E-ISSN: 2706-8927
P-ISSN: 2706-8919
IJAAS 2019; 1(1): 31-33
Received: 14-05-2019
Accepted: 18-06-2019

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Design, analysis and fabrication of pet bottle rope maker

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Abstract
Plastic contamination is a terrible issue nowadays. The oceans are flooded with plastic waste, which even causes it's entering into our food chain. Such bottles are constructed from high density plastics that are typically used to store liquids such as water, soft drinks, motor oil, cooking oil, medicine, shampoo, milk, and ink. They are non-biodegradable and the improper disposal of such products will definitely have a huge impact on our environment. Advances in technologies and systems for the collection, sorting and reprocessing of non-recyclable plastics are creating new opportunities for converting such bottles into useful products. This work is an attempt to figure out a solution to the disposal of plastic bottles that are usually dumbed into open environment. Bottles that commonly arrive at disposal sites are Poly Ethylene Terephthalate (PET). In this work, PET bottles are cut into strips, twisted and heated into a rope using an automated machine which consist of a cutting unit, temporary plastic strip storage unit and a strip joining unit. The rope thus produced is tested for strength and is found to be suitable for several applications. The work thus aids not only in solving the ill effects caused by disposed plastic bottles but also helps our society move towards sustainability.

Keywords: plastic rope, pet bottle, plastic bottle recycling, thermoplastic

Introduction
Plastic is a polymeric material that can be easily shaped or molded. It is derived from the polymers present in the natural materials like plants, minerals, oil, coal and natural gas. Polymers are a large group of monomers linked together by a chemical process called Polymerisation. But the contamination of the polymerised product (Plastic) in lands and water bodies cause serious impact on environment. Reduce, reuse and recycle is some of the most important actions currently taken to reduce these impacts and represents one of the most dynamic areas in the plastics industry today. This project is focused on the principles of reuse and recycle of plastic bottles by converting them to ropes. Plastics can be divided into two categories based on their ability to recycle, thermoplastic and thermo setting plastic. Poly Ethylene Terephthalate, a thermoplastic which is used to make bottles i s taken here for the experimentation.

Design analysis

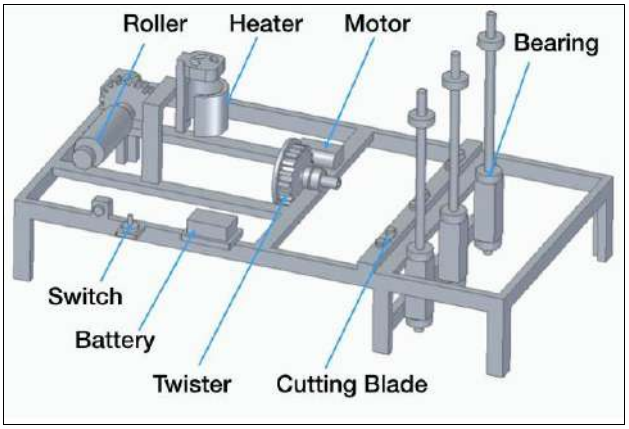


Fig 1: Design of rope maker machine

The overall dimension of the product is 120 cm x 65 cm x 15 cm. A 300 g weight is put over the bottle to press the bottle against the blade which give uniform and desired output. The bottles are separated 20 cm apart. The roller is designed to rotate at 3 rpm for the smooth functioning and for better heating. A supply of 240 V, 5A is required to operate the heater and the hot air flow is directed towards the rope using the 12 V DC cooling fan. Regulator functioning the temperature adjustment of heater where it can regulate up to 10 adjustments.

Components description

Table 1: Components specifications

Components	Specification
	12 V, 90 W, 60 rpm, Permanent magnet DC
	12 V, 7 A, DC rechargeable, Lead acid
	1000 W AC electric heater
	12 V, 3000 rpm, 1.08 W, DC
	152 mm length, 9mm dia, mild steel hollow
	178 mm dia, 6 mm thick, mild steel round

Circuit diagram

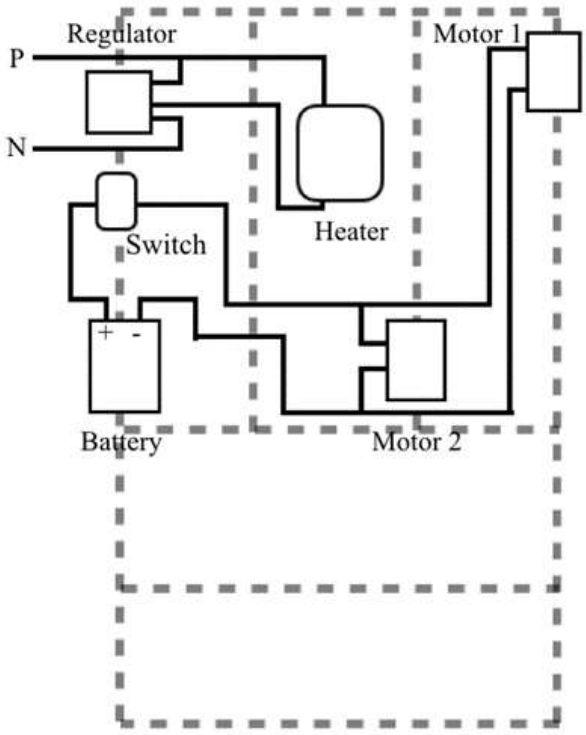


Fig 2: Circuit diagram of rope maker machine

Blade structure

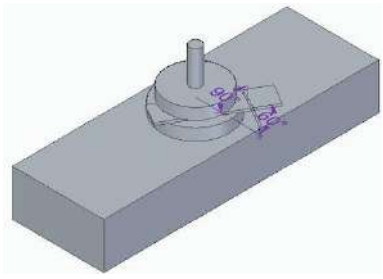


Fig 3: Blade setup design

Cutting blade made up of stainless steel is used here. The angle between the blade and supporting block axis is 600 and the designed angle between blade and the plastic strip is 900. This is because of maximum cutting force is obtained when the angle between the cutting blade and plastic strip is perpendicular.

Gear calculation

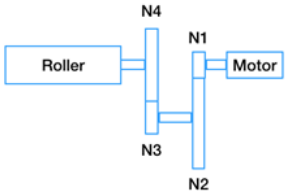
Let 'N' be the speed of rotation and 'Z' be the no of teeth.
Desired speed of rotation (roller): 3 rpm (For safe and smooth working).
Speed of motor: 60 rpm (rated)

$$\frac{N1}{N2} = \frac{Z2}{Z1} \Rightarrow \frac{60}{N2} = \frac{80}{8} \Rightarrow N_2 = 6 \text{ rpm}$$

Assume,

$Z_3 = 33$

$Z_4 = 66$



$$\frac{N3}{N4} = \frac{Z4}{Z3}$$

$N_2 = N_3 = 6$ rpm

$$\frac{6}{N4} = \frac{66}{33} \quad ; \; N_4 = 3 \text{ rpm}$$

Speed of the roller = 3 rpm

Load characteristics

Table 2: Load and thickness characteristics

Load on bottle (g)	Average thickness (Single strip) mm
150	1.6
200	2.1
250	2.76
300	3.04
350	4.1

It is found that for better twisting and fusing an average thickness of 3mm is better. To get an average thickness of 3mm, 300g static load (weight) is applied over the bottle.

Observations & analysis

Table 3: Properties of a single plastic strip

Property	Test Method	Value
Average thickness	Measurement	3 mm
Average width	Measurement	0.5mm
Average load	Universal Testing Machine	74.5 N
Average tensile strength	ASTM D638	48 Mpa
Specific gravity	ASTM D792	1.38

The plastic strip obtained by cutting the bottle is analysed and found that for an average thickness of 3mm, it shows the desirable properties that match the equipment property.

Equipment working

The aim of the rope maker machine is to produce the plastic rope from the plastic bottle. So that the bottom the plastic bottle is cut out by using the stainless steel blade. Then the

bottle is placed over the bottle holder, and the strip is peeling out the strips from the bottle. This is automated using a gear train mechanism which is set up to get optimum rpm (3 rpm). The peeled out strip is allowed to pass the rollers in order to avoid the tilting of the strip coming out from the plastic bottle. Then the strip twisted with other strips comes from the bundles and a gradual heating is done by using the heat gun about a 85 degree celsius. The heating is essential in order to the avoid the unwinding tendency of the plastic strips and got it as a single thread. And finally the rope is stored over the rotating storage wheel.

Conclusion

The aim of this work was to develop a pet bottle rope maker. For this purpose different types of cutting blades were designed, fabricated and analysed. Based on calculated value, a suitable motor was selected and successfully fabricated the pet bottle rope maker.

This equipment which facilitated easy tool change, distinct cutting speed and safety features, even when operated by an unskilled person. The pet bottle rope maker find application in local agricultural usages as well as in household uses. Performance evaluation was carried out on the universal testing machine and the results obtained indicated that the machine were efficient and could be used for reduction of PET bottle wastes littering our environment particularly in developing countries where there is insufficient technologies to handle this menace.

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