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Design, Analysis and Fabrication of Foot Operated Round Ring Cloth Peg Assembly Machine using Spring Lever Mechanism

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Abstract: Cloth pegs are used for holding clothes especially when kept for drying. There are different types of cloth pegs available in the market, made from different materials like plastic, metal or wood. The two pieces of the cloth peg are held together either by a metal ring, U-pin, or spring. The plastic parts and the metal ring are manufactured separately and then assembled together. Assembly of the plastic parts and the ring is done manually. This is a very tedious and troublesome process. So, the researcher has designed and fabricated a machine to reduce the human efforts and time.
Keywords: Cloth peg, Clothes, Plastic parts, Metal ring, Assembly machine

I. INTRODUCTION

A cloth peg is a fastener used to hang up clothes for drying, usually on a clothes line. They are made from plastic, metal or wood. A ring, spring or U-pin is inserted between the two parts of the cloth peg. The assembly of the cloth peg (two plastic pieces and ring) can be done manually by workers, or by semiautomatic or fully automatic machines.

Fig.1 Cloth peg assembly

II. NEED OF THE PROJECT

Inserting the ring in the two parts is very tedious and troublesome job for the workers. So, by developing the machine for the same will reduce the manual efforts of the workers which will ultimately benefit the company.

Fig.2 Cloth peg assembly parts

III. MACHINE DESCRIPTION

The machine consists of a mounting table of dimensions 355×355× 457mm. On one side of the top of the table two angle sections of height 180 mm are welded on two ends for mounting the spring lever mechanism. On the top of the angle sections a hole of diameter 5mm is drilled for fixing the fulcrum. On the two ends of the fulcrum, holes of diameter 3mm are drilled for inserting the spring ends. Each fulcrum is attached with two vertical springs and a horizontal spring. Instead of horizontal spring, a metal rod of diameter 1mm and length 14mm can be used. The horizontal springs are used for holding the metal ring. Two metal plates of dimensions 60×30×3mm are provided for supporting the horizontal springs or metal rods. The upper vertical spring is used for balancing the fulcrum and the lower vertical spring is used for transmitting the force. A steel rod of length 385mm is attached to the lower vertical spring from one end and its other end is welded to the foot pressure plate at the lower end of the table. The foot pressure plate of dimensions 380×40×5mm is provided at a height of 250mm from the bottom of the table. A footrest is welded at a height of 210 mm from the bottom of the table. Four wheels are attached to the table for easy handling.

IV. DESIGN CALCULATIONS

A. Design of Horizontal Spring

Maximum spring force required, P = 1*9.81= 9.81N

Deflection of the spring, δ = 4mm

Spring material: AISI 1045 Steel, cold drawn

Ultimate tensile strength, $S_{ut} = 625\ N/mm^2$

Permissible shear stress for the spring wire, $\tau = 0.30S_{ut}$

$\tau = 0.30*625$

$\tau = 187.5\ N/mm^2$

Consider spring index, C = 6

Wahl's factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$= \frac{4(6)-1}{4(6)-4} + \frac{0.615}{6}$

K =1.2525

Wire diameter (d)

$\tau = K\left(\frac{8PC}{\pi\times d^2}\right)$

$187.5 = 1.2525\times\left(\frac{8\times 9.81\times 6}{\pi\times d^2}\right)$

d= 1mm

Mean coil diameter, $D_m = C\times d$

$D_m = 6\times 1$

$D_m = 6$ mm

No. of active coils (N)

$\delta = \frac{8PD_m^3N}{Gd^4}$

Modulus of rigidity (G) for steel wires is 81370 N/mm^2

$4 = \frac{8\times 9.81\times 6^3\times N}{81370\times 1^4}$

N = 19.2

N = 20

Total number of coils, N_t = Active coils (∵ it is a helical extension spring)

$N_t = 20$

Solid length of the spring, $L_S = N_t\times d$

$= 20\times 1$

$L_S = 20$ mm

Actual deflection of the spring, $\delta = \frac{8PD_m^3N}{Gd^4}$

$\delta = \frac{8\times9.81\times6^3\times20}{81370\times1^4}$

δ = 4.16 mm

Total axial gap between coils = (N_t -1) × gap between two adjacent coils

It is assumed that there will be a gap of 1mm between the adjacent coils.

Total axial gap between coils = (20-1) × 1

= 19 mm

Free length of the spring, L_F = solid length+ total gap+ δ

= 20+19+4.16

L_F = 43.16 mm or 44 mm

Pitch of the coil, $p = \frac{free\ length}{(N_t-1)}$

$p = \frac{44}{20-1}$

p = 2.31mm

Required stiffness, $k = \frac{P}{\delta}$

$= \frac{9.81}{4}$

k = 2.45 N/mm

Actual stiffness, $k = \frac{Gd^4}{8{D_m}^3N}$

$= \frac{81370\times1^4}{8\times6^3\times20}$

k = 2.35 N/mm

B. Design of Upper Vertical Spring

Maximum spring force required, P = 1*9.81= 9.81N

Deflection of the spring, δ = 15mm

Spring material: Alloy steel (SS)

Ultimate tensile strength, S_{ut} = 723.8256 N/mm^2

Permissible shear stress for the spring wire, $\tau = 0.30S_{ut}$

τ = 0.30*723.8256

τ = 217.15 N/mm^2

Consider spring index, C=7

Wahl's factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$= \frac{4(7)-1}{4(7)-4} + \frac{0.615}{7}$

=1.2128

Wire diameter (d)

$\tau = K\left(\frac{8PC}{\pi\times d^2}\right)$

$217.15 = 1.2128\times\left(\frac{8\times9.81\times7}{\pi\times d^2}\right)$

d = 0.98mm or 1mm

Mean coil diameter, D_m= C×d

D_m= 7×1

D_m= 7mm

No. of active coils (N)

$\delta = \frac{8P{D_m}^3N}{Gd^4}$

Modulus of rigidity (G) for steel wires is 81370 N/mm^2

$15 = \frac{8 \times 9.81 \times 7^3 \times N}{81370 \times 1^4}$

N= 45.34

N= 45

Total number of coils, N_t = Active coils (∵ it is a helical extension spring)

$N_t = 45$

$N_t = 45$

Solid length of the spring, $L_S = N_t \times d$

$= 45 \times 1$

$L_S = 45$ mm

Actual deflection of the spring, $\delta = \frac{8PD_m{}^3N}{Gd^4}$

$\delta = \frac{8 \times 9.81 \times 7^3 \times 45}{81370 \times 1^4}$

$\delta = 14.88$ mm

Total axial gap between coils = (N_t -1) × gap between two adjacent coils

It is assumed that there will be a gap of 1mm between the adjacent coils.

Total axial gap between coils = (45-1) × 1

= 44 mm

Free length of the spring, L_F = solid length+ total gap+ δ

= 45+44+14.88

L_F = 103.88 or 104 mm

Pitch of the coil, $p = \frac{free\ length}{(N_t - 1)}$

$p = \frac{104}{45 - 1}$

p = 2.36mm

Required stiffness, $k = \frac{P}{\delta}$

$= \frac{9.81}{15}$

k = 0.654 N/mm

Actual stiffness, $k = \frac{Gd^4}{8D_m{}^3N}$

$= \frac{81370 \times 1^4}{8 \times 7^3 \times 45}$

k = 0.658 N/mm

C. Design of Lower Vertical Spring

Maximum spring force required, P = 1*9.81= 9.81N

Deflection of the spring, δ = 8.5mm

Spring material: Alloy steel (SS)

Ultimate tensile strength, S_{ut} = 723.8256 N/mm^2

Permissible shear stress for the spring wire, $\tau = 0.30S_{ut}$

τ = 0.30*723.8256

τ = 217.15 N/mm^2

Consider spring index, C=7

Wahl's factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

$= \frac{4(7)-1}{4(7)-4} + \frac{0.615}{7}$

$K = 1.2128$

Wire diameter (d)

$\tau = K\left(\frac{8PC}{\pi \times d^2}\right)$

$217.15 = 1.2128 \times \left(\frac{8 \times 9.81 \times 7}{\pi \times d^2}\right)$

d= 0.98mm or 1mm

Mean coil diameter, $D_m = C \times d$

$D_m = 7 \times 1$

$D_m = 7mm$

No. of active coils (N)

$\delta = \frac{8PD_m{}^3N}{Gd^4}$

Modulus of rigidity (G) for steel wires is 81370 N/mm^2

$8.5 = \frac{8 \times 9.81 \times 7^3 \times N}{81370 \times 1^4}$

N= 25.69

N= 26

Total number of coils, N_t = Active coils (∵ it is a helical extension spring)

$N_t = 26$

$N_t = 26$

Solid length of the spring, $L_S = N_t \times d$

$= 26 \times 1$

$L_S = 26$ mm

Actual deflection of the spring, $\delta = \frac{8PD_m{}^3N}{Gd^4}$

$\delta = \frac{8 \times 9.81 \times 7^3 \times 26}{81370 \times 1^4}$

$\delta = 8.6mm$

Total axial gap between coils = (N_t -1) × gap between two adjacent coils

It is assumed that there will be a gap of 1mm between the adjacent coils.

Total axial gap between coils = (26-1) × 1

= 25 mm

Free length of the spring, L_F = solid length+ total gap+ δ

= 26+25+8.6

L_F = 59.6 or 60 mm

Pitch of the coil, $p = \frac{free\ length}{(N_t - 1)}$

$p = \frac{60}{26-1}$

p = 2.4mm

Required stiffness, $k = \frac{P}{\delta}$

$= \frac{9.81}{8.5}$

k = 1.15 N/mm

Actual stiffness, $k = \frac{Gd^4}{8D_m{}^3N}$

$= \frac{81370 \times 1^4}{8 \times 7^3 \times 26}$

k = 1.14 N/mm

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V. CAD MODELLING

Fig.3 CAD Model of Foot operated Round Ring Cloth Peg Assembly Machine

VI. CAD MODEL OF DIFFERENT PARTS OF THE ASSEMBLY MACHINE

Fig.4 Table

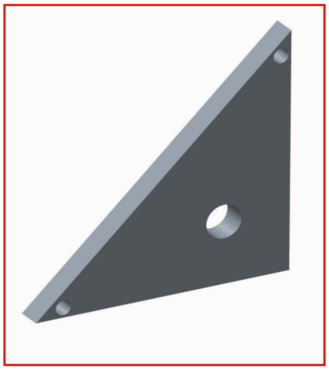

Fig.5 Fulcrum

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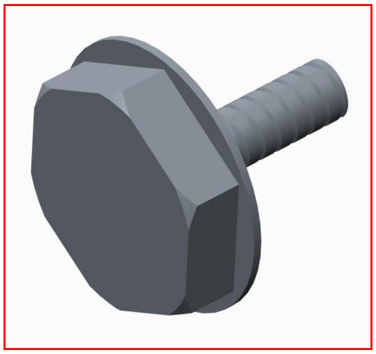

Fig.6 Bolt

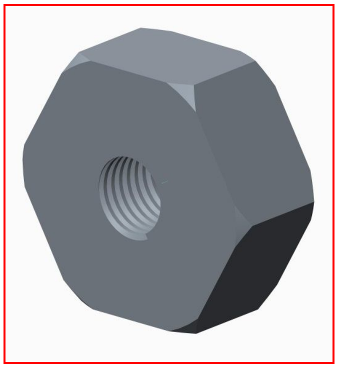

Fig.7 Nut

Fig.8 Horizontal spring

Fig.9 Vertical spring

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Fig.10 Foot pressure plate

VII. DESIGN ANALYSIS – ANSYS WORKBENCH – 16.2

Mild Steel is used for the fabrication of the machine.

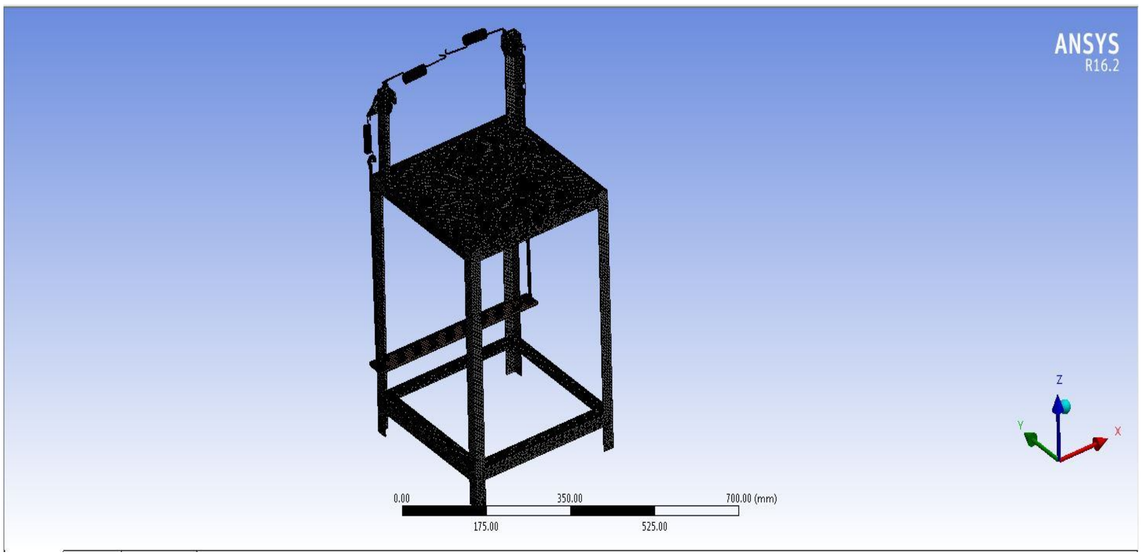

Fig.11 Meshing of the whole assembly

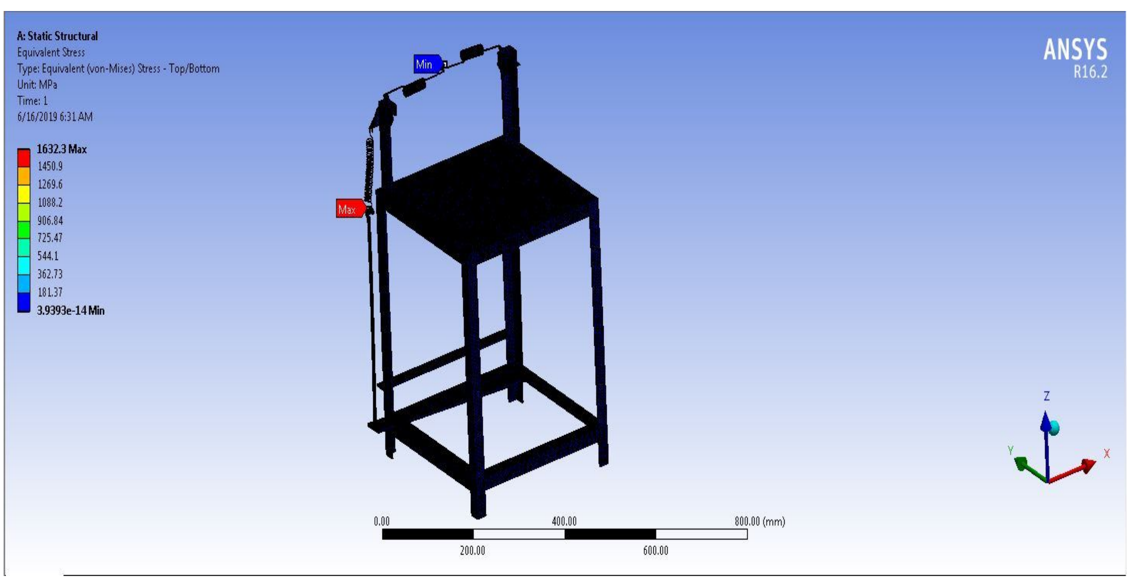

Fig.12 Maximum and minimum stress in the assembly

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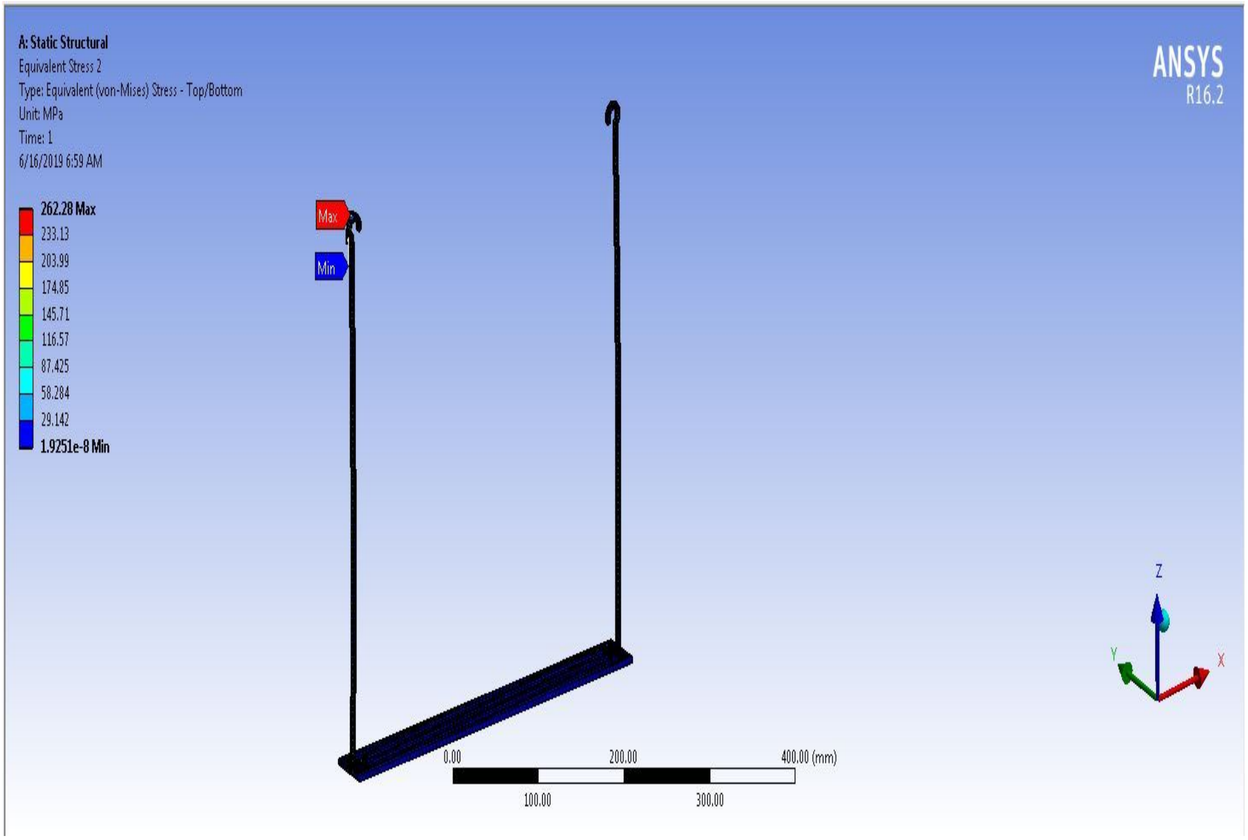

Fig.13 Stress in the foot pressure plate

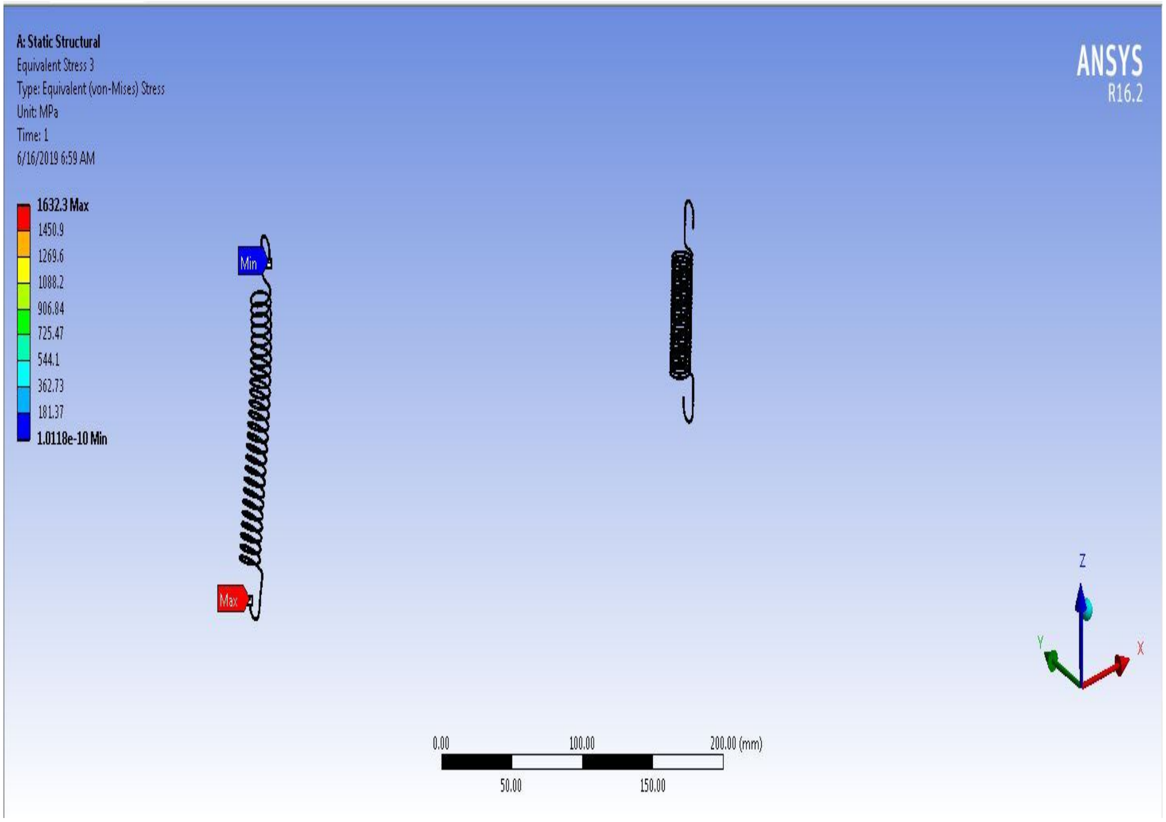

Fig.14 Stress in the vertical spring

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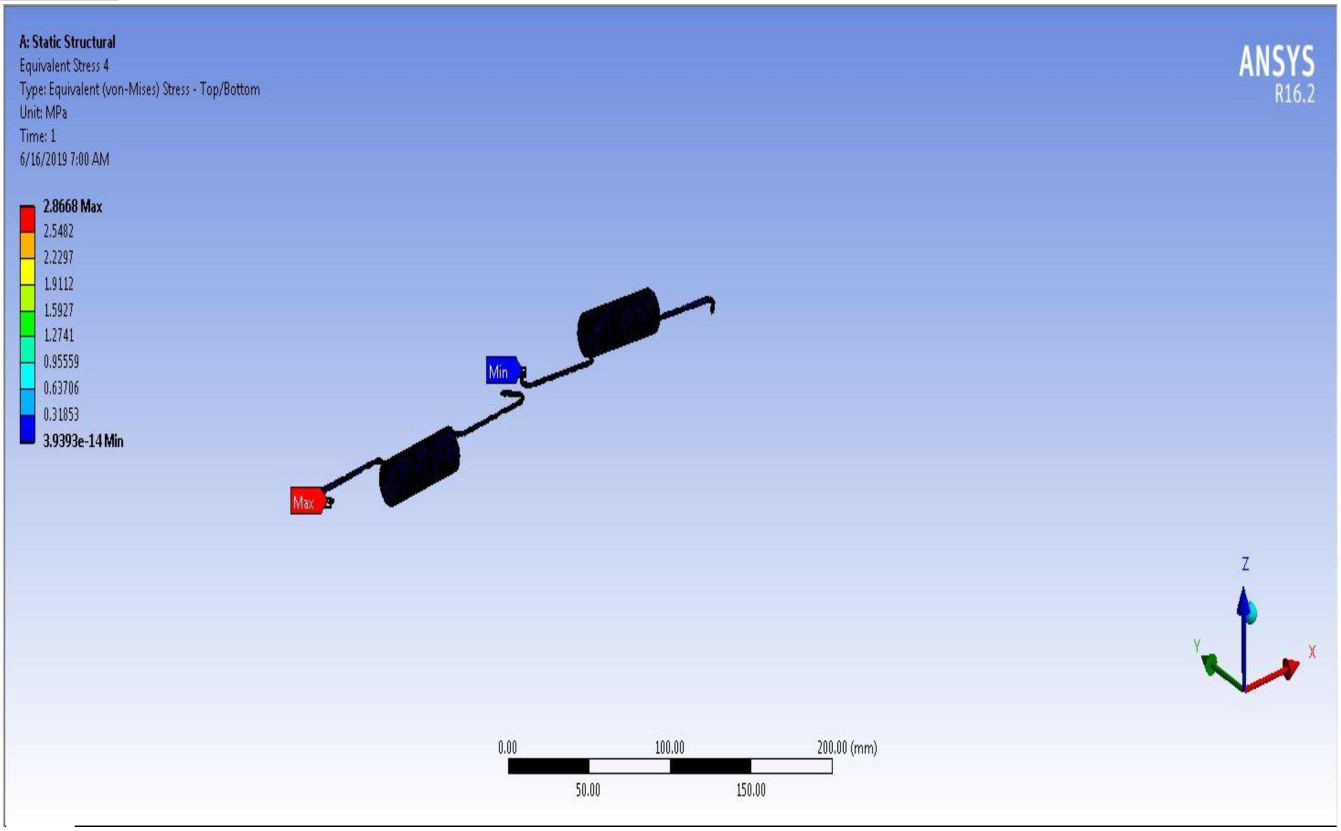

Fig.15 Stress in the horizontal spring

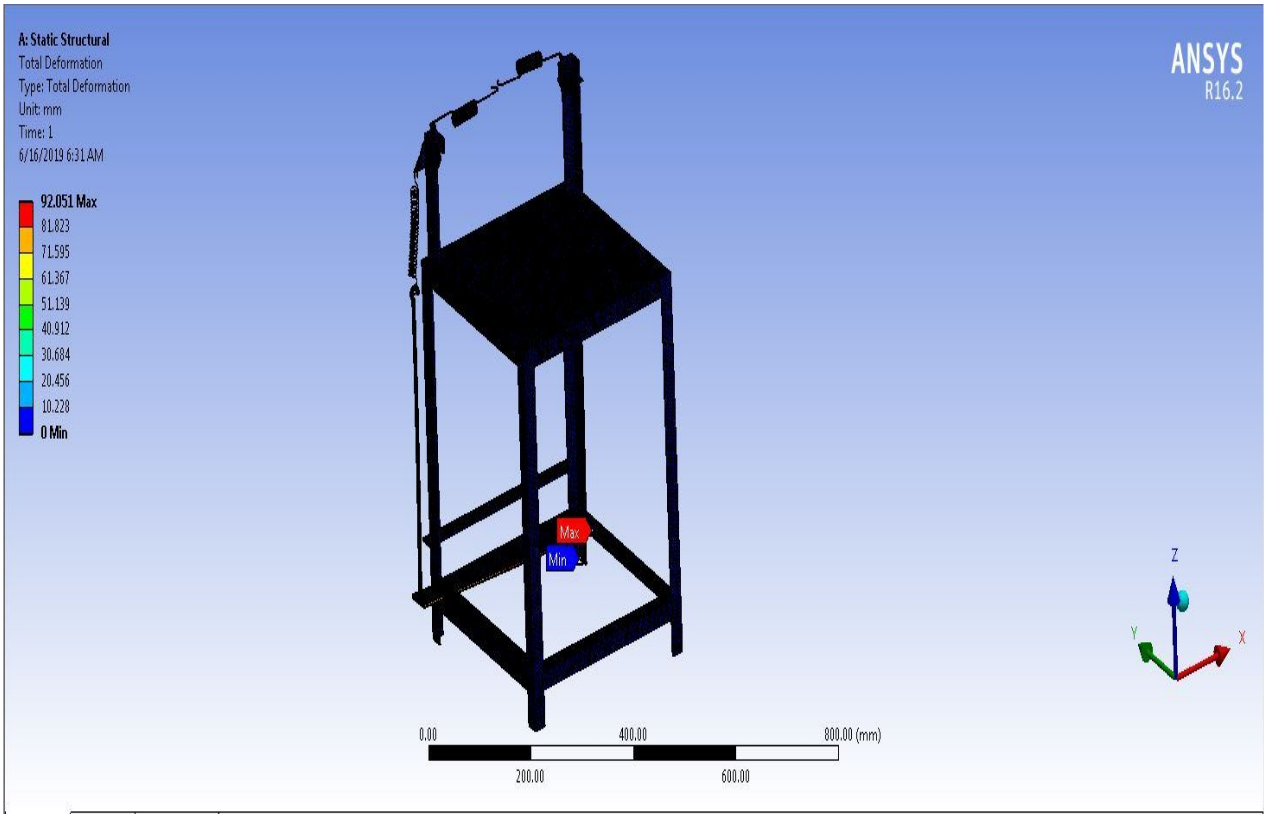

Fig.16 Deformation in the whole assembly

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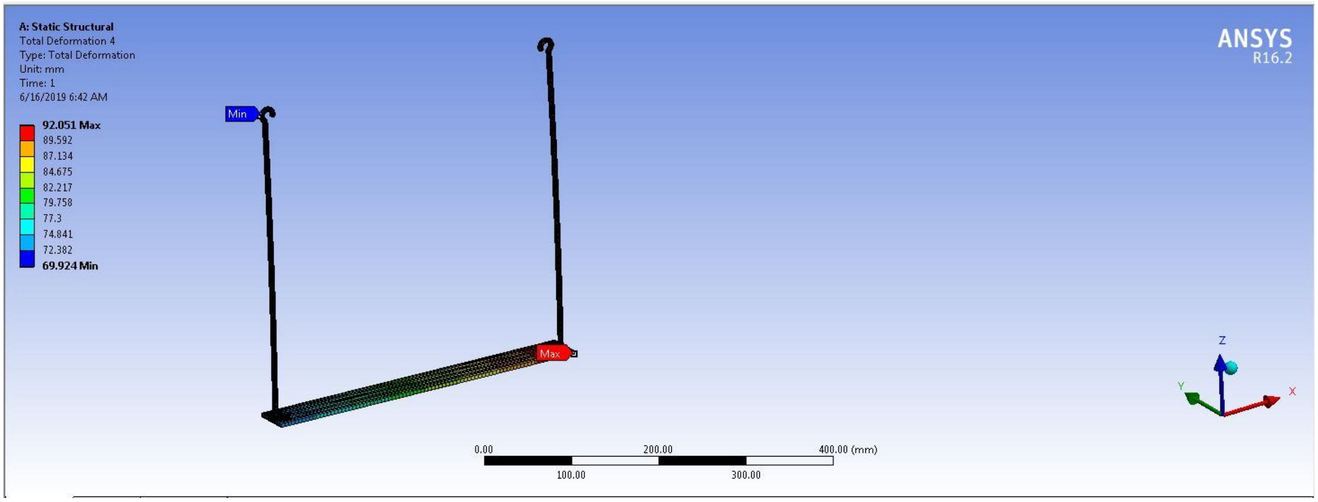

Fig.17 Deformation in the foot pressure plate

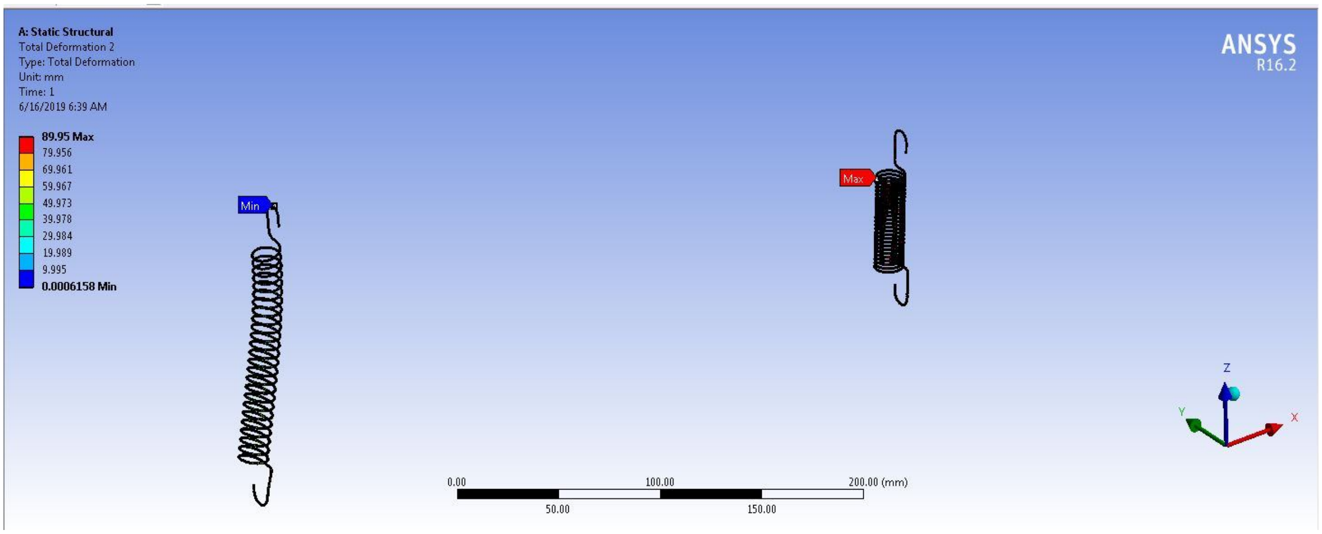

Fig.18 Deformation in the vertical spring

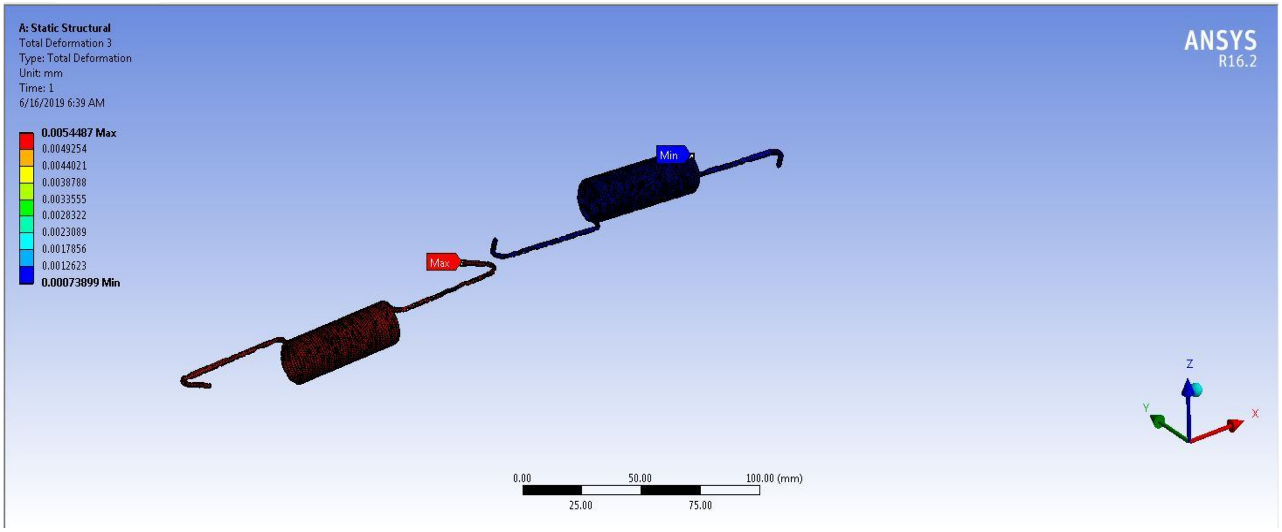

Fig.19 Deformation in the horizontal springs

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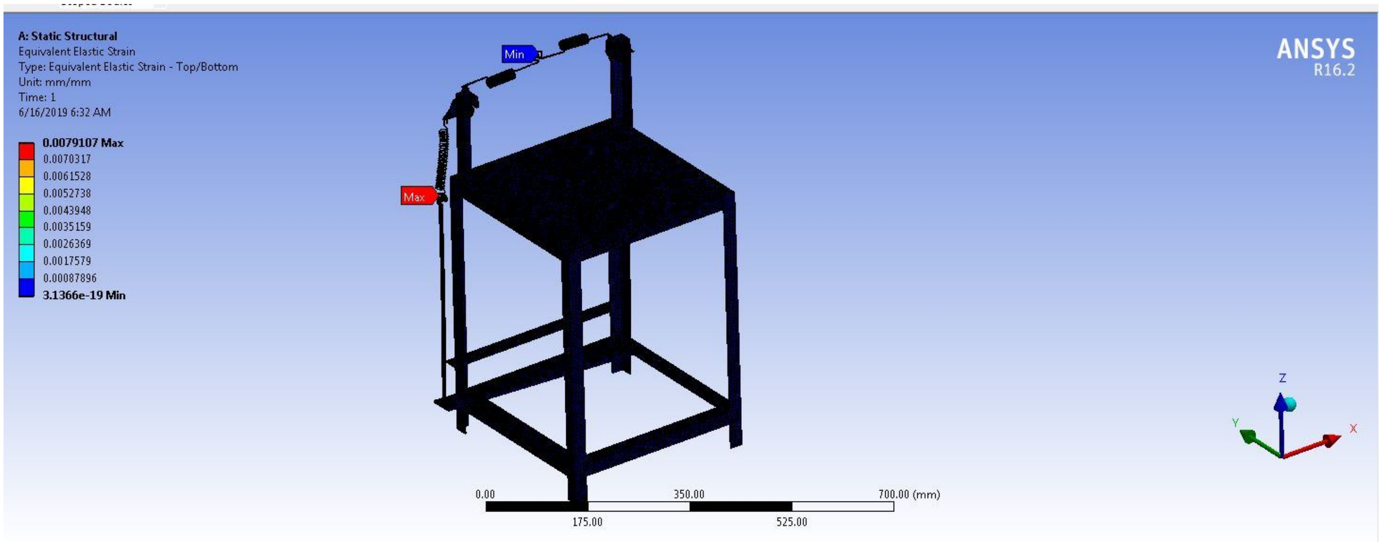

Fig.20 Strain in the whole assembly

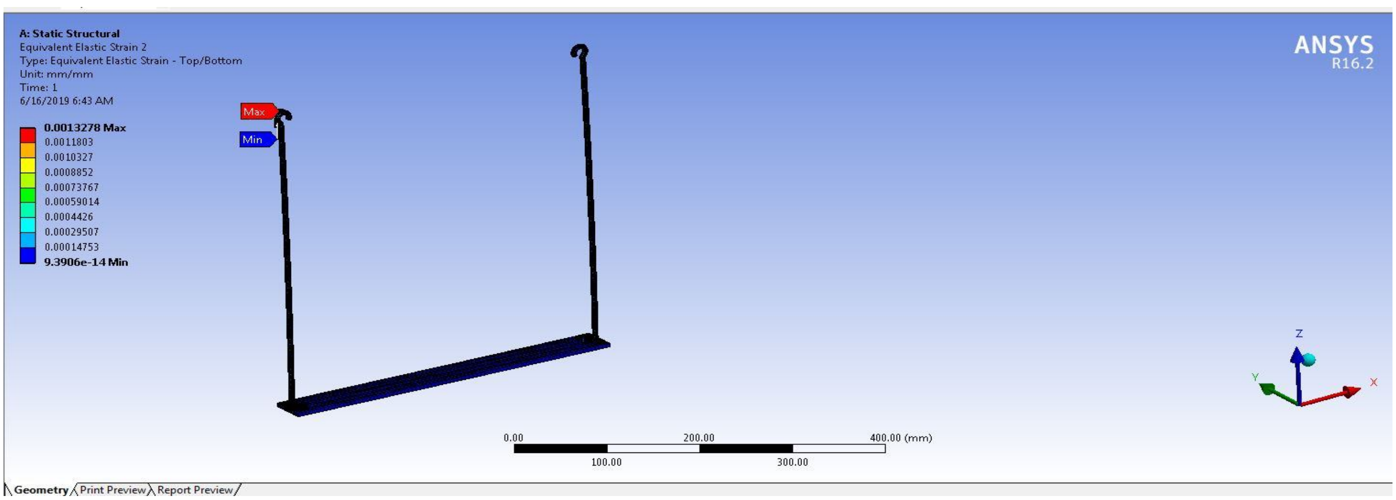

Fig.21 Strain in the foot pressure plate

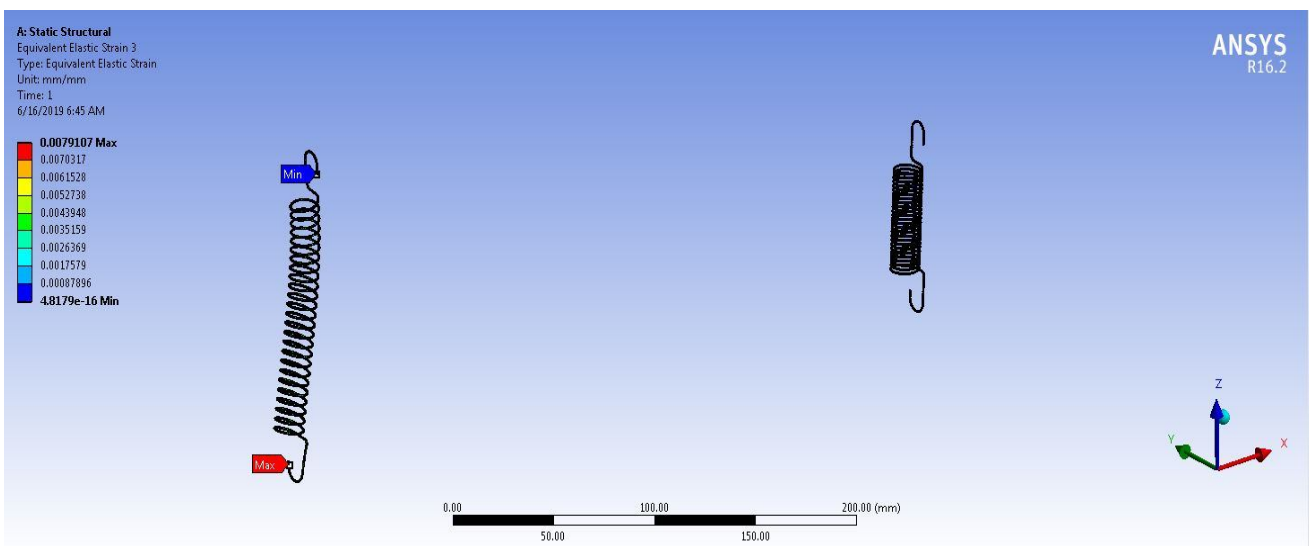

Fig.22 Strain in the vertical spring

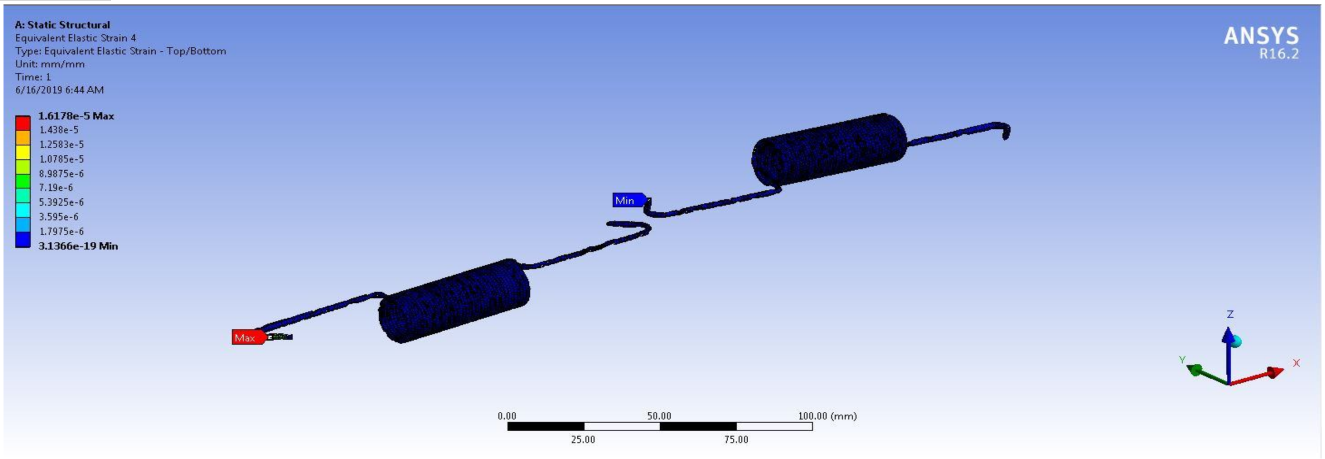

Fig.23 Strain in the horizontal spring

VIII. FABRICATION

For fabrication of this machine drilling and grinding machines are used. For joining the different parts of the machine electric arc welding is used.

Fabrication consists of the following steps:-

1) First a table of dimensions 355×355×457mm is fabricated.
2) On one side of the top of the table two angle sections of height 180mm are welded near the corners for mounting the spring lever mechanism.
3) On the top of the angle sections a hole of diameter 5mm is drilled for fixing the fulcrum.
4) On the two ends of the fulcrum, holes of diameter 3mm are drilled for inserting the spring ends.
5) Each fulcrum is attached with two vertical springs and a horizontal spring. Instead of horizontal spring, a metal rod of diameter 1mm and length 14mm can be used.
6) The horizontal springs are used for holding the metal ring. Two metal plates of dimensions 60×30×3mm are provided for supporting the horizontal springs or metal rods.
7) The upper vertical spring is used for balancing the fulcrum and the lower vertical spring is used for transmitting the force.
8) A steel rod of length 385mm is attached to the lower vertical spring from one end and its other end is welded to the foot pressure plate at the lower end of the table.
9) The foot pressure plate of dimensions 380×40×5mm is provided at a height of 250mm from the bottom of the table.
10) A footrest is welded at a height of 210 mm from the bottom of the table.
11) Four wheels are attached to the table for easy handling.

Fig.24 Foot operated Round Ring Cloth Peg Assembly Machine

IX. WORKING OF THE MACHINE

The horizontal springs are kept in position. Then the ring is inserted at its ends. Then the required foot pressure is applied on the pressure plate so that the inserted ring gets stretched. Then the two plastic parts of the cloth peg are inserted into the ring so that the ring gets inserted from the rectangular grooves. Then the cloth peg is removed. Then the overlapping portion of the ring is brought to the upper position. Then the cloth peg is loaded on the horizontal springs and the required foot pressure is applied on the pressure plate so that the ring gets inserted into the upper circular grooves. Now the cloth peg is removed and is ready for use.

X. TESTING OF THE MACHINE

The machine reduces the time and efforts of the worker in inserting the ring into the two plastic parts of the cloth peg. The machine is handy, portable, economical and simple in construction. The machine is more easy to use than the hand operated round ring cloth peg assembly machine as the use of plier is eliminated.

XI. CONCLUSION

Cloth peg consists of two plastic parts and a metal ring. The plastic parts and the ring are manufactured separately and then assembled together. Assembling of the plastic parts and the ring is a tedious and troublesome process. So, the “Foot Operated Round Ring Cloth Peg Assembly Machine” is designed and fabricated which will reduce the human efforts and time.

XII. ACKNOWLEDGMENT

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