Design Analysis and Fabrication of Automatic Chain Link Fencing Machine

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Abstract- *Fences can be defined as arrangement that provides an obstruction, enclosure, or a boundary, made up of posts or stakes linked together by boards, wire, or rails. The chains run vertically and are bent into a zigzag pattern so that each "zig" hooks with the wire immediately on one side and each "zag" with the wire immediately on the other. Now a days in rural areas conventional methods of manufacturing of wire fencing are used, in which wire fences are produced by manual operated chain link fencing machine. In manual operated chain link fencing machine first wires are cut in required dimension and then it is woven into each other manually. In this project attempt of Conversion of manual operated chain link fencing machine into automatic chain link fencing machine is done. The manufacturing of chain-link fencing is called weaving. A metal wire, frequently galvanized to reduce corrosion, is pulled along a rotating long and flat blade, thus making a somewhat flattened spiral. The spiral continuously rotate passing the blade and winds its way through the previous spiral that is part of the produced fence. When the spiral reaches the distant end of the fence, the spiral is cut near the blade. Then the spiral is pressed flat and the whole fence is moved up, ready for the next cycle. The end of each second spiral joins the end of each first spiral. The machine clamps both ends and gives them a few twists. This makes the links permanent.*

Keywords- Fencing, Galvanisedwire, Wire mesh, Automtic Chain Link.

I. INTRODUCTION

A fence is a arrangement that encircles a space, typically exterior, and is usually created from posts that are connected by panels, wire, railings or mesh. A fence varies from a wall is not having a rock-solid foundation along its entire span. A chain-link fences usually made from galvanized steel wire. The manufacturing of chain-link fencing is called weaving. A metal wire frequently galvanized to reduce corrosion, is pulled along a rotating long and flat blade, thus making a somewhat flattened spiral. The spiral continuously rotate passing the blade and winds it through the previous spiral that is part of the produced fence. When the spiral reaches the distant end of the fence, the spiral is cut near the blade. Then the spiral is pressed flat and the whole fence is moved up and ready for the next cycle. The end of each second spiral joins the end of each first spiral. The machine clamps both ends and gives them a few twists. This makes the links permanent.

An enhanced version of the weaving machine winds two wires around the blade at once, thus creating a double helix. One of the spirals is woven through the last spiral that is part of the already produced fence. This progress allows the process to advance twice as fast.

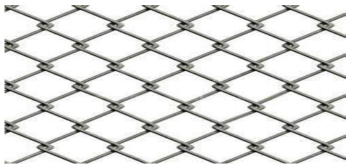

Figure 1. Fencing.

Typically, chain-link mesh is available in 3- to 12-foot heights. The different types of chain-link fencing revolve around the differences in wire. Available in stainless steel, galvanized steel and PVC coating, the wire chain-links are most often coated with zinc to prevent corrosion of the metals, leading to rust.

II. LITERATURE REVIEW

D. Pons, G. Bayley, R. Laurenson, M. Hunt, C. Tyree, D. Aitchison carried out research on “Wire Fencing: Determinants of Wire Quality” in this they studied about Knotted wire fences which are fabricated on specialised machines. The input material is typically galvanised steel wire. However, the quality of the input wire used by the Fence Producer is beyond control of the Machine Manufacturer. In this problem is that wire strand breakages have been identified during fabrication and subsequent field erection.[1]

DirkJ.Pons,GarethBayley,ChristopherTyree,Matthew Hunt,andReubenLaurenson Aitchison carried out research on “Material Properties of Wire for the Fabrication of Knotted Fences” in this they studied about the materials properties of galvanised fencing wire, as used in the fabrication of knotted wire fences. A range of physical properties was inspected: tensile strength, ductility in tension, Young's modulus, three point bending, and bending span.[2]

Sebastian Balos , Vencislav Grabulov, Leposava Sidjanin, Mladen Pantic carried out research on "wire fence as applique armour"in this they studied about the behaviour of wire fence. In this wire fences used was made from commercial high-strength patented wire and the supporting frames were made of mild steel L-profile were tested.[3]

Nurudeen A. Raji, Oluleke O. Oluwole carried out research on "Influence of Degree of Cold-Drawing on the Mechanical Properties of Low Carbon Steel"in this they studied about the Influence of Degree of Cold-Drawing on the Mechanical Properties of Low Carbon Steel. A 0.12%w C steel wire cold drawn progressively by 20%, 25%, 40% and 50% was checked. The influence of the degree of cold drawing on the mechanical properties of the carbon steel material were studied using the tensile test, impact test and hardness test experiments in order to replicate the service condition of the nails.[4]

Arshpreet Singh, Anupam Agrawal was studied about Comparison of deforming forces, residual stresses and geometrical accuracy of deformation machining with conventional bending and forming in this they studied about the Deformation machining. Deformation machining is a combination of thin structure machining and single point incremental form-ing/bending.[5]

Junichiro Tokutomia,, Kenichi Hanazaki, Nobuhiro Tsuji , Jun Yanagimoto carried out research on Change in mechanical properties of fine copper wire manufactured by continuous rotary draw bending process in this they studied about The mechanical behaviours of Cu–Sn alloy wire specimens processed by the newly proposed method of rotary draw bending are systematically investigated, It was found that during draw bending, the Vicker hardness(HV) was lower than that of the specimen subjected to wire drawing, particularly on the inside of the bend, and it was confirmed that the softening induced by plastic deformation is promoted by increasing the compressive residual energy.[6]

Christina Umstatter carried out research on "The evolution of virtual fences"in this they studied about virtual fences.A virtual fence can be defined as a structure serving as an enclosure, a barrier, or a boundary without a physical barrier.[7]

Siavash Rezazadeh and Jonathan W. Hurst carried out research on the Optimal Selection of Motors and Transmissions for Electromechanical and Robotic Systems With regard to the important role of motors and transmissions in the performance of electromechanical and robotic systems, this paper intends to provide a solution for the problem of selection of these components for a general load case.[8]

III. PROBLEM DEFINATION

Now a days in rural areas conventional methods of manufacturing of wire fencing are used, in which wire fences are produced by manual operated chain link fencing machine. In manual operated chain link fencing machine first wires are cut in required dimension and then it is woven into each other manually. Also in manual operated chain link fencing strength of wire is not uniform. In this project attempt of Conversion of manual operated chain link fencing machine into automatic chain link fencing machine is done. Here we are going to manufacture chain link fences automatically.

IV. OBJECTIVES

- Design of fencing machine.
- Analysis of component and check stress induced in it.
- Fabrication of automatic chain link fencing machine.

V. METHODOLOGY

Figure 2. Flowchart of Methodology of project.

VI. WORKING PRINCIPAL

Working of fencing is based on the basis of five mechanisms-

1) Wire bending mechanism
2) Wire fencing mechanism
3) Wire cutting mechanism

1. Wire Bending Mechanism –

Wire bending mechanism consist of two Assembly–

a. Wire tensioner assembly

When wire pull by bending mechanism tensioner maintain the tension on wire avoid shocks and fluctuation generated during the bending.

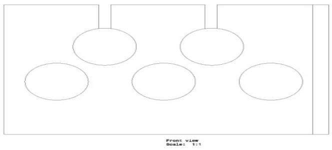

Figure 3. Wire Tensioner Assembly

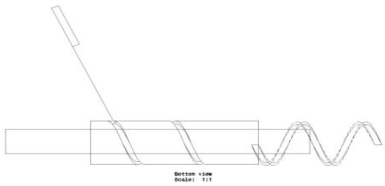

Figure 4. Wire bending assembly

Wire bending mechanism is used to bend. In this angle between tensioner and roller should maintain and velocity of motor also control to avoid jerk and breaking.

2. Wire fencing mechanism

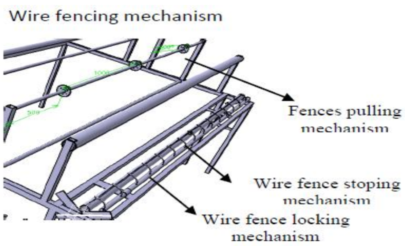

Figure 5. Fencing mechanism

3. Wire cutting mechanism –

After fencing wire cutting is done using cutting mechanism. Cutting is done by pneumatic cylinder.

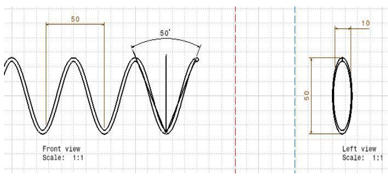

Figure 6. Cutting Mechanism.

VII. DESIGN OF MACHINE

Input Dimension of wire Mesh Required –

Selection of motor –

Elastic modulus of wire E=180GPa =180×10^3MPa
Moment of Inertia= $\frac{\pi}{64}d^4$==1.9174mm4.
By using Flexural Formula,

$$M = 69.026Nm$$
$$M = F \times L$$
$$L = 25mm$$
$$T = F \times L$$
$$F = 2761.16\,N.$$
$$P = \frac{2\pi NT}{60} = 1084.305\ Watt.$$

Assume FOS=2.

$$P = 3HP.$$

Hence we have selected 3HP motor.

Speed selection of Motor –

To determine speed of motor sum trial takes. At different rpm using Variable speed gear box motor and then decides motor rpm.

Table 1. Speed selection of motor.

Sr. no.	Wire dia.	Speed	Result
Trial 1	2.5 mm	1200	Very Large speed wire break and Heavy jerk wire velocity is high
Trial 2	2.5 mm	500	Still Wire break, speed is high
Trial 3	2.5 mm	250	Wire bending prepare, but slide crushing mark on bending surface
Trial 4	2.5 mm	150	Wire prepare with good quality

Determine velocity of wire calculate using rpm –

In one rotation wire pull 100 mm.
At 150 rpm, V= 15 m/min

Design of Shaft-

Shaft is subjected to only Twisting moment.
To check twisting Failure.
Mb at o=69029.14 N-mm.
For d=38mm.

Shaft subjected to twisting only. Therefore,

$\tau = \frac{16M_t}{\pi d^3}$, $\tau = 6.40N/mm^2$

Note that in pure shear or pure torsion σx =0. If σx=0, then

$$\sigma_v = \sqrt{3\tau_{xy}^2}$$

According to distortion energy theory, yielding occurs when σ v reached the yield strength Sy. Therefore in pure shear, yielding occurs when σ xy reaches 58% of Sy.

$$\sigma_v = \sqrt{3 * 6.40^2}$$

$$\sigma_v = 11.08\ 5\ N/mm^2$$

Speed of Pulley –

Speed of Motor = 1440 rpm
Output speed of pulley = 250 rpm
Belt Selection Calculation –
Diameter of pulley = 75 mm
Diameter of big pulley= 275mm
Centre distance =300 mm
Therefore power transmitted by belt = 3 HP = 2237.1 Watt
Calculate Design power =
Pd = Fa*P
= 3355.65 Watt
Belt selection of type A
Nominal width of belt b= 13 mm
Thickness of belt t= 8mm
Velocity of Belt = $\frac{\pi DN}{60}$
= 5.65 m/s
Velocity of belt = 5.65 m/s
Now,

$$\propto = \sin^{-1}\left(\frac{D-d}{2C}\right)$$

α= 19.45^0 i.e. 0.3395rad

Arc of contact $\theta = \pi - 2\alpha$
$= \pi - 2 * 0.3395$
= 0.679 rad

Bearing Design Calculation –

Load factor = Ka = 1.75
L_{h10} = 30,000 hours
Tensions on belt -

$$\frac{Tft}{Tts} = e^{\frac{\mu\theta}{\sin\phi}}$$

Tts=238.52 N
Tft =832.44 N

Equivalent dynamic load and rating life-

Pe = V. F_r. Ka

$$L_{10} = \frac{L_{h10} \times 60 \times n}{10^6} = \frac{30000 \times 60 \times 1440}{10^6}$$

L_{10} = 2592 million revolutions

Basic Dynamic Capacity-

$$L_{10} = [\frac{C}{Pe}]^{10/3}$$

$$C = (L_{10})^{0.3} \times Pe$$

C = 9.905 KN

From Design data book Bearing No. 1608 with basic dynamic capacity of 31.39 KN is selected.

Design of plate in twisting –

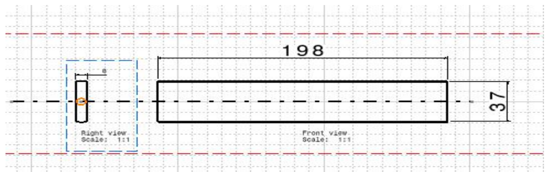

Figure 7.

A wire subject to twisting force on plate = 69.029 N-m

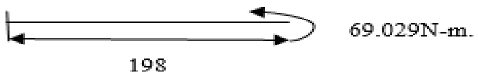

Figure 8.

M=69.029 N-m.
L = 198 mm

$$I = \frac{bd^3}{12} = 33768.667\ mm^4$$

y = d/2 = 18.5 mm

$$\sigma = \frac{M*y}{I} = 37.91N/mm^2$$

Design of cutting Blade-

Determine shearing force required to determine cut the wire. Determine shearing force required to cut the wire.

Syt = 350 N/mm^2
τ = 0.5*350 = 175 N/mm^2

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

$$175\ N/mm^2 = \frac{F}{\frac{\pi}{4}*(2.5)^2}$$

F= 859.029N

Selection of motor –

Radius of cutting blade from Cutting edge is 60 mm
Therefore toque = 859.029*60 = 51541.74 N-mm

Power = $\frac{2*\pi*N*T}{60} = \frac{2*\pi*150*51.541}{60}$ =809.58 Watt

Selected a motor of 2 hp.

Area = b*d =2*8 =16 mm^2

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

$\sigma = 53.68 N/mm2$

Motor selection for table movement-

Power required = $\frac{2*\pi*n*T}{60}$
$= \frac{2*\pi*300*3.29}{60}$
= 103.35 watt motor required

We assume FOS = 3
Power = 103.35 *3 = 310.075 Watt = 0.41 HP motor.

Therefore we select 0.5 HP Gear motor at 250 rpm for table movement.

VIII. VIRTUAL DESIGN AND ANALYSIS

Virtual Model of a machine prepares using CATIA V5 software and FEA analysis using ansys Workbench-.

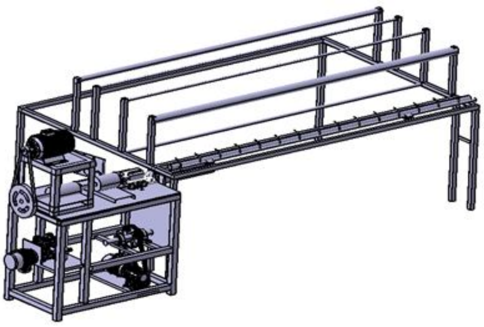

Figure 9. CAD Model of Fencing machine

Cad model are design to visualize all failure mode of machine and reduce chances of failure. Also helps to decided a dimension of component.

FEA Analysis of Shaft -

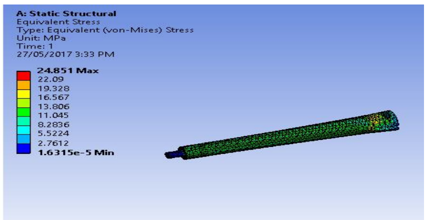

Figure 10. Von- misses stress of Shaft

Fig. shows maximum green region i.e. As per CAE result Von-misses stress = 11.045 MPa

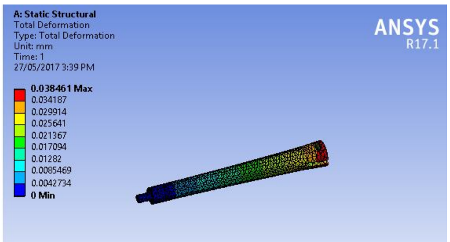

Figure 11. Total deformation of shaft

Maximum deformation of shaft=0.03mm

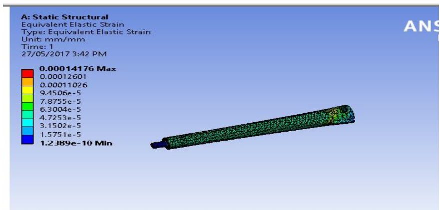

Figure 12. Equivalent Elastic Strain

Max strain value = 0.00014176
FEA analysis of Bending Plate –

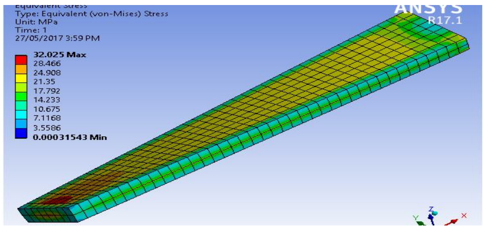

Figure 13. Von-mises stress on wire bending plate

Maximum Von-mises stress on plate 32.025 MPa.

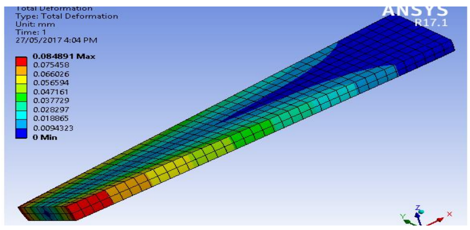

Figure 14. Total deformation of bending Plate

Figure shows maximum deformation of bending plate=0.08489mm

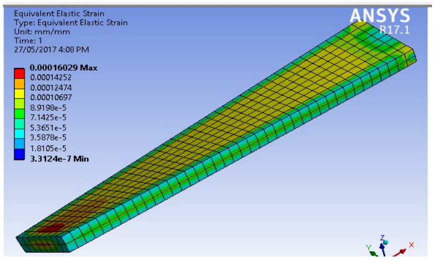

Figure 15. Equivalent Elastic Strain

Figure shows maximum deformation of bending plate=0.08489mm

Analysis of cutting blade –

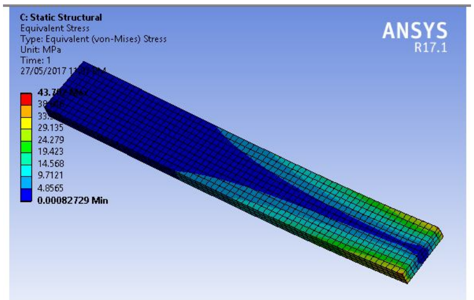

Figure 16. Von-mises stress on wire cutting blade.

Maximum Von-mises stress on cutting blade 43.32 MPa.

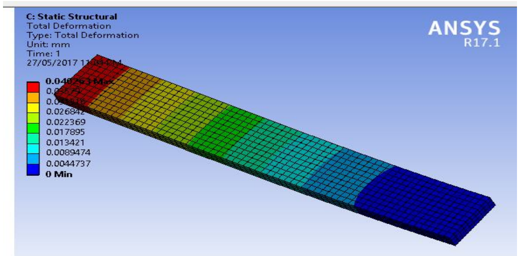

Figure 17. Deformation of cutting Blade.

Figure shows maximum deformation of cutting blade=0.0402mm

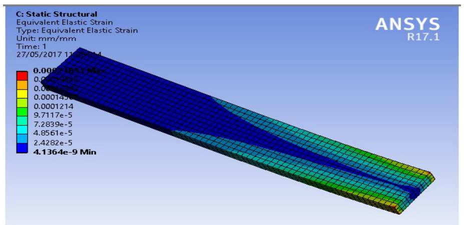

Figure 18. Equivalent strain on cutting blade

Figure shows maximum strain value of cutting blade = 0.000218

IX. MANUFACTURING OF PROJECT

Parts are manufactured as per design in Cad. List of parts to be manufactured as below –

1. Table for Motor and bending wire assembly mounting – 1 Nos.
2. Motor Shaft – 1 Nos.
3. Bending plate – 1. Nos
4. Bending wire Guide – 1 Nos.
5. Fencing Table frame – 1 Nos.
6. Fence locking Mechanism – 1 Nos.
7. Wire tensioner – 1 Nos.

X. ASSEMBLY OF MACHINE

Assembly of project done after manufacturing by using some standard part and manufactured part.

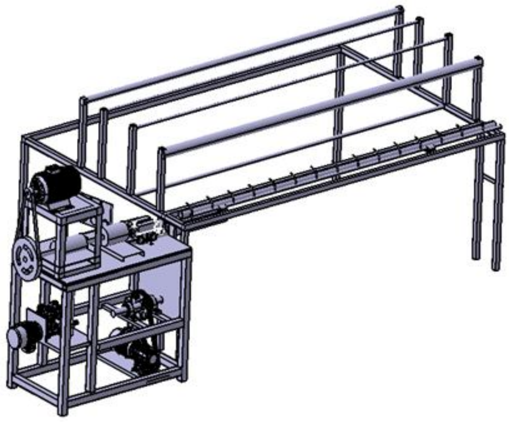

Figure 19. Assembly of Machine.

XI. WORKING OF MAHINE

First add wire bundle on wire stands. Then wire is attached on wire tensioner. Wire tensioner are used to maintain a tensioner. Wire tensioner roller adjusts such that it maintains wire tension which allows bending wire properly and guide a wire enter in a fence bender to maintain fences bending angle. Bend a wire and wound around the bending plate. Start a motor and detect no. of count. If count of machine is equal to number of count enter. Then first motor gets stop. As first motor gets stop second motor gets start. Second motor start the cutter to cut a wire by rotating blade and locks a fences wire. Again first motor start and fences wire start to bend and link with bend one. After completing no. of count third motor start and table moves and cut a fence wire by motor second, Table movement only for even no. of count. Due to weight fences moves forward. Again motor one start and cycle continues.

Following figure shows the flowchart of working-

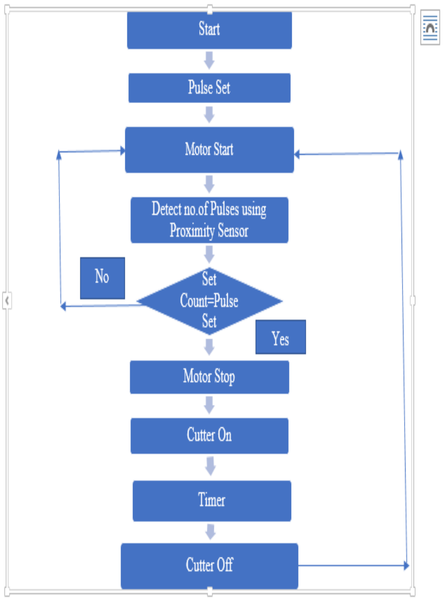

Figure 20. Flowchart of working of Machine.

XII. TRIAL ON MACHINE

Before starting the machine take following precaution -

a) To takes a trial we check all assembly of component is ok.
b) All nuts and bolts are properly tights.
c) Check oil level of reduction gear box.
d) Wire is properly maintaining tension.

Procedure –

1. Make some wire bend and lock with bending strip.
2. Switch on Machine.
3. Enter a width of fences.
4. Enter number of count.
5. Press Start switch
6. Take a reading as per table.

Trial is taken for preparation of 12 feet X6 feet Wire Fencing with diameter of wire 2.5mm.

Table 2. Trial Results on machine.

Wire Diameter	Fence Length	Fence Width	Time per bend wire without cutting	Total time
2.5	12 feet	6 feet	5 sec	20min

Comparision of Trial on Manually Operated, Semiautomatic and Fully Automatic Machine.

Table 3. Trial Results on Different machine.

Type of Machine	Manual Fencing machine	Semi-Automatic Fencing machine	Automatic Fencing machine
Time	70min	45 min	20 min

Above Table Shows that there is about 25% time saving in fully automatic machine as compared to Semi-automatic machine. Also it shows that near about 50% time saving in automatic machine as compared to manual operated Machine.

XIII. CONCLUSION

During the testing, machine performance was satisfactory. Chain link fences were successfully prepared.

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