Experimental and Analysis of Welding Electrode Wire Straightening and Cutting Machine

B.Babu
Assistant professor, Kongunadu College of engineering and technology, Thottiam, Trichy, Tamilnadu, india

S.K.Karthikeyan
Assistant professor, Kongunadu College of engineering and technology, Thottiam, Trichy, Tamilnadu, india

V.Selvam
Assistant professor, Kongunadu College of engineering and technology, Thottiam, Trichy, Tamilnadu, india

Abstract - A cutting machine for manufacturing wire-like rods, particularly for electrodes for welding. It comprises at least one advancement assembly adapted to receive and produce the advancement of a wire- like product at a preset advancement speed from an inlet to at least one cutting assembly which is adapted to cut the wire- like product into rods of preset lengths. The cutting assembly being interposed, along the advancement line of the wire- like product between the advancement assembly and at least one assembly for collecting the rods the cutting assembly comprising at least two rotating shears of the motorized type with rotation axes which are parallel and mutually opposite with respect to the advancement line of the wire-like product. Synchronization means being further comprised which are associated with the cutting assembly and with the advancement assembly for the adjustment of the tangential speed of the reciprocating shears. This project deals with increasing the production rate of the machine from 100rods/minute to 200rods/minute and reducing the down time of production.

I. INTRODUCTION

Wire Straightening and Cutting Machines (WSCM) are widely used to extend wires from a roll or coil in order to straight and to cut. These machines are offered with extensive features requiring diverse applications. Some machines are configured for straightening and cutting all kinds of cold drawing wires and other nonferrous metal wires. They may cut the wire as per requirements in the required dimension and thereafter, work continuously.

These machines are complied with three different processes such as feeding, straightening and cutting off. These machines are available with various features such as different diameter size wires for straightening, different cutting lengths and standard multi-power motor for both straightening and cutting of wires. The straightening is carried out in order to ensure the straightness of a rod work piece as well as to redistribute or reduce the residual stress in the material. The straightening is carried out in two ways either by means of using killing rollers or by means of using the spinner arrangement. From this two techniques the killing rollers arrangement is generally preferred when the length of the wire is high and it generally uses a reverse bending process. The object is to cause the wire to reversibly flex beyond its elastic limit as it traverses through the straightening rolls. The spinner arrangement is preferred for short length wires. The apparatus comprising a rotary member having a passage through which the material is guided. The removal of the twist enables the cutting head to cut the wire exactly to the predefined length.

II. DESCRIPTION OF THE MACHINE

2.1 PROPERTIES OF WELDING ELECTRODE

Welding electrode are used in welding various metals for chemical and allied industries, construction of steel structures such as bridges, factory sheds, in the manufacturing of ships and engineering alloys. Mild steel is welded by the electrodes to a maximum among all metals and Alloys. Therefore M.S. Welding electrode is the most widely used core wire.

Welding electrodes comprise basically of steel core wire and coating ingredients or flux mild steel, nickel, Nickel-copper, Nickel irons are also used for welding in fertilizer, chemical and surgical instrument making industry. In this fabrication process used mild steel welding electrode rod of grade C15.

Electrode	Mild steel
Grade	C15
Diameter	2.5,3.15,4,5mm
Length of electrode	350mm &450mm

Table No: 1 Specification of electrode wire

2.2 PREVIOUSLY EXISTING MACHINE

The previously existing Electrode wire straightening and cutting machine is capable of cutting and straightening 100pieces/minute. The feed rate of the rollers is around 35m/minute. The power to the roller, spinner and the cutting block is provided by a 5hp motor. The main objective of the project is to increase the production rate from 100pieces/minute to 200pieces/minute. So the feed rate of the roller should be increased to double the time i.e. around 70m/minute by making necessary modifications to the motor unit and the cutting block unit.

Motor specification	5hp,3ϕ,415v,50hz
Speed	2880rpm
Motor type	Foot mounted.

Table No: 2 Specification of the existing machine

2.3 THE PROCESS CARRIED OUT IN THE CUTTING MACHINE

Among the methods for production of rod-like electrodes for welding, it is known to use cutting machines that are adapted to cut a wire like product into rods of standardized lengths ranging from 350mm to 450mm and with a diameter comprised of 2mm to 6mm.The known type of cutting machine comprise an advancement assembly, generally of the type with pairs of motorized rollers with circumferential grooves of suitable diameter in which the wire like product is accommodated. In this manner, the wire-like products acquires speed and pushed into the straightening assembly or spinner consists of five dies which is used to straighten the wire effectively along its length. Then the straightened wire is again fed into another pair of advancement assembly which feds the wire into the cutting unit provided with the cutting shears provided with cutting tool made of tungsten carbide. The power to the reciprocating shear is provided by the flywheel and cam arrangement is powered by 1hp motor and driven by a V-belt. The measuring unit consists of stopper provided at the predefined length supported by a spring loaded arrangement.

2.4 COMPONENTS OF A WELDING ELECTRODE CUTTING MACHINE

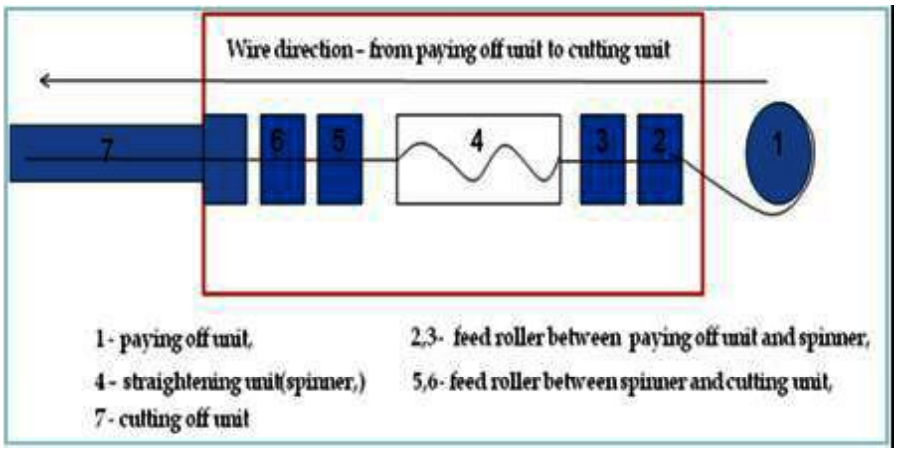
The main components of the cutting machine comprises mainly of,

1. Pay off stand
2. Advancement feed roller assembly
3. Straightening unit or spinner assembly
4. Wire cutting unit or scaling bar
5. Wire measuring unit & Wire collecting unit.

2.4.1 PAY OFF STAND

The electrode wire is rolled around this layoff stand. The layoff stand is a provided with a rotating body placed over the fixed base that provides constant feed to the machine. The base should be made wide enough that withstands vibration and force due to the pulling force provided by the roller.

Fig. No 2.1 Payoff stand



2.4.2 FEED ROLLER ASSEMBLY

The main purpose of the feed roller assembly is to provide the necessary pulling force for the electrode wire from the layoff stand into the straightening unit or spinner and from the straightening unit after straightening is carried out .For this purpose two pairs of rollers are used. The roller is provided with groove which matches with the various diameter of the wire. The power to the roller is provided by chain and sprocket assembly through the shaft.

Fig. No 2.3 Feed roller and Feed roller housing arrangement

The shaft is connected to directly to a gear which is again is meshed with another gear. The two gears provide the rotation motion of the roller. The rollers are placed one above another and the electrode wire travels on the meshing space between the two rollers. The necessary tension to the electrode wire is provided by adjusting the space between the two rollers through a spring loaded rotating hand lever arrangement.

SPECIFICATION OF THE ROLLER

Number of roller = 4
Diameter of the roller = 75mm
Diameter of the shaft =25mm

2.4.3 SPINNER ASSEMBLY OR STRAIGHTENING UNIT

Wire straightening apparatus is used to straighten wire, supplied in a rolled or coiled stock. The removal of the twist enables the cutting head to cut the wire exactly to the predefined length. The apparatus comprising a rotary member having a passage through which the material is guided. The material is deflected away from the axis of rotation. The first portion will be curved and is directed away from the side axis. The second portion which is substantially parallel with the axis of rotation is less tightly curved than the first portion. The arrangement being such that the rotation of rotary member about its axis straightens material fed through.

The second portion of the path enables the first portion to have a small radius of curvature. It is believed that this combination of relatively small radius of curvature and a small displacement from the axis gives rise to the improved performance compared with known type of wire straightening apparatus.

The spinner will be powered by a 7.5hp motor with the aid of flat belt assembly. The speed of the spinner will be 8784rpm.

Fig. No 2.4 Spinner arrangements

The passage is provided for fixed diameter of wire which causes the downtime while we are using different diameter wires since we want to replace the spinner every time we are using wires of different diameter. So, in order to reduce the downtime a dovetail is made on the spinner base and to the fixed base of the machine. Therefore it provides an easy way of replacement of the spinner unit by reducing the time for replacing and for again tightening the bolts. This may damage the screw threads and requires periodic maintenance.

2.4.4 CUTTING UNIT

The cutting unit is the one in which the cutting action on the electrode wire is provided by the reciprocating shears. The power to the reciprocating shear is provided by the cam arrangement which in turn is connected to the shaft. Flywheels are provided on both the ends of the shaft. The power to the shaft is transmitted through the V-belt arrangement powered by 1hp motor.

Motor	1hp
Power rating	3ϕ,415V,50Hz
Speed	1440rpm
Type	Foot mounted
Belt type	V-belt

Table No: 3 Cutting unit motor specification

The shaft is inserted into the cutter housing by a special type of bushing known as ultra bushing. The ultra bush is a cylindrical bush capable of absorbing axial, radial and torsional movements.

The main advantage of the ultra bush is its maintenance-free, prevents sound transmission, adjustments of manufacturing tolerances and as a coupling elements in drives.

The eccentric rotation of the cam arrangement provides the reciprocating movement of the cutting block. The electrode wire enters the cutting unit through the threaded nozzle arrangement.

The main purpose of the threaded nozzle is to support and guide the electrode wire into the cutting unit without any bending at the edge while the shear force acts on the wire for carrying out the cutting action.

2.4.5 MEASURING UNIT

Measuring unit is the very important unit since it determines the length of the electrode wire. It consists of a passage through which the electrode wire passes and hits the stopper. The stopper is provided with a spring loaded arrangement supported by a sliding contact bearing. The passage is provided with the close tolerance with the diameter of the wire. The stopper is provided at a distance equals to the length of the wire to be cut.

Fig. No 2.5 Scaling bar

When the electrode wire hits the stopper due to the spring loaded effect it reciprocates horizontally. The sliding block is in contact with the spring loaded stopper arrangement that makes the cutter block to come in contact

with the flywheel provided with a cam arrangement which in turn provides the reciprocating motion of the cutter block. The tool holder with the tool moves down and cuts the wire to the predefined length.

2.5 MODIFICATION OF CUTTING TOOL

Since the cutting speed increase the cutting tool should be designed to withstand high speed range. HSS or high carbon steel continues to be the best and cheapest. The advantage of HSS over carbide is its strength to withstand cutting forces and the low cost of the tools. From the tool life point of view, HSS performs very well at intermittent cutting applications.

But the greatest limitation of HSS is that its usable cutting speed range is far lower when compared to Carbide. Whereas tungsten carbide cutting tool possess high hardness over a wide range of temperatures, high thermal conductivity, high Young's modulus making them effective tool. Typical cutting speeds for high speed steel ranges from 10 - 60 m/min where as for tungsten carbide it ranges form 100 - 250 when coated.

Fig. No 2.6 Tungsten carbide tool and tool holder

2.5.1 THE AVERAGE ENERGY REQUIRED FOR CUTTING
PHYSICAL PROPERTIES OF C15 ELECTRODE WIRE ROD

Specific weight = 0.0785 N/CC

Modulus of elasticity = 2.080×10^5 N/mm^2

Shearing strength of mild steel = 300N/mm^2

The force required to shear of electrode rod = $(\pi/4)d^2\tau = (3.14/4)\times3.15^2\times300$

The shearing force needed = 2.336KN

The average energy = 0.5(force×punch travel)

Punch Travel = 10mm

Therefore average energy for cutting = $0.5\times2.336\times10\times10^3$ = 11.68KNmm

Fig.No 2.7 Eccentric Cam

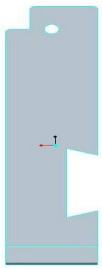


Fig. No2.8 Modified views of tool holder

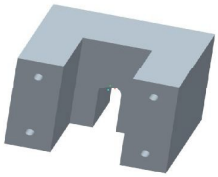
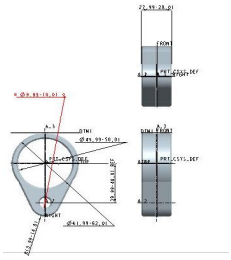


Fig. No 2.9 Orthographic views of cutter block

Fig. No 2.10 Orthographic view of 200 pieces



cutting machine cam

Fig. No 2.11Orthographic view of 100pieces cutting machine cam
Fig. No 2.12 Isometric view of Cam profile used in 100peces

cutting machine

2.6 BEARINGS

The main function of a rotating shaft is to transmit power from one end of the line to the other. It needs a good support to ensure stability and frictionless rotation. The support for the shaft is known as “bearing”. The shaft has a “running fit” in a bearing. All bearing are provided some lubrication arrangement to reduced friction between shaft and bearing. The bearings are classified into two main categories as follows,

- ✓ Plain or slider bearing
- ✓ Rolling or anti-friction bearing

2.7 BEARINGS USED IN THE ROLLER AND SPINNER ASSEMBLY

The bearings used in the roller arrangement is of deep groove ball bearings of bearing number SKF6208. The bearings used in the spinner assembly with specification of SKF6205. The specification of the bearing as per the design data book is as follows,

SPECIFICATION OF THE SKF6205 BEARING

Bore diameter= 25mm
Outer diameter of bearing=52mm
Abutment diameter of the shaft= 31mm
Abutment diameter of the housing= 46mm

SPECIFICATION OF THE SKF6208 BEARING

Bore diameter= 40mm
Outer diameter of bearing= 80mm
Abutment diameter of the shaft= 47mm
Abutment diameter of the housing= 73mm

Belt type	Dimension	Quantity
Flat belt	1500×40×1.6 (spinner)	1
V-belt(A53,A34)	1392×13×8, 860×13×8	1

Table No: 4 Belts used in the 200pieces/minute cutting machine

2.8 MOTOR SPECIFICATION

The power to the spinner assembly is provided by a 7.5hp motor through a flat belt assembly. The motor is of double sided shaft. The double sided shaft provides power to the spinner unit and also to the feed roller assembly through a gear box assembly of speed ratio 5:1. The specification of the motor is given as follows,

Table No: 5 Motor specifications

Motor	7.5hp, 415V, 3ϕ	
Shaft Type	Double sided shaft	
Type	Foot mounted	
Belt type	For roller	V-belt, Chain sprocket.
	For spinner	Flat belt

2.9 STRAIGHTNING INSPECTION UNIT

Straightening inspection unit is the unit that is used to continuously inspect the straightness of the wire after it gets straightened. If there are any deviations in the straightness on the part of the wire, it continues for the rest of the wire. So in order to check the straightness of the wire this unit is suggested. It consists of a cylindrical housing in which a metal region is placed on between the two nylon regions. The passage diameter of the nylon is 2.6mm and that of the metal is 2.65mm. The metal which is conductive is connected to +10V. A supply of -10V is connected to the body.

Due to this a negligible quantity of voltage passes through the electrode wire. In normal conditions it will not be in contact between the electrode wire and the metal region in the inspection unit. If there are any deviations in the straightness of the wire the electrode wire comes into contact with the metal region which is with close tolerance of electrode wire. The supply to the metal provided through a trip arrangement.

When the electrode wire comes into contact with the metal the NC (Normally close circuit) will become NO (normally open) due to the opposite polarity. The whole unit will halt until the error is rectified.

The straightening inspection unit will be provided with a separate control unit (ON/OFF unit). This is due to the fact that during inching and wire setting process the wire will be normally in contact with the metal at this situation the straightening inspection unit should be switched off.

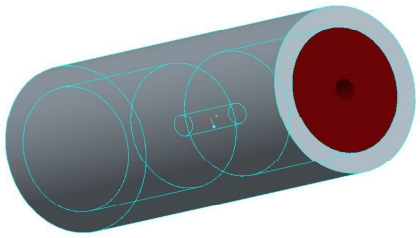


Fig. No 2.14 Wire straightening inspection unit orthographic representation

2.10 DOWN TIME

The term downtime is used to refer to periods when a system is unavailable. Downtime or outrage duration refers to a period of time that a system fails to provide or perform its primary function. Reliability, availability, recovery and unavailability are related concepts. The unavailability is the proportion of time span that a system is unavailable or offline. This is usually a result of the system failing to function because of unplanned event, or because of routine maintenance.

The term is also commonly applied in industrial environments in relation to failures in industrial production equipment. Some facilities measure the downtime incurred during a work shift, or during a 12 or 24-hour period. Another common practice having an operational, electrical or mechanical origin.

This machine is normally used for straightening and cutting wires of fixed diameters. But in some cases if wires of various diameters have to be manufactured some modifications are needed. Generally modifications are done on the feed roller, spinner and straightening unit. In order to reduce time for these modifications the design of the spinner base is changed. In the previously existing design the spinner is provided with bolt and nut arrangement which is found to be time consuming to replace. The spinner base is modified with an arrangement in the form of rack. The spinner base slides along the fixed base and is locked with bolt on one side.

III. MODIFICATION OF SPINNER ASSEMBLY

Fig. No 3.1 Modified spinner base

Fig. No 3.2 Modified view of spinner assembly

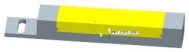


Fig. No 3.3 Modified view of spinner assembly base

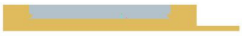


Fig. No 3.4 Front view of spinner base assembly

IV. ELECTRICAL COMPONENTS

4.1 IMPORTANT ELECTRIC COMPONENTS USED

The control panel of the Electrode wire straightening and cutting machine consist of the following controls,

1. Spinner on & off
2. Cutter on
3. Spinner forward inch and reverse inch
4. Emergency stop

The important electrical components that were used in the electrode wire straightening and cutting machine are as follows,

1. Distribution board
2. Circuit breakers
3. Contactors
4. Over load relays
5. Switched mode power supply

4.1.1 DISTRIBUTION BOARD

A distribution board is a component of an electricity supply system which divides an electric power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit, in common enclosure. Residual-current devices or residual current breakers with over current protection will also be incorporated.

4.1.2. CIRCUIT BREAKER

A circuit breaker is an automatically operated electric switch designed to protect an electrical switch from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset to resume normal operation. Circuit breakers are made in various sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits.

4.1.3 CONTACTORS

A contactor is an electric controlled switch used for switching a power circuit, similar to a relay except with higher current ratings. A contactor by a circuit which has a much lower power level than a switched circuit. Contactor come in many forms with varying capacities and features. Unlike a circuit breaker, a contractor is not intended to interrupt a sort circuit current. Contactors range from having a breaking current of several amperes to thousands of amperes and 24 VDC to many kilovolts. The physical size of contactors ranges from a device small enough to pick up with one hand, to large devices.

4.1.4 OVER LOAD RELAYS

Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits) or where several circuits must be controlled by one signal. When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contact either makes or breaks a connection with a fixed contact.

4.1.5 SWITCHED MODE POWER SUPPLY

A switched mode power supply is an electronic power supply that incorporates a switching regulator to convert electric power efficiently. Like other power supplies, an SMPS transfer power from a source, like mains power, to a load, while converting voltage and current characteristics. Voltage regulation is achieved by varying the ratio of on-to-off time. Switching regulators are used as replacement for linear regulators when higher efficiency, smaller size or lighter weight is required.

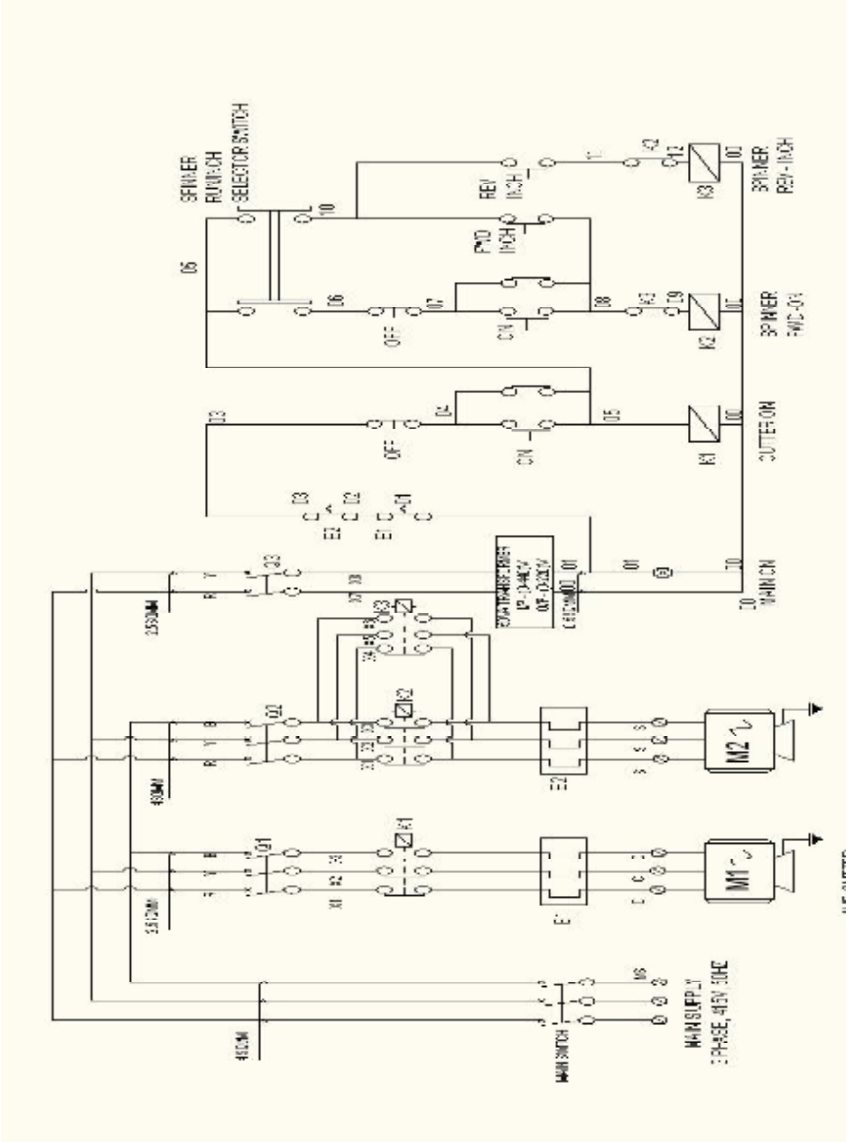


Fig. No 4.3 CIRCUIT DIAGRAM OF THE STRAIGHTENING AND CUTTING MACHINE

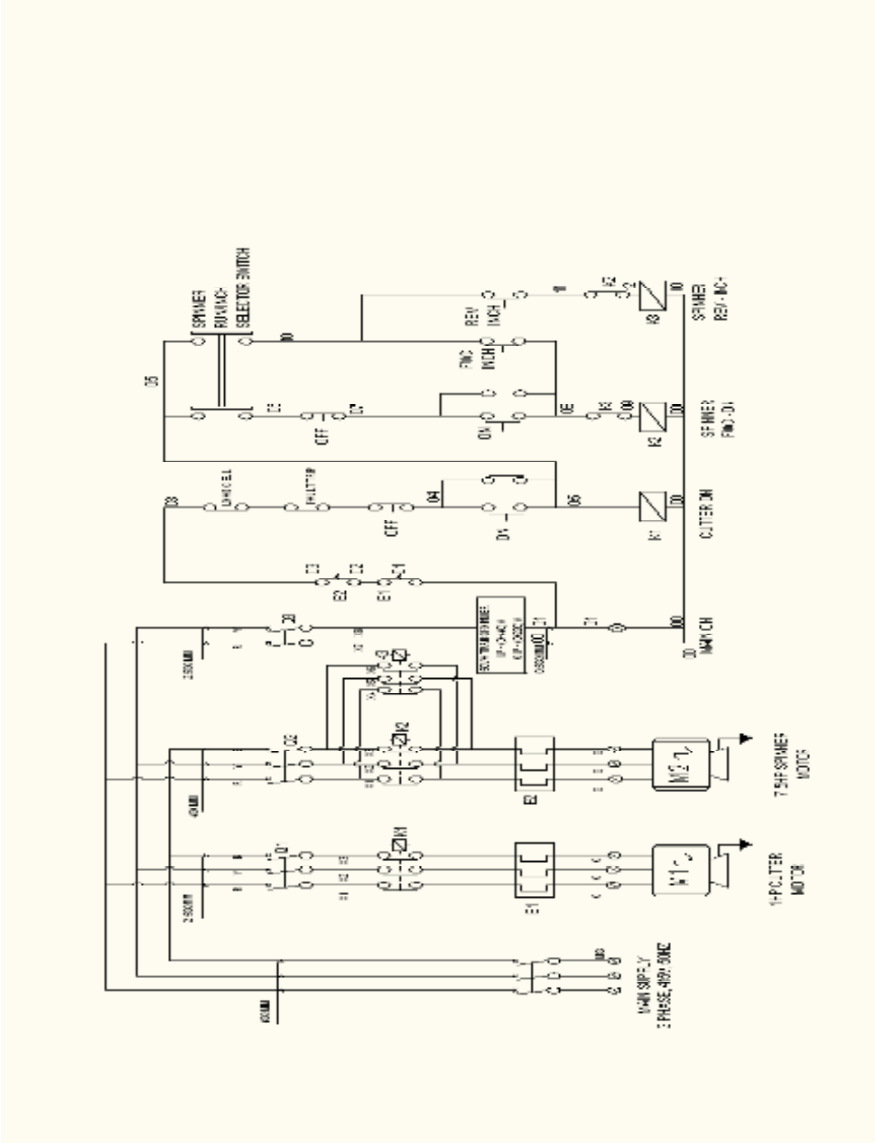


Fig. No 4.4 CIRCUIT DIAGRAM WITH LOAD CELL AND TRIP ARRANGEMENT

V. CALCULATIONS

5.1 FOR 7.5HP MOTOR

FOR SPINNER ASSEMBLY:

Belt type - Flat belt,

Diameter of Driver (D_1) - 183mm,

Diameter of Driven (D_2) - 60mm (maximum) - 70mm (minimum)

Speed of the Driver (N_1) – 2880rpm

Speed of the Driven (N_2) – Speed at which the spinner rotates=?

$$\frac{N1}{N2} = \frac{D2}{D1}$$

$$\frac{2880}{N2} = \frac{60}{183}$$

N_2 = 8784 rpm

Speed of the spinner = 8784 rpm.

5.2 SPEED OF THE ROLLER

Belt type – V-belt,

Diameter of the Diver (D_3) – 75mm

Diameter of the Driven (D_4) – 151mm

Speed of the Driver (N_3) – 2880rpm

Speed of the Driven (N_4) - ?

$$\frac{N_3}{N_4} = \frac{D_4}{D_3}$$

$$\frac{2880}{N_4} = \frac{151}{75}$$

N_4 = 1430rpm.

The driven pulley is connected to the gear box assembly provided inside with worm gear assembly and having a gear ratio of 5:1.The power is transmitted to the roller through a chain and sprocket arrangement

5.3 GEAR BOX

Gear box ratio – 5:1

Number of teeth on the driver sprocket (n_1) – 30 teeth

Number of teeth on the driven sprocket (n_2) – 21 teeth

Pitch of the chain – 12mm

Therefore effective diameter of the driver (D_5) = $\frac{P}{\sin\frac{180}{n_1}} = \frac{12}{\sin\frac{180}{30}}$ = 114.80mm

effective diameter of the driver (D_6) = $\frac{P}{\sin\frac{180}{n_2}} = \frac{12}{\sin\frac{180}{21}}$ = 84.32mm

The speed of the driver sprocket (N_5) = 287rpm

The speed of the driven sprocket (N_6) =?

The

$$\frac{N_5}{N_6} = \frac{D_6}{D_5}$$

$$\frac{287}{N_6} = \frac{84.32}{114.80}$$

Speed of the driven sprocket N_6 = 389rpm

5.4 THEORETICAL FEED RATE

Number of pieces per cut = 200pieces

Length of a piece = 350mm

Therefore feed rate = (200×350) = 70meters/minute

5.4.1ACTUAL FEED RATE

Diameter of the roller=75mm

Speed of the roller= 389rpm

Therefore actual feed rate=3.14DN

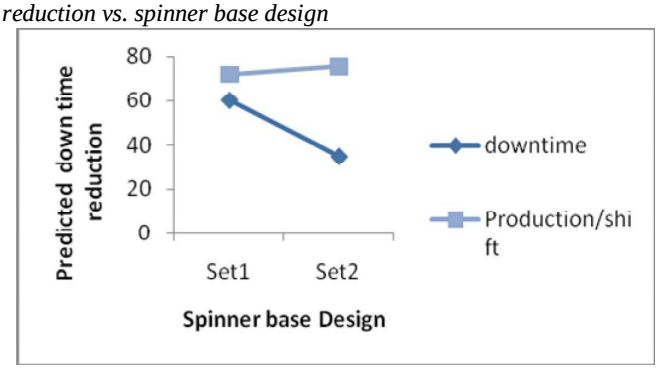
Where D= diameter of the roller

N= speed of the roller

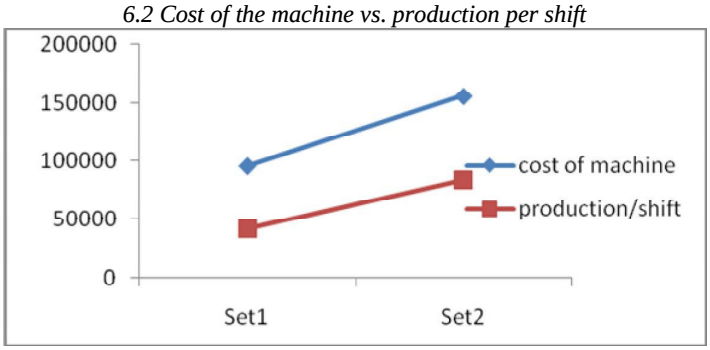
Actual feed rate=3.14(389)(75)=91845mm=91m

VI. GRAPHS

6.1 Predicted downtime reduction vs. spinner base design



6.2 Cost of the machine vs. production per shift



VII. CONCLUSION

Thus, by making some necessary modifications the productivity of the machine has been increased. In addition to this for decreasing the downtime while using base design that increases the productivity. In order to get the accuracy in the quantity in the collecting unit a load cell arrangement is suggested as per the circuit diagram mentioned different diameter wires, suggestion has been made for the modification of spinner

REFERENCES

[1] "A REVIEW ON INNOVATION OF WIRE STRAIGHTENING CUTTING MACHINE" by Ashvin S. Patel and DR.J.M. Prajapati, International Journal of Engineering science and Technnology.
[2] "CUTTING MACHINE WITH INCREASED PRODUCTIVITY FOR MANUFACTURING WIRE-LIKE RODS, PARTICULARLY FOR THE PRODUCTION OF ROD-LIKE ELECTRODES FOR WELDING" International publication number WO 2012/110136 A1, 23August 2012.
[3] "WIRE STRAIGHTENING AND CUTTING MECHANISM" by George W.Levi,Littleton; Patent number 4,391,307;July 5,1983.
[4] "WIRE FEEDING AND CUTTING MACHINE" by Roger J. Benedict; Craig S. Legaul;Patent number 5,570,728;November 5,1996.
[5] "WIRE STRAIGHTENING AND CUT-OFF MACHINE AND PROCESS" by Yair Wiesenfeld; Patent number US 6,705,355 B1.;March 16, 2004.
[6] "WIRE CUTTING MACHINE AND METHOD OF CUTTING WIRE SEGMENTS FROM AN ADVANCING STARND WIRE" by Michael Kern; Patent number 2008/0072721 A1.
[7] Project profile of Welding electrodes by APITCO limited;www.apitco.org.
[8] "Hand book of mechanical Design" by Maitra Prasad;TATA McGRAW HILL,Second edition.
[9] "Mechanical Engineering Design" by Shigley's;TATA McGRAW HILL.