Original Article

Design and Fabrication of Automated Soap Cutting Machine

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Abstract

The automated soap cutting machine helps the small scale industries by increasing the production rate. The soap cutting machine is fully automated which uses a lead screw mechanism for the movement of cutter and pushers. Usually by conventional method a person used to cut the soaps by manual cutters which may have disfigured shapes and do not have precise cuts. They also deal with the problem of collecting the soap bars after the cutting process. The primary objective of this project is to expand the production rate and also to have a precise cutting process. The collection of the finished products are also made easy. The microcontroller controls the motion of the cutter and pushers. The overall machine is electrically powered.

Keywords: Lead Screws, Stepper Motor, Soap Cutting, Arduino Atmega, Stepper Driver.

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INTRODUCTION

In present day life everybody needs to be brisk and quick at each work with less exertion. Organizations are requesting different various sorts of machines that can make their Production quick and less expensive. Organizations request machines that are mechanized where human endeavors ought to be less to make the work interaction less expensive. This Project gives the detailed plan of the handling of soap material.

Soaps are delivered in various shapes, sizes, tones and characteristics/grades relying upon their particular uses and producer. Nonetheless, soaps delivered by various producers may have indistinguishable shapes also, measures particularly when the shape isn't important for the producers exchange mark. On the conventional soap cutting machine the time consumed for marking and cutting is more and labor cost is also more. With this automatic soap cutting machine the time consuming process can be done easily.

LITERATURE REVIEW

Issa A.K, M.H Idris et al (2015) [1] discussed about the planning and fabrication of hand driven soap cutting and scraping machines suited for medium scale industries which attempts to resolve the various issues faced by the usage of the machines used earlier. The Problems include unavailability of skilled labour, failure of equipment and no facility for making the products of various sizes on a machine etc. The outcomes obtained infer that the machine has efficiency of 85%. The cutting and scraping machine cuts ten pieces at a time. It states that improvements should be done on corrosion.

Prof G.S. Jagushte et al (2017) [2] has discussed regarding the look of the machine and its working. Hydraulic cylinders are used for automatic bar cutting, holding, and feeding operations.

Ahmed M. T. Ibraheem Alnaib (2017) [3] has discussed the various characteristics of stepper motor. It also deals with different features, types, etc. It also helps us to know the concepts like sorts of excitation and calculations of torque for stepper motors.

Pavithra B et al (2017) [4] has discussed the behaviours of various sensors like Ultrasonic sensor, Laser sensor and IR proximity sensor by measuring the space of obstacle avoidance. For its own characteristics, each sensor has a unique behaviour.

SYSTEM DESIGN

This system is designed in the view to improve the soap cutting process. This is done to ensure perfection in all aspects such as accuracy, upgrading, reusability and safety. The components that being used in this system are:

- Lead screws
- Stepper motor

- Wire cutters
- Pushing blades
- Motor drive
- Arduino ATMEGA328P

SOLIDWORKS 3D strong demonstrating highlights empower us to: Produce 3D strong models of any part and get together, paying little heed to measure and intricacy. Synchronize every 3D model, 2D drawings and other plan and assembling reports because of inbuilt associativity which consequently tracks for any progressions and makes refreshes. Our 3D model setup has been designed with the help of this software.

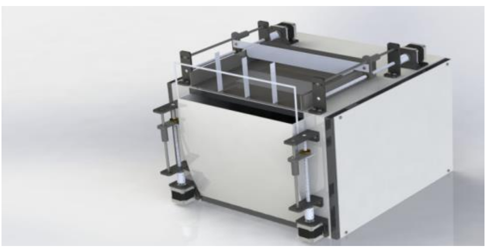

Fig. 1: 3D model

Fig. 2: Front view

DESIGN CALCULATIONS

Axial load P = F X l; force F = 6N; load l = weight of the soap X coefficient of soap = 34.335 X 0.1227 = 4.21 N

P = 6 X 4.21 = 25.27 N

Chosen thread type - Trapezoidal

Chosen material - Bronze nut, Stainless steel screw

Diameter Do = 10mm; Di = 7.5mm; d1 = 6mm

Thread pitch (p) = 2mm

Thread pitch diameter (dp) = Do - 0.5(p)
= 10 - 0.5(2)
= 9 mm

Reduced diameter (dred) = Do+Di / 2
= 10+7.5 / 2
= 8.75 mm

Friction angle (ᑭ) = 7°

Coefficient of friction (μ) = tan (ᑭ)
= tan (7)
= 0.1227.

Helix angle (β) = tan-1 (p / πdp)
= tan-1 (2/ π(9))
= tan-1(0.707)
= 4.04°

Frictional moment (Mf) = P X (dred / 2) X μ
= 25.27 X (9/2) X 0.1227
= 455 Nmm

Torque transmitted by Screw (Mt) = P X tan(β+ᑭ)+Mf
= 25.27 X tan(4.04+7) + 455
= 2012.45 Nmm

Shear stress (𝝉) = 16 Mt / πd13
= 16 X 2012.45 / π (6)3
= 47.47 N /mm2

Normal stress (σ) = 4 P / πd12
= 101.08 / π(6)2
= 7.28 N / mm2

Combined stress (σc) = √σ2+ 4(𝝉)2
= √(7.28)2+ 4(27.78)2
= 56 N/

Shearing of nut (τ) = Ps / π Do H Z h

Thickness (H) = 3 mm; Pitch (s) = 2 mm; Starts (Z) = 4; h = 2mm
= 25.27 X 2 / π 10 X 3 X 4 X 2
= 6700 N / m2

Efficiency (ɳ) = (P l / 2πMt) X 100
= (34.335 X 25.27 / 2 X π X 2012.45
= 0.686 X 100
= 68.6%

Torque transmitted by Screw (𝝉) = 2.012 N/m

Speed (N) = 360 Rpm

Power rating (P) = 𝝉2πN / 60
= 2.012 X 2 X π X 360 / 60
= 75.85 W
= 0.0785 Kw

Torque of the motor = P X N X 9.5488
= 0.0785 X 360 X 9.5488
= 269.84 Nm / 40

[∵ since using lead screw]
= 6.746 Nm

∴ Using 1 motor of torque 6.746 Nm or 2 motors of torque 3.373 Nm

Chosen motor NEMA 17 stepper DC motor of holding torque 5.6 Nm .

COMPONENTS USED

Lead screws are an exceptionally famous approach to change over engine revolution into direct interpretation. They can offer reasonable pivotal firmness and awesome, smooth little removals. Lead screws are for the most part preloaded with a pivotal burden that assists with keeping in touch between the nut and screw filets. a lead screw can undoubtedly be intended to act naturally bolting under payload activity and offer a protected arrangement.

Fig. 3: Lead screws

Electrical force is changed into mechanical force by a stepper motor. It is a electric motor (brushless) to convert a full revolution into an extensive steps.

Motor position can be controlled precisely with no input instrument, as long as the motor is painstakingly measured to the application. Stepper motors are an exchange hesitation motor.

In order to turn the motor shaft precisely, stepper motor makes use of hypothesis of activity, if beat power is given. The stator has eight posts, and the rotor has six shafts. One Complete transformation is made when rotor requires 24 beats of power to move 24 stages. For each beat of power that the motor gets, the rotor will move unequivocally 15°.The development of a stepper motor is identified with a DC motor. A perpetual magnet is incorporated like rotor which is in the center and it will turn one drive followed up on it.

The loop formed on the top of the rotor attracts the stator when twisted. The attractive fields inside the stators can handle the development of the rotor, if stator is kept close to the rotor.

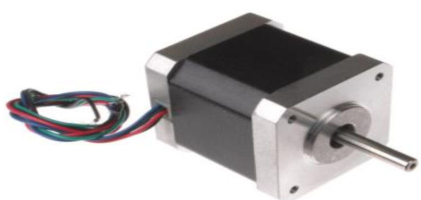

Fig. 4: Stepper motor

You'll need a sharp, smooth (not serrated), slim cutter to make good, clean cuts. The more the edge is tightened, the better. It's possible that freehand cutting won't result in indistinguishable, balanced bars.

Fig. 5: Wire cutter

The pushing plates are connected here to the lead screws, which are moved by stepper motors.

Fig. 6: Pushing plates

The TB6600 Arduino Stepper Motor Driver is a professional and unchallenging driver that powers two-phase stepper motors. It toils with Arduino and other microcontrollers which generates a 5 volt digital pulse signal. The TB6600 arduino stepper motor driver has a 942VDC power supply and a broad range power input. It also has a peak current of 4A, which is enough for majority of stepper motors. In addition, all signal terminals use high-speed optocoupler isolation, which improves the system's anti-high-frequency interference capabilities. It can drive 57, 42-type 2 and 4 phase, hybrid stepper motors as a professional unit.

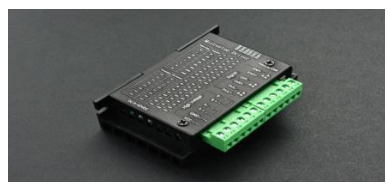

Fig. 7: TB6600 stepper motor drive

The Open source gadget platform is Arduino and it is easy-to-use and program. Those who need to understand the specialised degrees can skip from Arduino to the AVR C programming language on which it's based and can be expanded through C++ libraries. If needed, you can also incorporate AVR-C code directly into your Arduino programmes. With the aid of stepper motors, the Arduino is used to programme delays for controlling the motion of the blades. The microcontroller used has an 8 bit resolution and the Microchip's used (ATMEGA328P) is a high-performance, low-power controller.

Fig. 8: Arduino ATMEGA 328p

Fig. 9: Atmega

Working Principle

The machine works by employing a lead screw mechanism for pushing the soap bar front and for actuating the cutter. The lead screws are dual channeled and they are connected by a pushing plate. The pushing plate pushes the soap forward against the wires and cuts the soap vertically. The other pair of the lead screws are connected together with the wire cutting assembly. This wire cutter cuts the soap when it is actuated by cutting the soap perpendicular to the soap bar. Thus resulting in smaller bars cut.

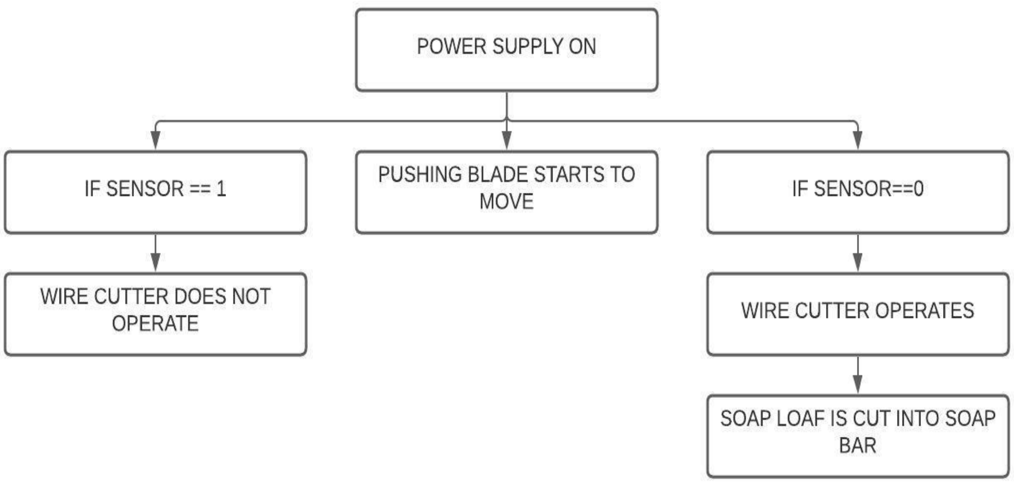

Fig. 10: Process flow chart

Results And Discussions

This project makes the soap cutting process as a simple one. The procured size and shape of the soap is independent upon the feed of the soap loaves at the tray. Thus, for getting the accurate shapes, the motion of the blades should be controlled accordingly and should be diffrentiated with the standard size and the most systematic outcome ie. consuming less power and energy given to the system.

the specifications of the components were discussed elaborately and the part drawings were done using solid works modelling software. Based on this diagram the design calculations were done and the machine is fabricated.

The design calculations for the soap cutting machine were done. These calculations were done based on the economic views. Thus values are well within the safer limit and the design is safe and accurate.

Conclusion

This project is more efficient in cost and can be used in small scale industries. It works smoothly and has precise soap cutting. The time consumed is also saved than the other methods. This project is successfully completed and tested. Further developments have been identified and can be improved in future periods.

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