

# **Design and Fabrication of Automated Hacksaw Machine**

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**ABSTRACT:** The objective of this work is to automate the conventional power hacksaw machine in order to achieve high productivity of work-pieces than the power hacksaw machine using Microcontroller. The automated machine acquires two inputs from the user namely the number of pieces to be cut and the length of each piece that is required to be cut. The inputs are given by the user with the help of a keypad and an LCD display, which will help the user to verify the data given by him. The operator need not measure the length of the work-piece that is to be cut and to load and unload the work-piece from the chuck each time after a piece has been cut. After acquiring the two inputs from the user, the machine automatically feeds the given length of work-piece in to a chuck and starts to cut till the given number of work-pieces has been cut. The machine feeds the work-piece with the help of a conveyor, which is driven by a DC motor and an IR sensor ensures that the feeding stops when the specified length has been reached. A pneumatic cylinder is used for holding the work-piece when cutting operation is done. An AC motor is used to bring about the reciprocating motion required for cutting the work-pieces. There is a self-weight attached with the reciprocating mechanism to provide the necessary downward force required for penetration of hacksaw blade in to the work-piece. When a single piece has been cut, a limit switch will get triggered by the self-weight mechanism, which is sensed by the microcontroller to start the cyclic operation again provided if the specified number of work-pieces has not been cut.

**KEYWORDS:** Automation, power hacksaw, microcontroller, relay and LCD

## **I. INTRODUCTION**

Power hacksaws are used to cut large sections of metal or plastic shafts and rods. Cutting of solid shafts or rods of diameters more than fifteen millimeters is a very hard work with a normal hand held hacksaw. Therefore power hacksaw machine was invented during 1920s in the United States to carry out the difficult and time consuming work. This power hacksaw machine shown in figure 1 is considered as an automatic machine because the operator need not be there to provide the reciprocating motion and downward force on the work-piece in order to cut it. Once the operator has fed the work-piece till the required length in to the machine and starts the machine, then the machine will cut until the work-piece has been completely cut in to two pieces.

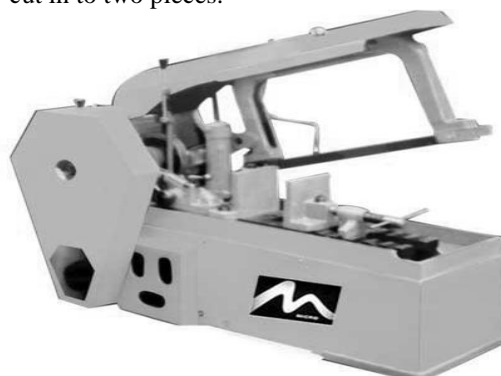


Fig 1. Power Hacksaw Machine

The fact that the operator has to feed the work-piece to the required length in to the vice is one aspect that motivated us to automate the feeding of work-piece automatically. Another one aspect is that after a shaft has been cut for one time,

the operator has to unload the work-piece and advance the rest of the work-piece to the required length again and again till the end of the work-piece is reached. The Power hacksaw machine though being able to cut the shaft or rod without requiring any human effort to cut, it does require a human intervention to feed the work-piece many times with measurements being taken each time before feeding. Therein, arose a need to completely automate the process of cutting, and here we are with a proposal which will aid in eliminate the effort of the people associated with it.

#### *A. Problem Identification*

The power hacksaw machines, which are operated by human operators as aforementioned, have the demerit of unloading and loading the work-piece many times. In industries manufacturing pumps, these machines are used to cut the motor shafts to the required lengths. It will be difficult for the operator if he has been assigned to cut a huge quantity of motor shafts and he has to measure the lengths each time for cutting. Since humans are not as versatile as machines, there is a possibility that there may be inaccuracies. Besides, if there is a slight time delay in between every cycle of cutting a piece, the cumulative delay in time will be found to have a considerable magnitude, which might have been utilized properly if the proposed machine were in use there.

#### *B. Proposed Methodology*

The demerit of power hacksaw machine is the automatic feeding of work-piece is eliminated by feeding of work-piece with the help of a conveyor, which directs the work-piece in to the chuck. The conveyor motor is stopped when it has fed the specified length in to the chuck with the help of a microcontroller and IR sensor. After this, a pneumatic cylinder is extended to hold the work-piece firmly to arrest the movement of work-pieces when being cut. This is achieved by a solenoid operated DCV, controlled by a microcontroller. Then the self-weight attached to the blade, which would be previously in a lifted position by means of another pneumatic cylinder will be lowered so that the hacksaw blade will contact the work-piece at the point where the cutting is to be done. This is achieved by retracting the weight-lifting cylinder operated by the same solenoid DCV. The cutting motor then gets turned on by the microcontroller, so that the blade is set to reciprocate on the work-piece to cut. After a piece has been cut, the cycle begins again from automatic feeding without any human intervention and proceeds till the specified number of pieces is cut.

## **II. COMPONENTS USED AND CALCULATIONS**

The components used in this project are discussed below.

#### *A. Electric Motor*

There are two electric motors in this proposed machine, a DC motor for driving the conveyor through a chain drive and an AC motor for providing the reciprocating motion of Hacksaw blade by means of a simple crank mechanism.

#### *B. DC Motor*

The conveyor roller is coupled to the dc motor shown in figure 2 through a chain drive and is driven when the microcontroller sends a signal to it. The conveyor runs till the specified length of work-piece is fed in to the chuck. This is achieved with the help of an IR sensor and a toothed disc attached to the conveyor shaft, which together function as an Encoder.



Fig 2 Conveyor motor

**B.1 Specifications**

The electric power supply necessary to run the DC motor is obtained from a step-down transformer and a bridge rectifier.

Table 1 Technical Specifications of DC motor

Voltage and Power	12 V DC, 50 Watts
Load Current	10 A
No load current	2 / 2.5 A
Speed	60 RPM
Torque	10 Nm

**C. AC Motor**

The reciprocating motion of the Hacksaw blade, which is where the cutting process takes place, is produced with the help of an AC motor shown in figure 3, which operates by a simple crank mechanism to convert rotary motion in to reciprocating motion.



Fig. 3 AC motor used for cutting process

The AC motor is turned on after the work-piece has been firmly fit in the pneumatic chuck. The Torque of motor is increased by transmission of power to a pulley by belt transmission.

**C.1 Calculations**

The torque of the AC motor must be increased so as to bring about the necessary power for cutting of work-pieces efficiently. This is achieved by coupling the rotor of the AC motor to a pulley by a belt drive. So, this will reduce the rotating speed while increasing the torque. The pulley is coupled to the reciprocating mechanism.

Motor Pulley diameter= 0.03 m

Driven Pulley diameter= 0.3 m

Therefore, Reduction Ratio= 10:1

Speed of motor, N (driving) = 1200 rpm

Driven speed N (driven) = 120 rpm

Power = 0.25 hp = 0.186 kW ;

Power =  $2\pi NT/60$

Torque T (Driving) = 1.48 Nm = 0.15 kgm, Therefore, Torque T (Driven) = 14.8 Nm = 1.5 kgm

**C.2 Specifications**

The Table 2 shows the information about the AC motor, in which the specified torque, power and speed pertains the torque obtained at the rotor of the motor shaft.

Table 2 Technical Specifications of the AC Motor

Voltage and Power	230 V AC, 186 Watts
Maximum Load Current	10 A
HP	0.25
Speed	1200 RPM
Torque	0.15 kg-m / 1.48 Nm
Motor pulley diameter	30 mm

*D. Double acting pneumatic cylinders*

There are two pneumatic cylinders used in this machine. One serves the purpose of a chuck so as to hold the work-piece for arresting the work-piece motions while cutting process takes place and another cylinder is for lifting and lowering of self-weight. The pneumatic cylinder used as chuck shown in figure 4 does the same function of vice in a Power hacksaw machine. It is controlled by a solenoid actuated DCV. The cylinder extends to hold the work-piece when a signal from microcontroller energizes the solenoid DCV.



Fig4. Chuck cylinder

*D.1 Specifications*

The chuck cylinder is one of the most important components in the automated hacksaw machine because it is responsible for holding the work-piece firmly so as to prevent any motions of work-piece during cutting.

Table 3 Technical Specifications of the Chuck cylinder

Bore Diameter	50 mm
Stroke Length	100 mm
Action type	Double acting
Maximum air pressure	10 bar
Rod diameter	20 mm

*D.2 Calculations*

The chuck cylinder must provide the optimum pressure required to hold the work-piece and if the force developed at the rod end of the cylinder is less than the cutting force of the AC motor, then the work-piece will obviously be damaged.

Diameter of bore = 0.05 m

Air Pressure supplied = 3 bar = 300000 N/m<sup>2</sup>

Area of cylinder bore =  $(\pi/4) \times d^2$   
=  $(\pi/4) \times (0.05)^2$   
= 0.0019625m<sup>2</sup>

Therefore, force obtained at the rod end

= Pressure x Area  
= 300000 x 0.0019625  
= 588.75 N = 60 kg

*E. Weight-lifting cylinder*

The weight-lifting pneumatic cylinder shown in figure 5 serves the purpose of lifting and lowering of the self-weight. Initially, the cylinder will be in extended condition. When cutting process takes place, it retracts so as to make the hacksaw blade rest on the work-piece. It is also controlled by a solenoid actuated DCV. The cylinder retracts to rest the blade on work-piece when a signal from microcontroller energizes the solenoid DCV.



Fig 5. Weight-lifting cylinder

*E.1 Specifications*

The weight-lifting cylinder is constantly subjected to an opposing force at the rod end by the self-weight and blade arrangement. The cylinder must be able to extend easily when the work-piece has to be fed in to the chuck.

Table 4 Technical Specifications of the Weight-lifting cylinder

Bore Diameter	30 mm
Stroke Length	100 mm
Action type	Double acting
Maximum air pressure	10 bar
Rod diameter	15 mm

*E.2 Calculations*

It is essential that a pneumatic cylinder of a reasonable bore diameter is chosen for withstanding the weight even when the pneumatic pressure is less.

Diameter of bore = 0.03 m

Air Pressure supplied = 3 bar  
= 300000 N/m<sup>2</sup>

Area of cylinder bore =  $(\pi/4) \times d^2$   
=  $(\pi/4) \times (0.03)^2$   
= 0.0007065 m<sup>2</sup>

Therefore, force obtained at the rod end  
= Pressure x Area  
= 300000 x 0.0007065  
= 211.95 N = 21.60 kg

*F. 5/2 Solenoid actuated spring return DCV*

The DCV shown in figure 6 serves the purpose of controlling the two pneumatic cylinders according to the signal received from the microcontroller. The DCV has a solenoid operating at 12 Volt. The normally open port of the DCV is connected to the extension port weight-lifting cylinder so as to keep the self-weight in a lifted condition. The normally closed port of the DCV is connected to the extension port of chuck cylinder so that when the solenoid is actuated by the signal from the controller, it extends and holds the work-piece tightly.

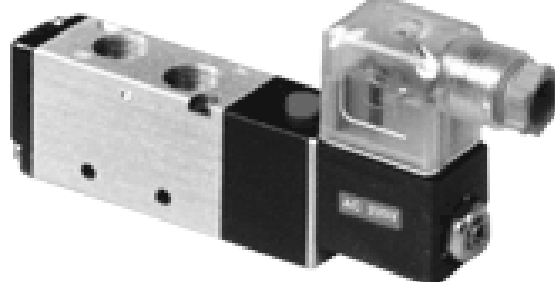


Fig 6. Solenoid operated spring return 5/2 DCV

*G. Microcontroller AT89C51 and LCD Display*

The microcontroller AT89C51 shown in figure 7 belongs to the family of 8 bit microcontrollers manufactured by Atmel. It plays the most important part in controlling the electric motors and pneumatic cylinders in the programmed sequence perfectly. AT89C51 has four input and output ports constituting a total of 32 individual inputs and output pins. These controllers are widely used for the purpose of automation because of they are easy to program and sufficient for most of the smaller applications. LCD display shown in figure 8 is used to view the inputs such as number of pieces to be cut, length of each piece to be cut, that the user specifies through keypad. The LCD prompts the user to enter his data.

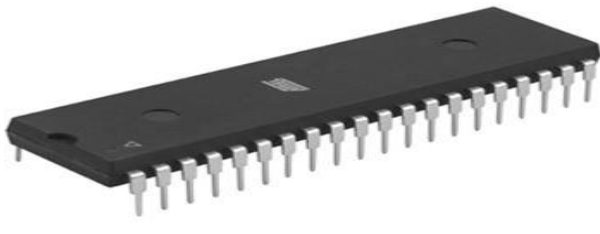


Fig. 7 Microcontroller AT89C51

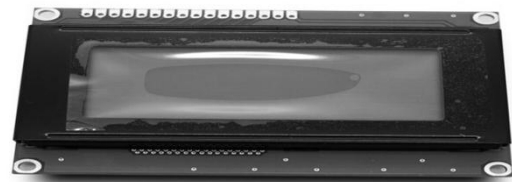


Fig.8 LCD Display

*H. Keypad*

A 4 X 3 keypad shown in figure 9 is used by the operating person to specify the number of pieces to be cut and length of each piece. The controller receives the inputs and displays it on LCD and also uses it for performing the cutting process. The Star key is used as a Reset button and Hash key is used as Enter key. The operator will be able to give the length of each piece to be cut only in terms of centimeter and there shall be no decimal points in the length.

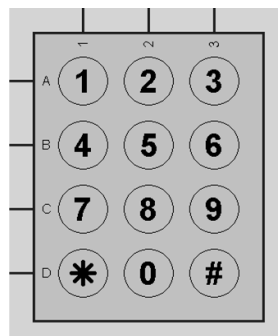


Fig. 9 Keypad

*I. IR Sensor and toothed disc*

The IR sensor along with a rotating disc shown in figure 10 attached to the conveyor roller, serves the function of an encoder. Each time a tooth passes before the IR sensor, it sends a positive pulse to the microcontroller, and it uses its counter to count the number of pulses. When it has received two pulses from IR sensor, it means that the work-piece has been moved one centimeter in to the chuck. So, the IR sensor is the key element in making the automated hacksaw machine to feed the work-piece to the required length in to the chuck. There is a provision for calibration of the IR sensor on its module itself, which is used for adjusting the sensitivity level of the sensor. The adjusting is actually done by a potentiometer connected to a comparator IC or an operational amplifier.



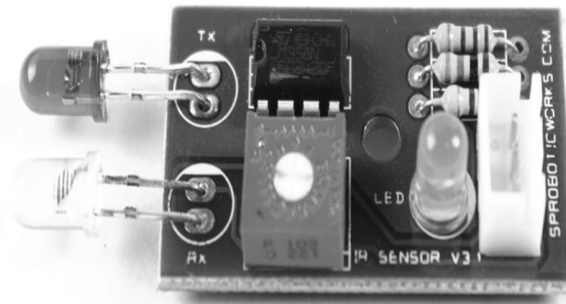


Fig10 IR Sensor and Toothed Disc

### 1.1 Calculations

The IR sensor and the slotted disc are designed and interfaced in such a way that the IR sensor will provide a positive pulse for each teeth crossing before it. The rotary motion causing two successive slots to pass the IR sensor will have created a linear motion of one centimeter. So, the distance between two slots is one centimeter whereas the thickness of each slot is half a centimeter. Thus the circumference of the toothed disc is designed by considering both the thickness of slots and as well as the tooth. The range of detection of IR sensor must be varied so that it is able to sense the teeth that are crossing accurately.

The radius of the rotating slotted disc is calculated as follows.

Circumferential Distance required between two successive teeth = 1 cm

Number of teeth = 12; Number of slots = 12

Considering the circumferential length of each slot as 0.5 cm, the circumference of the toothed disc must be  $[12 + (12 \times 0.5)] = 18$  cm

Required radius of the toothed disc = R

Since  $2\pi R =$  Circumference of disc,

$2 \times \pi \times R = 18$  cm

Therefore,  $R = 2.86$  cm, which means that a twelve toothed disc of radius 2.86 cm must be used.

## III. DESCRIPTION OF THE HACKSAW MACHINE

### A. Proteus Simulation

The figure 11 shows the simulation of electronic circuit using Proteus software. A 4x3 matrix keyboard is used for providing the human interface with the machine. Since the LCD display control pins such as RS and EN pins are connected to the port three of the microcontroller, whereas the RW pin is directly grounded. There has to be an external pull-up resistor in series with each of the pins connected to port zero because port zero has no in-built pull-up resistors. Since the output current of microcontroller will not be enough for driving the relay circuit, a IC for driving these relays called ULN2003 is connected with the output pins of microcontroller. But, there is a common problem encountered in relay circuits due to the reason that when current passes through a coil, an EMF will be generated in opposite direction to that of the applied current, and tends to oppose the applied current. So, this problem must be rectified by providing a diode connected in reverse bias to the applied current. This causes the EMF developed to flow to the positive terminal of the relay rather than allowing the EMF to oppose the supplied current. So, the relay circuit consists of an IC called the ULN2003, four relays and four diodes connected in reverse bias to the terminals of each of the four relays.

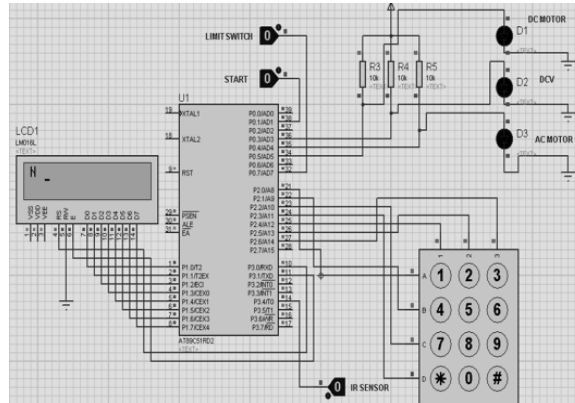


Fig 11 Proteus simulation

**B. Description of the Project setup**

There are three main parts in the Automated Hacksaw machine namely the conveyor, base and self-weight attached with the hacksaw blade. The DC motor is located on the conveyor setup along with the IR sensor and toothed disc, which are connected to the microcontroller. The base setup consists of the AC motor and the setup which consists of the self-weight mechanism is pivoted. The Hacksaw blade can be adjusted along its length so as to be stiff while cutting by means of a threaded screw arrangement at the free end of the self-weight mechanism. Fig 12 shows the photographic view of mechanical setup.



Fig.12 Photographic view of mechanical setup

**IV. WORKING OF THE PROJECT**

**A. Acquiring data from the user**

The Automated Hacksaw machine acquires two inputs from such as number of pieces to be cut and length of each piece from the operator through a keypad and an LCD display. The operator may reset the data during any stage before pressing the machine start push button.

**B. Sequence of operation**

After entering correct data and pressing the start button, the conveyor will feed the work-piece in to the chuck to the required length and gets stopped by the microcontroller. As mentioned earlier, the conveyor motor will get stopped by the microcontroller when the IR sensor has sent the necessary number of pulses to the microcontroller in relation to the



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user specified length of the work-piece. When the teeth of the rotating disc attached to the conveyor roller pass before the IR sensor, the IR sensor provides a pulse to the controller. The rotation of disc from one tooth to the next teeth means that the corresponding linear movement is one centimeter.

Then the solenoid DCV will make the chuck cylinder to extend and hence hold the work-piece in position and ready for cutting. At the same time, the self-weight gets rested on the work-piece with the blade pressing against the work-piece. Then the AC motor is turned on by the signal from controller, which initiates the cutting process. When a single piece has been cut, a limit switch gets turned on by the self-weight, which makes the microcontroller to start the whole process again until it has finished cutting the quantity of pieces as specified by the operator. The total cost accounting both to mechanical setup and electronics is shown in the table 5.

Table 5. Cost of fabrication

COMPONENTS	Quantity	COST (RS)
Conveyor	1	2,000
Base With Chuck	1	7,000
DC Motor	1	1,500
Pneumatic cylinder	2	2,500
Pneumatic DCV	1	800
Hacksaw Blade	1	250
Controller and Electronics	-	1,500
TOTAL COST		15,500

**V. CONCLUSION AND FUTURE SCOPE**

It is known that conventional power hacksaw machine can be replaced with automated power Hacksaw machine. Automated power hacksaw machine gives high productivity in short time period in comparison with the conventional power hacksaw machines. The major advantage of this machine is intervention of labor is reduced to maximum level. In this rapid emerging industrial section the use of power Hacksaw machine is wide, time and labor plays a major role in production process. This can be overcome by using this type of automated machines.

The automated hacksaw machine can be made use of at any of the industries like pump manufacturing industries that involve bulk amount of shafts that have to be cut frequently. The range of size of work-pieces that can be cut using the automated hacksaw machine can be varied by changing the blade size. Currently, the machine uses 12 inch blade for cutting. An another advancement that can be implemented in automated hacksaw machines is that the user can also get cut work-pieces of different lengths in one cycle itself. This means that the user has to specify the number of work-pieces that have to be cut in each of the different length values specified. This will be possible with the help of an advanced microcontroller than AT89C51, which should have high programmable memory.

**REFERENCES**

[1] Anthony Esposito 'Fluid Power with applications', 6th Edition, Pearson Education Inc. 2011  
 [2] Muhammad Ali Mazidi, Janice Gillispie Mazidi, and Rolin D. McKinlay 'The 8051 Micro Controller and Embedded Systems', 2nd Edition, Pearson Education Inc. 2008  
 [3] Pneumatic cylinder and solenoid DCV from product manual of Janatics Ltd,  
 [4] Standard blade sizes used in power hacksaw machines using the link <http://www.planomillers.com/> - viewed on August 2, 2013  
 [5] ULN2003 IC Pin configuration (used in relay circuit) using the link <http://www.engineersgarage.com/>-viewed on August 10, 2013