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Design and Development of Automatic Wire Cutting Machine: A Case Study in Small Scale Industry

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Abstract: ***This Paper gives the detailed information about the design and development of automatic wire cutting machine. At present conventional method is used for wire cutting and measuring which takes more time which requires man power. The accuracy obtained by conventional method is also poor. The automation system solves the labour problems it saves cost, increases accuracy, decreases human errors. By using automation our objectives to achieve low cost cutting which works fast and reduces cutting time. The practical objective of automatic wire cutting machine is to cut required length of wire in required number of pieces. This machine is simple and portable.***
Keywords: Automatic wire cutting, Cam Operated Cutting, Transportable, cost- effective

I. INTRODUCTION

In the underdeveloped small scale industries, nowadays labour is a major problem for the industries. Many a time's situations happen that labourers strike for their personal benefits which results in performance degradation and loss in efficiency. As a result the company owners have to bear great loss and hence cannot achieve their desired profit and goals .The system of automation in industry can solve this problem in a very effective way.

The automation system solves labour problems which saves cost, increases accuracy and decreases human errors. After surveying various electrical and electronics industries we conclude that, nowadays the industries have introduced automation in their systems to some extent but for some basic processes which are time consuming like wire cutting, packaging etc. they use human resources. If we introduce automation to these basic processes then it will be fruitful regarding the company's development and profit gain as it improves the system in many ways. One such industry found out in which they need a solution that is very efficient, fast and economical for cutting various lengths of wires which are required for producing capacitors. So we try to market cost effective wire cutting machine.

In an automatic wire cutting machine a stepper motor driven knurled roller is positioned between two wire guide channels to drive a wire toward a cutting station. The length of wire to be cut is set in a length counter. Drive cycles, during which the wire is driven a predetermined distance, are counted in the length counter. Then, the stepping motor is disabled and cutting blade is energized. This system prevents operation of the cutting blade solenoid at less than an acceptable duty cycle with short lengths of wire. This automatic cutting machine is fully electric, microprocessor controlled bench machine for processing wire, round and flat cable. It features LCD display prompts for easy-to-follow set-up and operation, automatic wire loading and unloading and universal V-type blades.

Present Status

Current Scenario

Company is using conventional method for wire cutting from conventional method the production rate is very low because they have to measure the length of wire for every piece before cutting which also take more time. Also sometimes wires unequal length as well as more man power is required.

A. Problems of Conventional Wire Cutting Method

Time required for wire cutting is more.

1) More manpower is required.
2) More floor space is required.
3) t is required to measure every piece of wire before cutting.

II. OBJECTIVES

The objectives of this project are to design and develop an automatic wire cutting machine to achieve low cost cutting. It works fast and reduces the cutting time. This equipment is not designed using complicated components. This machine is simple and portable. This machine is designed using angle bars, rollers, guide tubes, cutter and controller unit to control the entire operation of machine. The practical objective of the automatic wire cutting machine is to cut required length of wire in required number of pieces.

The objectives of the project are to design a system for an automatic wire cutting machine which is:

1) Automation
2) Efficient
3) User-friendly
4) Transportable
5) Cost-effective
6) Reduce strenuous and repetitive task
7) Functional requirement of proposed system
8) Respond as per user's input
9) Display user's input

III. METHODOLOGY

A. *Defining the Specifications of Machine*

The basic need of automatic wire cutting is to cut the wire of required length in required number of pieces, without labour, efficiently. So we decided to make a project named 'Automatic wire cutting machine. For that we decided some specifications given below:

1) To cut required length of wire.
2) The diameter of wire should be automatically adjustable.
3) The spool is provided to store wire stock.
4) Guide tubes are provided to keep wire in straight direction.

For making of the automatic wire cutting machine we will follow this procedure below:-

So firstly we decided to make a virtual design of the project and then we finalize that a final design for project.

B. *Industrial Wire Cutting Machine Consist of Two Systems*

1) Mechanical system
2) Electronics system

C. *In Mechanical System Step by Step Done Procedure for on that Format of Design Given Below*

1) Making of a base of the mechanical part: fabrication work
2) Select the material for the fabrication work
3) Purchasing of required material from market
4) Checking of all loads acting on that frame

D. *We Decided to Make Mechanical System into Different Sub-Category*

1) Base
2) Rollers
3) Guide tubes
4) Sliding rails
5) Supports for mounting dc motors
6) Spring attachment

IV. DESIGN AND CALCULATIONS (5)

A. *Selection of Motor*

r = radius of roller

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d = roller diameter
T= torque required for motor
Circumference of roller = wire length obtained in one revolution = πd
=3.142×70
= 220mm
In one revolution of roller 220mm of length of wire is covered.
Speed of motor = 30rpm

1) Torque Required= F × r: Where,
F= spring force.
r = radius of roller.
For grip purpose we assumed 2kg of spring force.
Therefore,
T = F × r
= 2×9.81×35
= 700N-mm.

Now,

2) Clamping Force =Frictional Force Where,
Frictional force= μ×Rn
μ = coefficient of friction
Rn = reaction force =20
We assumed coefficient of friction for rubber material 0.3.
f = frictional force.
f = μ× Rn
= 0.3×20
= 6N.
Assuming 25% loss in transmitted torque from motor to drive roller due to friction.
∴Torque of motor by considering 25% losses.
T = 700×1.25 N-mm
= 875 N-mm

3) Power Generated = $\frac{2\pi nT}{60\times1000}$
$=\frac{2\pi\times30\times875}{60\times1000}$
= 2.749watt.

4) Design of Spring:
Let,
Coil dia. = 2mm
d_m= 12.5mm
K = 1.11N-mm
$\tau_k = \sqrt[3]{\frac{8\times F\times d_m}{2\pi}}$
$=\frac{8\times12.26\times12.5}{2\times3.14}$
τ_k = 19.76 kgf-mm
$d = \sqrt[3]{\frac{8\times F\times D_m\times k}{\pi\times\tau_k}}$
$= \sqrt[3]{\frac{8\times5\times12.56\times1.11}{3.14\times19.89}}$
= 2 mm
Mean dia.,
$D_m = \frac{\pi\times(d)^3\times\tau_k}{8fK}$

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$= \frac{\pi \times (2)^3 \times 19.89}{8 \times 5 \times 1.11}$

= 12 mm

Inner dia.

$D_i = D_m - d$

= 12-2

= 10 mm

Outer dia. $D_o = D_m + d$

= 12+2

= 14 mm

B. Cutting Force Calculations

Calculation for Cu wire

S_{yt} = 70 Mpa

$= 70 \times (10)^6$ N-m^2

$S_{ut} = 0.577\, S_{yt}$

$= 0.577 \times = 70 \times (10)^6$

$= 40.39 \times (10)^6$ N-m^2

Force required to cut the Cu wire

$\sigma = \frac{F}{A}$

Where,

$A = \frac{\pi}{4} \times d^2$

d = 1.2 mm = $1.2 \times (10)^{-3}$ m

∴ Force required to shear 1.2 mm dia. Wire is,

$40.39 \times (10)^6 = \frac{4F}{\pi \times (1.2 \times (10)^{-3})^2}$

∴ F = 45.68 N

l_1 = length of cutter arm up to fulcrum point.

p_1 = force applied by cam on cutter arm.

l_2 = length of cutting edge

p_2 = cutting force required to shear the wire.

$\therefore l_1\, p_1 = l_2 p_2$

Now we have,

l_1 = 85mm

l_2 = 15mm

p_2 = 45.68N

p_1 = ?

∴ $45.68 \times 0.015 = 0.085 \times p_1$

$\therefore p_1 = 8.06$ N

1) Required Torque of Motor:

T = F×r

T = 8.06 × 0.045

T = 0.367 N-m

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C. Conceptual Design

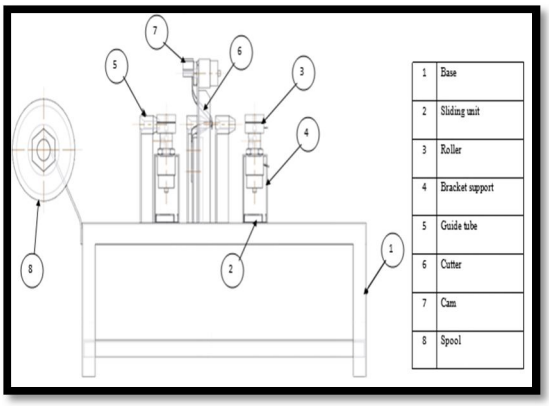

Fig.1 Conceptual Design

The base is made of angle bars of mild steel in a such a way that it can carry the whole equipment. The bars are welded in a work shop on which metal sheet of mild steel is welded. The first pair of rollers are attached to support in a order to uncoil the insulated wire from spool stock which are controlled by the dc motors which are further controlled by the microcontroller. The wire is passed through the guide tubes which keeps the wire in straight direction in such a way that wire reaches exactly in between the two rollers. After this the cutter is mounted. When wire of required length is passed the first pair of rollers are stopped and the movement of cutter is controlled by cam which is mounted on motor shaft. The second pair of rollers keeps the wire pieces away. The arrangement of whole assembly is shown in Fig.

D. Assembly

1) *Fabrication of Mechanical System:* We are started to manufacture the wire cutting machine .At first we made base for whole assembly on which different mechanical parts are assembled. Base is made up of sheet metal which is capable of carrying load of all mechanical parts .Manufacturing of base is done by spot welding process, which is commonly used welding process. Another important part of mechanical assembly is sliding unit .Sliding unit is mounted on base by spot welding process. The main purpose of sliding unit is to adjust the wire diameter.

Bracket support are used on which D.C. motors are mounted with diameter 13mm. D.C. motors of 30RPM with 0.5N-m torque are mounted below the support. There are four bracket support used in the system,out of which two are connected to sliding unit and two are attached to base assembly. Rollers of diameter 35mmwith centre whole 6mm are mounted on the bracket Rollers are manufactured on lathe with different operations such as outer diameter turning, facing, centering, growing of 0.5mm, machining of raw material of diameter 40mm,driiling,tapping.The no of rollers used in the system is four. Cam is made of metal strip .cam is mounted on motor shaft. Guide tubes are mounted on column support which is welded on base of thickness 2mm.Guide tubes are used to guide the wire .Total length of guide tube is 38mm with internal diameter 8mm, taper turning diameter of guide is 21mm. Spring are used to exert clamping force .one end of spring is attached to the bracket support and other end is hooked to the based.

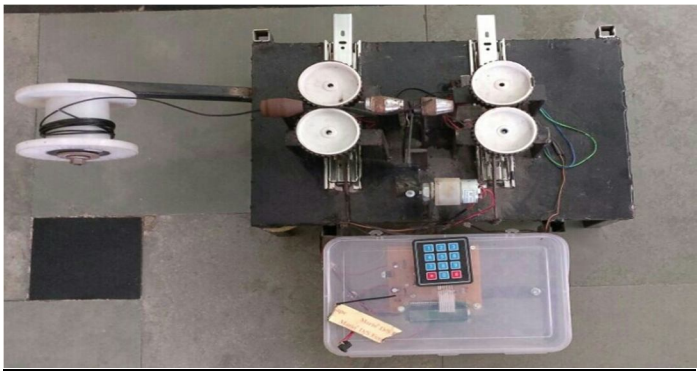

Fig. Mechanical System

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E. Electronic System Setup (6)

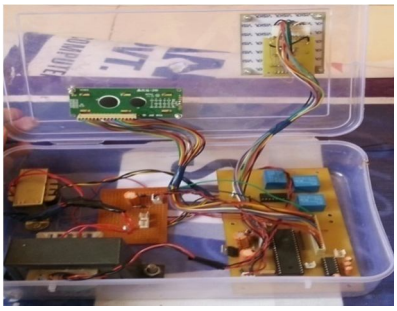
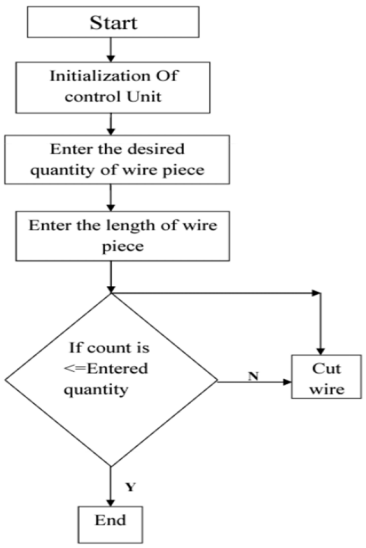


Fig. Electronic System

The 12V signal from the battery is given to the power supply unit where it gets regulated to 5V. The 5V signalis given to the microcontroller unit. Once the supply is ON, LCD gets initialized. The microcontroller "ON" the relay-2 to achieve reset position of rollers i.e. roller motor. The microcontroller sets to auto mode and the quantity and length of wire is given as input to microcontroller. Then microcontroller (by using microcontroller program) "ON" the relay -1, (conveyor Motor ON) and "ON" relay-3) for up to upper limit switch and once again "OFF" the relay-1, 3.

F. Flow Chart



V. CONCLUSION

Automatic Wire Cutting System" provides high level of accuracy and exact cutting of wires than the present cutting system in the market. Thus due to this the efficiency of production is increased. This system gives exact number of wires with the required length. The circuit complexity is reduced in this system. As the complexity in the circuit is reduced, it is easy to understand. The main advantage of this system is that the accuracy is increased and the required result is obtained in very less time. The time required to cut wires is less compared to the manual cutting of wires. Due to simple hardware it is handy for the people. As the price of the project is not high, it is economically affordable to common people and has been successfully implemented in the industry.

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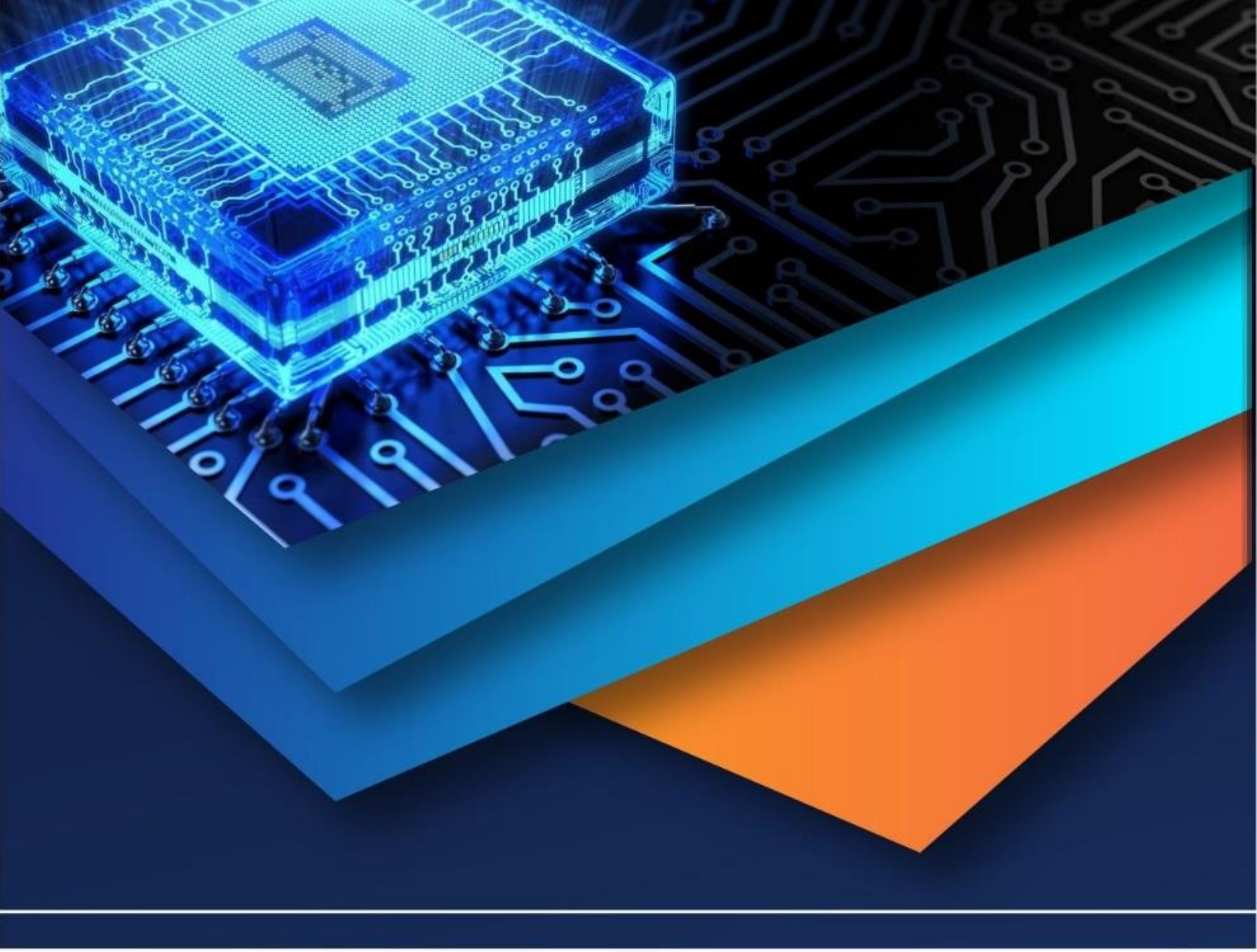

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