Fabrication of Spring Stiffness Measuring Apparatus Using Pneumatic System

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Abstract

Spring is one of the most utilized components in machines, equipment's in industries.The stiffness of the spring is the characteristic property of the spring which determine both the spring and its application. This paper shows the fabrication and designing of a spring stiffness measuring device based on pneumatic system, which measures the stiffnessof 8 springs(4 compression and 4 tension , wire dia 2 mm and coil dia 3 cm) in terms load and deflection, thereby establishing linearity and making calculations easy.

Keywords- *Spring stiffness, pneumatic cylinder, load and deflection.*

I. INTRODUCTION

An engineer is always focused towards challenges of bringing ideas and concepts to life. Therefore, sophisticated machines and modern techniques have to be constantly developed and implemented for economical manufacturing of products. At the same time, quality and accuracy factor is considered.Spring is an important element in industries that is often used in almost from small workshops to large scale industries and their studies in schools, engineering colleges in laboratories has been incorporated. It is often used as a vibration absorbing element or as storage of energy. Stiffness and spring index are the main parameters of spring design. Spring stiffness is the force per unit deflection [1]. In designing and developing the spring testing machine, these parameters are considered. Pneumatic principle is considered while designing and developing the stiffness machine.

In order to design the proposed model of the pneumatic spring stiffness testing machine, a literary survey has been made by consulting different research papers and a number of articles on spring testing machines. Some of the various findings obtained from the literary survey have been summarized below:

G. S. Jagushteet.al [2] studied the application of pressure on spring using hydraulic system.O.O Ayodejiet.al [3] designed and fabricated a hydraulically operated spring stiffness testing machine. Avdhut R Jadhav et.al [4] manufactured and studied a hydraulically operated spring stiffness testing apparatus. Saket Madhav et.al [5] designed a spring stiffness testing using various load cells e.g. hydraulic, pneumatic, strain gauge etc.

II. SPRINGSTIFFNESS MEASURING MACHINE USING PNEUMATIC CYLINDER

The setup of the experiment consists of the reciprocating compressor (within operating range of 0-0.5 kgf/cm^2) which is connected to the air cylinder by pipes (PVC; 4mm dia) through a hand lever (3-way type). The reciprocating compressor compresses the air to required pressure. The compressed air is then fed to the air cylinder (Model-SC 80×250mm) with proper arrangement of ports and use of hand lever. The air cylinder is perfectly clamped to the frame of the apparatus. Then different arrangements are used in measurement of the stiffness of the tension and compression springs which are explained below.

For compression spring testing a hollow cylindrical element (40mm) is attached to the piston (250mm) of the air cylinder. It is used to compress the spring whose other end is clamped to a plate kept at a fixed position. For tension spring testing an extension clamp rod is attached to the piston of the air cylinder. The clamp rod is of L shape (16cm). It has a hook which holds one end of a tensile spring whose other end is fixed at a hook placed at the middle of the frame.

When the compressed air enters the cylinder, it forces the piston out and thus exerts force on the spring which causes its deflection. Both are then measured to know the spring stiffness.

Abrief description of the parts are given below:

A. Frame

The frame is made of hollow iron bars having dimensions 84×32×12 cm. One end of the frame supports the air cylinder in such a way that it remains stationary. The other end of the frame has a screw pair which restrains one end of the spring during measurement of stiffness of tensile springs. In the middle of the frame there is a hook which restrains one end of the spring during compression spring measurements.

B. Pneumatic Cylinder

Pneumatic cylinder(s) (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Double-acting Cylinders (DAC) uses the forces of air to move in both extend and retract strokes.

C. Hand Lever

Hand Lever Valves are used to operate Pneumatic CylinderA 3-way directional control valve has three working ports. These ports are: inlet, outlet, and exhaust (or tank). A 3-way valve not only supplies fluid to an actuator, but allows fluid to return from it as well.

D. Reciprocating Compressor

A reciprocating compressor or piston compressor is a positive-displacement compressor that uses pistons driven by a crankshaft to deliver gases at high pressure.The compressor is employed with a gauge which can be read to control the pressure of the air generated as per requirements. The compressor is operated within the range of 0–0.5 kg/cm^2

E. Pressure Gauge

Pressure measurement is the analysis of an applied force by a fluid (liquid or gas) on a surface. The pressure gauge used has the range 0-10.6 kg/cm^2. It is connected to the pipe connecting the compressor and the hand lever with the use of a T-joint.

F. Clamps And Extension Rod

To fix the compression springs a plate is fixed at a position and from the other end force is applied by the plunger. The tension spring end is fixed by using a clamped hook. The other end is pulled by an extended rod. The extended rod is connected to the plunger itself by a screw bolt system.

G. Assembly

The different parts are carefully assembled during the testing. The arrangement during the compression test and tension test are different. The different views of the machine assembly are shown in the following figures.

Fig.1: Parts of the Assembly

Fig.2: Assembly Diagram Of The Apparatus

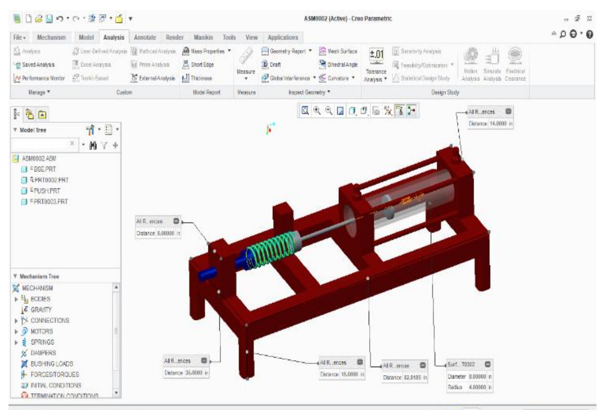

Fig.3: Cad Diagram Of The Assembly

III. WORKING PRINCIPLE

The working of “Spring stiffness measuring machine using pneumatic system” is based on Pascal’s law which states that “pressure applied at any point on any confined fluid is transmitted equally to all other points”. The pressure of the compressed air is utilized to move a piston which exerts force on the spring causing it todeflect. The deflection can be measured and hence the stiffness.For compression spring testing a hollow cylindrical element is attached to compress the spring whose other end is clamped to a plate kept at a fixed position.For tension spring testing an extension rod is attached to the piston of the air cylinder.It has a hook which holds one end of a tensile spring whose other end is fixed at a hook placed at the middle of the frame.When the compressed air enters the cylinder, it forces the piston out and thus exerts force on the spring which causes its deflection. Both are then measured to know the spring stiffness.

IV. RESULTS AND DISCUSSIONS

The testing is done with 4 tension springs and 4 compression springs. Spring is clamped in the arrangement and the pressure are applied which is measured by the gauge and deflection is measured

Suitably by the scale. The calculated value of stiffness has been compared with the standard value of stiffness
(Which is measured with the help of an app called SPRINGULATOR SPRING CALCULATOR [8]) to find the percentage error.

The springs are tested under different conditions of pressure applied to it without exceeding the elastic limit conditions. Different forces when applied to the springs cause varying deformations.
The different experimental results and the plot of the results are shown below:

A. Spring I

Table[1]:Observation of Deflections for Spring I Under Different Forces

Force (N)	*Deflection (mm)*	*Average stiffness (KN/m^2)*	*Standard Stiffness (KN/m^2)*	*Percentage error (%)*
0	0			
1	0.6			
3	2.6	12.3	12.3	0.08
5	3.8			
8	6			
9	7			
13	11			

The following graph shows the plot of force applied to the springI versus its deflection.:

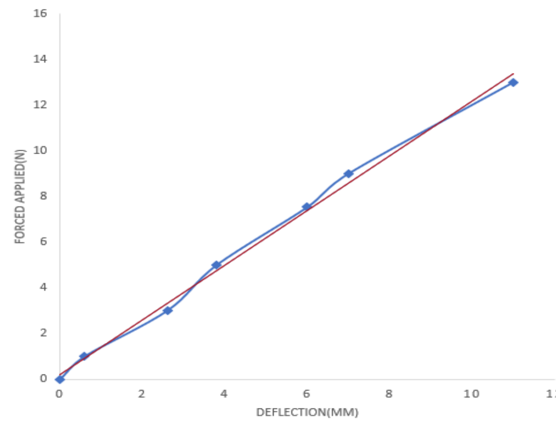

Fig.4: Plot Of Force Vs Deflection

Discussion**:** The experimental curve deviates from theideal straight-linecurve,the small percentages in error may be due to the buckling effects or clamping defects.

B. Spring II

Table[2]: Observation of Deflections for Spring Iiunder Different Forces

Force (N)	*Deflection (mm)*	*Average Stiffness (KN/m^2)*	**Standard stiffness (KN/m^2)**	**Percentage error(%)**
0	0			
1	6			
3	14.5			
5	25	1.9	1.895	0.26
8	39			
9	48			
13	67			

The following graph shows the plot of force applied to the spring II versus its deflection.

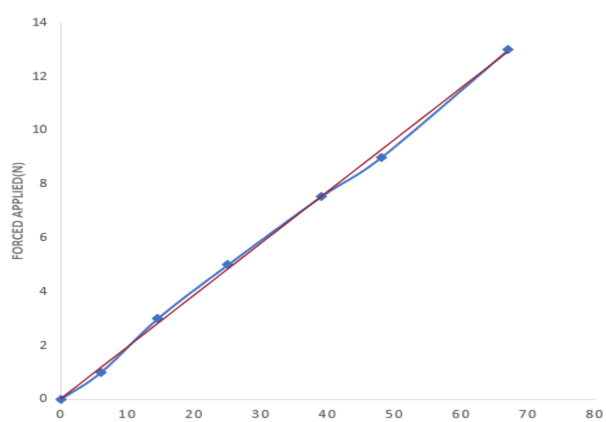

Fig.5: Plot Of Deflection Vs Force

Discussion*:* The small percentages in error may be due to the buckling effects or clamping defects. There is a small deviation at the beginning and at the tail of the curve. At higher force the error is marginally more.

C. Spring III

Table [3]: Observation of Deflections for Springiii Under Different Forces

Force(N)	*Deflection(mm)*	*Average Stiffness (KN/m²)*	**Standard stiffness (KN/m²)**	*Percentage error(%)*
0	0			
1	2			
2	6			
3	8	3.52	3.52	0
5	14			
7	20			
9	24			

The following graph shows the plot of force applied to the spring III versus its deflection.

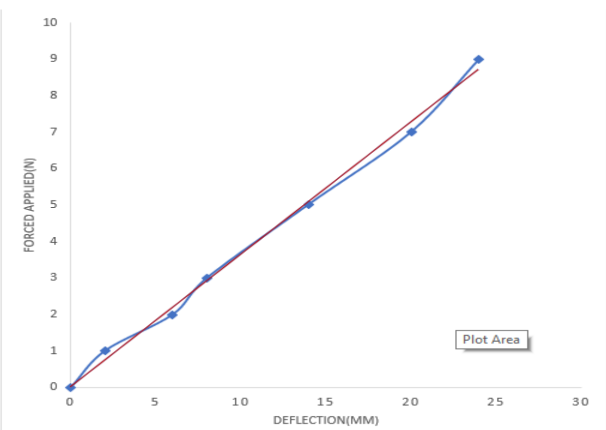

Fig.6: Plot Of Force Vs Deflection

*Discussion:*The small percentages in error may be due to the buckling effects or clamping defects. In this case the deviations are large at small forces.

D. Spring IV

Table[4]: Observation of Deflections for SpringIV Under Different Force

Force (N)	*Deflection (mm)*	*Average Stiffness (KN/m²)*	**Standard stiffness (KN/m²)**	*Percentage error(%)*
0	0			
1	2.2			
2	5.9			
3	7.8	3.65	3.65	0
5	13.5			
7	19.5			
9	24			

The following graph shows the plot of force applied to the spring IVversus its deflection.

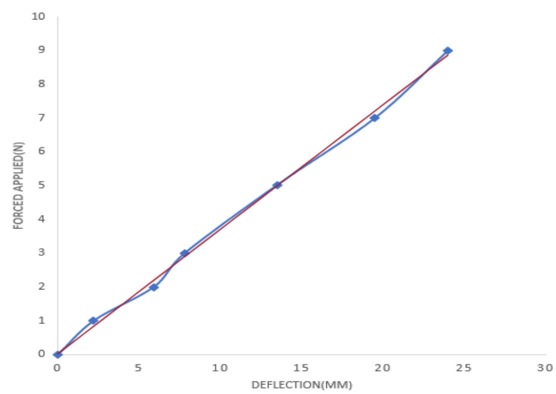

Fig.7:Plot of Force vs Deflection

Discussion*:*The graphical results show that the experimental curve deviates from theideal straight-line curve. In this case the error is very little which may be due to buckling.

E. Spring V

Table[5]: Observation of Deflections for Spring Vunder Different Force

Force (N)	*Deflection (mm)*	*Average Stiffness (KN/m²)*	**Standard Stiffness (KN/m²)**	*Percentage error (%)*
0	0			
2	18			
4	30			
5	40	1.19	1.23	3.36
7	54			
11	90			
15	122			

The following graph shows the plot of force applied to the spring Vversus its deflection.

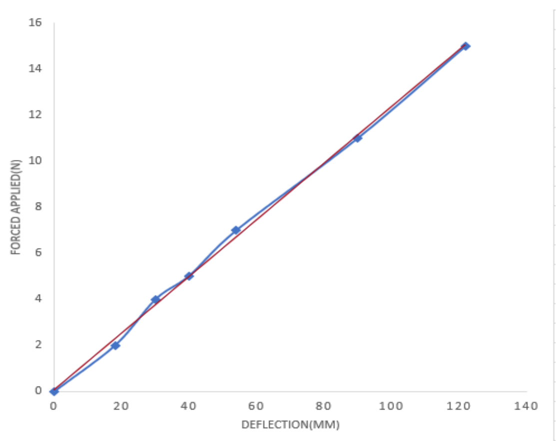

Fig.8:Plot of Force vs Deflection

Discussion:The graphical results show that the experimental curve deviates from theideal straight line curve. The errors may occur due to inefficient clamping of the hooks of the tension spring.

F. Spring VI

Table[6]: Observation of Deflections for Spring VI Under Different Forces

Force (N)	*Deflection (mm)*	*Average Stiffness (KN/m²)*	**Standard Stiffness (KN/m²)**	*Percentage error (%)*
0	0			
1	3.5			
3	9.5			
5.024	15	3.12	3.28	4.8
9	27.5			
11	31.5			
13	40			

The following graph shows the plot of force applied to the spring VI versus its deflection:

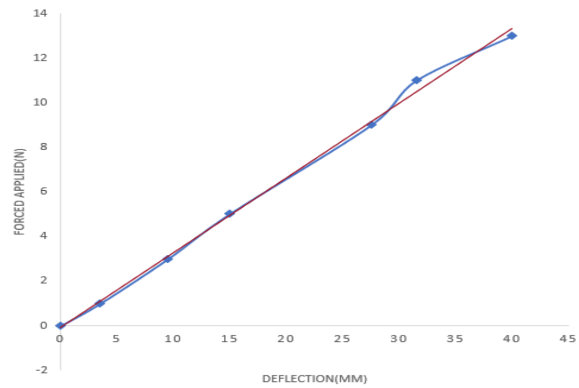

Fig.9: Plot of Force vs Deflection

Discussion:The graphical results show that the experimental curve deviates from theideal straight-line curve. The only error that occurs is at a higher force. The error may occur due to excess application of force to the tension spring

G. Spring VII

Table[7]: Observation of deflections for spring VIIunder different forces.

Force (N)	*Deflection (mm)*	*Average Stiffness (KN/m²)*	**Standard stiffness (KN/m²)**	*Percentage error(%)*
0	0			
1	2.8			
2	5.5			
5.024	12	3.95	4.107	3.97
7	16			
10	24.5			
12	29			

The following graph shows the plot of force applied to the spring VII versus its deflection:

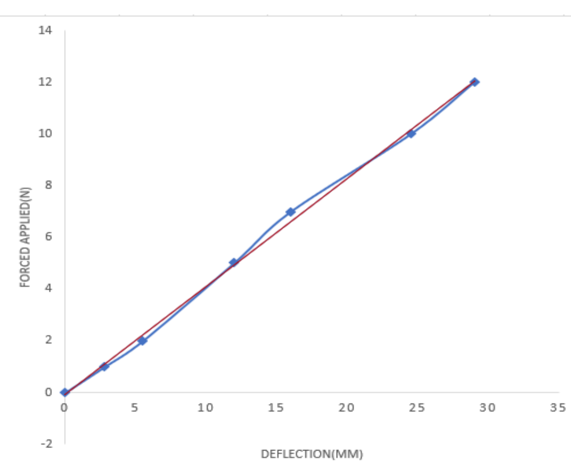

Fig.10: Plot of Force vs Deflection

Discussion:The graphical results show that the experimental curve deviates from theideal straight line curve.The errors may occur due to inefficient clamping of the hooks of the tension spring.

H. Spring VIII

Table[8]: Observation of Deflections for Spring VIII Under Different Forces

Force (N)	*Deflection (mm)*	*Average Stiffness (KN/m²)*	**Standard stiffness (KN/m²)**	*Percentage error(%)*
0	0			
2	8			
4	13.9			
5.024	17	2.89	2.81	2.84
8	29			
11	36			
14	48			

The following graph shows the plot of force applied to thespring VIII versus its deflection:

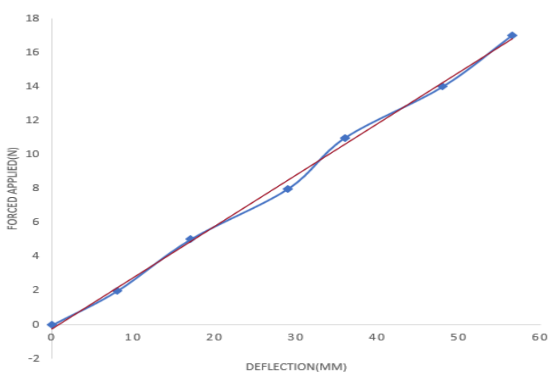

Fig.11: Plot of Force vs Deflection

Discussion:The graphical results show that the experimental curve deviates from theideal straight-line curve. The errors may occur due to inefficient clamping of the hooks of the tension spring. Also, the forces applied may be much higher.

V. ADVANTAGES

The pneumatic model has got the following advantages:

- Both tension and compression spring can be tested.
- Spring of different diameters can be measured.
- Spring can be checked without damaging it.
- The testing is carriesd out in very less ime so the production rate is high.
- One-men effort is enough to check the spring.
- Semi skilled and unskilled labour can easily operate the machine.
- The system is noiseless
- It s portable and can be carried out to anywhere.

VI. LIMITATIONS

The test machine can perform stiffness test only on compression and tension springs. The maximum force that can be exerted by the machine on the spring is 8kgf/cm^2 and the minimum force is 1.5kgfcm^2. However, springs of different diameters and lengths can be tested with a maximum length limit of 20-30cm.

VII. CONCLUSION

For a spring, stiffness is the most important performance characteristics. This work has been able to evaluate, design and construct a spring stiffness testing machine as a step towards making testing of spring stiffness easier and affordable by our automobile industries, hydro plants, local mechanics and also some manufacturing industries that use heavy equipment that has spring as an important integral of their part. Its attractive feature is that it can perform tests on tension springs as well as compression springs. In low cost we can use this pneumatic operated spring stiffness testing machine, this machine contains less parts and easilyunderstandable. Digital spring stiffness testing machine have high cost as compared to hydraulic spring stiffness testing machine, so by using this spring stiffnesstesting machine, we can check spring stiffness at low cost in motor garage, small industries etc.

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