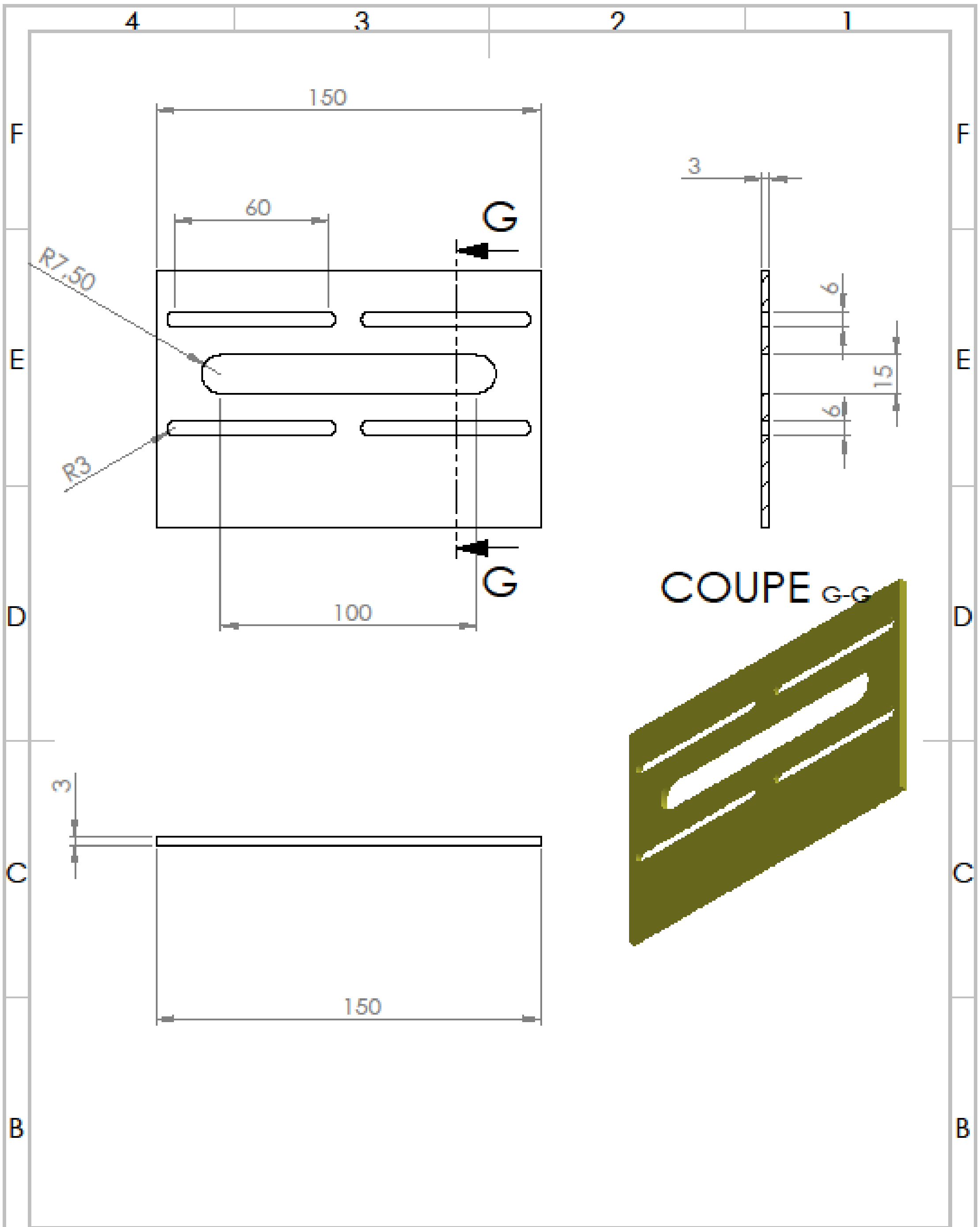
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-9	Square flange		Material: Steel
	Tolerance			Number: 4



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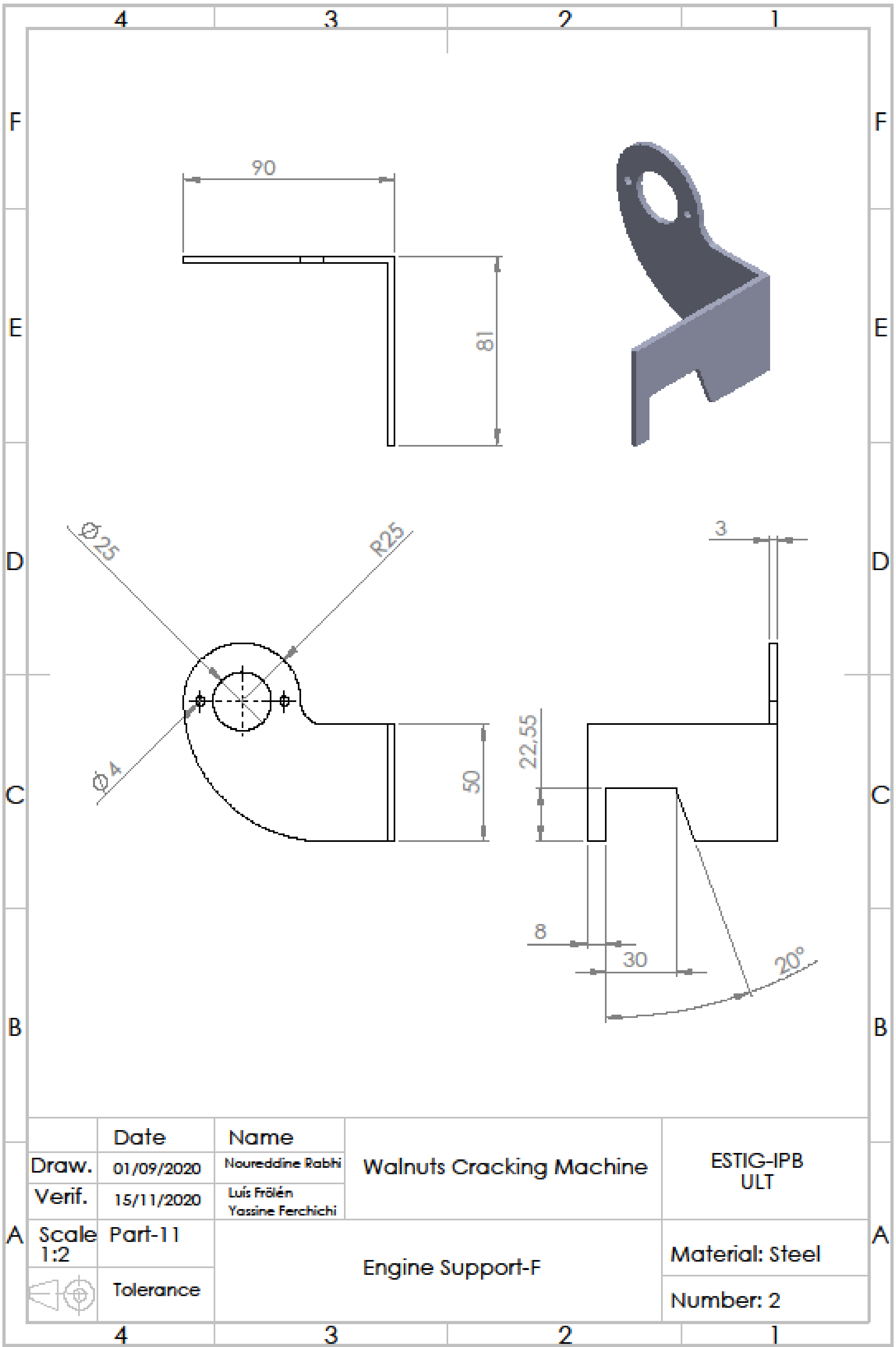
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-10	Roller Support		Material: Steel
	Tolerance			Number: 2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Noureddine Rabhi
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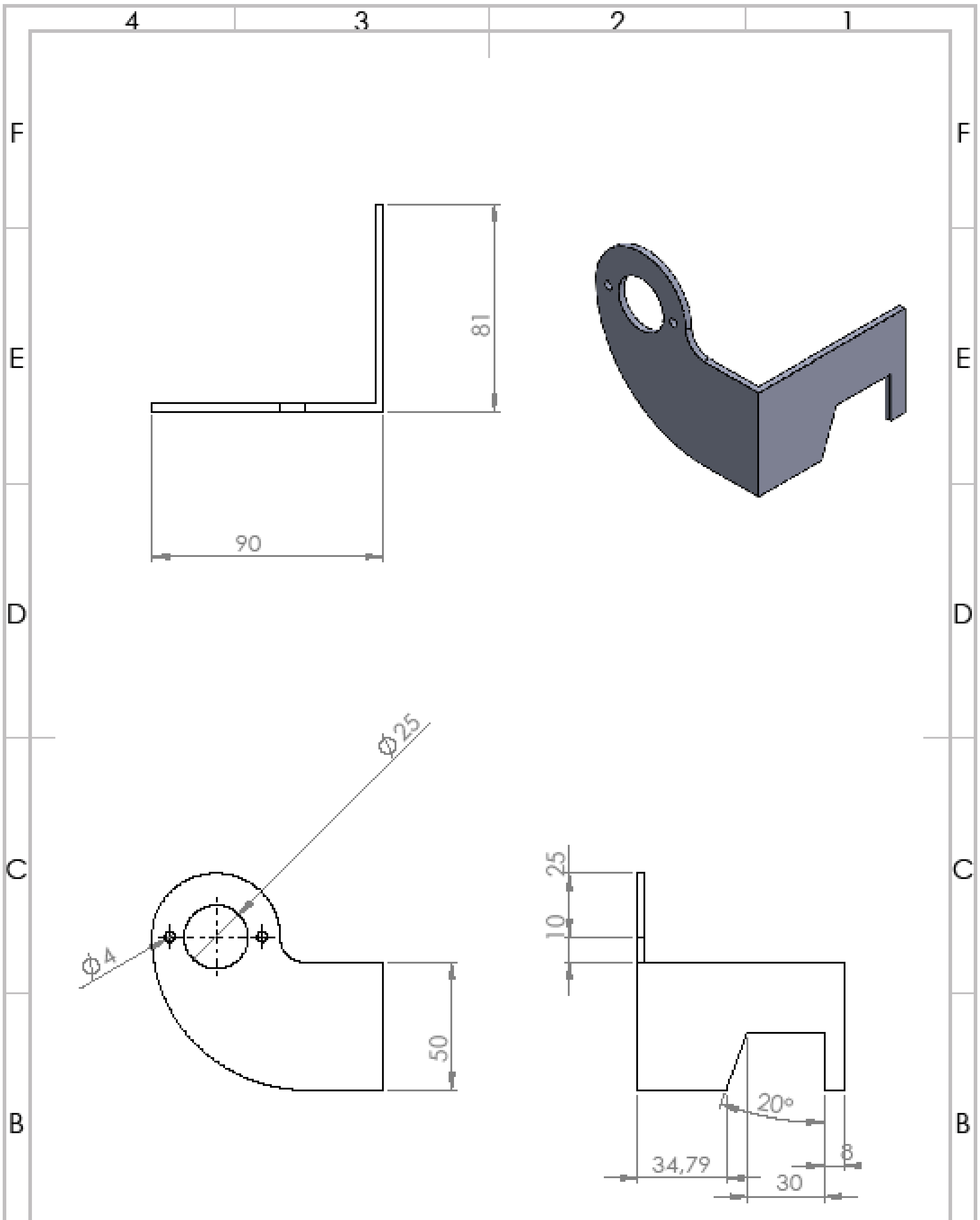
15/11/2020
Luís Frölén
Yassine Ferchichi
Walnuts Cracking Machine
ESTIG-IPB
ULT
Scale 1:2
Part-11
Tolerance
Engine Support-F
Material: Steel
Number: 2



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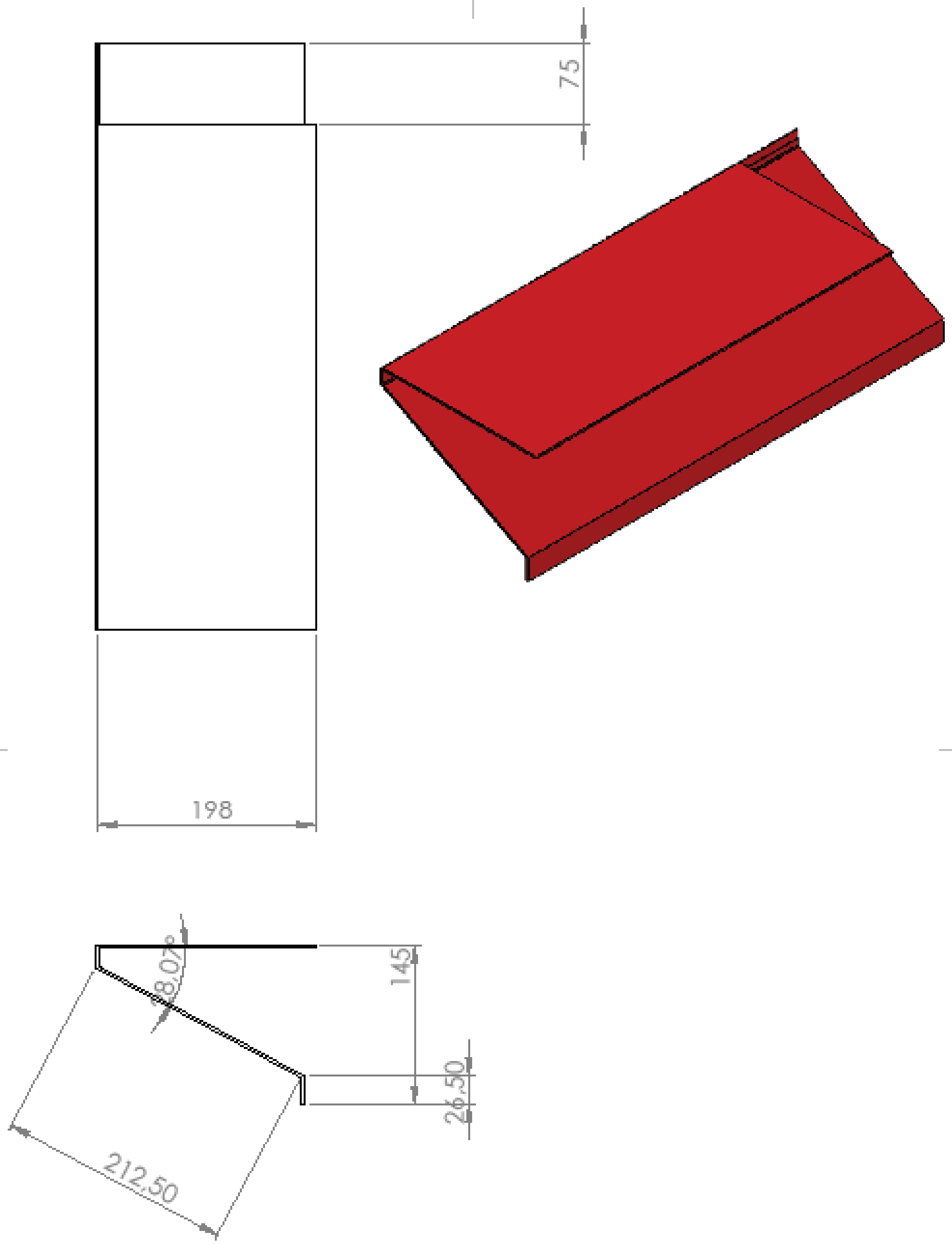
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-12	Engine support-D		Material: Steel
	Tolerance			Number: 1



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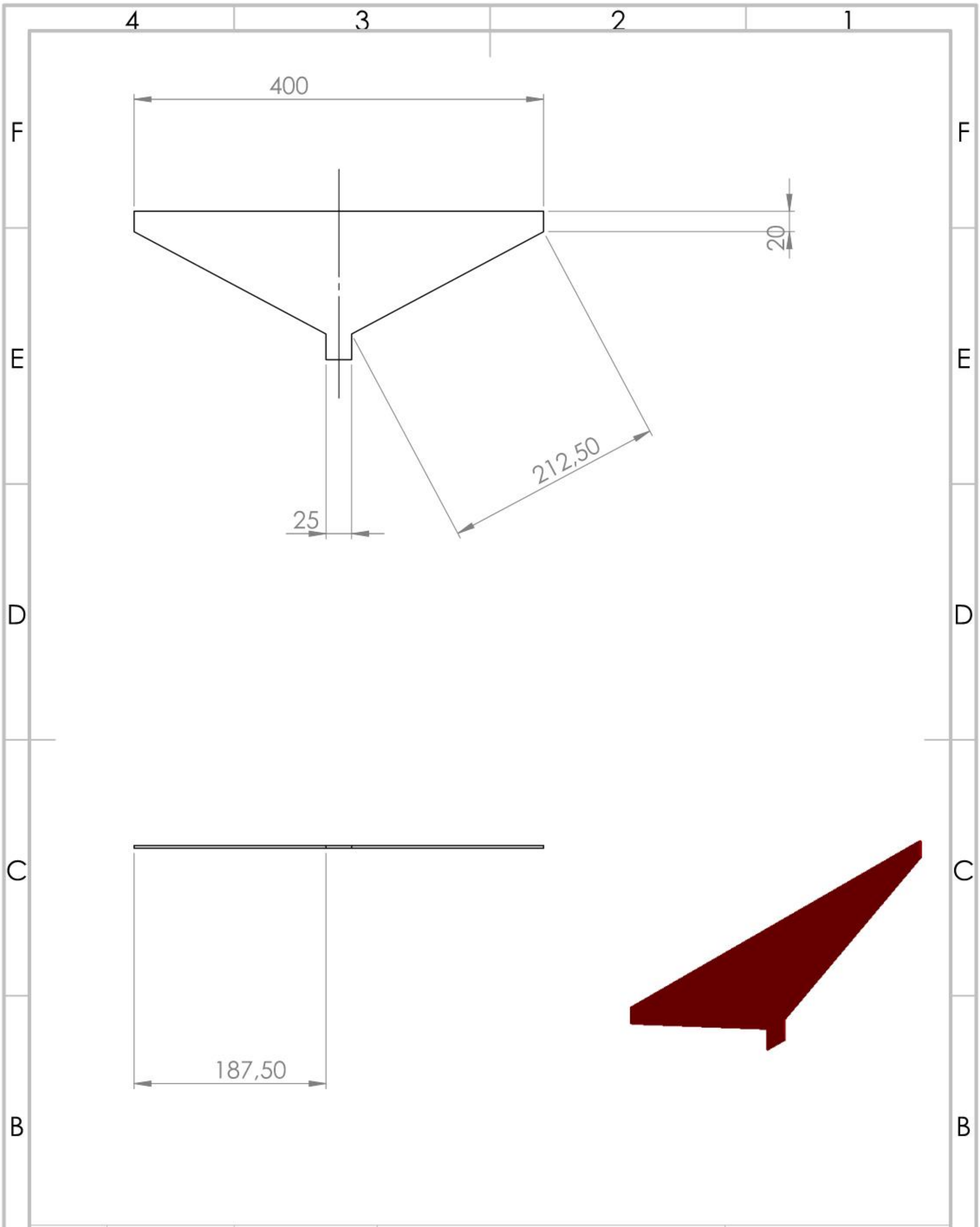
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:5	Part-13	Protection trough		Material: Steel
	Tolerance			Number: 2



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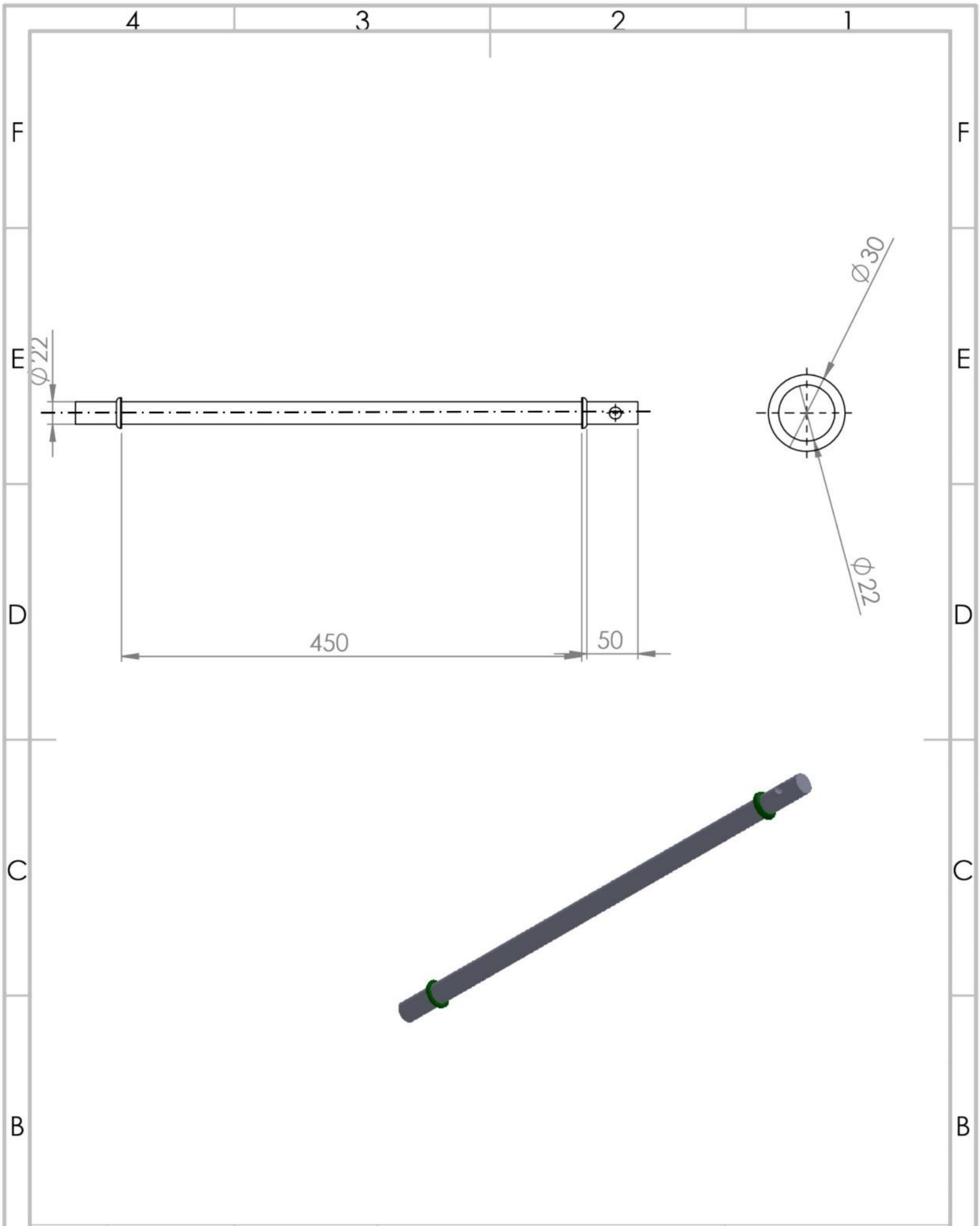
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-14		Cover	Material: Steel
	Tolerance			Number: 1



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Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:5	Part-15		Shaft cylindre	Material: Steel
	Tolerance			Number: 2

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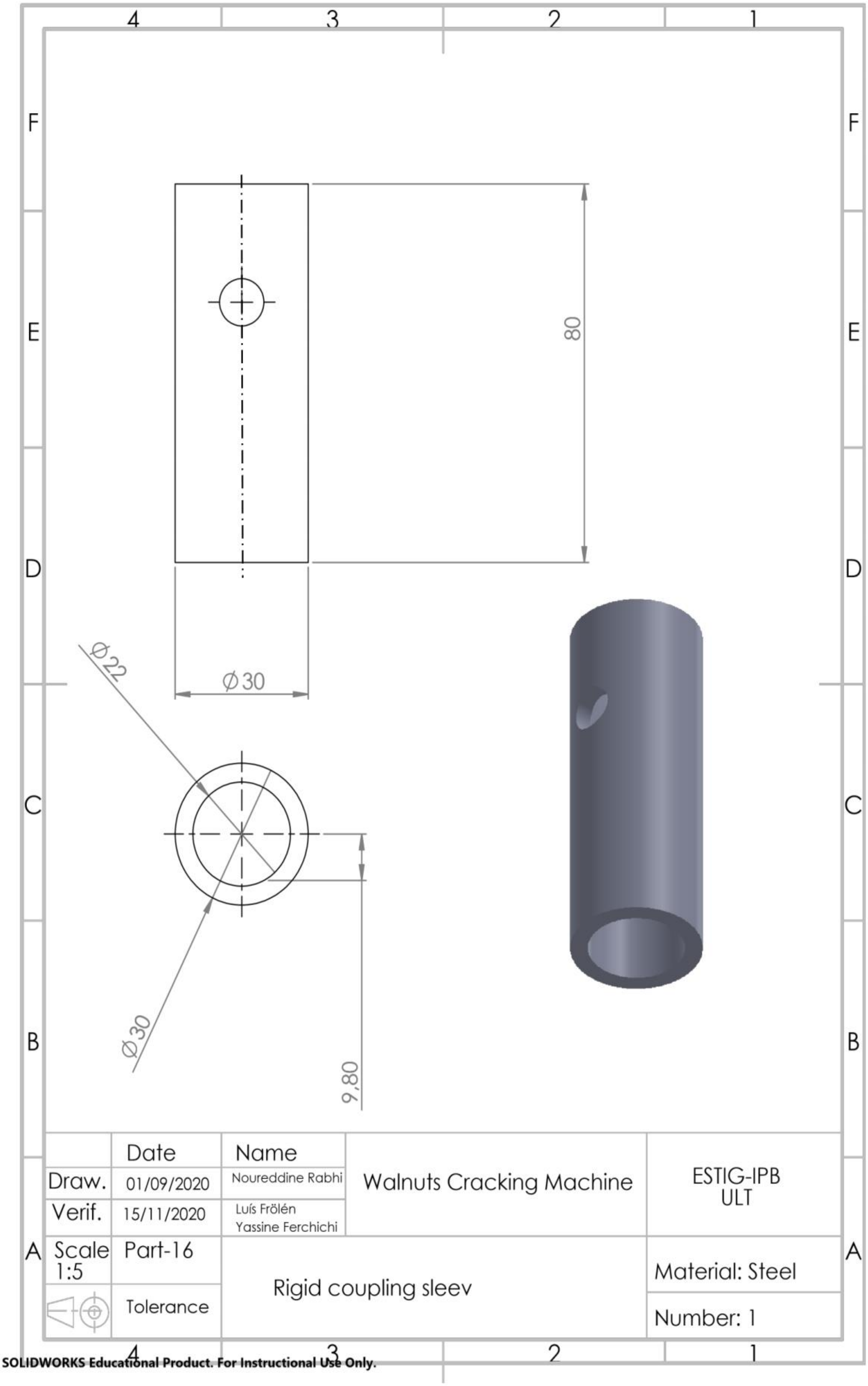
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Noureddine Rabhi
Verif.
15/11/2020
Luís Frölén
Yassine Ferchichi
Walnuts Cracking Machine
ESTIG-IPB
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Scale
1:5
Part-16
Tolerance
Rigid coupling sleev
Material: Steel
Number: 1
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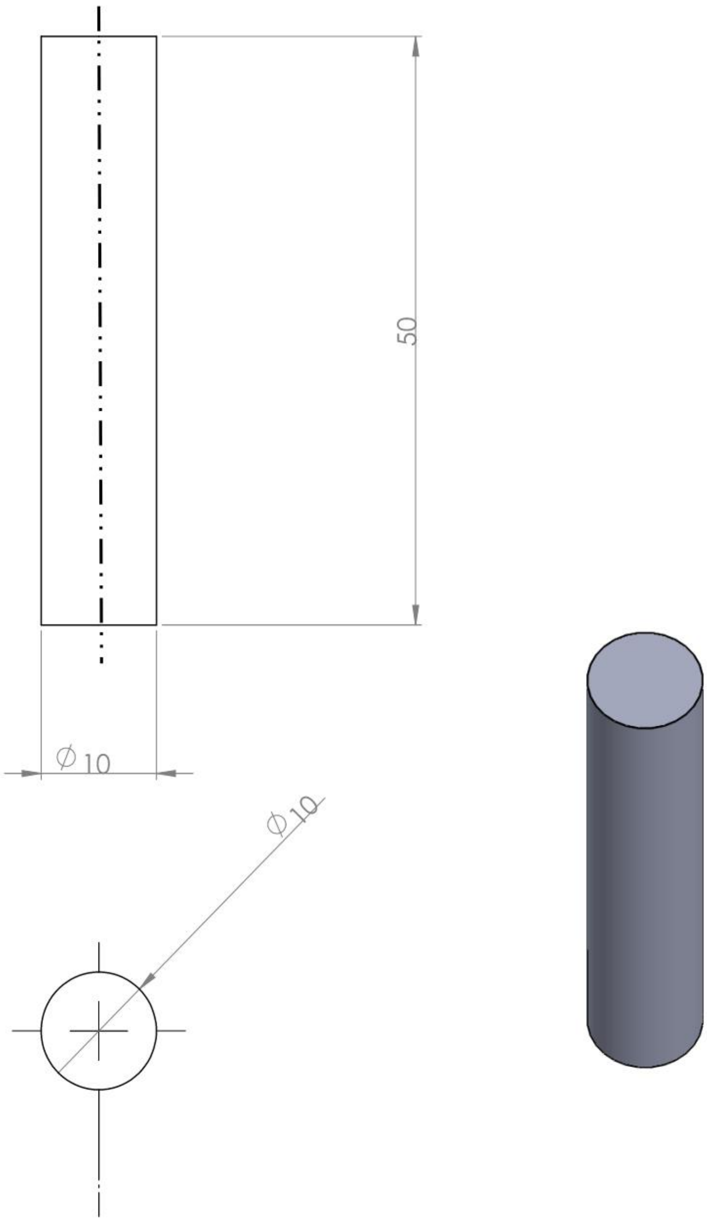

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Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 2:1	Part-17		Coupling nut	Material: Steel
	Tolerance			Number: 1

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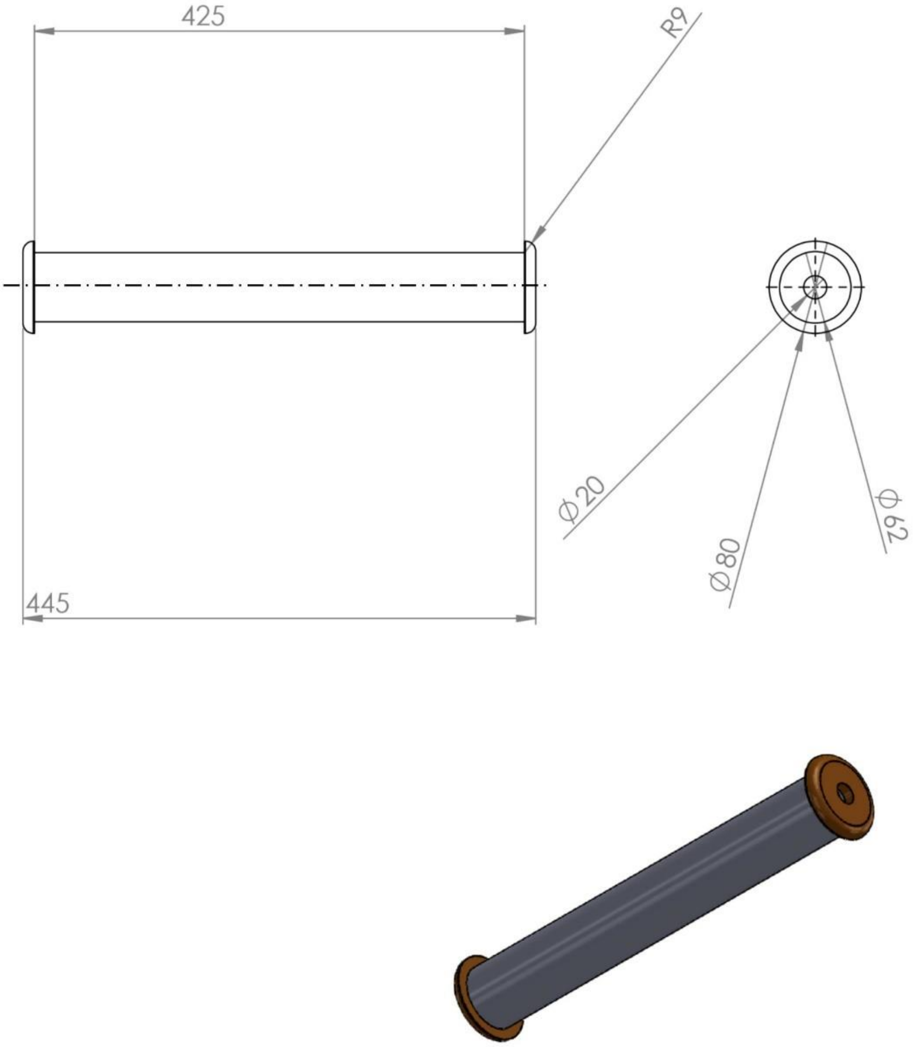

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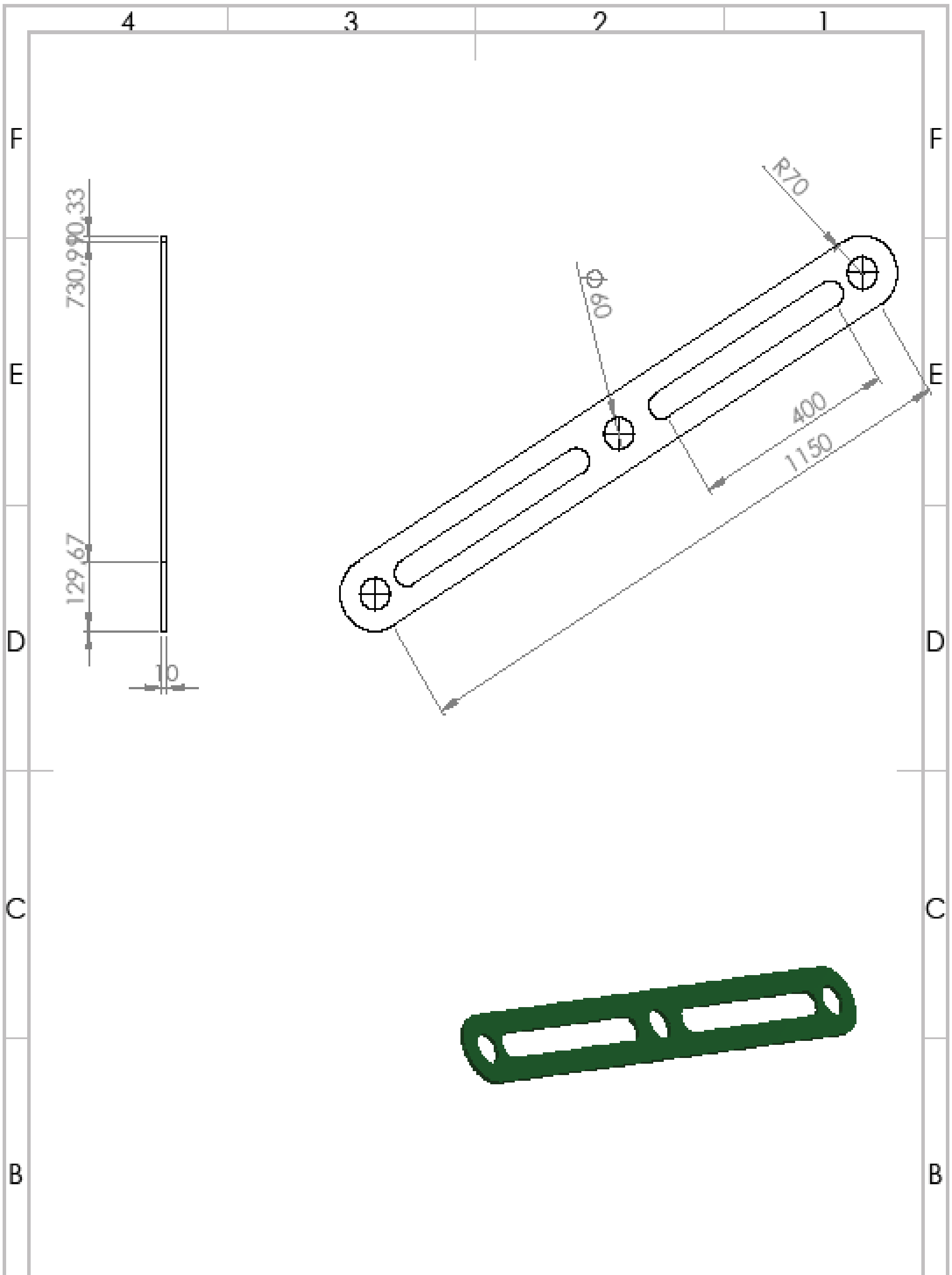
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:5	Part-18	Cylinder		Material: Steel
	Tolerance			Number: 1



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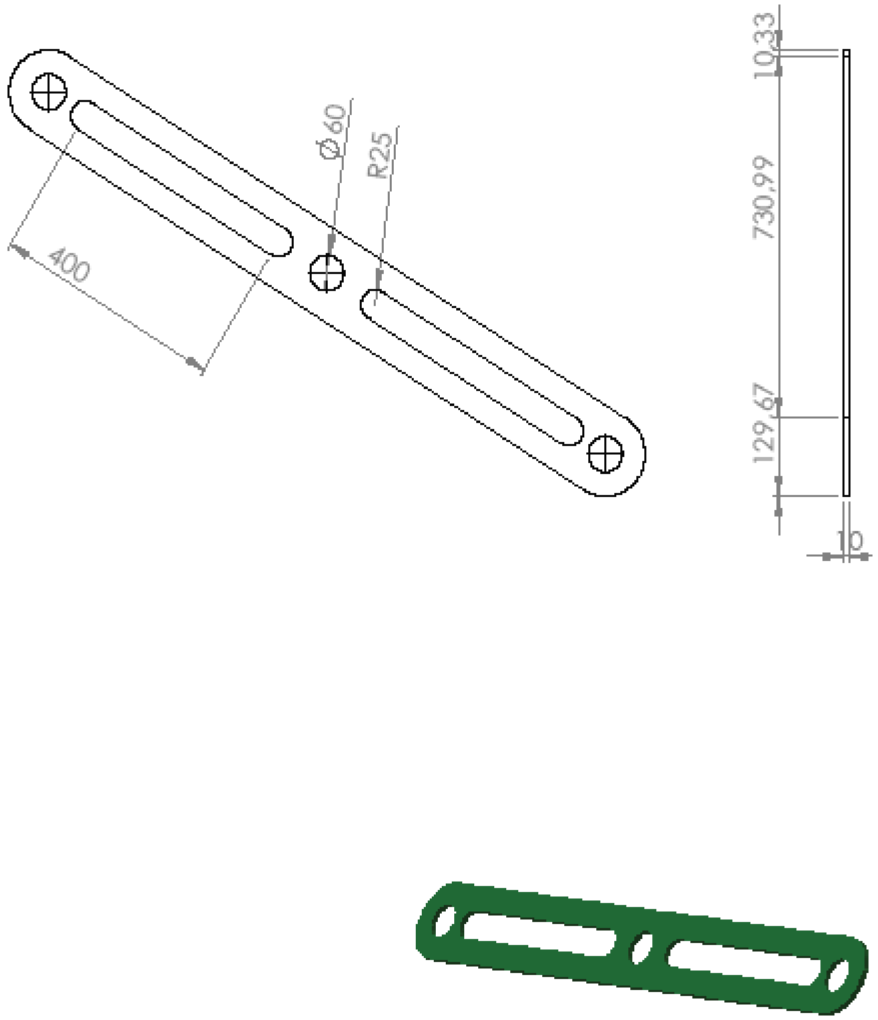
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:10	Part-19	Side support conveyor right		Material: Steel
	Tolerance			Number: 1



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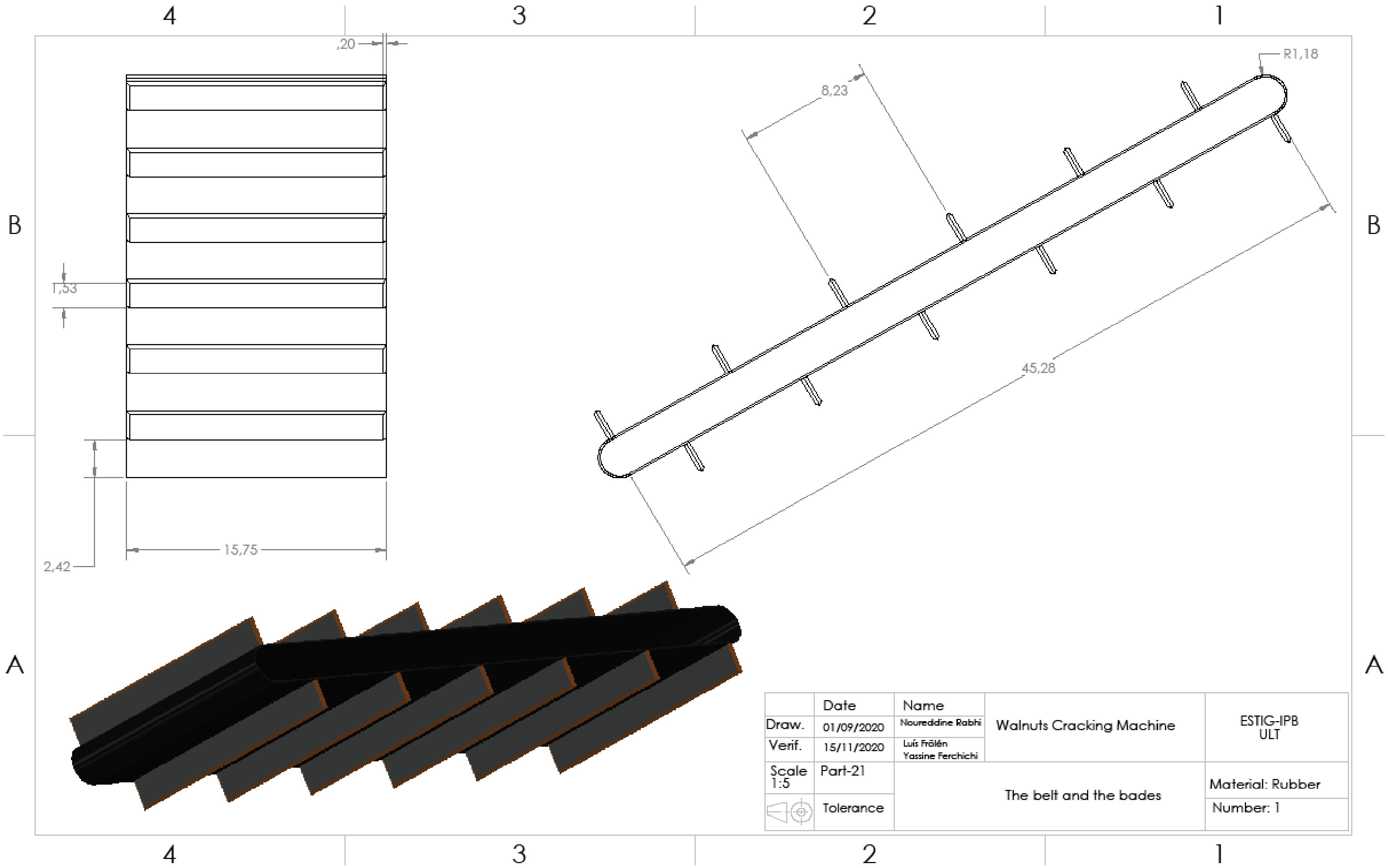
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:10	Part-20	Side support conveyor left		Material: Steel
	Tolerance			Number: 1



4
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8,23
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1,53
2,42
15,75
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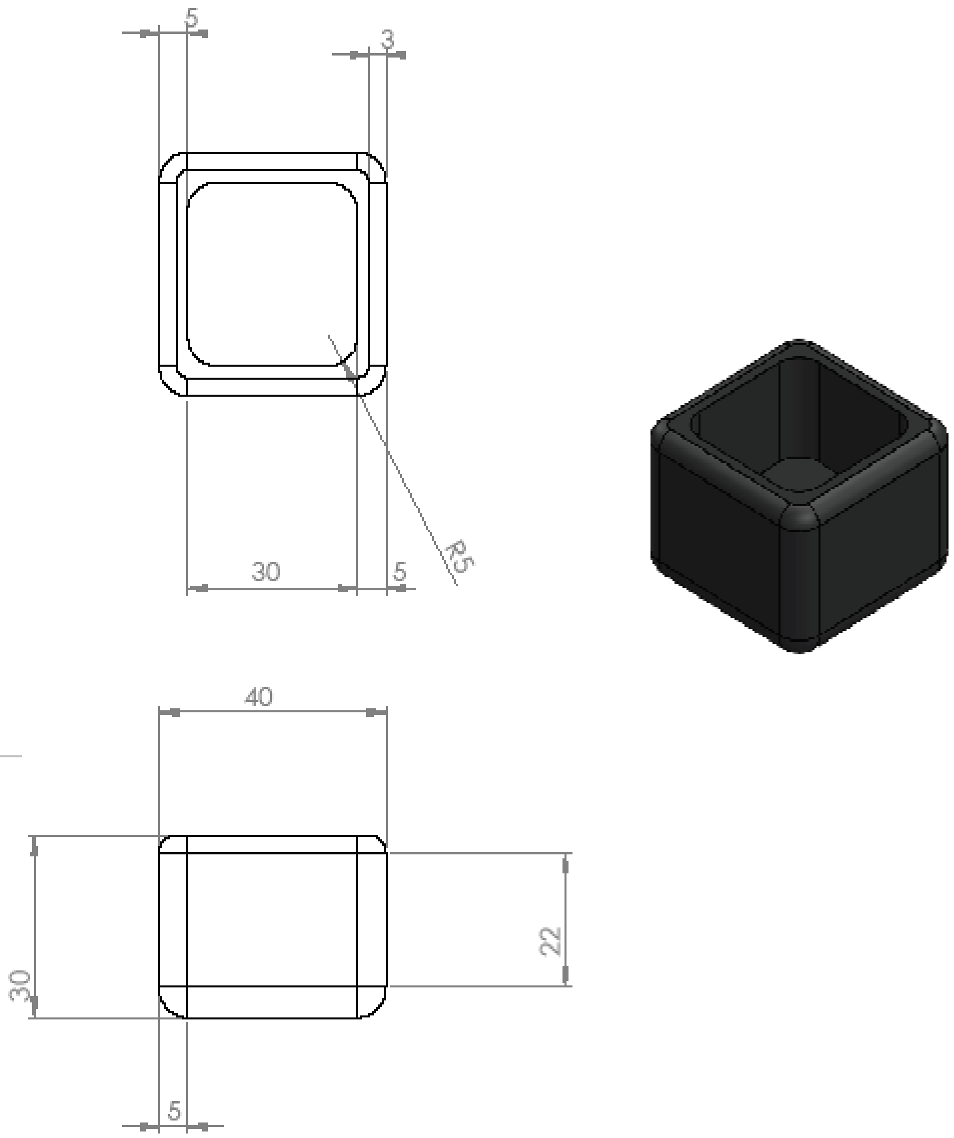
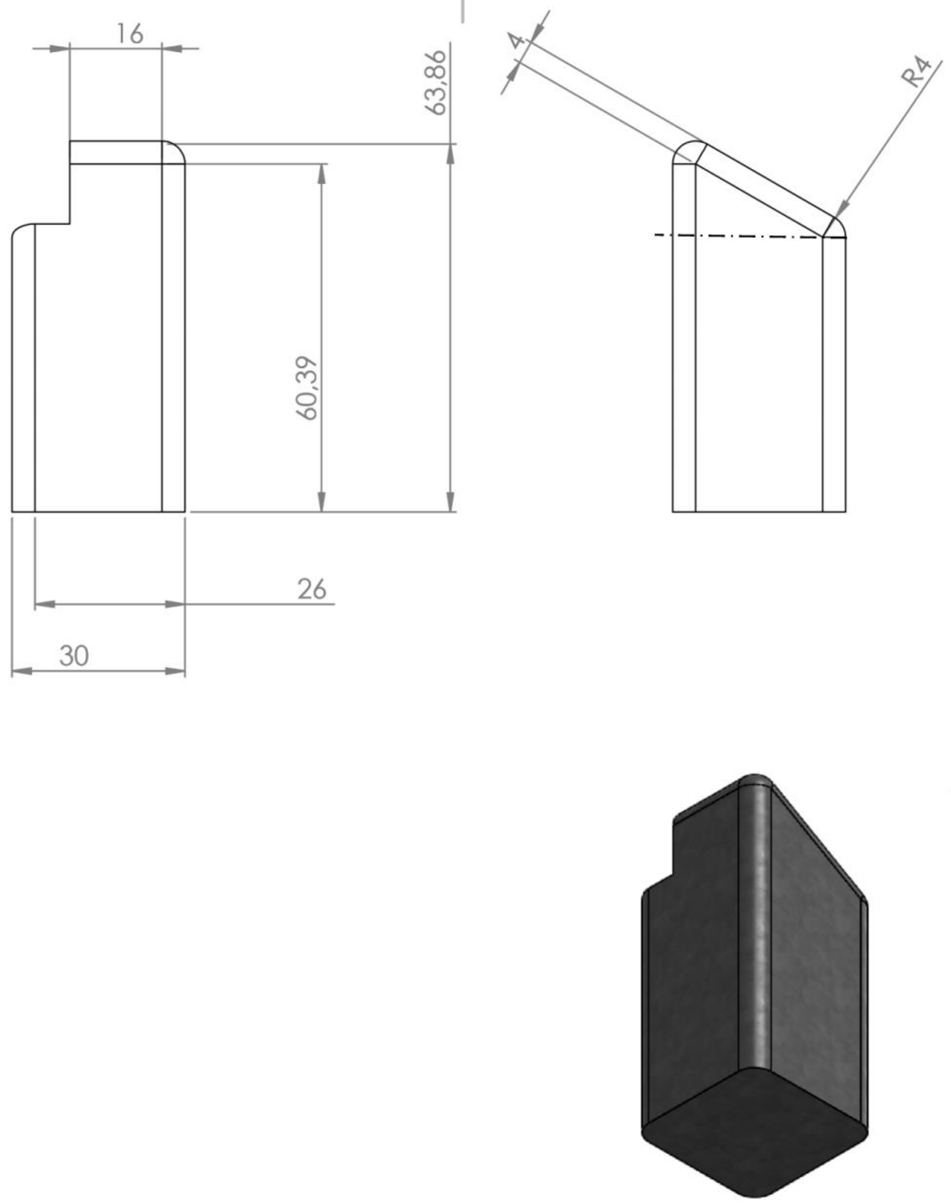
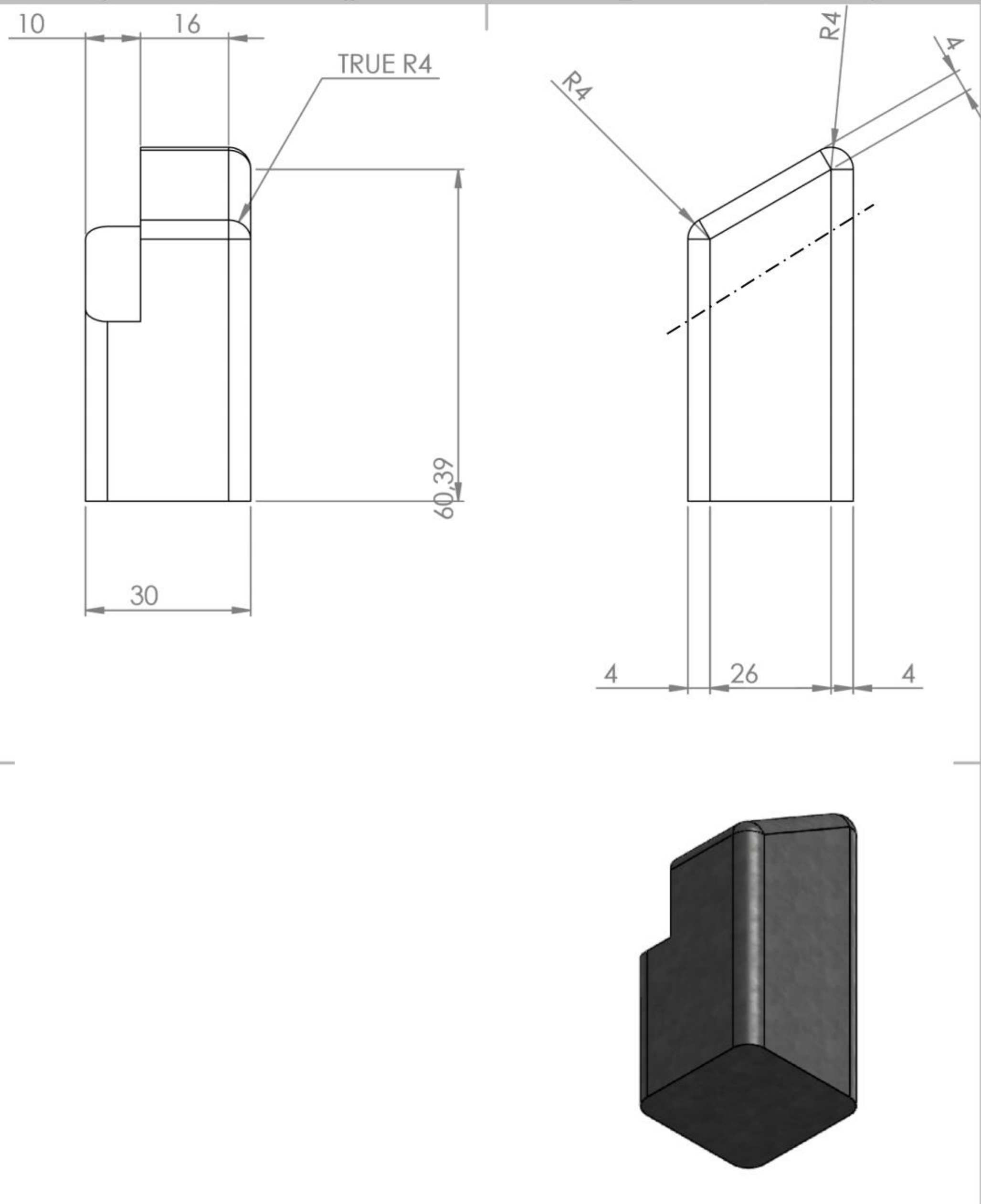
01/09/2020
Noureddine Rabhi
Verif.
15/11/2020
Luís Frölén
Yassine Ferchichi
Walnuts Cracking Machine
ESTIG-IPB
ULT
Scale
1:5
Part-21
Tolerance
The belt and the bades
Material: Rubber
Number: 1



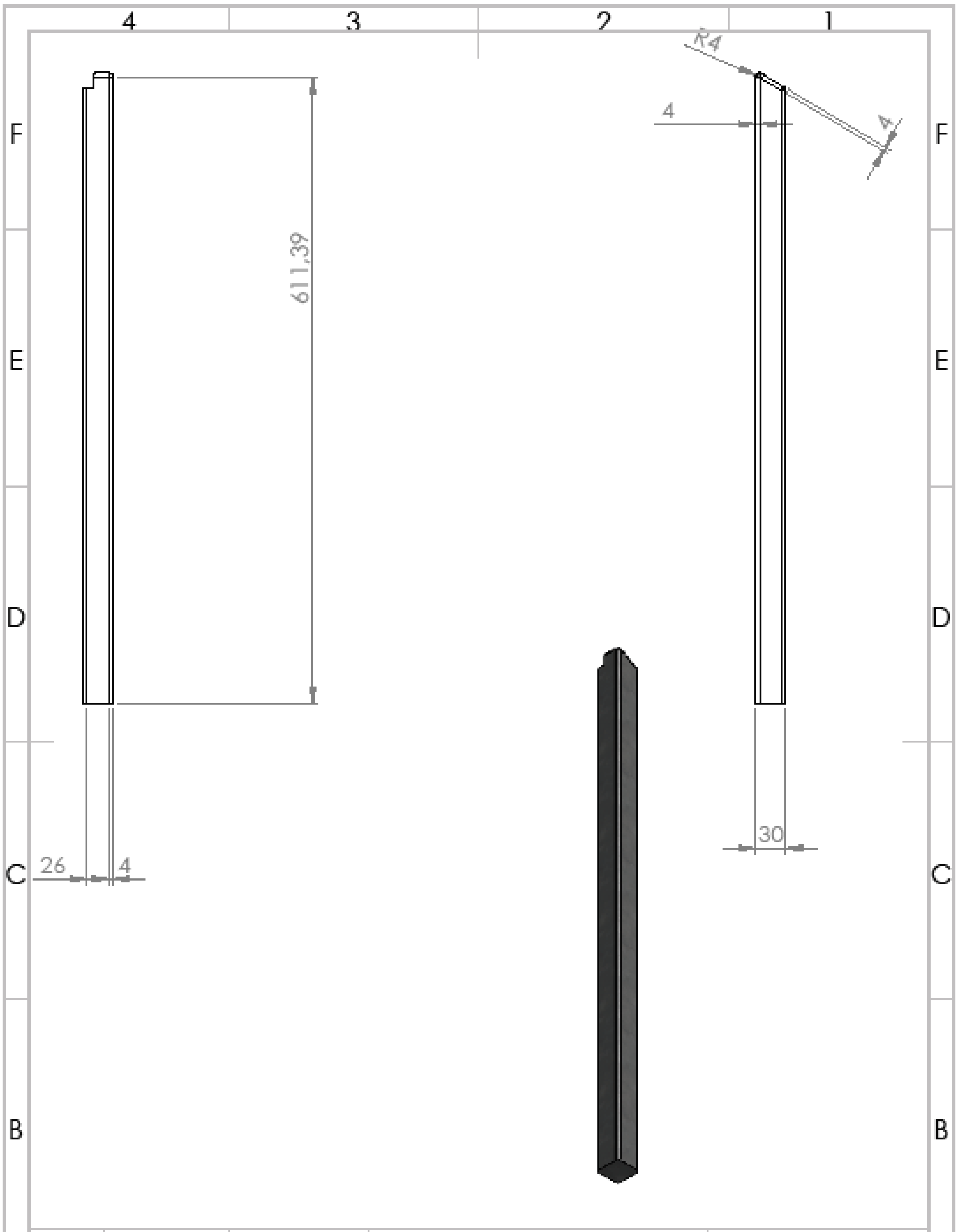
	Date	Name	Walnuts Cracking Machine	ESTIG-IPB ULT
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:1	Part-22	The Baz		Material: rubber
	Tolerance			Number: 4



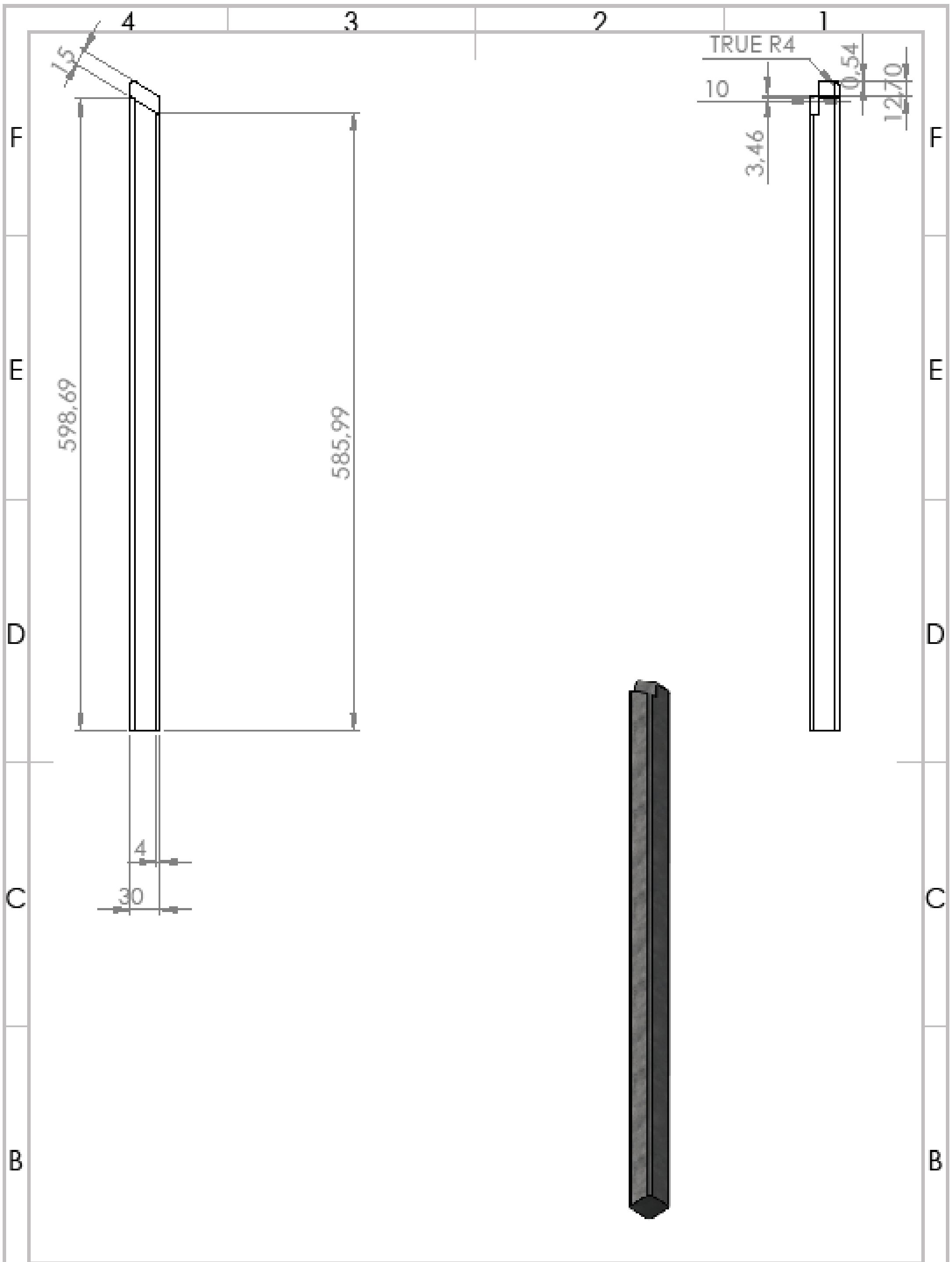
	Date	Name	Walnuts Cracking Machine	ESTIG-IPB ULT
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:1	Part-23	Front column A		Material: Steel
	Tolerance			Number: 1



	Date	Name	Walnuts Cracking Machine	ESTIG-IPB ULT
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:1	Part-24	Front column B		Material: Steel
	Tolerance			Number: 1



	Date	Name	Walnuts Cracking Machine	ESTIG-IPB ULT
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:5	Part-25	Back column A		Material: Steel
	Tolerance			Number: 1



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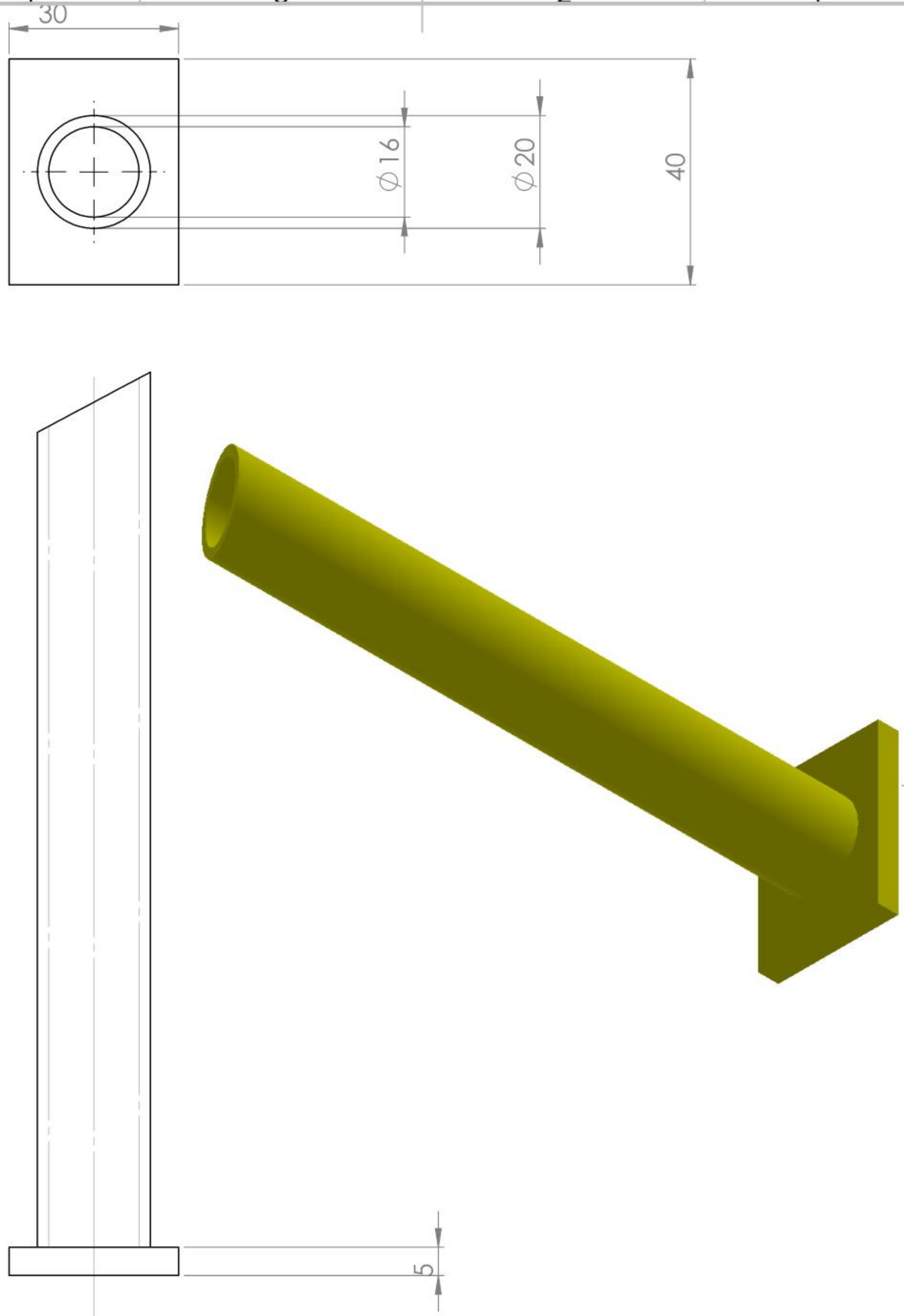
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:5	Part-26	Back column B		Material: Steel
	Tolerance			Number: 1



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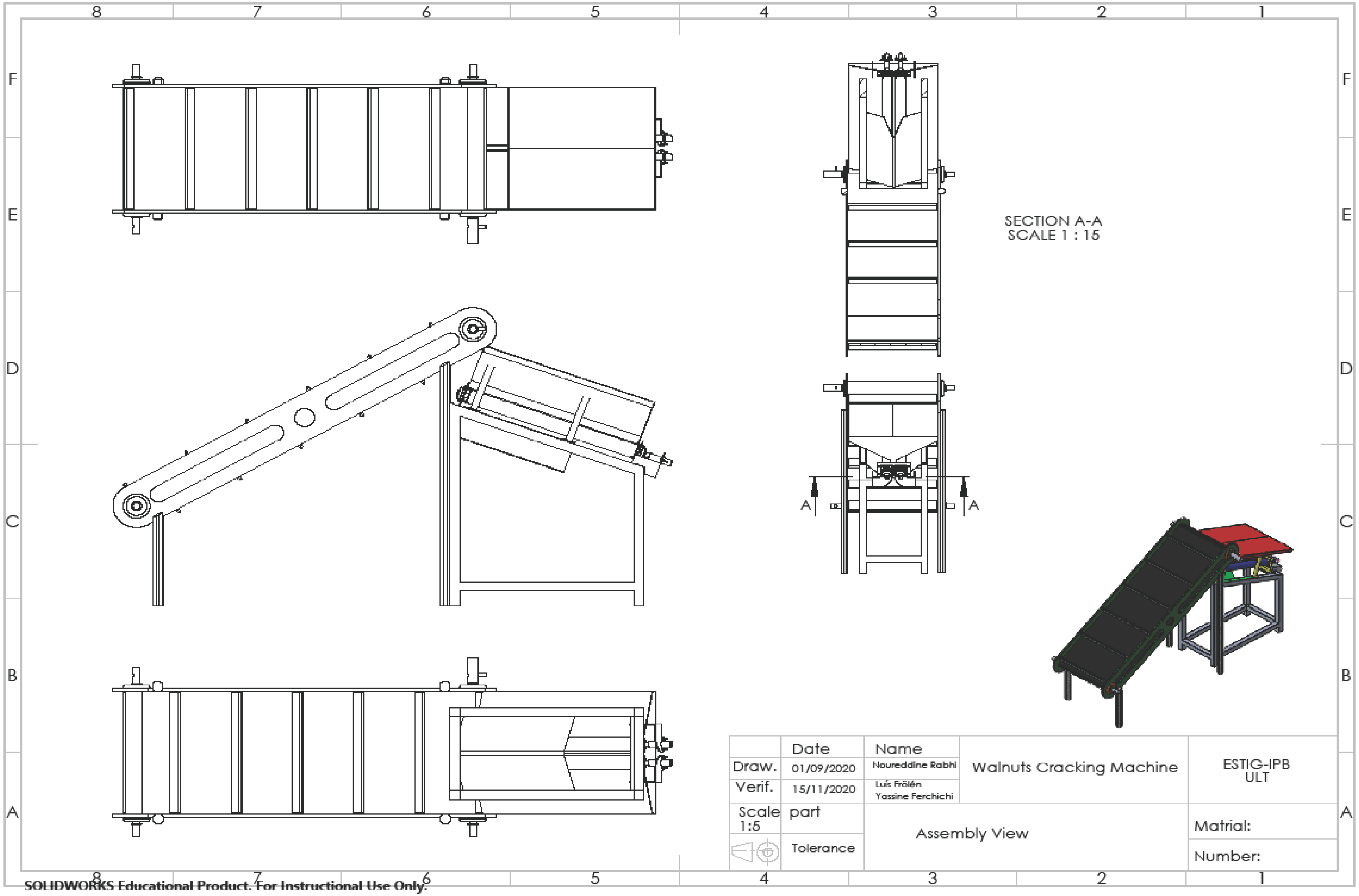
Draw.	01/09/2020	Noureddine Rabhi		
Verif.	15/11/2020	Luís Frölén Yassine Ferchichi		
Scale 1:2	Part-27	Support for protection trough		Material: Steel
	Tolerance			Number: 4


SECTION A-A
SCALE 1 : 15
A
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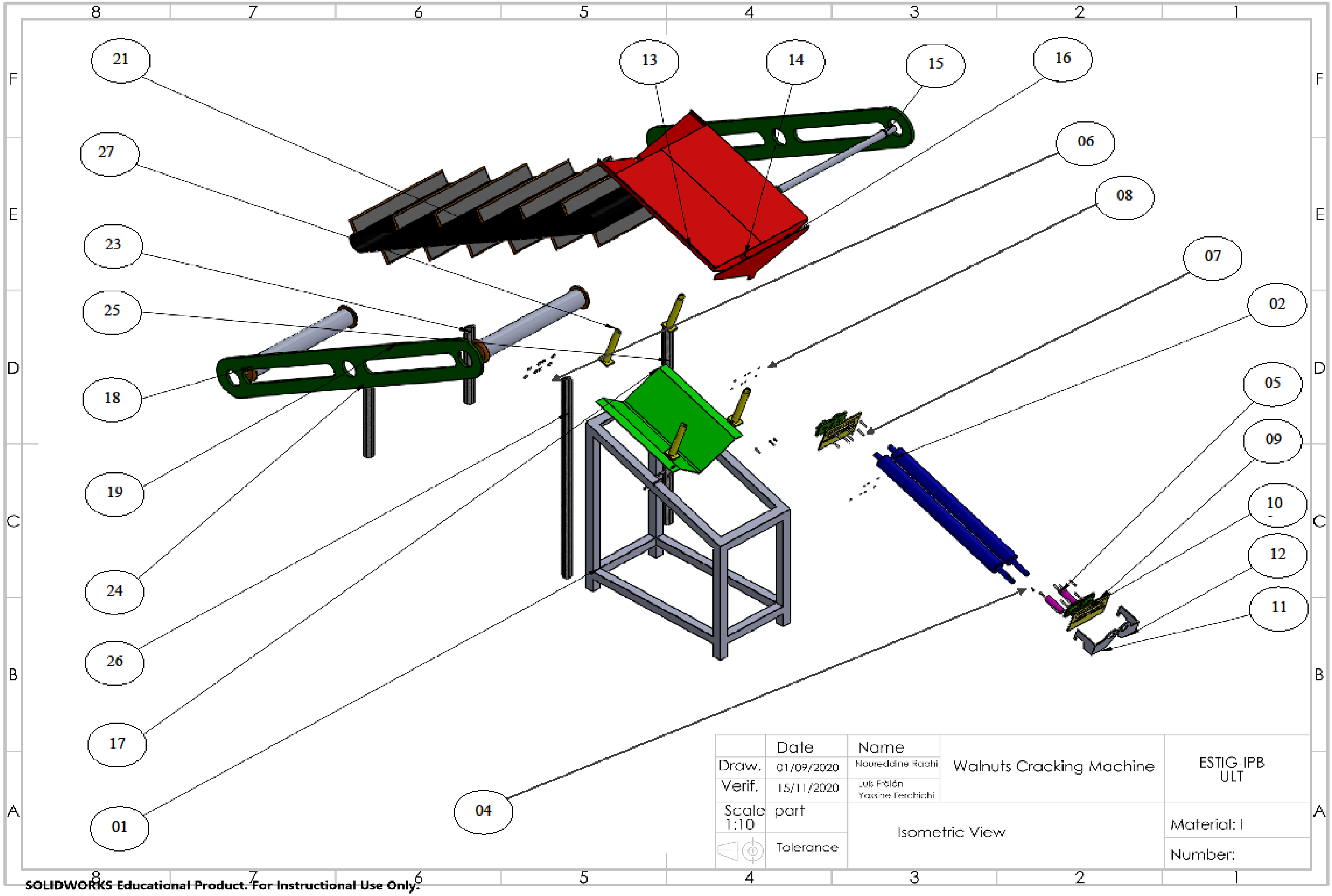
Date
Name
Draw.
01/09/2020
Noureddine Rabhi
Verif.
15/11/2020
Luís Frölén
Yassine Ferchichi
Walnuts Cracking Machine
ESTIG-IPB
ULT
Scale
1:5
part
Tolerance
Assembly View
Matrial:
Number:
SOLIDWORKS Educational Product. For Instructional Use Only.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12
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Date
Name
Draw.
01/09/2020
Verif.
15/11/2020
Scale 1:10
part
Tolerance
Walnuts Cracking Machine
ESTIG_IPB ULT
Isometric View
Material: I
Number:
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Chapter 5: Conclusions and future work

5.1. Conclusions

During this project we have started by studying existing nut cracking solutions and comparing them, in that phase we managed to find many cracking types and different ways to separate nuts from kernel, from among these solutions we had the idea of a simpler design based on rotating cylinders. After the choice of solution, we proceeded towards the functional analysis in which we carefully studied the needs and functions of the project. We defined the needs that the project satisfies, the different functions and objectives of the machine as well as its surrounding elements. We then proceeded to design the different parts of our machine such as the belt conveyer, main frame and cracking unit followed by a results and discussion part.

In spite of the fact that the outlined machine has not been manufactured and thus cannot be assessed, but since all vital walnut mechanical parameters are considered in planning the machine, it is anticipated the model machine work satisfactorily. In addition, the power out of our using engine is 692 W and for one walnut the topical force is 200N, and for the axial dimension (length, width) of cultivars varied from 20.35 to 26.74 mm and 15.09 to 21.20 mm and the diameter of walnut was 19,87 to 24.46 mm.

5.2. Future work

As mentioned in the previous part that the budget of the studied cracking machine is cheaper than other kind. These results allowing us to the next step of this work which is the construction.

This prototype with slight adjustment can be utilized for a few other types of nuts, also he is extendable by adding separation system.

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Annex

Adapted from: **Bulk Solids Handling: An Introduction to the Practice and Technology** C.R. Woodcock, J.S. Mason, BLACKIE ACADEMIC & PROFESSIONAL, 1987, XII				
Material	**Bulk density (tonnes/m^3)**	**Angle of repose***	**Recommended max, angle of inclination***	**Surcharge angle***
Alumina	0.8-1.08	22	12	10
Ashes (coal)-dry	0.56-0.64	45	20	30
Ashes (coal)-wet	0.72-0.80	45	20	30
Ashes (coal)-fly	0.5-0.8	42	22	30
Gravel, dry sharp	1.44-1.6	40	20	25
Gravel, pebbles	1.44 - 1.6	30	12	10
Barytes (fine)	1.8-2.0	35	15	10
Bauxite (granular)	1.20-1.36	30	20	20
Cement	1.20-1.36	30	15-18	10-20
Chalk (fine)	1.0-1.2	42	25	25
Chalk (lumpy)	1.2-1.4	42	15	10
Clay (dry fines)	1.6-1.9	35	20	22
Coal (bituminous)	0.72-0.88	35	18	18
Coke	0.4-0.5	38	18	25
Copper ore	1.92-2.56	38	20	25
Iron ore	2.08-2.88	35	18	20
Kaolin clay	1.0	35	19	20
Limestone	1.44-1.52	38	18	25
Limestone, crushed	1.36 – 1.44	38	18	25
Lime, pebble	0.850 – 0.9	30	17	20
Manganese ore	2.0 – 2.24	39	20	25
MSW		54		39
RDF		65		40
d-RDF		49		38
Heavy fraction		59		40
Phosphate rock, broken, dry	1.2-1.36	25 - 30	12 - 15	10
Phosphate rock, pulverized	0.960	40	25	25
Rubber, pelletized	0.8- 0.88	35	22	25
Rubber, reclaim	0.4 -0.48	32	18	20
Sand -foundry	1.3-1.4	-	24	30
Sand-dry	1.44-1.60	35	16	20
Slag, blast furnace, crushed	1.28-1.44	25	10	10
Slag, furnace, granular, dry	0.96-1.04	25	13 - 16	10
Slag, furnace, granular, wet	1.44 – 1.6	45	20 - 22	30
Slate, crushed, under 12 mm	1.28-1.44	28	15	20

Annex 1: Relevant properties of a selection of familiar bulk solids

Belt width **W**, m	Cross sectional area S* of the load, m^2
0,4	0,01444
0,45	0,0192
0,5	0,0242
0,6	0,0364
0,65	0,0436
0,75	0,0597
0,8	0,0686
0,9	0,0883
1	0,1106
1,05	0,1225
1,2	0,1625
1,35	0,2078
1,4	0,2242
1,5	0,2589
1,6	0,2961
1,8	0,3781
2	0,4697
2,2	0,5714

Annex 2: Cross-sectional area values S as a function of the conveyor belt width W

Horizontal, inclined or slightly declines installations	
Favorable working conditions (easy rotating idlers, material with low internal friction, good tracking, good maintenance)	0.017
Normal working conditions	0.020
Unfavorable working conditions (low temperature, material with high internal friction, subject to overload, poor maintenance)	0.023-0.027
Installations with steep declinations	0.012-0.016

Annex 3: friction factors for different working conditions at a belt speed of v=5m/s and a Temperature of T=+20°C (Dunlop-Enerka GmbH, 1994)