IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, August 2025
Impact Factor: 7.67

Design, Analysis of Automatic Nylon Rope Cutting Special Purpose Machine

Harshad N. Deshpande[1], Adwait Nadgauda[2], Abhishek M. Patil[3], Vishwajeet Yadav[4], Saurav Thorat[5]
Department of Mechanical Engineering [1,2,3,4,5]
PES's Modern College of Engineering, Pune, Maharashtra, India

Abstract: *At present manual rope cutting with poorly designed manual rope cutters leads to many work-related health issues, such as inaccuracy, low productivity and excess time consumption. Consequently, it can lead to a loss of revenue from the time utilized in the process. Acknowledging this issue and the recent developments in automation technology, design and analysis of special purpose automatic rope cutting machine which aims to give high productivity and accuracy is presented in this paper. This special purpose automatic will help in reducing the human error and man power, reliable work done and saving the wastage of rope. It works on the principle of cut to length and feeding mechanism, mainly consists of three processes: tensioning, rolling, and heat-cutting of rope. To increase the tension in rope we use rubber idlers which provide tension along with adequate friction to ensure no-slip condition. The fraying of nylon cut ends is resolved by providing a heater inside the cutter, which provides enough temperature to seal the ends of the rope simultaneously with the cutting process. The machine is PLC controlled, when provided length of rope and no of cycles, machine will run for that particular program and will continue till the program ends. The detailed structural analysis of critical part of this SPM and tool wearing is explored in the paper.*

Keywords: Automatic, High productivity, Nylon Rope, Special purpose machine, Tool life

I. INTRODUCTION

The use of automated machines and systems has made it possible to increase the manufacturing productivity, accuracy, reduces the overall time required and without compromising with the quality of the product. Since manual human efforts are either very less or not required at all, automation aids in solving labour related problems, avoids human errors and reduces the expenditure. One company in Pune, Tevikon Automations, had to design a machine which would cut a standard single braided nylon rope with minimal human intervention possible. So, our team, has tried to design and develop a machine which is very efficient, fast and economical in doing the job required. The work to be done is carried out in 3 sequential precisely timed stages viz. clamping and tensioning, rolling and cutting. The main objective is to slice out large number of ropes of required lengths and ensuring that the sliced end does not fray. Apart from the initial clamping of the rope before the machine starts, all of the operations are performed automatically. With the help of this machine, the job productivity is expected to increase greatly, which consequently reduces the time required as well as errors. The layout of the machine is compact and can be placed comfortable even in a small workshop. Another important factor is that this machine can be handled by semi-skilled workers with ease and is very safe to use, as no use of hazardous substances is involved. Automatic nylon rope cutting machine, being easy to operate and a flexible machine has a lot of future scope. In conjunction with the PLC, a Servo Motor can be used in place of a stepper motor which will improve the control and feedback mechanism of the machine and can provide a rotary control of ½ degree which will even make the machine even more accurate. The mechanism of cutting is same to cut various other materials like PVC pipes, metallic wires, metallic and non-metallic tubes and other synthetic ropes. The cutter of different material can be used as per convenience of the material which is to be cut.

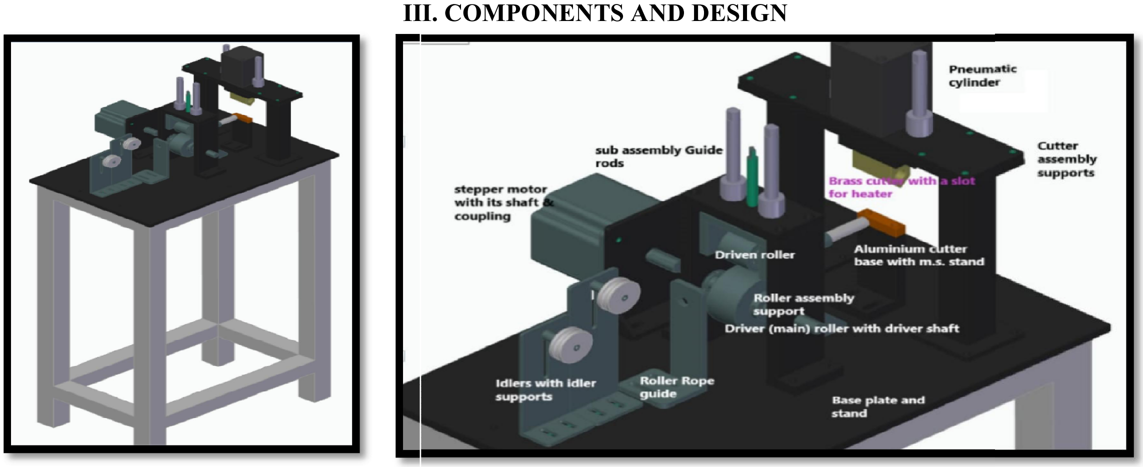
IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, August 2025
Impact Factor: 7.67

II. LITERATURE REVIEW

Dr.S. Sumathi et.al [1] their work talks about the advancement in programmed wire cutting, their methodology consists of defining the specifications, types of systems for modern cutting techniques and solving the multifaceted nature of circuits making it straightforward. Sammed Narendra Patil et.al [2] their case study in small scale industry gives emphasis on development of automatic cutting solving conventional methods issues. Various parameters calculated or selected are selection and required torque of motor and calculating cutting force. Mohan M et.al [3] their goal is to automate the hacksaw machine and try to eliminate the conventional methods providing more updates to existing pvc cutting machine. Austin B. Asgill et.al [4] their work shows another attempt to make affordable wire cutting machine replacing manual handheld tools making it portable, although the machine was able to cut one wire at a time more research can lead to multiple cutting of wire. Mr. Pratik R et.al [5] this paper emphasis on feeding mechanism, defining the wire flow path explaining the feed rollers mechanism giving the basic line for feeding. Ms. Poonam Mane et.al [6] work mainly focused on electronics and microcontroller-based system explaining the working of cutting machine driven by microcontroller unit. Rushikesh Gadale et.al [7] their work shows light on plc based cutting machine, also focusing on the safety of equipment and operators. This machine eliminates the use of relay contractor hence less hardware also reducing complexity in wires. Dhanshree Hirulkar et.al [8] they have built a machine for wire harnessing, for transmitting power to different components and modules in automotives. Parth K. Vagholkar [9] he has described the various properties of nylon, these properties widen the range of applications, few applications are suggested as well. Neeraj Pandita et.al [10] in this the use of pneumatic cylinders in sheet metal cutting industries was discussed and why pneumatic cylinders are highly efficient in industries was analyzed. Mr. Jagtap Sameer et.al [11] This paper gives us a brief introduction about automatic pipe feeding mechanism and cutting machine. The cut to length principle is used along with DC motors, electric circuits and cutter. T.S Ogedengbe et.al [12] This paper describes the effect of heat on tool and workpiece during various machining processes carried out under different conditions. It also gives us an overview about how the tool life can be affected under different heat conditions. Abhinav Bhatnagar [13] this paper gives basic research on tool materials and parameters of various turning processes, in this HSS tool are studied and draws conclusion that spindle speed affects inverse on tool life. M. Narasimha et.al [14] this review focuses on enhancing the tool life with the help of hard coatings, here we found out that coating improves the wear resistance of cutting tool.

Overall, the vast literature reviews helped in understanding the basis of cutting procedure with advancement in automation and optimum feeding mechanism. Learnt the basics of PLC and microcontroller-based machines, also got the knowledge regarding effect of temperature on cutting tool.

III. COMPONENTS AND DESIGN



(a) (b)

Fig. 1 (a) whole Assembly of automated rope cutting machine and (b) its components

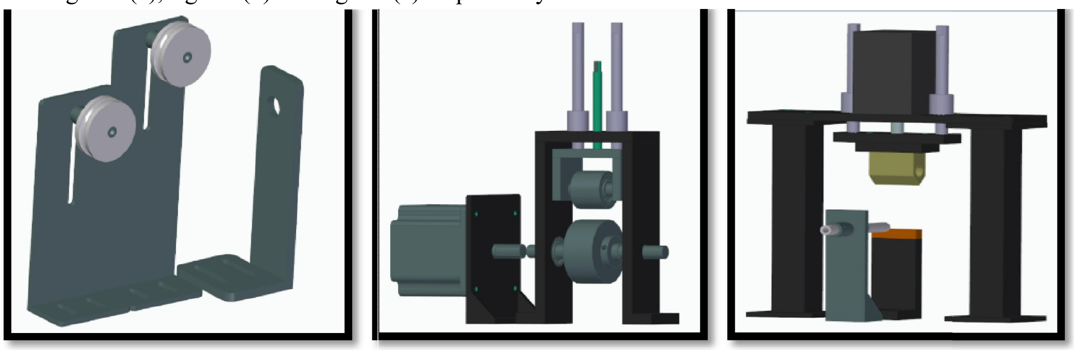
IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 1, August 2025 Impact Factor: 7.67

Here Figure 1(a) represents complete assembly of automated rope cutting machine and figure 1(b) shows the various components of the machine

Mainly the machine is divided into 3 parts,

1) Idler section
2) Roller section
3) Cutter section

Shown in figure 2(a), figure2(b) and figure2(c) respectively.



(a) (b) (c)

Fig. 2 (a) idler section, (b) roller section and (c) cutter section

At first, tensioning occurs when the rope first goes through the idlers to the rollers via the rope guide. In between the two rollers, there is just adequate enough force on the rope that a no-slip condition is created and at the same time, rope can still move forward with significantly less friction. The upper roller is driven by the lower roller (driver main roller with driver shaft) connected to stepper motor with its shaft coupling. Further the roller is guided via another terminal rope guide towards the brass cutter with an aluminum base and m.s. stand. Use of PLCs enable us to control the length of the rope under a specified time period.

Here cutter consists slot for the heater which is connected to pneumatic cylinder. The rope gets cut at the end and sealed at same time as its end is heated to avoid fraying of the rope.

Estimated production: (By using Automated Rope Cutting Machine)

To begin with, we are expected to choose:

Driving Roller diameter of radius ‘r’ = 30 mm

Therefore, in 1 revolution, the roller will cover ‘L’ = $2 \times \pi \times 30$

= 188.5mm

Angular velocity of stepper motor ‘w’ = 60rpm (250 rpm max)

Speed of production ‘V’ = $L \times w$ …………………. (I)

V = 188.5×60

= 11310 mm/min

= 37.7 ft/min

Hence, in 1 hour, rope which can be cut is:

= 37.7×60

= 2262 ft

Cutting force:

Here, cutting force required to cut the rope in practice is the extension force which be exerted by the double acting pneumatic cylinder to the rope via the brass cutter blade.

It is given by,

F = $P \times A$ …………………………. (II)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 1, August 2025 Impact Factor: 7.67

$F = \frac{\pi}{4} \times [P \times D \times D]$.................. (III)

Where, F = cutting force (N)

P = Pressure (N/mm^2)

D = Bore diameter

d = Rod diameter

Here, P = 5 bar = 0.5 N/mm^2, D = 40 mm, and d = 16 mm

Therefore, $F = \frac{\pi}{4} \times [0.5 \times 40 \times 40]$...........using eqn (III)

$F = \frac{\pi}{4} \times [0.5 \times 1600]$

F = 628.3185 N

The minimum cutting force required for the necessary operation is **628.3185 N**.

Shaft:

In the roller assembly, roller in the bottom is coupled to dc motor.

Roller diameter is 60 mm.

Motor Torque is 980.66 N-mm.

Friction force on Rope exerted by lower roller = 980.66/30 = 32.68 N.

Heat Wattage: 64 watts is needed to get the temp to 290 degrees Celsius in less than 5 minutes.

Cutter Tool:

Brass Alloy 360, more commonly known as cutting brass, is the choice of material for the pneumatic cutter, shown in figure 3.

It has a chemical composition of approximately 61.5% copper, 35.5% zinc, 3% lead, and 0.35% iron.

Tensile Strength of 400 MPa, Yield Strength of 320 MPa and Thermal Conductivity of 115.017 W/m-K.

It is the most widely used alloy in various industrial cutting related operations in India.

It exhibits excellent machinability and formability, as well as suitability for pressure cutting, heat-cutting, soldering and brazing operations as well.

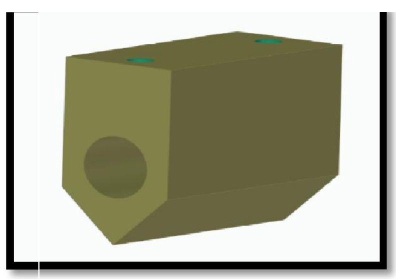


Fig. 3 Brass Alloy 360 Cutter tool

IV: STRUCTURAL ANALYSIS

The results of structural analysis of three main components are as below

Upper roller shaft:

Max stress = 0.64561 MPa

Min stress = 0.00029537 MPa

Max deformation = 3.9603e-5 mm

Min deformation = 0 mm

Lower Roller Shaft:

Max stress = 5.7161 MPa

Min stress = 1.5852e-8 MPa

DOI: 10.48175/IJARSCT-28646

Max deformation = 0.00067046 mm
Min deformation = 0 mm

Base Plate:
Max stress = 0.0096938 MPa
Min stress = 1.9098e-12 MPa
Max deformation = 3.8937e-7 mm
Min deformation = 0 mm

V. RESULTS AND DISCUSSION

Estimated speed of production is 37.7 ft/min, hence in 1-hour 2262 ft rope can be cut.

The minimum cutting force required for the necessary operation is 628.3185 N, with the cutter temperature at 280^0C - 290^0C

From the structural analysis through software, maximum deformation for upper roller shaft is 3.9603e-5 mm, for base plate is 3.8937e-7 mm and for lower roller shaft is 0.00067046 mm.

From the structural analysis through software, maximum stress for upper roller shaft is 0.64561 Mpa, for base plate is 0.0096938 Mpa and for lower roller shaft is 5.7161 Mpa.

Material used for the shaft is mild carbon steel (C25), its yield strength is 250 MPa, (allowed shear strength considering FOS is 70.2 MPa). As the maximum stress is below yield strength the shaft won't fail.

VI. CONCLUSIONS

In a particular span of time, it can be concluded that the automatic rope cutting machine cuts the rope at a rate which is slightly more than thrice of that which is cut manually.

The brass cutter which is heated around 280 - 290 degree ensures that the ropes are cut easily, smoothly and seals rope simultaneously without the fraying at the terminal end.

From the structural analysis ANSYS renderings, it is evident that components are strong enough to sustain any loads incurred during the operations of machine, as the stresses and deformation are in limits.

In this entire process cycle, it was found that no slacking of roof occurred or divergence from its path was seen.

REFERENCES

[1]. Dr.S. Sumathi1, D. Madhanprakash2, K. Prakash3, S. Prasanth4, R. Rajesh Kannan5, International Journal of Innovative Research in Science, Engineering and Technology Volume 9, Special Issue 1, ISSN (Online) : 2319 - 8753 ISSN (Print) : 2347 - 6710

[2]. Sammed Narendra Patil1 , Sourabh Popatlal Karyappa2 , Suraj Rajendra Patil3 , Shubham Deepak Patil4 , Prof. R. R. Joshi5, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5 Issue III, ISSN: 2321-9653

[3]. Mohan M1, Sathish M2, Prakash R3, Kalil Rahiman M4, International Research Journal of Engineering and Technology (IRJET) Volume: 06 Issue: 03, e-ISSN: 2395-0056, p-ISSN: 2395-0072

[4]. Austin B. Asgill, Jorge Portillo-Rodriguez, Rebeca Feregrino Rodriguez Eric Fernandez, Red Hayes Kennesaw State University – Marietta Campus ASEE Virtual conference, Paper ID #30446

[5]. Mr. Pratik R. Umathe1, Prof. V.H. Bankar2, IORD Journal of Science & Technology E-ISSN: 2348-0831 Volume 1, Issue V (JULY-AUGUST 2014) PP 12-15

[6]. Ms. Poonam Mane1, Ms. Shalaka Mali2, Ms. Pooja Korade3, Mr. Suhas Katkar4, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056

[7]. Rushikesh Gadale, Mahendra Pisal, Sanchit Tayade, S.V. Kulkarni, International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869, vol3, issue3

[8]. 1Dhanshree Hirulkar, 2Madhavi Andhare, 3 Priyanka Pethe, 4Tanushree Khorgade & 5 Santosh Sakore, International Journal of Advance Engineering and Research Development Volume 4, Issue 3.

ISSN: 2581-9429
Volume 5, Issue 1, August 2025
Impact Factor: 7.67

[9]. Neeraj Pandita, Naren Kesar, Akshat Jasrotia, Surya Dev Singh, Lakshay Jolly, Anant Khajuria, Vishwarth Singh, International Journal of scientific and technical advancements (IJESTA), ISSN: 2454-1532

[10]. Parth K. Vagholkar, Department of Polymer & Surface Engineering, Institute of Chemical Technology. Mumbai 400019. India. Volume: 5 | Issue: 9 | September 2016 • ISSN No 2277 - 8179 | IF: 3.508 | IC Value: 69.48

[11]. Mr. Jagtap Sameer, Mr. Jaunjal Akash, Mr. Mali Sanket, Mr. Mane Chaitanya, Prof. Dukale Deepak, International Journal for scientific research and development, vol 7, issue 2, ISSN: 2321-0613

[12]. Abhinav Bhatnagar, International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue, e-ISSN: 2395-0056, p-ISSN: 2395-0072

[13]. M. Narasimha1, K. Sridhar2, R. Reji Kumar3, Achamyeleh Aemro Kassie4, International Journal of Engineering Research and Development, e-ISSN: 2278-067X, p-ISSN: 2278-800XVolume 7, Issue 1May 2013), PP. 67-75

DOI: 10.48175/IJARSCT-28646