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Design and Analysis of Automatic Centre Stand for Motorcycle

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Abstract: Generally motorcycles come with side stand and centre stand. The side stand is easily operated by the rider which is on the left side of the bike. Sometimes the rider forgets to mount the side stand hence the rider gets injured and the side stand takes more parking area as compare to the centre stand. To mount the centre stand is very difficult for anyone. In order to overcome such problems automatic centre stand is a good solution. Hydraulic cylinders are used in the automatic centre stand one hydraulic cylinder is to rotate (77^0) the centre stand and other two hydraulic cylinders are move downward to lift the motorcycle. We used Autodesk Fusion 360 software, theories of failure and Euler's column theory for motion analysis, design cylinder and piston rod. Designed cylinder and piston rod satisfied theories of failure and Euler's column theory, the modified centre stand can bear the load of a bike. The automatic centre stand operated by the push button. The modified centre stand of the motorcycle is reduced the human effort. This research helps to make the design the automatic centre stand in different ways and different usage of hydraulic cylinders in the automobile sector.

Keywords: Automatic centre stand, Modified centre stand of motorcycle, theories of failure, Euler's column theory, Yield stress, Euler's buckling load.

I. INTRODUCTION

Normally automobile industries use side stand and centre stand for motorcycles. The side stand and centre stand is operated by the rider which is located on the left side and bottom side of the bike. Stands are used to mount the bike. Both the stand is manually or electrically operated. The stand is an integral part of motorcycles, the stand is used for stabilizing the motorcycle. Manual side stand and centre stands are present in the world, but there is some problem while operating side and centre stand.

A. While Applying side Stand Manually

1) Develop fatigue in a stand.
2) Increase chances of injury.
3) It requires more parking spaces.

B. While Applying Centre Stand Manually

1) Heavy weighted scooters and motorcycles require more effort for application.
2) May cause back or leg injuries and Women and old people face difficulty in applying centre stand.

William D. Hanners [1] has patented a locking mechanism of a centre stand for a two-wheeler motorcycle including a key lock with a cylinder that is connected to a cam that displaces a locking pin to engage a pivotal sleeve that connects the centre stands to the frame of the motorcycle such that when the lock is engaged. Pervez and Bharucha [2] have patented an automatic two-wheeler stand used by a DC motor and a hydraulic pump, coupled together with the help of a distributing manifold and having a reserve oil tank forming a power pack. Cylinder pneumatically operated, up to the pre-set height which lifts the two-wheeler and parks it on the stand automatically. Suggested by Ankit Kumar K. et al [3] which has comparative less stress in the edge of a stand than conventional stands as well as it is easy to operate. The lower side of the stand is modified. The bottom side of the stand is curved in shape inside view. Sarvesh Hinganikar et al [4] designed an automatic centre stand of a bike which is an operated by DC battery, first of all, they design frame of a centre stand which is moving up & down by the Mechanical linear actuator. Deepak Kumar A et al [5] designed an automatic electric-powered centre stand of a two-wheeler. The stand is controlled by a microcontroller. Linear Electric Actuator provides up & down motion of centre stand. Manjunath G. Kallur [6] designed an automatic centre stand which consists of a hydraulic pump or actuator powered by a battery source and controlled by a key-operated switch. The function of the hydraulic pump is to lower & the centre stand legs move down and lift the vehicle. Hem Pathak [7] designed a swing arm frame is mounted at rear wheel end at the centre bore of a wheel through swing arm centre rod. Centre rod connects two swing arm frames on both sides of wheel providing stability to the vehicle, set of roller wheels are pinned to a swing arm frame having a paddle

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attached at one end of swing arm frame. Swingarm frame is supported by a ball bearing, when swing arm moves down then the rear wheel moves upward direction but there is a chance to move the bike forward if a slip occurs and is difficult to tide the wheels. Ashish Jyoti et al [8] designed a centre stand frame which is moving up & down by the linear actuator powered by the battery. After going through works of literature [4,6,9] on a centre stand of bike it has been observed that the size of hydraulic cylinder is large, takes more power from the power source and extra space required in the above portion of the centre stand. Aakarsh B S et al [9] designed centre stand is fixed at the same location for that of the conventional stand. The linear actuator is powered by automobile battery, controlled by toggle DPDT switch which changes the polarities of the supply. The linear actuator is pivoted to the stand assembly which distributes the load equally on both the limbs of the stand but there is a chance to break bottom portion of centre stand while operating and hydraulic cylinder takes more power from the power source. By observing these problems, we have opted to modify centre stand.

II. METHODOLOGY TO ADOPTED

A. *Working Principle Of The Automatic Centre Stand Of Motorcycle*

The automatic centre stand is based on hydraulic press. The main principle in which the system works is Pascal's law. One cylinder is placed at point 1 and another two cylinders are placed at point 2, 3 respectively which is shown in fig. 1.

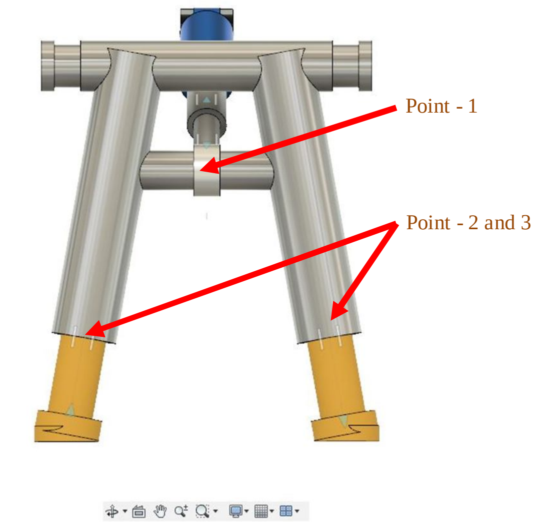

Fig. 1 Proposed automatic centre stand of motorcycle

Following are the steps the automatic centre stand works-

1) First of all the hydraulic cylinder one (Blue in colour) operated hence the stand rotates (77 angles), which is shown in fig. 2 (a) and 2 (b).

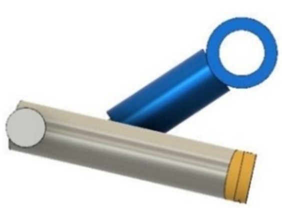

Fig. 2 (a) Side View of automatic centre stand.

Fig. 3 (b) Side View of automatic centre stand when first Hydraulic Cylinder operated.

2) The other two (Yellow in colour) hydraulic cylinder moves downward to lift the motorcycle, which is shown in Fig.3 (a) and 3

Fig. 4 (a) Front View of automatic centre stand when when first Hydraulic Cylinder operated

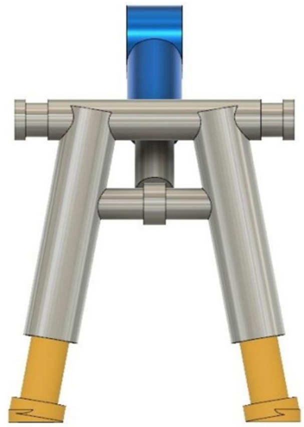

Fig. 5 (b) Front View of automatic centre stand when first and other two Hydraulic Cylinder operated

3) The other two (Yellow in colour) move up to set down the motorcycle.
4) The stroke moved downward of the cylinder one (Blue in colour) to rotate 77 angles. In this way, the automatic centre stand of motorcycle works.

B. Design of Hydraulic Cylinder Arrangement

For designing of Hydraulic cylinders we have chosen material- Stainless steel type 304
It's Yield stress (σ_{yt}) = 215 MPa
Young modules of elasticity (E) = 193-200GPa (we take E = 195GPa)
Weight of bike = 155kg

1) Design of piston rod of Hydraulic cylinder arrangement-

Let, Piston diameter D_p = 35mm
Factor of safety = 3
Actual maximum load (P_A) = Mass of bike X Factor of safety X Acceleration due to gravity
P_A= 155 x 3 x 9.81
Actual maximum load (P_A) = 4561.65 N

$$Stresses\ develop\ in\ piston\ = \frac{P_A}{A}$$

$$Stresses\ develop\ in\ piston\ = \frac{4561.65}{\pi/_4 \times 35^2}$$

Stress develop in piston = 4.741 MPa < σ_{yt}
Hence our piston diameter is safe because of Stainless steel type 304 yield stress is greater than stress develops in piston diameter.

a) *Buckling Load in Piston Rod:* For the required buckling the calculation for piston rod used for pushing, the following method may be used for control of buckling. We use Euler's buckling load.

$$Euler's\ load\ of\ piston\ rod\ (P_E)_r = \frac{E \times I_r \times \pi^2}{L_e^2}$$

Where,
E = Young's modulus of elasticity, N/ mm^2
I_r = Moment of inertia of the piston rod

$$L_e = \frac{L_r}{\sqrt{2}} \quad \text{(For one end fixed and other pinned)}$$

L_r = 105 mm

Euler's load of piston rod $(P_E)_r = \dfrac{2 \times E \times I_r \times \pi^2}{L_r^2}$

To find Moment of inertia of the piston rod –

Moment of inertia of the piston rod $(I_r) = \dfrac{\pi \times D_r^4}{64}$

Where,

D_r = Diameter of the piston, mm

Moment of inertia of the piston rod $(I_r) = \dfrac{\pi \times 35^4}{64}$

Moment of inertia of the piston rod (I_r)= 73661.76 mm^4

Now,

Euler's load of piston rod $(P_E)_r = \dfrac{2 \times 195 \times 73661.76 \times \pi^2}{105^2}$

$(P_E)_r$ = 25717.45N

$(P_E)_r$ = 25.717 X 10^3 N

Euler's buckling load of piston $(P_E)_r$ is greater than our Actual maximum load (P_A), hence our piston rod is safe.

2) Design of Hydraulic Cylinder

Let, cylinder inner diameter D_i = 39mm

Cylinder outer diameter D_o = 50mm

a) Three of the primary three stresses that can be applied to a cylinder are –

i) *Hoop Stress (Circumferential stress):* The stress in circumferential direction - hoop stress - at a point in the cylinder wall can be expressed as:

$$\sigma_c = \frac{(p_i \times r_i^2) - (p_o \times r_o^2)}{r_o^2 - r_i^2} - \frac{r_i^2 \times r_o^2 \times (p_o - p_i)}{r^2 \times (r_o^2 - r_i^2)}$$

Where,

σ_c = Hoop Stress (Circumferential stress) (MPa)

p_i = internal pressure in the cylinder (MPa)

p_o = external pressure in the cylinder (MPa)

r_i = internal radius of cylinder (mm)

r_o = external radius of cylinder (mm)

r = radius to point in cylinder wall (mm) $(r_i < r < r_o)$

Maximum stress when r = r_i (inside cylinder)

$$\sigma_c = \frac{(4.741 \times 19.5^2) - (0 \times 25^2)}{25^2 - 19.5^2} - \frac{19.5^2 \times 25^2 \times (0 - 4.741)}{19.5^2 \times (25^2 - 19.5^2)}$$

σ_c = 19.4728MPa = σ_1

ii) *Radial Stress:* The stress in radial direction at a point in the cylinder wall can be expressed as:

$$\sigma_r = \frac{(p_i \times r_i^2) - (p_o \times r_o^2)}{r_o^2 - r_i^2} + \frac{r_i^2 \times r_o^2 \times (p_o - p_i)}{r^2 \times (r_o^2 - r_i^2)}$$

Where,

σ_r = Radial Stress

Maximum stress when r = r_o (outside cylinder)

$$\sigma_r = \frac{(4.741 \times 19.5^2) - (0 \times 25^2)}{25^2 - 19.5^2} + \frac{19.5^2 \times 25^2 \times (0 - 4.741)}{19.5^2 \times (25^2 - 19.5^2)}$$

σ_r = -4.741MPa

Radial stress is compressive in nature hence σ_r = -4.741MPa = σ_3

iii) *Axial Stress (Longitudinal stress):* The stress in axial direction at a point in the cylinder wall can be expressed as:

$$\sigma_a = \frac{(p_i \times r_i^2) - (p_o \times r_o^2)}{r_o^2 - r_i^2}$$

Where,

σ_a = Axial Stress (MPa)

$$\sigma_a = \frac{(4.741 \times 19.5^2) - (0 \times 25^2)}{25^2 - 19.5^2}$$

σ_a = 7.366 MPa = σ_2

Hence our Principal stresses are –

$\sigma_1 = \sigma_c$= 19.4728MPa

$\sigma_2 = \sigma_a$= 7.366 MPa

$\sigma_3 = \sigma_r$= - 4.741MPa

b) Checking of induced stresses under triaxial load by applying different theories of failures –

i) Maximum shear stress theory – According to maximum shear stress theory the safe stresses are-

$$\frac{\sigma_1 - \sigma_3}{2} \leq \frac{\sigma_{yt}}{2}$$

$$\frac{19.4728 - (-4.741)}{2} \leq \frac{215}{2}$$

$$12.1069 < 107.5$$

$$12.1069 MPa < 107.5 MPa$$

Hence the chosen material is safe.

ii) A Maximum distortion energy theory - According to Maximum distortion energy theory the safe stresses are-

$$\sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - (\sigma_1 \times \sigma_2) - (\sigma_2 \times \sigma_3) - (\sigma_3 \times \sigma_1)} \leq \sigma_{yt}$$

$$\sqrt{19.47^2 + 7.37^2 + (-4.74^2) - (19.47 \times 7.34) - \{7.37 \times (-4.47)\} - \{(4.47) \times 19.47\}} \leq 215$$

$$20.9698 < 215$$

$$20.9698 MPa < 215 MPa$$

Hence the chosen material is safe.

c) *Buckling Load in Cylinder:* For the required buckling calculation for cylinder used for pushing, the following method may be used for control of buckling. We use Euler's buckling theory.

$$Euler's\ load\ of\ cylinder\ (P_E)_c = \frac{E \times I \times \pi^2}{L_e^2}$$

Where,

E = Young's modulus of elasticity, N/ mm^2

I = Moment of inertia

$$L_e = \frac{L_c}{2}\ (\ For\ both\ end\ fixed\ )$$

$$Euler's\ load\ of\ cylinder\ (P_E)_c = \frac{4 \times E \times I_c \times \pi^2}{L_c^2}$$

Where,

I_c = Moment of inertia of the cylinder

L_c = length of cylinder

L_c = 120 mm

To find Moment of inertia of the cylinder –

$$Moment\ of\ inertia\ of\ the\ cylinder\ (I_c) = \frac{\pi \times (\ D_o^4 - D_i^4)}{64}$$

Where,

D_o = outer diameter of the cylinder, mm

D_i = inner diameter of the cylinder, mm

$$Moment\ of\ inertia\ of\ the\ cylinder\ (I_c) = \frac{\pi \times (50^4 - 39^4)}{64}$$

I_c= 193235.388 mm^4

Now,

$$Euler's\ load\ of\ cylinder\ (P_E)_c = \frac{4 \times 195 \times 193235.388 \times \pi^2}{120^2}$$

$(P_E)_c$= 103304.3286 N

$(P_E)_c$=103.304 X 10^3 N

Euler's buckling load of cylinder $(P_E)_c$ is greater than our Actual maximum load (P_A), hence our cylinder is safe.

3) *Buckling Load in Inclined Cylinder:* For the required buckling calculation for cylinder used for pushing, the following method may be used for control of buckling. We use Euler's buckling theory.

$$Euler's\ load\ (P_E) = \frac{E \times I \times \pi^2}{L_e^2}$$

Where,

E = Young's modulus of elasticity, N/ mm^2

I = Moment of inertia

$$L_e = \frac{L_i}{2}\ (\ For\ both\ end\ fixed\ )$$

$$Euler's\ load\ of\ inclined\ cylinder\ (P_E)_i = \frac{4 \times E \times I_i \times \pi^2}{L_i^2}$$

Where,
I_i = Moment of inertia of the inclined cylinder
L_i = length of the cylinder
L_i = 170 mm
To find Moment of inertia of the inclined cylinder –

$$Moment\ of\ inertia\ of\ the\ inclined\ cylinder\ (I_i) = \frac{\pi \times (\ D_o^4 - D_i^4)}{64}$$

Where,

D_o = outer diameter of the inclined cylinder, mm

D_i = inner diameter of the inclined cylinder, mm

$$Moment\ of\ inertia\ of\ the\ inclined\ cylinder\ (I_i) = \frac{\pi \times (50^4 - 39^4)}{64}$$

I_i= 193235.388 mm^4
Now,

$$Euler's\ load\ of\ inclined\ cylinder\ (P_E)_i = \frac{4 \times 195 \times 193235.388 \times \pi^2}{170^2}$$

$(P_E)_i$ = 51473.437 N

$(P_E)_i$ = 51.473 X 10^3 N

Euler's buckling load of the cylinder $(P_E)_c$ is greater than our Actual maximum load (P_A), hence an inclined cylinder is safe.

4) *Buckling Load in piston rod of Inclined Cylinder:* For the required buckling calculation for piston rod used for pushing, the following method may be used for control of buckling. We use Euler's buckling load.

$$Euler's\ load\ in\ piston\ rod\ of\ inclined\ cylinder (P_E)_r = \frac{E \times I_r \times \pi^2}{L_e^2}$$

Where,
E = Young's modulus of elasticity, N/ mm^2
I_r = Moment of inertia of the piston rod

$$Euler's\ load\ in\ piston\ rod\ of\ inclined\ cylinder (P_E)_r = \frac{4 \times E \times I_r \times \pi^2}{L_r^2}$$

Where,

$$L_e = \frac{L_r}{2} \ (For\ both\ end\ fixed)$$

L_r = length of the cylinder

L_r = 110 mm

To find Moment of inertia of the cylinder –

$$Moment\ of\ inertia\ of\ the\ piston\ rod\ (I_r) = \frac{\pi \times D_r^4}{64}$$

Where,

D_r = outer diameter of the piston rod, mm

$$Moment\ of\ inertia\ of\ the\ piston\ rod\ (I_r) = \frac{\pi \times 35^4}{64}$$

I_r=73661.76 mm^4

Now,

$$Euler's\ load\ in\ piston\ rod\ of\ inclined\ cylinder (P_E)_r = \frac{4 \times 195 \times 73661.76 \times \pi^2}{110^2}$$

$(P_E)_r$ = 46865.264 N

$(P_E)_r$ = 46.865 X 10^3 N

Euler's buckling load of piston (P_E) is greater than our Actual maximum load (P_A), hence our piston rod is safe.

C. Buckling load in Modified Centre Stand

For the required buckling calculation for a centre stand, the following method may be used for control of buckling. We use Euler's buckling load.

$$Euler's\ load\ in\ centre\ stand\ (P_E)_s = \frac{E \times I \times \pi^2}{L_e^2}$$

Where,

E = Young's modulus of elasticity, N/ mm^2

I_s = Moment of inertia of the centre stand

$$Euler's\ load\ in\ centre\ stand\ (P_E)_s = \frac{4 \times E \times I_s \times \pi^2}{L_s^2}$$

Where,

$$L_e = \frac{L_s}{2} \ (For\ both\ end\ fixed)$$

L_s = length of a centre stand

L_s = 75 mm

To find Moment of inertia of the centre stand –

$$Moment\ of\ inertia\ of\ the\ centre\ stand\ (I_s) = \frac{\pi \times D_s^4}{64}$$

Where,

D_s = outer diameter of the piston, mm

$$Moment\ of\ inertia\ of\ the\ centre\ stand\ (I_s) = \frac{\pi \times 50^4}{64}$$

I_s = 306796.1576 mm^4

Now,

$$Euler's\ load\ in\ piston\ rod\ of\ centre\ stand\ (P_E)_s = \frac{4 \times 215 \times 306796.1576 \times \pi^2}{75^2}$$

$(P_E)_s$ = 34720570.24 N

$(P_E)_s$ = 347.206 X 10^3 N

Euler's buckling load of a centre stand $(P_E)_s$ is greater than our Actual maximum load (P_A), hence our centre stand is safe.

D. Working prototype model of automatic centre stand of motorcycle-

We made a prototype working model of automatic centre stand for motorcycle by using some component. Following are the main component of automatic centre stand –

1) *Centre Stand:* We made this by wood and its length is 210mm and diameter is 50mm, which is shown in fig. 4.

Fig. 4 Modified centre stand

2) *Hydraulic Cylinders:* We made this by 60ml syringes and we use normal water as fluid in syringes, which is shown in fig. 5.

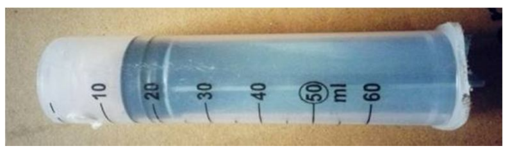

Fig. 5 Syringes of 60 ml

3) *Compressor:* We made compressor by combination of sliding crank mechanism and piston- cylinder arrangement (150ml syringe) which is powered by 12V battery source, which is shown in fig. 6.

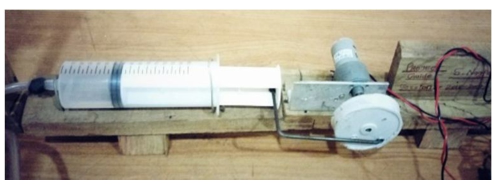

Fig. 6 Sliding crank mechanism and piston-cylinder arrangement

4) *Arduino Uno:* We use Arduino Uno to operate the hydraulic cylinder automatically by pushing a single push button, which is shown in fig. 7.

Fig. 7 Arduino Uno

a) Coding for Arduino Uno

```
int A;
int p=50;
int motor1a=4;
int motor1b=5;
int motor2a=6;
int motor2b=7;
void setup()
{
pinMode(2,INPUT);
Serial.begin(9600);
pinMode(motor1a,OUTPUT);    //rotatory motion
pinMode(motor1b,OUTPUT);
pinMode(motor2a,OUTPUT);    //vertical motion
pinMode(motor2b,OUTPUT);
}
void loop()
{
  A = digitalRead(2);
if((A==HIGH)&&(p==50))
  {
Serial.println(" ON ");
    p=100;
digitalWrite(motor1a,HIGH);
digitalWrite(motor1b,LOW);
delay(4000);
digitalWrite(motor1a,LOW);
digitalWrite(motor1b,LOW);
delay(10);
digitalWrite(motor2a,HIGH);
digitalWrite(motor2b,LOW);
delay(2000);
digitalWrite(motor2a,LOW);
digitalWrite(motor2b,LOW);
  }
if((A==HIGH)&&(p==200))
  {
Serial.println(" off ");
    p=50;
digitalWrite(motor2a,LOW);
digitalWrite(motor2b,HIGH);
```

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```
delay(2000);
digitalWrite(motor2a,LOW);
digitalWrite(motor2b,LOW);
delay(10);
digitalWrite(motor1a,LOW);
digitalWrite(motor1b,HIGH);
delay(4000);
digitalWrite(motor1a,LOW);
digitalWrite(motor1b,LOW);
  }
if(p==100)
  {
    p=200;
  }
}
```

5) *Motor diver L298N:* The motor driver receives the logic from Arduino Uno and drives motor by the 12volt battery, which is shown in fig. 8.

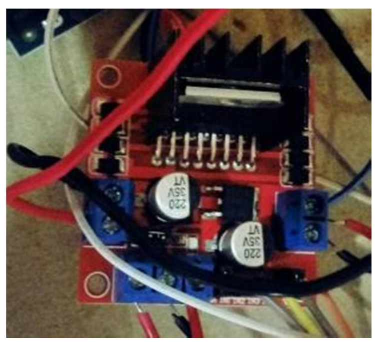

Fig. 8 Motor diver L298N

6) *12V Battery:* We use 12V battery as power source to operate the motor of sliding crank mechanism, which is shown in fig. 9.

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Fig. 9 12 Battery

a) *Principle of Automatic Centre Stand:* The basic principle on which prototype of automatic centre stand works is Pascal's law. When motor shaft moves then the link press the piston rod of a syringe of 150ml and the piston rod 60ml syringe comes out. By using the Arduino Uno we operate the centre stand by single push button.

b) *Working of Automatic Centre Stand*

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i) When we push the button then Arduino sends logic to move motor (M_1) 4 seconds clockwise direction, then piston rod of syringe tilde the centre stand.

ii) After 4 seconds anther logic sends by the Arduino to move motor (M_2) 2 seconds clockwise direction, then bottom side the piston rod of syringe moved to downward dissection to lift the bike.

Fig. 10 Prototype model of Automatic centre Stand for Motorcycle

iii) When we push the button second time then Arduino send logic to move motor (M_2) 2 seconds anti-clockwise direction, then bottom side the piston rod of syringe moved to upward dissection.

iv) After 2 seconds anther logic sends by the Arduino to move motor (M_1) 4 seconds anti-clockwise direction, then piston rod of syringe pulled the centre stand.

In this way the automatic centre stand works in 6 seconds by a single push of the push button.

III.RESULT

By calculation we found that Euler's buckling load of cylinders, piston rods and a modified centre stand is greater than our Actual maximum load (P_A), hence our cylinders, piston rods diameter and length of the centre stand are safe. By going through Failure of theory, we found the Stainless steel type 304 of the cylinder is safe.

The automatic centre stand lifts the bike of weight 155kg - 205kg. The automatic of the automatic centre stand is shown below, fig. 11 and taken round off value after the decimal.

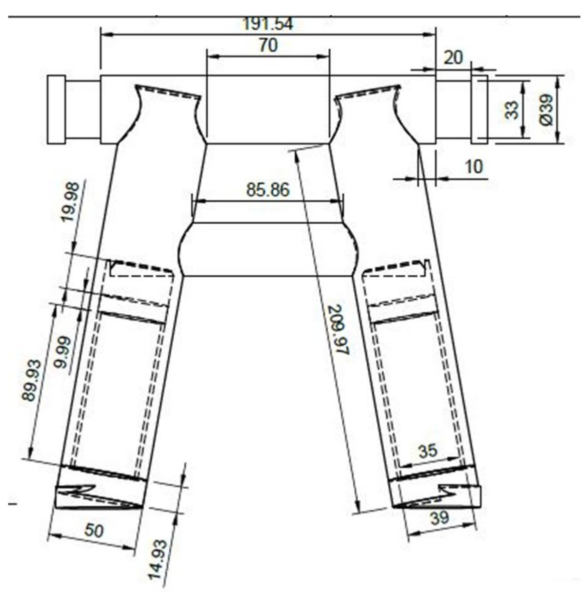

Fig. 11 Front view of the automatic centre stand with dimension

IV. CONCLUSIONS

The dimension of the automatic centre stand (fig. 11) is safe by the calculations, and our proposed design of the automatic centre stand can be use in automobile sector. The main advantage of this mechanism is a reduction of human efforts and less parking space required as compared to a vehicle parked on the side stand. The automatic centre stand reduces human afford. It will reduce leg/ back injuries, it can be used on uneven surfaces and it will eliminate the requirement of side stand. Centre stand gives more stability as compared to the side stand. This stand will give comfort as well as safety to the rider.

V. ACKNOWLEDGMENT

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