Design and implementation of broom sticks machine

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Submitted to the College of Engineering
in partial fulfillment of the requirements for the
Bachelor degree in Automotive Engineering

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Palestine Polytechnic University
College of Engineering and Technology
Mechanical Engineering Department
Hebron - Palestine

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Supervisor signature

....

Chair of the department signature

....

Dedication (Arabic)

إلى المعلم الأول .. إلى قائد هذه الأمة وقدوتها .. رسولنا محمد صلوات الله وسلامه عليه

إلى من كلله الله بالهيبة والوقار .. إلى من علمني العطاء دون انتظار .. إلى من أحمل إسمه بكل افتخار .. أرجو من الله أن يمد في عمرك لترى ثماراً قد حان قطافها بعد طول انتظار وستبقى كلماتك نجوماً أهتدي بها اليوم وفي الغد وإلى الأبد.
(والدي العزيز)

إلى ملاكي في الحياة .. إلى معنى الحب والحنان والتفاني .. إلى بسمة الحياة وسر التميز
إلى من كان دعائها سر نجاحي وحنانها بلسم جراحي إلى أغلى الأحباب.
(أمي الغالية)

إلى الشموع التي تحترق لتنير لنا الطريق .. إلى منهل العلم والمعرفة .. إلى من عبرنا على أيديهم وبمساعدتهم ورعايتهم إلى بر الأمان .. إلى من علمونا حروفاً من ذهب وكلمات من درر.
(أساتذتنا الأفاضل)

إلى الأسود القابعة خلف القضبان .. إلى من ضحوا بحريتهم من أجل حرية غيرهم.
(الأسرى الأبطال)

إلى من هم أكرم منا مكانة .. إلى من ضحوا بدمائهم في سبيل تحرير هذا الوطن.
(الشهداء الأبرار)

إلى من سرنا سوياً نشق الطريق معاً نحو النجاح والإبداع .. وإلى كل من مررنا بهم على درب العلم والمثابرة.
(الزملاء والزميلات)

إلى رفقاء الدرب .. رجال المواقف .. أصحاب الهمم والطموحات العالية .. عنوان المثابرة .. إلى من تحلوا بالإخاء .. وتميزوا بالصدق والعطاء.
(أصدقائي الأحباب)

إلى الوطن الغالي .. إلى الأرض التي إحتضنتنا..

إلى السنبلة الذهبية في بلادي و بيارات البرتقال...إلى كروم العنب وغصن الزيتون.. ودم الشهداء و دمعة الأطفال ..إلى رغيف الطابون و ريح الزعتر..
الى تلك التي صنعتني كي أكون هنا
(فلسطين الحبيبة)

Acknowledgment

We would like to express our gratitude for everyone who helps us during the graduation project, starting with endless thanks for our supervisor Eng. Jalal Alsalaymeh who didn’t keep any effort in encouraging us to do a great job, providing us with valuable information and advices to be better each time. Thanks for the continuous support and kind communication which great effect regarding to feel interesting about what we are working on.

Finally, Thanks are extended to the "Automotive and Mechanical society" for the beneficial lectures provided.

Abstract (in English)

Broom sticks are imported from abroad as there is no local manufacturer in Palestine. Import is expensive and consumption is high. However, there are technical problems such as curving the stick and the losing of threads sticks.

This project aims to solve this problem by designing and implementing the machine to make the broom sticks in a mechanical way. The machine takes the wood with a square cross section and does a cylindrical broom sticks by using the turning. Such machine makes the thread of these sticks then ready to be used. In addition, this machine will reduce the imports and produce a high-quality of local product.

Abstract (in Arabic)

يتم استيراد عصي المكانس في فلسطين من الخارج ولا يوجد تصنيع محلي ، حيث أن الإستيراد مكلف والإستهلاك عالي ويوجد فيها مشاكل فنية كتقويسة العصا وخروج أسنان العصي من مكانها .

يهدف هذا المشروع الى حل هذه المشكلة من خلال تصميم وتنفيذ ماكنة صناعة عصي المكانس بطريقة ميكانيكية حيث تقوم الماكنة بأخذ الخشب ذو مقطع عرضي مربع وتعمل منه عصي مكانس اسطوانية الشكل بواسطة الخراطة وتقوم الماكنة أيضاً بعملية تسنين هذه العصي بحيث تكون جاهزة للإستعمال .

الماكنة مطلوبة لتقليل الإستيراد وإنتاج منتج محلي عالي الجودة .

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Chapter 1: Introduction

This chapter deals with a general introduction of the project and then talks about the problem definition, why this topic is chosen, how the project is implemented, and the expected costs of this project, also we will talk about the outputs of this project and .the time distribution of each section.

1.1 Introduction

The broom sticks are a high consumption product in Palestinian society, it is imported from abroad because there is no local industry supplying the local market.

So, it was important to have an industry that matched the imported one, and competed in the price, quality and its life span.

There are several common uses in the Palestinian community for broom sticks such as: brooms, paint brushes, advertising banners, …, etc.

This project is one of the most important and required projects in the local market, and it is expected to have high production and great profit due to the uniqueness of it in the market and the urgent need for it.

What Is a Broom Stick

A broom is a cleaning tool consisting of usually stiff fibers (often made of materials such as plastic, hair, or corn husks) attached to, and roughly parallel to, a cylindrical handle, the broomstick. It is thus a variety of brush with a long handle. It is commonly used in combination with a dustpan.

A distinction is made between a "hard broom" and a "soft broom". Soft brooms are for sweeping walls of cobwebs and spiders. Hard brooms are for sweeping dirt off sidewalks.

The broom stick is a cylindrical wooden piece of different dimensions. It is manufactured by a special machine with a length of **120-200 cm**, and a diameter of **2.2-4 cm**. It contains teeth on one side to be fixed in the required part for use such as broom, and others, as shown in figure 1.1.

Fig. 1.1: Broom Stick

1.2 Problem definition

There are many types of problems in this scope broom sticks:

1.Economic problem: high consumption and high importation.

2.Technical problem:

* Curvature occurs in the stick.
* Losing of threads sticks.

1.3 Motivation

The importance of our project is to solve the existing problem by reducing imports and producing a local product with high quality, lower price and longer life.

How to solve this problem

1. Economically: issue manufacturing a local high quality, long life and a lower price machine, which reduces the external import.

2. Technically: Using high quality machine and raise the quality of the product and avoid defect.

1.4 Expected output

The design and implementation of a machine to manufacture broom sticks that ready for use.

1.5 Methodology

In this project we we'll design and implement a machine to manufacture the broom sticks in a mechanical way containing a rotating rotary head that turns the cross section into a cylindrical circular section by turning.

The thread of one end of the stick are then made to be ready for use, taking into account occupational safety requirements.

1.6 Budget

The Table below shows the budget of the project and its distribution. The budget of the project is estimated to be around 8500 NIS, In Table 1 is listed the needed components for the project, the price of each component's single unit, the number of units needed of each component, and the total price for each component.

Table 1: Budget

Components	**Price (NIS)**
Motor's and gears (3)	3000
Raw materials and lathing	3000
Belt (2)	50
Bearing (2)	80
Pulleys (4)	200
Inverter	1400
Contactors (2)	80
Emergency	35
Over load (2)	280
Screws, bolts and nuts	150
Other components	200
Total cost	8475 NIS

1.7 Time schedule

Table 2: Time schedule for introduction of the project

	First semester															
Task\Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Identifying the project idea																
Writing project name and abstract and proposal																
Literature review																
Drawing the machine and parts																
Writing the project																
Reference and make presentation and finishing																

Table 3: Time schedule for the project

Second semester																
Task\Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Mechanical and electrical design calculations																
Buying the machine parts																
Building the machine body and turning parts																
Mechanical and electrical parts assembly																
Writing the project and make presentation and finishing																

1.8 Machine Specifications

1- The production rate of the machine is 250 stick per hour

2- The machine is 85 cm in height, 40 cm in width, and 75 cm in length

3- The machine is 200 kg in weight

4- The body of the machine is made from steel, but the cutting head is made from very hard steel (S-52)

5- The rotating motor works on 1-phase, 3 HP, 380/220v, 50Hz

6- The push motor works on 1-phase, 0.5 HP, 380/220v, 50Hz

1.9 Broom stick specifications

1- The broom stick is 120 cm in length, and 3 cm in diameter

2- The broom stick is 0.5 kg in weight, and 0.7 g/cm^3 in density

3- The broom stick is made of pine wood " Hardwood"

4- The broom stick is used extensively for example: in brooms, Wipers, advertising and painting and other.

1.10 Literature Review

This subject will talk about previous studies which presents the methods used by researchers in this topic, which can benefit from their experiences and research done to complete our project.

Wooden Broom Assembly Adapter Means Therefore, Thomas J. Carey, Aug. 12, 1991

The main idea of this paper A broom assembly of a basically wooden push broom comprises a wooden head portion including top and bottom surfaces, leading and trailing edge portions and remote lateral extremities, considering the direction of its movement in use. This head has a laterally centered through bore opening at one end from the tope there of adjacent its trailing edge and at its opposite end from the bottom thereof, adjacent its leading edge. A counterbore of the upper end of this through bore produces an outwardly and rearwardly facing annular shoulder in its bounding wall surfaces. Securely wedged within this through bore, towards its bottom, is the short tubular body portion of a rigid plastic adapter means, an external flange at the base end of which overlies the bottom of the head and an external lip at the upper end of which clamps over the aforementioned shoulder in the wall bounding the upper end of the through bore. The adapter means is thereby clamped to and contains within the axial limits thereof an integral part of the head. In the lodging thereof within the through bore, differentially formed portions of the external surface of the tubular body portion of the adapter means differentially wedge in its bounding wall surface, effectively precluding its relative rotative displacement. A small portion of the inner surface of the adapter means has a short truncated thread the form of which enables an easy and most secure connection thereto of a complementarily formed portion of an applied handle.[1]

Design and Prototyping of a Low-Cost Manually Operated Bamboo-Cored Incense-Stick Making Machine, G. Keshav & M. Damodaran, India, Dec 18-20 2013

The main idea of this paper the design and prototyping of a low cost hand operated incense-stick making machine to alleviate the labor intensive work associated with the production of bamboo-cored incense sticks is outlined in this paper. The machine is based on the mechanism of extruding the incense stick paste over the bamboo stick. The main components of this machine include a hand-crank, a compound gear-train system, rack and pinion system and an extruder. As the paste used is of a semi-solid nature and a high force was needed for extrusion, a confined compression test using Universal Testing Machine was carried out to obtain rough estimates of the force required for the extrusion. During this experiment a known force was applied, varied and exerted on the rack until the paste was extruded out of the die. Using this force estimate, a suitable two-stage compound gear-train system with mechanical advantage of 9:1 and a hand-crank was designed. The lever and gear-train system was designed ergonomically so that the applied force results in a minimal arm-muscle fatigue for the operator.[2]

Broom Having Interlocking Components, Charles Nichols & Howard, Feb. 17, 1987

The main idea of this paper The broom assembly of the present invention comprises of a broom shroud having an opening in its top, said broom shroud including resilient means depending inwardly toward said opening; bristle retaining means including ferrule means integral therewith and extending upwardly therefrom, said ferrule means adapted to receive said resilient means; a broom handle removably received in said ferrule, and fastening means engaging the ferrule means, whereby said resilient means is flexed inwardly against the handle upon tightening said fastening means, as shown in figure 1.2 [3]

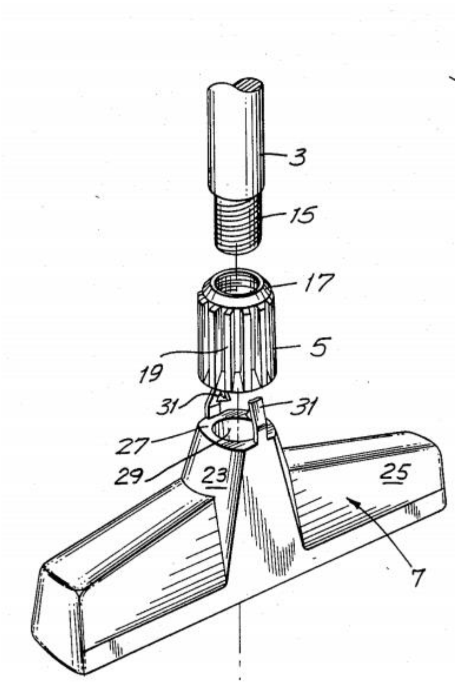


Fig. 1.2: Broom having interlocking components

Handle Socket Adapter, John C. Lewis, Aug. 4, 1987

The main idea of this paper A socket adapter for use with a broom block, the socket adapter for receiving a threaded handle such that the release torque required to remove the handle is aggrandized, i.e. greater than the application torque required to attach the handle. The socket adapter comprises a tube having an annular lip for abutting against a corresponding lip adjacent the threads of the handle and at least one thread on the tube.

The thread begins a predetermined distance below the annular lip such that an expansion space is formed above the thread to provide a space into which the handle thread material may expand. Upon tightening the handle in the socket adapter with a predetermined amount of attachment torque, the handle material will expand into the expansion space and create an attachment between the handle and the socket requiring a release torque greater than the attachment torque to remove the handle, as shown in figure1.3 [4]

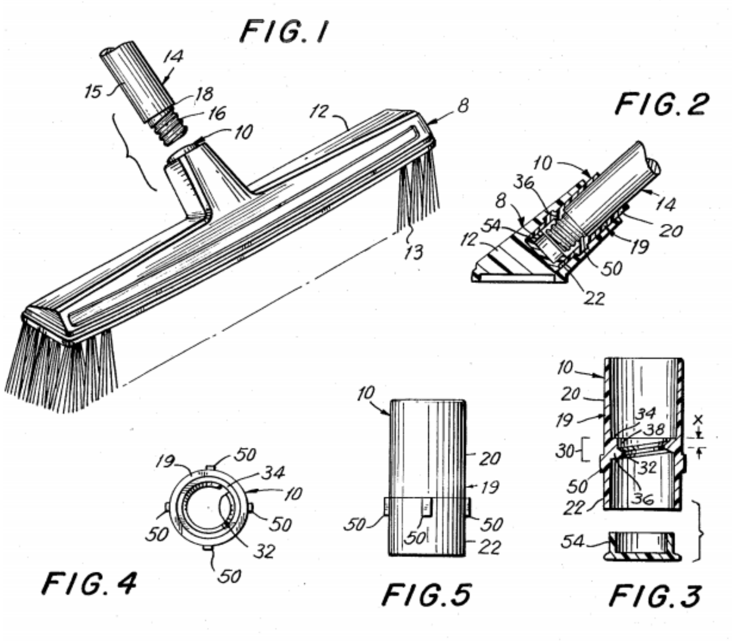


Fig. 1.3: Handle socket adapter

Universal Rotation-Inhibiting Connector Apparatus and Method For Threaded Utility Handles, Joseph L. Congdon, Mar. 30, 2010

The main idea of this paper A universal connector apparatus for securing a male-threaded utility handle end into a female receptacle of a tool assembly comprising a tool, comprising: a Substantially-circular friction ring; a Substantially-circular thread neck attached at a leading end thereof to, and centrally-aligned with, a trailing end of the friction ring; and a Substantially-circular threaded end aperture running centrally through the friction ring and thread neck combination.[5]

Modular Handle Particularly for Brooms and Like, Enrico Spinelli, Mar. 15, 2005

The main idea of this paper an improved modular handle for a tool having a plurality of handle Segments, at least a grasping Segment and a Support Segment for the tool, the Segments being provided with either a male end or a female end for coupling to each other by a forced introduction. The male end has a reduced diameter Zone with a undulate end Section, and the female end having a hollow Section with an inner diameter to receive by a forced coupling, the undulate Section of the male end, as shown in figure 1.4 and 1.5 [6]

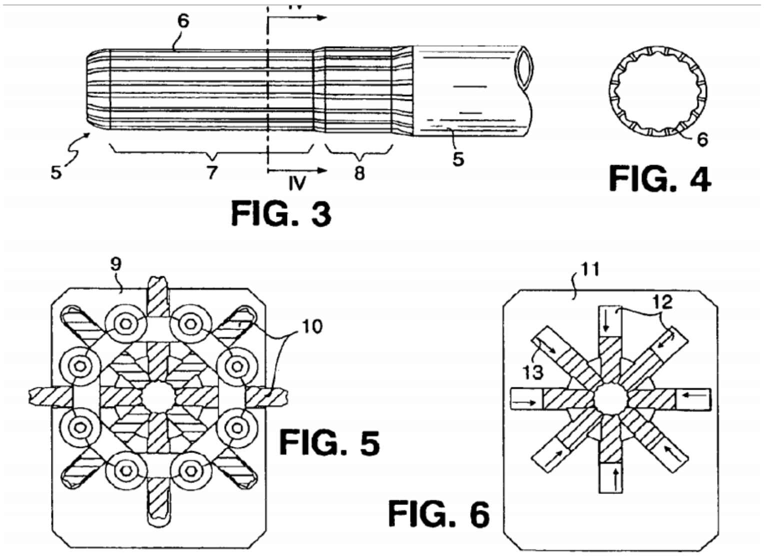


Fig. 1.4: Modular handle particularly for brooms and like

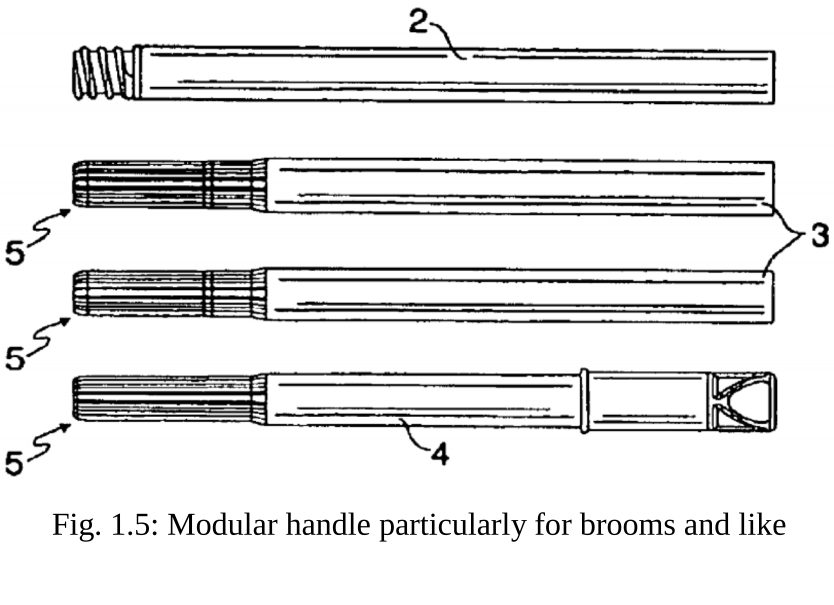


Fig. 1.5: Modular handle particularly for brooms and like

Chapter 2: Wood Turning

2.1 Introduction

Wood turning is the craft of using the wood lathe with hand-held tools to cut a shape that is symmetrical around the axis of rotation. Like the potter's wheel, the wood lathe is a simple mechanism which can generate a variety of forms. The operator is known as a turner, and the skills needed to use the tools were traditionally known as turnery. In pre-industrial England, these skills were sufficiently difficult to be known as 'the mystery' of the turner's guild. The skills to use the tools by hand, without a fixed point of contact with the wood, distinguish woodturning and the wood lathe from the machinists' lathe, or metal-working lathe.

Industrial production has replaced many of these products from the traditional turning shop. However, the wood lathe is still used for decentralized production of limited or custom turnings. A skilled turner can produce a wide variety of objects with five or six simple tools. The tools can be reshaped easily for the task at hand.

In many parts of the world, the lathe has been a portable tool that goes to the source of the wood, or adapts to temporary workspaces. 21st-century turners restore furniture, continue folk-art traditions, produce custom architectural work, and create fine craft for galleries. Woodturning appeals to people who like to work with their hands, find pleasure in problem-solving, or enjoy the tactile and visual qualities of wood, as shown in figure 2.1 [7]

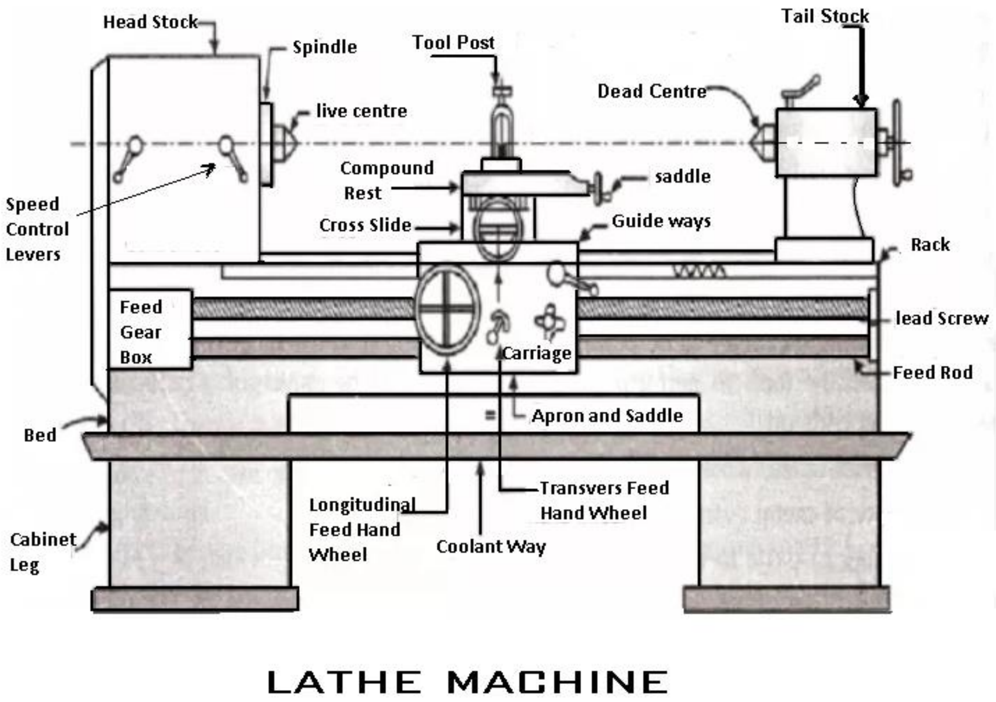


Fig. 2.1: Lathe machine

2.2: The Lathe

The sizes of turning lathes are given as 10", 12", etc. These figures denote the diameter, or size, of the largest piece of work that can be turned on them. The measurement is taken from the center point of the live center to the bed of the lathe (usually 5" or 6") and is one-half the diameter of the entire circle. The length of a lathe is determined by the length of a piece of work that can be turned.

This measurement is taken from the points of the live and dead centers when the tail stock is drawn back the full extent of the lathe bed, as shown in figure 2.2.

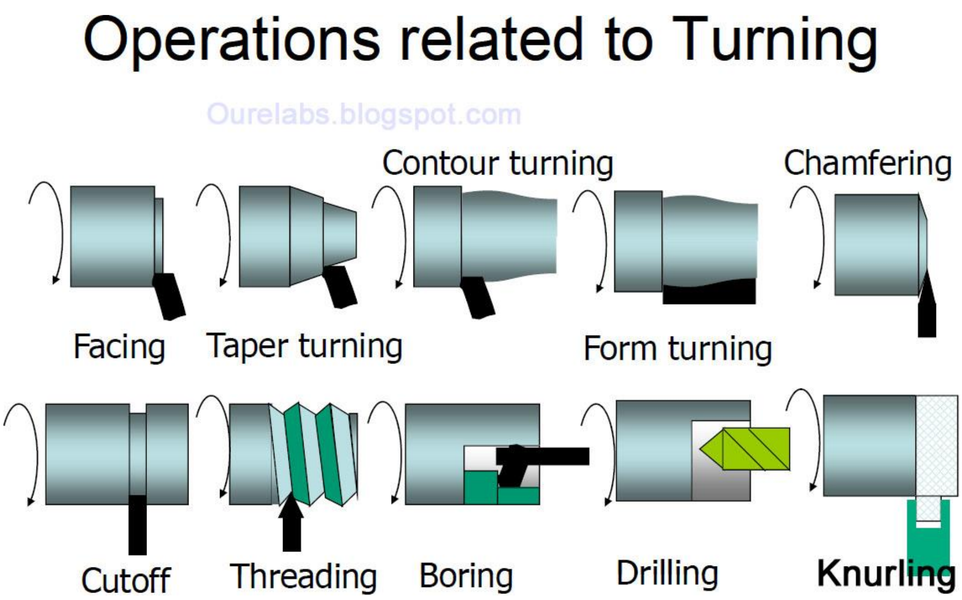


Fig. 2.2: Operations related to turning

2.2.1: Speed of the lathe

The speed of the lathe should 500 revolutions per minute when the belt is on the smallest step of the cone pulley. At this speed stock up to 3" in diameter can be turned with safety. Stock from 3" to 6" in diameter should be turned on the second or third step, and all stock over 6" on the last step. The speed at which a lathe should run depends entirely upon the nature of the work to be done and the kind of material used. Pieces that cannot be centered accurately and all

glued-up work with rough corners should be run slowly until all corners are taken off and the stock runs true. At high speed the centrical force on such pieces is very great, causing the lathe to vibrate, and there is a possibility of the piece being thrown from the lathe thus endangering the worker as well as those around him. After the stock is running true the speed may be increased, as shown in figure 2.3 and 2.4 [8]

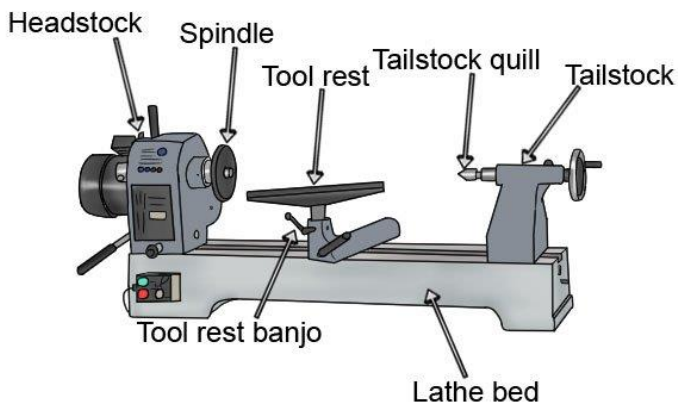


Fig. 2.3: Wood turning lathe

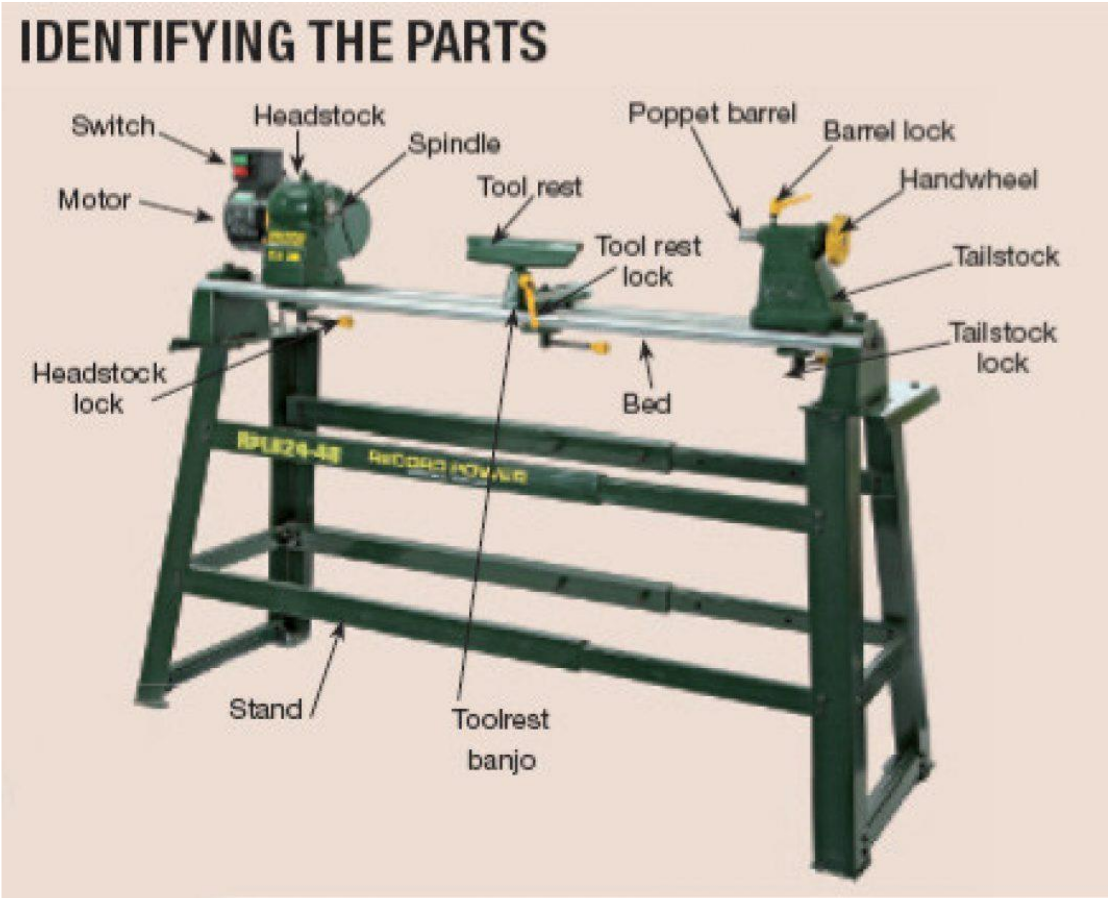


Fig. 2.4: Wood turning lathe

2.2.2 : Rules for finding the speeds and sizes of pulleys

1. To find the diameter of the driving pulley:

Multiply the diameter of the driven by the number of revolutions it should make and divide the product by the number of revolutions of the driver. (20 x 300 = 6000; 6000 ÷ 1500 = 4"-- diameter of motor pulley.)

2. To find the diameter of the driven pulley:

Multiply the diameter of the driver by its number of revolutions and divide the product by the number of revolutions of the driven. (4 x 1500 = 6000; 6000 ÷ 300 = 20"--diameter of the driven pulley.)

3. To find the number of revolutions of the driven pulley:

Multiply the diameter of the driver by its number of revolutions and divide by the diameter of the driven. (4 x 1500 = 6000; 6000 ÷ 20 = 300--revolutions of driven pulley.)

2.2.3 Grinding and whetting turning tools

The skew chisel is sharpened equally on both sides on this tool the cutting edge should form an angle of about 20° with one of the edges. The skew is used in cutting both to the right and to the left, and therefore, must be beveled on both sides. The length of the bevel should equal about twice the thickness of the chisel at the point where it is sharpened. In grinding the bevel, the chisel must be held so that the cutting edge will be parallel to the axis of the emery wheel. The wheel should be about 6" in diameter as this will leave the bevel slightly hollow ground. Cool the chisel in water
occasionally when using a dry emery. Otherwise the wheel will burn the chisel, taking out the temper; the metal will be soft and the edge will not stand up. Care should be exercised that the same bevel is kept so that it will be uniformly hollow ground. The rough edge left by the emery wheel should be whetted off with a slip stone by holding the chisel on the flat side of the stone so that the toe and heel of the bevel are equally in contact with it. Rub first on one side and then on the other.
The wire edge is thus worn off quickly as there is no metal to be worn away in the middle of the bevels. The chisel is sharp when the edge, which may be tested by drawing it over the thumb nail, is smooth and will take hold evenly along its entire length. If any wire edge remains it should be whetted again, as shown in figure 2.5 and 2.6 [9]

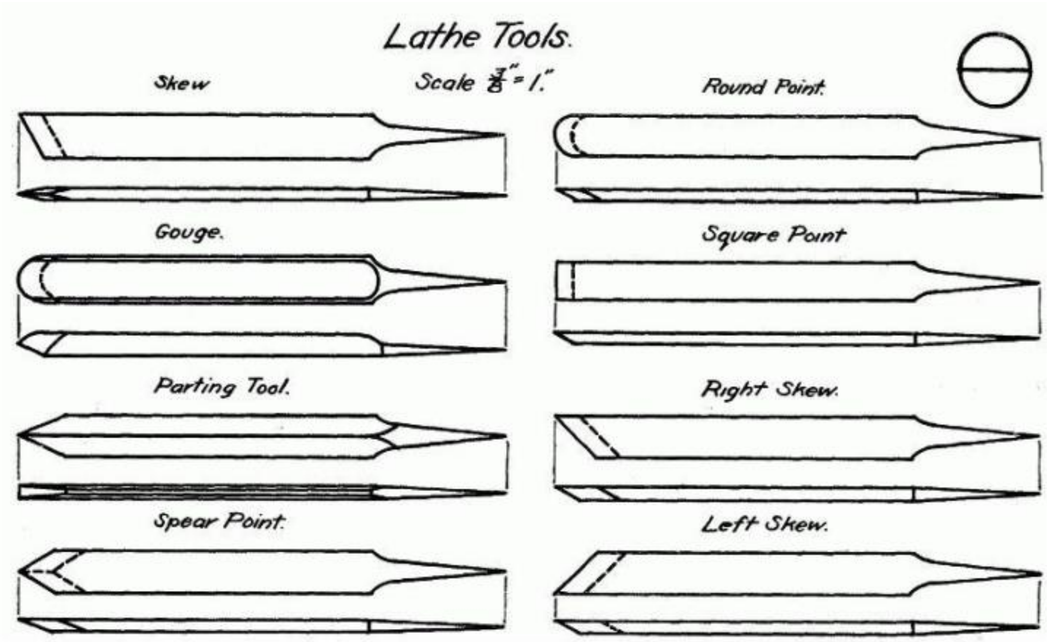


Fig. 2.5: Lathe Tools

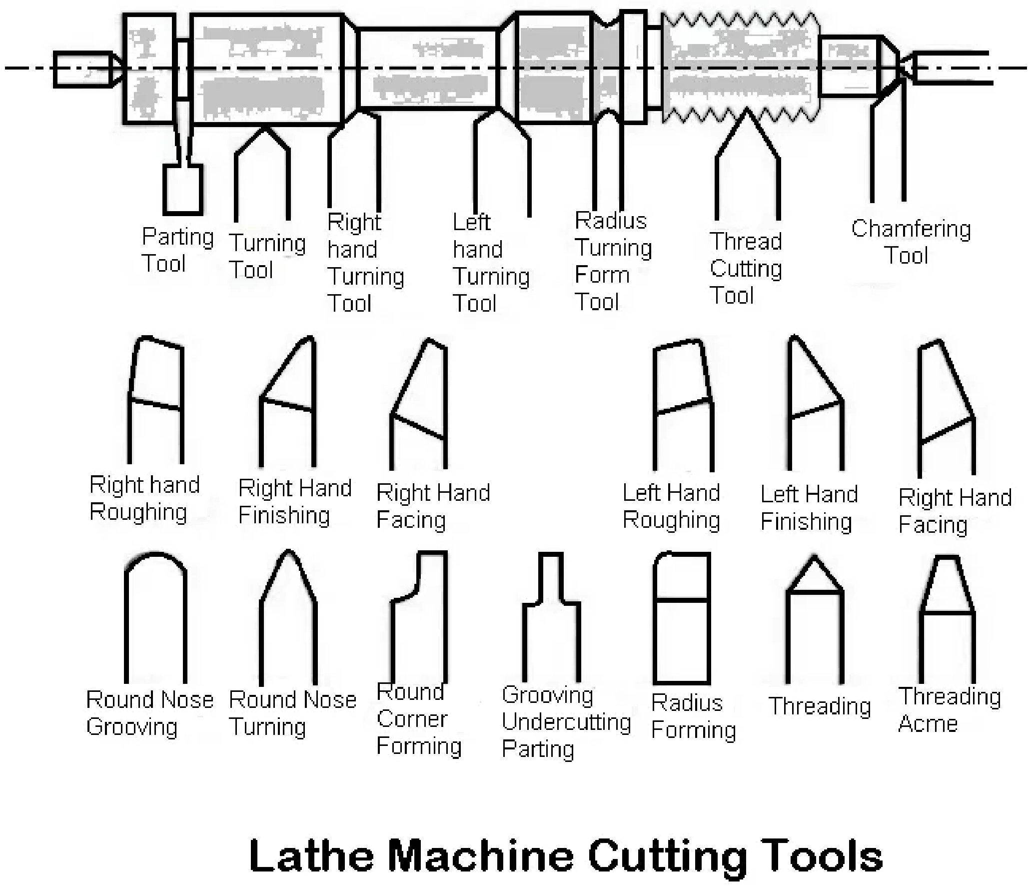


Fig. 2.6: Lathe machine cutting tools [10]

2.3 Threading process [11]

Thread cutting on the lathe is a process that produces a helical ridge of uniform section on the workpiece. This is performed by taking successive cuts with a threading tool bit the same shape as the thread form required.

2.3.1 Thread calculations

To cut a correct thread on the lathe, it is necessary first to make calculations so that the thread will have proper dimensions. The following diagrams and formulas will be helpful when calculating thread dimensions, as shown in figure 2.7

Example: Calculate the pitch, depth, minor diameter, and width of flat for a ¾-10 NC thread.

P = 1 / n = 1/ 10 = 0.100 in.

Depth = 0.7500 x Pitch = 0.7500 x 0.100 = 0.0750 in.

Minor Diameter = Major Diameter – (D + D) = 0.750 – (0.075 + 0.075) = 0.600 in.

Width of Flat = P/8 = (1 / 8) x (1/10) = 0.0125 in.

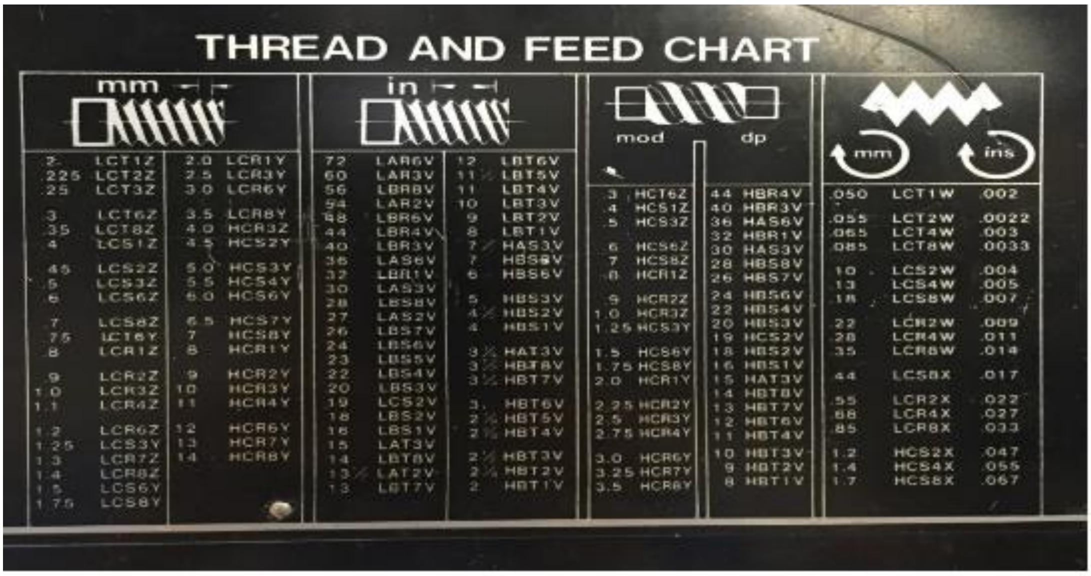


Fig. 2.7: Thread and feed chart.[13]

2.3.2 Screw thread cutting [12]

Screw threads are cut with the lathe for accuracy and for versatility. Both inch and metric screw threads can be cut using the lathe. A thread is a uniform helical groove cut inside of a cylindrical workpiece, or on the outside of a tube or shaft. 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, as shown in figure 2.8

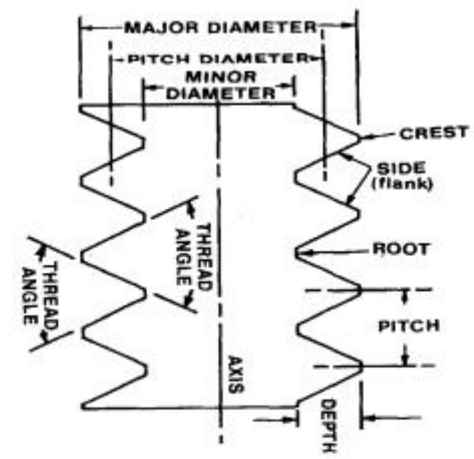


Fig. 2.8: Screw thread terminology.

2.3.3 Screw thread terminology

The common terms and definitions below are used in screw thread work and will be used in discussing threads and thread cutting, as shown in figure 2.9

- **External or male thread** is a thread on the outside of a cylinder or cone.
- **Internal or female thread** is a thread on the inside of a hollow cylinder or bore.
- **Pitch** is the distance from a given point on one thread to a similar point on a thread next to it, measured parallel to the axis of the cylinder. The pitch in inches is equal to one divided by the number of threads per inch.
- **Lead** is the distance a screw thread advances axially in one complete revolution. On a single-thread screw, the lead is equal to the pitch. On a double-thread screw, the lead is equal to twice the pitch, and on a triple-thread screw, the lead is equal to three times the pitch.
- **Crest** (also called "flat") is the top or outer surface of the thread joining the two sides.

- **Root** is the bottom or inner surface joining the sides of two adjacent threads.

- **Side** is the surface which connects the crest and the root (also called the flank).

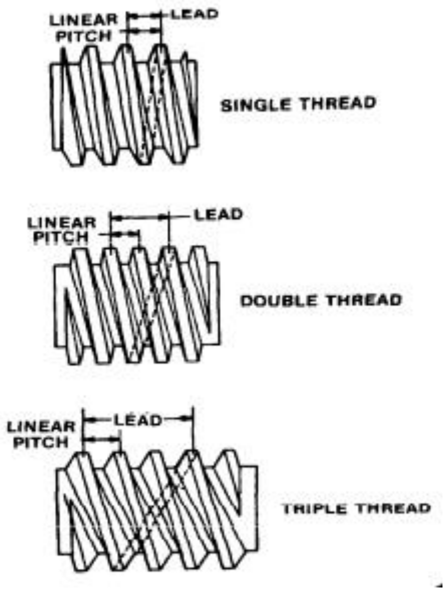


Fig. 2.9: Screw thread types

- **Angle of the thread** is the angle formed by the intersection of the two sides of the threaded groove.

- **Depth** is the distance between the crest and root of a thread, measured perpendicular to the axis.

- **Major diameter** is the largest diameter of a screw thread.

- **Minor diameter** is the smallest diameter of a screw thread.

- **Pitch diameter** is the diameter of an imaginary cylinder formed where the width of the groove is equal to one-half of the pitch. This is the critical dimension of threading as the fit of the thread is determined by the pitch diameter (Not used for metric threads).

- **Threads per inch** is the number of threads per inch may be counted by placing a rule against the threaded parts and counting the number of pitches in 1 inch. A second method is to use the screw pitch gage. This method is especially suitable for checking the finer pitches of screw threads.

- **A single thread** is a thread made by cutting one single groove around a rod or inside a hole. Most hardware made, such as nuts and bolts, has single threads.

Double threads have two grooves cut around the cylinder. There can be two, three, or four threads cut around the outside or inside of a cylinder. These types of special threads are sometimes called multiple threads.

- **A right-hand thread** is a thread in which the bolt or nut must be turned to the right (clockwise) to tighten.
- **A left hand thread** is a thread in which the bolt or nut must turn to the left (counterclockwise) to tighten.
- **Thread fit** is the way a bolt and nut fit together as to being too loose or too tight.
- **Metric threads** are threads that are measured in metric measurement instead of inch measurement.

2.3.4 Methods turning lathe screw

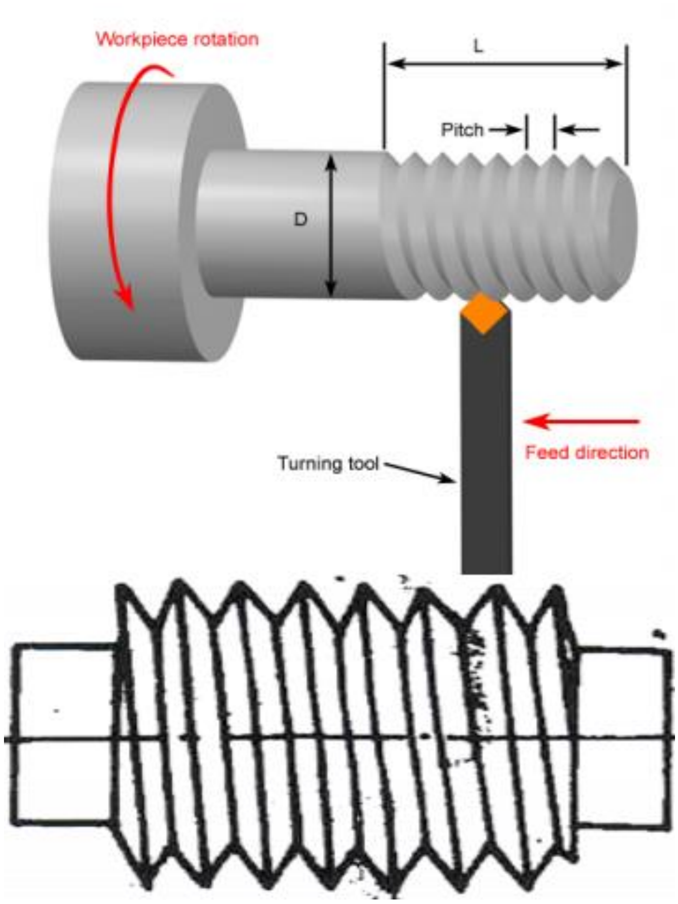


Fig. 2.10: Methods turning lathe screw

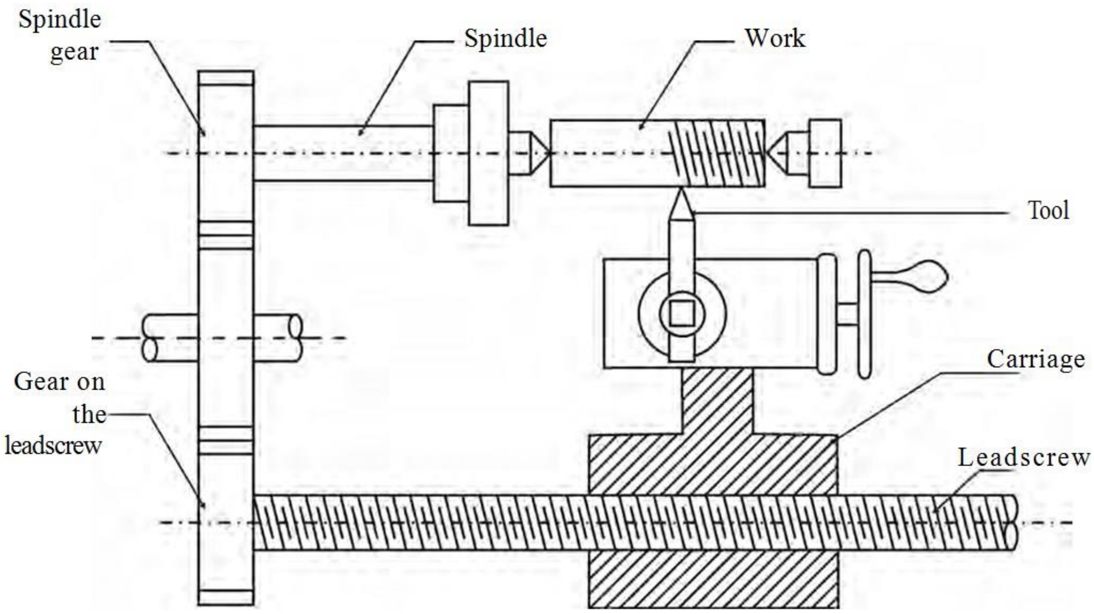
There are several methods of turning thread on a lathe:

1. The conventional method

The conventional method is a method of movement threading with feeds (additional incision depth / depth of cut), upright / using the cross slide.

2. Method slice one side

This threading method by tilting the top of the slide and use the top slide 60 as funeral movement (depth of cut). This method is efficient for turning lathe the screw with a large size, as shown in figure 2.11



Thread cutting

Fig. 2.11: Thread cutting operation on lathe machine

Chapter 3: Components of machine

3.1 Introduction

In this chapter we will talk about the components of machine and explain its parts and the function of each part.

This machine and parts were drawn using the SolidWorks software program.

3.2 Machine Parts

3.2.1 Machine Image

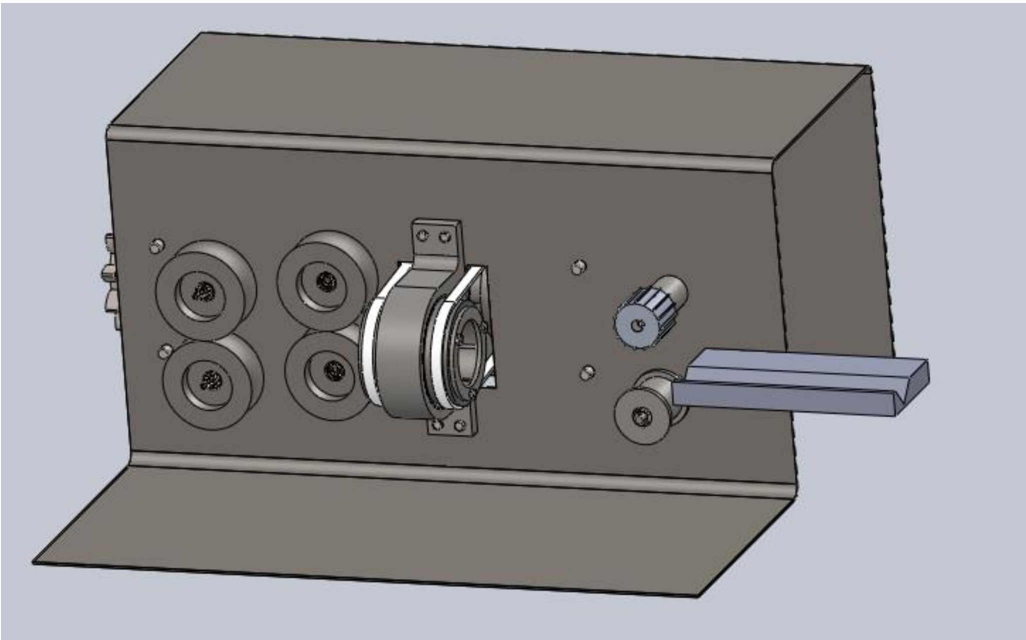


Fig. 3.1: Machine Image

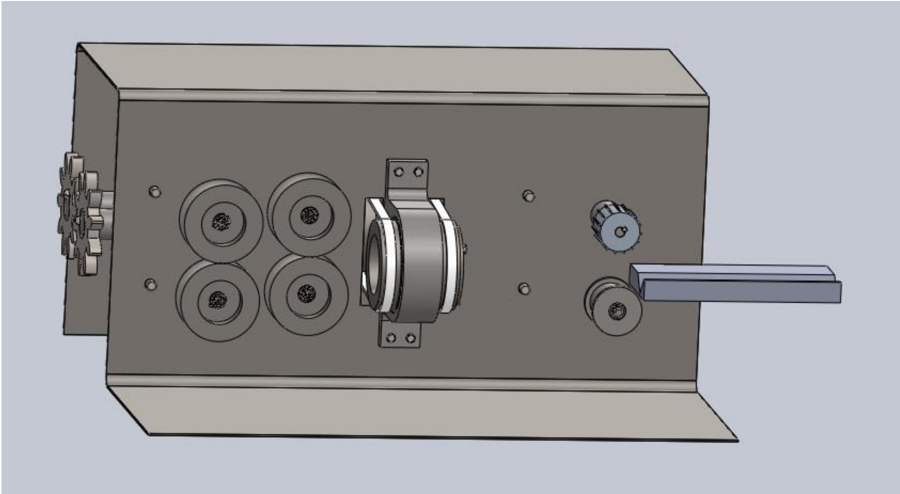


Fig. 3.2: Frontal machine image

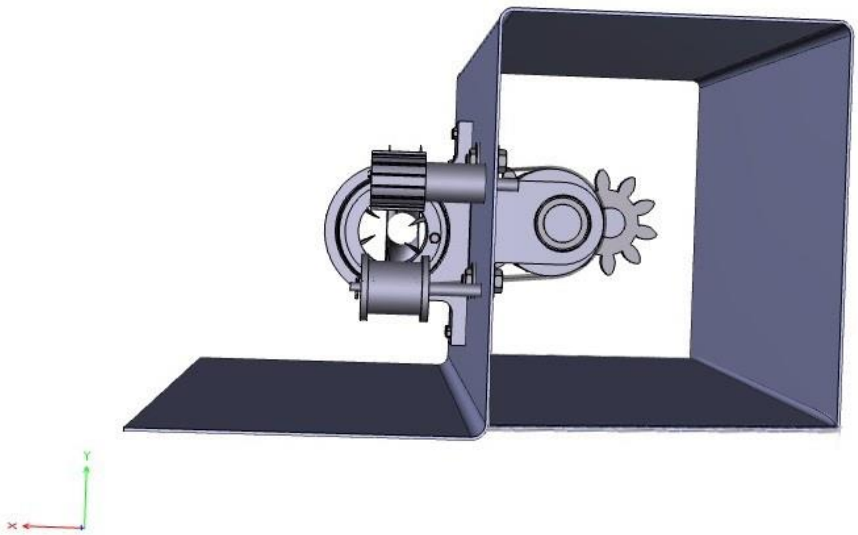


Fig. 3.3: Side machine image

3.2.2 Cutting Head

This part is used to turn the square shape to a circular through the knives inside it, as shown in figure 3.5

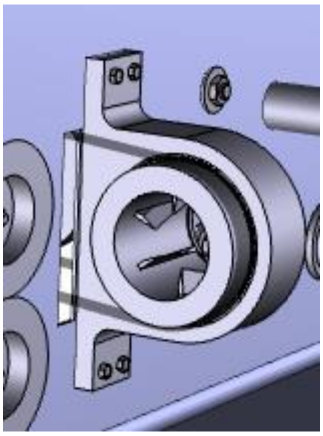


Fig. 3.4: Cutting Head

3.2.3 Knives

These part are used for lathing of the square wood inside, as shown in figure 3.6

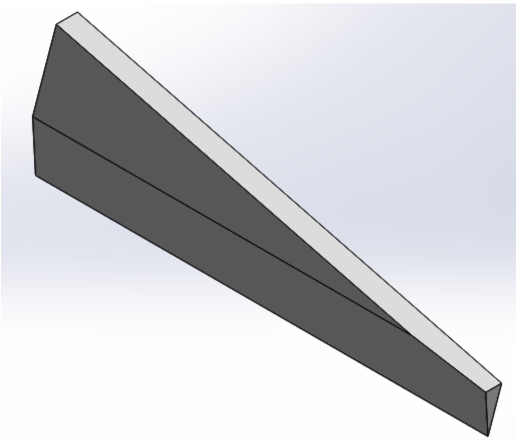


Fig. 3.5: Knives

3.2.4 Knives Base

This part is used to carry the lathe knives, as shown in figure 3.7

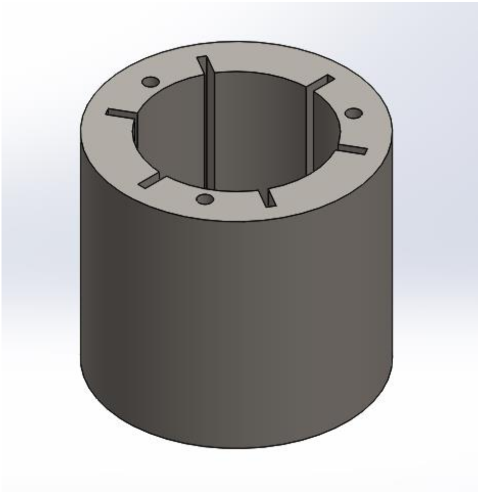


Fig. 3.6: Knives Base

3.2.5 Base cutting head

This part is used to carry the cutting head, as shown in figure 3.8

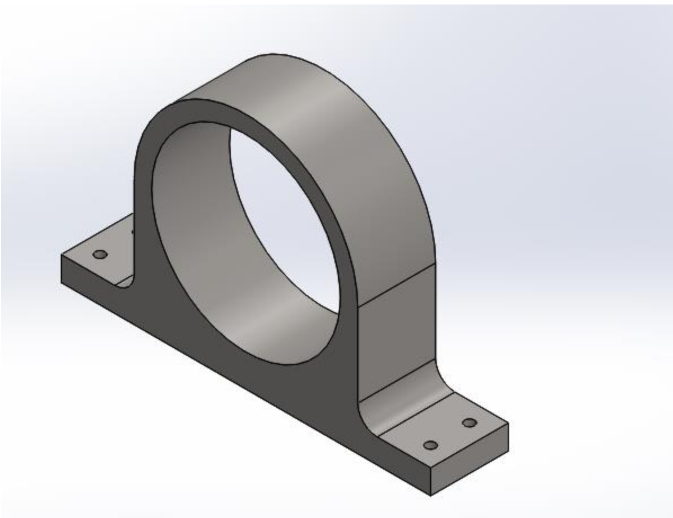


Fig. 3.7: Base cutting head

3.2.6 Types of Bering

A. Feed Bearing

This part is used to push the wooden piece to the cutting head, as shown in figure 3.9 and 3.10.

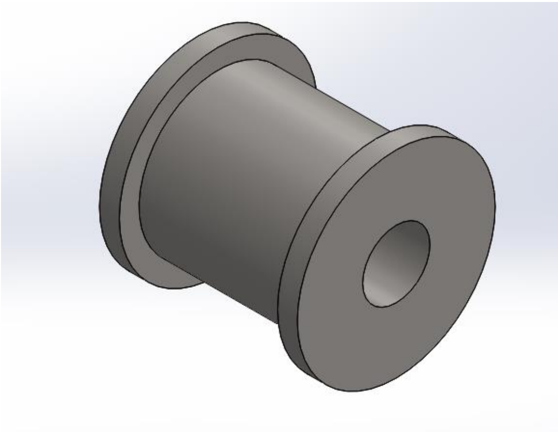


Fig. 3.8: Feed Bearing

B. Output Bearing

This part is used to pull a cylindrical wood from the cutting head, as shown in figure 3.11.

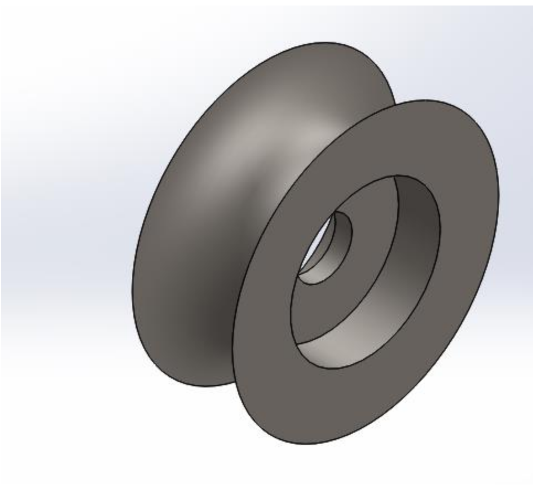


Fig. 3.9: Output Bearing

3.2.7 Motors

This part is used to drive the cutting head and push the wooden pole towards the cutting head, as shown in figure 3.12.

Fig. 3.10: Motors

3.2.8 Frame

Is the frame which carries part like cutting head and bearing and others, as shown in figure 3.13.

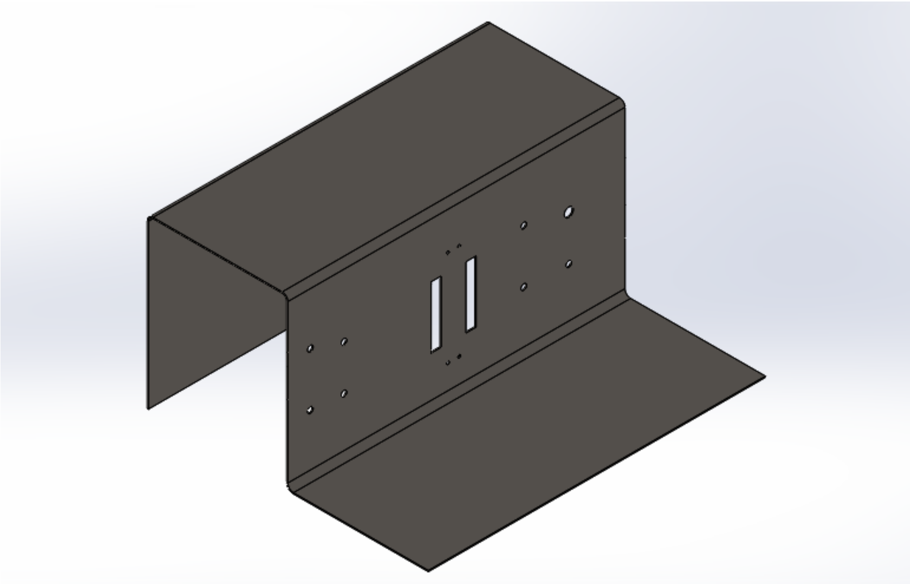


Fig. 3.11: Frame

3.2.9 Belt

This part is used to drive the cutting head, as shown in figure 3.14

Fig. 3.12: Belt

3.3 Threading parts

We can use special thread head:

By using an electric motor with a special thread head, the cylindrical wood enters the thread head, in first the motor rotating in one direction, this motion makes the thread, then motor rotating in other direction to bush the cylindrical wood out, as shown in figure 3.17

Fig. 3.13: Special thread head

Chapter 4: Machine design [14]

4.1 Introduction

Machine design is the most important part for any machine, so in this chapter the mechanical design and electrical design for every part in the machine are detailed.

Before starting in mechanical design, the material and dimensions of the mechanical part which will be designed must be known in addition to type of load and its material properties to be on safe side.

4.2 Mechanical design

4.2.A Calculate the cutting or turning part of the wood pole

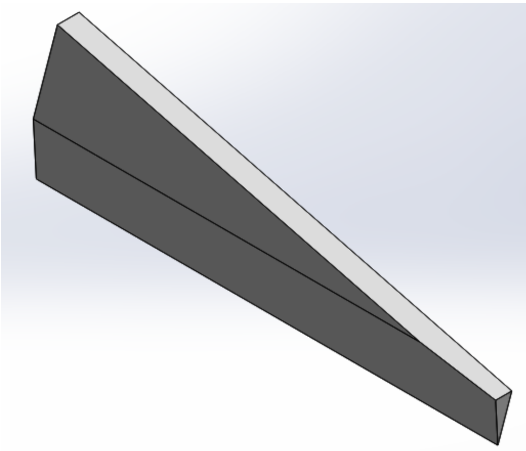


Fig. 4.1: Knife

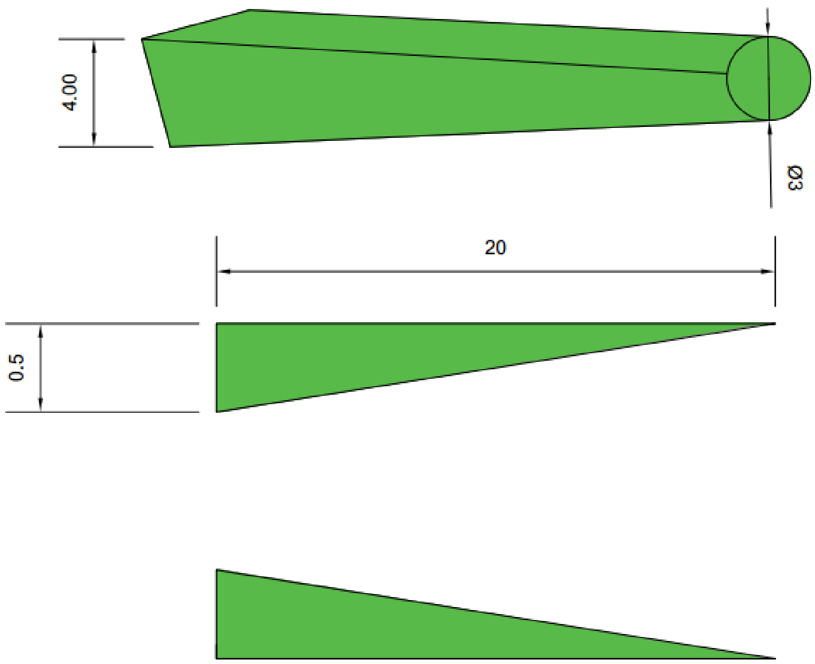


Fig. 4.2: Wood pole and abraded part

Corrosion ratio from one side to the length in two dimensions:

$\frac{0.5\ cm}{20 cm} = 0.025$ cm

Corrosion ratio from both parties to the length in two dimensions:

*0.025*2= 0.05 cm*

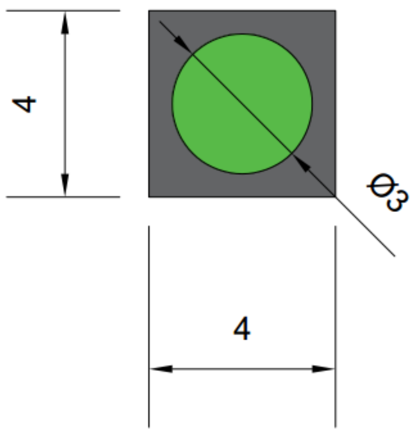


Fig. 4.3: Wood cutting section

$$\frac{square\ area - circle\ area}{total\ length} \quad (1)$$

$$= \frac{4cm * 4cm - (1.5)^2 cm * 3.14}{20cm} \quad (2)$$

$$= \frac{9}{20}$$

$$= 0.45 cm^2/cm \quad (3)$$

- Each 1 cm length should be less than 0.45 square cm area
- Every 1 cm length during turning should reduce the area of the square 0.45 cm square until it turns into a circle

The total volume Corrosion during the lathing process in a 20 cm length in three dimensions

$$0.45cm^2 * 20cm = 9cm^3 \quad (4)$$

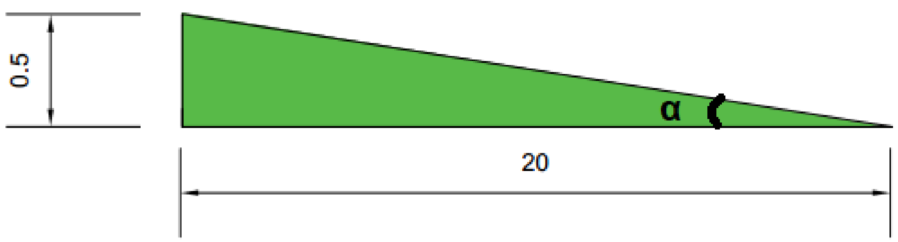


Fig. 4.4: Abraded part and knife angle

α=?

$$Tan\alpha = \frac{0.5}{20}$$

α=1.435° Knife angle

- Each 1 cm^2 length must be reduced in size 0.45 cm^3

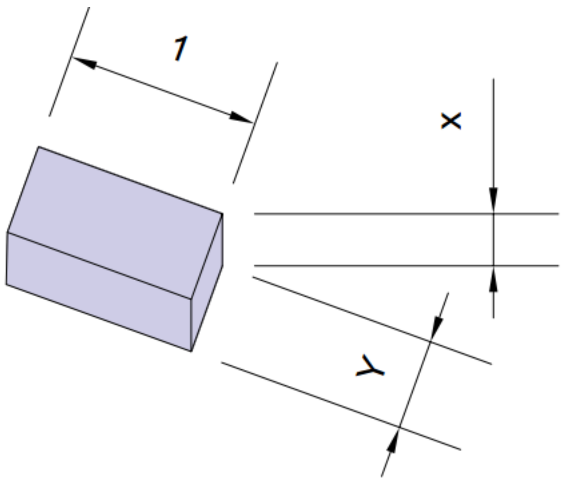


Fig. 4.5: Cutting volume

Y=> The circumference of a circle

$=2*\pi*r$ (5)

=2*3.14*1.5

$=9.42cm$ (6)

** I chose the perimeter of the circle because it is the least distance to be turning out and It is the most common case in which the lathe is the Max Load on the knife

** X: Overlap knife with wood for lathing and required of knife to enter the depth X for lathing.

$$Total\ volume= length*\ width*\ height \quad (7)$$

$$= X * Y * 1cm$$

$$0.45cm^3 = X * 9.4^2 * 1 \quad (8)$$

$$X=\frac{0.45}{9.42}$$

$$X= 0.04778\ cm$$

$$X=0.4778\ mm \quad (9)$$

** So, required of knives to enter the wood amount 0.4778mm

** So, the intersection of wood with the knife is 0.4778mm but it is divided into four knives.

$$\frac{0.4778}{4} = 0.119mm/knife \tag{10}$$

*** Let us multiply safety factor 5*

$$0.12*5 = 0.6mm >>> X=0.6mm \tag{11}$$

** On the occasion of a malfunction in three knives one remained working the knife must be lathe with safety therefore the safety factor 5

On the assumption we have 4 knives and at worst

4.2.B Find the relationship between the speed of the knife rotation and the speed of the wood pole

At worst the knife is too slow to rotate,1 cm from the circumference of a circle for every 1 cm, the wood moves towards the lathe.

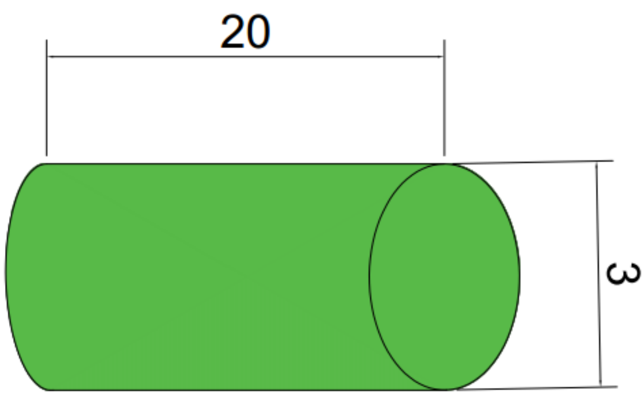


Fig. 4.6: Wood pole

** 0.06 cm at worst with safety factor 5

On the basis that for each 1 cm in which the wood pole is moves, we roll wood pole 1 cm from the perimeter

Circumference= 9.42cm

** That is, the wooden pole should move the least thing 9.42 during the knife and this is the highest possible speed

**Example: In case I want speed of 1m/s in the lathe or required speed lathe 100 cm/s we need a turnover of at least "Z".

** The Perimeter must intersect 1m/s at worst= 1m/s of wood length.

$$Circumference = 9.42 * Number\ of\ rolls\ in\ s = 100cm \quad (12)$$

$$Number\ of\ rolls\ in\ s = \frac{100}{9.42} = 10.615\ roll/s \quad (13)$$

$$Z = 10.615 * 60s$$

$$Z = 636.9 \approx 637\ roll/min \quad (14)$$

** In case we want a speed of lathing 1 m/s, the rotation should not be less than 637rpm for the knife ,and we conclude the velocity relation with the speed of the wooden pole or the speed of the turning:

The speed of lathing m/s $= \frac{0.0942 * Number\ of\ roll\ "rpm"}{60\ in\ min}$ (15)

$$Number\ of\ roll\ "rpm" \geq \frac{The\ speed\ of\ the\ wood\ pole\ or\ speed\ lathing * 60}{0.0942}$$

(16)

** This relationship is valid if we want to remove the volume of 0.45 cm^3

For each cm, the wooden pole moves in it towards the knife of the lathe.

4.2.C Calculate the forces located on the lathe knife

** There are three Forces Influential on the knife we can take them into account:

1- The centrifugal force of the impact of rotation, and this force will not enter into the calculations because there is a supportive of the knife eliminates the centrifugal force, "action and reaction".

2- Bending Force & Bending Moment, the forces affecting the knife as a result of turning "cutting force for turning wood"

** If the overlap is 0.6mm at worst and conditions the force required for lathing is approximately 9 kg/mm

$$F = 9 * 9.8 \quad (17)$$

$$= 88.2\ N/mm$$

$$\approx 90\ N/mm \quad (18)$$

**But the length of the knife is 200 mm

F=90*200

=18 KN

** The force required to cut part of wood 0.6 mm thickness along 20 cm.

** This force will be distributed to the four knives but we will take this force only on one knife so as to calculate the worst conditions.

3- The force affecting the knife result of pressure generated from pushing the wooden pole towards the knives

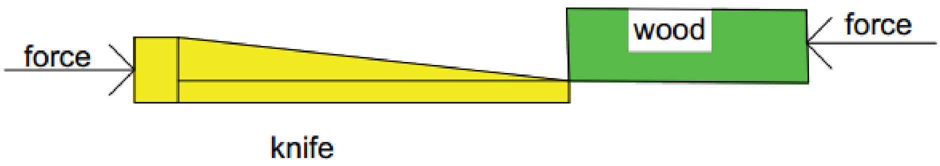


Fig. 4.7: Force acting on the knife

** The knife must be resistant effect effort because of the wood push

** Decreased area from the wood pole is 9 cm^2 during the lathing process

** Per 1cm => 0.45cm^2, the area of overlap between the knife and wood is 0.6 mm

** With the knife rotation we can roll the knife at an angle of 90° with the spindle axis by default only for calculations

** The perimeter of the final circle of the wood pole is 9.42cm based on previous calculations =94.2mm

***Reaction force= Pushing force of wood pole* (19)

*=9kg/mm * 9.8Gravity acceleration* 94.2circumference of a circle*

=8308.5 N ≈> 8.31 KN (20)

**The force needed to push the wood pole is the same force that the knife must resist, a reaction force

4.2.D Calculate knife properties

** The knife is made of ordinary iron to calculate the thickness of the knife, of course the selected knife will be stronger than ordinary iron, only here will we calculate its thickness

**cutting force for wood for our machine is 18kN

$$\tau shear = \frac{F}{A} \qquad (21)$$

$$= \frac{1800}{Length * Circle\ circumference} = \frac{1800}{9.42cm * 20cm}$$

$$= \frac{1800}{0.0942 * 0.2} = \frac{18000}{0.01884} = 955414\ N/m^2 \qquad (22)$$

** knife will not stand out more than 5 mm from the knife carrier cylinder

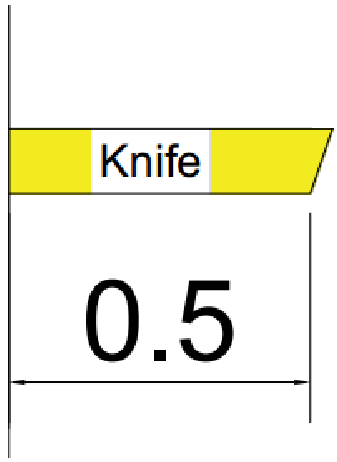
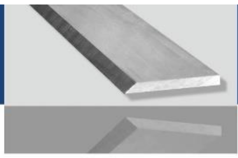


Fig. 4.8: Knife and stand out

** The knife CRV 400 * 25 * 3 was chosen from the table:

ILMA

Woodworking tools

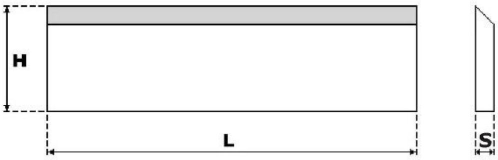


COLTELLI PIALLA CrV

Thin planer knives ***CrV***

Hobelmesser ***CrV***

Cuchillas para cepilladoras ***CrV***



mm

CODICE	**MISURA** *(LxHxS) mm*	**CODICE**	**MISURA** *(LxHxS) mm*	**CODICE**	**MISURA** *(LxHxS) mm*
CRV120203	120x20x3	CRV350203	350x20x3	CRV530203	530x20x3
CRV120253	120x25x3	CRV350253	350x25x3	CRV530253	530x25x3
CRV120303	120x30x3	CRV350303	350x30x3	CRV530303	530x30x3
CRV120353	120x35x3	CRV350353	350x35x3	CRV530353	530x35x3
CRV150203	150x20x3	CRV400203	400x20x3	CRV600203	600x20x3
CRV150253	150x25x3	CRV400253	400x25x3	CRV600253	600x25x3
CRV150303	150x30x3	CRV400303	400x30x3	CRV600303	600x30x3
CRV150353	150x35x3	CRV400353	400x35x3	CRV600353	600x35x3
CRV180203	180x20x8	CRV410203	410x20x3	CRV630203	630x20x3
CRV180253	180x25x3	CRV410253	410x25x3	CRV630253	630x25x3
CRV180303	180x30x3	CRV410303	410x30x3	CRV630303	630x30x3
CRV180353	180x35x3	CRV410353	410x35x3	CRV630353	630x35x3
CRV230203	230x20x3	CRV500203	500x20x3	CRV700203	700x20x3
CRV230253	230x25x3	CRV500253	500x25x3	CRV700253	700x25x3
CRV230303	230x30x3	CRV500303	500x30x3	CRV700303	700x30x3
CRV230353	230x35x3	CRV500353	500x35x3	CRV700353	700x35x3
CRV260203	260x20x3	CRV510203	510x20x3	CRV800203	800x20x3
CRV260253	260x25x3	CRV510253	510x25x3	CRV800253	800x25x3
CRV260303	260x30x3	CRV510303	510x30x3	CRV800303	800x30x3
CRV260353	260x35x3	CRV510353	510x35x3	CRV800353	800x35x3
CRV300203	300x20x3	CRV520203	520x20x3	CRV1080203	1080x20x3
CRV300253	300x25x3	CRV520253	520x25x3	CRV1080253	1080x25x3
CRV300303	300x30x3	CRV520303	520x30x3	CRV1080303	1080x30x3
CRV300353	300x35x3	CRV520353	520x35x3	CRV1080353	1080x35x3

Misure speciali su richiesta - Special sizes on request - Sonderabmessungen auf Anfrage - Medidas especiales sobre pedido

pag. 1

Fig. 4.9: Knife properties

** Because available in the market is a special knife for cutting wood or work wood carpentry from wood and trees and we will make the necessary calculations to make sure that the knife is suitable for the case of our machine.

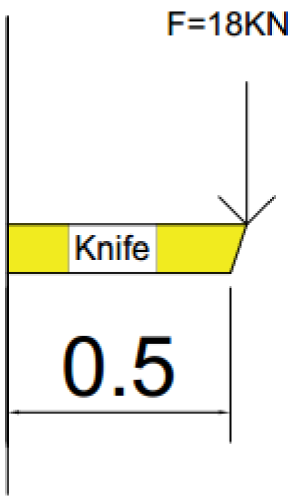


Fig. 4.10: Force acting on the knife

** E=200Gpa

I=second moment of inertia

$$I=\frac{bh^3}{12}=\frac{0.2*(0.003)^3}{12}=4.5*10^{-10}=0.45*10^{-9} \quad (23)$$

standard case bending

$$\text{Deflection}=\frac{wl^2}{2EI}=\frac{18000*(0.005)^2}{2*200*10^9*0.45*10^{-9}}=0.005mm \quad (24)$$

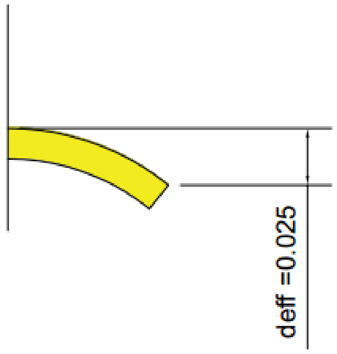


Fig. 4.11: Deflection on the knife

The result:

* The knife is very successful to work

* We will buy the knife length 40 cm and cut it by half

* The selected knife can resist the shear arising from the lathe

* Compared to the previously calculated shear amount

And the shear, which can be resisted by the knife in the knife characteristics table:

" The knife is successful for calculating"

1- Deflection or Bending

2- Shear

3- Force:
A- Horizontal
B- Vertical

4- Centrifugal Force

4.2.E Calculate the pressure on the wood pole to push the pole toward the knives

There are two cases in push:

1- Push in between the two wheels in the case of the Square

2- When the pole arrives to the next two wheels after turning in the case of a cylinder

1- Friction should be generated between the two wheels at first to push the square-shaped wood pole into the lathe

" Based on calculations of the forces necessary for lathing, previously"

Reaction force $F \approx 8310N$

Friction force $\geq$ *Reaction force*

So that can continue to move

** The force is very large so we will have to reduce it by reducing the eroded part of the wood in the lathing process Through a higher speed in the lathing and less speed in the pole move.

** Let's make it Interference between the wood pole and the knife:

Instead of 0.6mm we make it 0.1mm

*so instead of 9Kg/mm => 9** $\frac{0.1}{0.6}$ *=> 1.5Kg/mm* (25)

*F On the knives= 1.5*9.8*200=2.94KN* (26)

*F reaction=1.5*9.8*94.2 perimeter=1.385KN* (27)

** The forces are distributed on four knives

F Single knife=$\frac{2.94KN}{4}$*=0.735KN* (28)

F reaction single knife=$\frac{1.385}{4}$*= 0.346KN* (29)

𝓜s: Coefficient of static friction

𝓜s Iron and wood ≈ 0.3→ 0.6

𝓜s Wood and rubber ≈1

"So we will choose rubber with wood"

** It was selected 𝓜s not 𝓜x on the basis that there is no slipping between the wood and the wheel

** It was selected 𝓜s between wood and rubber because it is the largest friction coefficient

Friction= 𝓜s*mg (30)

=𝓜 s *2N => 1*2=2N (31)

F reaction= Friction=0.346KN=2N

N > $\frac{0.346\ KN}{2}$=

N >173N

*** N: Is the force needed to squeeze the wheel to generate friction*

"N is produced from the spring"

N=K **Δ** *X*

Δ*x: Amount of pressure*

K: constant spring

Let's make it **Δ***x=3cm*

*173=K*0.03*

K_1*=5767N/M*
For safety we choose =>6KN/M

** In the case of rotary or cylindrical wheels, the force needed to move the wood pole is distributed on the wheels in the beginning and the wheels in the end after the lathing

**K_2: Constant spring for cylindrical wheels

K_2*=3KN/M " Because the forces are evenly distributed between the wheels"*

4.2.F Calculate the motor needed to turn the turning pole

*** F On the knives=2.94KN ≈3KN, based on 1mm overlap*

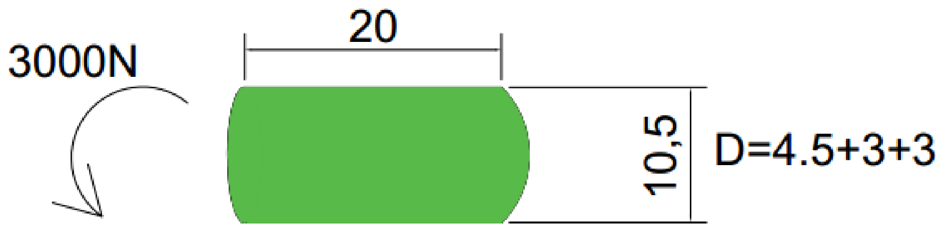


Fig. 4.12: Wood pole torque

$$\sum m = 0 \quad (32)$$

$$F\ Total\ knives*L_1 = F\ Required\ of\ the\ motor*(L_1+L_2) \quad (33)$$

$$3KN*2.25 = F\ Required\ *5.25 \quad (34)$$

$$F\ Required\ of\ the\ motor = \frac{3000*2.25}{5.25} \approx 1286N \approx 1.286KN \quad (35)$$

*From previous calculation

$$Number\ of\ rolls\ "RPM" \geq \frac{Movement\ speed\ wood\ pole\ "m/s"}{0.0942*60} \quad (36)$$

Let's make the movement speed 0.3m/s

Number of rolls "RPM" $\geq \frac{0.3*60}{0.0942}$ *=191 RPM* (37)

*** So required motor 200 RPM at least*

***and F=1.286 KN at least*

*** Every 3.33 seconds the machine is lathe 1m of the wood pole*

****Diameter of pulley cutting head and motor pulley

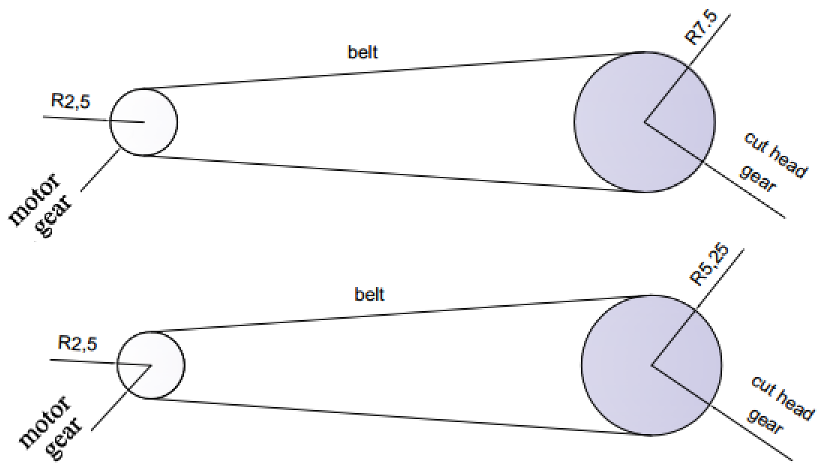


Fig. 4.13: Diameter of pulley cutting head and motor pulley

**F Required of the motor on the cutting head* $=\frac{10.5}{15} * 1.286KN \approx 0.88$KN (38)

*The rotation speed itself is *200 RPM*

* *F Required of the motor on the motor pole*$=\frac{5}{15}$*0.88≈ 0.3KN (39)

* Torque of our motor= F*r = F*D/2 (40)

=0.3KN*0.025= 7.5N/M (41)

* Based on we put the motor 1500RPM

lathing pole speed$=\frac{5*1500}{15}$*=500RPM* (42)

"So, you need to put an inverter to control the speed"

**1N.M/S = 0.1 KW*

**7.5= 0.75KW*

** But we have friction between the pulley and inertial in the turning pole because it is large and friction in the chain*

** So, we will put a safety factor=3 to enable the motor of working in extreme cases.*

** Motor required=0.75KW*3= 2.25KW* (43)

Motor required $\geq$ *3 H.P* (44)

** Based on the motor works on 220V*

**Power=I*V* (45)

*3H.P=2250W=I*220*

I=10.3 A (46)

** Wire clip area required to connect the current to the motor =1.03* mm^2

So, we will choose a wire with a area of 1.5 mm^2

4.2.G Calculate motor power to push wood

* A force of 2 Newton is needed to push the wood pole

" Whether pulling or pushing the distributor on 4 wheels"

2N=346

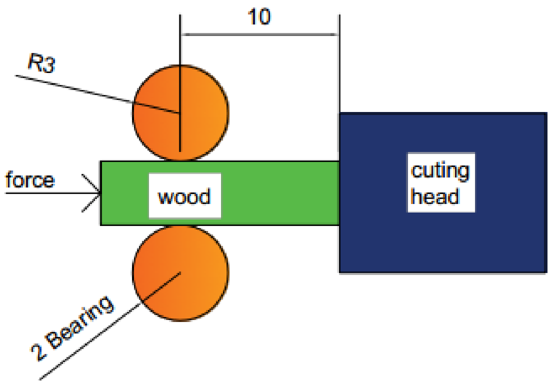


Fig. 4.14: motor power to push wood

*Of course, 4 wheels the same diameter=6cm for example

* Motor gear 3cm and the pole gear for push wheel 6cm

*Speed is decreasing to half

* Motor with gear slows down speed

* push motor 1500 RPM

Gear box=$\frac{1500*1}{10}$= 150 RPM (47)

* The difference between the diameter of the motor pole and diameter of the wheel pole is 6cm → 3cm

$\frac{150}{2}$=*75 RPM*

$\frac{75}{60}$=*1.25 Roll per second*

**But the diameter of the wheel is 6cm = perimeter =6*π=18.84*

**18.84= 23.55cm/s= 0.23 m/s*

*slow, so we will increase speed twice by making the wheels or wheels pole gear equal to the gear of the motor pole with gear

**Speed of turning=23.55*2= 47.1cm/s*

=0.471m/s appropriate

*Because we put 1→10 gear box

*Torque on the motor decreases by 10 times

* Torque is required from the motor is $\frac{2N}{10}$=34.6N

** Torque= F*R= 34.6*3cm " Radius of rubber wheels"* (48)

*=34.6*0.03m =1.038NM* (49)

* We have friction between the gears so we will multiply the inertial:

*F.O.S * 4 = 1 H.P*

"*Needed motor with gear box 1/10"*

4.2.H Buckling

$$*F_{KN}=\frac{\pi^2*E*I}{l.^2} \qquad (50)$$

$l. = 0.7l$

E=12.5 GPA

$$I=\frac{bH^3}{12}=\frac{4*(4)^3}{12}=21.33\ mm^4 \qquad (51)$$

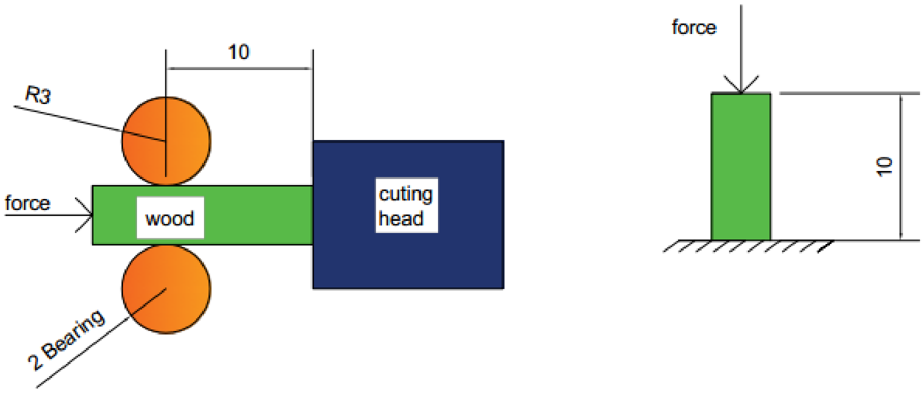


Fig. 4.15: Buckling

$$*F_{KN}=\frac{(3.14)^2*12.5*10^6*21.33}{0.7*0.1}=36.973KN \qquad (52)$$

* It Can bear buckling *compared with 2N*

4.2.I Torsional shear stress

$$\tau=\frac{T*r}{J} \qquad (53)$$

$$J=\frac{\pi*r^4}{2}=\frac{3.14*(15)^4}{2}=79481.25 \qquad (54)$$

*T=7.5*3=22.5 From previous calculation*

$$\tau=\frac{22.5*10^3*15}{79.5*10^3}=4.245MPA \qquad (55)$$

$$\frac{\tau}{r}=\frac{T}{J}=\frac{G\theta}{l}$$

G=13 GPA

$$\frac{4.245}{15}=0.283=\frac{22.5}{79.5}=0.283 \tag{56}$$

$$0.283=\frac{13GPA*\theta}{l}$$

$$\theta = \frac{200*0.283}{13GPA}=4.35*10^{-9}\ degree \tag{57}$$

" The angle is very small, there will be no friction "

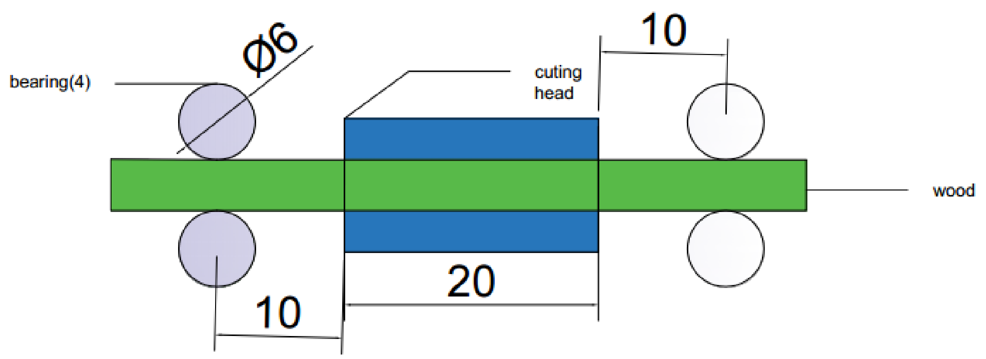


Fig. 4.16: Total machine dimensions

4.2.J Belt drive selection "V-Belt"

Note: All tables and attachments are attached in the appendix section

1500 rpm for fast shaft, 500 slow shaft, Hnom=2.25 KW

Speed ratio = $\frac{speed\ of\ fast\ shaft}{speed\ for\ slow\ shhaft} = \frac{1500}{500} = 3$ (58)

Design power :

From <u>table 17.6</u> ** find Ks

Ks* =1.2

Multiply Ks* by 1.18 Speed ratio effect:

Ks = 1.418

Nd =1

Hd = Ks*Nd *Hnom (59)

= 1,416 * 1 * 2.25

=3.186 Kw

From <u>figure 17.1a</u> ***** with speed 1500rpm, power 3.186

We select the belt A or AX.

We chose belt A

Sheaves:

$\frac{300}{\pi n} \leq d \leq \frac{1500}{\pi n}$ (60)

$$\frac{300}{\pi * 1500} \leq d \leq \frac{1500}{\pi * 1500}$$

60 mm$\leq d \leq 310\ mm$

From <u>table 17.5</u> for A section with SR= 3

D= 224mm d =75mm

Design power Hr :

Hr =Hbiss + Hadd (61)

From table 17.7 a with N=1500 rpm , d=75 ,SR =3

Hbiss= 1.07 Kw Hadd=0.28Kw

Hr = 1.35Kw

Specify a center distance:

$D \leq C \leq 3(D + d)$ (62)

$224 \leq C \leq 3(224 + 75)$

Use C = 560 mm

Lp = 2C +$\frac{\pi}{2} * (D + d) + \frac{(D-d)^2}{4C}$ (63)

Lp=1600mm

From table 17.1a:

Li to Lp =36mm

Li to La = 50 mm

Li= Lp – 36 = 1563mm

La = 1550 mm

From table 17.2 a:

We chose A60 with Li =1524 mm

Lp = Li + 36

= 1560mm

C=0.24{(Lp- $\frac{\pi}{2} * (D + d)) + \sqrt{(Lp - \frac{\pi}{2} * (D + d) - 2(D - d)\text{^}2)}$ (64)

= 519.5 mm

$\frac{D-d}{C} = \frac{224-75}{519.5}$ =0.286 (65)

From Table 17.8

$\theta = 163°$ K1= 0.96

From table 17.9

K2 =0.98

Ha =K1*K2*Hr (66)

=0.96*0.98*1.35 Kw

= 1.27Kw

Number of belt :

Nb = $\frac{Hd}{Ha}$ (67)

= 1.77

Therefor select Nb =2 belt

Belt tensions:

V= $\frac{\pi * d * n}{60}$ (68)

= 5.8 m\s

$\alpha = 20$ $\mu = 0.3$ $H = 1.27Kw$

T1 = $\frac{e^{\mu*\theta\backslash sin(\alpha)} * \frac{H}{V}}{e^{\mu*\theta\backslash sin(\alpha)} - 1}$ =238.7 N (69)

T2 = $\frac{\frac{H}{V}}{e^{\mu*\theta\backslash sin(\alpha)} - 1}$ = 647.2 N (70)

Ti =$\frac{T1+T2}{Ti}$= 442.9 N (71)

Minimum allowance:

From <u>table 17.3 a</u> with Lp = 1560

X= 25 mm Y=20 mm

Drive shaft load

$Fa = \sqrt{T1^2 + T2^2 + 2 * T1 * T2 * COS(\pi - \theta)}$ (72)

Fa = 885.9 N

Summary of belt design:

Input: Ac-motor, 2.25Kw ,1500 rpm

Serves factor Ks = 1.416

Design power = 3.186 Kw

Belt: A60, 2 belt

Sheaves: Driver 75 mm one grove

Driven 224 mm one grove

Center distance: 520 mm

Belt tensions: T1 = 238.7 N   T2=647.2 N   Ti=442.9 N

Minimum allowance: X=25mm   y=20 mm

Driving shaft load = 885.89 N

4.2.k To calculate the deflection:

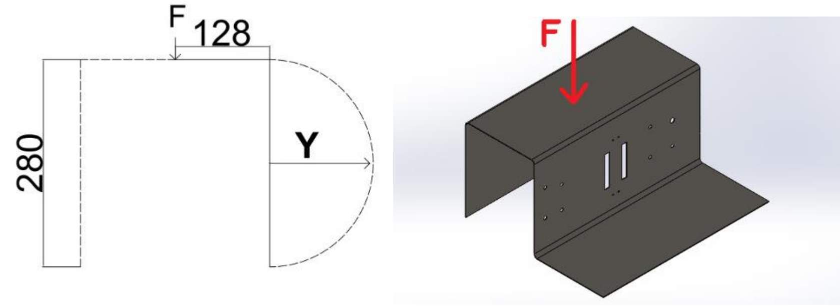


Fig. 4.17: Calculate the deflection

$$K=\sqrt{\frac{I}{A}} \quad (73)$$

$$=\sqrt{\frac{356.85mm^4}{1070mm^2}} = 0.57mm$$

Where:

K: radius of gyration

I: second moment of area

A: area

4.2.L To calculate Buckling:

$$P_{cr} = \frac{c\pi^2 EI}{L^2} \quad (74)$$

$$= \frac{(2)(3.14)^2(205)(356.85)}{(280)^2} = 18 * 10^3 N$$

Where:

Pcr: Buckling

C: the effective length factor

I: second moment of area

E: modulus of elasticity

L: length

4.2.M To calculate maximum normal stress:

$$\sigma_{\max} = \frac{P}{A}\left[1 + \frac{eC}{k^2}\sec\left[\frac{\Pi}{2}\sqrt{\frac{P}{P_{cr}}}\right]\right] \quad (75)$$

$$=\frac{2kN}{1070}\left[1 + \frac{128(2)}{(0.57)^2}\sec\left[\frac{\pi}{2}\frac{\sqrt{2kN}}{18*10^3}\right]\right]$$

=3.56 MPa

Where:

$\sigma_{\max}$: *maximum normal stress*

P: load

A: area
k: radius of gyration

e: Eccentric Loading

C: the effective length factor

P_{cr}: Buckling

4.2.N To calculate the deflection:

$$y_{max} = e\left[\sec\left(\frac{\pi}{2}\sqrt{\frac{P}{Pcr}}\right) - 1\right] = 19.8mm \quad (76)$$

Where:

y_{max}: Deflection

P_{cr}: Buckling

P: Load

4.2.O To calculate the deflection:

Use table A-9 to use the right equation use the simple supports uniform load.

$$v = \frac{wL}{2} - wx \quad (77)$$

$$R_1 = R_2 = \frac{wL}{2} \quad (78)$$

$$y = \frac{wx}{24EI}(2Lx^2 - x^3 - L^3) \quad (79)$$

Where:

v: shear stress

W: uniform load

L: length

R: reaction load

y: deflection

E: modulus of elasticity

I: second moment of area

b: thickness

h: Height

M_{max}: bending moment

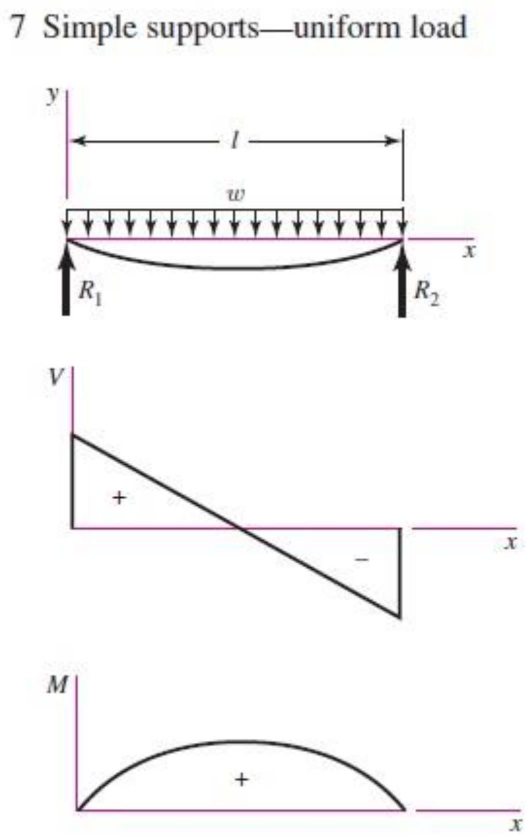


Fig. 4.18: Calculate the deflection-uniform load

$$I = \frac{1}{12}bh^3$$

$$= \frac{1}{12}(600)(2)^3$$

$= 400mm^4$

$$y_{max} = \frac{-5wL^4}{384EI} \quad (80)$$

$$= \frac{-5(2kN)(280)^4}{384(205)(400)} = -1.9 * 10^{-3}$$

V=0.0 when y_{max} (L/2)

$M = \frac{wx}{2}(L - x)$

$$M_{max} = \frac{(2kN)(140)}{2}(280 - 140) \quad (81)$$

$= 19.6kN \cdot m$

4.2.P To calculate the shear:

Where:

σ max : $maximum\ normal\ stress$

σ min: $minimum\ normal\ stress$

W: uniform load

X: length

V:shear force

τ_{max}: maximum shear stress

$$\sigma\, max = \frac{mc}{I} = \frac{(19.6kN)(1)}{400} = 49\ Mpa \quad (82)$$

σ min=0.0

Principle stress (σ max , σ min) $= (49Mpa, 0)$

$v = \frac{wL}{2} - wx$

$= \frac{2kN}{2} - (2)(0)$

$V_{max} = 1kN$

$$\tau_{max} = \frac{3V}{2A} = \frac{3(1kN)}{2(2)(600)} = 1.25Mp_a \quad (83)$$

4.2.Q To calculate the energy:

Where:

U: energy

G: modulus of rigidity

E: modulus of elasticity

I: second moment of area

C=1.2 rectangular

G for 1023 carbon steel =80 Gpa

E for 1023 carbon =140 Gpa

$$U = U_{shear} + U_{bending} \qquad (84)$$

$$= \int \frac{Cv^2}{2AG} dx + \int \frac{m^2}{2EI} dx$$

$$= \frac{(1.2)(1000)^2}{2(1200)\,(80Gpa)} + \frac{(19600)\left(280*10^{-3}\right)}{2(140Gpa)(400*10^{-10})}$$

= 0.025 + 0.49

U= 0.55 J

4.2.R To calculate the shear in shaft:

Where:

τmax: maximum shear stress

T: Torque

C: radius

J: second polar moment of area

Ssy: yielding strength

Sy: yield shear strength

$$\tau\text{max} = \frac{T \cdot c}{J} \qquad (85)$$

$$n = \frac{Ssy}{\tau max}$$

$$Ssy = \frac{Sy}{2}$$

$$Ssy = 1.20MPa$$

Carbon steel A36

Sy=240 MPa

$$120MP_a = \frac{T\,\text{max}(15)}{\frac{\pi}{2}(15)^2}$$

$$\text{T max} = 2.8\ \text{KN.m}$$

Assume (Motor):

T=1.5 KN.m

$$\tau = \frac{1.5(15)}{\frac{\pi}{2}(15)^2}$$

$$\tau = 63.69MPa$$

$$n = \frac{120mpa}{63.69}$$

=1.884

4.3 Electrical design

4.3.A Motors

An electric motor is an electrical machine that converts electrical energy into mechanical energy. In this section electrical motors specifications which includes AC motors and DC motors will be explained, where motors selection was based on the application of each motor:

1- Rotating motor:

The motor will rotate the cutting head through the belt and has the following specifications, Table 4

Table 4: Rotating motor specifications

Specifications	Value	Unit
Power	3	Horse Power (HP)
Rated Voltage Y/Δ	380/220	Volt
Frequency	50	Hertz (Hz)
Rated current Y/Δ	9.86/5.7	Ampere
No load speed	1500	r/min

2- Push motor:

The motor will push the wooden pole through the push pulley and has the following specifications, Table 5

Table 5: Push motor specifications

Specifications	Value	Unit
Power	0.5	Horse Power (HP)
Rated Voltage Y/Δ	380/220	Volt
Frequency	50	Hertz (Hz)
Rated current Y/Δ	1.27/2.2	Ampere
No load speed	200	r/min

3- Threading motor:

The motor will thread the cylindrical wood pole which output of the machine and has the following specifications, Table 6

Table 6: Threading motor specifications

Specifications	Value	Unit
Power	3	Horse Power (HP)
Rated Voltage Y/Δ	380/220	Volt
Frequency	50	Hertz (Hz)
Rated current Y/Δ	9.86/5.7	Ampere
No load speed	800	r/min

4.3.B Switches & Controlled switches

• Push-button switches

Push-button switch is one of the most important parts which used in automatic control and its function to turn on or off some functions, as in this project push-button used for start the machine process and stop it. Figure 4.19

Fig. 4.19: Push-button switches

• Contactors

A contactor is an electrically controlled switch used for switching an electrical power circuit. A contactor is typically controlled by a circuit which has a much lower power level than the switched circuit. Figure 4.20
Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contractor is not intended to interrupt a short circuit current. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V DC to many kilovolts.
Contactors are used to control electric motors, lighting, heating, and other electrical loads.

Fig. 4.20: Contactors

4.3.C Variable Frequency Drive (VFD) or "inverter”

Variable-frequency drive (VFD); also termed variable speed drive, or "inverter” drive is a type of adjustable-speed drive used in electromechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage.

VFD shown in Figure 4.21 used in this machine to control the speed of the lathe motor and the speed of the motor drive the wood pole

Fig. 4.21: Inverter

4.3.D Electrical protection

Power-system protection is a branch of electrical power engineering that deals with the protection of electrical power systems from faults through the isolation of faulted parts from the rest of the electrical network. The devices that are used to protect the power systems from faults are called protection devices which includes in this project: The devices that are used to protect the power systems from faults are called protection devices.

Protection Devices:

1- Circuit breaker:

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by excess current from an overload or short circuit, shown in Figure 4.22 and Figure 4.23

Fig. 4.22: Circuit breaker

Fig. 4.23: Circuit breaker

2- Overload:

Overload protection is a protection against a running overcurrent that would cause overheating of the protected equipment Figure 4.24

The operation current of overload determined depending on the motor current which appears in its name plate

Fig. 4.24: Overload

3- Fuses:

Is an electrical safety device operating to provide overcurrent protection of an electrical component or circuits, its essential component is a metal wire or strip that melts when too much current flows through it, thereby interrupting the current. In this project fuses used to protect DC motors from overcurrent, Figure 4.25

Fig. 4.25: Fuses

4- Emergency stop:

Emergency stop is a normally closed switch used to stop the machine process in emergency situations to protect human and machine parts from any danger or damage, Figure 4.26

Fig. 4.26: Emergency stop

4.3.E Lamp

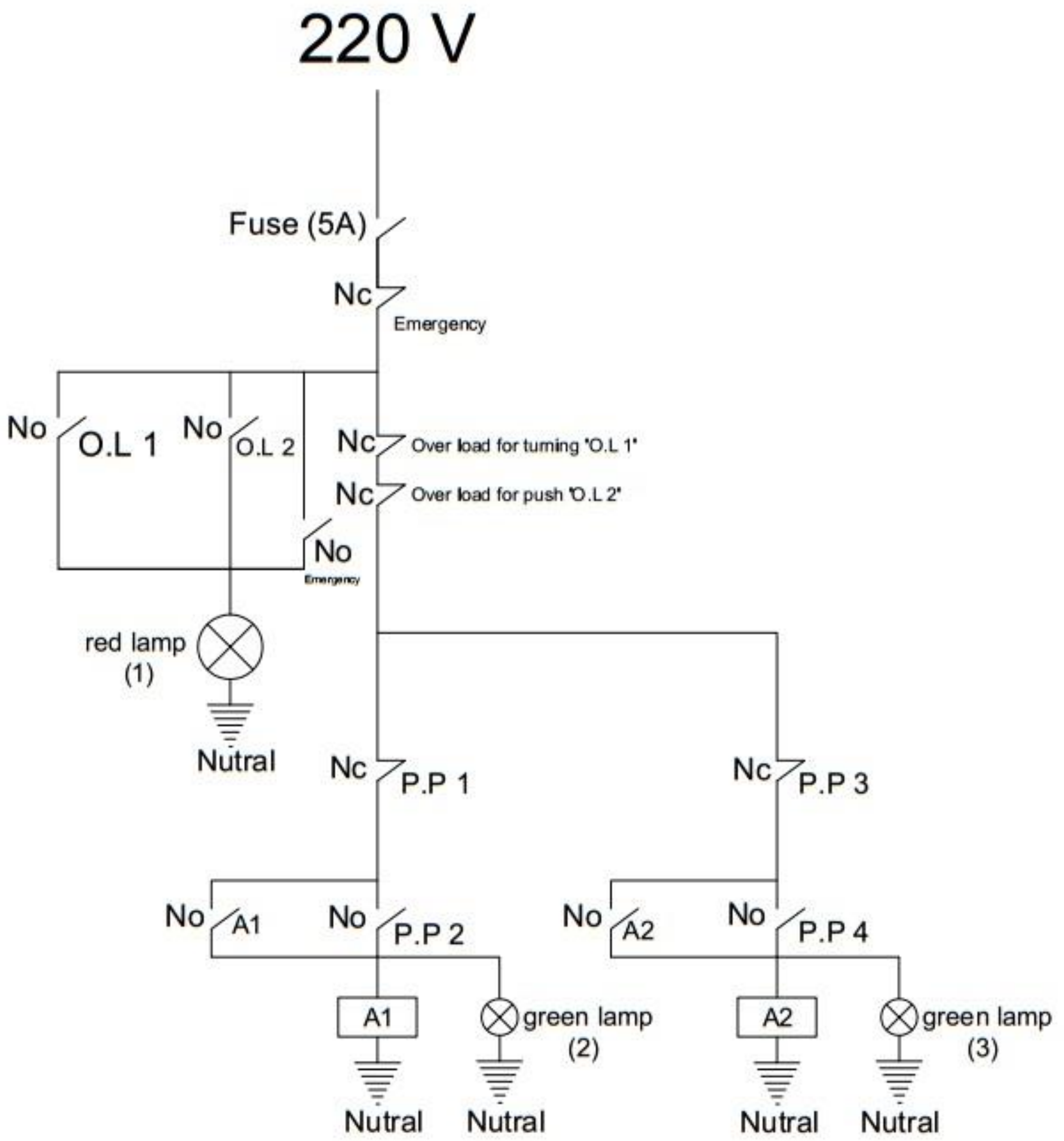
The lamp is used in our machine to know if there is an over-load on the motor to stop it or in case of pressing the emergency.

and to prove the work of the lathe motor, and to prove the work of the motor push the wood pole, Figure 4.27.

Fig. 4.27: Lamp

4.3.F Wiring diagram (power and control circuit)

Control circuit



P.P1 NC: Red button to turn off the lathe motor

P.P2 NO: Green button to turn on the lathe motor

P.P3 NC: Red button to stop the engine pulling the wood pole

P.P4 NO: Red button to turn on the motor pushing the wood pole

A1: Turning Contactor 220V AC

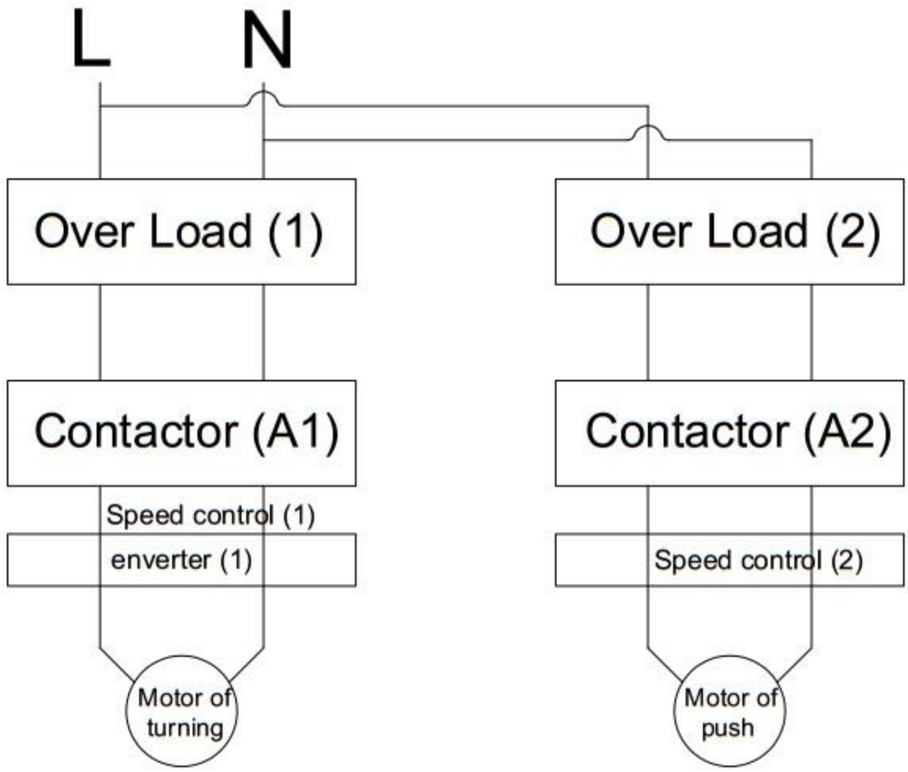
A2: Motor contactor pushing the wood pole 220V AC

Lamp(1): To know if there is an over-load on the motor to stop it or in case of pressing the emergency.

Lamp(2): To prove the work of the lathe motor.

Lamp(3): To prove the work of the motor push the wood pole

Power circuit

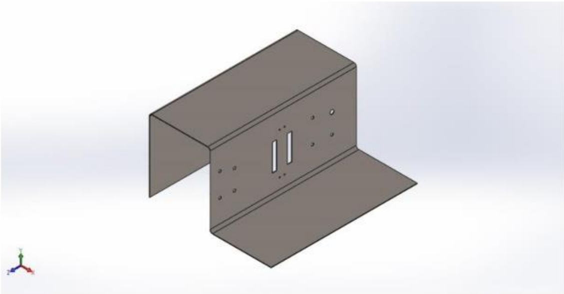


(1) Speed control: Inverter 3 H.P to speed control lathe motor

(2) Speed control: Inverter to speed control of the push motor the wood pole

Chapter 5: Simulation of frame and shaft

5.1 Simulation of frame



Simulation of frame

Date: Tuesday, December 4, 2018
Designer: Solidworks
Study name: Static 1
Analysis type: Static

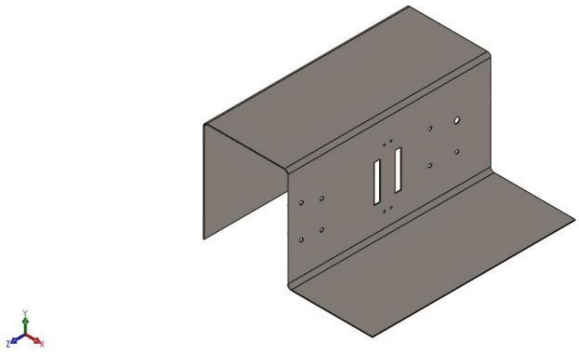
Description

No Data

Table of Contents

Assumptions

Model Information



Model name: fream
Current Configuration: Default

Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Cut-Extrude6 	Solid Body	Mass:10.0861 kg Volume:0.00129308 m^3 Density:7800 kg/m^3 Weight:98.8434 N	C:\Users\Desktop\solid\SO\fream.SLDPRT Nov 23 17:00:46 2018

Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users\Desktop\solid\SO)

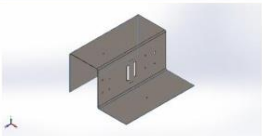
Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Material Properties

Model Reference	Properties	Components
	**Name:** Stainless Steel (ferritic) **Model type:** Linear Elastic Isotropic **Default failure criterion:** Max von Mises Stress **Yield strength:** 1.72339e+08 N/m^2 **Tensile strength:** 5.13613e+08 N/m^2 **Elastic modulus:** 2e+11 N/m^2 **Poisson's ratio:** 0.28 **Mass density:** 7800 kg/m^3 **Shear modulus:** 7.7e+10 N/m^2 **Thermal expansion coefficient:** 1.1e-05 /Kelvin	SolidBody 1(Cut-Extrude6)(fream)
Curve Data:N/A		

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 2 face(s) **Type:** Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	1.09948	1999.44	-0.408701	1999.44
Reaction Moment(N.m)	0	0	0	0

Load name	Load Image	Load Details
Force-3		**Entities:** 1 face(s) **Type:** Apply normal force **Value:** 2000 N

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	11.4084 mm
Tolerance	0.57042 mm
Mesh Quality Plot	High

Mesh information - Details

Total Nodes	105108
Total Elements	61664
Maximum Aspect Ratio	39.701
% of elements with Aspect Ratio < 3	1.44
% of elements with Aspect Ratio > 10	34.8
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:24
Computer name:	

Sensor Details
No Data

Resultant Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	1.09948	1999.44	-0.408701	1999.44

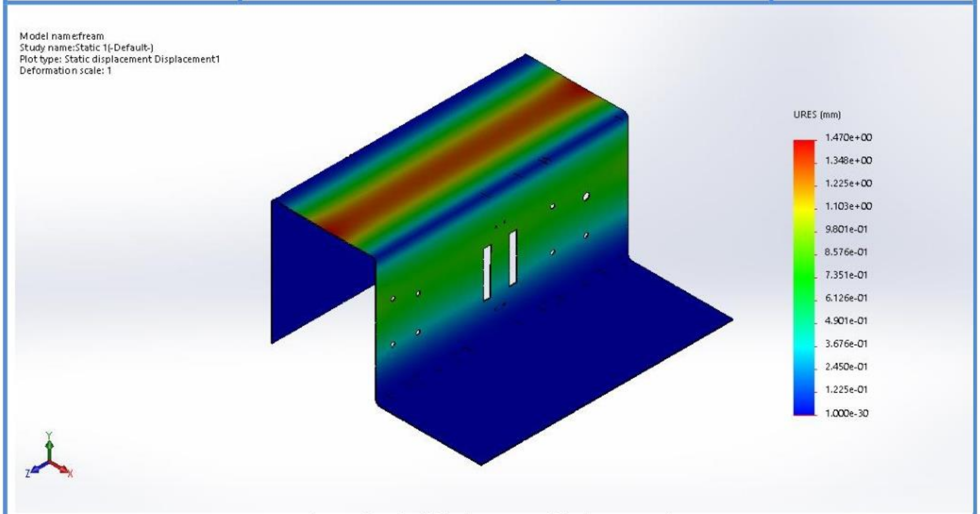
Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

Beams
No Data

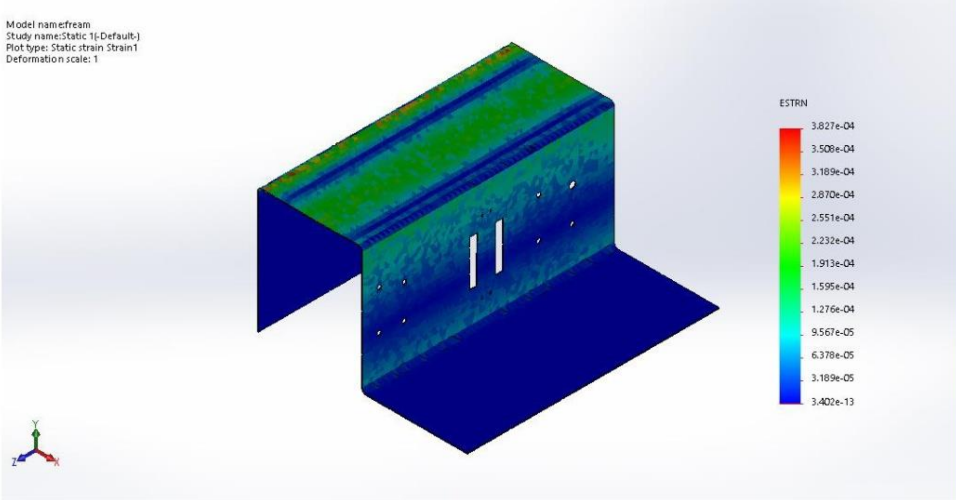
Study Results

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 2857	1.470e+00 mm Node: 89842



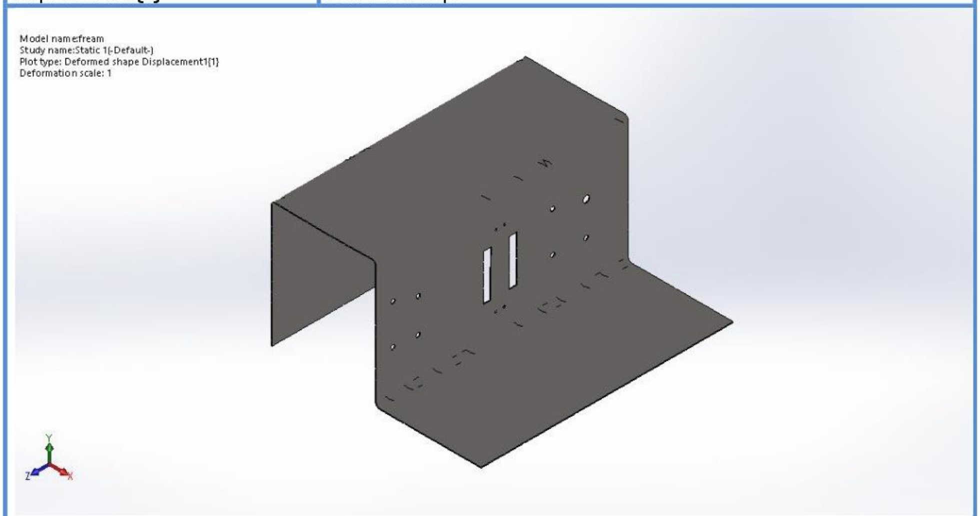
fream-Static 1-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	3.402e-13 Element: 13662	3.827e-04 Element: 5859



fream-Static 1-Strain-Strain1

Name	Type
Displacement1{1}	Deformed shape



fream-Static 1-Displacement-Displacement1{1}

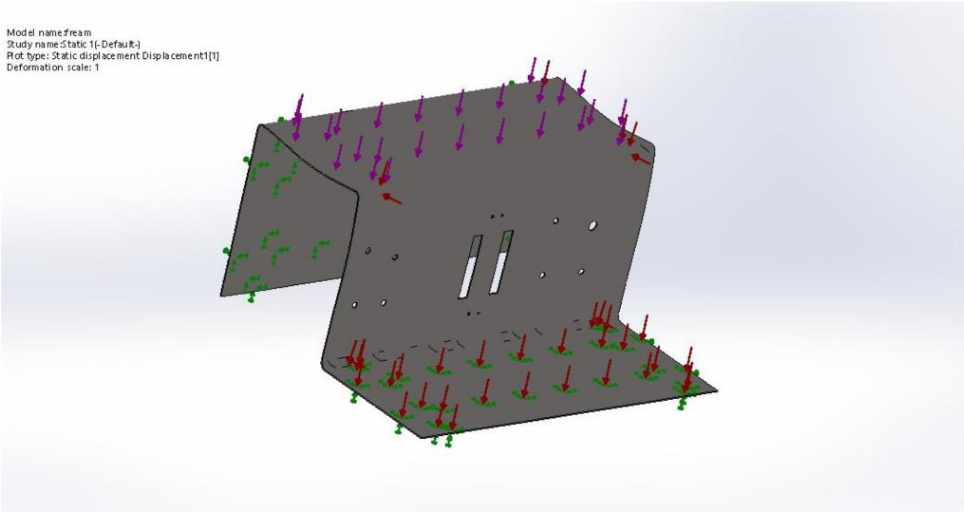
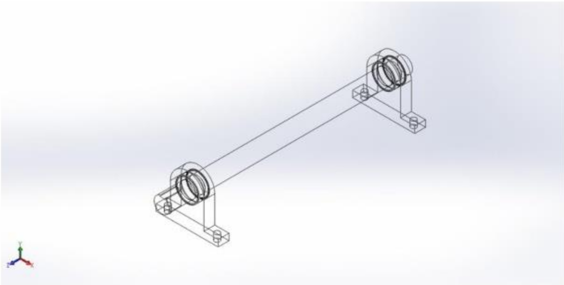


Image-1

Conclusion

5.2 Simulation of shaft



Simulation of shaft

Date: Sunday, November 25, 2018
Designer: Solidworks
Study name: Static 1
Analysis type: Static

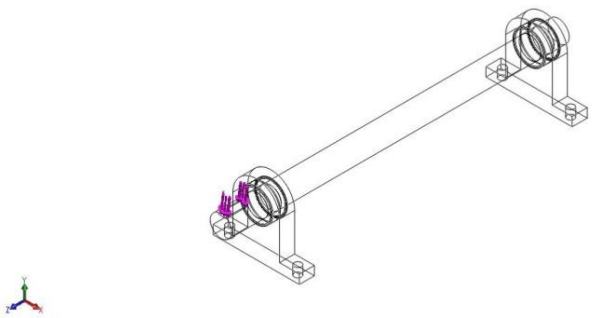
Table of Contents

Description

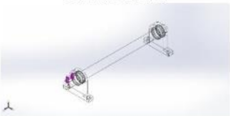
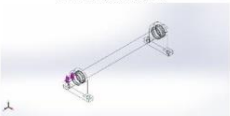
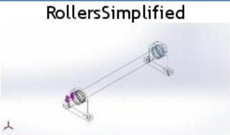
No Data

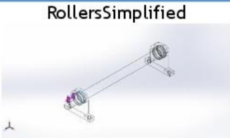
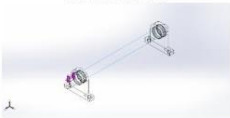
Assumptions

Model Information



Model name: Shaft
Current Configuration: Default

Solid Bodies			
Document Name and Reference	**Treated As**	**Volumetric Properties**	**Document Path/Date Modified**
Cut-Extrude1 	Solid Body	**Mass:0.790345 kg Volume:0.000102642 m^3 Density:7700 kg/m^3 Weight:7.74538 N**	**C:\Users \Desktop\solid\SO\bearing base.SLDPRT** Nov 23 17:33:43 2018
Cut-Extrude1 	Solid Body	**Mass:0.790345 kg Volume:0.000102642 m^3 Density:7700 kg/m^3 Weight:7.74538 N**	**C:\Users \Desktop\solid\SO\bearing base.SLDPRT** Nov 23 17:33:43 2018
RollersSimplified 	Solid Body	**Mass:0.130779 kg Volume:1.69843e-05 m^3 Density:7700 kg/m^3 Weight:1.28163 N**	**c:\solidworks data (2)\browser\ansi metric\bearings\roller bearings\needle roller bearing_na_am.sldprt** Nov 15 13:22:45 2018

RollersSimplified 	Solid Body	**Mass:0.130779 kg** **Volume:1.69843e-05 m^3** **Density:7700 kg/m^3** **Weight:1.28163 N**	**c:\solidworks data (2)\browser\ansi metric\bearings\roller bearings\needle roller bearing_na_am.sldprt** Nov 15 13:22:45 2018
Cut-Extrude1 	Solid Body	**Mass:2.61884 kg** **Volume:0.000331498 m^3** **Density:7900 kg/m^3** **Weight:25.6646 N**	**C:\Users \Desktop\solid\SO\shaft.SLDPRT** Nov 25 20:49:02 2018

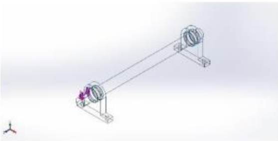
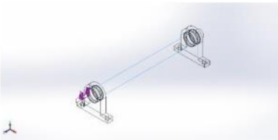
Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users \Desktop\solid\SO)

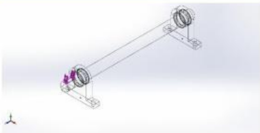
Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Material Properties

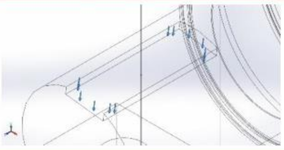
Model Reference	Properties	Components
	**Name:** Alloy Steel **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Yield strength:** 6.20422e+08 N/m^2 **Tensile strength:** 7.23826e+08 N/m^2 **Elastic modulus:** 2.1e+11 N/m^2 **Poisson's ratio:** 0.28 **Mass density:** 7700 kg/m^3 **Shear modulus:** 7.9e+10 N/m^2 **Thermal expansion coefficient:** 1.3e-05 /Kelvin	SolidBody 1(Cut-Extrude1)(bearing base-1), SolidBody 1(Cut-Extrude1)(bearing base-2), SolidBody 1(RollersSimplified)(needle roller bearing_na_am-1), SolidBody 1(RollersSimplified)(needle roller bearing_na_am-2)
Curve Data:N/A		
	**Name:** AISI 1020 **Model type:** Linear Elastic Isotropic **Default failure criterion:** Unknown **Yield strength:** 3.51571e+08 N/m^2 **Tensile strength:** 4.20507e+08 N/m^2 **Elastic modulus:** 2e+11 N/m^2 **Poisson's ratio:** 0.29 **Mass density:** 7900 kg/m^3 **Shear modulus:** 7.7e+10 N/m^2 **Thermal expansion coefficient:** 1.5e-05 /Kelvin	SolidBody 1(Cut-Extrude1)(shaft-1)
Curve Data:N/A		

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		**Entities:** 2 face(s) **Type:** Fixed Geometry

Resultant Forces

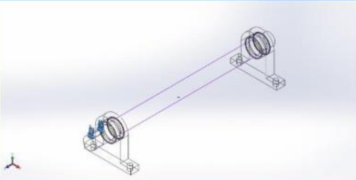
Components	X	Y	Z	Resultant
Reaction force(N)	24.2879	198.52	3.77526e-05	200
Reaction Moment(N.m)	0	0	0	0

Load name	Load Image	Load Details
Force-2		**Entities:** 1 face(s) **Type:** Apply normal force **Value:** 200 N

Connector Definitions

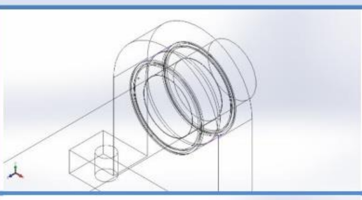
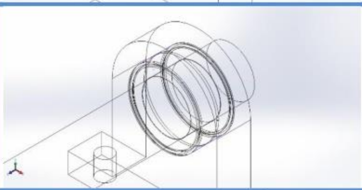
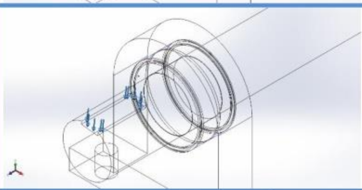
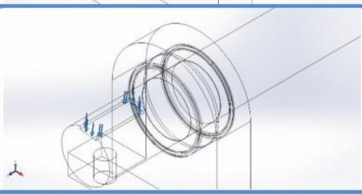
No Data

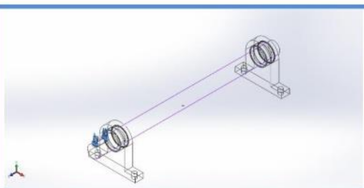
Contact Information

Contact	Contact Image	Contact Properties
Contact Set-1		**Type:** No Penetration contact pair **Entites:** 2 face(s) **Advanced:** Node to surface

Contact/Friction force

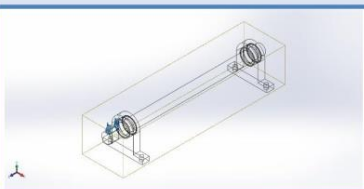
Components	X	Y	Z	Resultant
Contact Force(N)	**3.5527E-15**	**-6.4393E-15**	**7.1151E-20**	**7.3543E-15**

Contact	Contact Image	Contact Properties
Contact Set-3		**Type:** Bonded contact pair **Entites:** 2 face(s)
Contact Set-4		**Type:** Bonded contact pair **Entites:** 2 face(s)
Contact Set-5		**Type:** Bonded contact pair **Entites:** 2 face(s)
Contact Set-6		**Type:** Bonded contact pair **Entites:** 2 face(s)

Contact Set-7		**Type:** Bonded contact pair **Entites:** 2 face(s)

Contact/Friction force

Components	X	Y	Z	Resultant
Contact Force(N)	-0.70772	-8.7264	0.001357	8.7551

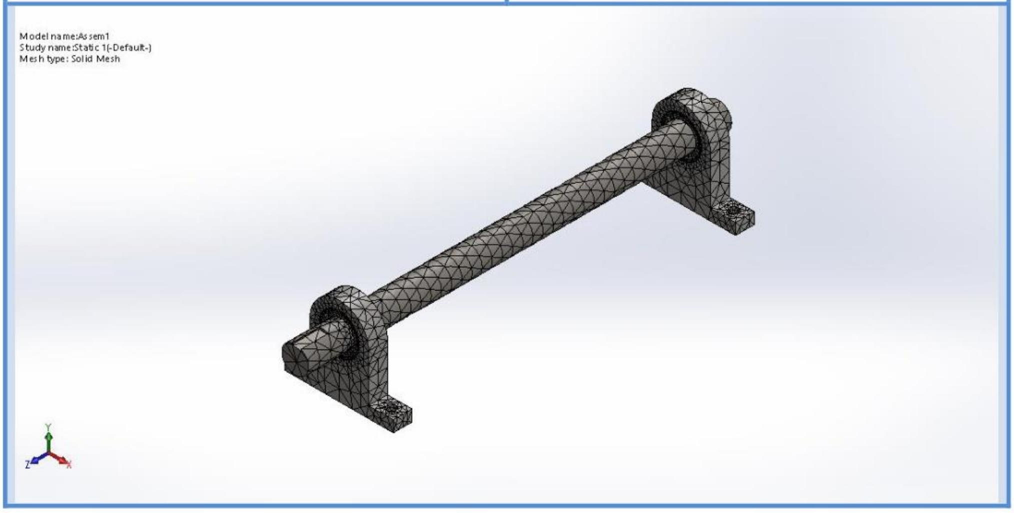
Global Contact		**Type:** Bonded **Components:** 1 component(s) **Options:** Compatible mesh

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Curvature-based mesh
Jacobian points	4 Points
Maximum element size	16.5941 mm
Minimum element size	3.31882 mm
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	Off

Mesh information - Details

Total Nodes	37302
Total Elements	22625
Maximum Aspect Ratio	98.764
% of elements with Aspect Ratio < 3	70.4
% of elements with Aspect Ratio > 10	6.7
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:04
Computer name:	



Sensor Details
No Data

Resultant Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	24.2879	198.52	3.77526e-05	200

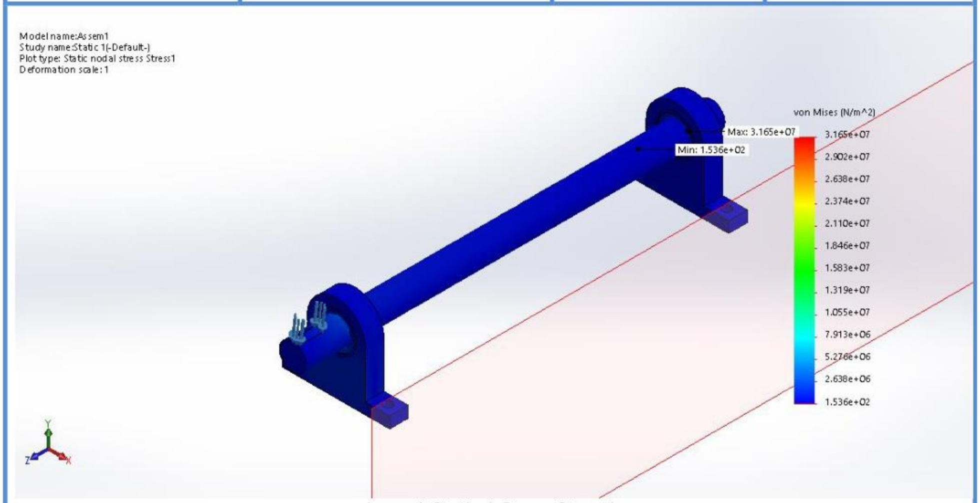
Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

Beams
No Data

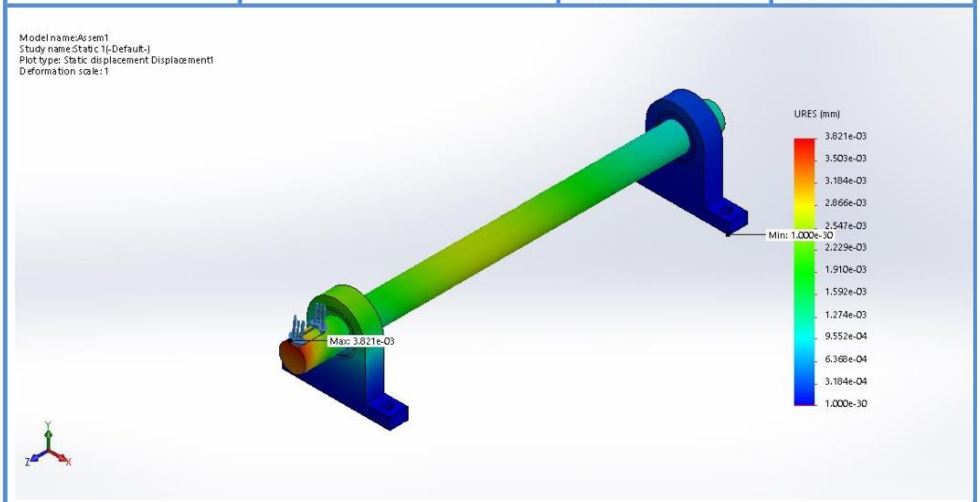
Study Results

Name	Type	Min	Max
Stress1	VON: von Mises Stress	1.536e+02 N/m^2 Node: 1157	3.165e+07 N/m^2 Node: 15216



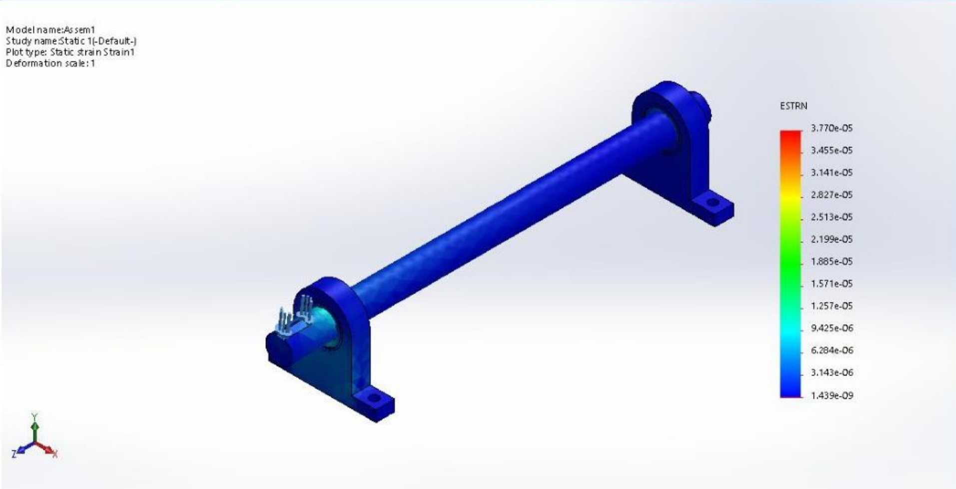
Assem1-Static 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 7	3.821e-03 mm Node: 30843



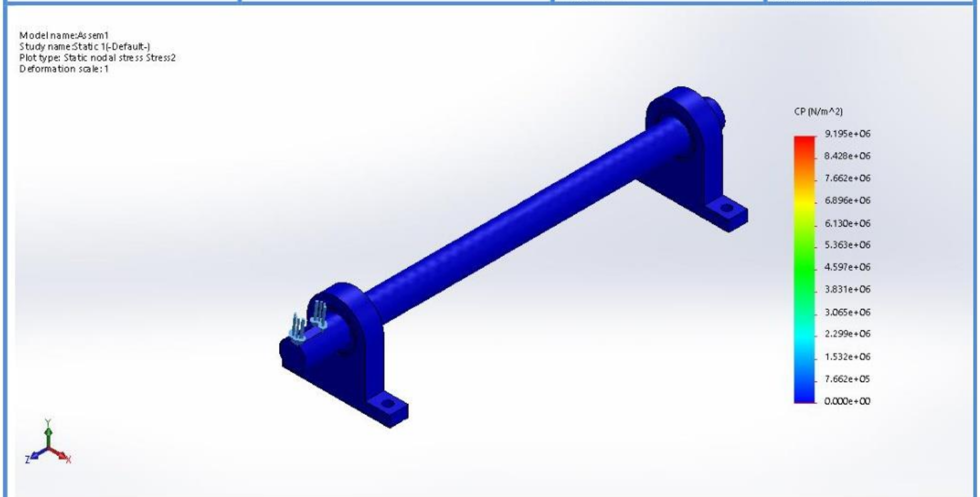
Assem1-Static 1-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.439e-09 Element: 3131	3.770e-05 Element: 17645



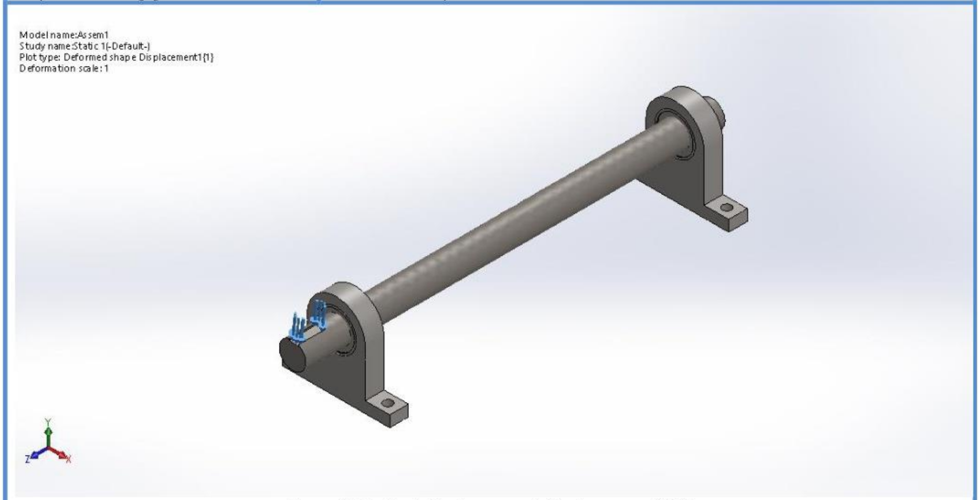
Assem1-Static 1-Strain-Strain1

Name	Type	Min	Max
Stress2	CP: Contact Pressure	0.000e+00 N/m^2 Node: 1	9.195e+06 N/m^2 Node: 12320



Assem1-Static 1-Stress-Stress2

Name	Type

Displacement1{1}	Deformed shape
	
Assem1-Static 1-Displacement-Displacement1{1}	

Conclusion

Chapter 6: Conclusions and recommendations

6.1 Conclusions

In this school year we were collected information, ideas and previous studies related to the idea of the project, and we drawn all parts of the project on the SolidWorks program and AutoCAD and created a proposed design to implement the required machine.

Then, we worked out calculations of mechanical and electrical design, to buy the machine parts and lathing the parts, and simulation to knowledge of the strengths and weaknesses of the machine and then then we started the process of assembling and building the machine based on the proposed design and calculations.

Knowing that will produce ready-to-use broom sticks to reduce imports, lower prices and produce a high-quality local product at a longer life.

6.2 Recommendations

The purpose of any project is continuity and develop the project, in this section recommendations suggested for this aim specially for those whom will work on the project in future, includes:

* The main problem we faced during implementing the project was find a lathe to turn the cutting head and was in obtaining some of the parts of the project.

* The university should provide the proper toolsets, which enable the student to assemble his project and to test it which will get benefit of experiences in the university.

* Make the machine automatically by adding PLC or Microcontroller and programing

***** Change the specifications of the machine product as needed by changing the cutting head specifications

Appendix

A.1: V-belt service factors, Ks

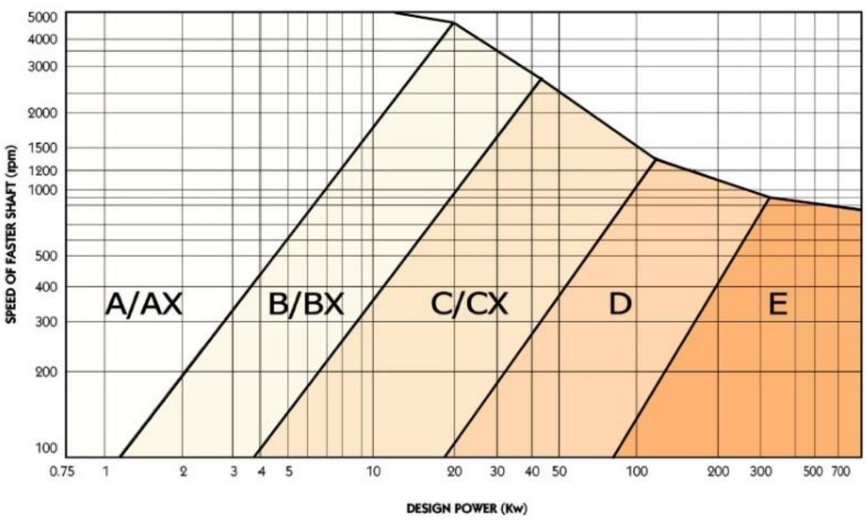
Table 17-6: V-belt service factors, K_s

Load Type	Driven machine type	Types of driver: Soft starts (AC motors: Normal torque[a], DC motors: Shunt-wound, Engines: Multiple-cylinder) <6 h per day	6–15 h per day	>15 h per day	Types of driver: Heavy starts (AC motors: High torque[b], DC motors: Series-wound, compound-wound, Engines: 4-cylinder or less) <6 h per day	6–15 h per day	>15 h per day
Smooth	Agitators, blowers, fans, centrifugal pumps, light conveyors	1.0	1.1	1.2	1.1	1.2	1.3
Light Shock	Generators, machine tools, mixers, gravel conveyors	1.1	1.2	1.3	1.2	1.3	1.4
Medium Shock	Bucket elevators, textile machines, hammer mills, heavy conveyors	1.2	1.3	1.4	1.4	1.5	1.6
High Shock	Crushers, ball mills, hoists, rubber extruders	1.3	1.4	1.5	1.5	1.6	1.8
Heavy Shock	Any machine that can choke	2.0	2.0	2.0	2.0	2.0	2.0

FOR SPEED - INCREASING DRIVES OF,
Speed ratio 1.00 to 1.24 : Multiply service factor by 1.00
Speed ratio 1.25 to 1.74 : Multiply service factor by 1.05
Speed ratio 1.75 to 2.49 : Multiply service factor by 1.11
Speed ratio 2.50 to 3.49 : Multiply service factor by 1.18
Speed ratio 3.50 & over : Multiply service factor by 1.25

A.2: Selection chart for classical V-belts cross section

Figure 17-1(*a*):
Selection chart for classical V-belts cross section



A.3: "A" Sheaves combinations

Figure 17-5(*a*): "A" SHEAVES COMBINATIONS

Speed Ratio, *D*/*d*																		
d \ *D*	71	75	80	85	90	95	100	106	112	118	125	132	140	150	160	180	200	224
71	1.00	1.06	1.13	1.20	1.27	1.34	1.41	1.49	1.58	1.66	1.76	1.86	1.97	2.11	2.25	2.54	2.82	3.15
75		1.00	1.07	1.13	1.20	1.27	1.33	1.41	1.49	1.57	1.67	1.76	1.87	2.00	2.13	2.40	2.67	2.99
80			1.00	1.06	1.13	1.19	1.25	1.33	1.40	1.48	1.56	1.65	1.75	1.88	2.00	2.25	2.50	2.80
85				1.00	1.06	1.12	1.18	1.25	1.32	1.39	1.47	1.55	1.65	1.76	1.88	2.12	2.35	2.64
90					1.00	1.06	1.11	1.18	1.24	1.31	1.39	1.47	1.56	1.67	1.78	2.00	2.22	2.49
95						1.00	1.05	1.12	1.18	1.24	1.32	1.39	1.47	1.58	1.68	1.89	2.11	2.36
100							1.00	1.06	1.12	1.18	1.25	1.32	1.40	1.50	1.60	1.80	2.00	2.24
106								1.00	1.06	1.11	1.18	1.25	1.32	1.42	1.51	1.70	1.89	2.11
112									1.00	1.05	1.12	1.18	1.25	1.34	1.43	1.61	1.79	2.00
118										1.00	1.06	1.12	1.19	1.27	1.36	1.53	1.69	1.90
125											1.00	1.06	1.12	1.20	1.28	1.44	1.60	1.79
132												1.00	1.06	1.14	1.21	1.36	1.52	1.70
140													1.00	1.07	1.14	1.29	1.43	1.60
150														1.00	1.07	1.20	1.33	1.49
160															1.00	1.13	1.25	1.40
180																1.00	1.11	1.24
200																	1.00	1.12
224																		1.00

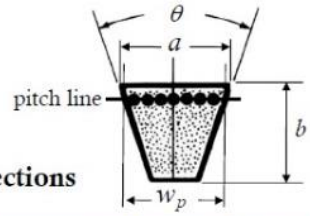
A.4: Basic power (kW) rating of section "A"/part1

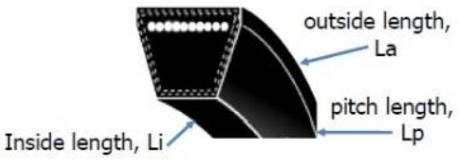
Table 17-7(*a*): Basic power (kW) rating of section "A" /part1

N RPM	Pitch diameter of the smaller pulley (mm)								Additional Power (Kw) per belt for speed ratio			
	71	75	80	85	90	95	100	106	1.01 to 1.05	1.06 to 1.26	1.27 to 1.57	For > 1.57
700	0.58	0.71	0.82	0.89	1.09	1.22	1.34	1.50	0.02	0.08	0.12	0.14
950	0.71	0.84	1.02	1.11	1.37	1.55	1.71	1.92	0.02	0.10	0.16	0.18
1450	0.91	1.07	1.36	1.49	1.87	2.11	2.35	2.64	0.03	0.16	0.25	0.28
2850	1.15	1.36	1.96	2.20	2.81	3.23	3.64	4.11	0.06	0.31	0.49	0.55
100	0.13	0.16	0.17	0.19	0.21	0.25	0.27	0.29	0.00	0.01	0.02	0.02
200	0.24	0.29	0.31	0.33	0.39	0.44	0.48	0.53	0.00	0.02	0.03	0.04
300	0.31	0.39	0.43	0.46	0.55	0.62	0.67	0.75	0.01	0.03	0.05	0.06
400	0.39	0.48	0.54	0.57	0.69	0.77	0.85	0.95	0.01	0.04	0.07	0.08
500	0.46	0.56	0.64	0.69	0.83	0.93	1.03	1.14	0.01	0.05	0.09	0.10
600	0.52	0.63	0.73	0.79	0.96	1.08	1.19	1.32	0.01	0.06	0.10	0.12
700	0.58	0.71	0.82	0.89	1.09	1.22	1.34	1.50	0.02	0.08	0.12	0.14
800	0.63	0.77	0.91	0.98	1.20	1.36	1.50	1.67	0.02	0.09	0.14	0.16
900	0.68	0.81	0.99	1.06	1.31	1.48	1.65	1.84	0.02	0.10	0.16	0.18
1000	0.73	0.87	1.06	1.16	1.42	1.60	1.78	1.99	0.02	0.11	0.17	0.19
1100	0.77	0.91	1.13	1.23	1.52	1.72	1.92	2.15	0.02	0.12	0.19	0.21
1200	0.81	0.96	1.20	1.32	1.62	1.84	2.05	2.30	0.03	0.13	0.21	0.23
1300	0.85	1.03	1.27	1.39	1.72	1.95	2.17	2.44	0.03	0.14	0.22	0.25
1400	0.88	1.04	1.33	1.46	1.81	2.06	2.30	2.58	0.03	0.15	0.24	0.27
1500	0.92	1.08	1.39	1.53	1.91	2.16	2.41	2.71	0.03	0.16	0.26	0.29
1600	0.95	1.12	1.44	1.59	1.99	2.26	2.53	2.84	0.03	0.17	0.28	0.31
1700	0.97	1.14	1.50	1.65	2.07	2.35	2.63	2.97	0.04	0.18	0.29	0.33
1800	1.01	1.16	1.56	1.72	2.15	2.45	2.74	3.09	0.04	0.19	0.31	0.35
1900	1.03	1.19	1.60	1.77	2.23	2.54	2.84	3.20	0.04	0.21	0.33	0.37
2000	1.05	1.21	1.65	1.84	2.31	2.63	2.95	3.33	0.04	0.22	0.35	0.39
2100	1.08	1.24	1.69	1.89	2.37	2.71	3.04	3.43	0.05	0.23	0.36	0.41
2200	1.09	1.26	1.74	1.94	2.44	2.79	3.14	3.54	0.05	0.24	0.38	0.43
2300	1.11	1.28	1.78	1.98	2.51	2.87	3.21	3.64	0.05	0.25	0.40	0.45
2400	1.12	1.29	1.81	2.03	2.56	2.93	3.30	3.73	0.05	0.26	0.42	0.47
2500	1.13	1.31	1.85	2.07	2.63	3.01	3.38	3.83	0.05	0.27	0.43	0.49
2600	1.14	1.32	1.88	2.12	2.69	3.08	3.46	3.91	0.06	0.28	0.45	0.51
2700	1.15	1.34	1.92	2.14	2.73	3.14	3.53	4.00	0.06	0.22	0.47	0.53
2800	1.15	1.35	1.94	2.19	2.79	3.20	3.61	4.08	0.06	0.30	0.48	0.54
2900	1.16	1.36	1.97	2.21	2.83	3.26	3.66	4.16	0.06	0.31	0.50	0.56
3000	1.16	1.36	1.99	2.24	2.88	3.30	3.73	4.22	0.06	0.32	0.52	0.58

A.5: Standard V-belt sections

Table 17-1(a): Standard V-belt sections





Section	Dimension		Angle	Pitch width	Belt Length Factor		
	a mm	b mm	θ Deg	w_p mm	Lp to La mm	Li to Lp mm	Li to La mm
A & AX	13	8	40	11.0	14	36	50
B & BX	17	11	40	14.0	26	43	69
C & CX	22	14	40	19.0	32	56	88
D	32	19	40	27.0	40	79	119
E	38	23	40	32.0	53	92	145
3V & 3VX	9.7	8	40	8.9	13	37	50
5V & 5VX	16	14	40	15.2	25	60	85
8V	25	23	40	25.4	53	92	145

A.6: Standard length of classical section, A

Table 17-2(*a*): Standard length of classical section, A

Belt Reference	Inside Length (mm)	Belt Reference	Inside Length (mm)	Belt Reference	Inside Length (mm)	Belt Reference	Inside Length (mm)
A 13	330	A 100	2540	A 190	4826	A 280	7112
A 15	381	A 105	2667	A 195	4953	A 285	7239
A 20	508	A 110	2794	A 200	5080	A 290	7366
A 25	635	A 115	2921	A 205	5207	A 295	7493
A 30	762	A 120	3048	A 210	5334	A 300	7620
A 35	889	A 125	3175	A 215	5461	A 305	7747
A 40	1016	A 130	3302	A 220	5588	A 310	7874
A 45	1143	A 135	3429	A 225	5715	A 315	8001
A 50	1270	A 140	3556	A 230	5842	A 320	8128
A 55	1397	A 145	3683	A 235	5969	A 325	8255
A 60	1524	A 150	3810	A 240	6096	A 330	8382
A 65	1651	A 155	3937	A 245	6223	A 335	8509
A 70	1778	A 160	4064	A 250	6350	A 340	8636
A 75	1905	A 165	4191	A 255	6477	A 345	8763
A 80	2032	A 170	4318	A 260	6604	A 350	8890
A 85	2159	A 175	4445	A 265	6731	A 355	9017
A 90	2286	A 180	4572	A 270	6858	A 360	9144
A 95	2413	A 185	4699	A 275	6985		

A.7: Angle of contact correction factor, K1

Table 17-8: Angle of contact correction factor, K_1

(D-d)/C	Arc of Contact on Small Sheave θ [deg.]	Correction Factor K_1
0.00	180	1.00
0.10	174	0.99
0.20	169	0.97
0.30	163	0.96
0.40	157	0.94
0.50	151	0.93
0.60	145	0.91
0.70	139	0.89
0.80	133	0.87
0.90	127	0.85
1.00	120	0.82
1.10	113	0.80
1.20	106	0.77
1.30	99	0.73
1.40	91	0.70
1.50	83	0.65

A.8: Belt length correction factor, K2

Table 17-9: Belt length correction factor, K_2

Length Factor	Belt Pitch Length, Lp [mm]							
K_2	A,AX	B,BX	C,CX	D	E	3V,3VX	5V,5VX	8V
0.80	630							
0.81		930						
0.82	700		1550	2740				
0.83		1000				630		
0.84	790		1760					
0.85		1100				710		
0.86	890			3130				
0.87		1210	1950	3330		800	1400	2540
0.88	990							
0.89						900	1600	3000
0.90	1100	1370	2190	3730				
0.91			2340				1800	3350
0.92		1560	2490	4080		1000		
0.93	1250						2090	
0.94			2720	4620	5334	1120		4060
0.95		1760	2800				2240	
0.96	1430		3080		6045	1250	2500	
0.97		1950		5400				5080
0.98	1550		3310			1400	2800	
0.99	1640	2180	3520		6807			6000
1.00	1750	2300		6100		1600	3150	
1.02	1940	2500	4060		7569	1800	3550	7100
1.03				6840	8331			8000
1.04	2050	2700				2000	4090	
1.05	2200	2850	4600	7620	9093			9000
1.06	2300						4500	
1.07				8410	9855	2240		10160
1.08	2480	3200	5380				5000	
1.09	2570			9140	10617	2500	5600	11430
1.10	2700	3600						12700
1.11			6100			2800	6300	
1.12	2910			10700	12141			
1.13	3080	4060				3150	7100	
1.14	3290		6860		13665			
1.15		4430				3550	7880	
1.16	3540	4820	7600	12200	15189			
1.18		5000		13700				
1.19		5370			16713			
1.20		6070		15200				
1.21			9100					
1.24			10700					

A.9: Minimum allowance

Table 17-3(*a*) Minimum allowance; x and y for adjusting drive center distance for classical belts

Belt length (mm)	Minimum allowance x (mm) – for tensioning	Minimum allowance y (mm) – for fitting				
		A/AX	B/BX	C/CX	D	E
≤ 200	5	—	—	—	—	—
> 200 ≤ 250	5	—	—	—	—	—
> 250 ≤ 315	5	—	—	—	—	—
> 315 ≤ 670	10	10	10	—	—	—
> 670 ≤ 1 000	15	15	15	—	—	—
> 1 000 ≤ 1 250	20	15	15	20	—	—
> 1 250 ≤ 1 800	25	20	20	25	—	—
> 1 800 ≤ 2 240	25	20	20	25	35	—
> 2 240 ≤ 3 000	35	20	20	30	35	40
> 3 000 ≤ 4 000	45	20	20	30	35	40
> 4 000 ≤ 5 000	55	20	20	30	35	40
> 5 000 ≤ 6 300	70	20	25	35	40	45
> 6 300 ≤ 8 000	85	20	25	40	45	50
> 8 000 ≤ 10 000	110	25	25	45	45	50
> 10 000 ≤ 12 500	135	—	30	45	50	55
> 12 500 ≤ 15 000	150	—	40	55	60	65
> 15 000 ≤ 18 000	190	—	40	55	60	65

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