DESIGN AND FABRICATION OF HYDRAULIC SPRING STIFFNESS TESTING MACHINE

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Abstract- Springs isolate the driver from road imperfections by allowing the tyre to move over a bump without drastically disturbing the chassis. If the chassis remains fairly steady then the tyres are better able to follow road contours automatically. While springs do an excellent job of smoothing over bumps, they will keep bouncing once started. In other words, the chassis continues swaying and the tyres keep hopping long after the vehicle strikes a bump. Left uncontrolled, springs give an uncomfortable ride with very poor tyre to road contact. To control this undesirable behavior, a shock absorber keeps the spring from over reacting to every bump or dips and not only prevents but also balances excess movement of the tyre and chassis. Springs are durable items and are easily inspected. If the ride height of a vehicle has decreased excessively or a coil/leaf has broken it is advisable to replace the springs in axle sets. Consumers also often change springs to alter their vehicle's ride and handling characteristics. Spring problems are generally easy to identify.

Keywords – Spring , Tyre , CAD model , Stiffness ,Shock absorber , Chassis , Vehicle

INTRODUCTION-

The most common method for checking the performance of shock absorbers is for the owner or mechanic to jump up and down on the car bumper and observe whether or not the car motion appears to be adequately damped. When the shocks are completely worn out, it is clear that the damping is inadequate, however by the time the wear is readily observable, the car owner has been driving for an extended period of time with bad shocks. By then the owner has learned to hate his vehicle, the tyres have been abnormally worn, and the road ability has deteriorated to the point that he or she has been driving dangerously all over the road.

Main reason for replacement of shock absorber(spring) is physical damage. Spring stiffness must be checked before replacement. This test rig will give the force applied on spring. With the help of force and deflection produced , we can calculate stiffness of spring. By varying the force , we can obtain corresponding deflections . We are going to study the suspension characteristics of spring by graphical method.

WORKING PRINCIPLE

The working of hydraulic stiffness testing machine is based on Pascal's law which states that **"PRESSURE APPLIED AT ANY POINT ON ANY CONFINED LIQUID IS TRANSMITTED EQUALLY TO ALL OTHER POINTS"** This principle is same as that used in hydraulic press.

 The pressure is transmitted from hydraulic cylinder to load cell by application of a lever. The smaller cylinder is having plunger and hydraulic cylinder is having ram (piston and piston rod). Hydraulic cylinder is having a lever mounted over it. When force is applied by lever, it gets multiplied to many times and that multiplied force acts on the plunger. Due to this force the plunger compresses the liquid. The liquid will be pressurized as it is confined between plunger and piston. This pressure in liquid is transmitted by liquid to piston. As the piston is having larger area than plunger, the force delivered by piston and piston rod is much larger then force acting on the plunger. The piston rod moves outwards and presses the spring placed between the hydraulic cylinder and load cell.When the release knob is opened the pressurized liquid gets escaped into the reservoir and due to the spring action of retracting spring the piston is brought backward.

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DESIGN-

First of all we have to calculate maximum output required to lift the load

DESIGN OF LEVER -
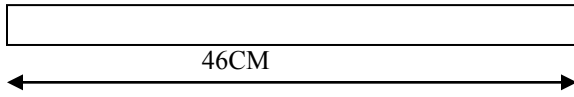
46CM

by law of moments
F x l = f x L

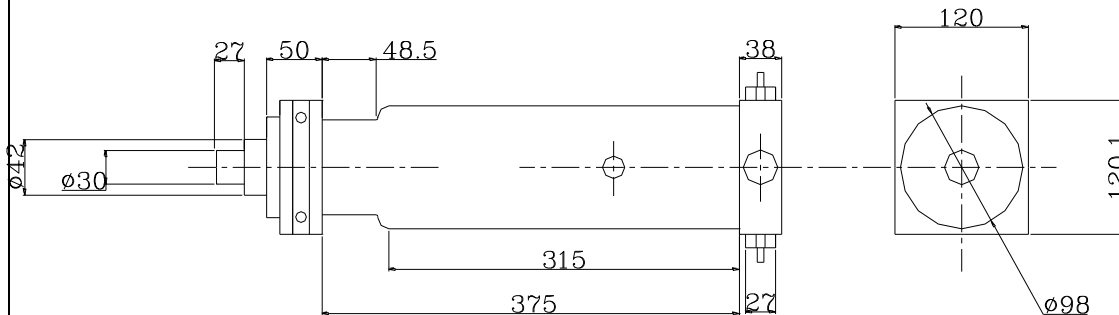F = f x L/l where f = force or effort applied and F = force obtained by leverage.

Now normally a person can apply a 20kg force. So we take f = 20kgf

Now L =46cm. And l = 4cm. Considered.

∴ F = 20 X 46/4 = 230kgf.

Force applied by leverage =230kgf.

DESIGN OF BIGGER CYLINDER -

CYLINDER (QTY. 1 OFF)

FROM HYDRAULIC PRESS FORMULA,
$$W = \frac{A}{a} \text{ x F}$$

$$W = \frac{\frac{\pi}{4}D^2}{\frac{\pi}{4}d^2} \text{ x F} = \frac{D^2}{d^2} \text{x F}$$

Now, d = diameter of smaller cylinder = 1.5 cm.

We have , W = 1500kg & F = 230kgf.

∴ $1500 = \frac{D^2}{15^2}$ x 230

D = 3.8cm , D actual ≈ 4 cm

Therefore diameter of bigger cylinder = 40 mm.

Now for thickness of cylinder wall of bigger cylinder,

We have, t = $\frac{pd}{2f_t}$ where p = internal pressure, & d = diameter of cylinder,

f_t = permissible stress.

We have p = F/A = $\frac{230}{\frac{\pi}{4}d^2}$

$$= \frac{230}{\frac{\pi}{4}4^2}$$

Internal Pressure (p) = 18.32 kg/cm^2

Now ultimate stress for cylinder material = 800 kg/cm^2

Considering factor of safety as 5.

We get permissible stress = $\frac{\text{Ultimate stress}}{\text{factor of safety}}$

$\therefore f_t = \frac{800}{5}$

f_t = 160 kg/cm^2

Inputting these value in the thickness formula,

We get,

t = 18.32 x $\frac{9.8}{2}$ x 160

= 0.753 cm.

t ≈ 0.8cm. = 8 mm.

Outer dia. of cylinder = 40 + (2 x 8) = 56 mm

DESIGN OF PISTON ROD -

The piston rod is subjected to compressive load.

We known (stress) = $\frac{\text{Force}}{\text{Area}}$

= 300 kg/cm^2 in compression for mild steel.

Taking factor of safety = 2

$$= \frac{300}{2}$$

$$= 150 \text{ kg/cm}^2$$

&   p = 1500 kg. (compressive)

∴ Area (A) = Force/Stress

$$= \frac{1500}{150}$$

$$= 10 \ cm^2$$

$$\frac{\pi}{4}d^2 = 10$$

∴   d = 3.5 cm
∴   d = 3.5 cm.

Therefore diameter of piston rod = 35 mm.

Length of piston rod is taken 20cm as per the requirement.

Design of C frame -
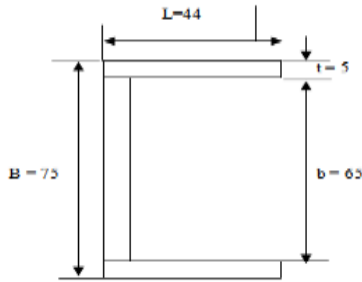
The c frame is subjected to pure tensile failure

ISLC 75 x 40 x 5 size

Area of cross section = 2 (50 x 5) + (90 x 5)

         A = 950mm^2

   Design force = 1500 kg

         = 1500x 9.81

         = 14715 N

Induced tensile stress $= \frac{F}{A}$ $= \frac{14715}{1000}$ = 14.715 N /mm^2

Allowable tensile stress = 320 N /mm^2

As induced stress is much more **less** than allowable stress design of C section is safe.

METHODOLOGY –

1. Close the pressure relief valve and adjust the spring in between load cell and hydraulic cylinder.
2. The machine contains hydraulic piston and cylinder arrangement to press spring under testing. By manual pumping hydraulic piston move forward and compress spring.
3. Due to compression in spring, force is applied on load cell and deflection occurred in spring.
4. Load cell is connected to microprocessor circuit. Potentiometer and load cell are connected to microprocessor. It calculates deflection from potentiometer and force from load cell.
5. With the help of program , spring stiffness is displayed on screen.

$$\text{Stiffness (K)} = \frac{Force\ (L)}{Deflection(D)}$$

TESTING RESULTS –

SR. NO.	LOAD (N)	DEFLECTION (mm)	SPRING STIFFNESS (N/mm)	AVG. STIFFNESS
1.	60	60	1	
2.	60	60	1	1
3.	60	59	1.016	

Advantages-

1. Spring of different diameters can be checked without damaging it.
2. The testing process is carried out in very less time, so production rate is very high.
3. One man effort is enough and no skill is required.
4. The system is self lubricating, noiseless and portable.

Disadvantages-

1. Spring wire dia. cannot be checked below 40mm and above 60mm. (If we check the diameter of spring below 40mm there are chances for spring to buckle)
2. As system is hydraulic, leakage may occur and hence refilling of oil is necessary.

Applications-

1. The machine is used for measuring spring stiffness for different spiral and helical springs in the range of 40mm to 60mm.
2. Can be used in garages where frequent inspection of the suspensions of various automobiles is carried out.
3. With the help of this machine it is possible to analyze when to replace the suspension by comparing the stiffness of the testing suspension with that of the standard stiffness.

DIAGRAM-
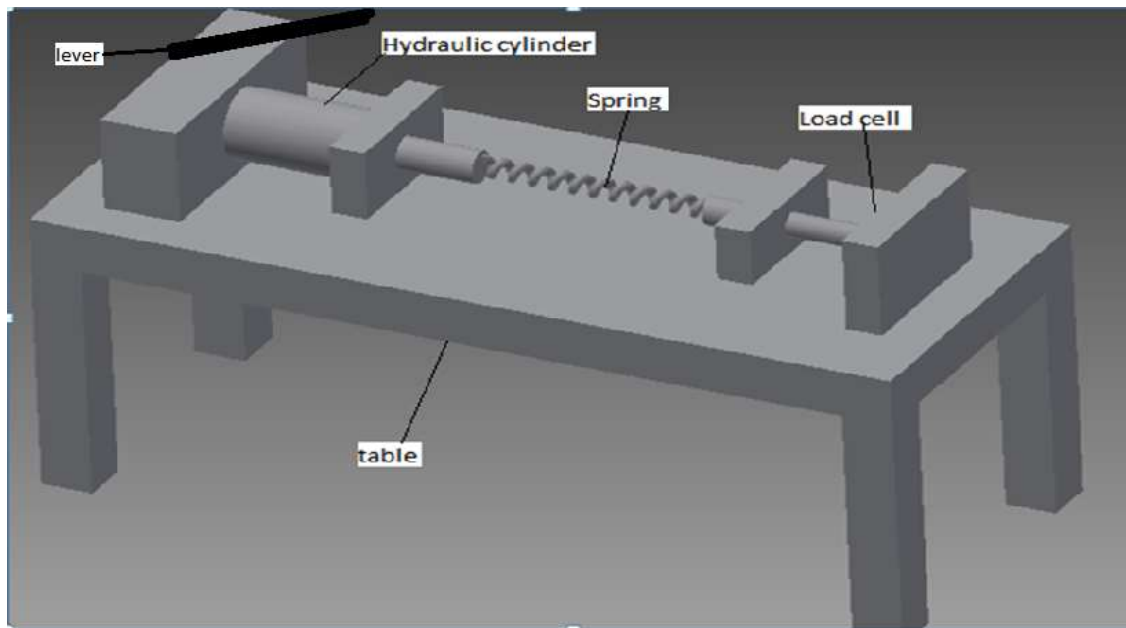
Fig., CAD model of project set up

CONCLUSION-

By this project, pressure is applied on spring with the help of hydraulic system. Applied load and deflection produced in spring is measured by microprocessor and value of spring stiffness is displayed.

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