A PROJECT REPORT

ON

"IMPROVEMENT IN SPOOLING OF WIRE ROPE"

Submitted by

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In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

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UNDER THE GUIDANCE

Of

Prof. ARSHAD QURESHI

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

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CERTIFICATE

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

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APPROVAL OF DISSERTATION

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Declaration

We declare that this written submission represents our ideas in our own words and where other ideas or words have been included, We have adequately cited and referenced the original sources. We also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the institute and also evoke panel action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

Wire rope contents dozens–even hundreds of individual wires which are formed and fabricated to move or operate at close tolerances to one another. When a wire rope bends, each of its many wires slides and adjusts to accommodate the differences in length between the inside and outside of the bend. The sharper the bend, the greater the movement this creates wrong spooling of wire rope. Ever since the development of wire rope, comprising multiple wire strands, spooling the wire has presented technical challenges. When wrapped in multiple layers, the upper layers have a tendency to crush the lower layers, while the lower layers have a tendency to pinch upper layers. The rubbing of rope against rope also has a tendency to cause wear. This paper analysis the parameters related to the spooling of wire rope like fleet angle, tension etc. This paper also presents design and analysis of rack and pinion mechanism for wire rope spooling process. For this we designed different conceptual models and analyzed them under maximum loading condition. After comparing the results best design is selected and it will be found easily possible for manufacturing and operating.

CONTENT

Chapter 01
INTRODUCTION

1.1: INTRODUCTION:

The multilayer wire rope spooling system has undergone continuous refinement over the years and adapted for any application where long lengths of steel wire ropes must be wrapped in multiple layers quickly and smoothly. Examples include: Cranes for construction sites, offshore oil rigs, ports or onboard ships, Deep mining, Oceanographic research vessels and pipe laying barges, Funicular railways and cable cars, cable-supported and cable suspended roofs, offshore drilling equipment and soaring suspension bridges.

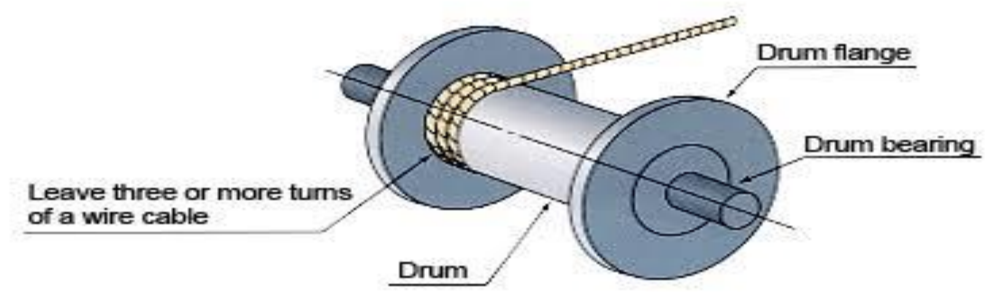


Figure 1.1: Spooling System

A common problem associated with wire rope is snagging on the winch drum, when an outer layer becomes trapped between wraps of underlying rope. Another common problem is damage to the lower layers caused by crushing from outer layers. With multiple layers of rope on a drum, the pressure on lower layers is immense. Also improper spooling induces torque within the rope, which in turn reduces the life of the rope. Wire ropes are highly loaded machine elements. When steel wire breaks it poses a serious threat to anyone nearby. It can cause great bodily injury or even death. The combination of the enormous energy and heavy weight causes recoil with incredible force. On top of that, steel wire is made up of many small steel strands, when these strands are broken they create very sharp edges. Huge force, unpredictable behavior and lots of sharp edges. A rope failure can have disastrous consequences. However most of the rope breaks can be find out during the inspection. If the wire breaks are concentrated in a very short section of the rope the rope must be discarded which increases the cost of manufacturing. Thus the optimization and selection of correct parameters such as fleet angle, wire tension, D/d ratio, speed etc plays crucial role in wire rope manufacturing industry.

Thus the optimization and selection of correct parameters such as fleet angle, wire tension, D/d ratio, speed etc plays crucial role in wire rope manufacturing industry. Because of the complexities and requirements involved, in actual practice it is preposterous to correct all the parameters simultaneously for a single process, so now a day's traverse assembly being used in India for giving directions to wire rope during the winding or spooling process. But the existing traverse assembly is inefficient and expensive.

Also failure of one component leads to shutdown of the entire system which increases idle time of machine and decreases productivity. Hence to improve and implement a new system for smooth spooling of wire rope is an undeniable and exigent need for wire rope industry.

1.2: PROBLEM DEFINITION:

Figure 1.2: Manual Operation

In wire rope making industries when the final product i.e Wire rope gets ready to dispatched , the wire rope has to be rolled over the drum surface in order to dispatched. Since it is final product it should be uniform and customer attractive. But in industries the way which is used to transfer the rope is traditional and required the new techniques in order to increase its efficiency. Apart from this one of the critical problem is in industries is uneven distribution of wire rope over the drum surface. Therefore to avoid this unavoidable circumstances one labor is engaged only for uniformly distribution of wire ropes. But this is increases man power and process would be not efficient as it is manually operated.

The problem statement given by BWR (Bharat Wire & Ropes) is Improvement in spooling system of wire ropes by applying Engineering techniques.

Chapter 02

LITERATURE REVIEW

2.1: What causes mis-spooling in the traditional method?

There are five classes of problem that either alone or in combination can cause mis-spooling. These are:

2.1.1: Wrong Fleet Angle:

If the fleet angle is too large or too small the rope will not spool correctly.

Fleet Angle: Of all the factors which have some influence on the winding of a rope on a smooth drum, the fleet angle, arguably, has the greatest effect.

Definition : " Fleet angle is usually defined as the included angle between two lines, one which extends from a fixed sheave to the flange of a drum and the other which extends from the same fixed sheave to the drum in a line perpendicular to the axis of the drum".

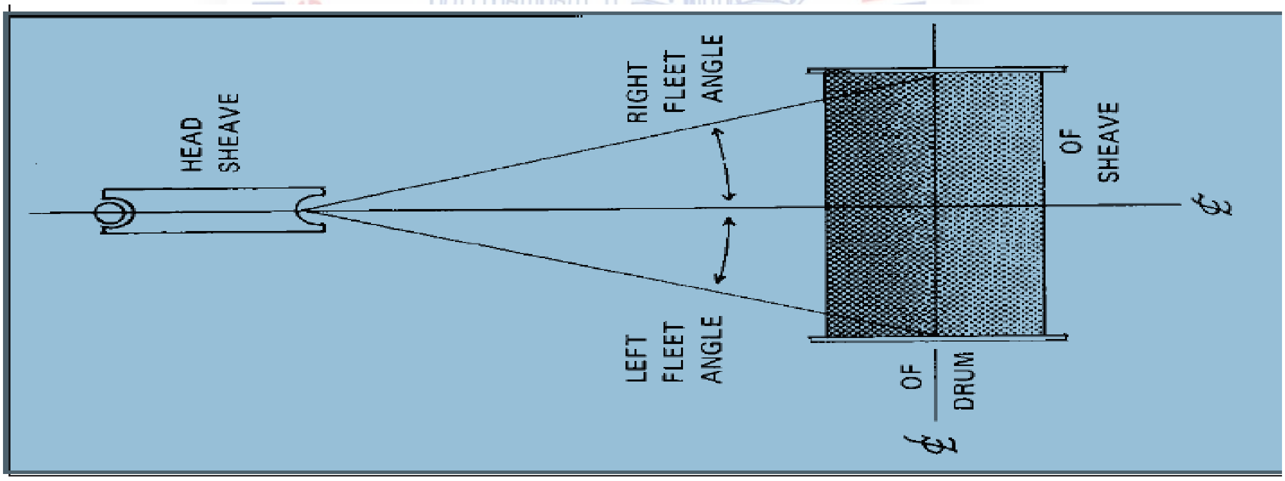
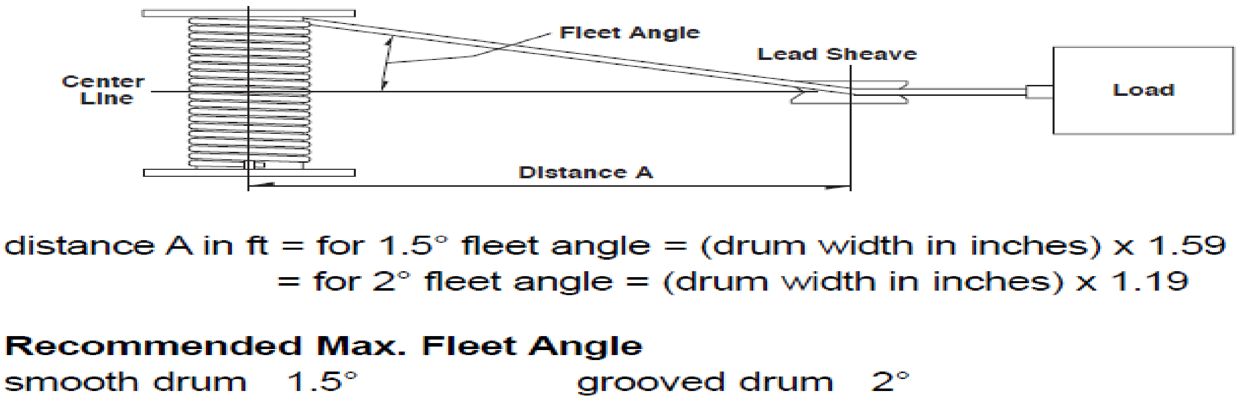


Figure 2.1.1(A): Fleet Angle

On installations where the ‘wire rope passes over a lead sheave then onto a drum, it is important that the lead sheave be located at a sufficient distance from the drum to maintain a small fleet angle at all times. The fleet angle is the side angle at which the rope approaches the sheave from the drum. It is the angle between the center line of the wire rope Experience has proven that the best wire rope services is obtained when the maximum fleet angle is not more than 1-1/2 degrees for smooth drums and 2 degrees for grooved drums.[1]

At the drum When spooling rope onto a drum it is generally recommended that the fleet angle is limited between 0.5° and 2.5°. If the fleet angle is too small, i.e. less than 0.5°, the rope will tend to pile up at the drum flange and fail to return across the drum. In this situation, the problem may be alleviated by introducing a ‘kicker’ device or by increasing the fleet angle through the introduction of a sheave or spooling mechanism.
If the rope is allowed to pile up it will eventually roll away from the flange creating a shock load in both the rope and the structure of the mechanism, an undesirable and unsafe operating condition. Excessively high fleet angles will return the rope across the drum prematurely, creating gaps between wraps of rope close to the flanges as well as increasing the pressure on the rope at the cross-over positions. Even where helical grooving is provided, large fleet angles will inevitably result in localized areas of mechanical damage as the wires ‘pluck’ against each other.



At the sheave Where a fleet angle exists as the rope enters a sheave, it initially makes contact with the sheave flange. As the rope continues to pass through the sheave it moves down the flange until it sits in the bottom of the groove. In doing so, even when under tension, the rope will actually roll as well as slide. As a result of the rolling action the rope is twisted, i.e. turn is induced into or out of the rope, either shortening or lengthening the lay length of the outer layer of strands. As the fleet angle increases so does the amount of twist. To reduce the amount of twist to an acceptable level the fleet angle should be limited to 2.5° for grooved drums and 1.5° for plain drums and when using rotation-resistant, low rotation and parallel-closed DSC 8 ropes the fleet angle should be limited to 1.5°.

2.1.2: Wrong tension:

Slack line may have worked its way down into the dead turn, causing the rope to miss a wrap by a rope being high or misplaced.

2.1.3: Wrong rope:

Mis-spooling sometimes occurs when a new rope is installed that is slightly larger in diameter than the groove pitch. Check that the rope is staying in the grooves in the first layer.

2.1.4: Wrong drum or D:d ratio:

Mis-spooling may also occur when the rope becomes worn and its diameter is reduced. Look for the rope beginning to lie low in the wraps adjacent to the drum flange and/or any cutting- in of the rope.

2.1.5 Wrong operator:

Human error. Wrong rope, wrong drum design (including wrong D:d), wrong fleet angle, tension problems, incompetent operator.

2.2: Research Work from Research paper:

2.2.1: Franklin L. Le Bus, Sr. [1] first developed A counterbalanced cable spooling system for providing a true and efficient winding of multiple layers of cable on a drum using conventional machining processes. Result signify substantially eliminated the disadvantages of prior grooving systems when counterbalanced spooling grooves on a drum core used.

2.2.2: Dr. John f. Bash [2] studied and discussed influence of fleet angle in spooling process. The author used smooth and grooved drums. Results has proven that the best wire rope services is obtained when the maximum fleet angle is not more than 1-1/2 degrees for smooth drums and 2 degrees for grooved drums.

2.2.3: Cris seidenatherm [3] Conducted multi objective optimization of parameters influence spooling process. Signify best spooling results when used spool under tension 2% to 10% of working load, D:d ratio 25:1 and fleet angle .5 to 2.5 degree.

2.2.4: Margus Tae [4] implemented Traversing mechanism driven by cam rotating grooved cam with a traversing guide running in the groove. The device removes traverse assembly in winch and drum spooling mechanism.

2.2.5: Oystein Gunnar Skalleberg [5] Designed a machine comprising a steering unit movable in a plane substantially perpendicular to the geometrical central axis of the formed coils between two end positions. Through this arrangement the steering unit can be used for guiding of the cable during the coiling process.

2.2.6: Bruce L. Butler VP [6] Implemented computerized servo driven traverse assembly for wire ropes. Enhanced accuracy and speed were obtained during spooling process.

2.2.7: Dhaivat Dholakiya [7] Designed and developed automated probe traverse mechanism which could be applied in wire rope industry for enhancement in spooling process.

2.3: Solution from research Paper:

2.3.1: Solution by managing director of Lebus International GmbH in Germany journal international cranes and specialized transport October 2007:

The smooth spooling of wire rope is critical to effective lifting and winching operations. For that certain operating conditions are required:

a) Spool under tension (2% to 10% of working load).

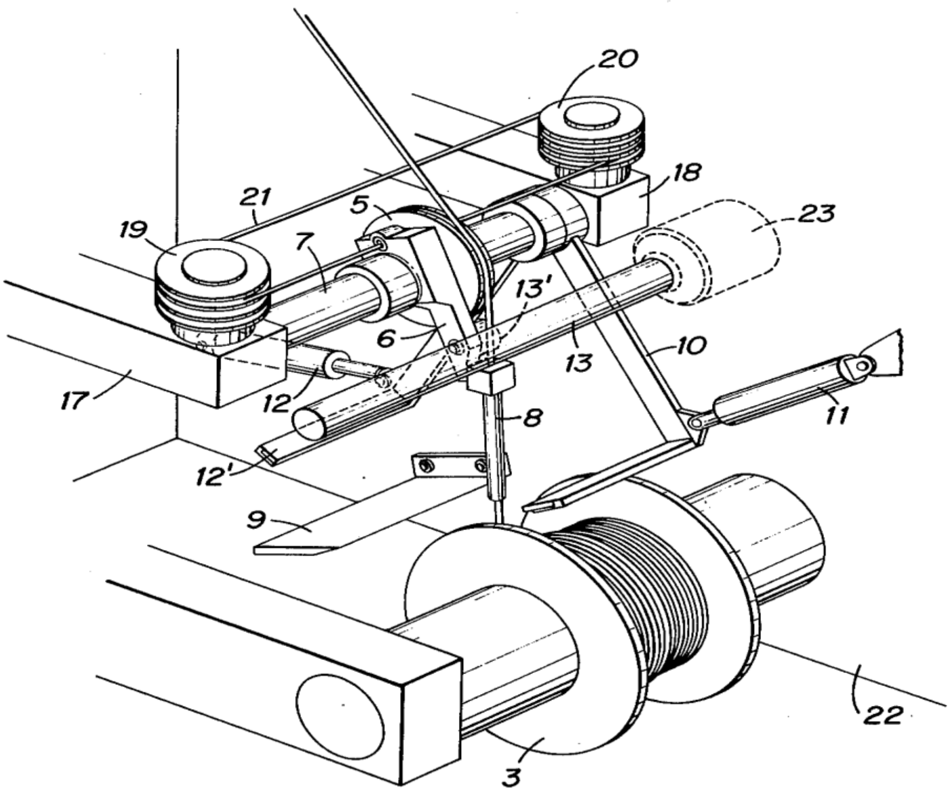
b) Correct fleet angle (.5 to 2.5 degree).

c) Correct D:d ratio (25:1).

d) Correct wire rope specification (flexible, strong, sturdy & rigid).

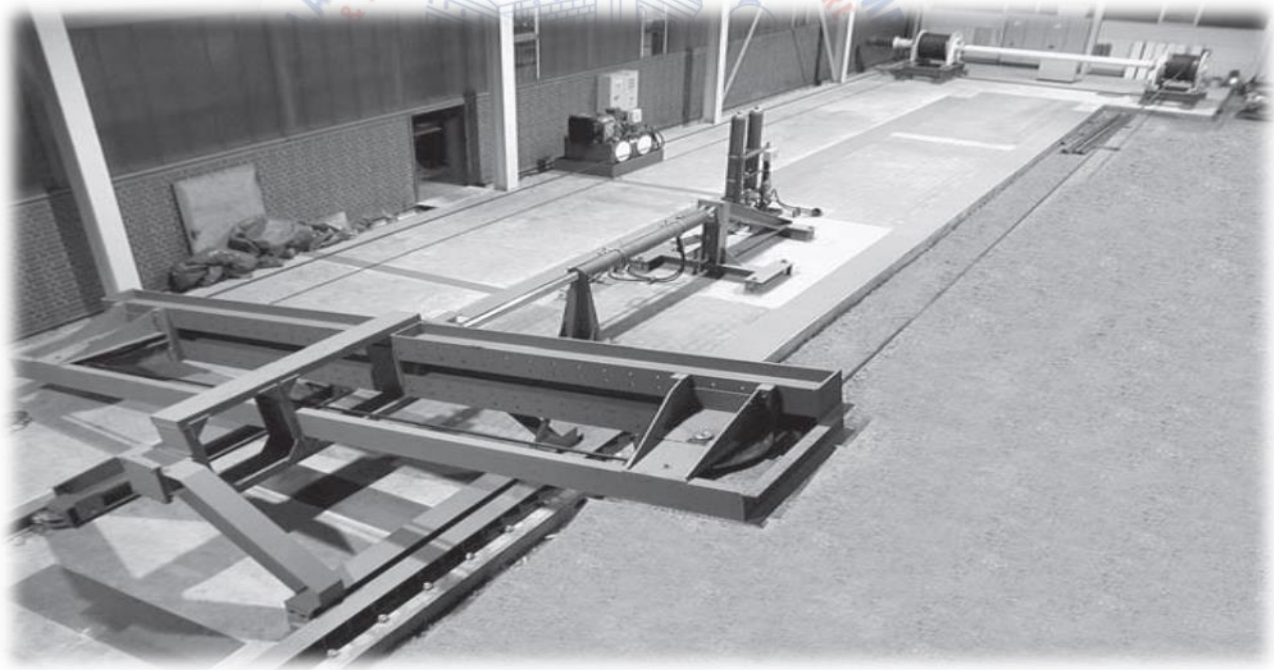
2.3.2: Solution by Oystein Gunnar Skalleberg Patent US 4026483 A May 31, 1977, Device for an apparatus for coiling of cable, wire, wire rope or the like.

A machine comprising a steering unit movable in a plane substantially perpendicular to the geometrical central axis of the formed coils between two end positions.



The invention relates to a device for an apparatus for coiling of cable, wire, wire rope or the like, preferentially an automatic coiling machine, designed for steering and cutting of the cable etc. in conjunction with its reeling on a reeling device for formation of coils. The especial characteristic of the invention is that the device contains a steering unit or cable feeding and guiding assembly which in addition to lateral reciprocatory movement thereof in a direction parallel to the axis of the take up drum is also rotatable in a plane substantially perpendicularly to the axis of the take-up drum, the assembly being effective after a coiling operation to cut the cable under action of a control unit, which forcibly brings the cable up against a knife edge Through this arrangement the steering unit can be used both for guiding of the cable etc. during the coiling and for cutting of the cable etc. the steering unit for this purpose being arranged rotatable around a revolving shaft and being displaceable along it between two end positions. The steering unit may suitably consist of a tube through which the cable etc. is fed.

2.3.3: Multi layer test strand at Casar. Two multi layer drums can be seen in the background. The rope spools from one drum to the other via the sheaves in the 45t tensioning unit in the foreground. This unit can slide, pivot and vary the fleet angles between the rope and the drums[3].



MULTILAYER TEST STRAND AT CASAR

2.3.4: Linear Motion In Winding System (Traverse assembly with a wire Guide mounted on Traversing nut): In winding machines or take up systems the traversing assembly is the component which moves the material being spooled back and forth across the spool/reel core. To achieve a finished spool with smooth, evenly spaced rows of material, it is necessary to synchronize the linear motion of the traversing nut with the rotation of the take up spool[4].

Fig. 2 Wire guide mounted on top of traversing nut.

There is a way to modify the pitch in mechanical traversing devices in order to expand the range of application. Looking again at fig. the traversing nut shaft is driven via a belt to the spool shaft. The pitch of the nut is set by moving the pitch control lever .In mechanical systems like this, regardless of spool shaft rotational speed, the traversing nut will always travel the same linear distance (pitch) per shaft revolution.

The pitch control lever affords a 10:1 pitch turndown capability. For example, if the thickest material being spooled is 0.500 inches, this system will accommodate material as thin as 0.050 inches using just the pitch control lever. This assumes the pulley wheel A and B are of equal size.

LIMITATIONS: In a mechanical system the pitch adjustment is either fixed or it is adjustable but within a limited range. In mechanical systems like this, regardless of spool shaft rotational speed, the traversing nut will always travel the same linear distance (pitch) per shaft revolution.

2.3.5: Computerized Traverse Winding For Wires and Ropes By Bruce L. Butler.

A computerized traverse utilizes "electronic gearing" to ensure the direct synchronization between winding spool and programmed traverse adjustment settings. An encoder provides a signal of the precise rotational spool position to the traverse controller which maintains the preset winding pattern from core to full diameter regardless of winding speed changes.

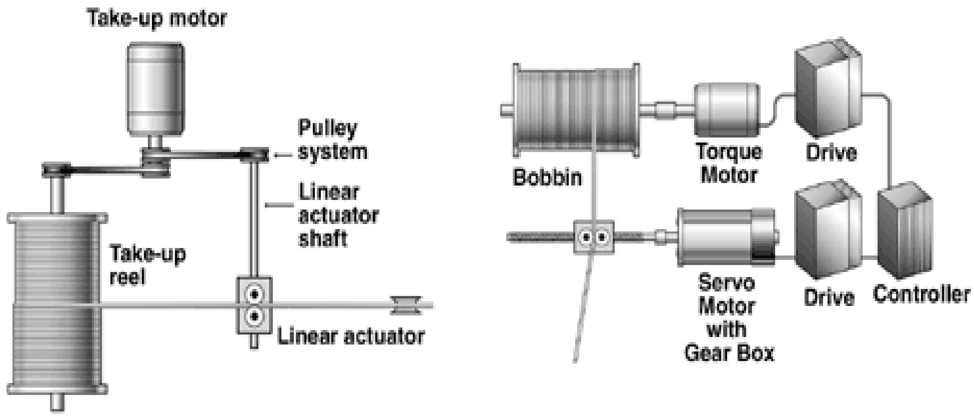


Fig.2.3.5: A mechanical system does require a controller or electronics.

A major advantage of a servo driven traverse over many mechanical assemblies is the accuracy of the "electronic gearing" which is not susceptible to over travel as a result of speed changes during winding. This over travel phenomenon is most often found in mechanical traverse units where adjustment is made through a friction type assembly.

Once the pitch setting has been established the end dwell is determined. This setting will fix the edge and will produce a flat spool across the face without an end node or concave appearance either of which may cause problems in shipping or unwinding.

2.4: OBJECTIVES:

1. To correct the parameters related to wire rope spooling process.
2. To implement simple mechanism for smooth spooling of wire rope.
3. To reduce the efforts of worker.
4. Decrease the cost of spooling process.
5. To reduce the idle time for machines and increase productivity of wire rope industry.

Chapter 03
REPORT ON PRESENT INVESTIGATION

3.1: Methodology:

We will approach to our solution by two ways :

1. Modification on traditional method.

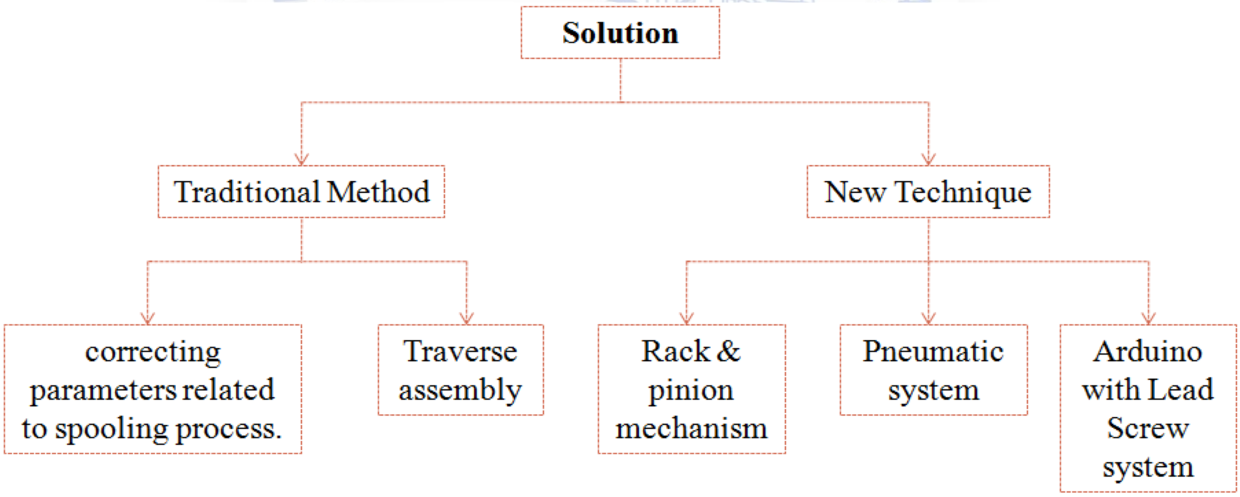
2. New method.

Modification on traditional method:

1. Briefly analysis of the existing traverse assembly and traditional method.
2. Finding the problems due to which the method is not uniform and not efficient.
3. Searching the solution to tackle the problems from the research papers.
4. If not possible then move to alternate new method.

New Mechanism :

1. Finding the solution to the given problem statement by new techniques.
2. Comparison between all methods.
3. Selection of the best suited method to the industry.
4. Fabrication of small prototype.



3.2: Rack and Pinion Mechanism for Improvement in Spooling Process:

3.2.1:Introduction:

Rack and pinion gears are used to convert rotation into linear motion. The flat, toothed part is the rack and the gear is the pinion. Rack and pinion gears provide a less mechanical advantage than other mechanisms, but greater feedback and steering sensation. A rack and pinion gear gives a positive motion especially compared to the friction drive of a wheel in tarmac. These are commonly used in the steering system of cars to convert the rotary motion of the steering wheel to the side to side motion in the wheels. They are also used in some scales to turn the dial that displays a weight.

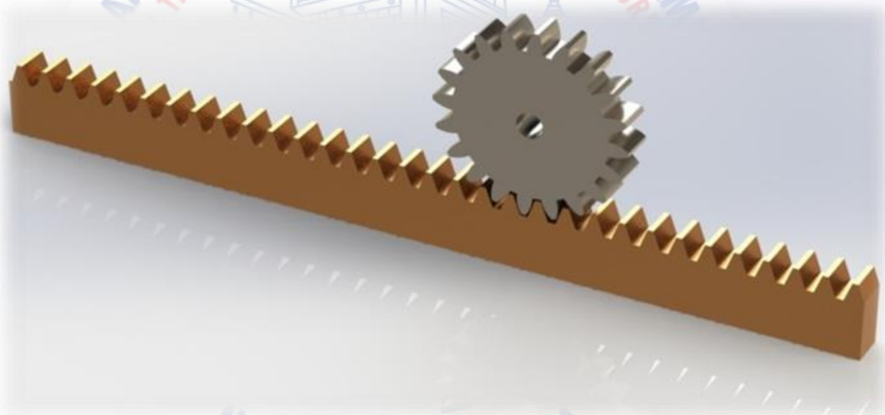


Figure 3.2.1: Simple Rack and Pinion

3.2.2: Components Used in the System:

The automatic rack and pinion prototype consists of following main parts:

Sr. N	Component	Quantity
1	Base frame	01
2	Ball Bearing	02
3	Winding Reel	01
4	Shaft	01
5	High capacity DC Motor	01
6	Rack and Pinion Set	01
7	Timing Gear	01
8	DC Motor	01
9	Rack Rail	01
10	Wire Guide	01
11	Power Supply	01
12	DPDT Switch	01
13	ON OFF Switch	01
14	Micro Switch	01

3.2.2.1: Base Frame:

To support the whole machine components and to provide rigidity to the system a Base frame is used made up of MS L angle. The frame is made enough strong in order to withstand the force generation during the motor rotation also while rack movement.

Specification :

Length	:	300mm
Width	:	450mm
Material	:	MS L Angle 25*5mm

Figure 3.2.2.1: Base Plate

3.2.2.2: Ball Bearing:

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least three races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other.

Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races.

Figure 3.2.2.2: Ball Bearing

Specification:

Type	:	Ball Bearing
Quantity	:	02

3.2.2.3: Winding Reel:

A cable reel is a round, drum-shaped object such as a spool used to carry various types of electrical wires. Cable reel which can also be termed as drums have been used for many years to transport electric cables, fiber optic cables and wire products. Cable reels usually come in four different types, each with their own uses: wood, plywood, plastic and steel.

Figure 3.2.2.3: Winding Reel

Specification:

Diameter	:	100mm
Shaft Diameter	:	12mm
Material	:	Plastic

3.2.2.4: Shaft:

Figure 3.2.2.4: Shaft

To rotate the winding wheel also to support the driven pulley a shaft is used which directly attached to the bearing and provide rotation. A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it.

Specification:

Shaft Length	:	160mm
Shaft diameter	:	12mm
Material	:	MS

3.2.2.5 High capacity DC Motor:

For the rotation of the wire drum initially high torque is required also for wire winding the power requirement is more hence high capacity motor is preferred. A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

Specification:

Type	:	DC Motor
Voltage	:	12V
Current	:	5amp
RPM	:	1000rpm

Figure 3.2.2.5: High Capacity DC Motor

3.2.2.6 Rack and Pinion Set:

A rack and pinion is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; rotational motion applied to the pinion causes the rack to move relative to the pinion, thereby translating the rotational motion of the pinion into linear motion.

Figure 3.2.2.6(A): Rack and Pinion

Figure 3.2.2.6(B): Half Gear

For example, in a rack railway, the rotation of a pinion mounted on a locomotive or a railcar engages a rack between the rails and forces a train up a steep slope. For every pair of conjugate involute profile, there is a basic rack. This basic rack is the profile of the conjugate gear of infinite pitch radius (i.e. a toothed straight edge).

For this automatic wire winding machine the requirement is continuous two and fro motion of the rack therefore there is need of special type of gear. The gear used for this purpose as shown in figure having half section of the full gear and attached in reverse direction with respect to each other.

3.2.2.7: Timing Gear:

In order to operate the pinion in opposite direction a set of gain pair called timing gear is used directly attached to the bottom side of half gear. The one gear of them is directly coupled to the dc motor and other rotates due to meshing of timing gear.

Figure 3.2.2.7: Timing Gear

Specification:

No of teeth	26
Shaft Diameter	6mm
Material	Nylon

3.2.2.8: DC Motor:

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line. DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications. A coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. The direction and magnitude of the magnetic field produced by the coil can be changed with the direction and magnitude of the current flowing through it.

A simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes. (Brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes.) The total amount of current sent to the coil, the coil's size and what it's wrapped around dictate the strength of the electromagnetic field created.

The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a force on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor.

At high power levels, DC motors are almost always cooled using forced air. Different number of stator and armature fields as well as how they are connected provide different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems which adjust the voltage by "chopping" the DC current into on and off cycles which have an effective lower voltage. Since the series-wound DC motor develops its highest torque at low speed, it is often used in traction applications such as electric locomotives, and trams. The DC motor was the mainstay of electric traction drives on both electric and diesel-electric locomotives, street-cars/trams and diesel electric drilling rigs for many years. The introduction of DC motors and an electrical grid system to run machinery starting in the 1870s started a new second Industrial Revolution.

Figure 3.2.2.8: DC Motor

3.2.2.9: Rack Rail:

A Rack rail, or rack strip, is used to mount rack-able electronic hardware and 19-inch rack mount accessories within a 19-inch rack. Within a rack a minimum of two rack rails are required to mount equipment. The height of rack rail is determined by the number of rack units required for mounting the equipment. Rack Rail comes in two different commonly used forms. Tapped/threaded rack rail has round holes tapped for 10/32 UNF screws. The other common form of rack rail is square hole rack strip which has square holes for M6 captive nuts that are clipped into the holes as needed to mount equipment.

In both cases, rack screws and washers are required to mount rack mount equipment to the rack rail. The size and strength of rack rail is determined by its application. Increased thickness of steel results in stronger rack rail and varieties of rack rail can be found such as double angle and single angle rack rail.

Figure 3.2.2.9: Rack Rail

3.2.2.10: Wire Guide:

For the to and fro movement of wire the rack and pinion is attached with wire guide generally provided with bearing. The wire guide is attached to a circular shaft and rotates on bearing to facilate the flow of wire.

Figure 3.2.2.10: Wire Guide

3.2.2.11: Power Supply:

In 360 degree rotating arm the DC motor is used therefore there is need to convert the available AC supply to the required DC supply in order to reduce the voltage and amplify the current a DC power supply is used.

Figure 3.2.2.11: Power Supply

Specification:

Input Voltage	230V AC
Output Voltage	12V DC
Output Current	2Amp

3.2.2.12: DPDT Switch:

In order to have reverse and forward movement of the arm it is required that the polarity to the DC motor must be reversed. Therefore to switch the polarity without inverting the motor connections a three way DPDT (double-pole, double-throw) switch is used. Which is directly connected to the motor from one side and from other side a power supply is connected.

Figure 3.2.2.12: DPDT Switch

3.2.2.13: Push Button Switch:

As the motion of DC motor can be reversed by operating the DPDT switch but the motion is continuous as we shift the position of DPDT switch. To rotate the pneumatic arm in precise motion it is necessary that the supply must be made when it is required. Therefore a push button type switch is used which is spring return and normally closed type. When the motion of arm is required the push button is pressed and the arm starts moving and as the push button is released the arm stops the motion.

Figure 3.2.2.13: Push Button Switch

3.2.3: WORKING:

3.2.3.1: Working of Linear Motion:

The mechanism requires two pinion to provide reverse motion in clockwise and anti-clockwise direction. Both pinion engagement and dis-engagement time synchronized so that either pinion will attach to the rack at a time. The first pinion gets engaged with the rack and rotates in clockwise direction providing linear motion to the rack in horizontally right x-direction until the first pinion gets dis-engaged with the rack. The second pinion completes its rotation in opposite side of the rack than engages with the rack rotating in anticlockwise direction provides horizontally left x-direction motion to the rack. This mechanism provides continuous linear forward and reverse motion of the rack.

Figure 3.2.3.1: Rack and Pinion Arrangement

3.2.3.2: Actual Working of the System:

When the wire comes out after stranding process it is manually first attached to the drum for providing desired tension. Then switch is pressed which start motors which in turn rotate drum as well as actuates the gear mechanism. The speed of motors is such maintained that when drum completes one rotation the rack will also moved by one teeth which continue providing uniform layer of wire on the drum. At the extreme end the second pinion gets engaged with the rack and starts the winding of second layer of wire rope above first layer in reverse direction. this process continuous to provide uniform and smooth spooling of wire rope on the drum. To stop the machine one limiting sensor is provided if the layers of the wire rope reach the clearance limit of the drum X (clearance as calculated above) It transmits the signals to the limiting switch which stops the motors.

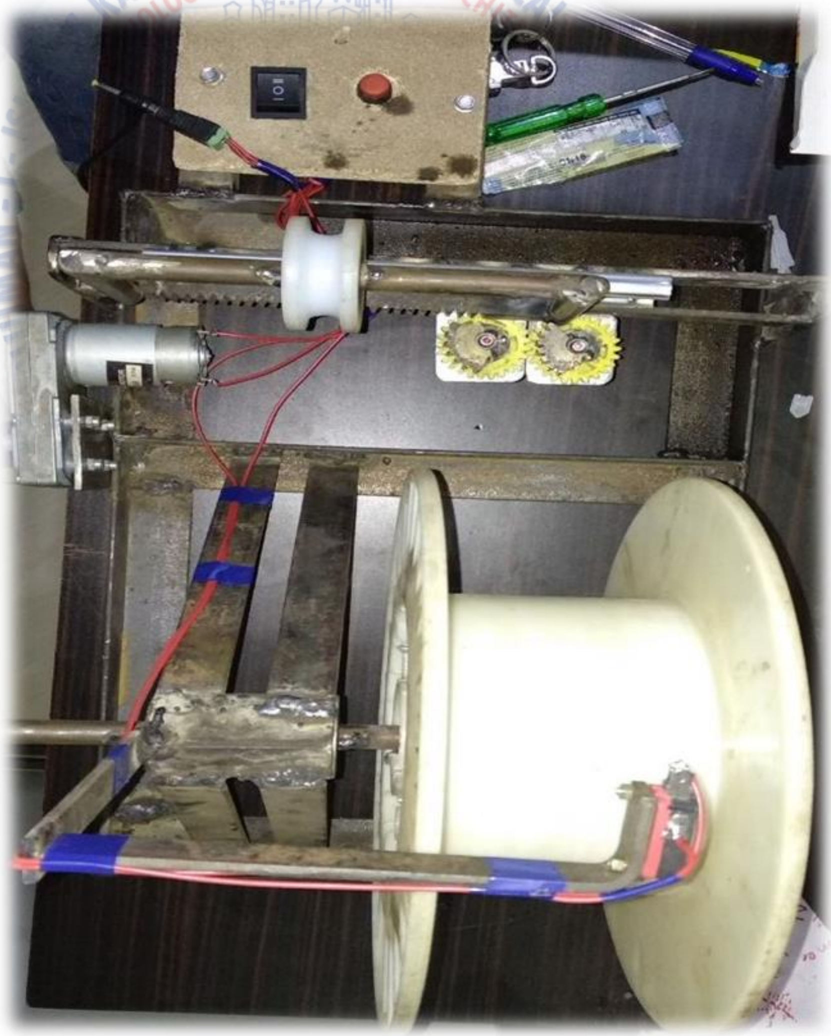


Figure 3.2.3.2: Top View of the System

3.2.4: CALCULATION:

3.2.4.1:. Rope Design:

Every wire has three basic components: the wires, strands and core. The core may be either fiber (FC) such as sisal, manila or jute, or an Independent Wire Rope Core (IWRC), which is actually a smaller wire rope within the strands of the outer wire rope. The wires are predominantly constructed from high-carbon steel, but may also be formed from various metals such as iron, stainless steel, monel or bronze. Carbon steel wire rope is manufactured in various grades, including Improved Plow Steel (IPS), Extra Improved Plow Steel (EIPS) and Extra Improved Plow Steel (EEIPS), which designate the nominal strength of the wire rope. EIPS is the most commonly used and manufactured grade today.

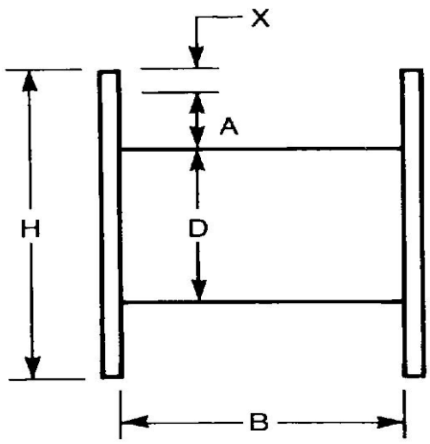
Wire rope generally comes with a "bright" or uncoated finish but several other options are available. A galvanized, zinc coating, a tin coating or a synthetic coating such as vinyl or nylon may also be applied to the rope's surface. Ropes with plastic coatings and plastic-filled interiors are also obtainable. It should be noted that these coatings can affect the characteristics and breaking strength of the wire rope. Wire ropes are identified by classifications based upon the number of strands and nominal number of wires in each strand. A 6 x 19 classification for example, includes six strands with each strand consisting of 15-26 individual wires. The six strands of a 6 x 37 class wire rope are constructed of 27-49 individual wires. Other popular classifications include 19 x 7, 7 x 19 and 8 x 19.

All the calculations obtained in consideration with the prototype model which can be used to determine the parameters required for implementation of actual system in wire rope industry.

3.2.4.2: Reel Design:

It is virtually impossible to calculate the precise length of wire rope that can be spooled on a reel or drum. The formula below provides a sufficiently close approximation based on uniform wire rope winding on the reel.

$$L = (A+D) \times A \times B \times K \quad (1)$$



L = length of wire rope in feet.

A = depth of rope space on reel in inches

B = width of drum between flanges in inches.

D = barrel diameter in inches.

K = constant for given wire rope diameter.

H = diameter in reel flange in inches.

X = clearance.

X = 0.78472 , A = 1.5748 inch , B = 3.54331 inch ,

D = 4.72441 inch,

K = 8.72 (for wire dia = 4mm) , H = 9.44882 inch.

L = (1.5748 + 3.54331) × 4.72441 × 8.72 × 9.44882

L = 306.504 feet = 93.422 m.

3.2.4.3: Pinion Design:

Material- Mild Steel

$\sigma b = 160\ N/mm^2$, BHN Number = 130 , Zp = 20

$$Yp = 0.154 - \frac{0.912}{20} = 0.1084$$

3.2.4.3.1: Beam Strength:

$Fb = \sigma b.\ b.\ m.\ Yp$

$Fb = 160 \times 10m \times m \times 0.1084$

$Fb = 173.44\ m^2$, N

3.2.4.3.2: Wear Strength:

$Fw = dp \times b \times Q \times K$ PSG 8.51

$$Q = \frac{Zg}{zg + zp} = \frac{20}{20+20} = 0.5$$

$K = 0.16 \times (B.H.N/100)^2$

$= 0.2704$

$Fw = (m \times zp) \times b \times Q \times K$

$= (m \times 20) \times 10m \times 0.5 \times 0.2704$

$Fw = 20.7\ m^2$, N

$$V = \frac{\pi .dp.\ Np}{60 \times 1000} = \frac{\pi \times 20\ m \times 20}{60 \times 1000}$$

$= 0.0209\ m$, m/s.

Assume , Kv = 1

$$Ft = \frac{P}{V} = \frac{0.052}{0.0209\ m} = 2.488/m\ \ N/mm^2$$

$$F_{eff} = \frac{Ka \cdot Km \cdot Ft}{Kv}$$

$$= \frac{1 \times 1.2 \times 2.488/m}{1}$$

F_{eff} = 2.37708/m , N

Considering F.O.S = 1.5,

Fb = F.O.S. x F_{eff}

173.44 m^2 = 1.5 x 2.488/m

m = 2.5 mm.

dp = m x zp = 2.5 x 20

dp = 50 mm.

Results:

Module	2.5 mm
Diameter	50 mm

3.2.4.4: Rack Design :

Material- Mild Steel

Np = No of teeth on pinion = 7

N_R = No of teeth on rack = 26

Pressure angle = α = 20^o

Pitch circle dia = Dp = Np × m = 7 × 2.5 = 17.5 mm.

Torsional movement = Mt = Ft × Dp = 266 × 17.5

Mt = 4.6547 Nm.

RESULTS:

Material	**Mild Steel**
Np = No of teeth on pinion	7
NR = No of teeth on rack	26
Module	2.5 mm
Diameter	50 mm
α = Pressure angle	20
Dp = Pitch circle dia	17.5 mm
Mt = Torsional movement	4.6547 Nm

3.2.5: Advantages:

1. The reversing mechanism of traverse assembly is inefficient and troublesome which gets smooth and efficient by using this mechanism.
2. Use of electronic components are eliminated which reduces life of the device.
3. Reduces cost of implementation and maintenance of traverse assembly.
4. Utilizes simple mechanical components which have long life and can be manufactured easily.
5. Implements simple mechanism for smooth spooling of wire rope.
6. Reduction in idle time of machines will have great effect on overall productivity of wire rope industry.

3.2.6: Disadvantages:

1. The variation of speed is not continuous for different diameters of wire rope.
2. Cutting and manufacturing gear teeth is expensive.
3. Sudden inertia forces due to meshing and un meshing can lead to wear and tear of gear teeth.
4. Programmable controllers are required to provide continuous variation in speed.

3.3: Electro-Pneumatic system for Improvement in Spooling Process:

3.3.1: Introduction:

The electro-pneumatic action is a control system for pipe organs, whereby air pressure, controlled by an electric current and operated by the keys of an organ console, opens and closes valves within wind chests, allowing the pipes to speak. This system also allows the console to be physically detached from the organ itself. The only connection was via an electrical cable from the console to the relay, with some early organ consoles utilizing a separate wind supply to operate combination pistons.

Figure 3.3.1(A): Electro Pneumatic System

When an organ key is depressed, an electric circuit is completed by means of a switch connected to that key. This causes a low-voltage current to flow through a cable to the windchest , upon which a rank, or multiple ranks of pipes are set. Within the chest, a small electro-magnet associated with the key that is pressed becomes energized. This causes a very small valve to open. This, in turn, allows wind pressure to activate a bellows or "pneumatic" which operates a larger valve. This valve causes a change of air pressure within a channel that leads to all pipes of that note. A separate "stop action" system is used to control the admittance of air or "wind" into the pipes of the rank or ranks selected by the organist's selection of stops, while other ranks are "stopped" from playing. The stop action can also be an electro-pneumatic action, or may be another type of action This pneumatically assisted valve action is in contrast to a direct electric action in which each pipe's valve is opened directly by an electric solenoid which is attached to the valve.

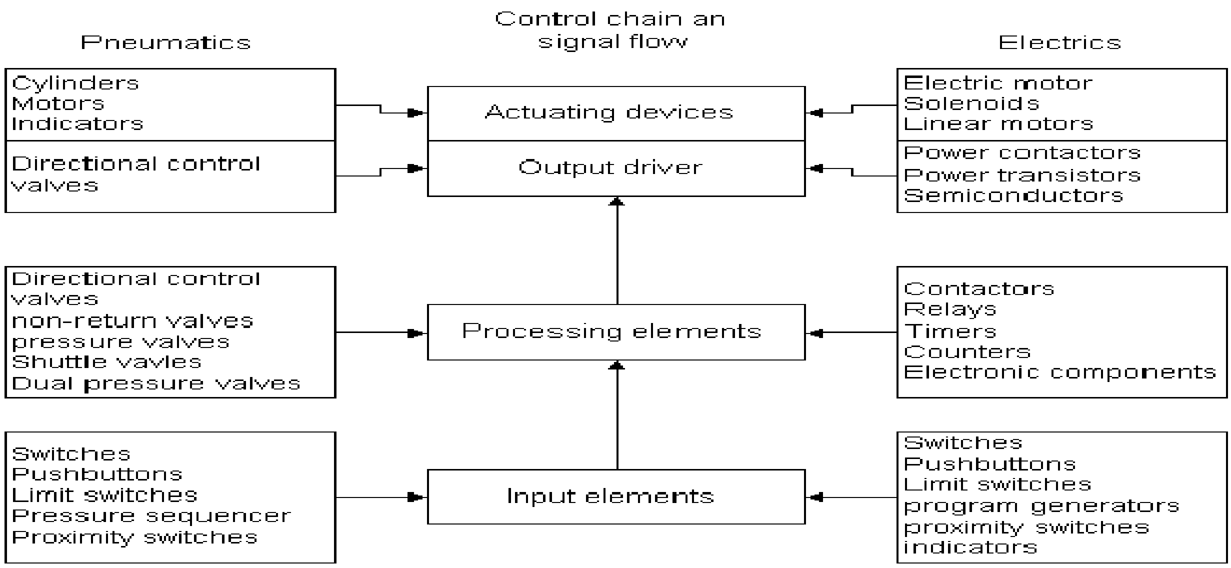


Figure 3.3.1(B): Block Diagram

3.3.2: Construction of the prototype:

The automatic electro-pneumatic system consists of following main parts except which stated above:

1) Pneumatic cylinder

Pneumatic cylinder (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Like hydraulic cylinders, something forces a piston to move in the desire direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage. Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement.

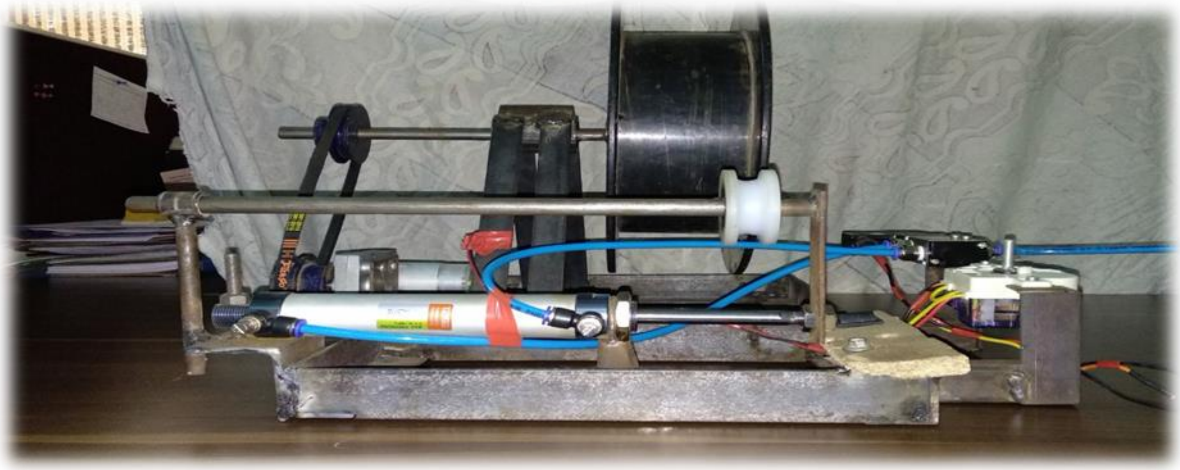


Figure 3.3.2: Construction of Pneumatic System

3.3.3: Double-acting cylinders:

Double-acting cylinders (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for in-stroke. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending. Additional calculations should be performed as well.

Figure 3.3.3: Double Acting Cylinder

3.3.4: Washing machine timer:

Since their introduction, automatic washing machines have relied on electromechanical timers to sequence the washing and extraction process. Electromechanical timers consist of a series of cams on a common shaft driven by a small electric motor via a reduction gearbox. At the appropriate time in the wash cycle, each cam actuates a switch to engage or disengage a particular part of the machinery (for example, the drain pump motor). One of the first was invented in 1957 by Winston L. Shelton and Gresham N. Jennings, then both General Electric engineers. The device was granted US Patent 2870278.

On the early electromechanical timers, the motor ran at a constant speed throughout the wash cycle, although it was possible for the user to truncate parts of the program by manually advancing the control dial. However, by the 1950s demand for greater flexibility in the wash cycle led to the introduction of more sophisticated electrical timers to supplement the electromechanical timer. These newer timers enabled greater variation in functions such as the wash time. With this arrangement, the electric timer motor is periodically switched off to permit the clothing to soak, and is only re-energized just prior to a micro-switch being engaged or disengaged for the next stage of the process.

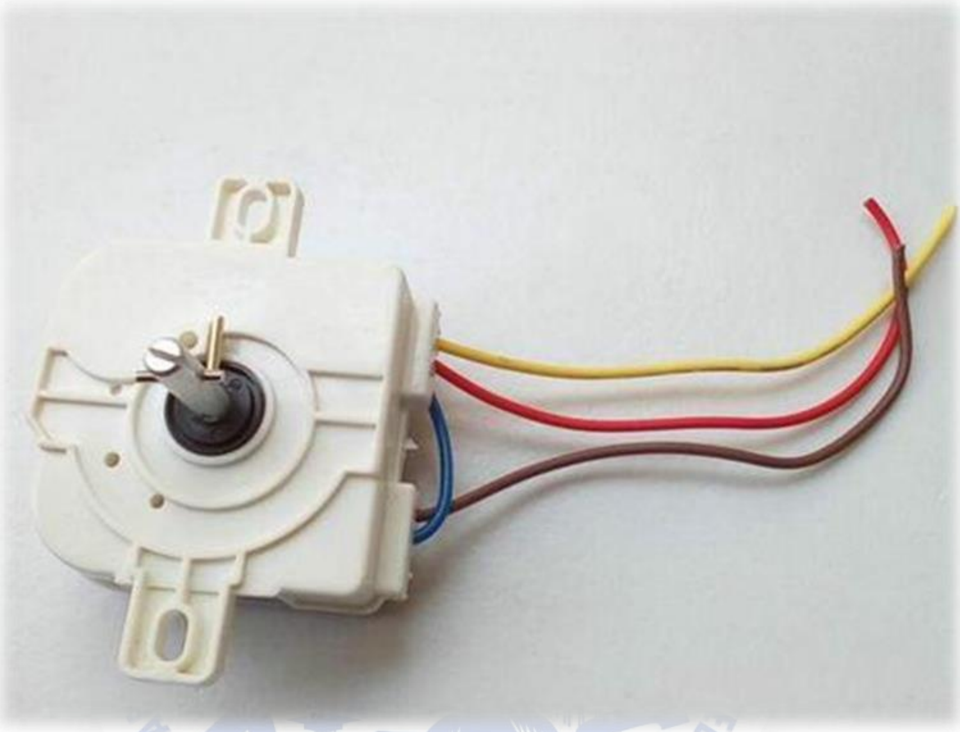


Figure 3.3.4: Washing Machine Timer

3.3.5: SOLENOID VALVE :

A solenoid valve is an electromechanical controlled valve. The valve features a solenoid, which is an electric coil with a movable ferromagnetic core in its centre. This core is called the plunger. In rest position, the plunger closes off a small orifice. An electric current through the coil creates a magnetic field. The magnetic field exerts a force on the plunger. As a result, the plunger is pulled toward the centre of the coil so that the orifice opens. This is the basic principle that is used to open and close solenoid valves.

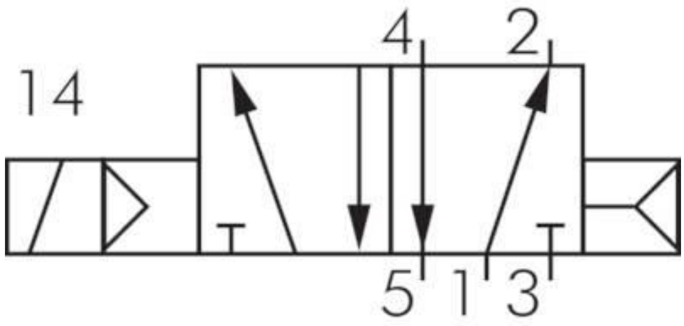


Figure 3.3.5(A): 5/2 Solenoid Valve

In the Illustration given, a single solenoid is used and a spring return is installed in the other end. The inlet pressure is connected to (P)1. (A)2 could possibly be connected to one end of the double acting cylinder where the piston will retract while (B)4 is connected to the other end that will make the piston extend. The normal position when the solenoid is de-energized is that the piston rod is blocking (B)4 and pressure coming from (P)1 passes through (A)2 that will make the cylinder normally retracted. When the solenoid is energized, the rod blocks (A)2 and pressure from (P)1 passes through (B)4 and will extend the cylinder, and when the solenoid is de-energized, the rod bounces back to its original position because of the spring return. (E)3 and (E)5 is condemned or used as exhaust.

Figure 3.3.5(B): 5/2 Solenoid Valve

3.3.6: WORKING OF ACTUAL MODEL :

The mechanism work when the pressurized air from the compressor goes to the cylinder through 5/2 solenoid valve and pushes the piston outside the cylinder so that the sheave covers the distance equal to the length of the cylinder at that time the timer used, switches off the electronic circuit so that the valve returns to its mean position then the timer starts the circuit so the piston moves forward similarly the cycle continuous till the timer returns to its position. The air from the cylinder goes to atmosphere from the solenoid valve passing through tubes when the piston is in opposite direction.

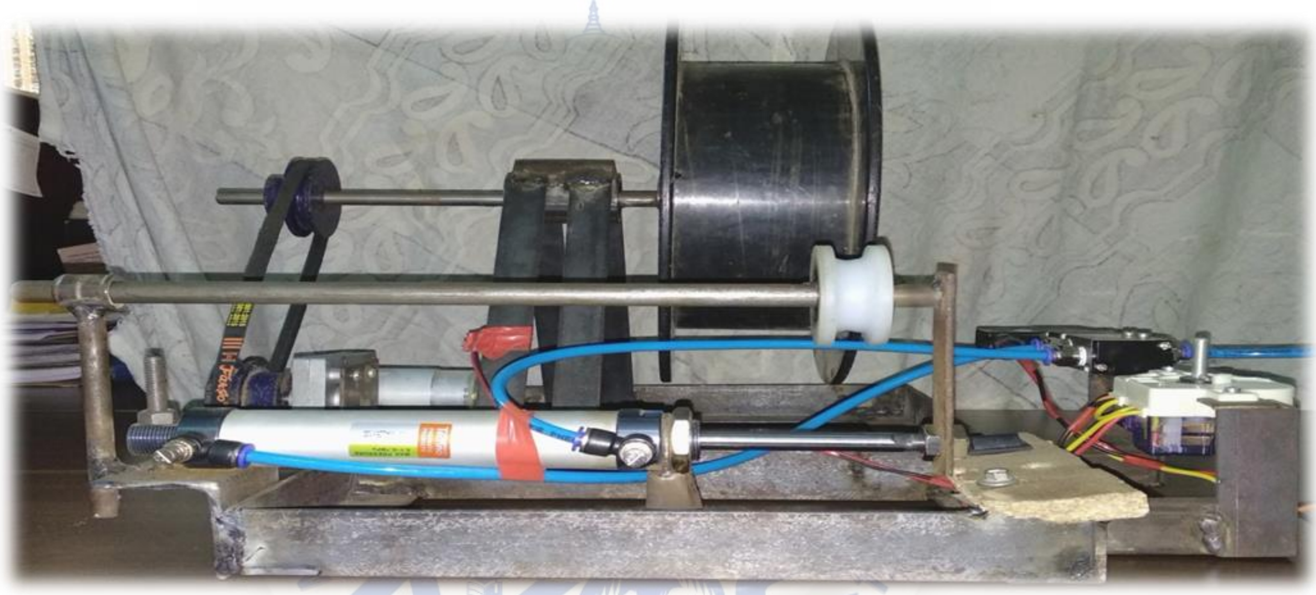
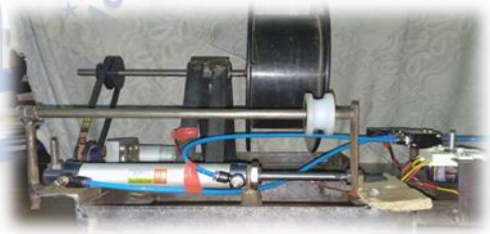


Figure 3.3.6: Actual Prototype Model

3.3.7: Advantages:

1) It is simple as compare to the Rack and pinion mechanism.
2) The main and best advantage is , we can control the speed of the cylinder by adjusting the pressure of air and the knob on the cylinder so that it can uniform different diameter of wires also
3) It does not require any external mechanism to reverse the motion like limiting switch, etc.

3.3.8 Comparison between Rack and pinion and Pneumatic System:

Sr. No.	Parameters	Rack and Pinion Method	Pneumatic Method
01	Linear Motion	In this Method Rack and pinion arrangement can be achieved by rack and pinion arrangement.	In this Method Rack and pinion arrangement can be achieved by Pneumatic cylinder.
02	Reverse Linear Motion	For reverse linear motion the first half is disengaged and second half gear engaged simultaneously to move the rack in reverse direction.	For reverse motion the solenoid valve gets trigger to release the air pressure.
03	Costly Components	Cost increases due to manufacturing of half gear.	Cost increases due to use of compressor.
04	Achieving Variable Speed	By changing the motor or advancement in motor the variable speed can be achieved.	By regulating the air pressure variable speed can be achieved.
05	Spooling of different wire rope	Changes in the speed of motor is difficult so the spooling of different size wire ropes.	By regulating the compressor the spooling process of different size wire rope is easy.
06	Diagram		

Chapter 05

USED MATERIALS AND THEIR PROPERTIES

The materials used in this project are detailed as follows

- **FERROUS MATERIALS:**

A) Mild steel – EN – 4 to EN – 6

Carbon – 0.15% to 0.35%

Tensile strength –1200/1420MPA

Yield strength – 750/1170 MPA

B) C30 Carbon – 0.25% to 0.35%

Tensile strength – 620 MPA

Yield strength – 400 MPA

Izod Impact Value – 55 Nm

% Minimum Elongation – 21

Typical composition — Carbon – 0.25% to 0.35%

Manganese – 0.60% to 0.90%

BHN – 207

C30 material is generally used for cold formed levers, hardened and tempered tie rods, Cables, Sprockets, Hubs and Bushes –Steel Tubes.

C) 40C8 Carbon – 0.25% to 0.35%

Tensile strength – 620 MPA

Yield strength – 400 MPA

Izod Impact Value – 55 Nm

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Chapter 06

COST ESTIMATION

6.1 COST OF MATERIAL

Sr. N	Part Name	Weight	Rate/kg	Total Cos
1	Base frame	3 kg	60	**180**
2	Bearing Mounting	2 kg	60	**120**
3	Reel Shaft	1kg	60	**60**
4	Motor Mounting plate	0.5 kg	60	**30**
5	Rack Slide Assembly	1.5 Kg	60	**90**
6	Wire Guide Assembly	0.5 kg	60	**30**
7	Plywood for circuit		50	**50**
			Rs.	**560 /-**

6.2 COST OF MACHINING:

Sr. No	Part	Time	Rate/hr	Total Cost
1	Power Hacksaw	210 min	360	**1560 /-**
2	Grinding Machine	140min	200	**470/-**
3	Drilling m/c	40 min	200	**150/-**
4	Welding m/c	140 min	350	**820 /-**
5	Soldering m/c	50 min	100	**100 /-**
			Rs.	**3100 /-**

6.3 COST OF STANDARD PARTS

Sr. No	Part	Quantity	Rate/unit	Total Cost
1	High Capacity Gear Motor	1	1500	**1500**
2	DC Motor	1	120	**120**
3	Small Pulley	1	100	**100**
4	Big Pulley	1	120	**120**
5	Ball Bearing	02	40	**80**
6	Wire Reel	01	250	**250**
7	Belt	1	120	**120**
8	Metal Gear	2	200	**400**
9	Nylon Gear	2	80	**160**
10	Metal Rack	1	300	**300**
11	Rack Slide	1	300	**300**
12	DC Motor Mounting	2	20	**40**
13	DPDT Switch	1	30	**30**
14	ON OFF switch	1	30	**30**
15	Power Supply	1	320	**320**
16	Flexible Wire	4m	15	**60**
			Rs.	**3930 /-**

6.4 OTHER COST

Sr. No	Details	Total Cost
1	Transport	**500**
2	Other/overhead	**1000**
	Rs.	**1500/-**

Chapter 07

CONCLUSION

This project presents the study of the design and analysis of special rack and pinion mechanism and electro-pneumatic system also evaluates the parameters related to smooth spooling of wire rope. The study gives the new design which efficiently removes the complexities involved in traverse assembly for smooth spooling of wire rope. This type of mechanism can be implemented in actual industry with calculation modification.

Chapter 08

FUTURE SCOPE

1. Both the mechanisms can be modified and used for large scale production process.
2. By using arduino a logic control can be provided to the traverse assembly which can provide controlled output of speed ratio by taking input data such as D:d ratio, Rope Dia, Wire tension etc.
3. Further research and modification can be done on the basis of above given prototypes.

Chapter 09

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