Automated Paper Cutting Machine

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Abstract— Now a days, there is lot of competition in the market. So there is need of developing a new method or process for effective manufacturing. That process or methods should fulfil the requirement about accuracy Productivity.

In industries the paper cutting machines go through a time taking process of paper marking which is required to cut the paper of required dimensions, This equipment is very accurate to cut the papers.

This concept will be mainly used in the paper manufacturing industry to cut the papers in huge numbers. The equipment is fabricated in less cost and good efficient. The aim of this concept is to reduce the human fatigue and time savings in industries by eliminating the paper marking time.

This project is centered on the design and fabrication of an Automatic paper cutting machine making use of some locally found materials. Paper is one of the majorly used material in our day to day activities in taking information's down necessary information's, it is very important that there is a machine that can handle it at a domestic level to give the desired form for various use. The machine is made up of a motor, an Arduino board, plastic materials, blade, and belt. The machine also uses code which is programmed on the Arduino board which helps to set the length of cut and the slider which holds the blade slides to cut the paper. The machine is tested and the output is evaluated.

Index Terms— Arduino,PCB

1 INTRODUCTION

In the world economy generally over the years has enjoyed the grand massive results of technological advancement in various sectors most especially in the usage of materials and recycle of scares material. Industries and firms have continuously devised innovative plans to keep customers at arm's length with the introduction of new technology, products and services that would help make life easier to people in general. As a result of this upshot, urban areas have appreciably expanded with rapid increase in population resulting in a high percentage of goods consumed per area which leads to recycling of materials. Goods after been put to use, are often times wrongly disposed or rather poorly managed, bringing about several hazardous effects in the environment and the ecosystem at large.

Wastes are materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his own purposes of production, transformation or consumption, and of which he wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Waste includes all the items that people no longer have any use for, which they either intend to get rid of or they have already discarded. All daily activities, therefore, gives rise to a large variety of different waste flows from different sources. These sources include, for instance, waste coming from households (e.g. plastic packaging waste), commercial activities (e.g. cardboard packaging waste from shops, food waste from restaurants and medical waste from hospitals), industry (e.g. fly ashes from thermal processes of energy generation, textile waste and tanning liquor from clothes manufacturers), agriculture (e.g. slurry), construction and demolition projects (Andrew et al., 2012). A small part of the waste which is generated is hazardous; that is, it poses substantial or potential threats to human health or to the environment as a whole.

Paper is a thin material produced by pressing together moist material produced by pressing together moist Fibre of cellulose pulp derived from wood rags or grasses, and drying them into flexible sheets. It is a versatile material with many uses, including writing, printing packaging, cleaning, and a number of industrial and construction processes. It and the pulp papermaking process is said to have been developed during the early 2nd century AD, possibly as early as the year 105 A.D. by the Han court eunuch, in china although the earliest archaeological fragments of paper derive from the 2nd century BC in China. The modern pulp and paper industrial is now global, with China leading its production and the United States right behind it. (Encyclopedia Britannica Ultimate Reference Suite).

Waste management and waste disposal have become a pressing need with the increasing population, change in the nation's living habits and rapid urbanisation, (Fillaudeau, et al., 2006; Unterstein, 2000). With this development the use of papers becomes the vogue and mandatory in schools, offices and homes and some processed into tissue paper. In hospitals, households, offices, social gatherings, shops, hostels, various types of institutions, both public and private etc., papers are in daily demand. From statistics and research, the annual the

demand for paper conservatively at 800 million tonnes per annum, while the total production and supplies is less than 100 million tonnes per annum. The shortfall of about 700 million metric tonnes are created calling for the wide gap to be bridged. Some of the products are still being imported from such countries as Brazil, Germany, Netherlands, and UK etc. Since not much has been done in the area of toilet roll production in Nigeria, the primary objective is to design and fabricate a Paper Cutting Machine, as a pivotal component in the entire tissue production using locally available materials, capable of winding tissues into roll and cutting it into different sizes.

2 Literature Review

Paper cutting is an art with a long history, cutting paper began long before the making of the book of bound leaves, and the necessity of making a number of sheets of the same size called for some mechanical means of cutting and trimming. The earliest cutting machine was no doubt a sharp stone or a stick; then a piece of metal, dragged across the parchment, with a guide to keep the cut in a straight line. The sheet was simply held by the hand, and later the straight-edge formed a clamp also. Its first origins date back to the 4th century after the invention of the paper by the Chinese. Some of their earliest uses for paper cutting were for religious decorations or stencils used for patterns in embroidery. For a long time, this art form was popular among high-society women, but it soon spread to other classes. About the fifth century the important step of folding the vellum into leaves became the practice. The instrument which we know to-day as scissors or shears probably had a large part to do in these early operations. With the invention of printing and the multiplication of books larger and stronger means were necessary to cut the sheets. Although the book with the untrimmed sheets was the rule of this earlier time, and of a later time, for the smaller books and for divisions of the sheet a cutter was necessary.

In the Haupt Halle at the great Graphic Arts Exhibition, Leipzig, 1914, were some illustrations showing the earliest German cutting machines and their evolution to date. The earliest among them is the lightly constructed hand-driven vertical cutter of 1855. This consisted of two side frames, the knife-bar guides in their slots and a large hand wheel at the right. The next stage was a cutter of 1876, a hand-driven wheel at the right turning gears above and outside the table. A crank and a rod connected to the center top of the knife-bar pulled the knife in the direction of the two slots in the knife-bar, giving it a shearing motion. This model is the same as that used by most German manufacturers for both hand and power-driven cutters until within a few years, when the greatly improved, rapid, and more convenient American examples became known.

The evolution of the cutting machine has been rapid and distinctly marked in all its essential features, from the oscillating plough to the vertical stroke, to the shear stroke, to the double-shear stroke; from a single-rod pull-down of the knife (by a chain, by a cam, or by a crank to the two-rod pull-down by cams, rolls, slots, slides, to the cranks which give a fixed dependable stroke; to the cranks which give a fixed dependable stroke, and at the same time pull the knife endwise; from swinging-link shear to a straight-line shear; from man-drive to power-drive; from driving by power fixtures in front and outside the frame to fixtures located back and underneath; from low piles to high piles; from hand clamp to power clamp, to self-clamp, to automatic clamp, finally to friction adjustable pressure clamp; from measuring by rule to the use of rapid automatic measuring and spacing devices.

In paper Modification of the Geneva Paper cutting tool by Nupur Jain, Feb 2019 , Scotch yoke mechanism over a crank lever mechanism is proposed which is more effective and is capable of performing various operations along with cutting such as stamping and punching. In the paper written by Mr. Mohit Kalamkar in march 2019, named Design and Fabrication of paper cutting machine by using Geneva mechanism states that the length of the feed can be managed by changing the depth of the slots in Geneva wheel and the path length of the crank can be increase by increasing the radius of the crank and the length of the lever cutter by changing the number of slots. But the operation is noisy and takes a lot time.

In the paper, Design and development of machine to perform stamping and cutting operation by Mr. Rakesh Prajapati says, Paper feed is adjusted by changing the circumference of the roller .thus the paper cutting in accurate dimensions without marking the paper is achieved by getting the intermittent motion by Geneva mechanism. But it cannot be used for large scale production and Manual input is required. The paper Universal paper cutting machine by Mr. Vipul Shah explains the intermittent gear mechanism with swinging sector is utilized for automatic operation for paper cutting as well as feeding. It has limitations that we cannot receive the size of paper, Limitation of size. According to Mr. Sunil. H. V and Mr. Ankit Yadav the paper Automatic Paper Cutting Machine using Geneva mechanism says Shape and size of paper dependent upon feed of the paper through roller. 60 number of slots of wheel plays important role. Thus for A-4 size int. motion used to change accordingly & compared with standard size.

2.1 Description of Typical Cutting Machines

2.1.1 PLOUGH AND PRESS CUTTER

An early form of cutting machine, made almost entirely of wood. The pile of paper or book was clamped to the table by the upper cross-bar of the clamp, which was brought down by the geared vertical arm. As shown by picture, these arms were raised and lowered by turning the large toothed wheel.
The steel chisel (A) operating in a holder running in a groove, was moved to and fro across the paper, cutting deeper each time as the chisel was gradually lowered by the handle.

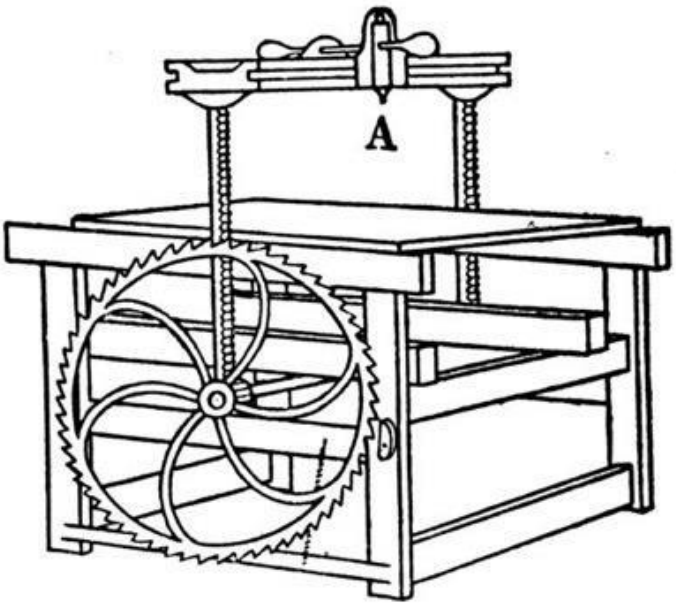


Figure 2.1: Plough and Press Cutter

2.1.2 CARD CUTTER OR TRIMMER

Card trimmers are knives hinged at one end to a base upon which the work is laid and held, while the knife is pulled down by hand to shear it off against a metal edge. Stock cut this way has a slight burr on its lower edge, caused by the "drag" or downward pressure of the knife. To cut cards free from burr a rotary card-cutting machine is used, with a rotating shaft carrying a small wheel cutter. These cutters are used on a workbench.

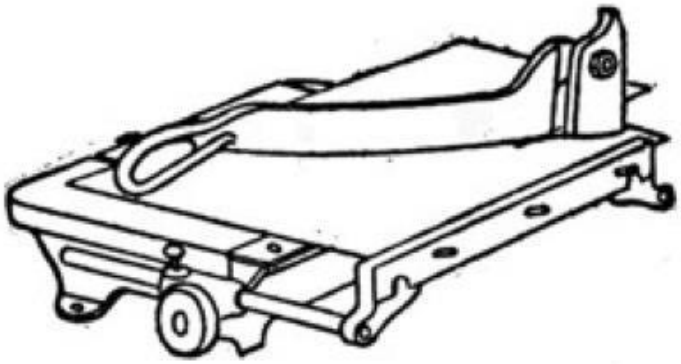


Figure 2.2: Card Cutter and Trimmer

2.1.3 HAND-LEVER CUTTER

Hand-lever cutters stand on the floor and have a convenient height table to lay the work upon. The cut is made by pulling the knife down through the pile. The knife is hung from two swinging links, and is easily operated when it has double shear and a toggle crank connection to the hand-lever shaft.

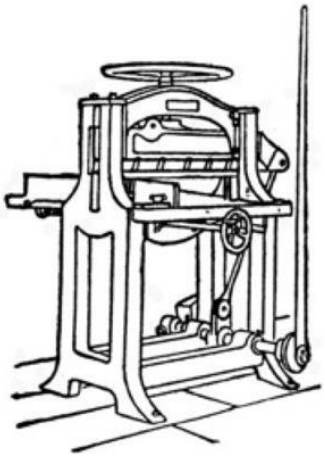


Figure2.3-Hand-LeverCutter

2.1.4 APPLICATION OF POWER

There are five methods of applying power necessary to operate paper cutters: by hand lever, by belt, by direct gearing, by chain and sprocket, and by direct connection of electric motor.

Figure 2.6. Shows a direct-geared connection of the electric motor through its noiseless rawhide pinion engaging an iron gear on the machine driving shaft. An adjustment is provided for taking up the wear in the gears, in order to maintain the noiseless running of the machine.

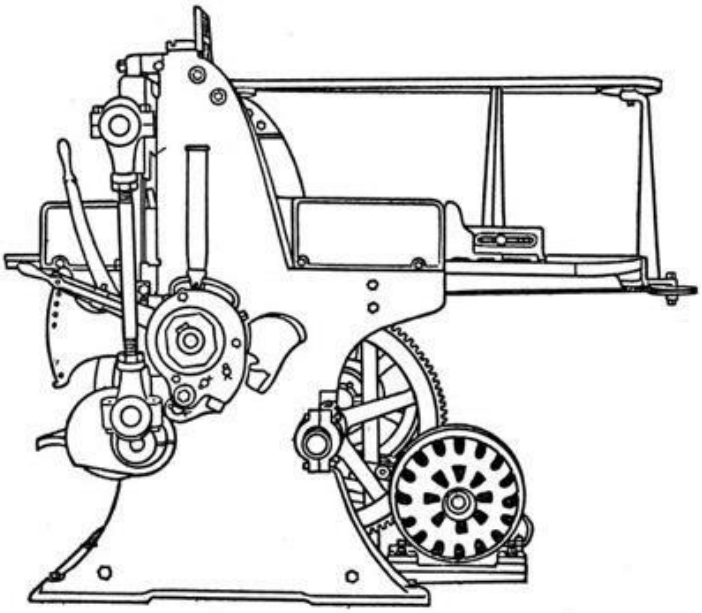


Figure2.6: Electric Motor Underneath Geared Drive

3.2 Material Selection

Material selection is an important aspect of machine design; it involves the selection of material from which the respective components of automatic paper cutting machine will be fabricated. To analyze the components of the various machines that make up the automatic paper cutting machine some factors have to be considered.

Many times, a material problem is one of selecting the right material from the many thousands that are available (Ashby, M. F. and Jones D. R. H., 2005). The selection of materials, fabrication techniques and final decision reached for the purpose of design and fabrication of the automatic paper cutting machine was based on a number of factors;

First is the weight and characteristics of the material to be rolled such as length, flow ability, thickness, etc. Material characteristics are very important in determining the design of blades. (Randall, et al., 1993). For this design, it was concluded that paper cutting machine would be reduce to smaller sizes, and the texture was also considered in designing the blade.

A second selection consideration is the maximum rate at which the paper cutting machine is been feed into the machine so that the paper feed into the machine does not tire or squeeze in the machine. (Rudenko N., 2004). This consideration is taken note of while designing the rollers of the machine. The result wasuseful as a guide in selecting the suitable machine components for service operation.

Third is the in-service requirement of the various machine components which must be characterized, for these will dictate the properties required of the material (Gordon K., et al., 1993). Plastic, with regard to mechanical characteristics, are relatively stiff, strong, ductile (i.e. capable of large amounts of deformation without fracture), good conductors of heat and are resistant to fracture (Bolz, H. and Hagemann, G. E (ed.), 1998). The property of metals and plastic and its lustrous appearance when ground and polished explains its selection as a major material in this project work.

Fourth consideration is any deterioration of material properties that may occur during service operation. For example, significant reduction in mechanical strength may result from exposure to elevated temperature or corrosive environment (Mangonon, P. L., 1999). This consideration was kept in mind while selecting parts that had to constantly rub against one another, those that had to roll at high speed, and others that would be exposed to factors of corrosion and rust i.e. the blade. In all these, appropriate materials were selected based on their deterioration period in order to prolong the useful life of such machine components.

Finally and probably the overriding consideration is that of economics. What will the finished product cost? A material may be found that has the ideal set of properties but is prohibitively expensive. Here again, some compromise is inevitable (Mangonon, P. L., 1999).

The overall cost of the finished product which includes all expenses incurred during fabrication to produce the desired machine was ensured to be at the barest minimum by ensuring that the parts selected were not too excessive.

Generally, in the design and construction of this synchronous machine, provision was made for cleaning and maintenance operations by incorporating more of bolting technique in joining component parts to another for easy access of the operator. This means that internal components such as blades, bearings and the rollers can easily be reached by unscrewing the bolts and nuts used to fasten their housing.

Also, parts such as the support frame can be easily taken apart for maintenance, future upgrade or replacement.

The design factors taken into consideration for selecting materials for the components of paper cutting making machine are:

Cost: The materials to be used for the fabrication of the component parts must be relatively cheap. They must meet up with the standard required for efficient workability and performance of the plant. As this factor will affect the marketability of the process plant and production cost of running the plant, it must be considered.

Availability of Material: The materials to be used for the fabrication of the components parts must be readily available in other to reduce the overall cost of fabricating the process plant and the cost of maintaining the plant during operation.

Rigidity and Strength: The frames of the machines used in the process plant must be rigid enough to withstand the load of various components been supported. This will help to reduce vibration effect during operation and improve efficiency of the process plant.

Overall Weight: The weight of the components that are used in the fabrication of each machine in the process plant should not be too heavy so as to reduce the stress involve in moving the components for maintenance.

Corrosion Resistance and Rust: Since the machine is a utility processing machine, the components of each machine especially those in direct contact with the utility material must be made from materials that are less vulnerable to oxidation so as to prevent rust breaks and corrosion.

3.3 Method of Fabrication

The fabrication of the machine involves cutting and joining of the various structural components that forms the main supporting structure of the machine, these component are wood and plastics. The main supporting structure holds all other parts of the machine in place both the major and the minor parts including the outer casing of the machine. The frames are cut into the required sizes and are joined together by gum, screws and temporary joints considering the ease of maintenance so that the components can be loosed and fixed again with ease. The prime movers of the machine are fixed on the main supporting structure to hold it in place and to bear the force generated by the electric motors, the blade and slider are bolted in place, the electrical components are connected and fitted inside the case of the machine, the cutter slider belt

and the roller belt are fixed in place. The main control of machine is an Arduino board, the computer program is written out in the Arduino interface and the uploaded on the board to control the cutting action of the machine and the feed rate of the roller. The machine control is achieved by buttons and a screen display which is cased beside the main machine. The fabrication generally involve soldering of electrical components, cutting of parts into the required sizes, drilling of some parts and screwing and gluing of all parts together to make up the complete machine.

3.1.1 Stepper motor and its specification:-

These steppers are a great way to get things moving, especially when positioning and repeatability is a concern.

◎◎Specification and features:

- Hybrid Stepper Motor
- 1.8⁰ Cool Stepper Motors
- NEMA 17 Bipolar (4 Leads)
- 300 mm Wire Length
- Gross Weight: 0.4kg
- Step Angle: 0.9
- Holding Torque: 4.5kg.cm
- Rated Voltage: 3Volt
- Rated Current: 1.7A/Phase
3
- Form Factor: NEMA 17

Fig.3.1: 4.5 KG-CM Hybrid Stepper Motor (Bipolar)

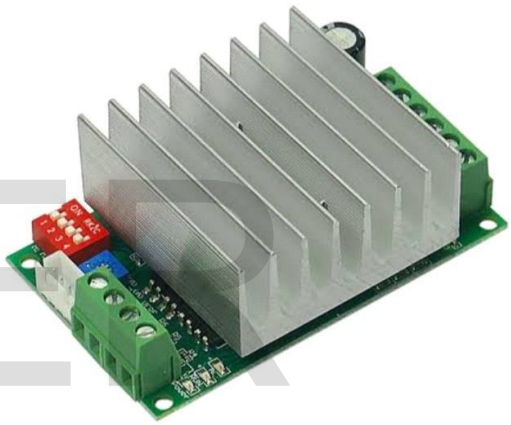
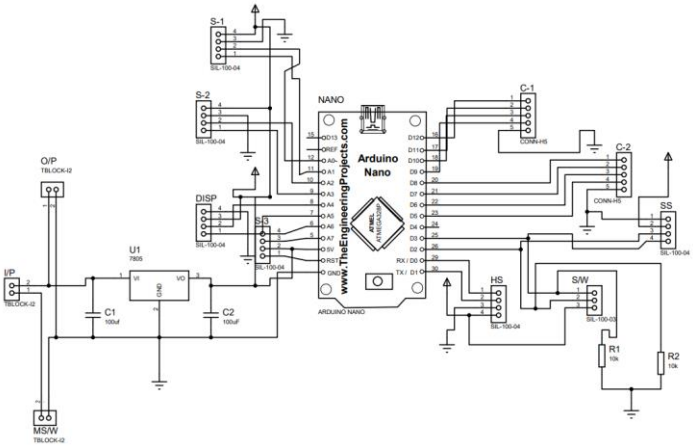


Fig 3.1.2 TB6600 Stepper Motor Drive

◎◎Specification for TB6600 Stepper Driver:-
- Operating voltage : 10 Volts to 45 Volts DC
- Maximum current : 4.5 Ampere
- Size : 82mm*50mm*35mm(L*W*H)

It can provide a maximum of 4.5 Ampere output current. TB6600 stepper motor driver with output short circuit protection, Low pressure shut-off, Over-heating and over current protection.
It has inbuilt high-speed opto-coupler 6N137 which ensures high speed without losing step. It can be used with two-phase / four-phase / four-wire / six-wire stepper motor and can be operated in full step, half step, 1/4-step, step 1/8, 1/16-step, up to 16 segments.

3.1.3 PCB (Printed circuit board) design



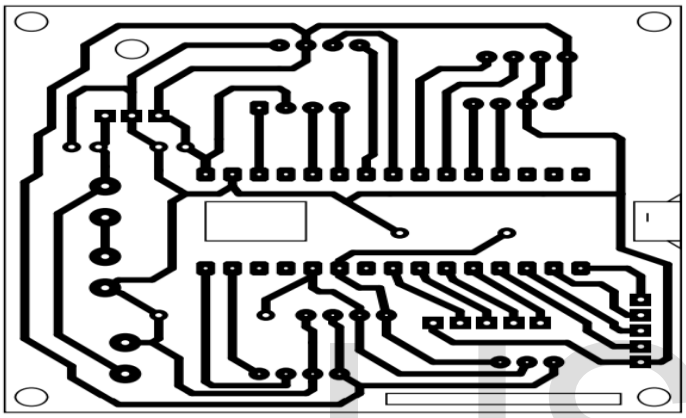


Fig.3.4: PCB Layout (Tack Side)

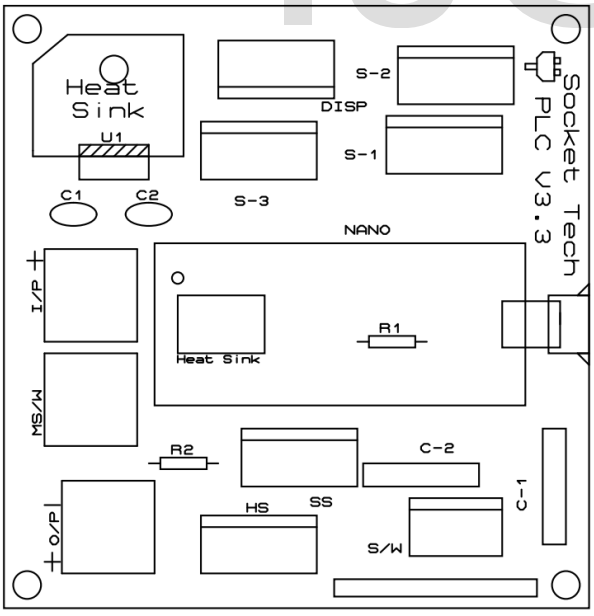


Fig.3.5: PCB Layout (Top Side)

3.2 Transmission Mechanism

The transmission of power from the electric motor to the roller and slider mechanism is by toothed belts which fits into the grooves of the pulleys of the motor and the mechanism being driven, the is the most suitable drive mechanism for the slider mechanism because it moves to and fro from the prime mover along the belt as required for the cutting process, the roller is also connected by belt in a reduced gear ratio. The advantage of the belt drive system used in this machine is that it allows for slippage when needed to reduce the torsional force produced on the bearing of the motor and drive mechanism especially for the slider mechanism.

3.3 Calculations for Generating Production Rate

Maximum Revolution = 200 rpm

Diameter of Roller = 8.6 cm

Radius = 4.3 cm

Paper Feed = 2 π r

= 2×π×4.3

=2×3.14×4.3

=27.19cm

which is standard size of A4 paper.

Production Rate = 1 paper per second

86400 papers per day.

4 RESULTS

- The results obtained from the design analysis of the component parts of the machine shows that the design functioned as intended.
- The primary aim of this project work is to design a digital paper cutting Machine.
- It is seen that there is variation in the time taken to cut different length of paper and significantly the time taken to cut an A4 paper is actually higher than other sizes.
- The efficiency of the machine after performance evaluation was carried out is 70%.
- Also, from the evaluation results, it can be concluded that the longer the time of rotation of the roller, the longer the size of the paper.

5 CONCLUSION

- This project work successfully

designed an Automatic paper cutting machine which can be used to cut paper into various sizes as required i.e. into textbook sizes exercise books etc. The design fulfils all of the major design criteria, as identified by the team.
The paper cutting Machine will allow the production of different sizes for use

- The development of the Paper Cutting Machine has been successfully completed and it objective fully achieved.
- It is very important to note that design and development of the Paper Cutting Machine was based on the materials locally available though some of it have to be imported in to the country.
- The outcome of the project was successful in the following ways: It requires little maintenance.
- There is ease of operation which makes it easy for any individual to operate irrespective of his/her education background as it does not require a training of license.
- The Paper Cutting Machine is not too expensive and has the required machine members to function

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REFERENCES

@@@@@@@Sunil H. V, Ankit Yadav, May 2007. Automatic Paper Cutting Machine using Geneva mechanism.

[2] Maryam Hashemitaheri, Sai Manish Reddy Mekarthy, Harish Cherukuri, 2020. Prediction of Specific cutting forces and maximum tool temperatures in orthogonal machining by Support Vector and Gaussian process Regression Methods. *Via www.sciencedirect.com*

[3] Ke Xu, Jiarui Wang, Chih-Hsing Chu, Kai Tang, 2017. Cutting force and machine kinematics constrained cutter location planning for five –axis flank milling of ruled surfaces. *Journal of Computational Design and Engineering. Via www.sciencedirect.com*

[4] Tim Rostek, Werner Homberg,2017. Locally Graded Steel Materials for Self- sharpening Cutting Blades. *International conference on the technology of Plastcity,ICTP2017, 17-22 September 2017, Cambridge, United Kingdom. Via www.sciencedirect.com*

[5] Runqing Liu, Tao Tao, Xuesong Mei, Xinping Xu, Xiaochao Sheng, Motion mechanism of rotating transverse paper cutting machine and its parameter optimization. *11th CIRP Conference on Intelligent Computation in Manufacturing Engineering. Via www.sciencedirect.com*

[6] Vipul Shah, Feb 2019, Universal Paper Cutting Machine

[7] Rakesh Prajapati, Jan 2018. Design and development of machine to perform stamping and cutting operation.

[8] Mohit S. Kalamkar, march 2019. Design and Fabrication of Paper cutting machine by using Geneva mechanism.