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# A PROTOTYPE OF PAPER CUTTING MACHINE

**Tran Vu Minh[1], Tran Thanh Tung[2]***

[1] Ha Noi University of Science and Technology, School of Mechanical Engineering, Ha Noi, Vietnam
[2] Vietnam National University, VNU University of Engineering and Technology, Faculty of Engineering Mechanics and Automation, Hanoi, Vietnam
* tranthanhtung@vnu.edu.vn

*Paper is a necessary component of life. It is used in a variety of settings, including offices, schools, and homes, enabling people to use it for a variety of tasks, including taking notes and packing. Typically, paper will be produced in a variety of sizes to match according to intended use. In the modern paper industry, larger machines are utilized to cut large stacks of paper, cardboard, or similar material. Such machines operate in a manner comparable to a guillotine. Commercial versions are motorized and automated and encompass clamping mechanisms to prevent material from shifting during the cutting process. The article proposes a paper cutter model using basic machine principles such as Geneva mechanism and chain transmission. Paper cutting is done by handwheel and lever mechanism. The main purpose of this machine is to reduce paper cutting time. The paper proposed a prototype of a paper cutting machine based on motion mechanism. The main target of the product is those people who need to cut paper not only at a low cost but also effectively. The project focuses on fabricating a machine that provides a simple and inexpensive paper cutting machine. Experimental results show that the cutting time for paper is less than 4 seconds. Moreover, the design of the proposed machine is mainly a mechanical aspect, the complicated controls methods aren’t needed.*

*Keywords: paper, prototype, cutting machine*

## 1 INTRODUCTION

Paper is a necessary component of life. It is used in a variety of settings, including offices, schools, and homes, enabling people to use it for a variety of tasks, including taking notes and packing. Typically, paper will be produced in a variety of sizes to match. according to intended use. Often, the paper was cut with a knife, scissors, or a specialized paper cutter. Today, the use of paper cutters has simplified and accelerated the paper cutting process. These types of paper cutters are frequently used in industries that require large quantities of paper of the same size, such as print shops, newsprint mills, or postcards.

Paper cutters are ubiquitous in schools, corporate offices, and manufacturing plants. Paper cutters vary in size, usually from approximately 30 centimeters (11.8 inches) in length on each side for office work to 841 millimeters (33.1 inches), the length of a sheet of A1 paper. The paper size could be adjusted by a grid that is either painted or inscribed on the machine table. The surface also includes a flat edge against which the user may line up the paper at right angles before passing it under the blade. On the right-hand edge is a long, curved steel blade, often referred to as a knife, attached to the base at one corner. Most modern paper cutters come equipped with a finger guard to prevent users from accidentally cutting themselves or severing a digit while using the apparatus. However, injuries are still possible if the device is not used with proper care or attention. People can quickly cut a large number of papers manually, which takes more time and has a lower degree of accuracy. In the modern paper industry, larger machines are used to cut large stacks of paper, cardboard, or similar material in various sizes. Such machines operate in a manner similar to a guillotine. Commercial versions are motorized and automated and include clamping mechanisms to prevent shifting of the material during the cutting process. These machines are either complicated to build or expensive for individual users.

A paper cutter is a machine that cuts paper to the user's specifications. Paper cutting machines produce high precision cutting products with beautiful cutting lines; they can cut significantly more paper than manual cutting. Paper cutters are a common piece of office equipment, as well as in government agencies, schools, photocopiers, printing shops, and bookstores. Indeed, there are numerous paper cutter machine options available (rotary trimmer, guillotine, hydraulic, cutting mechanism…) depending on what you want or need. It's impossible to say which machine is the best, and one isn't always more efficient than the other, but keep in mind what you're going to use them for [1, 2, 3, 4].

The article proposes a paper cutter model using basic machine principles such as Geneva mechanism and chain transmission. Paper cutting is done by handwheel and lever mechanism. The main purpose of this machine is to reduce paper cutting time. Therefore, this machine works purely on time. The paper proposed a prototype of a paper cutting machine based on motion mechanism. The main target of the product is those people who need to cut paper not only at a low cost but also effectively. The project focuses on fabricating a machine that provides a simple and inexpensive paper cutting machine. Experimental results show the effectiveness of the prototype. The cutting time is less than 4 seconds with the A6 paper size.

This paper is organized as follows: The second part discusses the working principle of the proposed machine and the design goal of the project. The third part provides the overall design and the calculation of important parts. The product and experimental results are presented in the fourth part. The conclusion is finalized the paper.

## 2 MATERIALS AND METHODS

Paper is a thin material made by compressing and drying fibers of moist cellulose pulp derived from cloth, wood, or grass. Used in a variety of forms, paper is characterized by a wide range of properties. In most of the available papers, these properties do not differ much. The determination of these properties is subject to the application of standard test methods, which are generally regulated by technical and industrial associations in the world's paper-producing countries. Before the design process, the mechanical and physical properties of paper size needed to be investigated, which include tensile strength, friction factor, shear stress, stiffness, hardness, resiliency, softness, specific heat capacity…

Design requirements: an automatic paper cutting machine with the following requirements:

- Cutting paper type: A6, A5 paper. A4 with a width of 105 mm, a thickness of 0.1 mm.
- Length of paper to be cut: 40 (mm)
- Cutting time: 4 seconds.

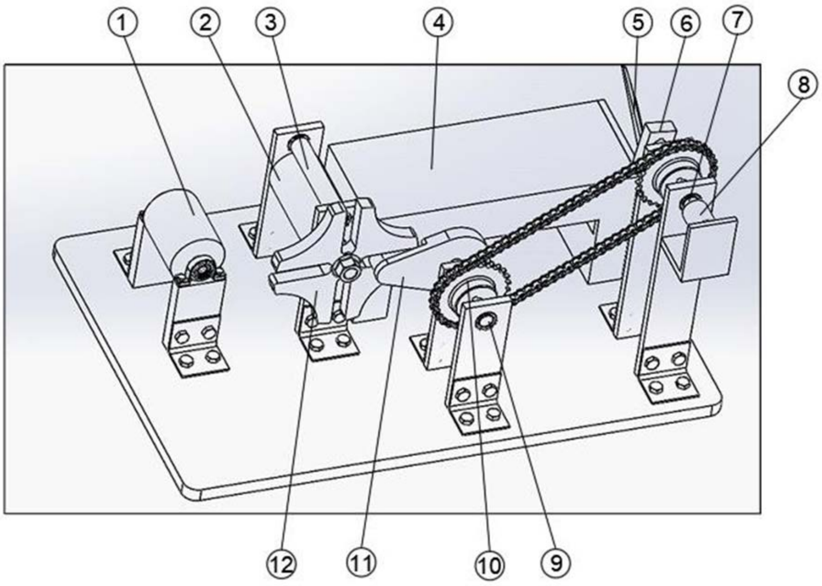


Fig. 1. Overview of the paper cutting machine

Working principle:

- Figure 1 shows the Overview of the paper cutting machine. Initially the paper roll is placed at the paper roll (1), the output of the paper is placed in the gap between the two rollers (2) and (3). When the motor (8) rotates, the shaft (7) rotates, causing the chain to move.
- The chain drive causes the shaft (9) to rotate and the pin on the mandrel will move into the grooves on the wheel (12) causing the mandrel to rotate. When the pin exits the groove on the mantel wheel, the man wheel will not rotate, resulting in intermittent motion.
- When the mandrel rotates, the shaft (2) will move.
- Thanks to the gear drive system, the shaft (2) will move in the opposite direction to the shaft (3). These two opposite movements push the paper out.
- The paper moves on the paper support plate (4) and moves to the cutter position.
- At the initial time when the motor rotates, the lever (6) also rotates.
- The cutter (5) consists of two blades, one fixed to the paper support (4) and the other movable for cutting paper. The blade is fixed to the paper support at the pinpoint and when in motion it rotates around the axis of this pinpoint. Below the knife handle connects to the spring (the spring has a fixed end), above it connects to the belt
- The belt moves, the knife will rotate around the axis of the pinpoint.
- When the belt is at the highest position, the cutter will cut the deepest (the angle between the blade and the base plate plane is the smallest); Conversely, when the belt is at the lowest position, the angle created by the blade and the base plate plane is the largest.

## 3 DESIGN OF PAPER CUTTING MACHINE PARTS

### 3.1 Chain drives

The paper length is an important parameter, so in order to prevent slippage, the chain drive is chosen to move the mechanism as shown in Figure 2. Select the number teeth on the sprocket $z1 = z2 = 27$ . From the figure, it can be proved that [5, 6].

$$D = \frac{p}{sin\left(\frac{\alpha}{2}\right)} \tag{1}$$

In which $\alpha = \frac{360}{z}$

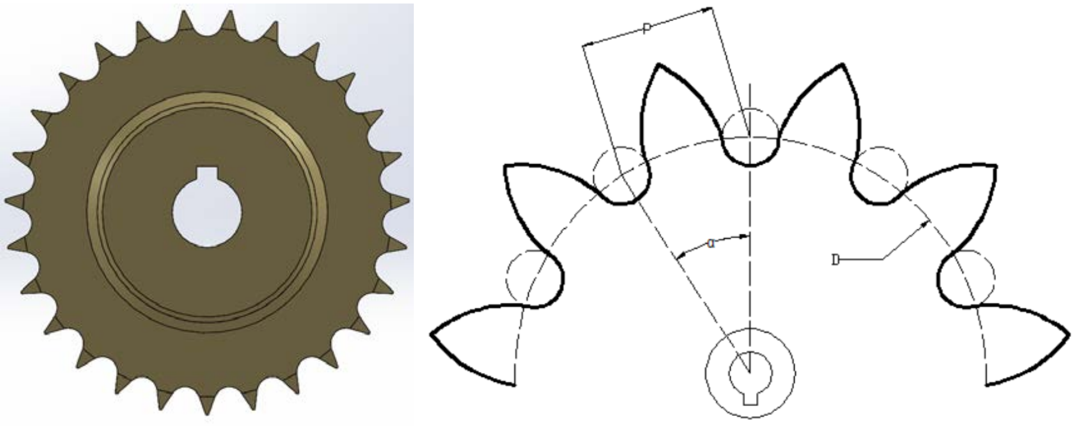

Fig. 2. Geometric of chain on sprocket wheel

The chain step p was determined with the condition: $P_t$≤ Power transmitted where:

Power transmitted: $P = \frac{P_1 v}{1000} d$ (kW)

Where P1: allowable tension in the chain (N)

v: velocity of chain (m/s)

Otherwise, we have kW rating of chain $R = (P.K_S)/ K_1 x K_2$

Where Ks: service factor

$K_1$: multiple strand factors

$K_2$: toot correction factor

For the given application, we have $K_s$= 1(Electric motor with light load), $K_1$= 1 (one strand), $K_2$= 1.46 (25-30 teeth on the sprocket)

The velocity ratio of the chain drives is given by

$$i = \frac{z_2}{z_1} = \frac{n_1}{n_2} \tag{2}$$

in which $n_1$, $n_2$= speed of rotation of shafts (rpm)

The velocity in m/s of the chains is given by

$$v = \frac{zpn}{60 \times 10^3} \tag{3}$$

We get:

- Chain pitch: p = 12.7 (mm)
- Pin diameter: $d_c$ = 4.45 (mm)
- Pipe length: B = 8.9 (mm)
- Power transmitted = 0.35 (Kw)

### 3.2 Determine the shaft distance and the number of links

Preliminary design as shown in Figure 3 was chosen: a = 25(12.7) = 317.5 (mm)

Number of links in the chain

$$x = 2\frac{a}{p} + \frac{Z_1 + Z_2}{2} + \frac{(Z_2 - Z_1)^2 p}{4\pi^2 a} = \frac{2.317,5}{12,7} + \frac{27 + 27}{2} + \frac{(27 - 27)^2.12,7}{2\pi^2.317,5} \quad (4)$$

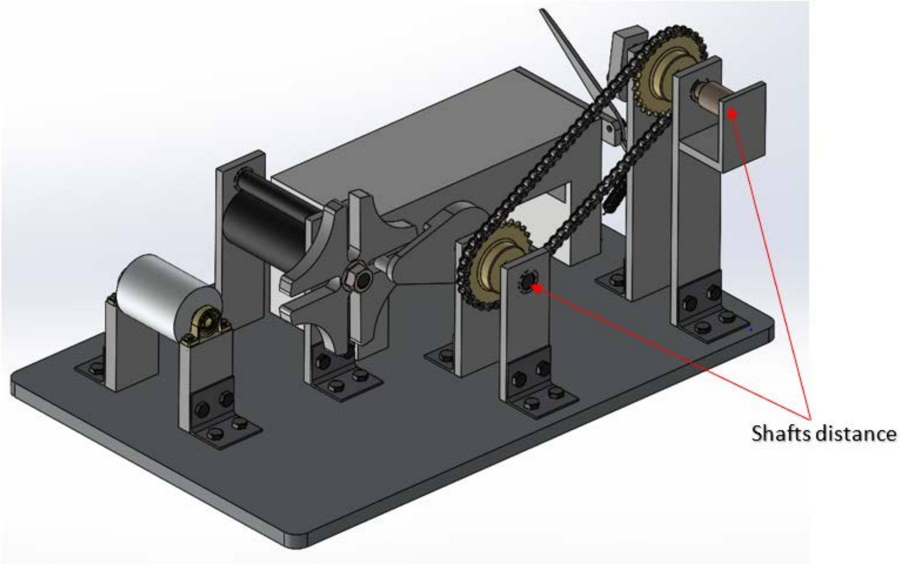


Fig. 3. Distance between two shafts

We have x = 77 (mm)
Chain length L = x. p = 77.12.7 = 977.9 (mm).
The shaft distance:

$$a^* = \frac{p}{4}\left[x - \frac{Z_1 + Z_2}{2} + \sqrt{\left(x - \frac{Z_1 + Z_2}{2}\right)^2 - 8\left(\frac{Z_2 - Z_1}{\pi}\right)^2}\right] \quad (5)$$

$$a^* = a^* \frac{12,7}{4}\left[77 - \frac{27 + 27}{2} + \sqrt{\left(77 - \frac{27 + 27}{2}\right)^2 - 8\left(\frac{27 - 27}{\pi}\right)^2}\right] \quad (6)$$

$$a^* = \frac{12,7}{4}(50 + 50) = 317,5(mm) \quad (7)$$

In order for the chain not to be too tight, it is necessary to reduce a by:
Δa = (0.002 ÷ 0.004) $a^*$ = (0.002÷0.004).317.5 = 0.635÷1.27 (mm)
Hence: a = a∗ - Δa = 317.5 – (0.635÷1.27) = 316.86÷316.23(mm) take a= 316.5 mm
The number of impacts of chain i:
For roller chain, pitch p = 12.7 (mm)
→The allowable number of impacts of the chain: [i] = 60

$$i = \frac{Z_1 n_1}{15.x} = \frac{27.20}{15.77} = 0,46 < [i] = 60 \quad (8)$$

Chain test for durability:

$$s = \frac{Q}{k_đ F_t + F_0 + F_v} \leq [s] \quad (9)$$

Q - Breaking load: with p = 12.7 (mm) we get:

- Q = 18200 (N)
- Weight of one meter chain: q = 0.75 (Kg)

$k_đ$- Dynamic load factor: $k_đ$ = 1.7 (starting load is equal to 2 times of nominal load) Average speed of chain:

$$v = \frac{Z_1.q.n_1}{60.1000} = \frac{27.12,7.20}{60000} = 0.1143(m/s) \tag{10}$$

$F_t$ – Ring force:

$$F_{t.} = \frac{1000P}{v} = \frac{1000.0.01}{0.1142} = 87(N) \tag{11}$$

$F_v$ – Tension force caused by centrifugal force:

$$F_v = \text{q. } v^2 = 0.75.\ 0.11432\ ^2 = \text{(N)}$$

$F_{v0}$ – tension produced by the weight of the passive chain branch:

$$F_0 = 9.81.\ k_f.\ \text{q. a} \tag{12}$$

Where: pitch angle = 120° and then $k_f$= 1.5

$$\rightarrow F_0 = 9.81.\ k_f.\ \text{q. a} = 9{,}81.1{,}5.0.01.0{,}3165 = 0.05\ \text{(N)}$$

Allowable factor of safety with p=12.7 (mm); $n_1$=20 rev/min we get [fs] = 7
Therefore:

$$fs = \frac{Q}{k_{đ}.F_t + F_0 + F_v} = \frac{Q}{1{,}7.87 + 0.05 + 9.8.10^{-3}} = 123 > [fs] = 7 \tag{13}$$

Determine the parameters of the sprocket:
Diameter of split ring:

$$\begin{cases} d_1 = \dfrac{p}{sin\dfrac{\pi}{Z_1}} = \dfrac{12{,}7}{sin\dfrac{\pi}{27}} = 109{,}39(mm) \\ d_2 = \dfrac{p}{sin\dfrac{\pi}{Z_2}} = \dfrac{12{,}7}{sin\dfrac{\pi}{27}} = 109{,}39(mm) \end{cases} \tag{14}$$

Tooth apex diameter:

$$\begin{cases} d_{a1} = p\left[0.5 + cotg\left(\dfrac{\pi}{Z_1}\right)\right] = p\left[0.5 + cotg\left(\dfrac{\pi}{27}\right)\right] = 115(mm) \\ d_{a2} = p\left[0.5 + cotg\left(\dfrac{\pi}{Z_2}\right)\right] = p\left[0.5 + cotg\left(\dfrac{\pi}{27}\right)\right] = 115(mm) \end{cases} \tag{15}$$

Bottom Radius

$$r = 0.5025.d_1{}' + 0.05 \tag{16}$$

we get: $d_1$ = 8.51 (mm)

$$r = 0.5025x8.51 + 0.05 = 4.32\ \text{(mm)} \tag{17}$$

Tooth root diameter:

$$\begin{cases} d_{f1} = d_1 - 2r = 109{,}39 - 2.4{,}32 = 100{,}75(mm) \\ d_{f2} = d_2 - 2r = 109{,}39 - 2.4{,}32 = 100{,}75(mm) \end{cases} \tag{18}$$

Test sprocket teeth for contact strength:

$$\sigma_{HI} = 0{,}47\sqrt{k_r(F_tK_{đ} + F_{vđ})\frac{E}{A.k_{đ}}} \tag{19}$$

In there:
$K_{đ}$ – Dynamic load factor: $K_{đ}$ = 1.2

A - Projection area of hinge with p = 12.7 (mm)

→ A = 39.6 ($mm^2$)

$K_r$: the influence coefficient of the number of sprocket teeth, according to the number of teeth $Z_1$ = 27, we get $K_r$ = 0.36

$K_đ$ – Load factor unevenly distributed between ranges: $K_đ$ = 1

E-Module of elasticity:

$$E = \frac{2E_1.E_2}{E_1 + E_2} = 2{,}1.10^5(Mpa) \quad (20)$$

$E$ is the Impact force per m chain:

$$F_{vđ} = 13.10^{-7}.n_1.p^3.m = 13.10^{-7}.20.12{,}7^3.1 = 0.05 \quad (21)$$

$$\sigma_{HI} = 0{,}47\sqrt{0.36(87{,}1 + 0.05)\frac{2{,}1.10^5}{39{,}6.1}} = 191{,}6(MPa) \quad (22)$$

The material of C45 Steel is chosen with hardness HB = 170÷210 has

[$\sigma_H$] = 600 > $\sigma_H$ = 191.6 MPa → Ensure contact strength for sprocket teeth.

Table 1 shows the chain drives parameters after designing

Table 1. The chain drives parameters

| Parameters | Symbol | Value |
|---|---|---|
| 1. Chain type | ----- | Roller hose chain |
| 2. Chain pitch | p | 12,7(mm) |
| 3. Number of links | x | 77 |
| 4. Chain length | L | 977,9(mm) |
| 5. Axis distance | a | 316,5(mm) |
| 6. Small sprocket tooth number | $Z_1$ | 27 |
| 7. Number of teeth of large sprocket | $Z_2$ | 27 |
| 8. Sprocket material | ------ | Steel C45 |
| 9. Small sprocket ring diameter | $d_1$ | 109,39(mm) |
| 10. Large sprocket ring diameter | $d_2$ | 109,39(mm) |
| 11.Small sprocket top ring diameter | $d_{a1}$ | 115(mm) |
| 12. Large sprocket top ring diameter | $d_{a2}$ | 115(mm) |
| 13.Bottom Radius | r | 4,32(mm) |
| 14.Small sprocket tooth diameter | $d_{f1}$ | 100,75(mm) |
| 15. Large sprocket tooth diameter | $d_{f2}$ | 100,75(mm) |

### *3.3 Calculation of Geneva structure*

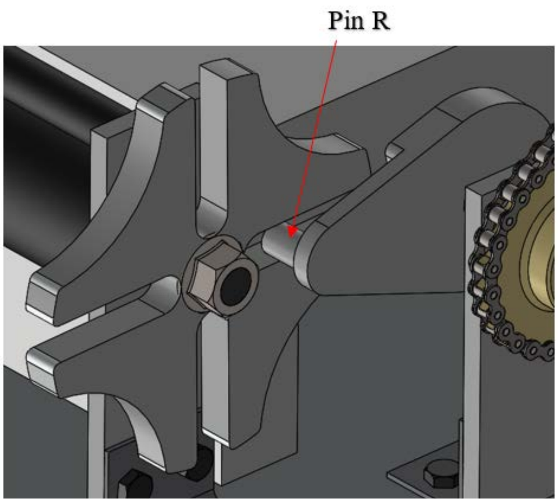


Fig. 4. Geneva mechanism

The Geneva mechanism is one of the most frequently employed devices for producing intermittent rotary motion, characterized by alternating periods of motion and rest with no direction reversal [7],[8] as shown in Figure 4.

A pin or roller R that fits into Geneva's four radial slots is depicted in Figure 5. Between the slots are four concave surfaces that fit the driver's surface and prevent the follower from rotating when it is fully engaged. In the depicted position, the pin enters one of the slots; upon further rotation of the driver, it will move into the slot and rotate the follower by 90 degrees. The number of pins on disc 1 can be increased to increase the number of movements of disc 2. Select Geneva mechanism with Z = 4.

Calculation of mantle's geometry.

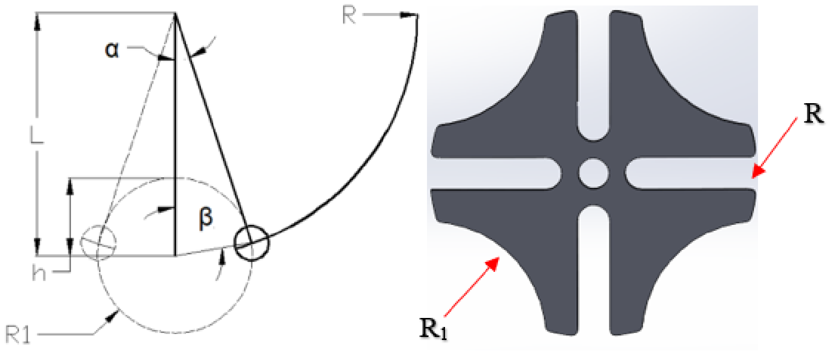


Fig. 5. Mantle's geometry

The conditions for impact resistance are:

$$\alpha + \beta = 90 \tag{23}$$

Where the angle α is determined by the number of tracks of the Geneva disk as Z = 4 tracks:

$$\alpha = \frac{180^0}{4} = 45 \tag{24}$$

therefore:

$$\beta = \frac{180^0}{2} - 45 = 45 \tag{25}$$

The geometrical parameters of the Geneva mechanism are determined:

Distance between the boom shaft and the disc shaft L:

$$L = \frac{R}{\cos\alpha} = \frac{R}{\cos 45^0} = 149{,}9(mm) \tag{26}$$

Take L = 150 (mm)

Length of Man disc groove:

$$h = L(sin\alpha + cos\beta - 1) + r \tag{27}$$

$$h = 150(sin45° + cos45° - 1) + 10 = 72 \text{ (mm)} \tag{28}$$

Take h = 75 (mm)

Orbital radius needed:

$$R_1 = Lsin\alpha = 150.sin45° = 106.1 \text{ (mm).} \tag{29}$$

### 3.4 Paper roll design

– The function of the paper roll

Figure 6 shows the paper roll unit in this paper cutter is a system of two axes that move in opposite directions. They are placed on the support plate fixed to the base plate. During the working process, these two axes will move in opposite directions and roll the paper to move to the cutter position.

– Choose material

Here, the paper roller only does the main task of transmitting motion, bringing the paper to the cutting position, without much load. We choose the material for both shafts to be CT5 steel, not heat treated.

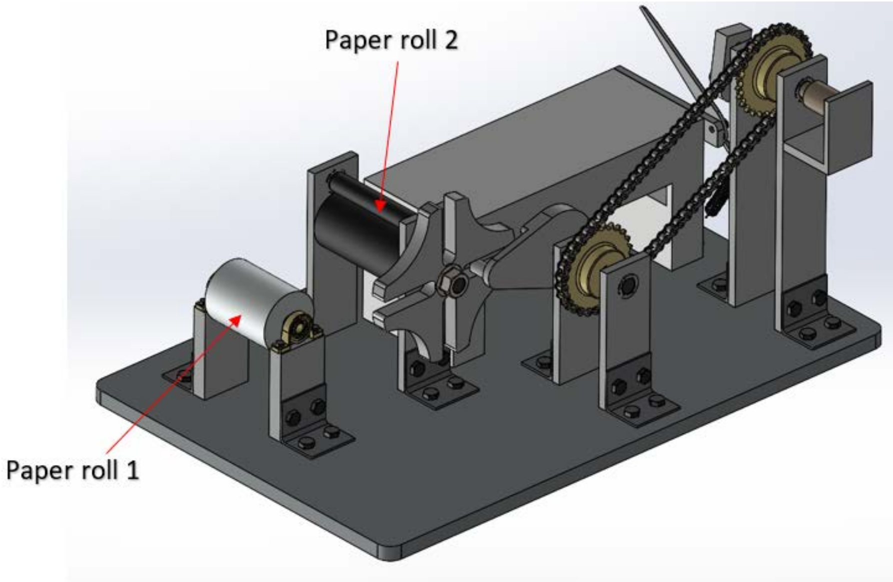


Fig. 6. Paper roll

- Roller 1:

Project the length of the paper to be cut 40 mm, select the 4-slot mannequin and then angle was 90 degrees

Paper length to be cut = ¼ roll circumference = $\frac{1}{4}.2.\pi.r$

$$50 = \frac{1}{4}2.\pi.r \tag{30}$$

$$r = 31.85 \tag{31}$$

Roller diameter: d = 63.7 (mm)

Select roll diameter as 60 (mm).

We will make the shaft diameter 20 mm, and the outside is covered with foam to save materials, costs and increase friction when rolling paper.

Shaft diameter in bearing cross-section: 20 (mm)

- Second batch:

Select roller 2 with diameter $d_2$ = 40 (mm).

Shaft diameter at bearing cross-section: 20 (mm)

Paper thickness 0.1 mm

The axis distance of 2 rolls is:

$$a = \frac{60}{2} + \frac{40}{2} - 0{,}1 = 49{,}9(mm) \tag{32}$$

### *3.5 Select bearing*

The roller bearing is used to support the paper roll and design as in Figure 7, receive the load and transmit it to the paper roll, as shown in Figure 8. The bearing was designed based on the Stribeck's equation [5], [6]:

C= $F_1$+ $2F_2\cos\beta+2F_2\cos(2\beta)$+ ………. = $F_1$ $[1+2(\cos\beta)^{5/2}+2(\cos 2\beta)^{5/2}+.....]$= $F_1M$

Where M= $[1+2(\cos\beta)^{5/2}+2(\cos 2\beta)^{5/2}+.....]$

C is the static load

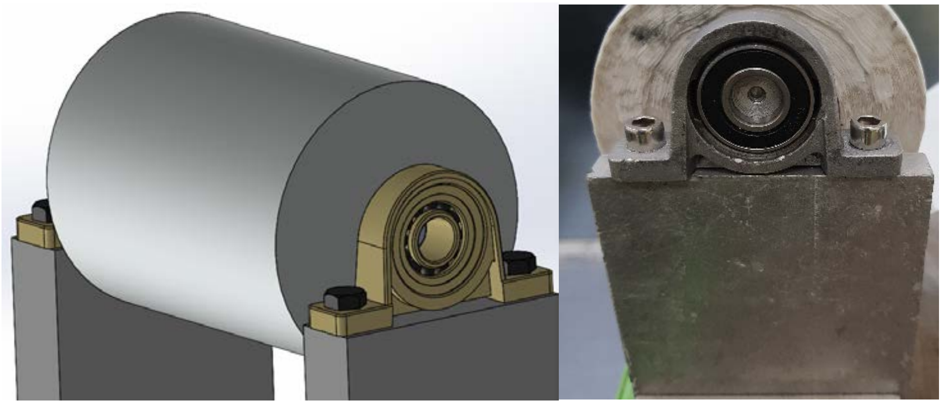

Fig. 7. Rolling Bearings design

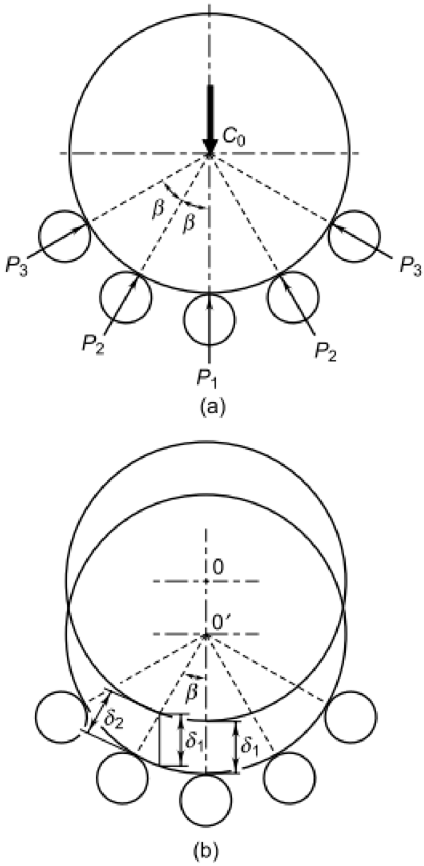


Fig. 8. Static load capacity of bearing a) Forces acting on Inner Race (b) Deflection of Inner Race

If Z is the number of balls, we have β= 360/ z

The values of M were chosen based on different values of Z. According to Stribeck suggestion, the value for M as z/5 or M= z/5. And then we have $C = \frac{zF_1}{5} = \frac{k\,d^2 z}{5}$ (Stribeck's equation)

The dynamic load is written as:

$$P = XVF_r + YF_a \tag{33}$$

In which

P: dynamic load (N)

$F_r$: radial load (N)

$F_a$: axial or thrust load (N)

V: race- rotation factor

The bearing parameter for a given application as expressed

Inner diameter: d=20 mm

Outer diameter: D=37 mm

Dynamic load capacity: $C_o$= 11.6 kN

Static load capacity: C= 7.79 kN

Bearing width: b=12 mm

### 3.6 Cutting blade

Fig. 9. The cutting blade

Evaluation of the cutting blade (Figure 9) is based on the required cutting force, paper length, and cutting time. In this research, the cutting blade was determined based on Drury's law and Hoffmann's theory [9], [10],[11]. When we make a stroke along a path of amplitude A and W using a stylus the time required to navigate the path MT (movement time) is:

$$MT = a + b\frac{A}{W} \tag{34}$$

Where a and b are empirically determined constants

Another formula presents speed V as:

$$V = c + dW \tag{35}$$

Where c and d are empirically constants and $V = \frac{MT}{A}$

For the purpose of research: it takes 4 seconds to cut paper

Taking the length of the A5 paper, so that from theory we have the cutting force equal to 1.8N

### 3.7 Motor selection

In the model, because a chain drive is used and a large load is not required, there is no need for a large-capacity motor. With quite simple requirements of the machine as:

- Continuous paper cutters can stop when needed.
- Does not require high accuracy, light load.
- Easy to control, low cost.

In this study, the DC motor was chosen for these reasons.


Fig. 10. DC motor

Figure 10 depicts the DC motor parameters:

- Model: K7011
- Power: 18W
- Voltage: 220V
- Rated speed: 20 round/min

Calculating the transmission outside the chain drive

$$\text{Required parameters:} \begin{Bmatrix} Power = 18W \\ n_1 = 20(rev/min) \\ T_1 = 4775(Nmm) \\ u = u_x = 1 \end{Bmatrix} \quad (36)$$

$$T_1 = 9{,}55.\frac{P_1}{n_1} = 9{,}55.10^6 = 5775 \text{ (N.mm)} \quad (37)$$

### 3.8 Strength Simulation

– Determine the force from the details, the transmission acting on the shaft

The shaft containing the mandrel and chain is one of the most dangerous axes of the paper cutter model. Figure 11 depicts the calculation of the force acting on this shaft.

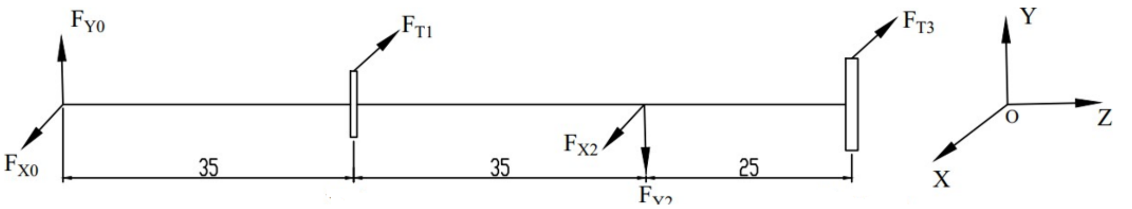


Fig. 11. Force Diagram

Force from the chain drive:

$$F_{t1} = 87(N) \quad (38)$$

$$F_{t3} = \frac{2T}{d} = \frac{2.4775}{10.6.2} = 45{,}05(N) \quad (39)$$

We have a system of equations:

$$\begin{cases} \sum \text{Fkx} = \text{Fxo} + \text{Fx2} - \text{Ft1} - \text{Ft3} = 0 \\ \sum \text{Fky} = \text{Fy0} - \text{Fy2} = 0 \\ \sum Mox = -Fy2.70 = 0 \\ \sum Moy = Ft1.35 - Fx2.70 + Ft3.95 = 0 \end{cases} \quad (40)$$

$$\begin{cases} Fy0 = Fy2 = 0 \\ Fx0 + Fx2 = 123{,}05 \\ Ft1.35 + Ft3.95 = Fx2.70 \end{cases} \quad (41)$$

$$\begin{cases} Fx0 = 27{,}41(N) \\ Fx0 = Fy2 = 0 \\ Ft1 = 87(N) \\ Fx2 = 104{,}64(N) \\ Fx3 = 45{,}05(N) \end{cases} \quad (42)$$

– Shaft strength simulation on Solidworks software

➢ Draw the axis and the point where the force is applied, as shown the Figure 12.

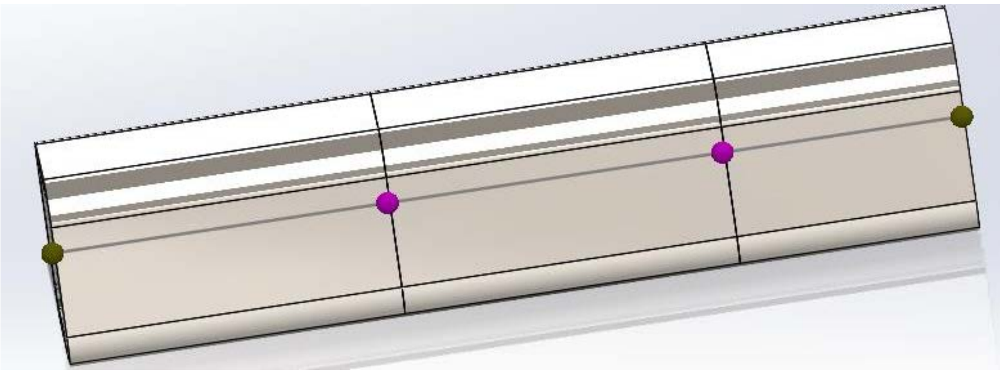

Fig. 12. Axes and force points in SolidWorks

- Figure 13 shows the Appling force at positions on axis

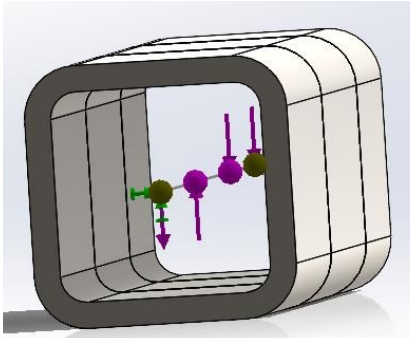

Fig. 13. Set force in the SolidWorks software

- Stress results at positions on the shaft, as shown in Figure 14

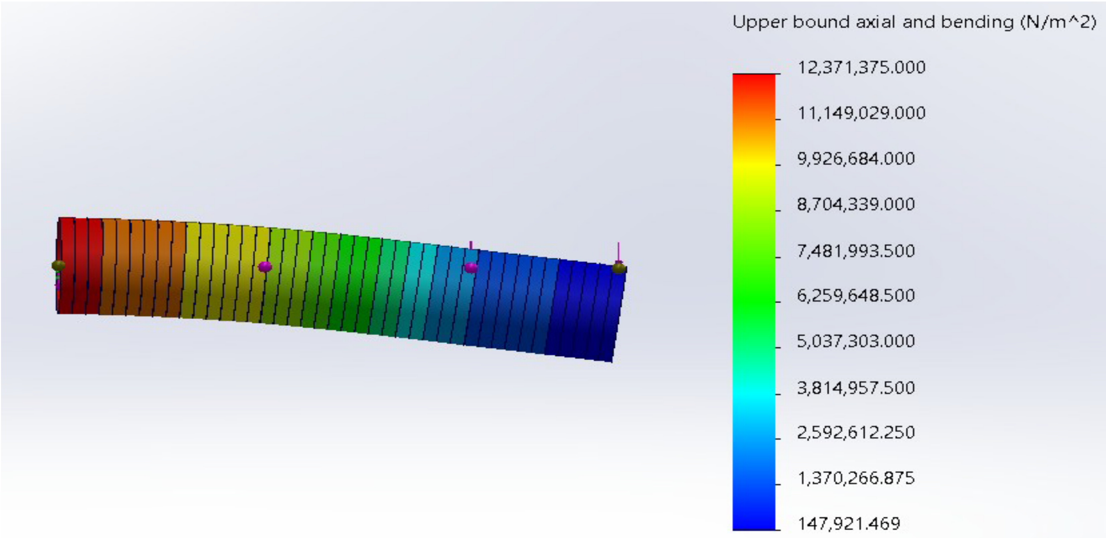


Fig. 14. Stress results in SolidWorks software

Thus, according to the above results:
The maximum stress at the shaft end 12371 kN/m$^2$
Minimum stress at man hand: 147.9 KN/m$^2$

- Figure 15 shows the transposition results at positions

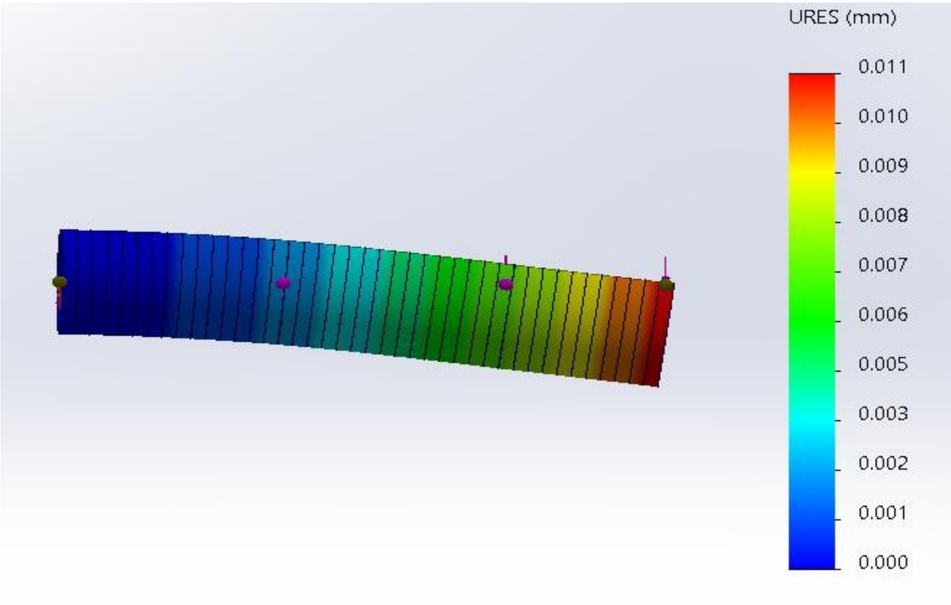


Fig. 15. Displacement results when simulating with SolidWorks

So according to the above results: the largest displacement at the position of the man's hand with 0.011 mm

## 4 RESULT AND DISCUSSION

Figure 16 shows the proposed paper cutting prototype. Priority number one in the design of the paper-cutting machine was safety. This was yet another reason why the use of metal cutting blades was deemed advantageous. Although the blades are sharp enough to cut paper under the right conditions, it is of the utmost importance to ensure the operator's safety; therefore, where the operator would have to feed paper into the machine, he would not have contact with the blades during operation; the cutting blades are kept at a safe distance from the operator's hands.

The results of the design analysis of the machine's component parts indicate that the design functioned as intended. This project's primary objective is to design a mechanical paper-cutting machine. The cost of the proposed machine is about 125 USD. The results of the tests conducted on the paper-cutting machine demonstrated the efficacy of the calculation procedure.

Fig. 16. Paper cutting machine prototype

In the experiment, 100 tests for cutting A6 paper were performed. There were 15 re-tests, 3 failed due to chain drives or the re-adjustment of the paper by moving it in the roll and the sharpness of the blade. The efficiency of the machine after performance evaluation was carried out is 82%. Figures 17 show the experimental results.

Fig. 17. Experimental setup

The average cutting time for a paper piece was 3.8 seconds. A good agreement was observed in the working principal mechanism and result parameters when comparing experimental and design analysis. All primary design criteria were satisfied by the proposed solution. Produce prototypes that can only cut a fixed length of paper, but whose length is variable by exchange the new Geneva mechanism. These proposed prototypes are intended to facilitate construction and transportation with limited time and resources, as well as to create a new form of portable paper cutters that are simple to maintain.

## 5 CONCLUSIONS

This project successfully designed a semi-automated paper-cutting machine that can be used to cut paper into various sizes, such as textbook and exercise book sizes, as required. The design satisfies all of the team's identified major design criteria. The paper-cutting machine will enable the production of a variety of usable sizes.

In addition, the team developed a functional prototype of the proposed design. This prototype demonstrates that the produced design is viable and capable of achieving the desired outcomes and output. The prototype also demonstrates that the Paper Cutting Machine can be constructed with limited tools and at a reasonable cost.

In the following ways, the project's outcome was successful:

- It requires minimal maintenance.
- The ease of operation makes it simple for anyone to operate, regardless of his or her educational background, because it does not require training or a license.
- The Paper Cutting Machine is reasonably priced and contains all necessary components.

In the future, the proposed machine could be upgraded as follows:

- The exchangeable Geneva mechanism should be included to change the paper size.
- The cover box should be added for safety

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